

## PANEL DISCUSSION WHAT SOCIETY NEEDS FROM OCEAN SCIENTISTS IN PREPARING FOR GLOBAL CHANGE

**Michael Mullin:** We have arranged the afternoon session as a discussion in which the panelists will have an opportunity to make opening statements from their individual perspectives about science and policy and the issues that will be facing society in global change.

The moderator of the discussion is Robert Sulnick, executive director of American Oceans Campaign. In addition to giving his own opinion, he will pick out points of agreement or contrast and guide the discussion after each member has had a chance to speak. We will, at that point, take written questions from the floor.

**Robert Sulnick:** First let me thank Scripps for giving me the honor of being the moderator for this session. I am truly impressed by the quality of the panel and feel quite humbled by it.

I want to briefly introduce this wonderful group. On my immediate right is the Honorable Byron Sher, assemblyman for the Palo Alto district in the state legislature. Next to Byron is the director of Scripps, Professor Ed Frieman. Next to Ed is Bert Larkins, who is a fisheries biologist and now the executive director of the Alaska Factory Trawlers Association. On my immediate left is Professor John McGowan, professor of oceanography at Scripps. Next to John is Boyce Thorne Miller, a marine scientist from the Oceanic Society, recently merged with Friends of the Earth. On my far left is Professor Harry Scheiber, UC Berkeley law professor and historian.

We will hear from Byron Sher first.

**Byron Sher:** Thank you very much. It's a great pleasure to be here. I appreciate the opportunity to participate in this important panel. Our topic is, what society needs from ocean scientists in preparing for global change. My special perspective is, what politicians need from science, although some would argue that politicians should not be considered a part of society, or at least civilized society.

A few months ago the Smithsonian Institution held a two-day conference in Washington on global environmental problems. Participants included some of the country's most eminent scientists, several prominent senators and congresspeople, and

some of President Bush's key environmental advisors. The scientists from various disciplines painted a very bleak picture of the effects of rapid urbanization: deteriorating air quality, ever-increasing water pollution, rapidly accelerating deforestation. Among other depressing statistics, they underscored that society is destroying forest land at the alarming rate of one acre per second. The U.S. production of synthetic organic chemicals has gone from zero to over 225 billion pounds per year in the last 75 years. And of course the world's fossil fuel use has soared. Chlorofluorocarbon emissions, which were almost nonexistent before World War II, are doubling every decade.

The scientists agreed that we could attack some of these problems if we imposed a two-dollar additional tax on gasoline. That would reduce the use of fossil fuel and thereby reduce these harmful emissions. But it's interesting to note that not one of the members of Congress who were present — and they included some of the best environmentalists in Congress — stepped forward and volunteered to introduce that legislation. Politicians simply do not want to tell their constituents that solutions to serious environmental problems require increases in taxes or dramatic changes in lifestyle.

That is not to say, however, that the voters cannot be aroused to approve dramatic programs to attack environmental problems. As you will remember, in 1986, sensing that the voters were deeply concerned about toxic contamination of the drinking water, and believing that the state legislature and governor would not adequately address the problem, several environmental groups qualified Proposition 65 for the ballot. In the November election the voters, while returning a very conservative, probusiness governor to office, also overwhelmingly approved Proposition 65, which, among other things, established strict new prohibitions on toxic discharges into the state's groundwater and surface waters.

Interestingly enough, for the first time ever, the scientific community was drawn directly into that election campaign. Experts in toxicology were used both by supporters and opponents of the initiative to bolster their respective cases. One prominent UC Berkeley professor, whom I shouldn't name but will — Dr. Bruce Ames — was pressed into service

by the opponents of Proposition 65, which he stated was environmental overkill. He appeared at public forums and urged voters to defeat the initiative. And indeed his so-called peanut butter argument (eating peanut butter poses a greater cancer risk than ingesting drinking water containing minute levels of toxic substances) became legendary during the campaign and was really the cornerstone of the business community's opposition.

Now that Proposition 65 has become law, scientists continue to be involved in implementing it. Under its provisions a scientific review panel has been set up and is required by law to determine which chemicals should be listed as carcinogens or teratogens. This panel has routinely been at the center of heated controversies between elected officials on both sides, and its determinations not to list certain chemicals have even been challenged successfully in court.

My point is that science and scientists are being drawn more and more into the political arena. Elected officials and society in general are demanding hard-and-fast answers to complex problems. But science often cannot provide such answers. And indeed, in those instances when science does propose a set of solutions, such as at the Smithsonian conference, we are often told that those solutions are politically impractical.

Global warming is one of the most vivid examples of the dilemma created as science and political decision making come together. The tremendous impacts that scientists have predicted from global climatic change demand responses. But so far California is doing little either to reduce its contribution to global warming or to prepare for the effects that are predicted.

For example, the Department of General Services, the agency that oversees new construction of state buildings, is not considering global warming effects when siting or designing new state facilities. The Water Resources Control Board, which has jurisdiction over the groundwater and surface waters of the state, has told us that it does not intend to address changes in runoff patterns resulting from global warming in its current hearings to determine the allocation of waters that flow into the Sacramento River Delta and San Francisco Bay. On the basis of this experience, we can justifiably conclude that these agencies, and indeed state government as a whole, are ignoring science.

There are several reasons why scientific warnings about the effects of global climate change have not generated much response from political bodies, or a demand for action by the public at large. First, these

warnings are predictive. Scientists are not absolutely certain that these changes will occur, and many, or some, profess not to know whether the proposed solutions will work.

Secondly, the public does not yet perceive the physical effects of global warming, and consequently science has not convinced the public of the need for action.

Third, many of the solutions offered by science are perceived to be extreme or impractical. Reducing greenhouse gas emissions seems to require enormous sacrifice on the part of the public.

And finally, other immediate concerns such as housing, AIDS, health care, and education are absorbing all of the state's limited resources. The public is unwilling to divert funds from these important programs to attack an uncertain global warming.

To return to the question before the panel: What answers does society need from science in preparing for global change? Well, here's the challenge. Science needs to provide the public and elected officials with precise, accurate information on the nature of the problem, and a range of realistic solutions that can be implemented within a reasonable time. State and federal governments will most likely not be moved to action on global climate change in any meaningful way until proposals of this nature are made.

I believe there is little chance that significant amounts of California state revenues will be devoted to broad-based programs to address the threat of global climate change unless we get something that's the political equivalent of the recent earthquake. In fact, in this past session of the legislature, the governor vetoed a couple of modest bills that would have inventoried greenhouse gas emissions in California and would have made a beginning on reducing those emissions.

So science must become part of the education process. Unless the public is well informed and demands action from its politicians, there will be no political will to address problems like global warming.

In summary, there is a gap between the answers to problems offered by science and the solutions acceptable to the public and therefore to politicians. That gap needs to be narrowed. Conferences like this one and the media attention that is paid to it are an important part of the process.

**Edward Frieman:** I'm here under false pretenses; you'll have to pretend that I'm Bill Frazer, senior vice president of academic affairs, who was supposed to be on this panel and is otherwise occupied

with earthquake activities. I'll base my remarks on the paper that he sent down.

He said, "It's a great personal pleasure for me to extend congratulations on the fortieth anniversary of the CalCOFI program."

He had been asked to provide an overview of the university's activities related to global change. The Global Change Advisory Group held its first meeting here at SIO just two days ago. The group consists of scientists from the campuses and the three Department of Energy laboratories — Lawrence Berkeley, Livermore, and Los Alamos — that are run by the University of California. The group was convened to advise the office of the president on how to build upon the already significant research being conducted throughout the university on this very important topic.

The group's specific charge is to suggest means by which the university administration can most effectively support the design and functioning of a coordinated systemwide research effort on global change, and to recommend elements that might constitute such a research effort.

Five options were presented to the group for discussion. These came out of a previous small rump meeting we had over two months ago. The options included establishing a research center focusing on one or more of the nationally identified high-priority research fields; creating a research center without walls to address one or more high-priority research fields; expanding the INCOR effort to develop a coupled ocean-atmosphere model, and you heard something about that this morning from John Knauss (I'll come back to this in a little bit); creating a global change minigrant program; and establishing an international clearing house for information on research activities and data about global change.

Presently there is a special project organized under the UC Institutional Collaborative Research Program (INCOR), which was started in October of 1988. We at Scripps, along with researchers at Lawrence Livermore and Los Alamos, won one competitive program with a project to understand exactly how pollution and other factors are changing the world's climate. All three of us have supercomputer facilities and programs in climate research. The project focuses on developing a coupled ocean-atmosphere model for global change. The Scripps researchers bring their expertise on ocean modeling, Los Alamos its expertise in areas of atmospheric science, and Lawrence Livermore the results of a decade of research on modeling the global climate. The first report is due this December. The total cost of this four-year project will be \$800,000.

A second initiative already under way is a joint UC Davis–Lawrence Livermore–Lawrence Berkeley Lab effort, funded partially by INCOR and partially by the Department of Energy, to conduct a series of workshops on global greenhouse effect. These workshops were designed to elicit the views of international and national global warming experts on problems of climate change. The first conference took place in July, and was aimed at identifying information needed to improve climate models and climate projections. The second conference, held in September, focused on options for reducing emissions of CO<sub>2</sub>. The third workshop, just a few days ago, brought together a small group of policy planners and researchers from fourteen Pacific Rim countries to examine the causes of climate change and its implications.

There is a third, very major, initiative under way, in which the university will participate. It's called the National Institute on Global Environmental Change and is just in its formative stages. This is a multiuniversity effort involving the University of California, Tulane, Indiana, and Harvard. It is written into legislation introduced by Congressman Fazio and calls for \$6 million in this first year and \$10 million thereafter. (This has caused some raised eyebrows.)

Those are the three major activities under way. The charge to our group was clear. Two days ago we examined these various issues, and I guess it's fair to say that we are in the very formative stages. One of the first things we did was to try to get an inventory of what's going on throughout all the laboratories and campuses in the University of California. We tried to map that into the Committee of Earth Sciences' famous document on U.S. global change research categories, which lists things in seven major chunks: climate and hydrological systems, biogeochemical dynamics, ecological systems and dynamics, system history, human interactions, solid earth processes, and solar influences.

The first result, which perhaps wasn't surprising, was that there isn't a one-to-one mapping; there is much more going on in the University of California that can be labeled under the rubric of global change, perhaps with a small g and a small c. In particular, this White House document doesn't really address issues of mitigation.

In our deliberations we examined three possible ways to move ahead. One was to expand the collaboration that now exists between Scripps, Livermore, and Los Alamos to other campuses. Two of them have major programs that would be a natural match: the atmospheric group at UCLA, and Sherry Row-

land's outstanding group at UC Irvine. Perhaps there will be others in the future.

The second point that was made was that it would be a good expenditure of a small amount of money to have a number of us talking to each other. We really don't know from one campus to another what's going on. The totality of the research going on throughout the UC system, as addressed to this particular problem, is just enormous. Some people made the statement—it's hard to prove that it's true—that it's perhaps the major powerhouse in the United States.

The last thing we examined was the issue of whether it makes sense at this point to somehow join forces across all the campuses for a new major initiative. We're still in the process of exploring this.

**Bert Larkins:** Even though I spent the first twenty years of my career as a fishery biologist in the Northwest Fisheries Center of the National Marine Fisheries Service in Seattle, I did get directly involved in some of the information that CalCOFI was collecting.

Many will remember that about 1965 the Soviet fleet came sailing around the corner and parked right off the middle of Washington and Oregon and began taking away 200,000 or 300,000 tons of hake a year. In its infinite wisdom our government thought that we ought to know something about these critters that the Soviets seemed to know so much about. So we instituted a groundfish research program at the Seattle lab, and I was its first director.

The Northwest rather prided itself in being way out in front of fishery research. It had the University of Washington and Oregon State University and the University of British Columbia and two or three others. But when we looked around for information that might indicate something about what went on off our coast, there was zip.

So we got on a mailing list for CalCOFI information. We did know enough about hake to at least surmise that they spawned down here somewhere. In those days the National Marine Fisheries Service was like a university; we had our little turf battles—Northwest came down so far and Southwest went up so far, and never the twain would meet. I have kiddingly said that those were the days when Paul Smith and I would talk to each other from phone booths—we didn't dare do it from the office. But nevertheless, we found out something about what they knew about hake.

So twenty years ago—halfway through your history—we were able to learn something about these animals, something about their migration paths,

something about their reproduction. In fact we bought the *Miller Freeman*, brand new, the first U.S. factory trawler research vessel. I think that it was on its second cruise when we came down here to try to find spawning hake.

We knew from your information that they spawned somewhere around here, probably from San Francisco to the southern end of Baja California in some years, sometimes out as far as anchovies spawn—probably 150–200 miles. They were very patchy some years. We had some new trawl gear, and we wanted to get our hands on fecund hake. We arranged through Paul to have help from one or two of the ships that were out doing the CalCOFI survey. Overnight they sorted their plankton samples from the previous day and looked for hake larvae or eggs. We started getting nightly reports that “Yes, we're getting more of them and they're getting younger, and we're heading west on such and such a trackline.” We'd run another forty miles west of them and drag our net around and look at our echo sounder. It took us about one week to find our first spawning concentration of hake. They were not where most people thought they would have been; they were farther offshore and farther south that year, as I recall. We would probably have spent our entire month looking for the first one if it hadn't been for this very simple colleague-to-colleague type of arrangement.

One thing I want to mention about what we're going to need from scientists in the future is to at least talk to each other and make sure that the information any of us has gets into the hands of our colleagues and of the public.

The organization I represent, as of two weeks ago, is the Alaska Factory Trawlers Association. It is made up of about forty-five vessels, and has become unbelievably powerful in the last three or four years. There were three or four small factory trawlers in 1980; now there are forty-five. Some of these are small, headed and gutted boats; they have a modest need for high-value fish during the year. Other boats represent \$30 million and \$40 million investments; they have not just the capacity, but also the financial requirement for about 60,000 tons of pollock a year. They can't make their payments without 60,000 tons; if they catch more than that they start making some money. Fifteen more of these big ships, which make surimi and fillets, are on the ways around the world and will be in the fleet in another year.

Right now we have a capacity—a necessity—for about a million tons of groundfish a year. Most of this is pollock. Next year, or two years from now,

we'll probably need two million tons. The scientists tell us that pollock is probably the biggest single groundfish resource in the world now. It has an allowable biological catch about 1.2 or 1.3 million metric tons in the Bering Sea and another 60,000 to 150,000 metric tons in the Gulf of Alaska. This fleet now has the capacity to take all of that. (There are no foreigners fishing this any more.) In another year we will have one and a half times the capacity for taking it.

We had our sardine situation ten years ago in Alaska. The big fishery at that time was king crab — weight 10 pounds each. The ex-vessel price in Alaska is now about \$5 a pound. In 1980 the record landings that had been peaking every year before that were something like 80 million pounds from the Bering Sea. The next year the landings dropped in half, the next in half, the next year in half. Now the landings are maybe between 10 and 20 million pounds. And this is after several years of some rebuilding.

Nobody quite knows why it happened. Was it a natural occurrence? Was it overfishing? I think the best judgment is that it was neither; it was probably both, very much like some people would guess about your sardine situation. King crabs were in a sort of natural decline; the fishery was very intense; and before people could get a handle on the decline, that very powerful fishery drove it a little further down than nature might have taken it, and got it down there a little faster than nature might have. These are long-lived animals; they don't mature until they are 6, 7, or 8 years old, when they enter the commercial fishery. They live to be 15 or so. So they are not like shrimp.

At the same time, one species of Tanner crabs, which was not being terribly heavily exploited, also took a downturn. Most of the shrimp in both the Bering Sea and the Gulf of Alaska virtually disappeared.

Also about that time, and it took us two or three years to figure this out, most of the finfish — like pollock and cod — expanded to historic highs and are still there. These highs even exceed those of some of the anecdotal reports from the turn of the century, when the groundfish fishery was pursued by sailing schooners and dories. I've heard some people say that what happened in the Bering Sea, probably starting in the late 1970s, might have had some sort of relationship, maybe an inverse one, to an earlier El Niño down here that had some effect, not really well understood, up in the Bering Sea. Others have said that for some reason a lens of cold water formed over the bottom of the Bering Sea and was detri-

mental to shellfish but was just wonderful for finfish. Again, I don't think anybody knows for sure.

What's happening now? I'm jumping around a bit, but I'm trying to relate some of the man-made problems that are going to occur in the fishing industry, particularly in the North Pacific. How they get mixed up with natural events is anybody's guess. It's probably not going to be for the better when we hit a natural downturn combined with all of the pressure that's out there now.

The fleet that I represent has now a billion-dollar asset value. As I mentioned, some of these boats are \$30 million investments, and there are others coming on line that are 40, 45, and \$50 million investments. Most of these boats have twenty-year mortgages on them; no longer is it a six- or seven-year mortgage.

As your experience down here would indicate, I'm sure, fishermen are generally very good theoretical conservationists. They understand. And they mean it when they say, "I want my son to be able to do this. I don't want to overexploit. I want to make a living ten years from now, and I want my son and grandson to do it." But then the bank says, "You owe me \$100,000." Well, suddenly they have to catch as many fish as they can, very quickly, to make this year's payments. This is in spades now, in the industry I represent. There are debt services that are unbelievable — \$10,000 a day on some of these boats. Their pro formas count on 270 days fishing.

The allowable catch is rather conservative now, because up to this point we had foreigners to boot out if there was any concern. But now the foreigners are all gone, and we're competing among ourselves. Not only is there concern on the part of vessel owners that they need more fish to make their payments — which is the case, and it's going to get even worse as more of these boats come on line. What this is going to do is put political pressure on management councils, on the government. John Knauss is going to see a lot of this as the politics overflows from the councils into Washington.

What we're going to need is scientists who understand what's going on in a multispecies, very complex, physical-chemical environment. They need to understand the relationships of both man-made and naturally induced changes in relative abundance of competitors, predators, etc. We don't know very much about this now, certainly not up north, where we are. Is it good to catch cod, because they probably eat king crab, even though you catch some king crab while you're trawling?

What we are going to particularly need from folks like you are scientists who are willing to get up,

work in the fishbowl, and learn to speak lay talk so councilmembers who have their hearts in the right place but don't understand the jargon can understand you. And then we need you to be willing to defend your conclusions. My experience has been that out of 130 people at the Seattle laboratory, there were 6 of us who wanted to do this kind of thing; we wanted to be management biologists rather than research biologists. It's been very rewarding for some of us. We need a lot more people like that.

**John McGowan:** Since I've had long experience with the CalCOFI program, I assume my role on this panel is to serve as some sort of a sea-truth referee, or perhaps a dull scientific answer man. While I'm willing, and may even be capable of serving in that role, I have something to say as a private citizen.

It seems to me that there have been some very important changes taking place in the world, especially lately, and there is really much cause for optimism. The threat of nuclear war or even large-scale conventional war is greatly diminished; human rights and even human welfare are now being seriously considered in many places; there have been relatively peaceful, popular, revolutions, major ones, as in Poland, Hungary, and other places. Democracy has become a fashionable word once again. We have now institutionalized the prevention of the great killer diseases such as smallpox and cholera. We can grow enough food to feed the world, although we don't distribute it very well as yet, and even the fine arts are flourishing. It's beginning to look as though humankind has learned how to deal with some of the great traditional adversities and afflictions that have been with us for so long.

But while our leaders and policymakers and politicians have been making this remarkable progress, an entirely new and unprecedented challenge has arisen, one with which we have not had any substantial, collective experience. I'm talking about our relationship with nature. This has become a critical issue, and it may become acute. The problem is so large and so complex that it can hardly be stated coherently. In the next twenty years or so we'll hear much about it.

It differs from previous problems due to our disruption of the natural order of things in that its scale is much, much larger, even global, and it is, therefore, much more complicated. Although we are short of much factual data, we know for sure that we have managed to change the atmosphere itself. What is not so clear is what the consequences of that

change will be, but almost everyone agrees that they will not be benign.

We don't know much about the rest of the global conditions or what we've done to them, but I suspect that maybe other such large-scale changes have gone on. But since we simply haven't monitored them the way we've monitored the CO<sub>2</sub> question, we are unaware of them. We can be certain, however, that these, over time, will become more and more evident.

So all of the marvelous progress we've made since World War II is now threatened in a new way. We must understand the magnitude of this threat. We absolutely must better understand what's happening to us.

Because the oceans are so large and such a big part of the world, and because they serve as a sink for many pollutants, especially CO<sub>2</sub>, it's crucial that we understand how they function and how their biota responds to changes. We must understand how to measure change and its direction and magnitude. We must understand its consequences.

The CalCOFI program — with all of its faults, and I understand many of them — was designed, in the first place, for the purpose of studying the magnitude and scale of environmental change. Although we've made a lot of mistakes, many of which only those of us who work in the program fully understand, we've made a lot of correct decisions as well, and have learned much. We understand now how to go about studying the large-scale problem of change, and it is the CalCOFI data that will help us do so. We're very fortunate to have this marvelous data set, for it can serve as a basis from which to proceed and as a template for further study. To quote someone from outside the system: "That data set, right now, is a national treasure." There is, in my view of things, room for optimism; we in fact started to study the problem of change forty years ago, and we now know how to go about it. This is an enormous advantage.

**Boyce Thorne Miller:** Global environmental change, as we are discussing it today, begins with humans and ends with humans. In between that beginning and end there will continue to be significant impact on the land, the oceans, the atmosphere, and all the life that knows this planet as home. Bill McKibben, in his powerful new book, has noted that this era of human-induced global change marks the "end of nature" — the title of his book.

No longer are humans responding to the forces of nature; now nature is responding to the forces of

human culture. We are dealing with a nature molded by human beings. Because of this, science is also changing. Scientists studying natural phenomena are now more often measuring and predicting nature's response to human manipulation of the environment. And they are called upon to distinguish natural variations from human-caused variations, though the two are often inextricably meshed.

There are two human factors driving this overwhelming influence we have on the natural world: explosive population growth and explosive economic development. Unless these are curtailed, we cannot hope to slow the rate of global change. And it is that unprecedented rate that has led many scientists to worry about the ability of species and ecosystems to adapt. There are many ways our individual lives and the structure of our societies will have to change if we are to succeed in slowing global change. But that is a discussion for another forum.

Today we have been asked to speak about ocean scientists and what they can do to help prepare for global change—and, I would like to add to that, to help moderate global change. I would suggest to scientists three contributions that you can make.

You can do basic and applied research relevant to global change; you can aggressively involve yourselves in environmental policy and management decisions; and you can take a strong public stand on environmental issues. Now, how does this apply specifically to ocean scientists?

I have no doubt that research is the easiest for me to convince you to do. We need more information about the ocean's role in climate change, in the oxygen and carbon cycles, and in other geochemical cycles. We need to learn more about how the ocean may influence and respond to global warming. We need to know more about the diversity of life forms and biological processes in ocean ecosystems—how they compare to terrestrial ecosystems, how they will respond to global environmental change, and on what time and space scales these responses will occur. Fisheries biologists need to learn more about the effects of pollution and harvesting on the health and abundance of fish and shellfish populations. We also see a need for more well-designed, long-term environmental monitoring programs in coastal and ocean ecosystems worldwide, similar to the CalCOFI program. But ocean scientists are eager to do this work. I don't have to convince you to do basic and applied research and monitoring.

Better that I sit here as a representative of the environmental community and tell you that we are working hard to try to get Congress and govern-

ment agencies to allocate more funds for such work, possibly even from that seemingly untouchable ocean of funds now set aside for defense. The environment, after all, is an issue of global defense.

I may need to work a little harder to convince some of you scientists to participate in environmental and management decisions at local, state, federal, and international levels. Ocean scientists are particularly important because the coastal zone is quickly becoming the front line—the place where the environmental battles will be first and biggest, because most of the pressures from population and economic development are focused on the coastal zone. Ever-increasing stresses are placed on the coastal environment as a result of industrialization, urbanization, residential and tourism development, waste discharge, dredging, poison runoff, and overfishing. Also, agriculture, forestry, and mining in interior as well as coastal regions create runoff that eventually enters coastal waters.

The threats to the coastal zone from all this human activity include pollution from overenrichment, toxics, and debris; habitat destruction, particularly on the coastline; and overfishing. Many coastal ecosystems are already impoverished. And even deep ocean waters are not immune from the impact. Our living marine resources are being jeopardized on a global scale.

Problems created by multiple usage of a fluid environment that cannot be compartmentalized and does not honor political boundaries are complex. The solutions are also complex and must be innovative. Sound decisions about coastal policy and management and how best to regulate human activities in the coastal zone require scientific and technical expertise. Decision makers often don't have this expertise. So it is imperative that marine scientists get deeply involved in the process.

I am asking you all to participate—locally, nationally, and internationally. One word of caution, however: don't expect this involvement to be a particularly rewarding experience. Don't expect to come away each time feeling that politicians and environmental managers will act on what you said, even if they listened. It is not an ego trip, and it requires perseverance. Keep going back with your message.

And you will have to learn to simplify your messages as much as possible. Those making the decisions often find it difficult to convert very complex scientific information into policy or regulation or management practice. So it is up to you to bridge that gap. And we of the environmental community can help also.

Let me give you some examples of what you can do. A very simple thing you can do if you are at Scripps is to march down to your aquarium and tell them to stop selling shells plundered from Philippine reefs. Another thing you can do, on a larger scale, is to involve yourself in the EPA decision about sites for dredge disposal off the coast of California. The EPA seems to feel that there are no data. Knock on their door, or make a telephone call and tell them about the CalCOFI program.

The secondary treatment issue is a big one, a controversial one. Many scientists have said that off the coast of California you don't have to have secondary treatment, or at least that's not the best use of funds. Let's look at it in a slightly more innovative way. It may be that pretreatment will have more of an effect than secondary treatment. However, both of these together would be even more useful. We cannot afford to waste our wastes by throwing them into the ocean. They should be put back on land and used. Get the toxics out, yes, and then use the organic matter to fertilize our fields.

Finally you can work on an international level. International cooperation of scientists, as you have here in the CalCOFI program, is admirable and should be encouraged. The regional sea programs offer another opportunity for that. International lending agencies need some advice. They believe that economic development is what all developing countries should be aiming toward. So the scientists in those countries—in Mexico and in other developing countries—need to get the message across to their governments and to the lending agencies that there is now a new goal—sustainable use of resources.

The last suggestion I have is that you scientists take a strong public stand on environmental issues. This is not for everyone. You have to tread a fine line between credibility and effectiveness. So I ask those of you who don't choose to go public to be tolerant of those who do. Don't criticize them for being what may seem to you too simplistic. Remember that the public and policymakers do not quite know how to deal with all the words of caution and conditions that you put into your scientific conclusions when presenting them to your peers. And they often use the uncertainty to further personal, institutional, and political goals.

For example, the World Bank recently declared global warming a nonissue in its lending policies because of the scientific arguments over the magnitude of what the impact will be. For the purposes of solid scientific research, it is important to be aware of the weak links and the possible sources of error.

But for environmental decision making, it is important to take strong action on strong scientific likelihoods. We can't wait for absolute proof before we act, because the proof comes after the damage is done.

**Harry Scheiber:** As a person trained in economic history and legal history, doing a considerable amount of teaching on law and technology and on the law of the sea, I found this a daunting assignment. I think that in some ways we who are trying to see the proper linkages between matters of policy and law must be more responsive to environmental needs and crises.

We're in much the same state as the scientists of CalCOFI were forty years ago—a state of great perplexity. If you were to draw a historical time line, as I've been seriously playing with in the last few years, of the relationship of changes in what we today call fisheries oceanography and international policy and law, I think there would be, from World War II to the present, working backwards, the following moments of really fundamental change and innovation—turning points.

One, I think, will turn out to be the current discussion of global change, which really started in a serious way two years ago.

Going back a considerable period, we'd go to the 1972 Stockholm Conference, which brought together worldwide United Nations representatives to discuss the problem of environmental crisis. This was certainly another of those watershed moments when our thinking was fundamentally changed around a really significant problem.

Going back again—a leap of fourteen years—we come to 1958, when there were conferences on the law of the sea in Geneva and then Rome. They were the beginning of the law of the sea movement, which has culminated thirty years later. At those meetings we began to discuss the possibility of some kind of convention that would bring the nations of the world to agreement on the regulation and conservation of the sea's living resources. There was a fundamental transforming effect, not only on those who tried to create a law of the sea—a long, difficult, somewhat frustrating and not altogether happy process, which has culminated in the current law of the sea convention. At the time, the introduction of the sustained yield concept, of the idea that the goal should be maximum sustained yield of ocean resources over time, crystallized thinking in a way that had not been done before.

In 1952, six years earlier, came the first of the postwar treaties of the Pacific, which Japan signed

after its sovereignty was restored. This treaty included for the first time in the postwar era the concept of maximum sustained yield. Japan, the United States, and Canada agreed with respect to salmon, halibut, and herring that they would maintain the goal of maximum sustained yield. From that came the very controversial abstention concept.

These, I think, are the major turning points — the watershed events when our thinking really crystallized in new ways.

But first, on this time line, really has to be CalCOFI. You may be startled to think that your being out on the edge of the continent worrying about the sardine and the California Current is such an event, but I don't think we exaggerate. In this venture — now forty years old, an extraordinary length of time for such a venture to have survived and be still so vital — we have some lessons to be learned. Not just about why things developed as they did later, because there are lines of continuity here, but also about how things can be done in the future. I'm not going to be able to talk about all of these; I just want to suggest that this is another in the series of important events in which thinking was crystallized on new lines.

Some of the consequences were not at all unanticipated. There are two interesting elements that I'd like to single out. One is the collaborative element from the very beginning. The other is something that was discussed as a longer-term consequence and outgrowth of the beginnings, and that is ecological vision — the ecosystemic approach to fishery problems.

The Marine Research Committee was approved by the legislature and funded from the beginning by a rather sizable tax on sardine landings. CalCOFI was a response to the sardine crisis, at the beginning. There is a little two-year prehistory here, which hasn't been mentioned. It was the formation of the Marine Research Committee, authorized by the legislature of California in the winter of 1947. The committee was financed by an industry tax on the landing of sardines and was really the progenitor of CalCOFI. It was the response to a crisis.

From the outset of the project there was a collaborative intent, with the argument made that it would bring together for the first time the resources of the Scripps Institution of Oceanography and the University of California generally; a federal agency — the Fish and Wildlife Service; and the California Department of Fish and Game, in which Frances Clark had done many years of very important sardine research. From the beginning there was the vision that the sum would be much greater than

its parts if they could be brought together. Something that hasn't been mentioned, but that I think is worth underlining, is that industry supported it from the start. The industry had a specific problem and went to the scientists for the solution.

This brings me to the second point, which is that the scientists' response was extremely creative and, in a fundamental way, "subversive" from the beginning of CalCOFI — California Cooperative Oceanic Fisheries Investigations. When this group first formed, the Marine Research Committee, which granted money for collaborative research, said, "We have to have a name for it." So John Marr of the federal service immediately provided a name that would fit nicely into the federal hierarchy and table of organization — the California Sardine Investigation. Frances Clark of the state agency responded and said, "Let's call it the Marine *Resources* Investigations." Roger Revelle came up with the California Cooperative Fisheries Investigations as a compromise. But of course it wasn't a compromise at all. From the outset it announced that CalCOFI wasn't just about sardines — it was also about fisheries in general.

From the very beginning there was an ecological vision as well. We think of it as something that evolved and was produced over time, and we associate it with the late sixties. But in fact, in the very first documents that were circulated — from Scripps, from Frances Clark, and from Oscar Sette of the federal agency — the idea was inherent that (with the new equipment and the new ships that Roger Revelle had produced as a gift from the navy, to President Sproul's shock, and with the new funding) for the first time they could get answers to questions that had been plaguing them for twenty years, and which they *already understood* were the important questions. So in many ways the scientists' vision prevailed here.

From the very beginning this vision was set forth; the scientists had an agenda right from the outset. The lesson was not lost on the industry, which was a little dismayed, but which continued to support the investigations. Over time, people in the industry and in the outside world supported the research, in considerable measure because of the efforts of a scientist who was also a great organizer — Wilbert M. Chapman, a very important force in the beginning, first working out of the California Academy, then in the State Department, and later in the industry. This project was watched closely from the beginning by ocean scientists in all nations. As John Knauss said this morning, it could be that its role as a prototype was understood from the beginning.

To wind up where I began, one of the really interesting things about the documentation of the meetings of the scientists who set up the protocol for the 1952 Japanese-American-Canadian convention and also many of the scientific papers that were presented at the Geneva UN meeting, was that they talked about the research done in the California Current as exemplary of what had to be done in order to make a concept like maximum sustained yield consistent with the best science. So the influence has been very great over the years.

The lesson, if you want to draw a lesson from it with regard to the role of science, is that a project well founded organizationally and well conceived scientifically is going to have an integrity of its own and a vision of its own. And room has to be left for that vision to be nurtured. And that has been done remarkably well indeed in the forty-year record of CalCOFI.

**Robert Sulnick:** Let me begin by saying that it's obvious to me, an environmental lawyer for over twenty years, that global change is inevitable and that we will all have to be involved in it. If we are not involved the change could be so disastrous that the human species will no longer thrive or possibly even survive.

So my approach to this discussion is going to be somewhat practical. My assumption is that I'm addressing an audience made up mostly of scientists. I myself am an environmentalist and an activist. I would like to give you an insight into how the people that I work with — my side of the fence — think about these problems. Because my premise is that unless we come together, unite, and go forward, the planet is in very serious trouble.

When I think about the oceans, and when I talk to people about the oceans, as I do all over the country, I say this: "The oceans are the lungs of this planet. They provide us with 70 percent of our oxygen." I don't know that that's absolutely true, but I've done enough reading to know that I'm in the neighborhood. And I also know that it grabs everybody's attention, from people in the White House to people on Smith Island in the middle of Chesapeake Bay. So I will continue to say it, unless people like you tell me, "You really can't say that, because it's absolutely not true."

I have been to Smith Island in Chesapeake Bay and spent days with the crab fishery there. They have shown me that from their point of view that fishery is disappearing. And when you look at the habitat through their eyes, it is disappearing. Their

explanation has to do with all of the non-point source pollution that flows in from all the rivers that enter into the bay.

I have been up on Puget Sound, where I've seen liver cancers in sole. And I've heard the explanation that they come from the toxins that the industrial complex puts into Puget Sound.

And I've been in Boston Harbor and Deer Island, where I've seen raw sewage in an overwhelming display — emptied daily into Boston Harbor. That's a very serious insult to the integrity of that ecosystem.

I've been around the country and have heard horror stories time and time again. In addition, I'm given intellectual input. By next year 75 percent of us will live within 50 miles of the coast, and we are toxic-dependent as a society. We humans, gathering on the coast, are dependent upon toxics that inevitably, as a waste stream, make their way into that coastal zone, which includes estuaries, bays, and coastal wetlands, and then kills the vitality of that coastal zone.

I am trained to be an advocate, and I now instinctively take all of that information and begin to campaign with it. I do this without even thinking about it, as do all my colleagues. The campaign is aimed at the the public at large, the general population, to seek a critical mass, and then at the decision makers in Congress. Because we want that critical mass to be translated into public policy.

Because I've been a lawyer for twenty-five years, I have learned that decisions will be made irrespective of who has the input, when a problem becomes large enough to be perceived by the political body. It's a reactive body. So we in the environmental community are going about our business of trying to create public opinion — critical mass (i.e., pressure) — and then we are trying to translate that into public policy. We will do that irrespective of the scientific input.

The danger is that much of what we do, by definition and not by any conscious intent, is polemic. It's not meant to be polemic, but we work in such a rampant atmosphere of no resources, no money, and no support system that we can only do the best we can. I don't have five days to research anything, normally. I'm either on the phone with the press or I'm in the field or I'm at a hearing. My schedule is jammed. And again, I'm not talking about me as an individual but me the species. So we work with what we have.

The danger is this: we move very quickly. And we will win our political battles because the public

now wants us to. But in winning the battle, if the solution is ineffective, we may lose the ultimate struggle.

Your danger, it seems to me, since I have a background in social science and methodology, is that you can be restricted by two things: your methods, which obviously you need, but which can restrict you because of the time involved; and the money to finance your methods, which is probably the root of the issue if we're honest about it. Because money is not being given to science, much less ocean science. And the next generation of ocean scientists is not getting in line, which is quite alarming. The money is obviously going to military spending and has been for quite some time.

However, we need to slow down, and you need to speed up. Somewhere in the middle there's a balance to be made. A dialogue must be created on how best to go forward. It's no longer a question of should we go forward together. The question is, how do we do it? Because we communicate in much different terms. We're out there in the spotlight all the time articulating, and you generally are not. I would not expect that to be natural for you. You're very cautious and methodical and precise in what you say. We do not have the time or, in our heads, the luxury to do that. So the question is, how do we blend those two things?

It seems to me that's what this panel has been talking about and what we need to continue the dialogue about.

**Frieman:** A number of issues have been raised that are of vital interest to the scientific community, and I'd like to try to address a few of them wearing my director's hat.

Let me start with the philosophical point of view. I see a mini intellectual movement going on. I've seen the essay by Francis Fukuyama earlier this summer from the State Department policy planning staff concerning the end of history. Fukuyama tells us that there is a triumph of capitalism and western liberal democratic thought, and we're condemned to a boring and static future.

In the last week or two we've seen reports of conferences on the end of science—that somehow we have lost our methods of dealing with objective reality, followed by a report (in probably the same newspaper) on exciting new discoveries from SLAC at Stanford and CERN in Europe on new particles that are the foundation of our universe.

And I read Bill McKibben's *The End of Nature* when it was first published in *The New Yorker*. He

says that humankind has come to dominate the planet, and we've carved our initials so deeply into the biosphere that we can no longer consider nature to be separate and pristine.

So I see some sort of a mini intellectual trend. I'm no historian, but my academic colleagues tell me that this is a phenomenon that has been seen before as the end of a millenium approaches.

But rather than accept these pronouncements by these intellectuals and philosophers, I prefer my own favorite philosopher—Yogi Berra, who said 95 percent of the experts in a certain field agree that such and such is the case, and the other half believe the opposite. It seems to me that is, in fact, the situation we are in with global warming.

We do not, I'm afraid, have the unique footprint, the scientific evidence to move ahead. You heard from John Knauss this morning about major global models, one of which says the Southern Hemisphere does not change, another of which says it does change. You will hear, if you choose to talk to Tim Barnett, who has analyzed the data of Jim Hansen (who testified in Congress last year that the global warming signal is upon us) and has printouts from Jim Hansen's monstrous computer code which indicate that even if you add no CO<sub>2</sub> the temperature goes up for fifty years. So it seems to me we are, unfortunately, left in the position of having both feet firmly planted in midair.

I guess I feel, as the director of a scientific institution, that we as an institution are responding to the University of California's motto, which is "Research and Teaching and Public Service," and we can serve the public by somehow trying to get at this vague notion of objective truth.

I agree with my colleagues here. We have a very serious societal issue on our hands. And I have absolutely no problem at all with Scripps scientists speaking out on these issues as members of the public. But I do think we have a responsibility not to do it as an institution. We have an issue of credibility on our hands, and we can debate that for a long time.

Let me turn to the second issue that has been raised. I look at the 1990 research plan for the United States to tackle the fundamental issues we're talking about. I look at the total expenditures for fiscal 1990: \$190 million. This is across all the agencies of the U.S. government. And I look at the fact that our total GNP across the world is \$14 trillion, and I try to argue, well, suppose the U.S. contribution of \$200 million is just one-fifth of the total. I have no idea whether that's true or not; I suspect that maybe it's wrong. But maybe the total amount of research

we are expending throughout the world, trying to cope with this problem is \$1 billion out of a \$14 trillion GNP. It is just ridiculous to assume that somehow we now have the science base to make industrial decisions that will make a major change in a \$14 trillion GNP.

I don't know how to cope with this. It's clearly a major issue for all of us to somehow get the major research engine moving. We must do that, and we must convince our elected representatives to do it. At the moment it seems to me that we are in a very serious situation in which we are trying to make vast global decisions on the basis of an extremely poor data base.

**Sulnick:** I'd like to establish some ground rules for what I hope will be a dialogue among all of us. I'll synthesize what I heard everyone say. Then I would like to direct some individual questions to the panelists, questions that I have been writing down as they were speaking. Then I would like you, the audience, to involve yourselves in their responses. And then we'll move on to questions from the audience.

As I listened to everybody talk, this is what I heard. (If I misquote anybody, by all means let that be part of our dialogue when I'm finished.) First, I heard Assemblyman Sher say that it is important for scientists to make themselves more accessible to the political process, so that the political process can make use of the science.

Professor Frieman, when you gave your initial remarks, I understood that there is a large need now to study things on a global, systemic basis, maybe even instead of on an individual scientific basis. From your last set of remarks I understood that this institution as an institution ought not involve itself in the political debate, but that its individuals are free to do so.

What I heard Bert say was that it's crucial to practitioners who make their livings from the ocean resources to have correct data so that their institutional approach to making a living from the ocean will be effective.

Professor McGowan, when I listened to your eloquent remarks, I heard you say that the things we have achieved since World War II are now being threatened and that we must approach the global problem or lose all of the benefits that we've gained in the last fifty to sixty years.

I heard Boyce say that it's important for scientists to get involved in the solutions to environmental problems.

Professor Scheiber talked about watershed events in history, which, in my mind, is like reaching a critical mass toward moving consciousness forward in a given area.

All of these points raise initial questions that I would like to direct to each of you.

To you first, Assemblyman Sher: What if, in fact, science cannot make its interpretations and its findings more accessible to the political process? How do you in the political arena then reach out to the scientists so that we can still have the input?

**Sher:** First of all, let me say that as politicians we don't need scientists who are captured by people who resist making changes, who are impacted by some of the regulations that we establish in reaction to problems. Unfortunately there are a lot of scientists, as there are a lot of medical people and a lot of lawyers and other specialists, who are out there and available. I remember a debate we had about so-called noncriteria air pollutants — not the things that cause smog but some other bad stuff. And we were told that our solution to a problem that we knew existed was based on bad science. There were expert witnesses for the industries that would have been impacted by the regulation who told us that. The answer was, don't do anything.

I think we're going to see the same thing in the global warming area. Only this week we saw President Bush's proposal for a new approach to pesticides, and it contains some good recommendations to help the EPA respond more quickly. But at the same time there is a big debate about whether the federal government should preempt efforts by the states to impose more stringent standards. The EPA representative I heard debate this said, "We set our standards based on good science, and we don't want the states to [complicate the matter]."

I don't think I'm answering your question, but I wanted to get all these things off my chest anyway.

**Sulnick:** Let me ask you this question: Let's assume that science could not give a precise, accurate solution to a political problem but would give a solution that is imprecise from a political point of view and not readily accessible to a political body. The way I view it, there will be one side in favor of social change and one side opposed to social change, at its most simplistic level, in a legislative debate — those who are going to push toxics reform and those who are going to favor the status quo. What I'm hearing you say is that whenever you have scientific input that is not in favor of pushing toxics reform, the opponents seize on it and say, "Well, see, there's really no reason to reform, and our industry

shouldn't have to spend millions of dollars on an imprecise solution."

Is there any way that you see, from your years of experience in the legislature, to still involve science in that debate and not give up the fight? Because what I'm hearing you say is that when science comes in and says, "Look, we really don't know what the effects of global warming are going to be," then everybody says, "Well, why should we spend billions of dollars on global warming?" Even though intuitively people believe and know that there is going to be a horrible effect of global warming. How do you deal with that?

**Sher:** I don't think there is a way to do it. When someone has convinced a member of the legislature or even the governor that we have a serious problem that we ought to be addressing, and that issue comes up and we start to debate it . . . if there is this difference of opinion (and I hear some scientists tell us we have a new ice age coming), people who would be adversely affected by the proposed regulations will seize on that difference of opinion as a reason to take no action at all.

And what frequently happens is that the process is long and complicated, with a scientific advisory panel. And nothing can be implemented until the proposal works its way through the deliberations of the scientists. Meanwhile the problem is overtaking us. Let me give an example of one that I worked on this last year.

As an environmental activist in the state legislature, I've been trying to do something to protect what's left of the ancient forests in California, particularly the redwood forests, where there used to be 2 million acres and now we're down to 100,000 acres. (And almost 20,000 are owned by one company that's cutting them down in order to pay the debt on the junk bonds that were issued when they were taken over by a conglomerate.) What the industry has proposed, and what has now passed, is a three- or four-year study of the ancient forest to determine whether there really are ancient-forest-dependent species. But in the meantime I tried to get some constraints put on cutting down the forest while we're studying whether we need it to preserve the spotted owl and other ancient-forest-dependent critters. But we were unable to do that. The industry supported the study, which they will use to say, "We don't need to do anything now because we're making the study."

We can't have a in-house panel of scientists that we depend on who will inevitably direct us to the right thing to do. But I do think we have to be

concerned about preserving what we're trying to protect while the science is going on. I think the state has an obligation to use tax money in significant amounts to promote the scientific study of these problems. But what do we do in the meantime?

We're told that tremendous impacts of global warming are coming. I would say we ought to at least make a start on trying to respond. What are the agencies that have jurisdiction over different areas, like the Department of Water Resources, doing to plan for the potential impact of global warming?

Whatever we do, we should do it in the context of existing programs, so that we're promoting the underlying policies of those programs. For example, there's a good reason to cut down on carbon dioxide for reasons other than global warming. So if we can bring the global change considerations in to help us do what we are already trying to do for other reasons, we may have more success.

**Sulnick:** Would anybody on the panel like to comment on this issue of science in the political process? From the moderator's point of view, it's a big issue, because those of us who get involved in the political process do so as advocates. We rarely get involved objectively. And we're looking for people to support our positions. That's the contest. And of course that's not a scientist's approach. And yet scientists have an enormous impact on that process.

**Larkins:** I started to touch on this in my presentation. A year or two ago at the University of Washington I participated in a symposium that had to do with science and fisheries. I made a lot of my old colleagues a little miffed — and one or two of them very pleased (the one or two who happened to share the same view). My training was in fisheries biology. I worked my first ten years as a researcher. I became very interested, on my own, in the application of science to fishery management. This was back in the days before the National Marine Fisheries Service had any management authority. We were a research institution.

We saw the Magnuson Fishery Conservation and Management Act coming along in the seventies; it looked as though NOAA, which was fairly new at that time, was going to have some management responsibilities. There were a very small number of us who just jumped at this opportunity. I guess we felt a little frustration. We had been doing science; we had some conclusions; and there was nobody to give them to, nobody who was going to do anything with them. No one had the wherewithal to do it.

So there were a few of us who found ourselves in a different frame of mind. And first of all, as we've

heard from many of the speakers today, it was obvious that we had to learn to speak human, rather than science. I don't know how many of you are familiar with the council system that the Magnuson Act set up, but it's the fishery management councils that advise the secretary of commerce, through Under Secretary Knauss, about fishery regulation. They've become a little bit more than advisory. In effect, what they say goes, unless they've done something blatantly illegal, and then the secretary of commerce may override them.

The folks who are appointed by the political process to these fishery management councils quite often come from the industry. This is unique. A lot of them have vested interests in the fishing industry that they have been charged to give advice on managing. They're not scientists, and they say, "Well, if the scientists can't give us 100 percent assurance, don't shut us down."

People in my association (I'll probably get fired if there are any of them here) do that. Part of my job, as I see it, is to advise them when to back off, so that they have something to be operating on five or ten years from now.

In any case, this is a long way of saying that I see the federal service—the National Marine Fisheries Service—and the state agencies as being applied science agencies. This doesn't mean they can't do some very fundamental research; I think they have to. But on the other hand, I think their job is to get their conclusions out to the public where they can be used. And by God, go out and do it as advocates to make the policymakers understand what the scientific ground truths are, to the extent they can be articulated.

A lot of us in fishery biology like to tell ourselves that we're worse off than most other scientists because it's such an inexact science; it's almost an art. You put a little net down in the middle of an ocean and get only a very small sample. I'm not sure we're unique in that. But what I've tried to tell some of the young fellows that were working for me when I was still a fed is: You guys have to have the courage of your convictions; you're the experts on the biology of these animals. The Magnuson Act requires use of the "best available scientific information" and that is what you must provide. No "insufficient data" cop-outs, but the best you can do with the data at hand and your best scientific judgment. I'm not asking you to be biostitutes. But put the outside parameters around it; tell them what your advice is as an expert. Because if you don't they are going to decide the "science" by themselves. And when policymakers, even those who mean well, don't get the kind of

strongly presented science that might be available, they usually make the very worst choice.

What all of this boils down to is part of what upset some of my colleagues a little: I see a need, way down in the science education programs, to start having people who are going to be in science understand that there may be two ways for their careers to progress. At least make them aware of these two avenues that they might follow as they get into their careers. One is as a researcher; that's finding knowledge for the sake of knowledge. The other is applying knowledge. Somewhere, probably at the graduate level, certainly when one gets into a governmental agency, there ought to be two distinct career tracks. Those who have the talent and the wherewithal should be encouraged to get out, live in the fishbowl, translate science into lay talk, and get the word across to the policymakers.

**McGowan:** This issue of advocacy on the part of scientists is a serious one. I've thought about it a lot because it has come up many times before. I'm very leery of having scientists advise policymakers and politicians on solutions to some of our environmental problems—not on the nature of the problems, but on solutions. Because scientists', or anyone's, advice is always value laden somehow. There's a certain amount of entrepreneurship involved, and self-promotion. Scientists, for better or for worse, often have a rather narrow view of the world. They come from a part of society that is remote from real world problems and concerns. I don't think that their notions about solutions to environmental problems or other serious problems are any better than anyone else's. In many cases they're worse because of the narrow value judgments they put on things.

I think the judgments about solutions should come from society, from people who have the information. It's our job to present them with the information. And the decision then is made at some other level.

**Sulnick:** Given that the decision will inevitably be based on value judgments, which are often subjective, why should a scientist not offer his or hers?

**McGowan:** Because they represent a very small segment of society, and a rather privileged segment of society at that. Their educational background is rather specialized, and they often lack even a rudimentary idea of human conditions. I'm not at all certain that they've got the best interests of society in general at heart. *(laughter)*

**Scheiber:** Just a footnote to that. At each of those watershed moments in the history of fisheries oceanography over the last fifty years, the scientists did take a very strong position on what needed to be

done. For example, in the case of CalCOFI, there really was an agenda. A few scientists had done some brilliant work at the University of Washington under William F. Thompson, here at Scripps Institution under Harald Sverdrup, and at other places including the California Department of Fish and Game under Frances Clark and Richard Croker. Those people knew what had to be done, and they said what had to be done.

The same was true of maximum sustained yield at the United Nations. Richard Van Cleve gave a very influential presentation that was based heavily on the work that had been done by CalCOFI scientists, who said, "This is what we need to do." So there have been moments when scientists have spoken out and have spoken out constructively.

Listening to Dr. Frieman, I think there's a difference between those cases and this one, because there is — as he said so eloquently — a lack of an agreed-upon agenda today on this larger question of global warming.

**McGowan:** The kind of issue I'm talking about can maybe be illustrated by an example well removed from CalCOFI and the oceans and us here. It's been said, and I believe it's true, that there are ten million homeless farmers in southern Brazil. They represent a very serious problem to the Brazilian government — a social problem and a potential political problem. The policy of the Brazilian government has been to cut down Amazonia to provide farms for homesteaders. Whether the farms will work or not, I don't know.

Most scientists, of course, are horrified by the idea of destroying Amazonia: look at all those species; look at all those beautiful trees; look at the diminishment of diversity. And after all, the jungle provides oxygen . . . and on and on and on. But what about those ten million peasants? That's the kind of advice that I'm very dubious about. How do you make a judgment about what it is we want to preserve? Which do you choose — those poor bastards who are trying to live and survive, or a bunch of parrots? *(laughter)*

**Sulnick:** I would like to make a response to that, although I've never represented parrots before. *(more laughter)*

I think that that is not a good argument. Clearly — and Boyce's remarks, I thought, were perfect on this — the problem is overpopulation. We rarely talk about it because it's verboten — then you get birth control, and that's a big deal. It's hard enough to raise money to run a 501(c)(3), much less tell your audience they've got to deal with birth control. But clearly that's the problem. And clearly, the

way we live, considering how many of us there are, exacerbates the problem.

Obviously the ten million peasants have to be factored into the solution. But you can still create a solution that preserves the rain forest, that promotes the health of the planet that we're all dependent upon. And you don't pit them against one another. That's a huge mistake, because no government can turn its back on its people and still be in power. So the people are part of the solution and need to be factored in, and need to be part of the dialogue.

**Frieman:** I have spent far too many hours and years advising the government on one issue after another to feel very sanguine about the prospect. We saw what happened to the President's Science Advisory Committee when they recommended against developing the supersonic transport because of environmental concerns. PSAC was then abolished, and it didn't exist through the rest of the Ford Administration or the Carter Administration; then something was put back together under the Reagan Administration.

At Scripps you will find many scientists who serve on all sorts of government advisory panels. Their advice is sought. I can't guarantee that their advice is often listened to. But at least there are recognized avenues. We have a political process — as some people say, we have the best Congress money can buy.

Nevertheless, it is important that tensions exist in our society, partly because of the environmental movement, which does a spectacular job in raising these issues and bringing them forward and pushing on them. You must continue. There are other sides who are also pushing forward. Somehow, in the tension, we work out a political process that is, unfortunately or fortunately, the best one we have.

Scientists do have a voice. There are many ways to get our views known, both to the federal government and to the state government. Because we are a public institution, all of our information is paid for by the state of California or the federal government, and is available to everybody.

And it is up to you, the environmental movement, to interpret it one way; it is up to other people to interpret it another way; it is up to the federal government to interpret it a third way, etc. I agree with John McGowan: we scientists do not have the necessary right to say that this particular scientific result has that particular effect on society. There is no reason why we should be any wiser than anybody else in that regard. I think we have to have a certain amount of humility about what our results mean. We should make them uniformly available. We

should take our teaching responsibilities seriously and get those messages out to as many people as possible. It just does not work in any other fashion that I can see at the moment.

**Thorne Miller:** I want to say that where scientists may represent only one viewpoint, it is an important one. And if you back off from the decisions, then the decisions will be made with an unbalanced viewpoint, because other people will not be afraid to come forth and offer solutions.

So I think scientists do need to take that extra step to suggest solutions and make sure that the information that they have provided is used. And the solutions finally chosen may not be the ones that the scientists suggest, but these must be considered as part of the equation.

**Sulnick:** I want to ask you, Boyce, a question, but first I'd like to say to Professor Frieman: the information is available, but it's really not accessible, and it's a mistake to believe that it is accessible. And I want to explain why that is.

When I took my job at American Oceans, my salary was cut more than half—dramatically more than half of what I made as a lawyer. And that's neither good nor bad. I just want to point out that environmentalists don't have a lot of money. And when you don't have a lot of money, you don't have a lot of support. So I don't have an associate, as I had in the law practice, and two secretaries, and a whole support system, to whom I can say, "Would you analyze this for me, please. I need it by tomorrow," and then have it.

Instead I would have to spend a lot of time on my own—which is not a bad thing: I certainly am capable of doing it—gathering that information and making it accessible, first to me and then to my audience. I don't have that process built in, because I can't pay for it. And I can't do it myself and still run the organization and do what else I have to do in life. So while it is clearly available, it's important for you to understand that it's not really accessible. And until it becomes so, it will only be used by those who can pay to access it, which is of course industry. That's not bad; it's not unfair. But that is the way it is.

So what environmentalists always have to do is work overtime, which is not a problem, but it's still very hard to compete with the opposition that will spend millions of dollars in accessing the information and then interpreting it. And in order to rebut the opposition's interpretation, you need to have an expert witness or you really lose credibility. I just want to make it clear that although the information may be available, if it is not easily accessible, it is going to be used by the side that can afford to access

it, which is the side of the status quo. Again, this is not necessarily bad, but without question has its consequences.

Let me ask Boyce a question: You clearly said that scientists need to become involved in the environmental dialogue. How do we environmentalists meet them halfway and bring them in? Because many times I hear from scientists, "You environmentalists really don't want to hear from science, and you reject our information if you don't agree with it."

**Thorne Miller:** We do want to hear from scientists. And it's not just I as a scientist who wants to hear what scientists have to say. The Oceanic Society has a service called a technical assistance program, and we hear from small groups around the country who say, "We need technical information. We're working in a vacuum. We feel that this particular coastal issue is an important one, but we don't have the expertise to fight this battle."

A good example is the proposed Monterey Bay Marine Sanctuary off the coast of northern California. A group came to us and said, "We want the sanctuary to be as large as possible. In fact, we think it should go up to the Farallons, but the Marine Sanctuaries Office [of NOAA] is resisting that. We don't have the scientific information." We contacted some scientists at Santa Cruz and found that, in fact, they believed the same thing that the environmental group did. So we can facilitate that interaction, get those people together, and get both the environmentalists and the scientists talking to the decision makers.

**Sulnick:** Would anybody who is a scientist like to respond to that?

**Frieman:** Just one quick point. Jackie Parker is the head of our Public Affairs Office. She will respond to phone calls from anybody, and will try as hard as she can to put people from the public in touch with Scripps scientists. If you want information in terms of reports, she will facilitate getting them. That's one of the reasons we have this office. I admit that it has a very small staff, in terms of the issues you're raising. But this is an important point: we are a public institution. We have a responsibility to get our information out. We have such an office to try to help, and when anybody calls Jackie, to the extent that she can (she works terribly hard and has an overworked staff, as we all do), she will endeavor to get the information to you. This resource is available to you.

**Sulnick:** Professor Scheiber, your remarks about the watershed events and the turning points were wonderful, I thought. My question is, do you see one coming up in the near future over the global

crisis that is perceived among us, and is the role of science in that to help initiate it, or simply to respond to what comes out of the grass roots?

**Scheiber:** I agree with Dr. Frieman's remarks entirely. I think we're not in a good position now, either as scientists or as people who study science in the policy process, to advance this enterprise. There's not agreement on what has to be done. There isn't the kind of agenda that existed in these turning point situations: one reason that they were turning points is that there was an agenda. Scientists were able to guide policy in a given direction, faced with a specific problem.

In the case of global change, there is enormous variation in how the dangers are perceived. Obviously, from the discussion in this room, there is enormous variation in the degree of confidence with which scientists from the various specialities or those seeking an ecological view approach the problem. Contrary to the moments in time that I mentioned in the post-1945 history of fisheries oceanography, the issue isn't really being presented to scientists in a coherent way today. They are being asked to give it coherence. So as I say, I share Dr. Frieman's rather gloomy assessment of how well equipped we are at this moment to deal with it. I think we're floundering, not in this room alone, but in the professions.

**Sher:** Does that lead you, then, to the conclusion that the government should not be taking any steps? Or if that's not your conclusion, what steps should government be taking, given this diversity of opinion about the problem?

**Scheiber:** One possibility would be to accept that, remote as we are from a coherent conception on which a great majority can agree, continuing support of the still-fragmented approaches is warranted. I'm not preaching standing back and doing nothing at all.

**Sher:** Do you think there should be more money for research, or should there be some. . . .

**Scheiber:** Yes. More money for research on lines that are directed toward a better and more coherent definition of the problem.

**Sher:** But how about the argument that the problem is overtaking us and that if we wait for the results of the research and don't take the preliminary steps it will be too late to deal with the problem?

**Scheiber:** Yes, I agree with that. You'll be happy to know I support you on the forests; I think there should be a moratorium and not just a study.

**Sher:** I wish you were a member of the legislature.

**Sulnick:** My last question is for Professor Frieman. If one assumes — which you may not, so part of my question is to ask you to clarify this — that the house

is burning down around us, so to speak, meaning that the problems are very serious on the global level, is it not possible that the role for an institution like Scripps in the twenty-first century should be different than it was in the twentieth and the nineteenth, and that it should be dedicating itself to setting this agenda rather than just doing objective research?

**Frieman:** I believe that my role here is to try to put Scripps on a course that I call Scripps 2000. I and my colleagues, as you can see by the color of our hair and the lines in our faces, are ready to depart this system. There are a huge number of young people out there who have to be trained to take over positions of leadership.

I regard the agenda of global change as really the future of Scripps in the next decade and beyond the year 2000. I've made that clear to our faculty. We are hiring new faculty, and we've organized new research divisions along those lines, and so on. That's our internal business, but nevertheless it is part of a major agenda. As a leading institution in the United States, we must take a scientific leadership role.

I then ask the other question: What else can we do as scientists? Suppose that this ecological disaster really does creep up on us. I think that we are in the very early stages of understanding mitigation. We understand global mitigation—reduce fossil fuel use, switch to alternate fuels, switch to nuclear, switch to solar, switch to fusion when it comes along; eliminate chlorofluorocarbons; we're doing that. We believe that methane is a major greenhouse gas; we have no idea what to do to control methane. Methane might be a much larger piece of this whole program. We can reforest. As I go further on in this list we find ideas that are more speculative: dispose of CO<sub>2</sub> by burying it in the oceans; ferry huge amounts of sulfur dioxide into the atmosphere to reflect sunlight; put satellites up like venetian blinds to control the sunlight. We as human beings have enormous intellectual power, and we haven't thought through the mitigation problem at all. We have not really encouraged ourselves or let ourselves do that. I think we have to get on with thinking about mitigation quickly, because it's a neglected part of the agenda, and it may be one way to cope with the problem if it comes on us rapidly.

**Scheiber:** I'd like to ask Assemblyman Sher, just to clarify his question to me: What would you put a moratorium on in this area? It's clear what you do about cutting ancient trees, but would you put a moratorium on all economic activity?

**Sher:** That's the kind of proposal, obviously, that I resist, and it's not going to be acted on. But what would the scientific community do in terms of

trying to promote a decrease in chlorofluorocarbons? What kind of drastic actions? Is that important enough? A number of bills were introduced this year. There was a perception that this is a very persistent problem, affecting greenhouse gas as well as causing a problem with the ozone layer. Is science ready to mobilize and say in a unified voice that this is something we must do now? We know it's important. We don't know how serious the global change problem is, but we know this will help, and there are other reasons to do it.

That's what we're looking for: we need help when we take these initiatives—there are people in the legislature who respond to this problem, who've been contacted about it, who read about it, and so they drop bills into the legislative hopper. That's what you elect us and pay our minimal salaries to do (*laughter*)—introduce legislation. So even though we don't know whether the problem is really going to overwhelm us, there are good reasons to take some steps anyway, and this is one of the strategies. I want to see that kind of thing put together with the help of the scientific community.

So often in the legislature, as the moderator was saying, when proposals are made, well-financed industry and business groups who will be impacted by the proposals use science in the other way. They find scientists who will say, "We don't know the answers, or we're not sure of this. It's not good science you're doing here." So in the legislation we set up scientific advisory panels. That's why there are a lot of them in federal government; they are not put there in order to collect the information to lead to action. A lot of them were put there to prevent action. And that's what's a little frustrating for me.

**Sulnick:** We have received a lot of written questions from the audience, some of them general and some addressed to individual panel members. I'll present the general questions first.

The first one reads: "Much scientific information and opinion is housed in institutions with political constraints, i.e., agencies and other governmental bodies. How can that expertise found in individuals be released into the public arena in the same way that Scripps allows its scientists to speak as individuals, while taking no position as an organization?"

This is directed to anybody on the panel, but first I'd like to comment. I read this as a two-part question. One part has to do with the myriad data that exist in different agencies like EPA or NOAA, data that are really astounding to try to tackle. I've tried, and I'm sure Boyce has tried. The way I handle it is that I call up my local congressperson and say,

"Look, I need your staff to do this," and some do and some don't. How do you handle it?

**Thorne Miller:** I try to call NOAA.

**Sulnick:** As I said, in my mind this is a matter of economics, because all of those data are available, but access is clearly not, from a practical point of view. Obviously the information is public; anybody can go and look at it, but one needs time to go and look at it, to write an analysis of it.

**Scheiber:** Actually, some of the federal data bases have been privatized; they are not public. A lot of the data that researchers want have to be purchased today. It's a very serious problem.

**Sher:** Let me tell you how we do it in government. We use moles. . . . There are a lot of agencies, and not necessarily for scientific information, particularly when the executive branch is in the hands of one political party and you're in the other party, or just generally in another branch of government. There are individuals in the various departments and agencies who know a lot of things, but they are under constraints. And yet they have friends on the outside, and they feel strongly about an issue. It's not just whistle blowing, but it's a lot of other things. They make knowledge available, and then the politicians on the other side can start digging without revealing their sources.

I suppose there are people in the scientific community who are under similar constraints, but who can furnish what they think is revealing information that ought to be known and acted on.

**Sulnick:** The second part of this question is rather interesting, the way I'm reading it. If a member of the faculty at Scripps makes a public statement, is that attributable to the institution, and how does the institution respond to that?

**Frieman:** As I said, as far as I'm concerned, any member of the Scripps faculty can make any statement in public that he or she would like. That is their right as citizens of this country. They cannot, however, make the statement in the name of the institution, because there are 1,200 people here, and maybe 1,199 disagree with them. So the individual simply should not speak for the institution. That's all we're saying.

**McGowan:** I can confirm what Ed has been saying. In my thirty years here at Scripps Institution, I've never felt any constraints against getting up and speaking my mind in public. (*laughter*) As a consequence, I'm not very often invited to do so. But it is a serious matter. One should not claim special consensus expertise or give the impression that one is speaking for the institution in general.

**Thorne Miller:** I see a little more to the question. I think it also is asking about the highly competent individuals in government agencies who perhaps cannot speak out. I think that this is not so much a question of cannot. I think Jim Hansen, for instance, showed us that they can speak out; they can express an opinion that is not necessarily representative of the agency, in his case NASA. But it's complicated. When they give testimony in Congress, very often that testimony is reviewed by members of the administration who say, "No, you can't say this; you have to say that." I think that the individuals in the agencies who feel strongly about this need to speak out and say, "Give us our chance."

**Sulnick:** The author of the next question begins by stating the function of this meeting—to talk about what society needs from science in preparation for global change—and then asks, "Ought not the question be rephrased to the following: Because humans must exploit the environment to some extent to survive, how can science help society to continue exploitation responsibly in the face of global change?"

A follow-up question is addressed to Bert Larkins: "Since the Alaskan factory tanker fleet will need to overfish the resource in the next two years to make mortgage payments, what do you feel is the first step needed to implement effective management to allow maximum sustained yield of the resource?"

I think the general flavor of these questions is good, because we are a society based upon the consumption and exploitation of resources. Some of our resources are nonrenewable, and some take a long time to renew. But all of them, once used, show a consequence in the global scheme of things. So the question becomes for all of us, in one way or another, How do we begin to retrofit our thinking so that we can sustain maximum yield?

**Larkins:** The members of my association are thinking about this themselves. They are sort of the last of the great pioneers. They've generally been opposed to limited entry; the ocean is the last place that's a common property resource; we can all go out and compete—"The cream floats to the surface," we hear daily. So government, stay out of our hair; just give us the biological maximum. If the quota's a million tons, okay, that's all we want. Some of us will make it, some of us won't.

That's a bit simplistic; some of the viewpoints are starting to change, particularly among those with \$30 million mortgages. They are starting to wish they had bought a 100,000-ton share five years ago.

Part of what I tried to say earlier is that none of these folks will argue that it's not important to live within the bounds of conservation, whether you describe it as the allowable biological catch, which is a term now in the fishery management area, or as the maximum sustainable yield (which, by the way, is a term I abhor, but I'll argue that some other time). But nevertheless, the pressures are strong.

Scientists, don't you start taking a conservative view of what these numbers are because you're concerned about other things. If you really think that the system can support a 1,200,000-ton removal of pollock for the next year, that's the number you should give to the policymakers. And you ought to do everything you can to support it and to stand behind it. Other people, for whatever reasons, will try to increase or decrease that. What we want from you folks is the ground truth. We want it stated very succinctly, very clearly. And we want you to stand behind it. And then the political system will start to work.

Other than that, I don't know how to answer this question. There are groups of bioeconomists and there are social scientists coming into the realm. So far, at least in my experience, the mix of biologists, economists, and sociologists has not really worked very well. There are social and economic aspects to almost all of the actions that my members and anybody else fishing for a living have to face up to. We're starting to hear such things now as, our fleet, because of its bigness, is responsible for increasing the suicide, abortion, and divorce rates of Kodiak. That's pretty powerful in a political arena. And how do you defend against it? Maybe it's right; I don't know.

**Sulnick:** Isn't it true that this debate about exploitation is really directed at each one of us? Because all of us are living a lifestyle dependent upon exploitation. We all have mortgages; mine isn't \$30 million, but I have to make the payment, and I assume everybody else has an equivalent. So isn't this the question: How do we no longer exploit and still manage to carry on with the work of living? This is not a question directed just to fisheries. It's a question directed to all of us. How do we change our lifestyles so that we no longer dump oil into the gutter that runs into the coastal zone, or so that we conserve miles per gallon? It's a generic question.

**Larkins:** I'd like to make one more comment about this. For a long time, even when I was working in Seattle in the sixties, I had some interface with the folks down here in the tuna industry. The superseiners were just coming on line; overcapitalization was

being talked about. But people always knew there was another opportunity. They weren't sure what it was, but "Okay, if we've overcapitalized this one and we can't make it in the tuna industry, sardines will come back, mackerel will come back." We, and even folks on the East Coast, and in the tuna fleets, looked to the Bering Sea. There was a 2 million ton-plus potential resource up there that was already marketable if you knew how to market in Asia, because there were Asian fleets up there exploiting it. I know of factory trawlers that were built in New England when things were rather depressed there (they have since gotten worse), and some people said, "Well, we may end up in the Bering Sea." That was their out.

There isn't any out any more. The whole commercial fishing industry—at least the groundfish, coldwater fishery—has suddenly, for the first time, met itself coming around the corner. And we are just now starting to face up to this. The political-scientific system that's been working within this community for thirty or forty years has suddenly come to the same conclusion. And I think the shock value is such that we really haven't sorted it all out collectively or independently. There is no place else to go.

We have tuna boats in the North Pacific fleet. We have some of the converted 200-foot seiners: they took the seine table off and put trawl winches on. They don't do very well, but they are probably doing better than if they'd stayed in the tuna industry. Many of the vessels that entered the Alaskan groundfish fishery in the last ten years were designed to do something else when they were built. King crab boats had stern ramps installed and have become draggers. I suppose there are rattails and sauries and perhaps one or two other species out in the middle of the ocean, but even FAO now says that there are no great untapped resources left.

**McGowan:** I'd like to address a couple of points, one that you just raised. And that is, How do we continue in the style to which we are accustomed and not exploit nature? I think this has been treated many times before. One of my favorite philosophers, Eric Hoffer, wrote an essay about that subject—a very good one. I think the answer is, we can't. We can't do it. We're going to have to exploit nature in order to live well.

It's the same question, or a very closely related question, as the one about the ten million Brazilian peasants. Amazonia has to be exploited in order to provide those people with the minimum adequate life. That at least is the argument. I don't know what we do about that.

**Sulnick:** I want to tell you. We were walking along on the same path, step for step, and then you went that way and I went this way. I said, "That's right," and I assumed your next sentence was going to be, "We're going to have to change the way we live." To me that's obvious.

**McGowan:** I don't want to. (*laughter*) It took me too long to get here.

**Sulnick:** That's the way it goes. To my mind, you don't cut down the rain forest to maintain your lifestyle. You can't kill all the dolphins to maintain your lifestyle. You're not going to have drift nets to maintain the lifestyle. To me, that is insane. Nothing personal. (*laughter*)

I think that this is the real debate. And we, each of us, will obviously determine the outcome. Because to the degree that you say you're not involved, you're teasing yourself—to put it mildly.

**Sher:** Conservation is not going to come about voluntarily, by individuals. It's going to be done by regulation. The best example of that is what's happening in the South Coast Air Quality Management District. We've been reading about the new air basin plan and the 120 or 130 regulations that have just come out in order to comply with ambient air quality standards.

These regulations—such things as not being able to barbeque in your back yard, and what kinds of paints you can apply to your structures—are going to affect everyone's life. A tremendous range of activities will be controlled. There will be very serious attempts to cut down the number of vehicle miles traveled, because all of the gains we've made in cleaning up the internal combustion engine—and we've made a lot of gain on points of basic science—have been wiped out by the increased number of vehicles on the road and the number of miles that they are traveling. So there are going to be very stringent restrictions on how you can use your personal automobile in the future. This will affect our lifestyle, and it will affect all of us. But it won't come about voluntarily. If we had to rely on its being done voluntarily we wouldn't make any gains.

**Scheiber:** Following along this line, the Bering Sea is an interesting case in which there are also conflicting uses, and terrible controversies that arise. Not only is it the place of last resort in the dreams of fishermen who are depleting stocks elsewhere, it has also been an arena for enormous international tension and a huge investment of American prestige over the years—first to keep the Japanese out, then a leading motivation for the 200-mile zone. There is a vast history there, and virtually overnight we

might see it all go to a point of extreme danger with oil rigs and tankers out there (a statement that doesn't sound as paranoid as it might have sounded before *Valdez*; we all understand that a little better now).

So that's the kind of controversy in which—in answer to you again, Byron—choices are clear. We can put off the day of involuntary gas rationing for another week by opening up all those wells and producing a week's supply for the nation out of the Bering Sea. That's a very discrete kind of situation. The global change problem is not that kind of a discrete situation in which you can bring either scientific or other kinds of expertise to bear as intelligently and as rapidly. So that's where the perplexity is.

**Thorne Miller:** I followed along your path, Bob, and made that same divergence with John McGowan. But I also want to remark on the comment about voluntary change. I think that there can be some impact from voluntary changes. A good example of this is the recycling issue. That is something that we have had to push policymakers hard on, and we've done it by people voluntarily showing that they can recycle. The local government refuses to legislate recycling requirements, saying residents won't go along with them. So the citizens take the matter into their own hands and establish voluntary recycling programs. The programs prove successful, so the local government decides, "Okay, then we'll put in recycling regulations."

**Sulnick:** I've got four more questions that are pretty good, and I'd like to get one or two of them in. The first one is to you, Assemblyman Sher.

"Environmental fads come and go, yet global change develops over a long time—decades, years. What mechanism can be implemented to ensure long-term commitment of federal and state agencies to document and understand environmental change?" That same idea was raised in the *New York Times* two days ago. . . .

**Sher:** Let me see if I understand: is that money for research again? (*laughter*)

**Sulnick:** You've got it. Next question.

**Sher:** I'm for it. I always support money for research.

**Sulnick:** This is an interesting question to me because I don't personally believe this is going to turn out to be a fad. When one gets sick, there are symptoms, and the earth is showing a lot of symptoms. If you don't see them, come to L.A. for a day and breathe the air. That habitat is so stressed out that it really is not supporting the quality of life for those

of us who live there. And we know it, even if not intellectually.

So I don't think the issue of global change is a fad. But in this question, the word *fad* is being used to mean politically popular. It's politically viable for the moment. The problem doesn't go away, but its attractiveness goes away. And then do we stop paying attention to it? That's the question. And how do we ensure that that doesn't happen? Even if it's not in a politician's best interest to promote x, but x needs to be promoted, how do we continue to promote it, especially when we're talking about global change?

**Sher:** I think there are a lot of fads that politicians respond to, one of which, for example, is whether we ought to amend the Constitution to make the burning of the American flag illegal. There are certain powerful emotions, and people read the polls. But in the environmental area, I don't believe that's the case. I think that where there are serious problems and there are people working on them seriously, we don't get that kind of political mileage out of working on them. There are too many organized forces against us. . . .

That may not be entirely true; you're going to find an environmental initiative on the ballot next year. One of the gubernatorial candidates is supporting it, and it deals with three major areas. One is offshore oil activity; a second is pesticides; and a third relates to various aspects of the global warming problem. It's true, people are using that because they detect a public awareness and involvement, and they think it will benefit them politically. But those issues are not fad issues; they are all serious. And we'll talk about them for a while, and the initiative may or may not pass, and if it passes it may not be implemented very well to deal with the problems. It isn't that the politicians will walk away from it because it's no longer fashionable.

**McGowan:** I'd like to make a comment in my role as a scientific answer man. I think there is absolutely no question among reputable scientists that concentration of CO<sub>2</sub> in the atmosphere has been increasing. We know that for sure, as well as we know anything. And so it is for other gases that affect radiative transfer of heat and energy from the sun. It is a virtual certainty that the increase in these gases is going to cause a warming of the global atmosphere. Almost every reputable scientist I know of believes the theoretical physics behind that argument.

What is uncertain is whether or not we have detected that warming as yet, because there are, after

all, cycles in climate, and this recent warming may be just part of a larger cycle.

What is even more uncertain, and in my opinion, virtually unpredictable now, are the consequences of that warming. We don't know what the magnitude is going to be; we don't know where it's going to take place; and we don't know how environmental systems, especially biological systems, are going to respond. That's where the real questions are. And that's where the uncertainty is. But it is a phenomenon — there's no question — that's going to happen. It's not a fad.

**Sulnick:** In your view, is it a phenomenon we should actively seek to stop?

**McGowan:** I wrote something down here earlier: Is our present knowledge sufficient for major political action, or are there uncertainties enough to delay action? Isn't that the question?

**Sulnick:** Precisely.

**McGowan:** Yes and no. There is sufficient knowledge right now to say that we absolutely must do a better job of understanding what the consequences of change might be. We must tune up and become much more elegant and sophisticated in studying change. Change as compared to what? What kind of a baseline do we have? We must know the magnitude and direction of change, and it must be compared to what the ordinary state of the system is, on a global basis. We really have very little of that information. And yes, we need action in terms of, if you'll excuse me, more research.

**Sher:** But you wouldn't take people's cars away from them, based on what you know?

**McGowan:** Not yet.

**Sher:** You wouldn't make them travel fewer miles in order to cut down the carbon dioxide yet?

**McGowan:** Oh, sure.

**Sher:** You would support a law that says you can only drive your car every other day?

**McGowan:** But there is already a lot of carbon dioxide in the atmosphere.

**Sher:** What I have to respond to is proposals that are made to at least try to stabilize how much CO<sub>2</sub> is going into the air. And what I want to know is whether you are going to support me.

**McGowan:** The economic consequences of some of the suggestions might be very severe. The cure might kill the patient, and that's what I worry about.

**Sulnick:** Let me add one other point of view. It seems to me that while we study things we should do so from a safe, or relatively safe, perspective. And if the environmental changes that are taking place are as potentially destructive as they appear to

be, we should put the brakes on as quickly as possible. I don't think that means that we should drive our cars every other day; I think that means we should drive cars that don't add to global warming, which, my information tells me, are technologically feasible. But not yet politically acceptable. But that debate would just go on and on. So, using the prerogative of the chair. . . .

**Question from the floor:** When we get down to the specifics, what are they really going to be, and are we prepared to advocate moving to nuclear power?

**Sulnick:** As moderator, I don't know that that ought to be what we are debating, because everyone has a point of view. As a quick response, I think there are alternatives that would promote an energy policy based on conservation and renewable fuels, and would not jeopardize the nation with the potential devastation of nuclear energy.

If I can avoid having a debate on this I would like to, simply because it's four o'clock and I have one more question I would like to present to the group before I thank you for your participation.

The question is: "How much money is the United States government giving CalCOFI to investigate the amount of contaminants the United States sends to Mexican territorial seas through the California Current?"

**Mullin:** I should point out that this question was translated from Spanish. Obviously there is a legitimate concern on the part of our Mexican colleagues that there is a flow of water from the coast of California to the coast of Mexico. I don't know that it will be possible for the panel to come up with a number, but it's certainly worth thinking about.

**McGowan:** The other part of that question is how much does the federal government support CalCOFI studies relevant to this? There is no support from the National Science Foundation or the Environmental Protection Agency; only NOAA supports the program. Most of the support comes from the state of California.

**Sulnick:** I have one final statement: I would like to thank the audience. You've been really attentive, and obviously involved, and that made it a much better discussion than it otherwise could have been.

**Mullin:** In closing, I suppose it's obvious to point out that a very large number of people have contributed, both to the symposium today and to the CalCOFI meeting for the last three days. I'd particularly like to thank Mary Olivarria, Sadie Gonzalez, Lari Maczko, Debbie High, and Kitty Haak, who have probably walked a hundred miles between here

and our office to try to get all of the details straightened out.

Again I'd like to say that I'm grateful to our panel, particularly those from the Bay Area and Sacramento, who have probably had enough disruption

in their lives in the last two weeks to keep them occupied for quite a while. We very much appreciate their coming here.

And finally, again, thank you to the audience for your participation and support.