Testimony for the U.S. Commission on Ocean Policy

Submitted by

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"Ocean Exploration"

Thank you, Admiral Watkins and distinguished members of the U.S. Commission on Ocean Policy for the opportunity to speak to you today about ocean exploration. My goal this morning is two-fold. First, I hope to convince you, in case you still need convincing, that our nation would greatly benefit from a program in ocean exploration. Knowledge acquired through exploration is already, and will become even more, essential for policy makers, researchers, resource managers, and conservationists. Second, I wish to share with you my thoughts on how such a program should be conducted for maximum impact and benefit. It needs full involvement of all relevant federal agencies, the academic community, and the private sector.

Why Ocean Exploration?

Consider for a moment the map of global biodiversity (Figure 1), in this case as measured by the number of species of vascular plants. Note the comparative biological wealth of New Guinea, as compared with the impoverished state of Canada. Maps such as this are essential for understanding the functioning of ecosystems, for gauging the impact of man on the environment, and for discovering useful new biological compounds. On all maps of this sort, the ocean is blank, despite the fact 80% of living phyla are found only in the oceans. The ocean's midwater alone contains more biomass than all of Earth's rainforests combined, and yet we cannot produce even a coarse estimate of marine biomass, much less biodiversity, because the oceans are largely unexplored.

Consider next this map of volcanoes (Figure 2) active at some point during the Holocene (the last 11,000 years). Maps such as this are the starting point for estimating geothermal energy potential, for forecasting volcano hazards, and for quantifying the flux of mass and energy from Earth's solid interior to its fluid envelopes. This map gives the false impression that all volcanic eruptions are subaerial – either on continents or on islands such as Hawaii, the Galapagos, or Iceland, when in actual fact most volcanic eruptions are submarine, along the vast midocean ridge system. Except for a few subsea volcanoes that can be monitored from land, such as Loihi Seamount offshore Hawaii and Axial

Seamount offshore the Pacific Northwest, we are ignorant of which submarine volcanoes are active and for how long. The hydrothermal power in these systems is 150 times the annual power consumption in the entire U.S., based on statistics of how many submarine volcanic systems must be active at any one time to create the 20 km^3 of new ocean crust each year required by plate tectonics,

When nations estimate their mineral wealth, such as this map showing mineral deposits in India (Figure 3), again the offshore region is blank, despite the fact that submarine hydrothermal systems produce rich deposits of sulfides, lead, cobalt, copper, zinc, silver, manganese, and other metals. The amount of iron alone deposited in hydrothermal vent fields is equivalent to creating another Mesabi iron range every 25 years. These deposits can be preserved long-term if buried in sediments close to continental margins. All nations have similarly poor knowledge of what mineral wealth may lie within their territorial waters or what it might be worth.

Finally, consider this map (Figure 4) of the elevation of Earth's solid surface on the island of Oahu (from the Shuttle Radar Topography Mission). Maps such as this should be the starting point for any exploration, in order to know where you are and to place all discoveries within a geographic and geologic context. But again, the ocean is blank. Of course we do have some idea of the depth of the ocean. However, the maps we have for 95% of the seafloor are a full two orders of magnitude poorer in resolution. To put these numbers in perspective, if you were shown this picture at full resolution, you would be able to find Aloha stadium, where the NFL plays the pro bowl. If downgraded to the resolution for the oceans, you wouldn't even be able to resolve Diamond Head, the most prominent Honolulu landmark.

Currently on the land surface, policy makers are most concerned about the changes in the state of natural systems and the impact of humans (Figure 5). For the oceans, we do not even have a baseline for saying what the state is now, much less the time series observations to appreciate how it might be further altered by natural or human-induced impacts.

So the point I want to make is that we are already very late in acquiring even the most basic information on the 70% of our world that is underwater. Initial objectives for ocean exploration should be to produce first-order estimates of marine biomass, three-dimensional views of biodiversity, and better maps of the seafloor, including information on habitats, mineral resources and geologic hazards. This information is critical to ensuring the health of our planet, our economic well being, and our national security. Furthermore, I know you have and will hear impassioned testimony on the sorry state of ocean literacy of the American public. Ocean exploration is exciting, will engage the public, and is the ideal vehicle for promoting ocean literacy. For these reasons, I hope that this Commission will advocate a program in ocean exploration.

Considerations in Structuring an Ocean Exploration Program

The sorts of systematic data sets necessary to “fill in the blanks” for the ocean will not self-assemble from individual PI proposals and do not fall squarely within the purview of only one federal agency. Therefore, it is not obvious how such a program should be structured. In making my own recommendation in this regard, I took the following approach: consider what outcomes for the program drive its management, and look for successful models that can be emulated.

First, the program must be discovery-based. For that reason, it should either not be housed in a mission-oriented agency, or if it is, steps should be taken to protect the program from the inevitable pressures to divert funds from exploration in order to tackle pressing, short-term, mission-related issues.

Second, the program must have a vision, and be conducted in an organized and systematic manner so that the fruits of each exploration mission can be incorporated seamlessly into that larger vision. For that it will require long-term funding (for example, 10 years for the first installment). Long-term funding allows long-term planning, such that assets and technology can be prepared and tested in advance for the challenges of upcoming missions.

Third, the program must be inclusive. This is a big job, and will require using the talents and marine assets of several federal agencies (notably NFS, Navy, NOAA, and NASA), the academic community, the private sector, and ideally, international partners. Any organizational structure must encourage the participation of any and all of these groups in order to maximally effective and should be judged on its success in this regard.

What the Federal Agencies Contribute

NSF’s mission is, of course, fundamentally discovery-based. It has a tradition of excellence, and a commitment to integrating across disciplines, advancing technology, expanding understanding, furthering formal and informal education, and collaborating internationally. It is the primary support for the UNOLs fleet, academic ocean research, and the deep-sea submergence facility. Ocean observatories, a required component to explore in the 4^{th} dimension of time, are already a high priority for the agency. Furthermore, NSF has no in-house science centers or research labs in oceanography, and thus would be immune from pressure to support exploration on anything but a merit basis. I honestly cannot imagine an ocean exploration program that excludes NSF.

The Navy has a distinguished history of innovation with respect to marine technology, and knows how to proceed orderly and systematically towards a long-term goal. It is thanks to the Navy that we have swath mapping systems, ocean bottom seismometers, environmental acoustic arrays, and autonomous underwater vehicles. The assets and experience that the Navy would bring to the program, in addition to the high probability that it will ultimately benefit from the fruits of exploration, argue for Navy involvement.

NOAA has already taken the lead in forming its own ocean exploration program, and is well ahead of the other agencies in this regard. Lack of a long-term budget line has prevented the agency from planning a systematic program integrating technology development, discovery, data management, and education, but the agency has done an excellent job in attracting media attention to new discoveries. Quite admirably, the agency has stated that no more than 50% of the funding for exploration will be allocated to its own NOAA centers and labs, but as you can imagine, this decision has not been well received by all within the agency. NOAA also has made a commitment to ocean observing. Its Equatorial array has figured prominently into operational forecasting while still allowing for research innovation.

And finally, there is NASA. If there is any agency that truly embraces the concept of exploration, it is NASA. And this agency always takes the big picture. Many maps of important environmental parameters that are NOT blank over the ocean (e.g., Figure 6, chlorophyll from SeaWIFS) are courtesy of NASA. This agency has much experience in managing large data sets and making them available to a wide audience. NASA is the master in high tech instrumentation and remote sensing. But NASA does not have much ocean experience, *in situ*. Teaming NASA with the other agencies mentioned previously is a powerful combination.

Other agencies as well, such as the US Geological Survey, the Minerals Management Service, the Environmental Protection Agency, and the Department of Energy, also have relevant expertise and much to gain from ocean exploration. The program must encourage their participation.

A Candidate Model

In looking to models for how to establish a program in exploration, I want to bring your attention to the example set by the Ocean Drilling Program (Figure 7). In its early days especially, ODP was an exploration program, albeit centered on one asset as opposed to the array of assets that will be needed for ocean exploration. While funding for the program is through NSF, the Foundation wisely recognized that its peer panels that consider unsolicited proposals would not be an appropriate organizational mechanism for building a coherent program. Therefore, through a contract with the Joint Oceanographic Institutions, ODP was established with a centralized advisory structure that sets long-term goals, looking out for the technology development that needs to be undertaken today in order to be ready for future drilling legs. Most of the infrastructure for the program, such as the drill ship, the sample archives, special services, etc. are awarded on a contract basis, with competitions reopened periodically and subjected to external review. ODP employs a rather small staff, mainly to provide systematic procedures for shipboard measurements and for oversight of the contractors. The program places a high priority on rapid publication of its results through the ODP volumes that sit in every marine research library.

ODP has entrained the broad community in planning through the COSOD workshops, but then uses panels of distinguished outside experts to sort through the ideas and weave the best into a coherent program. The broad oceanographic community is aware of that program and of the geographic priorities in any given year, and thus can respond with targeted proposals for each leg. Thematic panels sort through the proposals to select the very best strategies for achieving the long-term goals.

Representatives from the academic community, federal agencies, and the private sector have been involved in the program through attendance at workshops, participation on advisory panels, and as members of the shipboard science party. This broad ownership has been the best mechanism to ensure that the fruits of the program are transferred back into the research community – federal, academic, and private. I cannot stress enough that a closed program which merely creates wonderful databases, sample archives, and published volumes will not have the intended impact. People are the best vector for disseminating ideas and discoveries.

Finally, ODP is the premier example of a successful international program. Of course, the ODP model cannot be applied without some modification to ocean exploration. Agencies other than NSF must be involved and engaged, perhaps through an arrangement like NOPP. An ocean exploration program would place relatively more emphasis on assets of opportunity than on specialized program assets (such as an exploration flagship) than is the case for ODP, although ODP has certainly contracted for other ships and equipment when necessary. Ocean exploration would also likely need more committed, long-term leadership than the ODP panel structure allows, in that achieving the goals of exploration will require more patience and a consistent direction.

Other Considerations

In setting up a program in ocean exploration, some important decisions will need to be made on some expensive items, such as a flagship for the program or a new human-occupied submersible. These issues will no doubt be debated for a long time. I will take this opportunity to give you my opinion. It all reduces to the question of how much we can afford to devote to ocean exploration. The "moped" version of the program (~$30M/year) probably has neither a flagship nor an HOV. It uses vessels of opportunity, but loses much in terms of the visibility of the program, its potential for educational outreach, the consistency in the data sets acquired, and effort in mobilization for each voyage. The "Chevrolet" version of the program (~$75M) could have a flagship. The flagship would be equipped with a standard suite of multi-disciplinary sensors, a broad array of sampling gear, and a remotely-operated vehicle capable of reaching at least 6500-m depth. The ship would have 2-way, real-time communication with museums, aquaria, and classrooms such that the public can participate in the explorations and ROV dives in real time. Voyages of the flagship would be proceeded my more routine mapping exercises by vessels of opportunity, and succeeded by specialized investigations using other chartered vessels (including the possibility of occasional charter of ships with

HOVs such as the US *Alvin* or the Japanese *Shinkai 6500*). The “Cadillac” version of the program (~$100M) could have both.

Conclusion

Finally, in closing, I would like to thank the Commission for its interest in ocean exploration. If I were to hazard a guess as to what action has the potential be viewed as the most important legacy of this Commission one hundred years from now, it would be your support of ocean exploration.

June 17, 2002

Dear Members of the US Commission on Ocean Policy:

This will be the first of a series of emails from me prompted by questions and assignments resulting from the Seattle meeting of the Commission.

In Arthur Knowles testimony on ocean education, he made at least two main points:

1. We will be facing a shortage of trained professionals in oceanography and ocean engineering;

2. One strategy for addressing this problem is to establish more undergraduate degree programs in oceanography.

I agree with his first point. We are not seeing the best and brightest students entering into our graduate programs in oceanography and ocean engineering, and will be facing a shortage of PhD-level professionals within the next decade.

I disagree with his second point. The future stars in this area will not be those with a generalist background. We need to find some way to attract the star students from microbiology, chemistry, biochemistry, physics, information technologies, materials science, etc. to pursue graduate work in oceanography. Having undergraduate majors only deters such students from choosing this career path, since they tend to associate ocean- ography with "soft" science. I think a better approach would be to have an extremely visible and prestigious fellowship program (on par with the NSF Graduate Fellows) that funds the graduate work for star students in the oceanographic sciences and engineering.

I do see a role for courses (but not degree programs) in oceanography. I think it would have a huge impact on ocean literacy and stewardship if EVERY person with a college education had a course in oceanography prior to graduation. Such classes do have great appeal for fulfilling science requirements for non-majors.

Thanks for listening, and thanks for the very important work you are doing.

Sincerely,

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