# FRONTIERS IN OCEANIC RESEARCH

## HEARINGS

BEFORE THE

## COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

ON

**H.R. 6298**

APRIL 28 AND 29, 1960

[No. 7]

Printed for the use of the Committee on Science and Astronautics

Bostwick H. Ketchum



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# FRONTIERS IN OCEANIC RESEARCH
# (H.R. 6298)

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**THURSDAY, APRIL 28, 1960**

House of Representatives,
Committee on Science and Astronautics,
*Washington, D.C.*

The committee met at 10 a.m., Hon. Victor L. Anfuso presiding.

Mr. Anfuso. This meeting will come to order.

Gentlemen, this morning we are going to open up hearings in connection with H.R. 6298, a bill introduced by the distinguished chairman of this committee, Mr. Brooks, and which was referred to our committee.

The purpose of this bill is to amend the National Science Foundation Act of 1950, to provide financial assistance to educational institutions, for the development of teaching facilities in the field of oceanography and to provide fellowships for graduate study in such field.

Leading off this morning is a very distinguished professor, Dr. Harrison Scott Brown, professor of geochemistry of the California Institute of Technology, in Pasadena, Calif., and Chairman of the Committee on Oceanography of the National Academy of Sciences.

Dr. Brown has a very extensive biography. Because it will be of interest to this committee, I am going to have the biography of Dr. Brown entered in the record.

(The biography of Dr. Brown is as follows:)

Biography of Harrison Scott Brown

Professor, California Institute of Technology, Pasadena. Also: Chairman, Committee of Oceanography, National Academy of Sciences-National Research Council.

Born: Sheridan, Wyo., September 26, 1917.

B.S., University of California, 1938; Ph.D. (chemistry) Johns Hopkins, 1941. Instructor, chemistry, Hopkins, 1941–42; research associate, plutonium project, University of Chicago, 1942–43; assistant director, chemistry division, Clinton Laboratory, Oak Ridge, 1943–46; assistant professor, Chemical Institute for Nuclear Studies, Chicago, 1946–48; associate professor, 1948–51; professor geochemistry, California Institute of Technology, 1951– .

Prize, American Association Advancement of Science, 1947. Civilian with Office of Scientific Research and Development, 1944. A.A. (Prize 1947); Chemical Society (award) (1952); Geological Society; Physical Society.

Fields: Mass spectroscopy; thermal diffusion, fluorine and plutonium chemistry; meteoritics; geochemistry; planet structure; geochronology.

Mr. Anfuso. Dr. Brown, will you please come forward?

We are very happy to see you here, and we are glad you could take the time off and come from California to the hearing.

Dr. Brown. Thank you very much, Mr. Chairman.

## STATEMENT OF DR. HARRISON SCOTT BROWN, PROFESSOR OF GEOCHEMISTRY, CALIFORNIA INSTITUTE OF TECHNOLOGY

As you have already mentioned, my name is Harrison Brown. I am professor of geochemistry at the California Institute of Technology, and Chairman of the Committee on Oceanography of the National Academy of Sciences, and also I am a member of the Space Science Board of the Academy.

I would like to thank the Committee on Science and Astronautics for the opportunity of appearing before you to discuss the broad problems of oceanography, and something about the urgency of these problems.

About 4,500 million years ago a series of events took place which led to the formation of our Earth and the other planets of our solar system.

We know that when our Earth was first formed it had no atmosphere and no oceans.

We know that water did not exist on the Earth, or for that matter probably not on the other inner planets in liquid form.

The planets retained water chemically, and over a period of time following their formation this water was released.

Some planets apparently retained very little. The planet Mars, for example, we know, has some water. It has polar caps which are definitely ice. It has water vapor in its air. We know that because the polar caps migrate from one end of the planet to the other. But the temperature is so cold that water cannot exist in a liquid form. It exists as water vapor and as solid ice.

In the case of Venus——

Mr. ANFUSO. May I interrupt you for a minute?

Your information indicates that the water is not in liquid form on Mars?

Dr. BROWN. That is correct, sir.

Mr. ANFUSO. You may proceed.

Dr. BROWN. There is very little water. The polar caps are probably all of an eighth of an inch in thickness, and occasionally one can see deposits of hoarfrost on the planet in those regions when night is just beginning to turn into daylight.

In the case of Venus, for a long time we thought there was no water there at all. It seems clear that the temperature of the planet is quite warm, possibly over the boiling point of water. Recently, however, water vapor has been detected. It is questionable that there are any vast oceans.

In the case of the Earth, however, the conditions were particularly favorable for the chemical retention of water during the process of planet formation and over a period of time—we don't know how long it took—water was released, and the net result was the formation of vast oceans which, were our Earth perfectly flat—that is were we not to have mountains or continents—would cover the Earth to a depth of roughly 2 kilometers.

There are about 300 million cubic miles of water on the surface of the Earth.

We have reason to believe that at one time there was actually more than that, but we know that the rays from the Sun decompose water in the upper atmosphere, that the hydrogen that is formed escapes, and that the oxygen which results oxidizes the surface rocks of the Earth, and disappears. But the net result is a loss of water, and we believe that about 10 percent of our oceans have disappeared in this way.

To ward off any qualms you might have, even were this process to go on into the indefinite future, we have another 50 billion years or so of water left.

Fortunately for us we have continents. Fortunately we have mountains, with the result that the Earth is not completely covered by water. But two-thirds of it is.

This large quantity of water greatly affects the lives of all living species, both in the water and on the land—not the least, man.

The vast oceans determine in large measure what our climate is going to be like.

The oceans provide vast highways for transportation. They provide vast quantities of nourishment for human populations. And in the past they have traditionally supplied protection against enemy attack.

There are tremendous cycles which take place in the ocean. These cycles involve mass transport of water in the form of great ocean currents. They take the form of the evaporation of water by the rays of the Sun, the condensation of that water, which then falls back into the oceans or over the land areas. When it falls over the land areas it returns to the oceans by way of the rivers.

In doing this, the water erodes the great land areas and we find huge chains of mountains which at one time were as high as the Rocky Mountains which have been worn down by these processes.

The eroded material goes into the oceans and gets precipitated in the form of sediments.

These sediments frequently contain the remains of once living creatures and provide what we know as the fossile record, which, were we able to interpret it, would tell us the complete history of life upon our planet.

Were we to drain the oceans in some way we would find a myriad of geologic wonders. We would find trenches which go down as far as 7 miles, and I understand you are going to hear more about that today from persons who have actually visited one.

You would find mountains which approach Mount Everest in height. And in the oceans, as they exist today, we see a fantastic array of living things. It is complex. The array is enormous, and we have only begun to understand the interrelationships which exist among the various living species in the oceans.

Unfortunately, man's knowledge of the oceans is very small compared with their importance to him, and it is amply clear to those of us who have paid some attention to them that as time goes by their importance to man will increase.

Now, I should point out one other aspect of the oceans which is very important to us, to us creatures who are alive today. It is rather clear that the oceans provided the environment within which life had its origin on Earth, and indeed provided the environment within which a large part of evolution took place.

Many of the remains of the very earliest living creatures are trapped in these sediments which I have mentioned, and we can take cores of these sediments from the ocean floor and by slicing the cores and looking at them with microscopes we can obtain a picture of the whole history of the evolution of living creatures.

Now, I have mentioned a few of the things concerning the oceans which we know or believe we know. I would like to stress that what we really know is terribly small compared with what we should know.

Considering that the oceans cover two-thirds of the Earth, our knowledge of them today is insignificant when compared with what we know about the land areas of the world.

In 1957 the National Academy of Sciences recognized that neglect in this area might well result in our being placed in a precarious position, certainly from the scientific point of view, and in all probability from the technological and military points of view as well.

Recognizing that this neglect might well present serious difficulties in the future, the president of the academy, Dr. Bronk, appointed a committee on oceanography, and subsequently appointed me chairman.

He did this at the specific request of a group of Government agencies, all of which were involved in one way or another with oceanography, and all of which were concerned about what appeared to be a lag.

I should stress that in being asked to chair this committee, I am not an oceanographer personally. My own work is actually more intimately related with the space program than it is with the program on oceanography, but my interests border upon the oceans, and not being an oceanographer or connected with any of the oceanographic institutions, I believe I have been able to guide the committee objectively.

Over a period of 2 years our committee made a study of the status of oceanographic research in the United States—

Mr. ANFUSO. At this point, Dr. Brown, would you mind mentioning the names of the other members of the committee?

Dr. BROWN. I will be very happy to.

Mr. ANFUSO. They are oceanographers, aren't they?

Dr. BROWN. Some are and some are not.

I will attempt, when I name them, to explain why the individuals named were selected. As I mentioned before, I was asked to be chairman. We wanted the directors of our three largest oceanographic institutions to be members, and these included Dr. Maurice Ewing, who is director of the Lamont Geological Observatory at Columbia University, Columbus Iselin, who was then director of the Woods Hole Oceanographic Institute at Woods Hole, Mass., and Dr. Roger Revelle, who is director of the Scripps Institution of Oceanography at La Jolla.

We also wanted representation from some of the smaller oceanographic institutions, and we appointed Dr. Fritz Koczy of the Marine Laboratory of the University of Miami in Florida, and Dr. Gordon Riley of the Bingham Oceanographic Laboratory at Yale University in New Haven.

We wanted a person who was interested in and informed about the practical aspects of fisheries problems, and we appointed Dr. Milner

B. Schaefer, who is director of the Inter-American Tropical Tuna Commission—that is an international commission of North and South American states, and his activities center at La Jolla, in California.

Then we wanted someone who is well versed in engineering techniques and broad problems of science, but who is not an oceanographer, and we selected Dean Athelstan Spilhaus from the Institute of Technology of the University of Minnesota, who had also had a great deal of experience with the Department of Defense.

We wanted someone who is familiar with Government activities and Government structure, and we were very fortunate in obtaining as a committee member Mr. Sumner Pike, of Lubec, Maine, who was one of our original Atomic Energy Commissioners, who is retired and who has been happy to serve with us. His work with our committee has been extremely useful indeed.

In addition, we wanted someone again who is not an oceanographer but who is familiar with the broad problems of modern biology, and we selected Dr. Colin Pittendrigh, professor of biology at Princeton University.

We have since appointed two more biologists to our committee, Dr. Dixie Lee Ray from the University of Washington, and Dr. Per Scholander from the Scripps Oceanographic Institution in La Jolla.

Does that answer your question, sir?

Mr. Anfuso. Yes, thank you.

Dr. Brown. I should point out that we spent 2 years in our study during the course of which we held meetings and investigated the status of research at many of our major institutions and some of the smaller ones as well.

Our major conclusion was that relative to other areas of scientific endeavor, progress in the marine sciences in the United States has been slow.

I would like to discuss this area by area, if I may. Now, first, I would like to discuss the problems of defense in relation to the marine sciences.

When we look at the evolution of modern weapons systems, it is amply clear that one of the major problems which confronts us is that of creating hardness in our missile bases.

This is a very real problem on land. Coupled with this, we are faced with the brute fact that no matter how hard we might make a missile base on land, it is difficult to create it in such a way that people in neighboring communities are not going to be killed should there be an enemy attack.

I personally have thought a great deal about these problems, and again and again and again I am forced to the conclusion that we are being pushed into the oceans as a major answer to this problem.

I believe that in another decade or so warfare is going to be conducted primarily in the oceans.

I believe that the emergence of the Polaris submarine is a strong indication that we have already gone a long way down this path.

Now, if we are going to fight a war in the oceans, it means we have to know something about the oceans.

The victor, in such a war, will be that nation which knows most about the oceans.

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An analogy which members of my committee have used is that in the old days of the Indian wars the Indians often achieved victory over the whites, not because they were superior in strength, but rather because they knew how to handle themselves in the forests and in the woods.

Similarly, in the oceans, we must learn how to handle ourselves, and it is for this reason that essentially anything that we learn about how to maneuver in the oceans, how to find things in the oceans, will help us should we be forced to fight such a war.

Now, the problems of offense in the age of undersea warfare are difficult.

We have long-range nuclear submarines, but these submarines have to find out where they are under the water.

Now, how are they going to find out where they are under the water?

Well, one way is to recognize certain geographic objects such as mountains or valleys.

If they cannot find where they are under the water, then they have to surface, and then they are in danger of being found.

Similarly, how are they going to find out where they are without emitting radiation?

It is very difficult to communicate without giving out some kind of a signal or receiving some kind of a signal, and if you give out some kind of a signal then enemies as well as friends can find you.

So the problem of self-protection in relation to communications is extraordinarily difficult.

These problems really will only be answered as we learn more and more about the properties of water—sea water—and the properties of the life forms which exist within the sea.

Let us take the analogous problems of defense.

Today we find submarines using what is known as sonar. Here we take sound waves and shoot them down and they are reflected off objects.

The whole problem of the behavior of sound waves in sea water is a very complex one. For example, arrays of living organisms will give off background sound or noise. This has to be interpreted.

Aggregates of living organisms can confuse and attenuate acoustic signals which we ourselves send out.

All of these things make the problem of using sound waves for detection purposes, or for that matter for communication purposes, extremely difficult. And indeed, I believe myself that the long-range nuclear-powered submarine capable of carrying long-range missiles is in the long run the most serious military threat that the United States faces. And learning how to find such submarines is perhaps the most serious and difficult technical problem which we face today in the military field.

I don't believe that this problem is going to be solved really until we learn a lot more about the oceans than we now know.

If I might move to another area of defense, it involves the handling of submarines and it involves the handling of surface ships.

More knowledge of the oceans can greatly improve our capabilities involving forecasting. The forecasting of tides, today, we pretty much take for granted. But the forecasting of surf and of waves in the oceans is a relatively recent development.

Today it is possible to make fairly long-range forecasts of waves with the result that it is now possible to route transport vessels along the path of least resistance, rather than the shortest path in terms of miles, and in that way shorten the time for a transatlantic crossing appreciably, and indeed the Navy now is making very important use of these forecasting techniques in the scheduling of their own transports.

We have only seen the beginning as to what can be done, but already in savings to the Navy, the research that has gone into this has more than paid off by a considerable margin.

Ice forecasting is another important area. We are now doing this fairly well, but there is considerable room for improvement.

The forecasting of surface temperatures, and of surface and deep sea currents, can be very important from the point of view of aiding submarines in their navigations, in making full use of the rather newly discovered underwater currents which exist. There is one stream which has been found in the equatorial region which flows in an opposite direction to its surface current, and where the net waterflow corresponds to thousands of times the flow of the Mississippi River. Now, in principle, one can make use of these underwater currents. Submarines can just float along, so to speak, and in that way save fuel. This is perhaps not so important from the military point of view, as from the point of view of underwater marine transportation.

The forecasting of marine biology can be extremely important. Again from the defense point of view, but also from the point of view of being able to forecast where you are going to find fish and how many you are likely to find of what type.

All of these things can in principle be done if we were to know more about the oceans than we now know.

I have discussed the defense problems. I would like to close that discussion with one other aspect, and that is, today we hear quite a bit of discussion about disarmament. I believe that all of us would like to see a world created which is a peaceful world in which arms are in some way limited.

The submarine presents a very serious problem from this point of view, because today nobody knows how one goes about monitoring submarines.

Any disarmament program must contain as an essential part, rules and regulations and techniques for the monitoring and handling of submarines.

It may well be, as some of our committee members have suggested, that the law of the sea may have to be changed in such a way that any unknown—any vessel which is submerged, and which does not identify itself upon demand, is an aggressor.

I point this out just to point up another extremely difficult problem which we have but begun to comprehend.

Now, the next area of importance involves that of ocean resources. The population of the world is increasing with considerable rapidity. A large part of the world is badly undernourished, and the main aspect of the malnutrition involves a shortage of protein.

We don't know how many fish there are in the sea, but we can guess that the seas can be fished considerably more efficiently than they are being fished at the present time.

It is important that we learn how many fish there are, and where they are, in order to map out fishing programs that can help to relieve the situation with respect to food supplies which now exist.

There is another aspect of the resources of the oceans——

Mr. FULTON. Before you leave that point, as a matter of fact then you are in the school then instead of being against more birth control, you are for finding more fish?

Dr. BROWN. I am for a balanced program. [Laughter.]

Mr. FULTON. Very good.

Dr. BROWN. The other aspect of ocean resources, which is extremely important—and we have but begun to appreciate what we can be done eventually—involves the mineral resources of the sea.

You gentlemen in particular are well aware of the fact that we have continental shelves and that there is oil under the continental shelves. But from the long-range point of view, of equal importance, I believe, is the fact that there are minerals in the deep seas which in principle can be mined. Such elements as manganese cobalt, and nickel, I believe eventually can be secured from the ocean depths economically.

The other aspects of the oceans which should be studied intensively involves radioactivity.

With the liberation of nuclear energy man has brought into the world something which has not existed on a large concentrated scale before—at least since the Earth has come into existence.

We have to know what we are doing when we introduce these large quantities of radioactivity into living systems.

We are today introducing radioactivity into the oceans by means of the explosion of nuclear weapons. We are also talking about introducing large quantities of radioactivity in the disposal of waste from nuclear powerplants.

We are today introducing quite small quantities of radioactivity into offshore areas in the disposal of low-level radioactive waste from hospitals and from laboratories.

It is terribly important that before these quantities get much larger that we understand what is going to happen to them.

It is important that we prevent them from getting back into the food chain and then back into human beings.

Now, the only way we can guarantee ourselves that they won't get back into the food chains is to learn something more about ocean circulation patterns, to learn something more about the habits of living organisms in the seas, and to learn something more about how the various radioactive elements which are disposed of behave in sea water.

Certain elements, for example, like vanadium, are just concentrated fantastically by certain marine organisms, so if one were to dispose of a large quantity of radioactive vanadium, the chances would be good that this particular kind of organism would be killed off in that area.

Mr. MILLER. Aren't those primarily crustacea?

Dr. BROWN. That is correct, yes.

Mr. MILLER. In other words, that includes the shrimp, the lobsters?

Dr. BROWN. I'm sorry I am not enough of a marine biologist.

Mr. MILLER. We do know it is crustaceans?

Dr. BROWN. That is correct, yes.

So that the whole area of studying the behavior of radioactivity in the oceans we believe is a very important one.

Now, last but not least, we have the whole area of basic research, and this we believe is the most important area of all.

This is research which is done for its own sake, without any real thought of practical applications, yet the fact remains that practically all practical applications stem from the source of basic research.

The very nature of basic research is that the results which are obtained are unpredictable.

I am reminded of a little story in this connection which illustrates just how we have difficulty predicting.

One can project oneself back to the time when we were using lamps for illumination, and let us suppose that we were to establish a foundation to improve home lighting at that time. This foundation would probably give out all sorts of research grants to universities and to various organizations, and these research grants would almost all go to the pursuit of the obvious.

Large grants would be given to study the improvement in the efficiency of burning whale oil; perhaps some of the more farsighted grants would go to the study of the habits of whales; the mating habits, and so forth.

But one can ask, how much of this money would have gone to support the rather remote work of Michael Faraday and Clerk Maxwell? I believe that the answer would be very little, and yet their work provided the really basic foundations for the emergence of electricity.

Similarly, when we speak of basic research in the oceans, we speak of work which is done where the results are unpredictable and where the practical applications certainly are unpredictable. Yet, of all aspects of research that I have thus far mentioned, I believe that it is the most important.

Following this discussion of some of the problems, I would now like to discuss with you some of our recommendations.

We based our recommendations upon the assumption that it would be possible for us to double the volume of basic research being undertaken in the marine sciences in the United States in the next 10 years.

It would be very fine if we could proceed at a rate which is greater than that, and I believe all of the members of our committee would like to see us do that. But there are certain limiting factors which are involved, and perhaps the most important limiting factor is that of technical manpower.

It takes, well, really, about 22 years to train a scientist or an engineer these days. You've got to start awfully young.

So you just can't turn on a faucet and have oceanographers pouring out of it.

As a result we believe that we can double the number of scientists and engineers involved in basic research in the next 10 years, but it will be difficult to do more. Even the doubling is going to take a great deal of cooperation and a great deal of effort.

In addition to doubling our basic research during the next 10 years, we believe it terribly important that we institute a major program of oceanwide, ocean-deep surveys. These are surveys designed just to make maps of the oceans, and what is in the oceans.

These surveys would include detailed bottom topography, which incidentally would be of great use to our underwater navigators.

They would include measurements of surface temperatures, of the distribution of temperatures in the oceans, of salinities, general chemical composition, ocean currents, and so forth.

Mr. ANFUSO. These are the things we don't have now, is that right, Doctor?

Dr. BROWN. We do not have this on a worldwide basis.

We don't believe that all of this should be done by the United States, but we do believe it would be in the interest of the United States for us to plan on doing about 30 percent of it during the next 10 years or so. And we believe that other nations can be persuaded to carry out other aspects of these surveys themselves on a cooperative basis. I will discuss that a little more later.

Mr. ANFUSO. Doctor, may I ask how long your statement will take?

Dr. BROWN. I can trim it down to anything you want, sir.

Mr. ANFUSO. I would advise it, because we have other witnesses.

Dr. BROWN. Would you like another 5 minutes?

Mr. ANFUSO. Thank you.

Dr. BROWN. Fine.

Now, in addition to the oceanwide surveys, we advocate substantial increases in the applied marine sciences, and particularly in the defense areas, in the areas of marine resources, and in the study of radioactivity in the oceans.

As corollaries to the broad general recommendations we recommend a major program in education and manpower, increasing the output of marine scientists, a major program of ship construction, increasing our fleet of research and survey vessels from 45 to 85. When we count retirement of obsolete vessels this would mean a program of building 70 new ships in the course of the next 10 years. We recommend the construction of shore facilities to go along with these ships. We also recommend the establishment of a major program on developing new devices for the exploration of the seas, such as the bathyscaph, which you will hear about today.

The new activity over and above the present activity we believe will cost in terms of 1958 purchasing power, about $650 million over a 10-year period.

This compares with the expenditures for oceanographic research of a nonmilitary nature in 1958 of $23 million.

I would like to stress that we consider this a minimal program. This is a program which our committee considers to be absolutely essential from a long-range point of view, and when we look at it, it really is not quite as expensive as one might think considering the dividends to be gained.

The pursuit of space for peaceful purposes under NASA has a budget, as I understand it, somewhere in the neighborhood of $900 million. This entire program could be supported for 10 years on 1 year of NASA's budget. And with that I will stop and solicit your questions, if I may.

Mr. ANFUSO. Thank you, Dr. Brown, for a very fine statement. I understand that you have an additional admirer here, so my colleague from California informs me, Mr. Miller, in the person of Mrs. Brown, who is a distinguished citizen in her own right. I understand she is a candidate for the U.S. Congress. We welcome you here, Mrs. Brown.

Mrs. Brown. Thank you very much.

Mr. Anfuso. Perhaps you would like to take the seat of a Congressman.

Mrs. Brown. Thank you.

Mr. Anfuso. You may even ask questions.

Mrs. Brown. Thank you.

Mr. Miller. Mrs. Brown has a distinction as far as this side of the table is concerned: She is the granddaughter of William Jennings Bryan.

Mr. Anfuso. Dr. Brown, incidentally, before I ask you these questions, let me say I am sure other members will have some questions to ask you. I trust that you will try to answer them as briefly as you can, so we can move along.

What are the circumstances that led to the formation of the Committee on Oceanography?

Dr. Brown. The circumstances involved a very real concern upon the part of the many Government agencies which are involved in one way or another with oceanographic research.

This is a field of endeavor which cuts across a fantastic array of agencies. It includes the Navy, the National Science Foundation, the Bureau of Commercial Fisheries, the Atomic Energy Commission, the Coast and Geodetic Survey, the U.S. Geological Survey, and the Maritime Administration, and I have probably left some out.

Mr. Miller. Coast Guard?

Dr. Brown. The Coast Guard, yes, thank you.

Mr. Anfuso. Would you say, Dr. Brown, that your report represents the viewpoint of most U.S. scientists concerned with oceanography?

Dr. Brown. Well, we haven't exactly taken a public opinion poll, but on the basis of replies that we have obtained when we have solicited opinions, I would say that generally the bulk of the marine scientists in the country would agree with the broad objectives of the report and with the recommendations that we have made.

Mr. Anfuso. Now, your report implies, particularly in reference to obsolescence and inadequate number of research ships, that oceanography in the United States has been badly neglected. If it has been, will you please tell us who you think is responsible for this neglect?

Dr. Brown. Well, I think that the blame cannot be placed upon any one group, or any one person. It stems largely from a general lack of appreciation of its importance. I do know certain Government agencies have been doing everything they can within the limits imposed upon them by their budgets.

I know that the Navy, for example, has done a fine job of sponsoring oceanographic research over a period of years commensurate with the funds that it has been able to obtain in order to carry it out.

Mr. Anfuso. Do you think that other Government agencies, besides the Navy, share your concern about the urgency of this program?

Dr. Brown. I believe that all of the Government agencies which I have mentioned do share this concern. Indeed they share it to the point where jointly they approached the National Academy for the purpose of asking them to make this investigation.

Mr. Anfuso. Now, Doctor, without going into details of pending bills on marine sciences, do you believe that existing legislation is inadequate for the executive branch to fulfill its responsibilities in support of a national program in oceanography?

Dr. Brown. Pardon me, would you repeat that, I didn't quite get that.

Mr. Anfuso. Would you read it back?

(Question read.)

Dr. Brown. I believe that there are many features involved which must be clarified, and I believe that these aspects can be—should be clarified by new legislation.

There are many aspects of our recommendations which can be conducted with existing authorizations and within the framework of the existing structure, but certainly new ingredients have to be added to it.

Mr. Anfuso. What would you say distinguishes oceanography from other multidisciplinary sciences, which warrants special legislation?

Dr. Brown. I would say perhaps the most important distinguishing feature involves the very large capital investment required in order to get started.

You have to work in units, and the smallest unit involves one ship. One ship is very expensive, and requires the coordination of everything around it, so one cannot just sort of start in the marine sciences, you have to start in a big way.

Mr. Anfuso. You suggested the doubling of research efforts during the next 10 years. What is the present size of this effort in terms of scientific manpower, do you know?

Dr. Brown. I do not know in terms of scientific manpower. I believe that in terms of dollars——

Mr. Anfuso. Can you compare it with science and engineering efforts in outer space—for outer space?

Dr. Brown. I can compare it only qualitatively, and there it is tiny, extremely small.

Mr. Anfuso. All right.

Now, one important provision of the major bill now pending before the Congress is, and I quote:

> The Congress further declares that a coordinated long-range program of oceanographic research requires the establishment of a Division of Marine Sciences in the National Science Foundation which shall include representation from Government agencies having duties or responsibilities connected with or related to the seas and oceans, and oceanographic scientists associated with universities, institutions affiliated with universities, laboratories, or foundations, and which division shall be authorized and directed (A) to develop and encourage a continuing national policy and program for the promotion of oceanographic research, surveys, and education in the marine sciences: *Provided*, That the long-range program for oceanographic research developed and projected by the Chief of Naval Research, Department of the Navy, and approved by the Chief of Naval Operations, known as project TENOC (10 years in oceanography) be incorporated in the national program and policy.

Do you personally and does your committee on oceanography agree with this provision of the bill? You have read the bill, haven't you?

Dr. Brown. Yes.

Mr. Anfuso. What is your answer to that?

Dr. Brown. This is one area where my committee differs with the National Science Foundation, for example, in that we believe that there should be some provision made in the budgeting of fellowships and scholarships to take into account the fact that we are always going to be coming up against the areas of scientific and technological endeavor where there are shortages, and where some kind of a compensation has to be made.

Now, I believe that the philosophy of the National Science Foundation, broadly speaking, is correct, that most of the money should be for scholarships, which should be purely on a competitive basis without any reference to the field of endeavor.

But a small fraction of it, I believe, should go into specialized areas where it is widely recognized that there is a crisis, an emergency, and where, by putting that money there, one can catalyze educational activity in that area.

Mr. Anfuso. Do your personal views differ from that?

Dr. Brown. My personal views agree with that entirely.

Mr. Anfuso. All right.

Thank you.

Now, I am going to ask our distinguished citizen and Congressman from California, who, incidentally, is an authority on this subject, and he himself is chairman of the Subcommittee on Oceanography attached to one of our great standing committees of the House, and he has done an awful lot of work and probably dedicated the major part of his life in this study, and I'm going to ask him if he has some questions to ask our distinguished citizen from California.

Mr. Miller. I am always happy to see Dr. Brown, and Doctor, please disregard that statement from the Congressman.

Mr. Anfuso. I mean it now; don't take anything away.

Mr. Miller. I am not an authority on anything. You can't be an authority in this field unless you devote your life to it.

I am very much interested. Of course, the Committee on Merchant Marine and Fisheries and the Subcommittee on Oceanography are interested in this field, and I think you realize we have held extensive hearings.

We have plans for further hearings.

Now, as far as the current bill is concerned, we would like to establish in the Academy of Sciences a branch of oceanography, and I assume all other agencies would forgo their activities in this field.

Has your committee ever studied this?

Dr. Brown. I'm sorry, Mr. Miller.

Mr. Miller. Has the National Academy of Sciences' Committee on Oceanography—has it ever given any study to this bill?

Dr. Brown. To H.R. 6298?

Mr. Miller. Officially to the bill?

Dr. Brown. The National Academy of Sciences has a policy of giving advice when asked for it.

Mr. Miller. They haven't been asked?

Dr. Brown. Our committee has not been asked specifically for advice on this particular bill; no.

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Mr. MILLER. Then I will not embarrass you about asking you about the details of the bill, because it hasn't officially been brought before you.

Dr. BROWN. That is correct.

Mr. MILLER. All right, I will confine myself to saying, Dr. Brown, through his chairmanship of this committee, has pointed up the necessity for activity and interest in this field. His committee is still active. You have not filed all of your detailed reports as yet, I believe, have you?

Dr. BROWN. That is correct.

Mr. MILLER. So that it is in the process of getting these reports together.

I want to point out for the sake of the record, that this field cuts across a number of agencies of Government. First, the Navy has a primary interest in it in the interest of defense, and that is the emphasis that has been given and one of the things that has brought it to light.

The Bureau of Fish and Wildlife, or the Fish and Wildlife Service of the Department of the Interior has a major interest in the biological field of oceanography. This is one that perhaps has the overriding importance on the long haul. If we can bring some semblance of peace within the world within the next 40 or 50 years, when we are all gone, then the demands for the products of the ocean that we have not even begun to assess and evaluate, are going to be in the fore; do you agree with that, Dr. Brown?

Dr. BROWN. Yes; I do.

Mr. MILLER. So that this is not a short-term program. We are behind in this program.

We are not putting one-tenth or one-hundredth of the energy into this program that is so important—70 percent of the Earth, the area of the Earth, is in oceans.

The doctor mentioned things we get. We take magnesium from the ocean directly; do we not?

Dr. BROWN. Yes.

Mr. MILLER. Boron products come from the sea.

But we don't know much about the sea, there are so many possibilities, and so forth, that this is a field that too much emphasis cannot be put into, and the thing I subscribe to, and I hope that this committee will confine its interests to, is not trying to go in and upset the relationship between other governmental agencies that are presently working to—ad hoc committees and coordinating committees are beginning to work out the relationships of one with the other in the field of oceanography—but confine its efforts to trying to get some grants out of the National Science Foundation in the field of oceanography so that we can have the men that we so badly need in this field.

Now, this is not a field—there is, I think, the doctor will agree, and those who follow him—there is no such a thing as a degree in oceanography at the present time, is there?

Dr. BROWN. That is correct.

Mr. MILLER. In other words, this is composed of people from other disciplines of science. They come in through chemistry, or engineering, or physics, and then confine themselves or specialize in the science and the studies of the sea.

Dr. BROWN. Pardon me, may I just correct myself? There are two institutions which give bachelor's degrees in oceanography.

Mr. MILLER. They recognize the basis of these degrees is not a baccalaureate degree in oceanography, but it is a degree in one of the disciplines of science, is it not?

Dr. BROWN. Yes.

Mr. MILLER. You come in as a chemist, engineer, or physicist. These are the things so badly needed in this field. This is the shortage in the field.

Before we get into that we have got to do something too to make this field a little more attractive. In other words, if scientists are going to go into it, they know they are going to have something.

Let me use this as a sounding board, Mr. Chairman. There are two or three men sitting in this room who risk their lives every time they go into a bathyscaph, but under the rules of the Navy they can't be paid the pay given to submarine officers, because they are not in the submarine service, so they sacrifice this pay to go into this new field. I think I am very hopeful that by administrative action this can be corrected. If it isn't going to be corrected by administrative action, I am going to try to correct it by legislation. I think that here is the type of thing where oceanography has become the sort of "poor cousin" of the rest of the science in the Federal Government. This is the thing, the greatest contribution we can make, which is to begin to educate people to the absolute necessity of the recognition of science and the scientists in this field, and the great potentiality that oceanography holds. I have nothing further.

Mr. ANFUSO. Thank you Dr. Miller——

Mr. MILLER. Now, wait a minute, do you want to get rough?

Mr. ANFUSO. No, I meant that. I think you deserve it, I think I should say doctor.

Mr. FULTON. Call everybody doctor.

Mr. ANFUSO. I think some day we will have to award you a doctorate, and I think you deserve it.

May I say this committee for the record does not intend to infringe or trespass upon the rights of any committee, especially that of the committee on which I serve, too, the Committee on Merchant Marine and Fisheries.

I hope we can cooperate with all existing committees, and perhaps accomplish the things that you have testified to and the things that Mr. Miller would like to have accomplished.

Mr. Fulton?

Mr. FULTON. I am glad to have you here. I think you made an excellent statement.

The problem comes up on jurisdiction, while we are on that subject, among congressional committees.

There certainly must be a sphere for the pure research science approach separate and apart, and, of course, in cooperation with the committees that have a more direct practical reason for entering the field, for example, the Navy, for floating ships. The Merchant Marine and Fisheries has it for the purpose of food—as I imagine the Department of Agriculture has it for food—transportation and peacetime uses of the sea.

But there certainly is an area to me where pure science should have its rightful place, and on that basis it should be not only scholarships or grants from the National Science Foundation, but it should be seeing that the research is on a broad enough basis that we can look ahead far into the future.

That kind of a jurisdiction is under this Committee on Science and Astronautics. You agree that generally as a statement, that there should be a place for a broad view that is not particularly a practical application of science in oceanography?

Dr. BROWN. I would prefer not to get involved in problems of organizing the U.S. Congress.

Mr. FULTON. I didn't ask you on organization. I said—I will repeat it—is there a broad field for the application of pure science in oceanography, that is the only question I asked you.

Dr. BROWN. Oh, indeed there is, sir.

As I have already stated, I believe that basic research, pure science in oceanography, is perhaps the most important area on which we should concentrate our efforts at the present time.

Mr. FULTON. So that it is a real area, and it is a demanding area, and one in which we should make a good effort to keep the United States abreast of our friendly and unfriendly competitors in this scientific race in this generation?

Dr. BROWN. That is correct. May I just add one sentence or two to that? And that is, I believe it important, however, that those agencies, those Government agencies which are given practical problems to solve—for example, the Navy has practical problems of defense; the Bureau of Commercial Fisheries has practical problems of finding out how many fish there are and where they are; the Atomic Energy Commission has practical problems involving radioactivity—it is terribly important that they maintain close contact with basic research, with the pure scientific endeavor and, indeed, participate in it themselves, so that they can appreciate what is happening, so that they will know what is happening and can guide their own behavior accordingly.

Mr. FULTON. The problem in Government is, for example, in the Department of Defense, that the end result of the operations of the Department of Defense is often weaponry systems. The question then comes in budgeting, whether you always have to budget research and development for the purpose of entering into a weaponry system.

That is quite a limitation on the Department of Defense operation, but I do believe, not only within the Department of Defense but outside, there should be a place for the basic research and pure science; and don't you feel that, too?

Dr. BROWN. Indeed; yes.

Mr. FULTON. Then, on the budget you would come up—we have a pamphlet here from the National Academy of Sciences—National Research Council. They had recommended a 5-year budget from 1960 to 1964 of $47,900,000, and a 5-year budget for 1965 to 1969 of $52,500,000, totaling the budget for the 10-year period, 1960–70, of $100,400,000.

They have likewise stated the U.S. Navy should probably take care of one-half of the costs of that budget, which would mean a budget of about $50 million, which would be outside a direct application such as for defense purposes.

Do you think that that budget of $50 million for 10 years—it would be more or less of what we would call pure science or basic research, as distinguished from applied science—is enough?

Dr. Brown. Keep in mind, first, that these are 1958 dollars; but, quite apart from that, we based our recommendations on our best guess as to how quickly the manpower could be relieved.

Additional appropriations do not help one if you don't have people who are competent to make use of the appropriations.

As a result, I believe that our recommendations are realistic, given our best guess concerning what can be done about the manpower.

Now, if by some chance the manpower situation can be relieved more rapidly than we guessed, then I by all means would urge that more money go into basic research than we recommended.

Mr. Fulton. Would you comment now on the advance the Russians are making in this same field as compared to our U.S. advance? For example, they have the Russian oceanographic ship, *Vityaz*. They also have the *Lomonosov*, the new one. Are we keeping pace in the type of equipment and the type of work they are doing?

Dr. Brown. I believe that we have to keep in mind when we talk about Russian activity in this area, that they started intensive efforts in oceanography only quite recently.

I am told by my friends who have studied the situation that in effect what they are doing now on a large scale is training young oceanographers. They suffer from the same kind of problem from which we suffer and that is inadequate trained manpower in the field.

Their large ships are being used in part as training ships for young people in oceanography.

Now, on the basis of what I have read and on the basis of what I have learned from talking with Russian oceanographers, as well as with oceanographers from other countries who have studied what the Russians are doing, my best guess would be that the rate of improvement in the Soviet Union in this respect is considerably greater than the rate of improvement in the United States.

Now, this doesn't mean that they are ahead of us at the present time, but the curves are likely to cross.

Mr. Fulton. Thank you.

Mr. Anfuso. Thank you, Mr. Fulton.

At this time I wish to congratulate the members of this committee for limiting their questions, in view of the fact we have other witnesses from California.

Now, our distinguished member from Utah, Mr. King.

Mr. King. Thank you, Mr. Chairman.

I wish there were several days to go into some of the very interesting facets of this problem, but I will just ask one or two questions, Dr. Brown.

First of all, would you say that at the present time we have one coordinated oceanographic program in the United States? Is there such a thing?

Dr. Brown. I would not call it one coordinated oceanographic program as yet, but it does appear to be emerging.

For some months now there has been in existence an informal coordinating committee on oceanography with representation from those Government agencies which are concerned, and that has been more recently formalized within the Federal Council for Science and Technology, and the subcommittee, or the panel, I can't remember what it is called, on oceanography, under Secretary Wakelin's direction has been made an official subcommittee.

There is every evidence that a broad national coordinated program is emerging as a result of these efforts.

Mr. King. The enactment of the bill under consideration would no doubt accelerate the formulation of that one oceanographic program; is that correct?

Dr. Brown. I believe so; yes.

Mr. King. It would be a step in the right direction, would it, in your opinion?

Dr. Brown. I believe it would be a step in the right direction; yes.

Mr. King. In fact, I believe it would be the heart of the oceanographic program, would it not?

Dr. Brown. What bill are you speaking of now, to make sure I answered you correctly?

Mr. King. I'm talking about H.R. 6298.

Mr. Anfuso. Right.

Dr. Brown. Yes, the National Science Foundation bill, yes.

Mr. King. Now, let me pursue another matter briefly, Dr. Brown.

You mentioned that you felt that we were being sort of pushed into the sea with reference to, oh, the location of launching areas or sites or bases for ballistic missiles—that is, as a part of our defensive mechanism, we were going to the sea.

Dr. Brown. Yes.

Mr. King. The Air Force, of course, has come up with this mobile unit for launching Minutemen from flatcars and so on.

Would an extension or an elaboration of that concept of the mobile launching base on the land in any way alter your statement that we are being pushed into the sea?

Dr. Brown. I don't believe so.

What I have said does not exclude the use of the mobile Minuteman by any means. But if I were placing bets as to how things would go during the course of the next 10 to 15 years, I would bet that the return to the sea would be much more predominant than the increasing of flexibility on land.

Mr. King. Could you explore that for just about 1 minute—and we are pressed for time—but my question would be: What natural advantages would there be in establishing these bases in the sea, or by the use of the submarine and the Polaris, over its counterpart on land?

In other words, why are we being pushed into the sea?

Dr. Brown. In the sea one gets three-dimensional maneuverability. On a railroad track you get in effect one-dimensional maneuverability.

One can map not only railroads but railroad ties, from fantastic heights, with modern camera systems, and with modern reconnaissance techniques one can certainly map railroad systems in detail, and it does not take much effort to so disrupt the railroad system that your maneuverability would not be terribly great.

Now, please don't misinterpret me. I believe the mobile Minuteman has its uses, but I believe that the whole area of using the sea and its three dimensions is in the long run more important.

Mr. KING. Thank you.

Mr. Chairman, in the interest of time I will stop there.

Mr. ANFUSO. Mr. Van Pelt?

Mr. VAN PELT. No questions.

Mr. FULTON. May I ask a question?

Mr. ANFUSO. Yes.

Mr. FULTON. On the amount of research and exploration that has been made of the sea, graphically we know less about the bottom of the sea, don't we, than we know about the surface of the Moon?

Dr. BROWN. That is correct. We know more about the surface of the Moon than we know about most bottom topography in the oceans.

Mr. FULTON. Overall, Earth's people are very remiss in not making an adequate research of their own planet?

Dr. BROWN. That is correct.

Mr. FULTON. Thank you.

Mr. ANFUSO. Thank you very much, Dr. Brown.

I think this Committee on Oceanography is rather fortunate in having you as its chairman, because you recognize the importance of the security of our country in the field. Thank you very much.

Dr. BROWN. Thank you very much.

Mr. ANFUSO. Now, we have with us again this morning, some people who have recently made history.

We have Dr. Andreas B. Rechnitzer, Navy Electronics Laboratory, San Diego, Calif.

Will you please step up, sir? And with him are Captain Phelps, Lieutenant Walsh, Lieutenant Shumaker. I am inserting in the record at this point their biographies.

(The biographies referred to are as follows:)

### DR. ANDREAS B. RECHNITZER

Dr. Andreas B. Rechnitzer is the scientist in charge of the bathyscaph program, the continuing program of probing the ocean bottom, in the Navy's most unique submersible, the *Trieste*. He is a biological oceanographer, with his Ph. D. from the University of California at Los Angeles. On November 15, 1959, he descended 18,600 feet into the Marianas Trench, thereby bringing the depth record for a manned descent back to the United States.

He received the Distinguished Civilian Service Award from President Eisenhower on February 4, 1960. He is a life member of the National Geographic Society, and was awarded the Richard Hopper Day Memorial Medal by the Philadelphia Academy of Natural Sciences in April of 1960.

Dr. Rechnitzer was born in Escondido, Calif., and earned his bachelor of science from Michigan State University in 1947. He is a member of Sigma Xi, the Western Society of Naturalists, the Society of Systematic Zoologists, and a member of the National Academy of Science Panel on New Devices for Exploring the Ocean. He has written a number of scientific papers on fish and bird life, on pollution of ocean waters, and on scientific diving; and is a pioneer in the development of self-contained diving equipment for scientific research.

He and his wife, Martha Jean, have four children, and live in Solana Beach, Calif.

### CAPT. JOHN M. PHELPS, COMMANDING OFFICER AND DIRECTOR, NAVY ELECTRONICS LABORATORY

Captain John M. Phelps, U.S. Navy, has served as commanding officer and director of the Navy Electronics Laboratory, San Diego, Calif., since August 1956. Here he directs the activities of approximately 1,200 civilian scientists, engineers, and technicians in a $25 million establishment.

Captain Phelps compiled an impressive wartime record, participating in the campaigns at Guadalcanal, in the Central Pacific, at Saipan and Tinian, at Iwo

Jima, at Okinawa, and in the Occupation of Japan. Most of his combat sea duty was with the Commanders of Amphibious Group Two and the Fifth Amphibious Force.

His interest in electronics preceded the big expansion of this field which came after World War II. He graduated from the U.S. Naval Postgraduate School in 1942 after 2 years of electronics engineering, and followed this with advanced radar work at Massachusetts Institute of Technology later in 1942. Since World War II he has served as head of electronics design in the Bureau of Ships and as electronics officer at the Philadelphia Naval Shipyard. He came to NEL from a billet as repair and shipbuilding superintendent at Mare Island Naval Shipyard, Vallejo, Calif.

Captain Phelps was born July 15, 1912, in San Francisco. He is married to the former Rita Marie Dietrich of Buffalo, N.Y., and has three children, John Michel III, Janice Lynn, and James Roy. They live in Quarters A at the Navy Electronics Laboratory, Point Loma, San Diego.

### Lt. Don Walsh, U.S. Navy

Lieutenant Don Walsh, USN, is assigned to the Navy Electronics Laboratory as Officer in Charge of the bathyscaph *Trieste*. He is one of the craft's three pilots. He is a 1954 graduate of the U.S. Naval Academy.

After graduating from Annapolis, Lieutenant Walsh attended the Amphibious Warfare School for two months. His other service has included U.S.S. *Mathews* (AKA 96); CIC School, Glenview, Ill.; Submarine School, New London, Conn.; and the U.S.S. *Rasher* (SSR 269). Before reporting to the Navy Electronics Laboratory in March of 1959, he was staff secretary for Comsubflot 1 for 6 months.

He is a member of the U.S. Naval Institute, the American Aviation Historical Society, and a life member of the National Geographic Society. He has a pilot's license, and his other off-duty activities include sailing, skin diving and photography. As time allows, he is working toward an advanced degree in political science at San Diego State College evening school.

Lieutenant Walsh was born November 2, 1931, at Berkeley, Calif. He is single and lives at 2957 Lawrence Street in San Diego.

Lieutenant Walsh was pilot, along with Jacques Piccard, when the *Trieste* dove nearly 7 miles to the deepest known spot in the ocean. This was the Challenger Deep near Guam in the Marianas Islands. For this operation he was awarded the Legion of Merit by President Eisenhower on February 4, 1960. At the Academy of Natural Sciences of Philadelphia on the 26th of April 1960 he was awarded the first annual Richard Hopper Day Memorial Medal for exploration and discovery in natural science.

### Lt. Lawrence A. Shumaker, U.S. Navy

Lieutenant Lawrence A. Shumaker, USN, Assistant Officer in Charge of the bathyscaph *Trieste*, is a native Californian. He was born February 13, 1932, in Los Angeles. He graduated from the U.S. Naval Academy in Annapolis in 1954.

He has also studied at East Los Angeles Junior College, and attended submarine school at New London, Conn. His other service has included assignment as Engineer Officer, U.S.S. *Mansfield* (DD 728); Supply Officer, U.S.S. *Bonita* (SSK 3); Torpedo Officer and Engineer Officer, U.S.S. *Rasher* (SSR 269).

His hobbies include skin diving and pistol and rifle shooting. He won the Secretary of the Navy Pistol Trophy in 1954. He is a member of the National Rifle Association, and a life member of the National Geographic Society. In February 1960, he was awarded the Navy Commendation Ribbon with metal pendant for his work with the bathyscaph *Trieste*, by President Eisenhower. In April of 1960, he received the first annual Richard Hopper Day Memorial Medal for exploration and discovery in natural sciences, from the Academy of Natural Sciences of Philadelphia. Lieutenant Shumaker, his wife Ione, and their two children, Lawrence and Curt, live at 3514 Mt. Lawrence Drive, San Diego, Calif.

Mr. Anfuso. We welcome all of you gentlemen, and again I congratulate you for what you have done, but I think you best tell it to the committee yourself.

May I suggest, however, Dr. Rechnitzer, you have submitted a 17-page statement. Obviously we could not hear that statement and finish in time. Would you have any objection if we submitted this statement of yours for the record and then you give us a brief analysis of what you want to testify to and taking such part of this statement as you like? Is that agreeable to you?

Dr. RECHNITZER. Fine, thank you, Mr. Chairman.

Mr. ANFUSO. Proceed.

Mr. FULTON. May I likewise welcome the doctor, and say we are glad to have somebody in a field where we are clearly ahead of the Russians.

## STATEMENT OF DR. ANDREAS B. RECHNITZER, SCIENTIST IN CHARGE OF THE BATHYSCAPH PROGRAM, ACCOMPANIED BY CAPT. JOHN M. PHELPS, U.S. NAVY, COMMANDING OFFICER AND DIRECTOR; LT. DON WALSH, U.S. NAVY, OFFICER IN CHARGE, "TRIESTE"; AND LT. LAWRENCE A. SHUMAKER, U.S. NAVY, ASSISTANT OFFICER IN CHARGE "TRIESTE," U.S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIF.

Dr. RECHNITZER. I am Andreas Rechnitzer——

Mr. ANFUSO. Excuse me, Doctor, would you like to have the other gentlemen sit by you?

Dr. RECHNITZER. Please.

Mr. ANFUSO. Will you come up, gentlemen, the gentlemen I have mentioned, and sit around the table?

Proceed, sir.

Dr. RECHNITZER. Thank you.

I am Andreas Rechnitzer, oceanographer and scientist in charge of the bathyscaph, U.S. Navy Electronics Laboratory, San Diego.

Mr. Chairman and members of the committee, it is a pleasure to be here again and to bring you a more detailed account of our more recent diving activities in the Pacific Ocean.

We are now talking about facts and what is going on currently in deep oceanic research.

As you know, the U.S. Navy bathyscaph *Trieste* successfully penetrated to the deepest known location in the oceans on January 23, 1960.

Carrying two men 7 miles below the ocean's surface this scientific breakthrough opens up all of the oceans' depths to exploration and exploitation.

In the execution of this feat and the preliminary dives leading up to the achieving of the ultimate in deep dives, the bathyscaph program has yielded scientific and technical information of major importance to future manned exploration of the oceans.

The Honorable George P. Miller, member of this committee, recognized the importance of this deepest dive and acknowledged the feat by an entry in the appendix of the Congressional Record published February 3, 1960.

Herein he acknowledged the relatively unheralded accomplishments of the U.S. Project Nekton, that included in its program the deepest known possible descent by man, that is, to the bottom of the Challenger Deep, 35,800 feet.

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This 5-hour descent permitted adequate time for observations of the environmental conditions characteristic of the 7-mile water column.

On the sea floor, 35,800 feet down in the Challenger Deep, the occupants of the sphere viewed living organisms, observed the physical characteristics of the sea floor, and conveyed to the surface by voice via an electronic acoustic device that they were safely at the bottom.

The deep dive stands by itself as a significant achievement by man in his unending attempt to expand his capabilities to occupy and investigate more of the Earth's spaces.

The record descents made during Project Nekton of 18,600, 24,000, and 35,800 feet are in reality only a byproduct of a scientific program seeking information of diverse types.

Technologically it does represent a significant milestone which will undoubtedly incite future development in deep submersibles and equipment for manned and unmanned exploration and exploitation of inner space.

The development of the vehicle with the capabilies of the *Trieste* makes the greater part of the ocean's 1,370 million cubic kilometers of water available as an operating medium for national security.

It also renders much of the 361 million square kilometers of sea floor accessible for the search of minerals, fuels, and other natural resources.

Prior to any significant utilization of this geographic frontier, there is a requirement for the development of basic knowledge about the deep sea environment, and the operational problems that are to be encountered.

This, of course, represents a tremendous task, and we are only initiating it through the bathyscaph program. The bathyscaph program is in effect but it obviously involves only a modest nucleus of equipment and personnel.

The bathyscaph, as purchased by the United States, is in reality a model "T" of the deep submersibles. It has, however, conquered the depth barrier, and points the way to more advanced vehicles. Nevertheless, as far as we know it is still the best in the world. French and Russian bathyscaphs under development will undoubtedly surpass the versatility of the *Trieste.*

In view of the recent U.S. Navy contribution to the deeep-sea exploration, a news release from Washington, D.C., dated April 21, 1959, which appeared in the San Diego Union, is of interest.

Pertinent excerpts are as follows:

> Deep-sea diving operations of the San Diego-based bathyscaph *Trieste* are "opening the way to a new era of undersea exploration," Gordon Lill, Chief of the Geophysical Branch of the Office of Naval Research, said today.
>
> "The *Trieste*," Lill said, "is the forerunner of a fleet of deep diving craft of several types that within a few years will be exploring the ocean fully in its third dimension—depth."

The bathyscaph was a proven oceanographic research platform program before purchase by the U.S. Navy. In 1957 dives were conducted in the Mediterranean under the auspices and support of the U.S. Navy Office of Naval Research. Utilized by a team of American scientists from several Government laboratories, the craft was found to be useful for oceanographic studies.

Herein we had to prove its worth before we could purchase it.

The success of the Mediterranean operations prompted the outright purchase of the craft by the U.S. Navy. Since its purchase the bathyscaph has provided an effective research platform for operations out of San Diego and Guam.

The craft alone was a skeleton, and had no scientific instruments, and these have been under development at the laboratory and by other institutions. As you might well realize to provide instruments that can withstand the tremendous pressures of the great depths is not an easy one. Pressure at the bottom of the Challenger Deep amounts to 8 tons per square inch.

Unfortunately we could not go out and buy the instruments we desired "off the shelf," so to speak.

In the record I would like to include the entire presentation, but just to give you some idea of the versatility of the bathyscaph, and what will be required of other deep submersibles for man's research in the oceans, they have to include the studies of submarine geology, physical oceanography, biological oceanography, and acoustic projects, as brought out by Dr. Brown. At the present time acoustics is the equivalent of our eyes under water, and the only way we can view great distances.

The capabilities of the bathyscaph are somewhat limited. It is primarily an elevator. It is built to go up and down. Its mission was to make the deep sea available, even if only on a limited basis.

Carrying oceanographers and scientific equipment, the bathyscaph can descend to any depth in the sea and provide an in situ base of operations; that is one in the environment, and to provide an opportunity for visual observations and measurements.

I think it would be easy to understand that if you are going into a new environment, the first thing you want to do is look at the environment and see what is going on there. It is difficult to make instruments to measure certain phenomenon, while others are going on of which we know nothing or relatively little.

One of the primary attributes of the bathyscaph, the observation window, which, supplemented with external illumination, extends the capabilities of the bathyscaph to the best known servomechanism—man himself.

It also offers a new feature for oceanographic research, in that it vitiates the need for operating equipment such as samplers hung at the end of extremely long cables lowered into the abyss.

This classical groping method is clearly analogous to the student of conditions prevailing in the barren deserts of the great Southwest when he uses an airplane flying, say, at 35,000 feet at midnight. Lowering a cable to the desert floor with a grab device on it, he hopes to pick up a piece of a lizard's tail, a creosote bush, sands, and rock. From this meager tidbit, the scientist then is expected to interpret what the desert floor looks like and some of the dynamic happenings that are occurring there at the time he flew over that area.

Dives with the *Trieste* have given us some insight into the quantity, size, distribution, and behavior of animals at all depths.

There, without exception, animals have been viewed on each and every dive made with the *Trieste.*

When they reached the bottom of the Challenger Deep they were pleasantly surprised to find a fish swiming around just outside of the window, making its way along in the sediments. It was clearly made out to be a flatfish, or flounder, similar to what we observe in shallow waters.

In addition to this animal, a shrimp was seen swimming about 6 feet up off the bottom.

This small amount of evidence can tell us quite a bit about the ocean. Obviously, animals of this high an order require oxygen, and for this amount of oxygen to be sustained, or replenished, it requires current to bring it from the surface areas, the only known source of oxygen for the water masses. It must be absorbed from the atmosphere, or produced by organisms living near the surface.

It also means that these animals must have an adequate amount of food to sustain themselves, or we have to consider that they might swim all the way up to the surface, or up to the higher levels. This is very unlikely, because flatfishes normally remain near the bottom. We have observed animal life throughout the water column. This is quite significant, because it indicates that, in this land of perpetual darkness, animal life can exist, and there is a continuous food chain for the myriad forms that do exist there.

I mentioned that it was a land of perpetual darkness. This is not quite true, because we observe bioluminescence, light produced by the living organisms in the water column. They are in an area where it is quite dark. What function bioluminescence plays, or of what value it is to these animals, we are still not certain. It gives the illusion of a starry night, as you view out of the port of the bathyscaph.

When Lieutenant Walsh was at the bottom of the Challenger Deep, he observed no detectable current. As a matter of fact, when he touched bottom, the very fine sediments were raised into suspension, and remained there for the greater part of the 20 minutes he remained on the bottom.

However, this showed only that currents were not present at that time. They were obviously present some other time in the past. We need to know more about the seasonal changes in currents at these great depths.

The bathyscaph operations off of San Diego have been hampered in some respect because, as you know, the oceans have served as a garbage dump for many of manmade wastes. Dispersion is assisted by current systems and deep basins have been utilized for chemical and explosive waste depositories. Out of sight and out of mind in the past, these areas are now within the operating domain of the bathyscaph and future deep submersibles. Several areas of interest off California are out of bounds to the bathyscaph for diving as they are reserved for hazardous materials disposals.

I bring this up to indicate that prior to the advent of the bathyscaph, we could get away with relinquishing some space in the ocean, thinking that we would never be there.

In addition to the visual observations made during the deep dive, there was a complete temperature profile obtained above the Challenger Deep, continuous all the way from the surface to the sea floor. It was clearly recorded that the temperature decreased to $2\frac{1}{2}°$ centigrade at a depth of approximately 25,000 feet, and below this depth there occurs a minor but significant increase to $3\frac{1}{2}°$ centigrade. This is not to be construed as a new observation, but the record obtained by the bathyscaph and its personnel is the first continuous record of the temperature phenomena from the surface to the bottom of such a water column. This advantage is being extended to many other physical measurements so that we will have simultaneous measurements of a variety of parameters all the way from the surface to the bottom, rather than the point checks dictated by lowering devices on a cable, taking samples, and interpolating between the points.

Mr. Miller. Do you have any reason, Doctor, to indicate why the temperature should go up?

Dr. Rechnitzer. This is due to the compression of sea water. It can be compressed as much as 5 percent in these great depths. In compressing any material, be it a gas or a liquid, it heats up when compressed. The temperatures increasing as they do, in these great depths, along with other oceanographic information, it is held to be due to compression.

It might be well to go back and take a quick look at the history of the bathyscaph to give us some understanding of how slowly things actually move in the scientific field at times.

The concept of the bathyscaph preceded that of Piccard's stratospheric balloon. It has been almost 50 years now since he originally laid down the designs for the bathyscaph.

Now, to come up to more recent times, the *Trieste* was constructed in 1952 and 1953. Between its launching and 1958, the bathyscaph operated only in the Mediterranean Sea.

During that period, 48 dives were completed. Twenty-six of these were made in 1957 under the sponsorship of the U.S. Navy, Office of Naval Research.

After August 1958, the craft was brought to San Diego, reassembled, and put into operation where it reached a maximum depth of 4,200 feet.

Following these preliminary dives, the craft was prepared for the Project Nekton which was to be conducted near Guam, in the Mariana Islands group in the Western Pacific.

The objectives of the operations were both scientific and technological. Some of the details I have already given you.

There are problems with the bathyscaph, as there are with any other prototype vehicle.

Although it has the capability of operating down to depths where it encounters tremendous pressures, it cannot be safely operated in rough seas. It is also limited to near shore operations due to the lack of an adequate mother ship.

Therefore, the present scope of operation of the craft is seriously curtailed as deep ocean areas are not usually located close to major shore based facilities, due to shallow depth continental shelves.

As the average depths of the oceans are approximately 2 miles, we should make every effort to explore these deeper areas which are, after the big dive, actually only wading depths for the *Trieste*.

To reach 2 miles of water, it requires at least a 120-mile tow from San Diego, and this is not easily achieved when you move along about 1½ knots average speed. You can walk faster than that.

Many important military projects under study involve deepwater investigations. Such studies could be markedly advanced if the capabilities of the bathyscaph could be employed.

Unfortunately the limitations imposed by ocean surface conditions, and the cumbersome towing that is involved in moving the craft to the diving location, renders the craft limited to these near shore operations. Remote locations, such as Hawaii and Guam are satisfactory insofar as shore-based logistic support is concerned, but again the diving operations must be limited to a radius of approximately 200 miles from the port until a mother ship is available.

One thing I would like to point out, the bathyscaph was purchased for American scientists, and not for the exclusive use of U.S. Navy personnel.

In this regard, we would like to be able to transport the bathyscaph to the Atlantic Ocean, so that some of the Woods Hole oceanographers could have an opportunity to utilize the craft. Obviously this is very difficult to do at the present time.

It is interesting to note, too, that in the National Academy of Sciences—National Research Council, Committee on Oceanography Report No. 7, which I have made available to you, that the committee envisages the development of a variety of manned and unmanned submersibles and cites the need for such craft in an expanded oceanographic research program.

Already the commercially designed 15,000-foot Aluminaut is well advanced.[1] This is a commercial enterprise of the Reynolds Aluminum Co. Several deep submersibles are being designed by other organizations in the United States, but none are in the construction stages.

We hope that our operations with the bathyscaph have stirred interest in this direction.

It has been pointed out that man's knowledge of the oceans is meager indeed when compared with their importance to him. Recognizing that neglect in this area of endeavor might well result in our being placed in a precarious position from the scientific, technological, and military points of view, it is mandatory there be an increased American effort in the last geographic frontier.

If we are to pursue an expanded program, it is considered essential to the orderly progress of pursuing the host of studies involved in manned exploration of the deep sea, that deep submersible vehicles and shore facilities, scientific personnel, and existing experience be integrated to provide the United States with the most effective means of maintaining leadership in oceanographic research.

The established operating base for the bathyscaph at the U.S. Navy Electronics Laboratory, which is adjacent to the most suitable location for bathyscaph operations in the United States, appears to be the most propitious location for such a base.

This may sound like a little bit of advertising, but we would like to draw attention to this fact, that the Nation's largest community of scientists and personnel concerned with basic and direct oceanographic research is located in the San Diego area.

One of the prime reasons for the seemingly poor diving record, that is, the number of dives, made by the *Trieste* during its first year of operation in the United States, was due to the fact that we had to provide the logistic support for this unique craft. In doing this, we

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[1] See Wenk, Edward, Jr., Dehart, Robert C., Mandel, Philip, and Kissinger, Ralph, Jr., "An Oceanographic Research Submarine of Aluminium for Operation to 15,000 Feet," paper No. 5 before the Royal Institution of Naval Architects, London, Mar. 23, 1960.

had no one who was really thoroughly trained or thoroughly acquainted with the bathyscaph.

There were no printed instructions, or precepts, other than the personal experience of one man, Jacques Piccard. He was brought to the United States in a consultant's status, and has worked with us up to the culmination of the deep dive in the Pacific.

Despite the small number of dives, those that have been made, I think, are of significance. We expect that we will have the bathyscaph instrumented and operated for a variety of oceanographers off San Diego starting in the fall.

We have a few miscellaneous problems which are outlined in the statement, and I will leave these for the record, and conclude with that statement.

(The full text of Dr. Rechnitzer's prepared statement is as follows:)

STATEMENT BY DR. ANDREAS B. RECHNITZER, U.S. NAVY ELECTRONICS LABORATORY, SAN DIEGO, CALIF., ON THE U.S. NAVY BATHYSCAPH PROGRAM

Mr. Chairman and members of the committee, the U.S. Navy bathyscaph *Trieste* successfully penetrated to the deepest known location in the oceans on January 23, 1960. Carrying two men 7 miles below the ocean's surface this scientific breakthrough has opened all of the ocean waters to exploration and exploitation. In the execution of this feat and the preliminary dives leading up to achieving the ultimate in deep dives (70 in total for the *Trieste*) the bathyscaph program has yielded scientific and technical information of major importance to future manned exploration of the oceans.

The Honorable George P. Miller, member of this committee, recognized the importance of this dive and acknowledged the feat by an entry in the Appendix of the Congressional Record published February 3, 1960. The item was entitled "Oceanography: Jules Verne 1960." Herein he acknowledged the relatively unheralded accomplishment of the U.S. Project Nekton that included in its program the deepest known possible descent by man; that is, to the bottom of the Challenger Deep (35,800 feet).

The 5-hour descent permitted adequate time for observations of the envioronmental conditions characteristic of the 7-mile column of water. On the sea floor, 35,800 feet down in the Challenger Deep, the occupants of the sphere viewed living organisms, observed the physical characteristics of the sea floor and conveyed to the surface by voice via an electronic acoustic device that they were safely at the bottom. The deep dive stands by itself as a significant achievement by man in his unending attempt to expand his capabilities to occupy and investigate more of the Earth's spaces. The record descents made during Project Nekton (18,600 feet, 24,000 and 35,800 feet) are in reality only a byproduct of a scientific program seeking information of diverse types. Technologically it does represent a significant milestone which will undoubtedly incite future development in deep submersibles and equipment for manned and unmanned exploration and exploitation of "inner space." The development of a vehicle with the capabilities of the *Trieste,* makes a greater part of the oceans' 1,370 million cubic kilometers of water available as an operating medium for national security. It also renders much of the 361 million square kilometers of sea floor accessible for the search of minerals, fuels, and other natural resources. Prior to any significant utilization of this geographic frontier there is a requirement for the development of basic knowledge about the deep sea environment and the operational problems that are to be encountered. This bathyscaph program and the era of undersea operation is now in effect, but it obviously involves only a modest nucleus of equipment and personnel. The bathyscaph, as purchased by the United States, is in reality a model "T" of the deep subersibles. It has, however, conquered the depth barrier and points the way to more advanced vehicles. Nevertheless, as far as we know, it is still the best in the world. French and Russian bathyscaphs under development will undoubtedly surpass the versatility of the *Trieste.*

In view of the recent U.S. Navy contribution to the deep sea exploration, a news release from Washington, D.C. dated April 21, 1959, which appeared in the San Diego Union is of interest. Pertinent excerpts are as follows:

"Deep sea diving operations of the San Diego-based bathyscaph *Trieste* are 'opening the way to a new era of undersea exploration,' Gordon Lill, Chief of the Geophysical Branch of the Office of Naval Research said today.

" 'The *Trieste*,' Lill said, 'is the forerunner of a fleet of deep-diving craft of several types that within a few years will be exploring the ocean fully in its third dimension—depth.' "

The bathyscaph was a proven oceanographic research platform before its purchase by the U.S. Navy. In 1957, dives were conducted in the Mediterranean under the auspices and support of the U.S. Navy Office of Naval Research. Utilized by a team of American scientists from several Government laboratories, the craft was found to be useful for oceanographic studies. The success of the Mediterranean operations prompted the outright purchase of the craft by the U.S. Navy. Since its purchase, the bathyscaph has provided an effective platform for deep sea research off San Diego and near Guam.

New instruments for wresting information from the abyssal depths where temperatures and pressure often pose serious problems for the design engineer have been slow in development. Prototypes have been tested under actual operating conditions. Instruments for the deep sea often involve completely new ideas and are not available as an off-the-shelf item. In many instances, the pressure requirements preclude the use of standard components and some manufacturers refuse to guarantee their products at the pressures to which the equipment will be subjected. In addition, until the environment has been observed and phenomena observed, it is not possible to adequately design equipment to make measurements. During the 1959–60 dives with the *Trieste* new ultrasensitive water current meters, electronic depth gages, and temperature-sensing devices were tested. The bathyscaph has provisions for housing and powering delicate instrumentation and the vital component—man—to monitor the new devices that can effectively obtain more complete data than ever before. Continuous profiles of certain physical conditions from the surface to the bottom can be obtained. The capability is extended by a compact multichannel tape recorder, that effectively provides a simultaneous record of data obtained by all the instruments providing information for correlation analysis.

The bathyscaph is readily recognized and accepted to have unique capabilities of direct use to all of the major oceanographic disciplines as is exemplified by the bathyscaph research program that will involve many scientists that is scheduled for execution off San Diego, Calif., and other areas of the world when adequate logistic facilities are made available.

### CURRENT NAVY RESEARCH PROGRAM

*1. Oceanographic projects*

(*a*) Submarine geology:

(1) Topographic studies—study of features too large to photograph and too small to study easily with echo sounders.

(*a*) Channels at mouth of La Jolla and Scripps Submarine Canyon.

(*b*) Study of "levees" on channels in San Diego Trough.

(*c*) Study of detailed topography of upper continental slope—50–500 feet.

(*d*) Study of topography of continental slope between borderland and deep ocean.

(2) Mass physical properties of sediments.

(*a*) "In situ" sound velocity and absorption measurements.

(*b*) Strength and penetrability study of sediments.

(*c*) Slope failure and slump studies and relation to topography sediment types.

(*d*) Temperature studies in sediments.

(3) General studies.

(*a*) Geology and hydrology of closed basins.

(*b*) Areal distribution and environmental studies of phosphorite and other minerals.

(*c*) Geology, topography, and hydrology of borderland basin sills.

(*d*) Dynamic processes affecting the distribution of sediments and sedimentation processes.

(*b*) Physical and chemical oceanography:
(1) Physical properties of the sea.
(*a*) Temperature structure.
(*b*) Density.
(*c*) Water transparency.
(*d*) Light penetration.
(2) Chemical properties of the sea.
(*a*) Salinity.
(*b*) Dissolved gas.
(*c*) Dissolved solids.
(*d*) Suspended colloids.
(*e*) Radioactivity (cooperative study with other naval laboratories).
(*c*) Biological oceanography:
(1) Distribution of animal and plant life.
(*a*) Plankton and relationships to sound transmission.
(*b*) Organic detritus and relationships to sound transmission.
(2) Biological noises.
(*a*) Kinds, distribution, and intensity of biological noises.
(*b*) Biological noises and target classification.
(3) Ecological studies.
(*a*) Ecology and sound transmission—physicochemical relationships of deep-water and marine organisms.
(*b*) Benthonic organisms and their relationship to food chains, influence on topography and sedimentation, and possible influence on the concentration of radioactive materials that occur in limited quantities in the water mass.
(*c*) Deep-sea organisms and sound generation.
(*d*) Distribution and quantity of bioluminescence.

2. *Acoustic projects*

(*a*) Continuous sound velocity profiles (continuation of the measurements planned for Project Sonus to be conducted in June 1960 in the Marianas Trench).
(*b*) Deep scattering layer investigations correlating acoustic measurements, visual observations, and photography.
(*c*) Study of sound field levels in the sea from near surface sources at various frequencies.
(*d*) Reciprocal case of shallow receivers and source at various great depths.
(*e*) Investigation of ambient noise types, levels, vertical, and geographical distribution.

3. *Evaluation of the "Trieste" and its possible relation to future submarines*

(While the craft is being operated and developed as a research vehicle, many technological developments arise that appear to be useful for other military submersibles.)
(*a*) Logistic support problems and general operations.
(*b*) Research and development of new equipment and materials for deep submersible craft construction and more effective operation.
(*c*) Development of construction techniques.

The bathyscaph *Trieste* is available to scientists from universities and Government laboratories for the pursuit of studies that warrant the use of the craft and are compatible with the capabilities of the craft.

### CAPABILITIES OF THE BATHYSCAPH "TRIESTE"

The bathyscaph represents the first U.S. untethered deep-sea research platform for man and his machines. Carrying oceanographers and scientific equipment, the bathyscaph can descend to any depth in the sea and provide an in situ base of operations for direct visual observations and measurements. This capability renders the craft unique and is its most important attribute. It can—even in its primitive state of development—serve the same purpose as a manned atmospheric balloon sent aloft for investigating meterological phenomena. Atmospheric studies can be viewed much more easily than the deep sea. What lies below the air-sea surface boundary remains much of a mystery. The window of the bathyscaph, supplemented with external illumination capabilities of the bathyscaph, makes possible the use of the best known servomechanism—man himself. The craft vitiates the need for operating equipment or samplers hung at the end of extremely long cables lowered into the abyss. This classical group-

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ing method is clearly analogous to the student of conditions prevailing in the barren deserts of the great Southwest when he uses an airplane to fly at a height equal to the greatest depth in the sea on a dark night. The samples that would be obtained might include the tail of a lizard, a piece of creosote bush, a bit of cactus, and a little sand and rock. From this he is expected to fit together the overall picture of what the desert floor looks like and what dynamic happenings are occurring there. Obviously, if man is present to view and correlate the events, a great deal more information can be derived from this method wherein a manned vehicle is employed.

It is often difficult to conceive of the proper instruments required to extend our knowings prior to making an observation of a particular phenomenon. As more of the deep sea areas are probed by manned vehicles new instruments will be tailored to extend man's senses. Prototypes of these instruments are best evaluated when the operator is in close proximity to his device and he is cognizant of factors that are affecting his measurements.

Dives with the *Trieste* have given us some insight as to the quantity, size, distribution, and behavior of animals at all depths. The existence of near-microscopic life throughout the water column and animals as large as a 1-foot flatfish at the greatest known depth indicates that devices are needed for selectively sampling these organisms. Bioluminescence is present in the area below that of sunlight penetration. The light level produced by living organisms is usually no greater than that encountered on a clear night from the stars. It is, however, a measurable amount and it would be advantageous to obtain readings of the intensity.

The magnitude of water current near the sea floor can be readily determined when the bathyscaph reaches the bottom. Visual observations are being supplemented with meters that automatically record the current velocity and direction. Currents off San Diego at 4,200 feet approached a velocity of 1 knot. At the bottom of the Challenger Deep there was no detectable current present during the 20-minute stay. Repeat dives to the sea floor off San Diego at approximately the same location revealed that the current velocities are variable and more observations will prove advantageous to our understanding of the variations.

On the sea floor the types of sediment and rock outcrops can be viewed and photographed. Physical and biological activities tending to alter the topography and sedimentation processes have been observed. These observations would be difficult to photograph and in some instances the detail that can be observed cannot be resolved from photographs or television cameras. The behavior of animals, their mode of locomotion, stimuli to move, and the effects of their moving and general disruption of the sea floor sediments is clearly visible from within the bathyscaph sphere. In the supposedly barren depths of the Mediterranean, fishes were observed on nearly every dive and the water above the bottom was seen to possess a variety of animal forms. Off San Diego the animal population on the sea floor is more varied and the populations are significantly larger than in the Mediterranean areas visited.

The most significant observation made using the *Trieste* were those made at the bottom of the Challenger Deep. During the landing a flatfish was observed swimming close to the bottom or squirming into the very soft sediment. A free-swimming shrimp swam through the area illuminated by the external lights. These meager biological observations offer several types of evidence about the physical conditions of the environment. Such animals are active types that require oxygen. The principal supply of oxygen for these depths is generally recognized to come from surface sources where plants generate oxygen and oxygen is dissolved in the sea water from the atmosphere. Current systems are then responsible for carrying the oxygenated water into the great depths. Although no current was observed at the time of the landing it is obvious that currents were active in the past. What the magnitudes of the current velocities are and whether or not they are seasonal cannot be learned from a single dive. The extent of vertical versus horizontal currents is also an unknown for this area.

The oceans have served as satisfactory garbage dumps for many forms of manmade wastes. Dispersion is asssisted by current systems and deep basins have been utilized for chemical and explosive waste depositories. "Out of sight and out of mind" in the past, these areas are now within the operating domain of the bathyscaph and future deep submersibles. Already areas of interest off California are out of bounds to bathyscaph diving as they are reserved for hazardous materials disposal.

A complete water temperature profile above the Challenger Deep was obtained during the deep dive. It was clearly recorded that the temperature decreased to 2.45° C. at a depth of approximately 25,000 feet. Below this depth there occurs a minor but significant increase to 3.35° C. This is not to be construed as a new observation, but the record obtained by the bathyscaph personnel is the first continuous record of this phenomenon. More detailed observations of this inversion will be conducted in future operations and will be supplemented by water samples.

### OPERATIONAL HISTORY OF THE "TRIESTE"

Between the completion of construction of the *Trieste* in 1953 and December 1958 the bathyscaph had operated only in the Mediterranean Sea. During that period 48 dives were completed; 26 of these were in 1957 under the sponsorship of the U.S. Navy Office of Naval Research. After the August 1958 delivery of the vessel to San Diego a nominal dive series of 10 was conducted off San Diego to a maximum depth of 4,200 feet in preparation for Project Nekton and for familiarization for U.S. personnel. In October of 1959 the craft was transported to Guam for Project Nekton operations. A total of 11 dives were made between November 1959 and January 1960, culminating with the 35,800-foot dive.

Although the bathyscaph has the capability of operating to any depth in the oceans it cannot be safely operated in rough seas and is limited to near shore operations due to a lack of adequate mother-ship facilities. Therefore, the present scope of operation of the craft is seriously curtailed as deep ocean areas are not usually located close to major shore base facilities. The average depths of the oceans are approximately 2 miles. To reach this depth from San Diego requires, at least, a 120-mile tow. The craft is necessarily constructed to be as light as possible. Therefore, it is structurally weak against surface waves and swell.

Many important military projects under study involve deepwater investigations. Such studies could be markedly advanced if the capabilities of the bathyscaph could be employed. Unfortunately the limitations imposed by ocean surface conditions and the cumbersome towing that is involved in moving the craft to the diving location renders the craft limited to near shore operations at present. Remote locations such as Hawaii and Guam are satisfactory insofar as shore based logistic support is concerned. But again the diving operations must be limited to a radius of approximately 200 miles from port before a mother ship is available.

It has been planned, since the purchase of the *Trieste*, that the craft would be made available to scientists of the United States. Many of these individuals have special problems that require dives to be made in other areas than San Diego or Guam. Ideally the craft should be transported to the desired location wherever it might be operated. To do this effectively an oceanographic research ship capable of servicing the craft would be very necessary in such an operation and would serve as a mobile base for applied oceanography.

The National Academy of Sciences—National Research Council "Committee on Oceanography Report No. 7, 1959," envisages the development of a variety of manned and unmanned submersibles and cites the need for such craft in an expanded oceanographic research program. Already the commercially designed 15,000-foot *Aluminaut* (Reynolds Aluminum Co.) is well advanced. Several deep submersibles are being designed by other organizations in the United States. None are in the construction stages.

### THE FUTURE

Man's knowledge of the oceans is meager indeed when compared with their importance to him. Recognizing that neglect in this area of endeavor might well result in our being placed in a precarious position from the scientific, technological, and military points of view, it is mandatory that there be an increased American effort in this last geographic frontier. Exploration and exploitation of "inner space" has received a significant impetus with the historic plunge that reached the maximum depth in the sea. Technological development required for the Mohole project will effectively advance man's knowledge of the Earth's structure and may enable him to extract vital minerals and fuels from the bottom of the ocean.

As our technological civilization increases in complexity, as human populations grow at an ever-increasing rate, and as problems of military defense become increasingly more difficult, it is imperative that the United States acquire a greater knowledge of the oceans for the socioeconomic future of the American people, military security, and the assurance that the United States develop scientifically and technologically so as to begin harvestng vital resources from the sea and to utilize the advantage of deep sea operations for strategic military purposes.

It is considered essential to the orderly progress of pursuing the host of studies involved in manned exploration of the deep sea that deep submersible vehicles and shore facilities, scientific personnel, and existing experience be integrated to provide the United States with the most effective means of maintaining leadership in deep oceanic research. The established operating base for the bathyscaph *Trieste*, at the U.S. Navy Electronics Laboratory, which is adjacent to the most suitable location for bathyscaph operations in the United States, appears to be the most propitious location for such a base. In addition, the Nation's largest community of scientists and personnel concerned with basic and directed oceanic research is located in the San Diego area.

Coupled with the oceanic specialists is a scientific, technical, and educational community that will contribute to the overall effectiveness of such an establishment. As a military center, San Diego continues to encompass one of the Nation's largest Navy establishments. The U.S. Navy Electronics Laboratory, in particular, possesses many facilities that would be immediately available to any expanded deep submersible program. Future developments in subsurface vehicles and oceanic research is also of extreme concern to fleet commands; several of these are located in San Diego. The scientific community surrounding the United States Navy Electronics Laboratory is fully cognizant of the needs of military operations and that there is no comparison between the urgencies of the problems of the oceans and those of outer space. In the great depths of the sea, there rest strong potential advantages for detection, evasion, surveillance, and control of vast areas of the sea by those vessels that can master the problems of operating in the abyss. Utilization of the third dimension in the sea by the Navy is becoming more of a reality with the advent of deep submersibles. Adding the potential of being nuclear powered, the deep-traveling vehicle will be the craft of the future that will be able to utilize all of the strategic advantages offered by the deep sea environment. Therefore, it is vital that the United States endeavor to maintain a significant lead in deep sea research using manned deep submersibles and advanced instrumentation to accelerate our knowledge of this newly opened domain.

### SUPPORT REQUIREMENTS

One of the prime reasons for the seemingly poor diving record during the *Trieste's* first year in the U.S. Navy was that of securing proper support for the craft. The personnel had to have time to become properly indoctrinated with operation and maintenance of *Trieste*. There were no printed instruction manuals or precepts other than the personal experience of one man, Jacques Piccard. It was a case of learn by doing. No formal classes were held; rather, we learned by the apprenticeship system. A great deal of equipment had to be procured, much of which was neither military standard nor off the shelf. Time-consuming delays were experienced in trying to find the U.S. equivalent to many of the *Trieste's* European-made parts and in converting many of the craft's fittings from metric to U.S. standards. Shore facilities were allocated at the Navy Electronics Laboratory. However, they were assigned before anyone had seen the bathyscaph, and some revision of the space estimates was in order when it finally arrived. It was a very slow process getting used to this completely unorthodox craft.

#### *Shore facilities*

Shore facilities for the bathyscaph are all located in the waterfront area of N.E.L. and, besides office space, include the following: A fenced concrete compound for drydocking stowage and shop spaces, and berthing space between two wooden piers.

Deficiencies in shore facilities include the following:

(*a*) The present fenced compound is inadequate, if another vehicle should be built and assigned to N.E.L.

(*b*) A ballast storage area should be provided.

(*c*) A fuel handling system capable of absorbing the 30,000 gallon fuel load of the *Trieste* should be provided at the facility.

(*d*) Shop space in the order of 5,000 square feet should be available and expandible to provide a machine shop, instrumentation shop, storage of delicate equipments and spare parts, work area for sphere instrumentation and repair, a darkroom for special deep-sea cameras, and a high pressure test facility.

(*e*) The berthing space for the *Trieste* should be a protected space which gives good insurance against waves from passing vessels, boarding by unauthorized personnel and maximum protection against possible fires. The group also has a 53-foot landing craft converted to a workboat and a 17-foot wooden lobster boat which is used as a tender boat during operations. These two craft require docking space near the bathyscaph.

(*f*) Machinery stowage space should also be provided.

(*g*) A stowage area for flammable fluids should be built.

*Afloat facilities*

The delicate bathyscaph was not built to withstand the stresses of a long tow at sea. During the recent operations on Project Nekton it was necessary to tow the craft for several days at a time through fairly rough sea conditions. At the completion of each tow and prior to diving a careful inspection was made of the craft and each time we found several items either destroyed or missing. Thankfully, nothing was damaged such that we could not make the dive; however, this was just a matter of luck and if we continue to operate in this fashion we will most certainly sustain a disabling casualty.

The large workboat cannot be taken to sea on any operation more than a few miles off the coast. The small tender boat can be put aboard the towing vessel for transport to the diving area.

The afloat facilities necessary to support the *Trieste* and other deep submersibles should consist of the following:

(*a*) A mother ship which is capable of picking up and cradling the vehicle or vehicles and the attendant small boats. This ship would also have numerous laboratory and shop facilities such that it would be a floating research facility capable of carrying out independent bathyscaph operations in any ocean. Until this ship is available the *Trieste* is virtually limited to coastal waters due to the extremely slow rate at which she can be towed.

(*b*) A converted LCM landing craft has been modified so that it is able to tow the *Trieste* in sheltered waters thus obviating the need for requesting a tugboat each time we wish to move the 120-ton bathyscaph.

(*c*) The small tender boat is a small lobster boat which now fills the bill perfectly.

(*d*) A rubber raft is often used when the seas are too high to permit the launching of the tender boat.

*Personnel*

A combined military-civilian organization in support of the *Trieste* is most desirable. This organization should consist of a chief scientist in charge of the program, an officer in charge of the *Trieste* and other technical military and civilian personnel who would also handle bathyscaph operations.

This concludes my prepared statement.

Mr. ANFUSO. Thank you very much, Dr. Rechnitzer, for a very fine statement. I should like to ask you just a few questions.

Do you consider the bathyscaph has been proved operational?

Dr. RECHNITZER. Yes, the bathyscaph has been proved operational. We have two naval officers as alternate pilots, and we have a limited number of civilian personnel and enlisted naval personnel at hand.

Mr. ANUFSO. What scientific expeditions are you planning for next year?

Dr. RECHNITZER. Next year we will confine most of our operations to areas off San Diego, and these will be down to depths approaching 6,000 feet, or about 1 mile. We have already found that the area, the sea floor, and the water over the sea floor in the San Diego area, are extremely rich in animal life, far more than we really expected. We also encountered rather strong currents at both 1,000 and 4,000 feet. And these are of interest to us. The current is so strong that even the animal life is tumbled along the bottom.

These measurements, very close to the bottom, are extremely hard to make by surface-lowered instruments, because you never know precisely how far you are up off the bottom.

Mr. Miller. What direction are these currents?

Dr. Rechnitzer. This varies on different visits. The quantity of animal life varies in the water masses. These dynamic changes are things we are extremely interested in, and understand poorly today.

Mr. Anfuso. Do you think, Doctor, the urgency of the program, as you have described it, requires additional vehicles?

Dr. Rechnitzer. Yes, I do, because the bathyscaph moves primarily in the vertical sense. We need other crafts that lack perhaps the great depth capability of the bathyscaph, but which entail a great deal of mobility. This mobility will be utilized particularly to investigate the Continental Shelves, so we only need a craft initially, we will say, that will go to something like 3,000 feet, but which can move long distances, and cover a great deal of the sea floor during one dive.

Mr. Anfuso. Would you recommend that the Navy build a duplicate?

Dr. Rechnitzer. We have given this particular problem a great deal of thought, and it is most likely that we will continue to improve the bathyscaph that we now have at hand, as we, in addition to the sphere that went to the greatest depth, we also have a more modest one which will go to 20,000 feet. So we have a rather versatile bathyscaph vehicle on hand at the present time, and see really no need for a second one.

Mr. Anfuso. If you did have a second one would you recommend, then, improvements in the construction of the bathyscaph?

Dr. Rechnitzer. Oh, very definitely. As we continue to make dives into the great depths, we are richly rewarded by having been able to test in the environment various concepts of structural design and materials. The overall engineering development of any craft will, of course, evolve after using the initial prototype.

Mr. Anfuso. Would you tell us briefly what improvements you would recommend?

Dr. Rechnitzer. We have a need for improved lighting. We have need for an improved or extension of our physical senses. In that regard we could use television, better sonar devices, current measuring equipment, and devices for measuring the chemical content of the water.

Mr. Anfuso. How can measurements with the bathyscaph contribute to the Navy's underwater information?

Dr. Rechnitzer. I think the easiest way to explain it would be to compare it with the airplane going up into a new environment. Until it was being utilized by the fliers, there was no real need to give it a great deal of consideration. The science of meteorology was given a great impetus by the need for people who were going to use that environment as a means, or a mode, of travel. We have the same problems facing us in the deep sea.

Mr. Anfuso. How important are these measurements to, let us say, building antisubmarine defenses?

Dr. Rechnitzer. Any additional information, particularly if it is more refined than we can get it today, and if we can get it more completely, will add to any operations of equipment that will be subjected to great pressures or placed in various spots in the ocean.

Mr. ANFUSO. Can these measurements which you have talked about be made with equipment other than the bathyscaph, such as from surface ships?

Dr. RECHNITZER. At the present time, not with the completeness, nor does it have the advantage of having man's eyes and mind backing up the observations and measurements, because you can interpret directly and save a tremendous amount of time by having man in the environment observing what is going on and making measurements at the same time. If you do it by a surface ship, you do not see these other dynamic activities that are going on.

Mr. ANFUSO. Doctor, I am curious to know why the bathyscaph has to be towed so slowly to the different sites? Why does it have to be towed at all? Why cannot it be carried by a ship to the site?

Dr. RECHNITZER. There is one serious complication at the present time: The bathyscaph cannot be lifted until the ballast and gasoline are removed from the craft, and to do this requires more facilities than we have available. A mother ship, capable of receiving the gasoline, some 30,000 gallons, and some 16 tons of ballast, is required. And then, of course, it requires that a ship be relatively large to lift the 45-ton craft and set it on deck.

Mr. ANFUSO. Do you think that in the future you would have to have something like that?

Dr. RECHNITZER. Yes. We feel that this is almost mandatory not only for the bathyscaph, but for other small submersibles that are in planning, and will probably be coming along in the near future.

Mr. ANFUSO. What kind of logistic support does the bathyscaph now have assigned to it, and what are the Navy's future plans regarding the support of this?

Dr. RECHNITZER. At the present time our fleet consists of the *Trieste*, a converted landing craft, and one small lobster boat.

During our operations we require a towing vessel, and this is assigned for the specific periods at which we expect to go to sea.

But working with the bathyscaph, it is somewhat like launching a missile. It isn't always ready to go at the specified date. We then have to fit it in with other Navy operations, and sometimes we are forced to then sit on the beach and wait until we have our next reservation.

Mr. ANFUSO. My final question is, Is the experience with the bathyscaph applicable to other deep submerged vehicles and, if so, how does the Navy presently plan to exploit the experience obtained by the bathyscaph crew through its record dives?

Dr. RECHNITZER. I think one of the most trenchant examples of the benefits that can be derived from the bathyscaphs are the electrical leads that penetrate the sphere. These have held up against the tremendous pressures involved in these deep dives, and will be the nucleus for the development of better hull fittings for newer submarines.

Mr. ANFUSO. I want to conclude by congratulating all of you gentlemen, and may I just say, or, rather, inquire. Lt. Don Walsh was the commanding officer of the *Trieste*; is that correct?

Lieutenant WALSH. I still am.

Mr. ANFUSO. You still are?

Lieutenant WALSH. Yes, sir.

Mr. MILLER. May I interject here?

Mr. ANFUSO. Sure.

Mr. MILLER. Lt. Don Walsh comes from my district in California. I merely glory in this. When he was an even younger man I gave him an alternate appointment to West Point. In the meantime he wiggled and waggled an appointment to the Naval Academy. I am in a great spot, otherwise I could have said this is my boy.

Lieutenant WALSH. I hope we are still friends.

Mr. ANFUSO. I would like to take some pride——

Mr. MILLER. Incidentally, Lieutenant Shumaker is also a Californian.

Dr. RECHNITZER. And I am also a Californian.

Captain PHELPS. I am also a Californian.

Mr. ANFUSO. I would like to get New York into this. There is some similarity.

Mr. MILLER. There is some similarity.

Mr. ANFUSO. Who else was with you, Lieutenant Walsh?

Lieutenant WALSH. Jacques Piccard was with me. However, he is back in Switzerland designing another craft.

Mr. MILLER. I want to compliment you gentlemen. They did more than Lindbergh. These are the Wright brothers of the deep sea diving area, and I am very happy and honored to have them here.

Mr. ANFUSO. Mr. Van Pelt.

Mr. VAN PELT. No questions.

Mr. ANFUSO. Mr. King.

Mr. KING. I have about several dozen, but there isn't time.

Mr. ANFUSO. We have 5 minutes. If you want to finish by 12, we have plenty of time, Mr. King, go ahead.

Mr. MILLER. Knowing Mr. King's penetrating questions, he wouldn't ask him over 5 minutes.

Mr. KING. When the *Trieste* went down, am I correct that there were no cables or hoses of any kind, it was completely independent; is that right?

Dr. RECHNITZER. That is correct.

Mr. KING. Carrying its own air supply. How was that managed?

Dr. RECHNITZER. Well, the bathyscaph is primarily an underwater balloon, and for buoyancy we used gasoline, because it is much less compressible than any gas, such as helium or even air.

Now, in contrast to a submarine, which alternately pumps water in and out for control, we do not do this. The pressures that would be involved preclude the use of air pressure. Instead, we go down with the craft being heavy, and release weight at the depth to return back to the surface. To gain positive buoyancy you release weight, such as a balloon coming to Earth, it will release ballast to slow its descent.

Using gravity as the power to move the craft, and regulating the weight of the craft hydrostatically by either being too heavy or too light is the mode of operation.

Mr. KING. I suppose a steel cable would have involved so much weight it would have been impracticable, is that right?

Dr. RECHNITZER. Its weight is impractical. When we go back to thinking about Beebe, and his bathysphere, which was lowered on a cable, a limitation and danger become apparent. You know if you played with your mother's clothes line, and you whipped it, then you would have the waves going along from end to end; if these come back in the proper mode, they are apt to break even the strongest cable.

Of course, the surface ship is going up and down, and you don't know what the sphere is doing down below. It is a more dangerous occupation than the bathyscaph.

Mr. KING. You explained the bathyscaph was essentially an elevator, and there was little or no mobility on the bottom, I think that was explained the last time you testified.

Dr. RECHNITZER. Yes.

Mr. KING. Will the day come when we can design a craft that will actually travel around on the bottom as an automobile?

Dr. RECHNITZER. Well——

Mr. KING. Not as fast, but with reasonable mobility?

Dr. RECHNITZER. It is necessary to get up a few feet off the bottom, it is rather soft mud, by the way, and it would be difficult, it would be sinking in all the time. Yes, it will come in time. The bathyscaph, as you know, was built on a shoestring. The objective was not so much to make horizontal motions, as to go up and down.

We do have motors on it, we can drive along the bottom using the motors, or drift with the current, either one at our disposal. But this is a limited horizontal mobility.

Mr. KING. That will be achieved in due time, where we can explore the bottom effectively and stay down much longer. You were down 20 minutes, I believe?

Lieutenant WALSH. Some 9 hours total, 20 minutes on the bottom.

Mr. KING. About 5 down and 3½ up?

Lieutenant WALSH. Right.

Mr. KING. Will the day come when we can spend many hours on the bottom?

Dr. RECHNITZER. We hope.

Lieutenant WALSH. Not only that, but making each hour count more than it can now, by proper instrumentation.

Dr. RECHNITZER. It is all feasible. It is a matter of time and funding, and moving in that direction.

Mr. KING. You can work out prosthetic devices, I think you call them, to reach out and grab things for samples. You had very few at this time, if any; is that correct?

Dr. RECHNITZER. That is right.

Mr. KING. But you will work that out.

What did the fish eat down there—use the droppings from above, is that their diet?

Lieutenant WALSH. Apparently, in that there were none of the usual low forms of life apparent on the bottom, such as worms or evidence of worms, worm holes. Any kind of animals apparently must feed on material that drops from the higher regions of the water.

Mr. KING. And the oxygen you suggested would be brought there either by currents or flora of some sort?

Dr. RECHNITZER. It has to be brought by the currents. The flora, of course, are restricted to the upper few hundred feet of the ocean.

Mr. KING. Light disappears at about 1,000 feet, is that right?

Dr. RECHNITZER. That is right.

Mr. KING. So you have no photosynthesis, you have no self-generating light, so to speak?

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Dr. Rechnitzer. That is correct.

Mr. King. So it all comes from above?

Dr. Rechnitzer. It comes from above.

One individual will eat another, and this chain continues all the way down to the sea floor.

Mr. King. We have seen drawings frequently of artists' conception of these marine creatures with these—well, in fact, some of them have been photographed at not such great depths, with the big pop-eyes, carrying little lamps on the end of these proboscises, or whatever it is. Did you see any of those weird creations on the bottom? The fish that you described, Lieutenant Walsh, when you were here before, sounded like a very conventional fish with conventional eyes, and so on.

Lieutenant Walsh. That is right.

Mr. King. Did you see the weird type?

Lieutenant Walsh. No. I have never personally sighted such beasts. Of course, they do exist, and I believe perhaps Andy has in one of his dives, but I have not.

Mr. King. If that fish had been brought up would it have exploded because of the pressure being released?

Dr. Rechnitzer. No, it would be extended a small amount, just the amount you can compress any liquid such as are included in most of our tissues. So it would be only an expansion of maybe 7 percent. They would come up intact. This is why we have our large collection of deep sea fishes.

Mr. King. And would live?

Dr. Rechnitzer. It would most likely die of heat prostration, rather than suffer from a change in pressure, because of coming up from cold waters into the warm surface waters.

Mr. King. Then we have had to relearn, or unlearn a lot of lessons, as a result of your experience; is that right?

Dr. Rechnitzer. We feel we have, yes.

Mr. King. What you testified to here, and the last time you were here, was rather contrary to some of the things I have read, for example, in Life's, The World Around Us, that came out 5 or 6 years ago.

I think you said several things that constituted quite an improvement on what they said.

That is all I have, Mr. Chairman.

Mr. Anfuso. Thank you, Mr. King.

Mr. Fulton, we are through, except for you.

Mr. Fulton. Well, as a newspaper man, might I say you made one tremendous mistake when you were down here, you didn't even see a sea monster or a Soviet submarine.

Mr. Miller. They are scientists.

Mr. Fulton. You saw neither one of those?

Dr. Rechnitzer. Perhaps that showed that the Soviets couldn't do it.

Mr. Anfuso. Right.

Mr. Fulton. I am interested seriously, though, in how you were funded for your current operations. In the current fiscal year are your funds adequate?

Secondly, are your equipment and instruments adequate?

Thirdly, for the coming fiscal year, has there been any cutoff of any appropriation or authorization you have requested so that you are without any major equipment or ancillary equipment, for example?

Do you have a better equipped mother ship, or a better bathyscaph, or a more mobile bathyscaph, that you might do better than, what is it, 1 mile an hour laterally? Have you been cut off?

There has been a rumor around that you have received a cut by somebody.

Dr. RECHNITZER. I think that we are being adequately funded for the coming fiscal year, and that progress toward an adequate mother ship is moving along just as fast as it is practicable.

Mr. FULTON. Then you have not in any respect had an appropriation cut, either in the current fiscal year, or a cut in the request for authorization in the next fiscal year?

Dr. RECHNITZER. We will not know probably until some time after the end of the fiscal year just where we do stand.

Mr. FULTON. Yes, but at the present time there is no cut that you are complaining about?

Dr. RECHNITZER. No, I have no serious complaint.

Mr. FULTON. Is the appropriation adequate enough to keep you moving on your research on a level with the Russian effort?

Dr. RECHNITZER. Yes, as far as we can see in the coming year, we will certainly continue to be ahead of the Russians. There is definitely room for expansion in this field. More people, better vehicles, and more minds and hands need to be put to the task of getting more manned vehicles into the deep sea.

Mr. FULTON. Rather than take the time now, would you put in the record a program where we could expand further beyond the present plans? Put that in the record later. If we were going to expand the program, how should we do it.

Mr. ANFUSO. Just put that in the record.

(The material requested is as follows:)

SUPPLEMENT TO TESTIMONY BY DR. ANDREAS B. RECHNITZER TO COMMITTEE ON SCIENCE AND ASTRONAUTICS, HOUSE OF REPRESENTATIVES, APRIL 28, 1960

Mr. FULTON. If we are going to expand the deep-sea oceanography program, how should it be done? What would you recommend for a continuing program?

Dr. RECHNITZER. I consider it essential to the orderly progress of pursuing the multitude of developments required for a more extensive manned exploration of the deep sea that an expanded group of qualified scientists and support personnel be equipped with adequate facilities to pursue a program of deep submersibles and equipment development and to conduct basic and applied research in and on the oceans.

The team effort has proven its value in establishing many U.S. firsts. Therefore, the complicated problems facing us in our plans to operate in the deep sea should be tackled by a team of adequate size (I visualize a minimum of 25 scientists and 40 support personnel in addition to a civilian crew for a surface mother ship) and a scientific program of wide scope that will assure continuity and an economically sound expansion of our efforts by focusing technical and professional competence in the direction of expanding our deep-sea research capabilities.

Rapid progress could be made most efficiently by expansion of the U.S. Navy Electronics Laboratory group and facilities for deep-sea oceanographic research: this would assure maximum utilization of: (*a*) oceanograpers already trained in deep-sea research, (*b*) established logistic support of the only U.S. deep submersible (the bathyscaph *Trieste*), (*c*) the only U.S. personnel experienced in operating in the great depths (bathyscaph crew), and (*d*) a Government research and development facility already engaged in an oceanographic instrumentation program. In addition, the Nation's largest community of scientists and personnel concerned with basic and directed oceanic research are located in the San Diego area.

The bathyscaph team is already providing guidance to diverse types of industrial firms interested in the design, development, and construction of deep submersibles and instrumentation systems. An expansion of this "sharing" of experience and practical knowledge can be of significant benefit to the Nation by bringing more talent to bear on deep-submergence problems. Expansion of the U.S. Navy Electronics Laboratory nucleus of personnel and equipment investment would improve our posture as a leader in deep-sea research more rapidly than any other way that I can conceive.

Mr. FULTON. That is all.

Mr. ANFUSO. Thank you, gentlemen. We are most happy to have had you here. Just remember we are your friends, and if you need anything from us just holler.

Dr. RECHNITZER. Fine.

Lieutenant WALSH. Thank you very much, sir.

Mr. ANFUSO. The meeting stands adjourned.

(Whereupon, at 12:07 the committee adjourned to meet again at 10 a.m. on Friday, April 29, 1960.)

# FRONTIERS IN OCEANIC RESEARCH (H.R. 6298)

FRIDAY, APRIL 29, 1960

House of Representatives,
Committee on Science and Astronautics,
*Washington, D.C.*

Following a presentation of Navy and Marine Corps colors by Secretary of the Navy William B. Franke to the committee at 10 a.m., the committee resumed its hearing at 10:25 a.m., Hon. Overton Brooks (chairman) presiding.

The Chairman. The committee will come to order.

This morning, gentlemen of the committee, we conclude these hearings. We have Dr. James H. Wakelin, Jr., Assistant Secretary of the Navy for Research and Development; speaking on "Next 10 Years of Research in the Oceanic Sciences," and Dr. James E. Lipp, director of development planning, Lockheed Aircraft Corp., on the subject of "Pioneer Ventures in Underseas Engineering."

Dr. Wakelin, Assistant Secretary of the Navy, we are very, very happy to have you here, sir, this morning, and mighty glad that you participated with us too in the presentation of the flag that we just had.

(Dr. Wakelin's biography is as follows:)

James H. Wakelin, Jr.

James H. Wakelin, Jr. was born in Holyoke, Mass., on May 6, 1911. He attended the public schools in Holyoke, graduating from high school in 1928. He received an A.B. degree in physics from Dartmouth College in 1932. During 1932–34 he attended Cambridge University, Cambridge, England, where he was granted a B.A. degree in the natural sicences in 1934 and a M.A. degree in 1939. Dr. Wakelin received his Ph. D. degree in physics from Yale University in 1940, where he specialized in the field of ferro-magnetism. During 1939–43 Dr. Wakelin was a senior physicist in the physical research department of the B. F. Goodrich Co., Akron, Ohio. His work there was concerned with the structure and physical properties of natural and synthetic rubber, and with X-ray diffraction and electron microscope studies of high polymers.

From 1943 to 1945 he was ordnance staff officer to the Coordinator of Research and Development, Navy Department, Washington, D.C. During 1945–46, as a lieutenant commander, U.S.N.R., he was head of the Chemistry, Mathematics, and Mechanics and Materials Sections of the Planning Division, Office of Research and Inventions, and was active in the planning and organization of the Navy's program to sponsor basic scientific research, now under the direction of the Office of Naval Research. Following World War II, Dr. Wakelin joined a group of former Navy research scientists in the establishment of Engineering Research Associates, Inc., of Washington, D.C., and St. Paul, Minn., and held the position of director of research. While with this company he was also director of the field survey group of ONR Project Squid under contract to Princeton University. In 1948 he became associate director of research of the Textile Research Institute in Princeton, and in June 1951 was appointed director of research of the institute, serving in this capacity for 3 years. In 1954 Dr. Wakelin established his own consulting business in Princeton and has been a consultant on research planning and organization to the Lamp Division, General Electric Co., Cleveland, Ohio; Stanford Research Institute, Palo Alto, Calif.; American Radiation & Standard Sanitary Corp., New York City; J. P. Stevens & Co., Inc., New York City; Frenchtown Porcelain Co., and Star Porcelain Co., of Trenton, N.J. He was one of the founders in 1954 of Chesapeake Instrument Corp., Shadyside, Md., established to conduct research and development for the Navy in the fields of underwater sound and acuostic devices. He has been a vice president and consultant of that company. During this period he was also a research associate on the staff of Textile Research Institute working on the structure and physical properties of high polymers under a program sponsored by the Office of Naval Research.

Dr. and Mrs. Wakelin, the former Margaret Cushing Smith of Concord, Mass., have lived in Lawrenceville, N.J., for the past 10 years. They have three boys: James H. III and Alan B., who attend the Lawrenceville School, and David, a student at the Princeton Country Day School. The Wakelins have been active with the Cub Scouts and the Parent Teachers Association in Lawrenceville and with the American Red Cross in Princeton. Dr. Wakelin served as President of the Nassau Club of Princeton in 1955 and as a member of the Board of Trustees 1956–59; he is also vice president of the Fathers' Association of the Lawrenceville School. Mrs. Wakelin is active as a volunteer with the Princeton Hospital where she is now chairman of the hospital aid committee. The family's recreational hobbies include golf and sailing and they spend their summer vacations on Pickering Island in Penobscot Bay, Maine.

Dr. Wakelin is a member of Sigma Xi, the American Physical Society, American Association for the Advancement of Science, the Association for Computing Machinery, the American Crystallographic Society, Textile Research Institute, the Textile Institute of Great Britain, and is a contributor of scientific papers to the Journal of Applied Physics, the Industrial and Engineering Chemistry and Textile Research Journal in the field of high polymer physics. He is a co-author with C. B. Tompkins and W. W. Stifler, Jr., of "High-Speed Computing Devices" published by McGraw-Hill Book Company in 1950.

Dr. Wakelin was appointed by the President of the United States to the position of Assistant Secretary of the Navy for Research and Development on June 30, 1959.

Dr. WAKELIN. It is a pleasure, Mr. Chairman.

The CHAIRMAN. I reiterate the committee is grateful to the Navy and the Marine Corps for their interest in the welfare of our committee.

If you have a prepared statement, will you proceed, sir, with your prepared statement?

Dr. WAKELIN. Yes, sir.

## STATEMENT OF DR. JAMES H. WAKELIN, JR., ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH AND DEVELOPMENT

Dr. WAKELIN. Mr. Chairman, gentlemen, I appreciate the opportunity of appearing before you today to discuss our long-range plans in oceanography. The comments I have to make to you will stem from two points of view.

First, as Assistant Secretary of the Navy for Research and Development, I am concerned with the Navy's traditional interests in the oceans; oceanography affects every aspect of our operations from the Polaris fleet ballistic missile system to undersea warfare to amphibious and mine operations.

Second, as chairman of the Interagency Committee on Oceanography of the Federal Council for Science and Technology, I am concerned with increasing this Nation's knowledge of the oceans—

their content, their boundaries—by substantially accelerating our efforts in an orderly program during the next 10 years.

From the witnesses who have preceded me you have had expert testimony concerning the importance of the oceans in our national defense. Within the past few days some of the Nation's most distinguished oceanographers have described to this committee and to Senator Magnuson's Committee on Interstate and Foreign Commerce our urgent needs in this most important field of oceanography. They have emphasized that a thorough understanding of the ocean medium is essential for our country's defense, for harvesting the abundant foods, minerals, and chemicals from the seas, for the safe disposal of low-level atomic wastes, for worldwide transportation, and for an understanding of the ocean's effect on climate and weather. We are painfully aware that our knowledge and understanding of this inner space is indeed limited but we are not completely ignorant of the problems we are required to solve in this area.

The scientists who have discussed oceanography with you are leaders in their fields. Through their efforts and their continuing enthusiasm we are now beginning to push back the frontiers.

It is my purpose to describe for you what is being done to provide a well-planned and coordinated national oceanographic program. Our needs in this field are real and pressing—our efforts need not be expanded simply to overcome a lag behind some other world power in this field of science.

Recognizing the seriousness of inadequate oceanographic information from the scientific, technical, and military points of view, the Federal Council for Science and Technology established a subcommittee last summer to prepare a coordinated national oceanographic program. This committee, now called the Interagency Committee on Oceanography, has recently been made a permanent instrument of the Federal Council with representation from the Departments of Defense, Commerce, Interior, Health, Education, and Welfare, the National Science Foundation, and the Atomic Energy Commission.

The Interagency Committee carefully reviewed the report of the National Academy of Sciences—National Research Council's Committee on Oceanography. In this report the Academy recommended a minimal program for long-term growth at an achievable rate in training of scientific manpower, construction of adequate ships and laboratories, as well as a technical program for research and ocean surveys.

The Interagency Committee concurred generally with the National Academy and concluded that the report accurately stated the Nation's scientific needs in oceanography. In the development of a national oceanographic program, we are concerned on the one hand with the assessment of the needs of oceanography and, on the other, with the limitations upon its development. The critical limitations are scientific manpower, funds, and time. Of course, I refer to a special kind of time—leadtime for the construction of ships and shore laboratories and for the training of the additional scientists.

The Interagency Committee recommended to the Federal Council that the United States undertake a substantial and orderly expansion of activity in oceanography. The Committee stated that vigorous action must be taken to stimulate the growth of educational programs, that a permanent interagency committee should be established to review and coordinate the national effort and that international cooperation is essential to the research and survey program.

These recommendations were accepted and endorsed by the Federal Council.

The Interagency Committee then developed by joint planning the budget for a 10-year national program to implement these general recommendations. In the development of the initial funding request for this program in the fiscal year 1961 budget, the agencies had to consider other competing needs of their respective departments while striving to give greater support to oceanography.

The total funding requested for the oceanographic program in fiscal year 1961 totals about $56 million, an increase of almost 50 percent over the fiscal year 1960 level of $37 million. For the previous year, fiscal year 1959, funds for this work amounted to $24 million.

I feel that this program provides for growth at a reasonable rate and that it satisfies the most critical needs of the departments and agencies in the field of oceanography.

All of the Secretaries of the departments and heads of the agencies represented on the Interagency Committee have indicated to me that they consider this Committee an effective means for achieving coordination and cooperation in our national program. I believe that this organization, assisted by working groups or panels comprised of representatives from the interested Federal agencies will be responsive to the needs of this country.

What will a 10-year program require in terms of funds, facilities, and manpower? The National Academy of Sciences report indicated that the program would cost $651 million in 1958 dollars over and above the rate at which the program was then being supported. This estimate is probably low when translated into 1961 dollars because the cost of doing business has increased.

Also, we believe that the unit cost of construction of ships has been underestimated. Taking these factors into consideration, the Interagency Committee has estimated that the total cost will approximate $1 billion during the 10-year program if our goal to double our present capability is to be realized. This is a modest goal when the level of our present knowledge is considered in relation to our needs. And I would like to say that doubling the present activity in oceanography will require more than doubling the rate of expenditures because of the capital investments required.

The Interagency Committee has estimated the major cost elements of the 10-year program to be as follows:

(*a*) Oceanographic research and ship operations, $490 million.
(*b*) Ocean surveys and ship operations, $144 million.
(*c*) Construction of 78 new ships and facilities, $405 million.

In the first few years the annual cost of this program will of necessity be greater than the average cost per year over the 10-year period because of the immediate need for additional ships and shore facilities—both are high cost, long leadtime items. Little expansion can take place unless these capital items are provided.

The United States currently operates about 52 ships, mostly of small size, for oceanographic research and surveys. About 30 of these will require replacement during the next 10 years because they will be overage.

The recommended 10-year program requires the construction of 78 new ships of sizes varying from about 500 tons to about 4,000 tons. Conversion of existing ships, principally from the Navy Reserve Fleet, has provided us with an oceanographic capability in the past and will undoubtedly continue to do so in the future for many purposes.

However, construction of new research ships in preference to the conversion of existing hulls is considered essential for a number of reasons. The Navy is making a study of the efficiency and economy of new construction versus conversion for various applications to point to the most feasible methods of providing the Navy with the required oceanographic ships in the next 10 years. This includes those ships we plan to make available to nonprofit universities and institutions as well as those for inhouse laboratories.

The most critical elements in expanding our effort in this field is the shortage of scientific personnel to man the ships and carry out a creative program. Recently, we have compiled data from 10 major universities and institutions concerned with training of oceanographers as well as the conduct of research. This information is most encouraging and we must do everything possible to continue the trend. The number of professional oceanographers at the Ph. D., M.S., or equivalent level and the number of their graduate students for the past 3 years is summarized in the following table. These data show that there has been an increase of 28 percent in the professional level and of 80 percent graduate students over the last 3 years.

| | 1958 | 1959 | 1960 |
|---|---|---|---|
| Professor level (Ph. D., M.S., or equivalent) | 253 | 290 | 327 |
| Graduate students | 137 | 176 | 246 |

By 1970 I believe we can expect the annual cost of the program to level off at approximately $85 million. This annual investment will offer a great return in national defense and in economic benefits to this country and to mankind. Here I would like to emphasize that beginning in fiscal year 1962 the annual cost of the program for several years may require funding in excess of $100 million.

This large sum of money will be required specifically for the construction of ships and shore laboratories necessary for a significant expansion in the program. The training and educational program, however, will not be a large percentage of the total program cost. We feel that approximately $15 million will provide the means whereby an adequate number of oceanographers can be trained in the next 10 years. This figure is a cost of education only—not the cost for facilities at educational institutions.

The Navy, by far the largest supporter of oceanographic research, contracts with universities and nonprofit institutions for about three-fourths of its basic research program, the remainder is conducted in Navy-operated laboratories. The funding of this research and development work constitutes our contribution to the national oceanographic program. In addition, the Hydrographic Office of the Navy conducts our extensive military survey program and the technical bureaus of the Navy contract for many other closely related military programs scattered throughout universities, Government laboratories, and industry. The cost of this effort approximates $14 million for military surveys and about $10 million for military research. Because of the peculiarly military character of these programs, their funding is not included in the national oceanographic program.

The Navy's concern about the oceans today, as in the past, stems directly from military requirements. Here the most pressing and best known problem lies in the field of undersea warfare. I have brought with me a tape recording of sounds of undersea creatures which illustrates the nature and complexity of the problem of underwater detection and classification.

Now, Mr. Chairman, with your permission I can run this off, which will take about 5 minutes.

The CHAIRMAN. Fine.

Dr. WAKELIN. It is a tape prepared by Rear Adm. John S. Thach, the then commander of Task Force *Alpha* working out of Norfolk for his staff and for our use, and with your permission I might turn it on.

The CHAIRMAN. I think the committee would be very much interested in it.

Dr. WAKELIN. Thank you, sir.

(The recording is as follows:)

Admiral THACH. North America is virtually an island, and right off our doorstep is a relatively unexplored jungle, whole mountain ranges, deep canyons, and many strange creatures are hidden there beneath millions of cubic miles of sea water.

This liquid space, about which we know so little, is a murky mass of discontinuities, full of sound ducts, currents, and thermal layers. Most incredible of all is the noise racketing through the undersea jungle.

I have a tape recording I would like to play for you to give you an idea of what some of the undersea creatures sound like.

The first example is a recording of snapping shrimp against the background of typical ambient sea noise caused by waves and other marine creatures.

[Recording of sounds.]

Admiral THACH. This next one is a drum fish.

[Recording of sounds.]

Admiral THACH. Now we have an unidentified moaning sound. No one can tell us exactly what is making this noise.

[Recording of sounds.]

Admiral THACH. The next sound is that produced by a white whale. You will be able to distinguish a high-pitched whistling, followed by creaking sounds. We do not know exactly how the white whale makes these noises.

[Recording of sounds.]

Admiral THACH. Next is the sound of an electric eel killing a small fish. The regular rapid clicking is believed to be the eel's own sonar that he uses to find his prey and the sinister burst of sharp buzzing sound is the electric discharge of the coup de grace.

[Recording of sounds.]

Admiral THACH. The noises you have just heard illustrate some of the many sounds against which the submarine noises must be distinguished.

The next sound is that of a submarine trim pump in an otherwise quiet submarine.

[Recording of sounds.]

Admiral THACH. Now we have the sound of a submarine raising a periscope. This was recorded rather close aboard.

[Recording of sounds.]

The CHAIRMAN. That is very interesting. Would that help us with our fishing, Mr. Secretary?

Dr. WAKELIN. It may, very definitely.

It doesn't help us with our antisubmarine warfare though.

The CHAIRMAN. Do you mean by that, the disturbances distract from the detection of submarines?

Dr. WAKELIN. They do, indeed, and they form a large part of the whole ambient noise background which must be separated from what you are looking for.

In a great many cases the sounds that are produced here are in the same frequency range in the sound spectrum with that which is produced by submarines and ships. So it is a delicate matter to be able to take the background noise away and improve our signal-to-noise ratio in looking for and locating submarines.

Mr. MILLER. Those are only a few of the noises you get too.

Dr. WAKELIN. Yes.

Mr. MILLER. There are dozens of them.

Dr. WAKELIN. Yes, there are, sir. There are additional noises also from the whole dynamics of the wave motion.

Mr. BASS. How are these noises recorded, Mr. Secretary?

Dr. WAKELIN. These are recorded, part of them on a sonar device, and part of them just using a straight transducer, with a normal audio frequency amplifier.

Mr. BASS. If you were a skindiver, would you hear the same thing?

Dr. WAKELIN. Yes, if you had earphones with an audio amplifying device, you could pick up these same sounds. It would be an interesting experiment to do.

The CHAIRMAN. A fresh water fish would produce different noises from that?

Dr. WAKELIN. They probably would produce noises characteristic of the fish themselves, yes.

The CHAIRMAN. I had heard some of fresh water fish.

Dr. WAKELIN. Yes.

Mr. FULTON. You never had a characteristic pattern picked up of Soviet submarines, have you?

Dr. WAKELIN. I am afraid I can't answer that, sir.

The CHAIRMAN. Can you pick up the noise of Polaris submarine?

Dr. WAKELIN. Oh, yes.

The CHAIRMAN. You could distinguish that from non-Polaris submarine?

Dr. WAKELIN. I am afraid I can't answer that, sir.

The CHAIRMAN. Just proceed with your statement. We don't want to go too far afield.

Dr. WAKELIN. It is simple enough to define research in underwater acoustics as the study of the generation, propagation, and reception of sound in the ocean. And yet we have just heard that the problems involved are as complicated as the ocean itself. To exploit fully this complex environment for offensive and defensive purposes, we must know and understand the characteristics of the oceans, and we must know why and when these characteristics change.

Other activities using knowledge of the oceans include the forecasting services performed by the Hydrographic Office. On the basis of sea and wave forecasts of the North Atlantic and Pacific Oceans, ships can be routed in such a manner as to arrive at their destinations more quickly and with less chance of damage from heavy sea conditions than might otherwise be the case.

Similarly, the Hydrographic Office provides forecasting service for ice conditions in the Arctic to assist the ships in resupplying the DEW line bases.

Aside from the military aspects of oceanography a knowledge of the interaction between the atmosphere and the ocean with the resulting effect on climatic changes may produce profound effects in the eventual control and modification of weather.

The resources of the sea, particularly the living resources, must ultimately play a larger role in the world's economy. The seas also may be expected to provide potential mineral and chemical resources, as well as exotic sources of power.

The Coast Guard, Coast and Geodetic Survey, Hydrographic Office, and Maritime Administration are all concerned with problems of commerce at sea. Numerous types of charts showing bottom topography, weather conditions, sea states and swells, currents, tides, and ice conditions are all essential for successful maritime operations.

A great deal of additional research must be conducted to establish the whys and wherefores of these conditions in order to make them more reliable.

I could describe for you some of the intriguing possibilities for exploiting the oceans to benefit mankind, but I am sure you are already familiar with many of them. Instead, I would like to make a few comments about how the Government is going about the important task of coordinating and expanding our oceanographic capabilities.

The report of the National Academy of Sciences has focused national attention on the needs of oceanography. The Interagency Committee has demonstrated its effectiveness in a short time as a coordinating mechanism. In response to the tasks facing it, the Committee has established working panels for specific purposes. The function of one panel is to plan and coordinate our ocean survey program. A second panel has the responsibility for working out the details for establishing and the policies for operation of a national data center. We are considering additional panels for training and education, for basic research, and possibly one for special devices and instrumentation.

Our next major task is to develop the budget for fiscal year 1962. Each agency's program and the national program as a whole will be reviewed critically by the committee for balance and technical validity. The final result must be adequate to meet our most immediate needs using the resources available while emphasis must be placed on providing the tools we need on a long term basis.

We expect to seek endorsement of this program and budget from the Federal Council for Science and Technology and approval from the President before presenting it to Congress as a complete national program in oceanography.

Finally, I come to the contributions which the Congress has made and can make to oceanography. Each of the several bills which are now being considered by the Congress has had a salutary effect by attracting widespread interest in oceanography both within and outside of the Government. However, I believe that the Federal agencies now have the authority necessary to carry out our oceanographic program. We need your favorable consideration of the budget requests of the several departments and agencies cooperating in this program.

An analysis shows us that oceanography is being emphasized and that our national effort in this field is being expanded considerably. I suggest that oceanography has a high probability of providing us with a greater return on our investment than some of the programs of equal magnitude which are currently more fashionable.

It has been said that, like the subject "Atoms for Peace," we can use the oceans for peace. We must have leadership on the oceans in the face of the threat of war and equally we must have leadership on the oceans in our hopes and our work toward peace.

Thank you, sir.

The CHAIRMAN. A very excellent statement, Mr. Secretary.

I notice especially your approach to the problem and to this committee. I notice also you refer to the Interagency Committee and to its financial needs in the future.

You refer to personnel being a very critical problem, especially scientific personnel, and it so happens that the bill under which you are testifying today refers to that.

Did you place in the record a list of the universities, colleges and institutions which are doing this training work throughout the country?

Dr. WAKELIN. I have it here, if you would like me to place it in the record, Mr. Chairman.

The CHAIRMAN. Is it a short list? Would you read it then, and read it into the record?

Dr. WAKELIN. All right.

The institutions which submitted the data which you have just requested, Mr. Chairman, include the following:

Columbia University, Johns Hopkins University, Oregon State College, Texas A. & M., University of Miami, University of Rhode Island, University of Southern California, University of Michigan, Scripps Institution of Oceanography, and the Woods Hole Oceanographic Institution.

The CHAIRMAN. I wasn't here yesterday and I am not up to date on what was said yesterday, therefore, I am going to recognize my colleague, Mr. Miller.

Mr. MILLER. Mr. Secretary, I have no questions, but you mentioned Scripps Institution of Oceanography. I believe the record should show this is a part of the University of California.

Dr. WAKELIN. Yes, sir.

Mr. MILLER. It is a branch of the university.

Dr. WAKELIN. Yes.

Mr. MILLER. Woods Hole is an independent institution.

Dr. WAKELIN. Yes, it is.

Mr. MILLER. But Scripps is a part of the university.

Of course, Mr. Secretary, I have been through hearings of this kind before on another committee that is interested in this field, but I am interested in some of the things that you said.

Early in your statement you said the harvesting of the abundant foods, minerals and chemicals, were part of the work you are interested in.

This implies, I believe, biology.

Dr. WAKELIN. Yes; it does.

Mr. MILLER. Are we doing, today, sufficient in this field?

I understand the Navy's interest in physical oceanography, but as a scientist, do you feel that we have gone far enough in trying to reap the peaceful benefits?

Do you feel that at this time we should be laying the foundation for that, which is not inconsistent with the other thing, in order to have knowledge of the biology of the sea and what it is going to offer in the way of peaceful benefits?

Dr. WAKELIN. Yes; I do, Mr. Miller. There are two aspects of it with which we are concerned on the Interagency Committee. The Bureau of Commercial Fisheries, of course, is increasing its budget for the study of the fisheries part of the oceanographic program. In general I concur in the National Academy's report that much more has got to be done in the field of marine biology to lay the foundation, not only in the research vein, but also a study which will lead to the development of methods by which we can harvest both the organic and inorganic materials from the oceans.

Mr. MILLER. Of course, you are familiar with the organic materials because they are the life from the sea, and men have been taking food from the sea since the dawn of history, since the dawn of time, but we have done little in the other fields, of the inorganic phase of taking the wealth of the seas; is that true?

Dr. WAKELIN. Except for the production of things like magnesium.

Mr. MILLER. And the boron products?

Dr. WAKELIN. And things of this kind; yes.

Mr. MILLER. Other than that, there is a field here, the manganese, that I think you touched upon.

Dr. WAKELIN. Yes; those are most interesting. Nodules have been found in the area southwest of Bermuda, of the size of a baseball, appearing to be rich in the oxides of manganese, cobalt, and nickel. Scientists from Woods Hole are now beginning to feel, as a result of their work on the structure of the nodules, that the nodules may have an organic rather than an inorganic origin.

Now, these are things we don't understand; the production and the concentration of materials like manganese, nickel and cobalt in nodules, rich in these and other materials in this part of the periodic table, are difficult to understand, in terms of mechanism.

Mr. MILLER. When I was out at Scripps they gave me a shark's tooth that was taken out of one of these nodules. Whether it is the usual thing, whether it had to have something to build itself around or not, I don't know, because it was purely incidental; they were showing them to me, and picked one out of the tray and gave it to me. They had to break the manganese away from the tooth.

Dr. WAKELIN. Yes.

Mr. MILLER. Of course, I was anxious to get the tooth because there is a popular song now about the sharks having white teeth. These 60 million years old were a little bit yellow to me. [Laughter.]

You also mentioned the matter of the disposal of low-level atomic waste. This is a matter that is of concern and I don't want to go from one committee to another, but one which has given us a great deal of concern.

Dr. WAKELIN. Yes.

Mr. MILLER. I imagine the low-level waste material going into the ocean now is inert by the time it gets there?

What is going to happen to it? I notice the Department of Defense has disposed of surplus or toxic gases, mustard gas, by taking it out and dumping it into the sea. In one instance they loaded a Liberty ship, took her out and sank her.

Do you feel the sea should be used as the dumping ground for the refuse of the land, and can it have an effect upon the biology of the sea if we continue this, to make it a refuse pile for those things we find on land that we want to dispose of?

Dr. WAKELIN. I think purely in the field of chemical, as well as atomic waste, that we generally don't know enough about the circulation of the oceans and the effect of these materials in their own environment, regardless of where they are being spread, to be able to tell, to be able to decide intelligently, where, if we have to dump them in the oceans, we should do it.

Mr. MILLER. I am happy to have you say that.

May I call your attention to the fact that the National Geographic magazine, a few months ago, had a story about some French oceanographers who had been hired by the Japanese Government to study some of the upwellings off the Japanese coast to see whether it was safe to dump atomic wastes there, and the answer was no. We don't known where these upwellings are coming on our coasts; we don't know enough about this subject yet, other than there is a wide expanse and this is a cheap place to dump it, take it out to sea and get rid of it; isn't that the attitude?

Dr. WAKELIN. And it is far removed from land. Right.

Mr. MILLER. Well, how far can you remove atomic waste from land when you don't know where the currents in the ocean will carry it?

Dr. WAKELIN. That is correct; you can't. Until both our static and dynamic studies are much more nearly complete in terms of the circulation of various areas, of even the Atlantic Ocean off of our own coast.

Mr. MILLER. In any event, we don't know. Ten years ago we didn't know there was a Cromwell current, did we?

Dr. WAKELIN. That is correct. That was discovered during the IGY, I believe.

Mr. MILLER. I believe it was the IGY. The Cromwell current is the one Dr. Brown referred to yesterday, but not by name, that runs from west to east, along the equator.

Dr. WAKELIN. Yes.

Mr. MILLER. And is as big as 1,500 Mississippi Rivers, they say.

Dr. WAKELIN. The rate of flow; that is right.

Mr. MILLER. The rate of flow?

Dr. WAKELIN. Yes, and this was one of the principal discoveries in the dynamics of the oceans resulting from the IGY.

The CHAIRMAN. The rate of flow of the Mississippi River now down toward the lower part of it is about, as I remember, about one and a half million cubic feet per second, up to 3 million cubic feet per second.

Mr. MILLER. This current I believe is about 1,000 feet below the surface of the ocean, maybe not quite that far, and it is nearly 200 miles wide, roughly 200 miles, and 1,500 feet deep. Figure that kind of a river flowing back.

Dr. WAKELIN. Yes.

Mr. MILLER. I am not a biologist, but every once in a while there showed up on the west coast of South America a species of fish particularly common to the east coast and people wondered how they got there. Now we are beginning to see they got into the current.

Dr. WAKELIN. Yes.

Mr. MILLER. Thank you, Mr. Secretary.

Dr. WAKELIN. Yes, sir.

Mr. MILLER. I want to congratulate you on a very forceful statement. I am familiar with the work of the Interagency Committee. I should tell the Chairman for the bill he is considering now, I have been on another committee trying to do the same thing; the reports were very unfavorable. I notice we haven't any reports in this bill, so this may interest you in passing.

Dr. WAKELIN. Thank you.

The CHAIRMAN. Mr. Fulton.

Dr. WAKELIN. Mr. Chairman, may I put in one remark?

The CHAIRMAN. Surely.

Dr. WAKELIN. I believe in regard to the questions you asked me about the submarines, I can answer them privately for the committee at your convenience.

The CHAIRMAN. All right.

Dr. WAKELIN. It is a question of military security.

The CHAIRMAN. Before you leave perhaps we will have an opportunity to go in for an executive session for a moment.

Dr. WAKELIN. Yes, sir.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. I would like to have a comparsion put in the record between the proposals of the National Academy of Sciences and their budget for the next 10 years, as distinguished from proposals of the Interagency Committee, so that we can see what the differences are, and what the difference in cost is.

Secondly, I would like to have put in a comparison between our program projected and what we know has been done in the past few years of the Soviet program and then a projection of the probability of what they will be doing based on the present gradient they have established. That is all.

(The information requested is as follows:)

*Comparison of fiscal year 1961 oceanography budget recommendations*

[Millions of dollars]

| Agency | Recommendation of NASCO [1] | Recommendation of ICO [2] | President's budget submission |
|---|---|---|---|
| Navy [3] | $28.830 | $40.511 | $22.919 |
| Commerce | 9.890 | 36.114 | 13.233 |
| Interior | 14.110 | 20.418 | 7.448 |
| Health, Education, and Welfare | 0.500 | 1.795 | .664 |
| National Science Foundation | 8.350 | 18.580 | 9.280 |
| Atomic Energy Commission | 2.950 | 2.810 | 2.210 |
| Total | 64.630 | | |
| Plus 1958 level of support | 23.630 | | |
| Comparative totals | 88.260 | 120.228 | 55.754 |

[1] The National Academy of Sciences Committee on Oceanography recommendations in 1958 dollars for costs over and above 1958 level of support for oceanography.
[2] Interagency Committee on Oceanography recommendations in 1961 dollars. High total is result of recommended ship construction.
[3] Not including military research and development.

## Comparison of United States and U.S.S.R. Projected Programs

The U.S. oceanographic capability can be measured in number of ships, scientists, and dollar support. At the present we operate about 52 ships and have about 500 to 600 professional oceanographers. The fiscal year 1961 budget for oceanography exclusive of ship construction is $36.6 million. By 1970 we expect to have increased the number of our oceanographic ships to about 85 or 90 and to have engaged about 1,100 or 1,200 competent scientists in oceanography. It can be expected that the costs for conduct of oceanographic research and surveys by 1970 will level off at approximately $85 million annually.

Although receiving greater emphasis since World War II, oceanography has undergone a marked expansion in the Soviet Union since 1955, following the announcement of its plans to participate in the oceanography program of the International Geophysical Year (1957–58). Theretofore, Soviet oceanographic research was limited mostly to the regions bordering upon the U.S.S.R., and scientific relations with foreign scientists were essentially nonexistent. Since 1955, the U.S.S.R. has displayed a large, modern research fleet second to none, has announced the construction of new research facilities, has operated its research fleet throughout the oceans of the world, and has organized a sizable manpower force to conduct oceanographic research. The period from 1955 to 1960 definitely has been one of acquiring facilities, manpower, and scientific data.

The Soviet oceanography program has been a survey effort to collect oceanographic observations of all types over broad geographic areas. (See attached chart of the IGY cruise tracks of Soviet ships.) The present research fleet of the Soviet Union to support this type of effort is comprised of a large number and variety of ship types ranging from small fishing vessels to the *Mikhail Lomonosov* (5,960 tons). It also includes the research submarine *Severyanka.* New vessels have been acquired almost annually for this fleet. Since 1957, the *Mikhail Lomonosov,* 5,960 tons; the *Severyanka,* 1,050 tons; the *Voyeykov,* 3,600 tons; and the *Shokal'skiy,* 3,600 tons, have been added. The rate at which new ships are being acquired probably will continue for the next several years. Other converted submarines for research and underwater research vehicles, such as bathyspheres and bathyscaphs, also are expected to be acquired and supplement the surface research fleet within the next few years. Soviet plans to construct a bathyscaph were announced earlier this year and bathyspheres have been used for several years.

Shore-based facilities also have been expanded and constructed during the past several years, mostly located in the Moscow area. However, plans to construct scientific bases for two oceanographic institutes were announced in 1958 and a branch of the Marine Hydrophysics Institute was opened recently in Kaliningrad on the Baltic Sea. Considering the distance from Moscow, and the Soviet effort that has been expended in the Pacific Ocean and bordering seas, the expansion and construction of facilities should be expected in the Far East during the next several years.

The number of Soviet oceanographers, excluding marine biologists and fisheries researchers, is greater than 500. The total of their professional oceanographers is estimated as high as 800 to 900. The greatest expansion of manpower probably took place when the Soviet Union expanded its program to participate in the International Geophysical Year. Many of the oceanographers are young and lack experience, a partial explanation for the placing of the great numbers of scientific personnel on the large ocean research ships. However, the quality of these young scientists should improve from the experience being gained from present shipboard research and the analyses of data collected since the International Geophysical Year. It seems that quality rather than quantity of scientists is now needed in the Soviet Union.

The present research effort is oriented toward applications. Even the basic research conducted at the institutes of the Academy of Sciences tends to be directed toward ultimate applications. The institutes subordinate to ministries direct their research to support the efforts of the parent organizations. Polar and deep sea oceanographic research are the strongest areas in the Soviet program. Continued and intensive scientific activity in arctic regions to develop the Northern Sea Route has achieved a leading position in arctic oceanography for the Soviet Union; and the operations of the research fleet throughout the oceans of the world have shown an impressive ability to collect oceanographic data. High quality work also has been conducted in biology and fisheries research, marine geology and seismology, particularly in conjunction with deep sea research. The work in other areas of oceanographic research generally has not been of comparable quality. There is no information available concerning their military research efforts in oceanography. As the oceanographers gain experience, the quality of the research should generally improve within the next several years.

It is generally conceded that the present size and the rate of expansion of the Soviet manpower and ships for oceanographic research are considerably greater than those of the United States, and possibly of the entire free world. Their oceanographic research, rated as excellent in some fields of the science, is generally not as scientifically comprehensive as that of the United States. During the IGY their effort consisted of a well-rounded, exploratory-type program to collect basic information about the characteristics of the seas and oceans of the world. It did much to increase the stature of the U.S.S.R. among the world leaders in oceanography as well as to provide scientific support for the Soviet economic and political aspirations.

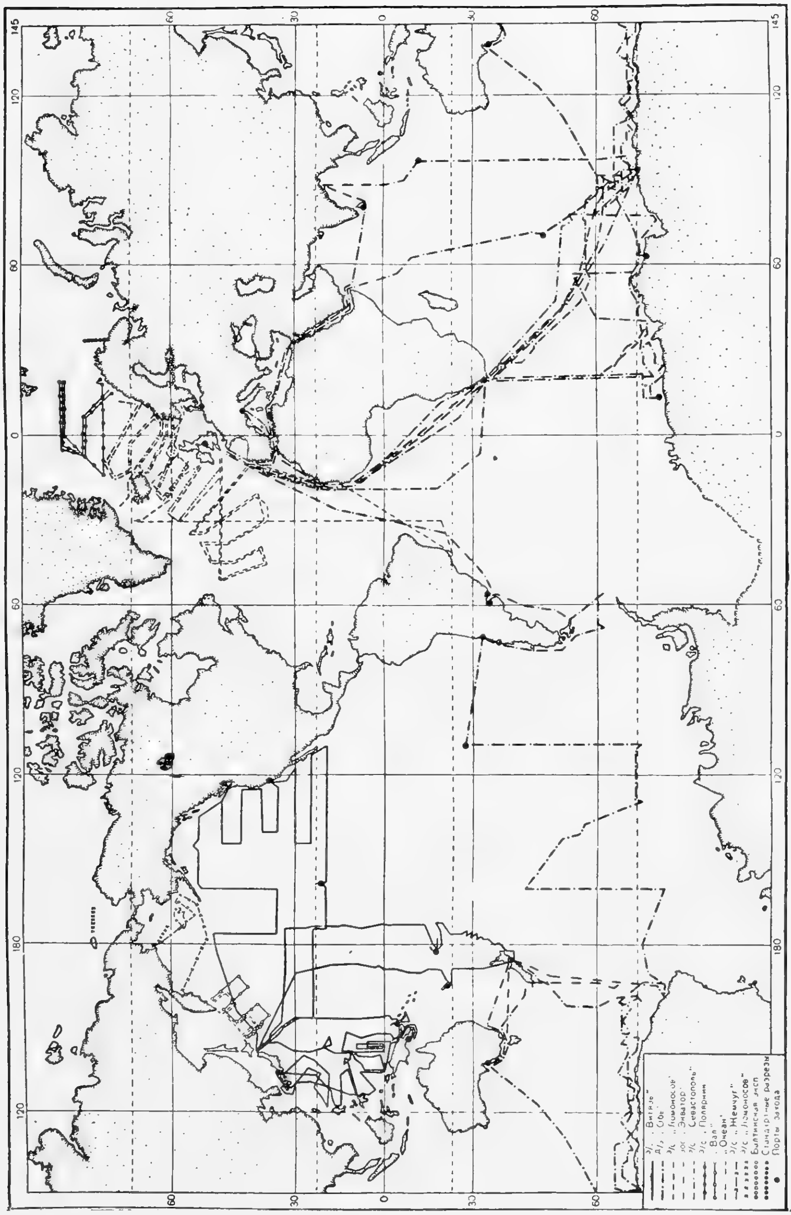

Схема океанографических разрезов, выполненных судами СССР по плану МГГ

*IGY Cruise Tracks of Soviet Oceanographic Ships*

The CHAIRMAN. Are there any questions? I am not going down the line, but does any member have a question?

Mr. Wolf.

Mr. WOLF. Has there been any international study made on the possibility of developing the mineral and oil rights below the sea? Who has jurisdiction and so on? Or is it a first-come-first-served basis?

Dr. WAKELIN. I am not sure I can answer that, Mr. Wolf. We can supply that for the record.

Mr. WOLF. That is all right. It doesn't have to be answered at this point.

Dr. WAKELIN. Would you like that supplied for the record?

Mr. WOLF. That will be satisfactory.

(The information requested is as follows:)

(*a*) There has been an international convention declaratory of international law in which it is recognized that the coastal state is entitled to construct and maintain or operate on the Continental Shelf installations and other devices necessary for its exploration and exploitation of its natural resources (art. 5, par. 2, Convention on the Continental Shelf).

(*b*) Jurisdiction over the Continental Shelf off the coast of the United States for purposes of exploration control rests by statute with the Department of the Interior, under terms of the Outer Continental Shelf Lands Act enacted on August 7, 1953 (67 Stat. 462). Regulations controlling the operations and leasing of these areas appear in the Code of Federal Regulations, 30 C.F.R. 250.1 and 43 C.F.R. 201.1.

(*c*) Article 5, paragraph 8 of the Continental Shelf Convention provides that "consent of the coastal state shall be obtained in respect of any research concerning the Continental Shelf and undertaken there." A review of records available in the Department of the Navy, as well as a review by representatives of State and Interior Departments, has revealed no international studies having been made to date under this provision of this convention concerning development of mineral and oil rights. The Legal Adviser's Office of the State Department informs that there was a preparatory document No. 20, dated January 3, 1958 (preparatory to the 1958 Conference on the Law of the Sea), which was prepared by Admiral Mouton of the Netherlands, at the request of the Secretary General of the United Nations. The title of the document is "Recent Developments in the Technology of Exploiting the Mineral Resources of the Continental Shelf." The foregoing was apparently an individual effort by Admiral Mouton rather than an "international study" by any group of representatives of the community of nations. This document was not published.

Mr. MILLER. At the third conference of the sea, there was recognition of the right of the people adjacent to the Continental Shelf, adjacent to the country, to have the oil rights, or have rights to the minerals, and that attached to the floor of the sea, but by contrast, in the sea itself, the fisheries, or the life in the sea, are viewed as international. That is in this last Conference on the Law of the Sea that Mr. Van Pelt and I attended as observers for the Merchant Marine and Fisheries Committee, what they tried to do was to limit this and we took a terrible beating as we didn't get the limits we wanted.

So we went back to the 3-mile limit, and it means now a uniform rule has been thrown out of the United Nations and every country can determine its own limits and hold them against anyone else. So if Ecuador wants to say it is going to go out 200 miles, the only way we can controvert is to go to war with Ecuador. This is the bad thing that has taken place at this conference of the sea.

This came out, a good deal of it was brought about by concern with the Gulf of Mexico, as to who was going to own the oil wells. We can prospect on the Continental Shelf, that is all.

Mr. Wolf. If we go beyond that, we are engaging—we would be raising the possibility of international conflict.

Mr. Miller. It is open sea, belonging to everyone.

The Chairman. We lost it by one vote, the limit to 6 miles, and 12 miles for fishing rights. One vote more would have established an international rule which would have recognized all nations out 6 miles as against our position which has been 3 miles.

Mr. Fulton. It should be commented on, it takes two-thirds.

The Chairman. That it right. It takes two-thirds to establish international law.

Mr. Wolf. On that same point, but off the subject of oceanography, last Monday at Cape Canaveral they made a point of the fact they would like to have the shelf extended a little for security reasons, for some of the work they are doing there.

The Chairman. My own State of Louisiana would like to have it extended further out for several reasons.

Mr. Wolf. I am aware of that.

Mr. Miller. But the thing that comes up now, suppose Mexico, who stood out very strongly and led the fight for a 12-mile limit, a 12-mile territorial limit, announces to the world that she now recognizes and is claiming 12 miles out. This would destroy part of the fisheries of Louisiana and Texas for the men who have to fish in these waters. We didn't want the 12-mile limit. We reluctantly accepted the 6 and 6 because even with the 6 and 6 the Pacific Northwest fisheries are going to be greatly embarrassed. The great salmon fishing area will practically be an inland Canadian lake. We can't go into that.

The Chairman. I don't want to go into that too far, but I would like to ask the Secretary an easy question: What would happen in the event Russia proceeded to demolish some of our oil and gas wells out beyond say the 12-mile limit, or suppose Russia came in and put in its own oil and gas wells?

Mr. Miller. I think the Secretary of State would be involved.

The Chairman. Maybe he has an idea on it, but at least it presents a problem of a hostile nation invading our own territories, and approaching our coastline to destroy property beyond the limits of this country as accepted by international law at this time.

Dr. Wakelin. I think if there were an interplay between what happened in the international region and something which was territorial to us, this would present a completely new problem.

The Chairman. Are there any further questions here? We don't want the Secretary to get out too deep here.

Mr. Wolf. May I suggest, Mr. Chairman, I would be grateful for whatever information you can make available to the committee in this subject.

Dr. Wakelin. Yes, sir.

(The information requested is printed on p. 56.)

The Chairman. Mr. Karth.

Mr. Karth. Mr. Secretary, I am sure you are aware of the fact that the Congress is economy minded and I appreciate the fact you are too, sir. With that, I would like to address myself to several questions relating to your testimony on page 4.

The last sentence of the first paragraph, you say, "I feel that this program provides for growth at a reasonable rate and that it satisfies the most critical needs," meaning I assume an absolute minimum requirement. Is that correct, sir?

Dr. WAKELIN. Yes, sir.

Mr. KARTH. In 1960 I notice the level of expenditures was $37 million; is that correct?

Dr. WAKELIN. That is correct, sir.

Mr. KARTH. What was recommended by the Navy for fiscal 1960?

Dr. WAKELIN. I don't know that I could answer that right here in terms of the oceanographic research program. With respect to what the Navy went in for on a requirements basis, and what actually resulted in the appropriation for 1960, I can supply that for the record if I may.

Mr. KARTH. If you would, please.

Dr. WAKELIN. Yes, I will.

(The information referred to is as follows:)

*Fiscal year 1960 Navy oceanographic program*

[Millions of dollars]

| Appropriation | Item | Fiscal year 1960 new obligations authorized |
|---|---|---|
| R.D.T. & E.N. | Oceanographic research | $11.230 |
| S.C.N. | One oceanographic research ship | 5.200 |
| O. & M.N. | Data handling and processing | 0.295 |
| Total | | 16.725 |

NOTE.—This table outlines the Navy's contributions to the national oceanographic program. Because of the peculiar character and classification of research and survey projects for military application, their funding is not included in the national oceanographic program.

Mr. KARTH. Can you answer this question? Was it less than what the Navy recommended?

Dr. WAKELIN. My offhand guess is it probably was not, in the field of research and surveys.

This work has been predominantly sponsored by the Office of Naval Research; work in this field has been well supported within the Navy itself in terms of both research and development.

Mr. KARTH. Was the $37 million for example less than was recommended by the Committee on Oceanography?

Dr. WAKELIN. Yes.

Mr. KARTH. Then in 1961——

Dr. WAKELIN. The National Academy of Sciences' report?

Mr. KARTH. Yes.

Dr. WAKELIN. Yes.

Mr. KARTH. In 1961, you are requesting $56 million?

Dr. WAKELIN. This is the total program.

Mr. KARTH. How does that compare with what the budget is recommending for that total program?

Dr. WAKELIN. I can speak only for the Navy on this.

The Navy program is $22.9 million. We requested an additional large oceanographic ship which was in competition with ships of the line, military vehicles, and we were only able to fund, to put in a request for one auxiliary general oceanographic research ship, an AGOR of 1,200 to 1,300 tons.

The request for support in oceanography comes in three different appropriational areas, and if I might address myself to those just briefly for your information:

The research and development area, of which the program of the Office of Naval Research is probably the largest component, is about $17.624 million.

The shipbuilding and construction program, which is under a different appropriation commonly referred to in the Navy as SCN, with which you are familiar, is not under my purview. Out of that comes $4.9 million for one AGOR.

There is another appropriation, "Operations and maintenance, Navy," from which there is a sum of $295,000 for data processing and handling, for a national data center.

Mr. KARTH. These are requests, Mr. Secretary?

Dr. WAKELIN. Yes, these are requests in the budget.

Mr. KARTH. The $56 million is more, however, than what is recommended in the budget, is that correct? Could you address yourself to that question?

Dr. WAKELIN. Well——

Mr. KARTH. Without being specific, is it more or less than requested in the budget for that program?

Dr. WAKELIN. Well, on the Navy's part, if I might address myself to that part of it first, the Navy's part is low probably by one AGS which is about $17 million—this is an oceanographic survey ship.

The distribution of requests in the 1961 budget among the agencies making up the $56 million, if I might give you those for your information, includes for the Navy $22.9 million; for the Department of Commerce, $13.2 million; for the Department of Interior, $7.5 million; for the National Science Foundation, $9.3 million; for the Atomic Energy Commission, $2.2 million; and for Health, Education, and Welfare, $664,000.

That makes a total of $55,754,000.

Mr. KARTH. Then if the budget recommendations are less than your minimum requests, I suppose I could conclude that the budget requests will not satisfy the most critical needs of our departments, is that correct?

Dr. WAKELIN. This is correct as a general statement, but I think that the problem actually arises in the construction of ships and facilities, rather than in research and surveys and data processing.

If I may expand on that just for a minute——

Mr. KARTH. What about the amounts? Of course, if you don't have the ships, you can't do the proper kind of research.

Dr. WAKELIN. Yes, this is correct.

Mr. KARTH. Irrespective of how much money you have in that particular category.

Dr. WAKELIN. Right.

The problem we are going to have over the next 10 years is going to become very critical in the 1962 to 1964 era because during that period we are not only required to replace overage ships that are included in the number of 52 that I talked to, but in order to augment our potential we will have to build additional new ships.

The funding of these is a major item in increasing our capability by 1970 to more or less double our present total oceanographic effort.

Mr. KARTH. The $17 million; Mr. Secretary, I think the chairman would probably like to give the opportunity to other members of asking questions. May we just put some of this in the record?

Dr. WAKELIN. Yes.

Mr. KARTH. The $17 million, as I understood you, was spent in the research end of this overall program.

Dr. WAKELIN. Yes, that is correct.

Mr. KARTH. Was that sufficient?

Dr. WAKELIN. Yes, that is entirely sufficient, yes.

If one plots the expense——

Mr. KARTH. On a long-range basis, if the needs for your ships are not satisfied, then you could not carry on this program to meet your critical needs, is that correct?

Dr. WAKELIN. In terms of new construction, yes. We would have to consider running the older ships for a longer period, or trying to find semisuitable conversions in the Navy reserve fleet to use.

Mr. KARTH. Thank you, Mr. Secretary.

Dr. WAKELIN. Right.

The CHAIRMAN. Thank you very much, Mr. Secretary.

If you would, I want to ask you to place into the record something additional about the need for more basic research. You refer to that as being needed in the program. You refer to several other things in your statement as needed, but basic research and scientific training are two.

If you could amplify that at your leisure, we would like to have that amplification in the record.

Dr. WAKELIN. Yes, sir.

(The information requested is as follows:)

### THE NEED FOR MORE BASIC RESEARCH IN OCEANOGRAPHY

In discussing the need for basic research in oceanography, one must carefully consider the definition of the term. Basic research seeks an understanding of things without concern for the practical application of the results for defense or economic exploitation. But history provides many illustrative examples of unexpected applications arising from research of the purest, most nonapplied character. That it is in the best interests of our Nation to increase our knowledge and to deepen our understanding of the world in which we live is sufficiently self-evident so as to require little more justification.

The National Academy of Sciences' Committee on Oceanography has identified many of the broad significant problems that are unique to the sea whose solution will require a major effort in the marine sciences. Generally, basic research in oceanography can be considered in five broad categories:

(1) History of the oceans: A study of the evolution of our planet is a most powerful means for studying the history of the universe. We can reconstruct the Earth's history and the fluctuations of the land-water-climate relationship through studies of the composition of the Earth's crust and the distribution of the sediments over the ocean basins and by studies of the intensities and variations of the magnetic and gravity fields. New tools and techniques can reveal much that has until now remained shrouded in mystery and speculation.

(2) Life in the sea: It is likely that animal life as we know it originated in the sea. Our present knowledge of its great diversity and richness, though extensive, is still very fragmentary. The many areas of basic research interest which may help fill the gaps in our knowledge of marine life include the structure of marine communities, the interdependence between species and their fluctuations in abundance, the role of microorganisms, the significance of migration of organisms in transporting materials, including radioisotopes from deep water

up to shallow water, bioluminescence, and the production of underwater sound and its use in recognition, communication, and animal migration.

(3) Motions of waters: The restless seas and how the ocean waters move have excited the imagination since the dawn of history. We have learned much about the great patterns of surface circulation and movement, but little is known about the enormous streams which flow along the bottom and at intermediate depths in the oceans. Upwelling, convergence and divergence, turbidity streams, the movements of identifiable water masses or cells within the larger body, are related phenomena whose study new techniques have now made possible.

(4) Ocean surface-atmosphere relationship: It is well recognized that the winds driving across the sea set the surface water in motion, create waves, absorb heat, take up moisture that later falls as rain, and in general modulate the climates of continents. The fertile fields of basic research which may help us to understand how these things happen include studies of the heat and water budget, of carbon dioxide interaction between water and air, of the transportation of salt and nutrients, of the birth of storms. Practically we hope that these may lead to more accurate long-range weather and sea condition predictions and possibly to weather modification and control.

(5) Coastal waters, estuaries, and rivers: These places, though far removed from the deep open oceans, are in continuity with them. A few of the problems the marine scientists are investigating include the interaction and consequences of the meeting of land and water, the geological and biological processes of the near-shore area, the mechanisms of sediment erosion, transportation, and deposition on the shelf and in the surf zone and the causes of destruction and buildup of the shoreline. There are many practical implications of research in inshore waters where most fish are caught and most pollutants are dispersed.

The CHAIRMAN. We could ask many, many questions more from you, sir, but we have one more witness this morning and we want to be sure to reach that one witness.

I think you have made an excellent statement and it certainly is what the committee wanted, and I think you can use some help as time goes on in the basic program, scientific and educational program, and things of that sort where the committee can really help you.

So we are glad to have your statement.

I didn't place in the record the biography of the Secretary here, but I would like to do it in the record, Mr. Reporter, so everybody will know the background that this distinguished witness of ours has with reference to education.

(The biography referred to is on p. 41.)

Mr. Van Pelt.

Mr. VAN PELT. Mr. Secretary, do any of our national academies—have they set up a program covering the subject which you were discussing this morning? I am thinking of Annapolis or the Merchant Marine Academy.

Dr. WAKELIN. You mean for training of personnel?

Mr. VAN PELT. For training, yes.

Dr. WAKELIN. Apart from—well, I don't believe so, for this reason: That oceanography is a composite of a number of basic disciplines, such as physics and chemistry and biology and geology. The training that has gone on in the Government-supported institutions at the undergraduate level is predominantly in the basic sciences as primary disciplines.

There are training programs at the University of California, at Scripps, which take not only high school and college students on a summer basis, but also go on to give the master's degree in oceanography. They all combine a whole group of studies in the basic sciences under the one subject cover of oceanography.

I am not aware of an oceanographic—any oceanographic part of the curriculum at the U.S. Naval Postgraduate School, for example, which I think would be the first place in the Navy where we would address ourselves to oceanography because then the undergraduates of the Academy would have had the proper training in the basic sciences, so they could broaden themselves into oceanography.

Mr. VAN PELT. That is all.

Dr. WAKELIN. I can supply anything we pick up for the record on this if you would like it, sir.

Mr. VAN PELT. Well, it might be interesting because we have a bill pending before the committee for the establishment of a national academy or scientific academy.

Someone might want to refer to that.

Dr. WAKELIN. Yes.

Mr. VAN PELT. That is all, Mr. Secretary.

The CHAIRMAN. That will be very helpful.

(The information requested is as follows:)

The U.S. Naval Academy offers two elective courses for academically qualified midshipmen:

Oceanography: 14 midshipmen enrolled.

Underwater acoustics: Eight midshipmen enrolled.

Postgraduate training is sponsored by the Navy as follows:

Oceanography at University of Washington (2-year course): one officer per year now, to be increased to five officers per year in September 1960.

Hydrography (geodesy) at the Ohio State University (2-year course): three officers per year.

Meteorology at U.S. Naval Postgraduate School offers basic course in oceanography related to meteorology: 35 officers per year.

The CHAIRMAN. Mr. Secretary, also we don't have time to ask you directly this morning, but these questions compiled by the staff are very important questions. If we could give you a list of these questions, there are eight of them, and if you could place the answers in the record it would help.

Dr. WAKELIN. Yes, sir.

The CHAIRMAN. Round out the entire record. I think it will be very useful.

I will give Dr. Sheldon the questions and he will give them to you in due course.

Dr. WAKELIN. Yes, sir.

(The questions and answers are as follows:)

1. Q. In what way will oceanographic research contribute to an improved antisubmarine defense for the United States?

A. The present antisubmarine defense for the United States is based almost entirely upon the use of underwater acoustics. This applies to open ocean surveillance, submarine detection, localization and classification as well as to the operational use of ASW weapons systems. Oceanographic research will contribute an improved antisubmarine defense by providing us with an understanding of, or a working knowledge of the following phenomena of the sea:

(*a*) Effect of wind on the water surface in producing ambient noise;

(*b*) Effect of sea state and swells in producing sound scattering, reverberation, and ambient noise;

(*c*) Effect of the thermocline, salinity, biological organisms, and internal waves on sound propagation and volume reverberation for sonar systems;

(*d*) Effect of deep velocity profiles on propagation of long-range sonar signals;

(*e*) Effect of the slope, roughness, and reflectivity of the sea floor on bottom reflection characteristics;

(*f*) Means to predict the thickness and temperature gradient of upper water layers to determine the propagation for surface sonar systems; and

(*g*) Effect of ice thickness, roughness, and composition on acoustic scattering and reverberation.

In addition, oceanographic research is required to explain many of the phenomena associated with nonacoustic methods of submarine detection now under study. It is anticipated that it will serve as the basis for understanding or for evaluating detection methods yet to be devised.

2. Q. (*a*) Does the Navy have an operational requirement for oceanographic research?

(*b*) Is it regarded as part of the ASW program and what priority does it enjoy?

(*c*) Could you trace the Navy's program in oceanography over the past 5 to 10 years?

(*d*) Do you believe that the Navy has catered adequately to military needs of oceanography in the past? That is, are there any military needs for scientific information of the sea that are going unanswered because of inadequate programs in the past?

A. (*a*) The Navy's program for basic research in oceanography is contained in the TENOC program (for 10 years in oceanography). This document describes the research supported by the Navy in nongovernmental laboratories and institutions. In addition, the Chief of Naval Operations has provided the technical bureaus with operational requirements for military systems in which oceanographic research is necessary.

(*b*) The oceanography program is included in the Navy ASW program and enjoys the same high priority.

(*c*) Since World War II the Navy has been the principal supporter of oceanography in the United States. Recognizing in early 1956 that the needs for knowledge of the oceans were increasing more rapidly than were the capabilities of the science, the Navy, with the Atomic Energy Commission and the Bureau of Commercial Fisheries, was instrumental in the establishment of the Committee on Oceanography under the aegis of the National Academy of Sciences—National Research Council.

In 1958 the Office of Naval Research prepared a long-range plan (TENOC) for the orderly expansion of oceanographic research to meet the extrapolated needs of the Navy. The Chief of Naval Operations approved the plan on January 1, 1959. In February 1959 the summary of recommendations for oceanography 1960–70 of the National Academy's Committee on Oceanography was promulgated.

The Navy is expanding the TENOC program to include aspects of military research and surveys, shipbuilding, and facility construction. National program coordination is now accomplished through the Interagency Committee on Oceanography established by the Federal Council for Science and Technology in mid-1959.

In terms of financial support, the Navy's funding for basic and applied oceanographic research has increased over the past 5 years as follows:

| | |
|---|---|
| Fiscal year 1957 | $6,076,000 |
| Fiscal year 1958 | 5,646,000 |
| Fiscal year 1959 | 9,391,000 |
| Fiscal year 1960 | 13,886,000 |
| Fiscal year 1961 | 17,724,000 |

These do not include funds expended for applied military research in support of weapons and weapon systems development.

(*d*) The most critical military needs of oceanography have been given every consideration by the Navy. However, as in many disciplines of science, we recognize that a more extensive basic research program over the past decades would have provided us with a better understanding of the complex oceanic environment. Obviously, better understanding leads directly to better utilization. The Navy's TENOC program formalized for the first time the Navy's needs in basic research in oceanography. It is under constant review and is being expanded to include all aspects of the Navy's oceanographic requirements including basic and applied research, military surveys, oceanwide surveys, shipbuilding and shore facility construction.

3. Q. (*a*) Do you subscribe to the contention of the Committee on Oceanography that the program should be accelerated from its present pace?

(*b*) The committee report recommends construction of a large number of oceanographic research ships and special underwater vehicles. What are the Navy's immediate plans in this regard? That is, what is budgeted for 1961 for ships or new vehicles and facilities?

A. (*a*) Yes, as we learn more about the characteristics of the oceans we find that there are even more characteristics about which we know very little. We should at least double our Nation's capacity to conduct research in oceanography by substantially accelerating our efforts in an orderly program during the next 10 years.

(*b*) In the fiscal year 1960 budget the Navy made provisions for the construction of its first ship specifically designed for oceanographic research. A second ship of this type will be constructed in fiscal year 1961.

The Reynolds Metals Co. is designing and constructing the *Aluminaut,* a manned deep research vehicle. It is designed to operate to a depth of 15,000 feet with safety and convenience and with sufficient range, mobility, and endurance to satisfy even the most demanding requirements for an oceanographic research vehicle. The Navy will initially assist in designing and providing for this craft its scientific instrumentation. The Office of Naval Research is considering a proposal to lease the vehicle through the Woods Hole Oceanographic Institution. Another program for a manned maneuverable undersea research vehicle is funded in fiscal year 1961. This craft will be used to investigate problems in oceanography concerning deep undersea military applications and to assist in the design and feasibility tests of hull, control, propulsion and other components directly applicable to undersea vehicles for research, submarines or for weapon systems.

There is no request for funds in the military construction appropriation for oceanographic facilities in fiscal year 1961.

4. Q. Does the Navy have an oceanographic research laboratory of its own? Do you believe that such a laboratory should be established to enhance inhouse capabilities?

A. The Navy does not have an oceanographic research laboratory, per se, of its own. It is not believed that such a laboratory would enhance the Navy's inhouse capabilities. Approximately three-fourths of the Navy's basic research program is conducted by contract with universities and nonprofit institutions. The remainder is conducted in Navy-operated laboratories, such as the Navy Electronics Laboratory and the U.S. Navy Underwater Sound Laboratory.

5. Q. What is the Navy's budget for oceanographic research for 1961, divided between basic and applied? How do the funds for basic research compare with those of last year? What percentage of funds made available for oceanographic research have been left to the discretion of the research investigator?

A. The Navy's budget for oceanographic research for 1961 can be divided into several categories. The research, development, test, and evaluation portion amounts to $17,724,000. The applied military oceanographic research necessary to support instrumentation development and weapon systems will require $9,940,000. Programs in closely related areas of study such as the Arctic, hydrobiology, and coastal geography programs amount to $2,005,000, and overlap the field of oceanography to some extent. The total sum of these categories is $29,669,000. This does not include the cost of construction of research ships.

Of the total $29,669,000 to be spent for oceanographic research by the Navy in fiscal year 1961, $9,379,000 or about 30 percent will be used for basic research. This is an increase of about 20 percent over the funds expended for basic research during fiscal year 1960. The remainder will be used for the various applied research programs.

All of the basic research funding (30 percent of the Navy's total oceanograhpic research budget) is left to the discretion of the research investigator. The only limitation placed on these funds is that the investigator must specify his research program before the contract is written. Even in this case, he need only consult with the Navy scientific officer and acquire concurrence if he discovers promising new areas of research that he wishes to pursue during the course of his investigations.

6. Q. Do you feel that oceanography offers the same potential in scientific achievement as an element in international affairs as has outer space? If so, how do you believe this program can best gain emphasis? What do you think the Congress should do to underscore the importance of oceanography in terms of our scientific capabilities and in terms of its relationship to international affairs?

A. The oceans represent the last frontier on Earth of a truly international character. They are indeed analogous to outer space, and hence our endeavors in this area should command the same importance in international relations as our efforts in outer space. Perhaps for the immediate future, with mankind's needs for foods and minerals from the oceans, commerce on the seas and the military requirements of the free world, the oceans may be of greater importance internationally than outer space. The United States is now one of the leaders in oceanic research and in developing international cooperation in the study of the sea, but this leadership is being challenged by the Soviet Union. In order to maintain our international leadership, we must have a well-coordinated national program and by cooperation with other nations take the fullest advantage of the potentials of the sea.

The Congress can assist in emphasizing the importance of oceanography in international affairs through its continued interest in the marine sciences as has been evidenced in the past with its hearings and legislative actions.

7. Q. (*a*) Who makes decisions within the Navy with regard to relative emphasis of research programs?

(*b*) What criteria are used for evaluating their relative merits and significance?

(*c*) By what procedure can a new program of increasing importance be accelerated, recognizing that it may be at the expense of other existing programs? That is, at management levels, what process of review is employed to evaluate the payoff of research programs and thus to accelerate those showing greatest promise or representing greatest need or arrest those which fail to bear fruit?

A. (*a*) Decisions within the Navy with regard to relative emphasis on research programs are made by the Assistant Secretary of the Navy for Research and Development upon advice of the Chief of Naval Research and the Deputy Chief of Naval Operations for Development. The Chief of Naval Research is responsible for the conduct and coordination of naval research and exploratory development in augmentation of and in conjunction with the research and development programs of the technical bureaus and offices of the Navy. The Deputy Chief of Naval Operations for Development, who represents the Chief of Naval Operations, is responsible for the coordination and integration of the research, development, test, and evaluation program of the Navy to insure that the total effort is continuously responsive to long range objectives, immediate requirements, fiscal limitations, and advancing technology. The DCNO(D) is Chairman of the Navy Research and Development Review Board. Advice from two additional groups is available to the Assistant Secretary of the Navy for Research and Development. The first is the Navy Research and Development Committee composed of representatives from the Office of the Chief of Naval Operations and the technical bureaus and offices. The second is the Naval Research Advisory Committee, a group of distinguished civilians from industry and universities, which was established by Congress to advise the Secretary on the broad aspects of the Navy's research program.

(*b*) The criteria used for evaluating the relative merits and significance of basic research programs are: a critical assessment of their potential contribution to increased knowledge in fields of interest to the Navy; validity of the approach; results of prior related work; probable impact on Navy technology and operations; and the competence of the principal investigator.

(*c*) A new program of increasing importance can be accelerated by reprograming (funds, manpower, and facilities), and augmented funding by emergency funds or otherwise.

Reviews of research programs are both formal and informal. Informal reviews by management personnel with working level personnel are on a continuing basis. Formal reviews are conducted as a result of periodic reports such as the annual technical progress report on each project, report of significant accomplishment, etc., and a detailed review is made annually of the research, development, test, and evaluation program submissions for conformance to the guidance contained in operational requirements and annual program objectives. It must be realized that the payoff on research programs is not always immediate or even immediately obvious, but often forms a background of knowledge for future effort or application. Furthermore, the realization of some new and important scientific or technical discovery or breakthrough often follows a large amount of seemingly unproductive effort.

8. Q. (*a*) Could you describe present mechanism for interdepartment cooperation?

(*b*) Does the coordinating committee for oceanography control funds or exercise any line responsibility over oceanographic programs?

(*c*) Does it plan any Government-wide programs jointly and, if so, are copies of such a program available?

(*d*) Can you give examples of how the committee coordinates requests for funds and uses of facilities?

A. (*a*) The Interagency Committee on Oceanography is a permanent mechanism of the Federal Council for Science and Technology with representation from the Department of Defense, Department of Commerce, Department of Interior, Department of Health, Education, and Welfare, National Science Foundation, and the Atomic Energy Commission. The purpose of the Interagency Committee is to implement, coordinate, and review the national program in oceanography. The Committee meets periodically to review the individual agency programs in the context of the national effort and to consider special problems that may arise in implementing the national program. The Committee has been enjoined by the Federal Council to consider other matters it deems relevant and important and to include additional agency representatives where this may be required or helpful.

It will engage in coordinated budget planning for fiscal year 1962. Of primary concern to the Committee is the development of a program which provides for reasonable increase in our national capability when faced with the critical limitations on scientific manpower, funds, and leadtime for the construction of ships and shore facilities.

(*b*) The Interagency Committee does not directly control funds nor exercise direct line responsibility over individual oceanographic projects. Each member of the Interagency Committee holds a position of policy and budget responsibility within his parent agency. The agency representatives were selected at this level to permit them to be able to commit their agencies in the coordination of the national program.

(*c*) The Interagency Committee has not to date planned a Government-wide project or program. However, the Committee has established two working panels for specific purposes. The function of one panel is to plan and coordinate our ocean survey program. A second panel has the responsibility for working out details for planning and the policies for joint operation of a national data center. Additional panels are being considered—one for training and education, one for basic research, and possibly one for special devices and instrumentation.

(*d*) The development of the fiscal year 1961 budget required that the Interagency Committee review the individual programs and needs for funds of the principal Government agencies concerned with oceanography. The total funding requirements were presented to and endorsed by the Federal Council for Science and Technology concurrently with their submission in the President's budget. In the short time it has been established, the Committee has not had to consider coordination among the agencies of the use of facilities. In the development of the budget for fiscal year 1962, each agency's program and the national program as a whole will be reviewed critically by the Committee for balance and technical validity. The Committee expects to seek endorsement of this consolidated program and budget from the Federal Council for Science and Technology and approval from the President before presenting it to Congress in the form of a package containing the complete national program in oceanography.

The CHAIRMAN. We want to thank you very much. Do you have something further to add?

Dr. WAKELIN. I have something to add in reply to your question, sir, and it is qualitatively as I have given it to you, but this information may be of interest.

In terms of the Navy there are two officers at the University of Washington working for master's degrees, two at the University of Washington, in Seattle for doctor's degrees. There are 76 at the U.S. Naval Postgraduate School in Monterey working in the field of aerology and getting some training in oceanography, but this is not a primary function of that particular part of the curriculum.

Mr. VAN PELT. Thank you.

The CHAIRMAN. We want to thank you for being here this morning, Mr. Secretary, and appreciate your fine testimony.

Dr. WAKELIN. Thank you, sir. I was happy to be here for the commencement exercises also.

The CHAIRMAN. Off the record.

(Discussion off the record.)

The CHAIRMAN. If there are no further questions then I want to make the announcement here which our technical director has given me.

At 2 o'clock today in this room there will be a private filming for our members and the staff by the National Academy of Sciences, two of 20 minutes each—there will be two films. One is on ocean sciences, and the other on satellites.

Dr. Hugh Odishaw will provide the commentary on both of them. All of the members that can—I know we are pretty hard at work and everybody has his problems this time of the year—but whoever can attend, we would appreciate their coming.

Let's see now, we have another distinguished witness this morning, Dr. James E. Lipp, director of development planning of the Lockheed Aircraft Corp., Burbank, Calif.

Mr. MILLER. Mr. Chairman, before Dr. Lipp starts, I think it would be fine if we placed the biographical record of Secretary Wakelin in the record. I suggest that of Dr. Lipp also, who is before us, and that the biography of Dr. Harrison Brown, who testified yesterday, that they all be made a part of the record.

The CHAIRMAN. I think that is an excellent suggestion. If there is no objection then, we will place those in the record also.

(The biographical sketches for previous witnesses referred to have been inserted at the beginning of the testimony of each witness. The biography of Dr. Lipp is as follows:)

BIOGRAPHY OF DR. JAMES E. LIPP, CORPORATE DIRECTOR OF DEVELOPMENT PLANNING, LOCKHEED AIRCRAFT CORP.

Born: July 3, 1910, Washington, D.C.

Education:
- California Institute of Technology, Pasadena, 1928–32, B.S. in aeronautical engineering.
- California Institute of Technology, Pasadena, Graduate School, 1932–35: M.S. in mechnical engineering, 1934; Ph. D. in aeronautics, 1935.
- Boeing School of Aeronautics, Oakland, 1933.

Professional record:
- Kinner Airplane & Motor Co., about 1931.
- Douglas Aircraft Co., Santa Monica, July 1935 through October 1948.
- The RAND Corp., Santa Monica, November 1948 to July 1955; chief of missiles division.
- Weapon Systems Evaluation Group, Office, Secretary of Defense, 1949–50; on loan.
- Lockheed Aircraft Corp., Burbank, August 1955 to present; now corporate director of development planning.

Advisory activities:
- Member, Technical Advisory Panel for Aeronautics, Department of Defense. Was chairman of ad hoc group to study STOL and VTOL aircraft.
- Member, Panel on New Devices for Undersea Exploration, National Academy of Sciences.
- Member, Technical Advisory Group, Space Weapons Panel, Air Proving Ground Center, ARDC, Eglin Air Force Base, Fla., September 1957–59.
- Consultant, Air Force Scientific Advisory Board, Aircraft Panel, July 1956 to June 1957.

In 1957 represented the Department of Defense on mission to Paris and Madrid, concerning MWDP program for Spain.
Chairman, NSIA Panel on Navigation and Oceanography.

Professional memberships:
Tau Beta Pi (honorary engineering fraternity).
Sigma Xi (scientific society).
Institute of Aeronautical Sciences (associate fellow).
American Rocket Society.
Association of the U.S. Army.
Atomic Industrial Forum.
American Management Association.
Air Force Association.
Navy League of the United States, Civilian Wing.
International Oceanographic Foundation.

The CHAIRMAN. Dr. Lipp, not to cut you off, we will ask you to proceed with your statement.

## STATEMENT OF DR. JAMES E. LIPP, DIRECTOR, DEVELOPMENT PLANNING, LOCKHEED AIRCRAFT CORP., BURBANK, CALIF.

Dr. LIPP. My name is James E. Lipp, director of development planning of the Lockheed Aircraft Corp. I am a member of the National Academy of Sciences Panel on New Devices for Exploring the Oceans, and chairman of the National Security Industrial Association's Task Group on Undersea Navigation and Oceanography.

### INTRODUCTION

An opportunity to appear before this committee is a distinct honor and privilege which I sincerely appreciate. If this short presentation, or my answers to your questions do not appear adequate, I shall be glad to collect and send to you any supplementary information which you request.

The CHAIRMAN. May I interrupt you and ask you a question at that point?

On page 10 of the statement made by the preceding witness he referred to the fact that a certain panel has the responsibility for working out details for establishing the policies for operation of the National Data Center. We are considering additional panels, he says, and one possibly for special devices and instrumentation. Is that what you had in mind?

Dr. LIPP. No, sir. This panel has been in existence for over a year, and it wrote chapter 7 of the committee report which you have probably seen.

Although man and his ancestors have lived in, on, and around the world oceans since primeval times, there seems to be something special about the second half of the 20th century in man's technical progress relative to the sea. Scientifically inclined nations recently have been making an organized, all-around exploration of the human environment; witness, for example, the major Antarctic operations and the rush into outer space. More specifically, there is a growing realization that the oceans are coming within our grasp for major technical exploitation, and that the benefits to be obtained from them can be enormous.

The purpose of this talk is primarily informative to give your committee a view of some engineering efforts to take practical advantage of the sea today or within the next few decades.

I should like to subdivide the field of ocean development into half a dozen parts and handle each very briefly. These are; naval weapons, underwater transportation and communication, fresh water conversion, mining or chemical extraction of minerals, food production, and finally research activities.

## NAVY TRENDS

I am sure that you are all aware of the revolution that is now taking place in undersea warfare. Nuclear propelled submarines and the Polaris missile system are but two outstanding examples. Parallel advances are being made in methods of detecting and destroying enemy submarines, in underwater communications and navigation. The significance of these developments is that the U.S. Navy is moving toward operation in the full depth of the ocean, freeing itself from the shallow zone of a few hundred feet to which it has been constrained in the past. Development work directed and sponsored by the Navy is of such scope and importance that I could not presume to describe it all here today. Of course, most of the Navy budget, running into billions of dollars, is devoted to operating in and on the oceans.

## TRANSPORTATION AND COMMUNICATION

However, there will surely be many peacetime commercial and industrial activities which will gain impetus from the Navy program. As one example, advances in structural materials, submarine hull design and powerplants are steadily bringing us closer to an economical cargo submarine. The chief advantage of this type of craft lies in relative immunity to heavy weather or destruction by enemy submarines. Also, the drag of a submerged hull tends to be lower than for a surface vessel, so that ultimately a lower operating cost should be attainable. I can visualize a tractor-trailer combination in which the powered tractor can be kept in continuous use, like a locomotive, while the trailer hulls are tied up for loading. This development, in turn, will give rise to new kinds of shore facilities for efficient loading and unloading. Although various studies of cargo submarines have been made, I am not aware of any development projects. The present studies do not justify this type of craft economically for general cargo handling; however, I think it is only a matter of time until vessels for special applications are developed.

Another form of undersea transport is the pipeline. A study is being made in Europe of a gas pipeline from North Africa to southeastern Spain. That project undoubtedly is the forerunner of a network of pipelines across narrow seas and straits all over the world. As one example, the Suez Canal will cease to be a critical bottleneck to the free world if this technique is developed.

We must not overlook the pipeline for human traffic—that is, the tunnel. About a month ago, a formal proposal was made to the Governments of Great Britain and France for construction of a tunnel beneath the English Channel from a point near Dover to Calais, an underwater distance of about 20 miles. This is actually a renewal of an attempt to build such a tunnel about 85 years ago. Generally, the pressure of increasing traffic and the financial success of toll road operations should help revive the demand for underwater tunnels in places where bridges are not practical.

Underwater communications probably will be used on a modest scale and in special situations since radio has overtaken the underwater cable for general transoceanic use. For example, undersea cables may be useful in and across the Arctic where magnetic disturbances seriously affect most other forms of communication. The nuclear-powered submarine now gives us the technical capability to lay a cable beneath the Arctic ice if this becomes desirable. Some day in more peaceful times, we may see a substantial network of direct undersea communication between the United States and Russia across the polar region.

### FRESH WATER CONVERSION

Conversion of sea water into fresh water is one of the outstanding areas of technical development today. Several methods are physically practical so that the chief problem is to reduce operating costs to a competitive level with natural sources of fresh water. At present the Department of Interior's Office of Saline Water is sponsoring five pilot plants, each working on a different principle and all located in different parts of the United States.

One such plant will be located in southern California, will consist of a nuclear reactor as a source of heat, and will distill fresh water from sea water at a rate between 1 and 2 million gallons per day. Others will use freezing or electrical methods of removing impurities.

Implications of this line of development are tremendous, since new areas of the world may be opened up for settlement and improvement. Nuclear power will give impetus to the whole movement, not only in yielding process heat, but also as a source of power in pumping water uphill from sea level to the consumer.

### MINING AND CHEMICAL EXTRACTION OF MINERALS

Thus far, undersea mining has been accomplished most extensively by the oil industry. The technical skill and daring which has been displayed by that industry is one of the engineering feats of our time. Oil is a logical subject for undersea exploitation because it is easier to locate and handle than solid minerals.

The latter, mining of solid materials from the ocean floor is beginning to resemble offshore oil drilling. The Grand Isle Sulphur Mine in the Gulf of Mexico will soon operate from a very large and elaborately equipped steel tower structure. Among other noteworthy features, the plant will use hot seawater in the process of melting and handling the sulfur. Also, the hot sulfur-bearing liquid is transported 7 miles to shore through a heated pipeline.

Development of other undersea mining is still largely exploratory. Perhaps the next step will be to recover manganese and cobalt from the so-called manganese nodules which have been discovered in large numbers on the ocean floor.

We now turn to a different type of mineral exploitation; namely, the extraction of minerals directly from sea water.

For the past decade, the outstanding examples of mineral extraction have been magnesium and bromine, both of which are largely obtained from sea water. These processes were developed during World War II, but have since proven their economic worth. An interesting sidelight of the magnesium process is that it employs lime made from oystershells.

Further development in this area depends considerably upon the availability of cheap process heat and power. Fortunately, we are approaching the day when chemical mineral extraction can be made a byproduct or accessory of the fresh water conversion process using the atomic reactor as an energy source.

## FOOD PRODUCTION

Food production in the oceans is another vast resource which lies awaiting our call. At present the United States has an agricultural surplus and a considerable amount of marginal untilled land so that talk of a greater food supply may seem academic. But the population trend, both in the United States and worldwide, is strongly upward; and our present excess of food surely will be overtaken within a few decades. Present efforts at fishing, seaweed reduction and the like will pale by comparison with the future effort. I can visualize the systematic husbandry of fish, whales, and other sea animals on a scale far to exceed our present cattle industry, including scientific breeding feeding, pest control and all the rest.

Likewise, vegetation in the sea will be developed and formed on a large scale for human consumption. Note that these activities like mineral extraction, will be performed anywhere in the world, wherever the need exists, and the distinction between fertile versus sterile agricultural areas will tend to be reduced.

Note also that ocean farming will avoid the need for elaborate irrigation projects or short-term dependence on the weather. Prototypes of future ocean farming equipment are to be found today in kelp harvesters and floating factories for extracting whale oil.

## DEVICES FOR UNDERSEA RESEARCH

My last area for attention is undersea research. You have already heard a description of the overall research needs from Professor Brown, so I shall confine this discussion to engineering aspects. Much of the acceleration of oceanographic activity has depended upon, or been accompanied by, new devices for exploring the oceans. To mention a few: the scuba, or "Aqualung" has enabled thousands of people to rediscover the other world that lies at our doorstep and scientists to see and feel the underwater habitat; the bathyscaph has carried man repeatedly to the greatest depths in prosaically reliable fashion; buoys of all kinds and remotely operated instruments have facilitated the measurement of ocean characteristics. What steps will or should come next?

There must be a mid-depth type of vehicle or mesoscaph, to operate at depths of 15,000 to 18,000 feet, to have good maneuverability and a substantial scientific payload. Special accessories such as remote handling and grasping devices will be needed. In my view, about a dozen such craft are desirable, since roughly half the geographic area of the world will fall within their capabilities. These are technically feasible now.

Bathyscaphs should be improved as to payload and maneuverability to explore the very deep parts of the ocean. Three or four of these are desirable within the next several years. A moderate amount of practical research and new design will be required for the best results.

A number of fixed habitable underwater laboratories should be emplaced in different parts of the world, and at different depths, to enable scientists to conduct underwater experiments in deep water. I am not familiar with all of the technical problems involved, but some undoubtedly will prove difficult.

Substantially increased shore facilities are essential, especially for systematic, rapid data handling, reduction, and publication. Here a single large facility may be better than several small units.

The more conventional devices such as surface research ships, instrumented buoys, survey and utility aircraft and various instruments must be multiplied and made easily available to the research community. And perhaps most important of all, funds will be needed to support the continued operation of these devices after they are once provided.

In my opinion, the estimate of the Committee on Oceanography—and here I am speaking purely as an individual—that the research effort can double in 10 years and reach a level about one-tenth of our present space effort, is very conservative.

That estimate is based on the rate of training of new oceanographers, yet I am reminded of the space program which in a few short years has exploded from essentially no effort into a major profession.

This has been done by drawing on industry for scientists and engineers, and can be done again in developing the oceans. It is only necessary to provide the same kind of funding and priorities that have been given to the space program.

A discussion on engineering and research devices would not be complete without mention of the Mohole. This is a project, under the National Academy of Sciences and National Research Council, to drill all the way through the Earth's crust, for geological and geophysical study. The attempt will take place in the ocean since the crust is thinner there than on land.

There is roughly 15,000 feet of rock to drill through underneath roughly 15,000 feet of water. Extensions of present deepwater drilling techniques appear promising, and we expect to see the initial test drilling started within the next several years.

In addition to some great advances in scientific knowledge, the project will result in substantial improvements in oil drilling technology.

My motives in favoring such research devices are twofold. First, I agree with the need for an accelerated basic research program as a foundation for future progress in the sea. In addition, however, the engineer, as well as the scientist, must become familiar with the new environment and thereby learn how to exploit it and behave in it. He must encounter turbidity flows, stress corrosion, thermal layers, and a hundred other problems in the full scale environment before he can design a workmanlike production machine or process.

The total scientific and technical competence of the United States can be described in billions of volts, billions of light years, and certainly in billions of dollars. It seems inevitable that we shall focus an increasing fraction of these talents on a third of a billion cubic miles of salt water.

I have collected several reports and magazine articles which I shall leave with Dr. Sheldon after the meeting. The subjects covered in them are: the tunnel beneath the English Channel, the sulfur mine in the Gulf of Mexico, magnesium and bromine extraction, and the Mohole.

Thank you very much.

The CHAIRMAN. Doctor, you have a very illuminating and imaginative statement which we appreciate very much.

You referred lastly to sulfur mining in the Gulf of Mexico, but that is not entirely new, is it? There are sulfur domes in the Gulf of Mexico which have been known for 40 years, and they have done marginal development; isn't that right?

Dr. LIPP. It is my understanding the previous work was done in what you would call swampy areas near the shore. This facility——

The CHAIRMAN. Close to land?

Dr. LIPP. Yes, sir. The facility to which I refer is located well out to sea, is a $30 million installation and is really going to be an elaborate sea-based operation.

The CHAIRMAN. That is a city they are building out in the sea?

Dr. LIPP. Yes, sir.

The CHAIRMAN. It is four or five blocks long there, with stores, housing, and everything in it. Is that what you mean?

Dr. LIPP. Yes, sir.

The CHAIRMAN. Now, that is true.

You refer to the fact that this drilling into the bottom of the sea will give us means of improved recovery of oil.

Actually it will undoubtedly open up new oilfields, too, in the marginal sea, perhaps out in the depths of the sea. Is that right?

Dr. LIPP. Yes, sir. The oil companies are helping sponsor the Mohole program by furnishing or lending ships and equipment and advice to it, simply on a basis that it will improve their own techniques for developing new oilfields.

The CHAIRMAN. That is a private enterprise, isn't it?

Dr. LIPP. I think it will end up by being a mixture of private enterprise, foundation money, and perhaps even some Government money.

The CHAIRMAN. At the present time though it is largely a private investment—a private enterprise proposition, isn't it?

Dr. LIPP. That is correct, I believe.

The CHAIRMAN. With reference to the chemical plants, you referred to the use of sea water and shells from the ocean and the beaches. That is already in existence there?

Dr. LIPP. That is true. The Dow Chemical plant has been in existence down on the gulf since World War II.

The CHAIRMAN. They use the seashells there for chemical purposes. They use the water too from the gulf for the extraction of chemicals.

That would fit into your program of distillation of water from the ocean.

Dr. LIPP. Yes, sir.

The CHAIRMAN. That would make it much more economical for us in the West where they need water so badly, they can make it more economical to produce it. That is correct, isn't it?

Dr. LIPP. Yes, sir.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Dr. Lipp is knowledgeable on more practical fields, but I think we better let some of that go for the time being because it involves some things we don't want to go into. I want to compliment the Doctor for a very fine statement.

The CHAIRMAN. I would have thought the gentleman would have alluded to his education there in California.

Mr. MILLER. I didn't do that because we have so many distinguished Californians before this committee we just take it for granted.

The CHAIRMAN. Mr. Van Pelt.

Mr. VAN PELT. No questions.

The CHAIRMAN. I think you have given us a very fine statement, sir. It is the type of statement that we might spend days and weeks developing because it covers many subjects, and subjects that need exhausting.

Mr. MILLER. Mr. Chairman, it seems if the committee is interested in the Mohole, the Subcommittee on Oceanography and Subcommittee on Fisheries, have heard it and we would be glad to furnish it.

The CHAIRMAN. I think it is nice to have reciprocity and on behalf of the committee will accept the invitation, Mr. Miller.

I think that covers the program this morning, Dr. Lipp, and we do appreciate your action in coming here.

Don't you envision in this development greater possibility for the raising of the standards of the peoples of the world by these innumerable developments you refer to? Isn't that true?

Dr. LIPP. I do, indeed.

The CHAIRMAN. Do you envision this will make more difficult the security of nations or less difficult?

Dr. LIPP. Do you mean in the sense of economic security or military security?

The CHAIRMAN. Well, you can't have one without the other.

Dr. LIPP. Improving the economics of many countries around the world will tend to stabilize affairs so that there will be less tendency toward military action.

On the other hand, greater knowledge about the oceans will help our own Navy in providing a defense for us.

The CHAIRMAN. But the use of the ocean beds, further and further out, will create a greater contention.

Dr. LIPP. There will certainly be legal problems, but we faced those before in fishing and so on, and have been able to solve them.

The CHAIRMAN. It will require a greater need of international cooperation within these fields.

Dr. LIPP. Yes, sir.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Doctor, you heard the earlier discussion about the disposal of atomic waste at sea.

Dr. LIPP. Yes.

Mr. MILLER. Using the sea as a garbage pit, do you subscribe to that?

Dr. LIPP. My reaction is the same as Dr. Wakelin's. We need to know more about this before we start getting careless with it.

Mr. MILLER. Do you think we have gone off a little bit halfcocked, when you take ships loaded with mustard gas out to sea and sink them to get rid of them, without knowing where this gas may go?

Dr. LIPP. I really don't know enough about mustard gas to answer that question.

My impression of the atomic wastes that have been dumped so far is that they are allowed to cool off very greatly, so there is not much radioactivity that has been thrown into the ocean up to now.

Mr. MILLER. But you know there have been plans, and there are plans to put high-level waste into the ocean?

Dr. LIPP. Yes, and I would go slowly with that.

Mr. MILLER. In your own committee, or the Committee of the National Academy of Sciences, released in its report—its report on the disposal of waste on the east coast and the gulf coast was released. It wasn't too well received in Congress. They are making additional studies on the west coast before they are going to do this, a study that was supposed to be in 6 months ago, but hasn't been filed as yet with us.

Dr. LIPP. I have not been very close to that particular panel.

The CHAIRMAN. I will say this if the gentleman will yield: It seems to me more and more you are going to have to be more guarded in using the seas for a dumping ground.

I wonder whether it was advisable for our people to take the silt out of the bed of the Mississippi River and dump it there into the Gulf of Mexico.

Mr. MILLER. You ought to make a bigger State out of the State of Louisiana.

The CHAIRMAN. It is a small, relative amount, but we lost that silt forever, perhaps, and it does affect the fishing generally in that section of the gulf, doesn't it? Don't you think so?

Dr. LIPP. I would guess so. An oceanographer could answer that question much better than I, however.

The CHAIRMAN. Doctor, we certainly thank you for coming here this morning and I want to remind members of the committee still here of the briefing at 2 o'clock if you can possibly make it. Dr. Lipp, I have some additional questions I want to leave with you which can be included in the record at this point, together with your answers.

(The questions and answers referred to are as follows:)

1. Q. What are the special difficulties of engineering operations under the sea as compared with those on the surface of the sea and how do these problems compare with those of, for example, establishing a manned station in space?

A. Operations under the sea are governed primarily by the great pressures and by the vulnerability of humans and devices to those pressures. Supplying air to people underwater would be relatively simple except that the human body is vulnerable to the "bends," to oxygen poisoning, and to narcosis when breathing air under pressure. Therefore all human operations more than a few feet below the surface must be protected structurally so as to approximate sea level conditions for the operators.

These problems are similar to those of operating in outer space, where protected breathing is likewise the most important problem. In outer space, the operator is also endangered by wide temperature changes, high energy radiation, and small meteors—hazards which are not found in the sea.

2. Q. The program recommended by the Committee on Oceanography visualizes financial support primarily from Government sources. Do you believe that oceanographic research can attract private venture capital?

A. Oceanographic research will attract private venture capital in those areas where a near future profit can be predicted; for example, in offshore oil surveying and drilling.

Other areas, like conversion of salt water to fresh water, will require subsidy for a few years until the processes or projects gradually can be made economical, at which time further improvements may well be sponsored by industry.

In still other areas, like the effects of the oceans on weather, a commercial profit is difficult to foresee, and the entire programs will require Government support.

3. Q. What kind of incentives could be established, perhaps through congressional legislation, that would encourage investment of private capital?

A. Investment of private capital could be encouraged in several ways.

(*a*) A sufficiently stable legal and tax environment for reliable planning by industry.

(*b*) Special weather forecasting, rescue, and other protective measures where needed.

(*c*) Favorable tax concessions or subsidies to encourage marginal industrial ventures. This requires, of course, provision for incentives to outgrow the need for such support.

4. Q. Is it practical to conduct exploration and production of oil in deep water? Why has there been so little industrial development in this direction?

A. Drilling of oil in deep water is now under development by the oil industry. Two ships have been equipped as floating oil derricks for drilling in water a few hundred feet deep. The chief technical problem is to hold the shop in an exact position in the face of wind, waves, and currents. One of the ships is being used for preliminary tests in the Mohole program with a view toward improving the techniques of deepwater drilling generally.

5. Q. Do you visualize the need for and practicability of research laboratories situated at sea, either as a floating platform or as a submerged research station? Would these have advantages over research now being conducted on ships? Do you know of any plans for such stations?

A. As indicated in my prepared statement to the committee, submerged research stations will be needed so that scientists can study the natural, pressurized environment. Although I did not specifically mention floating laboratories, they, too, will be desirable for making stationary observations of relatively long duration.

Of the two kinds of laboratories, the underwater variety will handle research that no ship can hope to duplicate. Ships could serve as floating laboratories, and often do. However, a ship is costly to operate and is relatively crowded for performing careful laboratory experiments.

Some floating laboratories are included in chapter 7: Engineering Needs, of the National Academy of Science's report on "Oceanography 1960 to 1970." I do not know of any projects underway to provide laboratories at sea.

6. Q. Would fixed undersea stations have any practical value as part of a system of antisubmarine defense?

A. Fixed undersea stations could be useful in an undersea warfare role. Considerable study would be required to analyze their justification in comparison with other kinds of antisubmarine systems. One problem would be the self-defense of the undersea stations against attack by the enemy submarine fleet.

Mr. MILLER. I could have made that singular, the member of the committee.

The CHAIRMAN. Well, there are two members.

The committee is adjourned until Tuesday morning at 10 o'clock.

(Whereupon, at 11:55 a.m., the committee was adjourned, to reconvene at 10 a.m., Tuesday, May 3, 1960, on another subject.)

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