UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

REPORT TO THE ALVIN REVIEW COMMITTEE

on

LONG-TERM SCIENTIFIC UTILIZATION OF ALVIN

A Workshop held at
Stanford University - 8 December, 1976

CONTENTS

Submitted by

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I. INTRODUCTION

On the 8th of December 1976, a workshop was held at Stanford University under the sponsorship of the University National Oceanographic Laboratory System (UNOLS) to discuss the long-range scientific utilization of the research submersible ALVIN. Those in attendance were a broad cross-section of past and future ALVIN users from the marine science areas of biology, chemistry, geology and geophysics. Also present were representatives from the Office of Naval Research, National Science Foundation, National Oceanic and Atmospheric Administration, and the U.S. General Accounting Office (see list of participants, Appendix A).

II. PROCEEDINGS

The purpose of the workshop and its anticipated objectives were to assess and define the necessity for an ALVIN program to effectively address significant scientific problems. (see agenda, Appendix B).

As an update on the overall situation of deep-diving submersibles in the United States, a brief history of ALVIN was presented, dealing with its major milestones, funding base, and the growth and changing emphasis of its users. Because of the potential impact the U.S. Navy submersible program might have on future science programs, a brief summary of the activities of the Navy's Submarine Development Group One was presented. It included a statement of (1) their present capabilities and in particular the diving limits of SEA CLIFF, TURTLE, and TRIESTE II, (2) their future plans to decommission the TRIESTE II, convert SEA CLIFF to a 20,000-foot diving capability, plus their needs for an improved surface support ship and (3) their recent history of providing limited scientific access to their submersibles.

Other items presented to the workshop were (1) possible long-range conversion of ALVIN to a 20,000-foot diving capability, (2) consideration of a continuous day and night diving operation, (3) the possible use of SEA CLIFF after its conversion to a 20,000-foot capability, (4) SEA CLIFF's potential involvement in a long-range, two-ocean/two-submersible program, (5) the possible involvement of other government agencies such as ERDA and USGS as well as other countries such as Canada and Japan in future utilization of ALVIN and the direction along which such international programs might proceed, and (6) the impact a well-defined submersible program might have on other technological programs now evolving within the marine science community.

Many workshop participants already had reviewed the initial draft copy of the "Report of the ALVIN Review Committee on the Continued Role of DSRV ALVIN". Those that had not, were given a copy for review. This document was discussed, with particular attention given to the sections on (1) problems that require submersibles in 1977-1980, (2) communications with scientific community, (3) future technical improvements, and (4) recommendations of the ALVIN Review Committee.

III. SCIENTIFIC PROBLEMS REQUIRING THE SUBMERSIBLE FOR ULTIMATE SOLUTION

Marine science has advanced at a significant rate during the past two to three decades and in many facets has progressed beyond the broad regional or reconnaissance stage. Marine geology and geophysics studies have defined the major structural and sedimentary characteristics of the ocean basins as well as provided a significant understanding of the processes active on and within the seafloor. Marine biological investigations have provided considerable insight into the distributions (both areally and vertically), metabolic rates, and life processes of a great many organisms.

Many aspects in both geological and biological studies have advanced to the point where little significant progress can be expected without achieving much higher degrees of observational resolution. Remote sensing by acoustic and magnetic techniques or by dangling various sensors on a wire from a ship have served to provide a sense of understanding of the general setting. The ability to attain the degree of resolution required by many facets of these programs, however, can be achieved only through the use of the unique characteristics of the submersible. There are a number of studies such as the detailed sampling of mid-ocean ridge strata (Project FAMOUS) or in situ metabolic rate studies (WHOI's deep ocean stations) which have readily shown that the submersible is the only effective means by which systematic advances will be made on certain problems.

As our need for improved resolution increases, the necessity to accurately position sensors, test chambers, and other assorted instrumentation becomes very critical. Here again, the manned submersible can provide the most trenchant means of attaining these positioning needs.

Participants felt that Table 1 in the draft ALVIN Review Committee Report place too great an emphasis upon the functionary aspects of the submersible to solve scientific problems rather than on the significant problems themselves. For that reason, it was decided to make two tables for this report with Table 1 listing those scientific areas of significance where researchers using ALVIN could make a major contribution. It is important to remember that this workshop addressed ALVIN specifically as opposed to submersibles in general, since ALVIN is the only submersible that presently has the diving capability, scientific instrumentation, and techniques to carry out the research programs discussed. Table 2 is similar to the draft ALVIN Review Committee Report and represents examples of specific programs which the submersible might undertake to solve the problems listed in Table 1.

TABLE 1

AREAS OF SCIENTIFIC RESEARCH ESPECIALLY SUITED TO STUDY BY SUBMERSIBLE, PARTICULARLY ALVIN
·Determining the volcanic, tectonic and plutonic processes associated with crustal genesis at spreading centers and the subsequent modifications of oceanic crust.
·Determining deformation and strain rates within the oceanic crust.
·Defining rates and recent history of marine weathering and erosion.
·Measuring heat and mass transfer associated with hydrothermal processes.
·Assessing normal temporal and fine scale variations in benthic and pelagic community structure and function, and delineating the responses of these communities to selected types of disturbances.
·Determining the metabolic rates and life history processes of selected organisms or entire communities.
·Determining the mechanical, chemical, and magnetic properties, and structures of the oceanic crust and upper mantle.
·Investigating small-scale hydrodynamic processes and their interactions with organisms and sediments.
·Determining rates of organic and inorganic mass transfer in the pelagos and benthic boundary layer.
·Delineating sedimentary processes on the deep seafloor.

·Determining the volcanic, tectonic and plutonic processes associated with crustal genesis at spreading centers and the subsequent modification of oceanic crust.

Geological and geophysical studies of the ocean basins over the past decade or two have greatly advanced our awareness of the tectonic and plutonic processes associated with the seafloor. These studies have provided documentation of the distribution and occurrence of these processes in a general or regional sense.

We are, however, unable as yet to answer such questions as: a) is the elevated region over a fast spreading center a true horst, or due to volcanic processes; b) are volcanic processes totally different at fast versus slow spreading centers; c) what is the local tectonic setting where a transform fault intersects the axial high of a mid-ocean ridge; and d) is volcanic and hydrothermal activity prominent at such an intersection?

Our level of understanding has now reached the point at which we cannot hope to advance significantly in these studies unless observations can attain an increased degree of resolution.

Past efforts have attained the data base from which we can now effectively move ahead to the high-resolution studies required to adequately document and understand these crustal processes. The need now, as has been done on land, is to literally "walk the outcrop", mapping and sampling the formations and tectonic features in sufficient detail to delimit the mechanisms, compositional and zonal characteristics, and relationships of the crustal features to activities occurring on the seafloor and impinging on the continents. The manned submersible provides the only means within the realm of today's technology to attain this degree of resolution in our studies.

· Determining deformation and strain rates within the oceanic crust.

Remote sensing by geophysical means and random sampling by various sensors or samplers lowered from surface vessels have readily revealed that deformation of the oceanic crust is a prominent process. The rates and manner in which these processes take place are only generally understood. We have the belief we are in the "ball park", but until more definitive measurements and detailed studies are made of critical sites, we are limited to our general impression of the rates at which crustal strain develops and later dissipates through deformation.

Much higher degrees of resolution in our measurements must be attained before we can hope to answer such questions as: a) what degree of change do strain patterns undergo when there is a transfer of motion from one plate to another or from the ocean to the continent; and b) what difference exists between the stored elastic energy of the oceanic lithosphere and that of the continental lithosphere?

Before significant advances can be made in seismological studies and possible prediction of earthquake activity, a means must be established wherein rates of strain in the oceanic crust can be determined with a considerable degree of accuracy. Precise geodetic measurements are required if the desired accuracy and detailed data are to be obtained. The submersible is uniquely suited to the task of selectively positioning geodetic systems at strategic locations on the seafloor.

·Defining rates and recent history of marine weathering and erosion.

The process of marine weathering--the physical and chemical breakdown of submarine strata, and the erosion rate of the resultant products are relatively little known. Other than realizing that these processes are prominent on the seafloor and that they impact significantly the basic compositional characteristics as well as the distribution of certain deep-sea sediments, little is actually known about the processes involved. Not only must the basic principles of the weathering process be understood, but the historical aspects must be resolved in order to interpret the significance of certain facies in seafloor deposits. The occurrence of distinctive mineral assemblages in deep-sea sediments and their importance in attempting to understand the formation and location of terrestrial ore deposits is heavily dependent on a knowledge of the source of these minerals and the manner in which they are concentrated in the sediment. Selective sampling is the key needed to adequately research the problem of marine weathering. Samples must be collected in an exacting manner to relate samples to samples as well as to the local physical and dynamic characteristics of the environment.

· Measuring heat and mass transfer associated with hydrothermal processes.

There is increasing evidence that hydrothermal systems extract and transport heat and metals from newly intruded or erupted oceanic crust and that this may be a fundamental process which influences the composition of seawater. Indirect evidence indicates that large concentrations of heavy metals evolve from the oceanic crust through hydrothermal systems and become deposited on or in the surrounding sediments and strata. The need for an understanding of this metal-enrichment process is paramount to gaining an insight into the problem of metallogenesis and the occurrence of ore deposits. Basic data such as thermal and chemical properties of such flows, rate of flow, rate of deposition and concentration of metals on and in the seafloor away from the hydrothermal vents, and vent morphology cannot be obtained in any meaningful manner from sensors dangled from a surface vessel. Here again, the submersible with its trained observer and selective sampling ability is essentially the only means by which the required data on this process can be adequately obtained.

· Assessing normal temporal and fine-scale variations in the benthic and pelagic community structure and function, and delineating the responses of these communities to selected types of disturbances.

Until recently, the deep-sea marine biologist has had two approaches available for the study of variations in the benthic and pelagic communities: a) extensive field sampling with various nets, trawls, grabs, and corers, the effectiveness of which is poorly known or b) controlled laboratory experiments. Although each of these approaches has played a significant role in community studies, they leave much to be desired. In the case of field observations only the gross variations and structure of the community can be defined; even then major errors due to improper assumptions about the sampling procedures have been found in a number of cases. Laboratory experiments are severely limited in the scope of the problem that can be addressed. In-place observations are obviously the ultimate means of documenting community structure, function, and variation. Inserting foreign bodies such as nets or cameras into a community results in a certain bias in the observations; unfortunately the extent of such bias is unknown. If we are to advance our understanding of benthic and pelagic communities, a part of the study must be conducted within the natural habitat of the particular community. Time and again the positioning of a trained observer in the natural habitat has led to significant advances in community as well as other dynamic faunal studies.

Man continues to increase his impact on the benthic and pelagic communities, the degree of impact can only be assessed with in-place measurements. The submersible has proven to be the most effective means for conducting these studies. It is the only means whereby a trained observer can be positioned in the midst of a deep-sea community and not only make pertinent measurements but also make an assessment as to the effectiveness of the sampling procedure.

· Determining the metabolic rates and life history processes of selected organisms or entire communities.

Determination of how rates of metabolism and life history processes as a function of the physical and chemical environment are translated into the diversity of life forms characteristic of the deep sea is of utmost importance in understanding community development. Until recently, metabolic rates and life processes investigations have been conducted either under artificial conditions in laboratory tanks or by such hit-or-miss sampling procedures as hanging various instruments on a wire from a surface vessel. Neither approach has resulted in significantly advancing this field of study relative to the recent progress of studies conducted via submersible. The ability to establish and monitor long-term test sites in the natural environment with a number of integrated studies (biological, chemical, geological, and physical) has resulted in major advances in studies of life-rate processes, e.g: the permanent bottom stations off Cape Cod. These advances would have been impossible without the unique capabilities of the submersible (ALVIN).

· Determining the mechanical, chemical, and magnetic properties and structures of the oceanic crust and upper mantle.

The geological-geochemical community has made great advances in the past 20 years in their effort to understand the structural, physical and compositional characteristics of the oceanic crust and upper mantle. The importance of these advances has led to entirely new concepts of global tectonics, crustal formation, and overall solid earth dynamics. We are, however, still far from being able to answer such questions as: a) do fine-scale compositional zonations occur in lavas erupted from ridge crests and if so to what degree; b) how do compositional data compare with that inferred about magma chambers from seismic data; c) why are reversely magnetized rocks frequently found within the axial valley; and d) do short periods of magnetic reversal occur commonly, and if so, how short are they and how well are they recorded by the extrusion process? Our studies have brought us to the threshold where the degree of resolution, if significant advances are to continue, must be improved drastically. Precisely located and oriented samples from strategic sections of the seafloor are required to take these studies forward in a meaningful manner. The recent advances made in crustal studies by utilizing ALVIN to selectively sample portions of the Mid-Atlantic Ridge and Cayman Trough would not have been possible without the use of this unique tool.

· Investigating small-scale hydrodynamic processes and their interactions with organisms and sediments.

In addition to the emphasis on rate measurements, the fine-scale interactions between individual animals and sediment as well as the interaction between currents, topographic features, and sedimentation patterns are all major components of benthic boundary studies. The components are particularly relevant to determining the effects of disturbance to benthic boundary layer organisms and the spreading rates of nutrients and organic matter. They are also essential to the development of various systems models concerning population diversity and ecological stability. The interrelationship between organisms and the mass physical and chemical properties of sediments is not well understood, yet some relationship clearly does exist. Use of remote techniques to document and sample the numerous interfaces involved in these studies is not practical. Here again the most effective way to carry out relevant studies is to place the trained observer and his sampling tools directly into the environment.

• Determining rates of organic and inorganic mass transfer in the pelagos and benthic boundary layer.

Available energy and metabolic rates of the open ocean pelagos and benthos are linked closely to the flux of organic matter to the deep sea. Organic analytical analysis of particulate matter from different levels in the water column as well as at the sediment-water interface is important in delineating the various diagenetic pathways for biochemicals in the deep sea. Determination of the rates of organic and inorganic mass transfer in the pelagos and benthic boundary layer is essential to provide estimates of the fraction of organic matter reaching the organisms and supporting their metabilism.

Although a great many related studies can be accomplished without the use of a submersible, defining pathways of organic carbon cycling and the fluxes along them calls for very detailed in-place measurements. Such studies require selective placement of sensors and test chambers such as bell jars with radioisotopically labeled organic compounds. These experiments require the unique positioning abilities of a submersible.

·Delineating sedimentary processes on the deep-sea floor

In the last few decades it has become clear that the abyss is not a realm of absolute tranquillity where sedimentary particles, once having arrived, are permanently entombed. On the contrary, evidence is mounting for extensive erosion and redeposition by thermohaline, bottom and tidal currents, aided frequently by dissolution of carbonates and silica. Although the scale of the processes may be large, examination of the processes themselves and their effects on the sediments tend to be on the scale of hundreds of meters or smaller, requiring microscale topography, sediment maps, pinpointed sampling of bedforms, and manipulation of the environment for appropriate study.

Emplacement of in situ experiments and direct observations by a trained observer are often the only way to approximate abyssal conditions.

A number of ALVIN capabilities are critical to attaining the resolution required to advance our understanding of the study areas discussed above: 1) the ability to selectively and precisely locate and collect samples; 2) the ability to selectively locate and deploy experimental apparatus; and 3) the ability to relocate, monitor, manipulate, and sample experiments on a long-term basis.

Table 2, which is slightly modified from that presented in the draft ALVIN Review Committee Report, outlines the unique functions of the submersible that can lead most effectively to an understanding of the research areas outlined above.

IV. COMMUNICATIONS WITHIN THE SCIENTIFIC COMMUNITY

The participants agreed in principle with the ALVIN Review Committee's discussion on communications within the scientific community, but also wanted to add the following comments:

a. The formulation of regional workshops under UNOLS for the purpose of providing "a valuable first cut at future programs" is recognized as a needed input to the ALVIN Review Committee. It is also recognized that such meetings

TABLE 2

APPLICATIONS OF SUBMERSIBLE CAPABILITIES TO SCIENTIFIC STUDIES

Studies	Submersible Capabilities (functions)
Volcanic processes	Inventory, describe, and delineate fine-scale volcanic topography; distinguish volcanic phases of different age; identify axes of intrusion; collect precisely and closely-spaced samples to determine petrologic, geochemical and age gradient showing existence and evolution of magma chambers.
Hydrothermal activity, geochemical processes, and metalliferous sediment	Locate active vents; determine heat and seawater budgets; quantify fluxes of matter from seawater into rocks during alteration of mid-ocean ridge crust.
Crustal deformation and strain rates	Select sites, secure ocean-bottom seismometers, acoustic bench marks, and other geodetic instruments to the seafloor, and service equipment.
Magnetic characterization of oceanic crust	Investigation of possible short reversals and the Brunhes/Matuyama reversal boundary by detailed sampling of reversely magnetized lavas and by determining crustal polarity in place.
Transform faults and transform fault-rise intersections.	Sample precisely-identified crustal levels and tectonic situations in complex geologic terrains
Metabolic rates of deep-sea organisms and communities.	*In situ* innoculation of potential substrates for assimilation by the biota; precise sampling of the water column and sediments; monitor and subsample *in situ* incubations over varying time intervals; placement of instruments with minimum disturbance of organisms or environment; selectively capture animals.
Rates of recruitment and growth of benthic populations.	Modify bottom (azoic sediments, concentration of organic material) and sample precisely with respect to the disturbance over time intervals of a year and longer; assess natural spatial variability of benthic communities on appropriate spatial and temporal scales.
Fluxes of inorganic and organic materials across and in the benthic boundary layer	Study organisms and organic geochemical processes with respect to large concentrations of organic matter such as wood islands or garbage; collect bottom samples in immediate vicinity of sediment traps; monitor operation of sediment traps.
Bottom dynamics, sedimentary processes and bioturbation	Place sensitive current meters with respect to bottom topography, sedimentary structures, and organisms; monitor tracers placed on or near the bottom; make visual observations of local irregularities in bottom dynamics and sediment properties; visually assess sediment-organism interactions.

will provide an opportunity for experienced users to meet with new users to relate to them the technologies and techniques presently available on ALVIN, which could significantly improve the quality of future research programs. It is also believed, however, that spontaneous workshops such as those held in 1976 at Scripps and WHOI should be encouraged in an attempt to formulate comprehensive programs.

It is recommended that the ALVIN Review Committee serve as the focal point to promote topical and/or regional workshops in order to develop 3-5 year plans for ALVIN. The need for such workshops could be announced via the annual notice requesting proposals for the use of ALVIN as well as through letters to a number of institutions and potential users. The point to be made to the scientific community in such a notice would be the necessity to work through the ALVIN Review Committee in order to prepare long-range plans which will lead to significant programs for ALVIN with the least amount of scheduling conflicts.

b. Concern was expressed for the poor manner in which past ALVIN dives have been archived. In particular, it was pointed out that specific rules governing the handling and archiving of dive photographs are being ignored and that a large number of the dive data from ALVIN are either lost or in the process of being lost to future analysis. Along this same line, the present reporting procedure for dives is totally inadequate. All chief scientists in the future should be required to submit detailed cruise reports. The precise nature of these reports needs to be developed.

c. At present, some of the users of ALVIN have established an ad-hoc arrangement that permits scientists with future programs on ALVIN to make an orientation dive. Dr. P. J. Fox of the Cayman Trough program, for example, was able to make an orientation dive in 1975. In 1976 Dr. J. Corliss was able to dive during the Cayman Trough effort in preparation for his Galapagos Program.

Dr. Corliss has subsequently agreed to reciprocate by taking someone involved in a science program in 1978. It is felt that more scientists should be encouraged to make such arrangements but that it should not be required or formalized.

V. FUTURE TECHNICAL IMPROVEMENTS

Considerable time was spent discussing possible improvements which could be made to the present ALVIN diving system. This discussion led to the realization that over the short-term (next three years) the major improvements which are possible will have a greater effect upon the operational efficiency of ALVIN than upon its ability to do unique and important science that it is not capable of presently.

The single most important short-term improvement which can be made in the present ALVIN system is improved surface support. The ALVIN program has evolved from coastal studies to deep-sea, mid-ocean projects. The mode of operation required for today's program makes the present support vessel, LULU, totally inadequate. It has now become a major drawback in the utilization of ALVIN (see limitations listed in draft ALVIN Review Committee Report). Whether the improvement can be accomplished with LULU or through modifications to ships within the present UNOLS community was beyond the scope of this workshop. To accomplish this improvement, however, certain priorities should be taken into consideration. These are as follows and are roughly in their order of importance:

1. Provide the ability to make at-sea repairs to ALVIN which traditionally have required LULU to seek protected waters.
2. Attain a speed of at least 10 knots
3. Achieve independence from an additional escort vessel.
4. Provide for continous (day and night) operation.
5. Maintain the present sea-state launching capability.
6. Provide the ability to conduct conventional and supporting operations using a deep-sea winch.

7. Add berthing in the science party for a total of 6-10.

8. Increase cruise duration to 30 days.

A second short-term improvement which received a high priority dealt with submersible instrumentation. Over the long history of the ALVIN program a constant need has existed for advanced scientific instrumentation. In general, such developments have been the responsibility of the individual scientists with funding coming from their own project grants. Such a funding arrangement should continue for specialized instruments but for those basic systems on the submersible which serve the majority of users, a different method to insure their development is needed. An excellent example of one way to solve this problem occurred in 1975 when a number of users collectively asked and received from the National Science Foundation funds to improve ALVIN's external camera systems. It is recommended that an arrangement be formalized under UNOLS guidance whereby a funding procedure be established to insure that some funds (perhaps 4 to 5% of the block funds) be reserved for common scientific instrumentation development or replacement. It is expected, for example, that the transponders used in ALVIN's precision navigation system will undergo a slow attrition rate.

The single most important long-term improvement is the conversion of ALVIN to a 20,000-foot diving depth. It was the belief of those present that such an increased capability would permit ALVIN to work on several significant scientific problems presently beyond its ability. It was recognized that such a conversion could not take place until the early to mid-1980's but that steps should be taken now to lay the foundation for this program.

The second long-range improvement needed is the construction of a new surface support ship. A new support ship should have all the characteristics outlined on page 14. In addition it should have a greater ability than a conventional surface ship to support both the diving operation and the overall scientific program. These would include:

(1) A limited scanning sonar or multi-narrow beam sonar system which would permit the ship to conduct detailed dive-site surveys immediately prior to an actual dive; particularly needed for dives along a transit between major operating areas.

(2) Specialized laboratory facilities to process film, water, sediment, and rock samples as well as ambient pressure and temperature chambers for biological investigations.

(3) Free-fall and towed unmanned systems to complement ALVIN's mission.

Of major importance but clearly not receiving the priority of a 20,000-foot ALVIN or a new surface support ship is the need for a better working relationship between UNOLS and the submersible program within the U.S. Navy. Since SEA CLIFF is scheduled to undergo a 20,000-foot conversion, it is clear that a similar ALVIN conversion could be closely tied; particularly in the construction of a new sphere. The Navy has also given the problem of surface support ships and the handling of submersibles a great deal of consideration of which UNOLS should be aware. It is also clear that the user base of ALVIN is growing rapidly and conflicts of working in the Pacific and Atlantic in the same year are close at hand. For that reason, discussions should be taking place with the Navy regarding the long-range utilization of a 20,000-foot SEA CLIFF in the early to mid-1980's. These discussions should cover partial use of SEA CLIFF for scientific programs, improved SEA CLIFF scientific instrumentation, long-term scheduling, and operational continuity and reliability. This need for detailed discussions with the Navy is readily apparent from what appears to be a growing need in the 1980's for a two-sub/two-ocean submersible scince program.

VI. FUTURE FUNDING ARRANGEMENTS

The participants felt that commenting on the ALVIN Review Committee's proposed future funding procedures was untimely since the report was only in draft form. The broader issue of future involvement of other funding agencies such as ERDA or USGS and other countries such as Canada or Japan, however, was discussed. It was believed that once ALVIN obtains a 20,000-foot capability, ERDA and EPA scientists and specifically those working on nuclear waste disposal would more than likely become major users of ALVIN time.

Dr. B. D. Loncarevic, Director of the Atlantic Geoscience Centre for the Canadian Geological Survey, expressed an interest on behalf of several Canadian scientists in the use of ALVIN. He felt that this involvement would initially begin on an individual basis. The majority of the participants expressed a strong feeling that should such involvement reach a point of major foreign participation, funding of ALVIN time by foreign countries should be on a project basis and should <u>not</u> follow the path taken by the JOIDES Program.

VII. IMPACT OF SUBMERSIBLE PROGRAM ON MARINE SCIENCE EFFORTS

It was obvious to those present that a well planned and executed submersible program will have a significant impact on other marine programs presently underway or in various planning stages. Since many submersible programs, for example, require extensive pre-dive surveys, the delineation of a long-range submersible program will in many cases define in part the future use of deep-towed, multi-narrow beam, and surface ship systems. For that reason, it is important that submersible planning be integrated with these other efforts. It is believed that such planning must take place in a variety of forums at the national level. Perhaps UNOLS in its role of overseeing the seagoing facilities could serve as one such forum. Workshops, as recommended above, would address this need.

VIII. CONCLUDING REMARKS

In the field of undersea studies the past decade saw a facet of technology, in this case the submersible, advance beyond the science as well as beyond some supportative technologies. The submersible became available before the scientist knew how or was ready to use it effectively. Initially, dives were disorganized, scientific objectives were not compatible with the abilities of the submersible, and adequate background information was not available (e.g., detailed bathymetric maps, prior studies of suitable detail to effectively apply the capabilities of of the submersible to full use.

This situation has changed drastically for certain areas of marine science in the past three to four years. Scientists have delineated and are now delineating problems to the point where the submersible can be used to provide the resolution needed to solve important problems. Supportative technologies such as seafloor navigation systems, submersible sensors, and data loggers have also advanced dramatically to markedly improve the data collecting abilities of the submersible.

As has been readily revealed by such projects as FAMOUS, CAYMAN TROUGH and the biological bottom station studies, science has caught up with the technology. We are witnessing a breakthrough in undersea studies and there is little doubt, based on the planning of scientific studies taking place around the country, that use of ALVIN and hopefully other deep-diving vehicles, will contribute significantly to major scientific advances in the very near future.

Because we can easily see the development of a greater demand for the use of submersibles, the workshop took time to address the need for both short-and long-term improvements to the submersible program. Our use of this facility, especially ALVIN, has changed markedly, and there is a pressing need to carry out long-range planning at a national level to insure that the technology does not now fall behind the science. Organized workshops are an effective mechanism for such planning and should be employed more often.

IX. INDIVIDUAL CORRESPONDENCE REGARDING LONG-RANGE SUBMERSIBLE PROGRAMS

In addition to the collective comments made within this workshop report, many scientists wanted to express individual remarks relative to this subject. For that reason, their correspondence has been compiled in Appendix C.

ATTENDEES

UNOLS Sponsored ALVIN Workshop
Stanford University - Dec. 8, 1976

Name	Organization	Field of Research	Use of ALVIN Past, 1977, Future	Funding Agencies
Robert D. Ballard	W.H.O.I.	Geology/Geophysics	Past,1977,Future	ONR/NSF
Wilfred B. Bryan	W.H.O.I.	Volcanology	Past,1977,Future	NSF/ONR
John Corliss	Oregon State	Marine Geochem	1977, Future	NSF-IDOE
J. Frederick Grassle	W.H.O.I.	Benthos	Past,1977,Future	NSF
James Hall	Dalhousie	Magnetics of volcanics	Future	Canada NRC
Bruce C. Heezen	Columbia Univ.	Submarine Geology	Past,1977,Future	ONR
Donald Heinrich	NSF	Geology/Geophysics	-----	-----
Peter A. Jumars	Univ. Washington	Benthos	Future	-----
George H. Keller	Oregon State	Submarine Geology	1971-77	NOAA
Bosko D. Loncarevic	Bedford Institute	Geophysics	-----	-----
Ken C. Macdonald	Scripps	Geophysics	Future	NSF
James G. Moore	USGS	Volcanology	Past, Future	USGS
William P. Muellenhoff	MUS&T, NOAA	Oceanography	-----	NOAA
Darrell Papin	General Acctng. Office	N/A	N/A	N/A
Rafael J. Parrilla	General Acctng. Office	N/A	N/A	N/A
John Peirce	Dalhousie	Paleomagnetics	Future	Canada
Thomas F. Pyle	ONR	Geology/Geophysics	-----	-----
Kenneth L. Smith, Jr.	Scripps	Biology	Past,Future	NSF
Fred Spiess	Scripps	Geophysics/Oc.Tech.	Future	NSF/ONR
Thomas Stetson	UNOLS	-----	-----	-----
Tjeerd van Andel	Stanford	Marine Geol./ Geophysics	Past,1977,Future	NSF/ONR

AGENDA FOR UNOLS WORKSHOP ON THE LONG-RANGE UTILIZATION OF ALVIN
Stanford University, 8 December 1976

MORNING SESSION

1. Opening Remarks - Purpose and Objectives of Workshop
2. Background on ALVIN Program
    a. Major Milestones
        1. 1964-1969: O.N.R. block funding/WHOI managing and operating
        2. 1970-1974: Diversified project funding, ONR underwriting/WHOI managing and operating
        3. 1975-1977: ONR/NSF/NOAA block funding, UNOLS managing/WHOI operating
    b. Growth and Changing Emphasis of ALVIN users
        1. 1964-1969: General biological and geological reconnaissance
        2. 1970-1974: Emphasis upon detailed sampling
           Establishment of bottom station program
           Major instrumentation program (Nav., magnetics, gravity, geological and biological sampling).
           First comprehensive submersible science program
        3. 1975-1977: Rapid growth of user base and initiation of large programs (Cayman Trough, Galapagos Rift, Benthic Boundary Layer)
           Further development in instrumentation and sudden influx of geophysists, geochemists and geologists
           First use of ALVIN in Caribbean and Pacific
3. ALVIN's Utilization in 1978-1983
    a. Factors of Consideration
        1. Draft ALVIN Review Committee Report
            a. Problems that require submersibles in 1977-1980
            b. Function of Review Committee
            c. Communications with Scientific Community/Workshops
            d. Funding arrangement (present and future)
            e. Technical improvements
            f. Recommendations
        2. Additional factors
            a. U.S. Navy deep submersible activities
                1. Present capabilities - SEA CLIFF, TURTLE, TRIESTE II
                2. Programs underway
                    a. Decommissioning of TRIESTE II
                    b. Conversion of SEA CLIFF to 20,000'
                    c. Construction of surface support ship

b. Conversion of ALVIN to 20,000'

c. Consideration of 24-hr. diving operation

d. Use of SEA CLIFF with the concept of developing a long-range two-ocean two-submersible capability

3. Involvement of other organizations such as ERDA or USGS in the utilization of ALVIN

4. Involvement of other countries such as Canada or Japan

b. Impact of submersible program on other programs such as JOIDES; Multi-narrow beam development, bottom instrumentation programs, deep-tow/ANGUS field programs

c. Priority and timing of our recommendations

1. Long-term 1981 and beyond

2. Intermediate 1979-1981

3. Short-term 1978

LUNCH

AFTERNOON DISCUSSION SESSION

1. Review Factors of Consideration

a. Future funding arrangement

b. Technical improvements (priority, time needed)

1. Improved surface support

a. Improved LULU

b. Modification of KNORR/MELVILLE

c. New Support Ship

2. Conversion of ALVIN to 20,000'

3. Use of Navy facilities

4. Two-sub two-ocean program

c. Problems that require submersibles in 1978-1980 - Outline of programs needed to address these problems

d. Function of Review Committee

1. In the selection of science programs in different fields of science

2. Relationship between Committee and agency program managers

e. Communications within Scientific Community/Workshops and relationship to Review Committee

2. Recommendations

3. Appendices of Potential Research Programs

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : R. D. Ballard

DATE: November 24, 1976

FROM : R. P. Von Herzen

SUBJECT: Long range ALVIN Science Program

This is to comment on one possible future area of studies for ALVIN, namely the hydrothermal circulation problem. Although we won't be using ALVIN until February 1977 for this work on the Galapagos, I believe that work will show the uniqueness of a tool like ALVIN to obtain scientific data on this problem. I believe that future work will include:

1) similar investigations to that of the Galapagos on both slower and faster spreading ridges,

2) the quantitative influence of fracture zones on hydrothermal circulation.

I don't have any particular feelings about which of these problems should be approached first. I believe that the fracture zone problem might profitably be investigated in the same region of the Galapagos we are investigating in 1977, where we have the detailed Navy survey. After the 1977 work we should also have a much better idea as to which methods and techniques are most useful in this study.

Dick

FVH/meb

cc Art Maxwell

APPENDIX C-2

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : J. Ewing
R. Ballard

DATE: December 2, 1976

FROM : C. D. Hollister CDH

SUBJECT: Some future efforts of Sediment Dynamics Group

I see an increasing emphasis within the Sediment Dynamics Group to work on Benthic Boundary Layer processes. For example, recent work of Flood/Gardner/Milliman and myself are particularly focused on Benthic Boundary Layer problems and these efforts are often closely tied to near bottom observations (submersibles and deep-tow). We will probably expand this effort with upcoming students (e.g. Richardson and Tochko) and perhaps also new scientists (e.g. Nick McCave) and with more help from Physical Oceanography and Chemistry Departments.

In short I feel that this Benthic Boundary Layer effort will use an increasing amount of research submersible time in the deep sea, particularly on deeper portions of the Continental margins, and I expect to seek research funds for submersible work in the 1978/1979 time frame.

CDH/meb

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : R. D. Ballard

DATE: December 2, 1976

FROM : C. D. Hollister CDH

SUBJECT: Research submersibles

In light of your recent efforts vs. a 20,000 research submersible and probable future need, I would like to point out the following.

The U.S. E.R.D.A. Seabed program is now assessing Mid-Plate regions as a potential waste repository. We will be working for the next year (1977) on laboratory experiments with the next field season in 1978. I would estimate that sometime in early 80's we will have selected a few candidate areas and I feel fairly certain that we will then have a need for a submersible to both monitor near bottom experiments and to observe some of the effects of trial emplacement techniques.

The areas that I feel are most likely to be chosen are red clay covered mid-plate regions in the North Pacific and North Atlantic. These areas are 5 to 6 km in depth.

It's not unreasonable to expect significant funding for research submersibles (capable of working in these depths) from U.S. E.R.D.A. during the early '80's.

CDH/meb

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

12 December, 1976

Department of Oceanography, WB-10
Cable Address: UNIWADO

Dr. Robert Ballard
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

Dear Bob:

I think it is safe to say that every deep-sea biologist has a pet experiment he or she would like to perform using the DSRV Alvin. As Ken Smith has informed you, a number of us on the West Coast are integrating our individual interests to put together a viable package of proposed observations and experiments. This package will include our pet experiments as well as several cooperative experiments that no single investigator could carry out alone. I personally hope to do some feeding experiments with benthic macrofauna as well as to cooperate on several larger efforts we have been designing for the last few years. I hope you don't find it offensive that a fair proportion of the background data for these experiments comes from an earlier collective effort with the RUM-ORB system. The Alvin review committee should receive the details after our planned January (or February) meeting.

It is unfortunate that no submersible is yet in use in the DOMES project of NOAA. A submersible with 20,000 ft. capability would be an invaluable, if not indispensable, asset to the program. Perhaps some provision could be made for marking preliminary mining sites for easy relocation should Alvin obtain this depth capability in the future. Fred Grassle's Alvin experiments suggest the effects should be detectable for several years.

I and the other West Coast deep-sea biologists are certainly excited about the prospect of Alvin use in the Pacific.

Sincerely,

Peter A. Jumars

Peter A. Jumars

UNIVERSITY OF CALIFORNIA, SAN DIEGO

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SCRIPPS INSTITUTION OF OCEANOGRAPHY LA JOLLA, CALIFORNIA 92093

November 30, 1976

To: Distribution

From: K. L. Smith

Subject: Integrated research program to utilize DSRV Alvin on West Coast

It has become apparent that there is strong interest among several of us in developing an integrated biological research program to use Alvin on the West Coast. This interest has also been expressed by the National Science Foundation, and in particular Dick Williams - Program Director Biological Oceanography.

The Alvin is now scheduled to come to the Pacific in '79 primarily to do geological work on the East Pacific Rise. It seems like a very opportune time to put together a multidisciplinary proposal to study say the "energetics of an open ocean water column" using Alvin as a tool. I suggest such an approach because, 1) it is sufficiently broad to include both structural and functional ecologists as well as chemists, geologists and physical types, and 2) rate studies seem to be of current interest to NSF and other funding agencies. The lack of a reliable research oriented submersible on the West Coast enhance our chances of success. The time frame we would be talking about for such work would be '78 and beyond. Funding possibilities are dependent on the size package we generate but I would imagine IDOE would be the likely candidate.

I would like to organize a meeting here at Scripps of those strongly interested in putting together such an integrated proposal. How is the first week in February '77? Please let me know as soon as possible what day of that week (31 January - 4 February) is best for you.

For those of you unacquainted with Alvin, it has a maximum depth capability of 3650m and can carry two scientists in addition to the pilot. There is a surface support ship from which it is launched and a normal dive lasts up to 12 hours. Alvin has a mechanical arm and is capable of working in midwater as well as on the bottom with some degree of dexterity.

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KLS:kml

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Marine Geology & Geophysics Laboratory, AOML
15 Rickenbacker Causeway
Miami, Florida 33149

RF203-16d-984U

November 23, 1976

Dr. Robert D. Ballard
UNOLS Coordinator
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Dear Bob:

I am writing to inquire about the possibility of working with ALVIN to continue our investigation of hydrothermal processes at the TAG Hydrothermal Field on the Mid-Atlantic Ridge crest at latitude 26°N.

The TAG Hydrothermal Field was discovered and is being investigated by NOAA and university scientists collaborating on the NOAA Trans-Atlantic Geotraverse (TAG) project. Using NOAA Class I research vessels with satellite navigation during field seasons in 1972, 1973, 1975, and 1976, we have delineated the bathymetry (narrow-beam; McGregor and Rona, 1975; Rona and others, 1976), magnetics (McGregor and Rona, 1975; Rona and others, 1976; McGregor and others, 1976); determined the distribution of rock and sediment types including surficial hydrothermal metal deposits (Scott, M.R., and others, 1974a, b; Scott, R.B., and others, 1974, 1976; Rona and others, 1976; Cronan, D.S. and others, in preparation); carried out photographic transects (McGregor and Rona, 1975; Temple and others, 1976); performed near bottom water sampling for suspended particulate matter (Betzer and others, 1974), dissolved silica (Fanning and others, 1974), and ^{3}He (Jenkins, W. and others, in preparation); defined a near bottom water temperature anomaly attributed to hydrothermal discharge (Rona and others, 1975; Lowell and Rona, 1976); and inferred the pattern of hydrothermal deposition in the TAG Hydrothermal Field (Rona, 1976). Additional dredging, seismic reflection, and an OBS seismic refraction experiment were performed at the TAG Hydrothermal Field in 1975 on a cooperative cruise with the Research Vessel AKADEMIC KURCHATOV as part of TAG participation in the US-USSR Agreement for Cooperation in World Ocean Studies.

Having laid a groundwork of geological, geochemical and geophysical studies of the TAG Hydrothermal Field using surface ships with satellite navigation, we are ready for the next generation of studies requiring acoustic navigation, deep-towed instrumentation, and submersible observations. An objective in the next generation of studies is to delineate the sub-sea floor hydrothermal convection system that is inferred to be active at the TAG Hydrothermal Field, to define the special structural and thermal conditions that are concentrating the activity of the hydrothermal system, and to relate this information to metallic ore-forming processes.

I anticipate a team of about five experienced scientists representing the disciplines of geology, geochemistry, and geophysics. As a preliminary estimate we would require 10 to 15 ALVIN dives in water depths of 2 to 4 km in and adjacent to the rift valley employing the modified GEOSECS system for hydrothermal measurements. We would need to use the ANGUS deep tow system from the support vessel to compliment ALVIN observations.

I have ship time scheduled in May-June 1977 with the NOAA Ship RESEARCHER to continue interdisciplinary studies of the TAG Hydrothermal Field. Part of this ship time could be devoted to any additional studies recommended as further groundwork for the proposed submersible work.

Thank you very much for your consideration.

Sincerely,

Peter

Peter A. Rona
Chief Scientist, NOAA Trans-Atlantic
Geotraverse (TAG) Project

cc: Dr. W.N. Hess
Dr. D.C. Beaumariage
Mr. A. Lane
Dr. H.B. Stewart, Jr.
Mr. J.W. Kofoed

TO: R. D. Ballard

FROM: J. D. Milliman

SUBJECT: Use of ALVIN

Beginning in 1978-79, I am hopeful of having a long-term Atlantic U. S. continental margin project in full swing at WHOI. As a part of this project, the use of ALVIN is envisioned for at least 2 months every year. Among the operations scheduled for ALVIN are: 1) installing long-term geophysical monitoring instruments (e.g. seismographs, heat flow probes); 2) sampling and observing exposed substrate; 3) installing and servicing long-term sedimentological, oceanographic and biological experiments (such as bioturbation studies).

Once begun, this project should continue at least 5 years, and includes both the slope and rise. Although present depth capabilities of ALVIN will suffice, a deeper capability will allow us to extend our studies considerably seaward.

Although it is premature to consider such matters, it is entirely possible that OSU and WHOI will alternate using ALVIN (every other year), Vern Kulm at OSU being interested in similar long-term studies on the west coast.

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : Dr. R. D. Ballard DATE: December 2, 1976

FROM : J. Ewing

SUBJECT: UNOLS Workshop on the Long-Range ALVIN Science Program

It seems to me that research on continental margins is bound to constitute a substantial part of the effort of the Geology and Geophysics community during the next 5-10 years. Presumably, Industry, Governmental Agencies and Academies will all be involved, although it is not yet clear what roles each group will play. Regardless of the assignment of roles, someone is going to get, or take, the responsibility of detailed geological sampling -- particularly on starved margins where older geological formations are not covered by young sediments.

Undoubtedly a lot of good work can be done in geologic sampling by careful surveys with surface ships, followed by remote sampling with dredges and corers controlled by a good bottom navigation network. However, it is likely that in many instances some careful observation and sampling by manned submersibles will provide a valuable follow-up. I think you and your colleagues have demonstrated these points very well in your work in the FAMOUS area and in the Cayman Trough.

I believe it is very important for our community to have the deep submersible capability for this kind of research in the future. It is a unique tool which, used properly, can supplement enormously the results of other methods. Therefore, I wish you good luck in working for solid scientific programs that properly utilize submersibles, which is the best way to assure their availability and continued development in the future.

John Ewing

WOODS HOLE OCEANOGRAPHIC INSTITUTION
WOODS HOLE, MASSACHUSETTS 02543

Department of Geology and Geophysics

Phone (617) 548-1400
TWX 710-346-6601

24 November 1976

Dr. R. D. Ballard
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

Dear Bob:

Most of the critical work using deep research submersibles has been in belts of plate divergence--FAMOUS, Cayman Trough, and now the East Pacific Rise-Galapagos Ridge. Many interesting things have been learned about the mode of emplacement of sea-floor basalts and the development of subsequent structures, but now is the time to put these observations in perspective.

Continued successful use of submersibles should involve rather broad planning, including the investigation of other kinds of plate margins: namely, those due to convergence and translation. While on a recent trip to Korea, Taiwan, and Japan I had convergence margins in mind and spent some time talking about detailed mapping by surface ships possibly to be followed by use of research submersibles. From the enthusiastic responses I am sure that there is high potential for cooperative studies of the convergent margins in these areas even if the maximum depth for ALVIN should remain at 3600 meters. Similarly, I expect that cooperative studies might well be arranged for investigations along the Indonesian archipelago and elsewhere off eastern Asia. Many of these areas are ones that supply detrital sediments at a low enough rate to permit examination of bedrock by visual means.

Parallel programs can be arranged for other regions having transform plate movements. In these areas the understanding by geophysical methods is apt to be limited, so that visual examination may be the most appropriate approach.

Sincerely,

K. O. Emery

ADDITIONAL SUPPORTATIVE MATERIAL

In addition to the letters included here, the following proposals and ALVIN workshop reports which were made available to this workshop, are further evidence of the sound scientific thinking going into submersible use.

a. THE OCEANOGRAPHER FRACTURE ZONE (35°N, 35°W): A PROPOSAL TO DEFINE AND UNDERSTAND THE GEOLOGY OF AN OCEANIC TRANSFORM - Paul J. Fox

b. GEOLOGICAL STUDIES OF THE NEW ENGLAND SEAMOUNTS James Heirtzler, Dec. 3, 1976.

c. EAST PACIFIC RISE SUBMERSIBLE PROGRAM WORKSHOP REPORT - Ken Macdonald & Fred Spiess, Nov. 1, 1976.

d. RESULTS OF ALVIN WORKSHOP HELD IN WOODS HOLE, May 24, 1976 - J. Frederick Grassle.