RESULTS OF ALVIN WORKSHOP HELD IN WOODS HOLE

May 24th 1976

J. Frederick Grassle

Convener

CONTENTS

LIST OF PARTICIPANTS

Robert Ballard	Woods Hole Oceanographic Institution
Richard Cooper	N.M.F.S., Woods Hole
Wilford Gardner	Woods Hole Oceanographic Institution
Frederick Grassle	Woods Hole Oceanographic Institution
Bruce Heezen	Lamont-Doherty Geological Observatory
Robert Hessler	Scripps Institution of Oceanography
Charles Hollister	Woods Hole Oceanographic Institution
Holger Jannasch	Woods Hole Oceanographic Institution
Laurence Madin	Woods Hole Oceanographic Institution
Paul McElroy	Bolt, Beranek and Newman, Inc.
Michael Rawson	Lamont-Doherty Geological Observatory
George Ridgway	N.M.F.S., Woods Hole
Howard Sanders	Woods Hole Oceanographic Institution
Clay Sassaman	Woods Hole Oceanographic Institution
Jon Steiger	Rosenstiel School of Marine & Atmospheric Science
Lawrence Shumaker	Woods Hole Oceanographic Institution
Ruth Turner	Harvard University
Joseph Uzmann	N.M.F.S., Woods Hole
Allyn Vine	Woods Hole Oceanographic Institution
Robert Whitlach	University of Chicago

LETTERS RECEIVED

R. S. Carney	University of Oregon
R. R. Colwell	University of Maryland
R. F. Dill	West Indies Laboratory, Fairleigh-Dickinson
R. S. Dyer	Radiation Programs, E.P.A.
R. B. Gagosian & J. W. Farrington	Woods Hole Oceanographic Institution
W. D. Gardner	Woods Hole Oceanographic Institution
R. Y. George	University of North Carolina-Wilmington
J. F. Grassle, R.R. Hessler and H. L. Sanders	Woods Hole Oceanographic Inst., Scripps Inst. of Oceanography & Woods Hole Oceanographic Inst.
S. Honjo and K. O. Emery	Woods Hole Oceanographic Institution
S. Honjo	Woods Hole Oceanographic Institution
H. W. Jannasch, C. A. Wirsen	Woods Hole Oceanographic Institution
P. T. McElroy	Bolt, Beranek & Newman
M. Rawson	Lamont-Doherty Geological Observatory
G. T. Rowe	Woods Hole Oceanographic Institution
C. A. Sassaman	Woods Hole Oceanographic Institution
W. Schlager, R. N. Ginsburg	Rosenstiel School of Marine & Atmospheric Science
J. C. Staiger	University of Miami
R. D. Turner	Harvard University
A. J. Williams, III	Woods Hole Oceanographic Institution

On May 24, 1976 a workshop was held in Woods Hole to discuss the existing ALVIN program and to identify more broadly-based and well-integrated scientific programs for the years beyond 1977. Although the meeting was held at short notice, representatives of eight institutions attended and letters were received from individuals at five other institutions.

The research interests of the majority of those attending centered around rates of biological and physical processes and fine scale interactions of physical, chemical and biological features of the environment at a series of permanent ocean bottom stations. Most of the proposed research could be included in a single major program of Deep-Ocean Benthic Boundaries Studies including studies of sediment dynamics and dynamics of deep-sea communities. Interest was expressed in using ALVIN's ability to conduct *in situ* experiments to measure the following rates:

1. Rates of organic flux into the benthic boundary layer. Farrington, Gagosian, Rowe.
2. Rates of microbial activity. Jannasch, Wirsen.
3. Rates of recruitment, growth and mortality of animal populations. Grassle, Hessler, Sanders, Turner.
4. Rates of community succession and variation in community structure. Grassle, Hessler, Jumars, Sanders, Turner.
5. Rates of biological mixing of sediments. Gardner, Heezen, Hessler, Hollister, Rawson.

6. Rates of respiration and nutrient cycling in benthic and bentho-pelagic organisms. K. L. Smith.
7. Rates of carbonate dissolution. Emery, Honjo.
8. Rates of response to food concentrations and genetic structure of amphipod populations. Sassaman.
9. Rates of water movement at the sediment-water interface including variation with respect to small-scale topographic and biological features of the environment. Gardner, Hollister, Williams.
10. Rates of particle flux and residence time of the nepheloid layer. Emery, Gardner, Heezen, Hollister, Honjo, Rawson, Rowe.

In addition to the emphasis on rate measurements, the fine-scale interactions between individual animals and sediment and the interaction between water movements, topographic features of the bottom and patterns of sedimentation are major components of the benthic boundary program. All of the participants at the workshop and a number of individuals not present expressed interest in animal-sediment relationships. The effects of disturbance on benthic boundary layer organisms and rates of spread of concentrations of organic matter are of particular interest to Farrington, Gagosian, Grassle, Hessler, Jannasch, Jumars, Rowe, Sanders and Staiger. Wishner (S.I.O.) and Madin (W.H.O.I.) are interested in observing and collecting organisms in the water column in the benthic boundary layer.

The NOAA group of Cooper, Ridgway and Uzmann are primarily interested in the geology and ecology of heads of submarine canyons where sampling with surface ships is difficult or impossible.

Benthic Boundary Layer Studies

The rate measurements already obtained in the benthic boundary layer at permanent bottom stations using ALVIN suggest that life moves in slow motion in the deep sea. Rates of microbial activity and respiration of deep-sea organisms are 10-500 times lower than in other environments. Recent experiments indicate that populations living on the sea floor can recover only very slowly from sudden changes in the environment. From ^{228}Ra chronology, at least one small clam species does not reach maturity for 50 years and may live for a hundred or more years. Studies of the environmental extremes presented by the deep sea will contribute significantly to our understanding of the environmental determinants of biological rates. The same features of the environment that have resulted in the low rates of biological activity have permitted the evolution of an enormous diversity of life. With an integrated program of study at a few localities we may learn how rates of life processes and the small-scale variation in physical processes are translated into the diversity of life forms characteristic of the deep sea.

Most knowledge of the ocean floor comes from instruments that haphazardly strike the bottom from the end of a mile or more of steel cable. This has provided a series of snapshot views of conditions in the deep sea. The major questions concerning the biology of the deep sea and the dynamics of physical processes of the deep ocean environment will require instrumentation that provides much higher resolution of temporal and physical variation. At permanent bottom stations, it is possible to return to the same spot and sample within and between small-scale features of the bottom. The increased number of experiments projected for the future at each bottom station should result in increased efficiency of ALVIN operations. A dozen or more experiments might be serviced on a single dive. Some of the advantages of using ALVIN for oceanographic research discussed at the workshop are outlined in Appendix A.

Some discussion of the location of future permanent bottom stations was held. In addition to the existing sites off New England (1830 and 3640 m) and in the Tongue of the Ocean (2030 m), the geologists are particularly interested in establishing a station on the Blake-Bahama Outer Ridge. The radioactive waste dump sites at 2800 m off New England will still be used for a number of experiments including the work of Bob Dyer at EPA. There is also considerable interest in stations in the San Diego Trough and the equatorial continental slope in the Pacific. Most participants at the meeting agreed that future scheduling would be likely to include work in both the Atlantic and Pacific. In 1978 it is possible to conduct a series of programs in both the Atlantic and Pacific starting at Scripps, and including work off New England in the latter part of July and all of August. Such a program could make much more efficient use of ALVIN time.

APPENDIX A

ALVIN capabilities discussed at the May 24th Workshop.

Ability to:

1. Put instruments and sampling devices onto and into the bottom without disturbing the sediment.
2. Conduct experiments over time intervals of a year or more.
3. Precisely sample small-scale features such as sediment forms, rocks, or individual organisms.
4. Provide continuity of observation for behavioral studies and fine scale surveys.
5. Conduct experiments requiring complex manipulations and precise sampling.
6. Sample areas such as the heads of submarine canyons where bottom topography is such that no standard gear can be operated.
7. Sample from specific layers in the water column (for example, layers of high turbidity or dense zooplankton populations).
8. Observe and provide controls for free-vehicle experiments that may eventually be done without ALVIN. New approaches to high resolution bottom studies using surface ships will be developed much more rapidly if ALVIN is available to observe the operation of new instruments and control against artifacts resulting from inadequate instrumentation.

APPENDIX B

The following letter was sent to UNOLS offices and to 70 individual scientists.

The responses of those who were unable to attend, and the members of the workshop, are appended.

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

An association of Institutions
for the coordination and support
of university oceanographic facilities

5 May 1976

Dear Colleague:

The present funding arrangement for DSRV ALVIN ends in 1977. It is therefore important to plan and develop scientific projects so superior as to compel support. Towards this end members of the UNOLS Review Committee for DSRV ALVIN recommended a workshop to plan broadly-based and well-integrated scientific programs for the immediate future.

ALVIN has at least two important research capabilities. One is to view unique features of the bottom at first hand and sample with respect to topographic features. This has been used to great advantage in the FAMOUS Mid-Atlantic Ridge studies and the very recent Cayman Trough work. Another unique feature of ALVIN (and other submersibles) is the ability to conduct in situ experiments on the sea floor. At present, ALVIN is the only readily available means for returning to the same spot on the deep ocean floor to conduct experiments and precisely sample the surrounding environment. Research at permanent bottom stations could be done more efficiently, productively, and with fewer scheduling uncertainties, with addition of a number of well-planned and coordinated projects in both physical and biological oceanography.

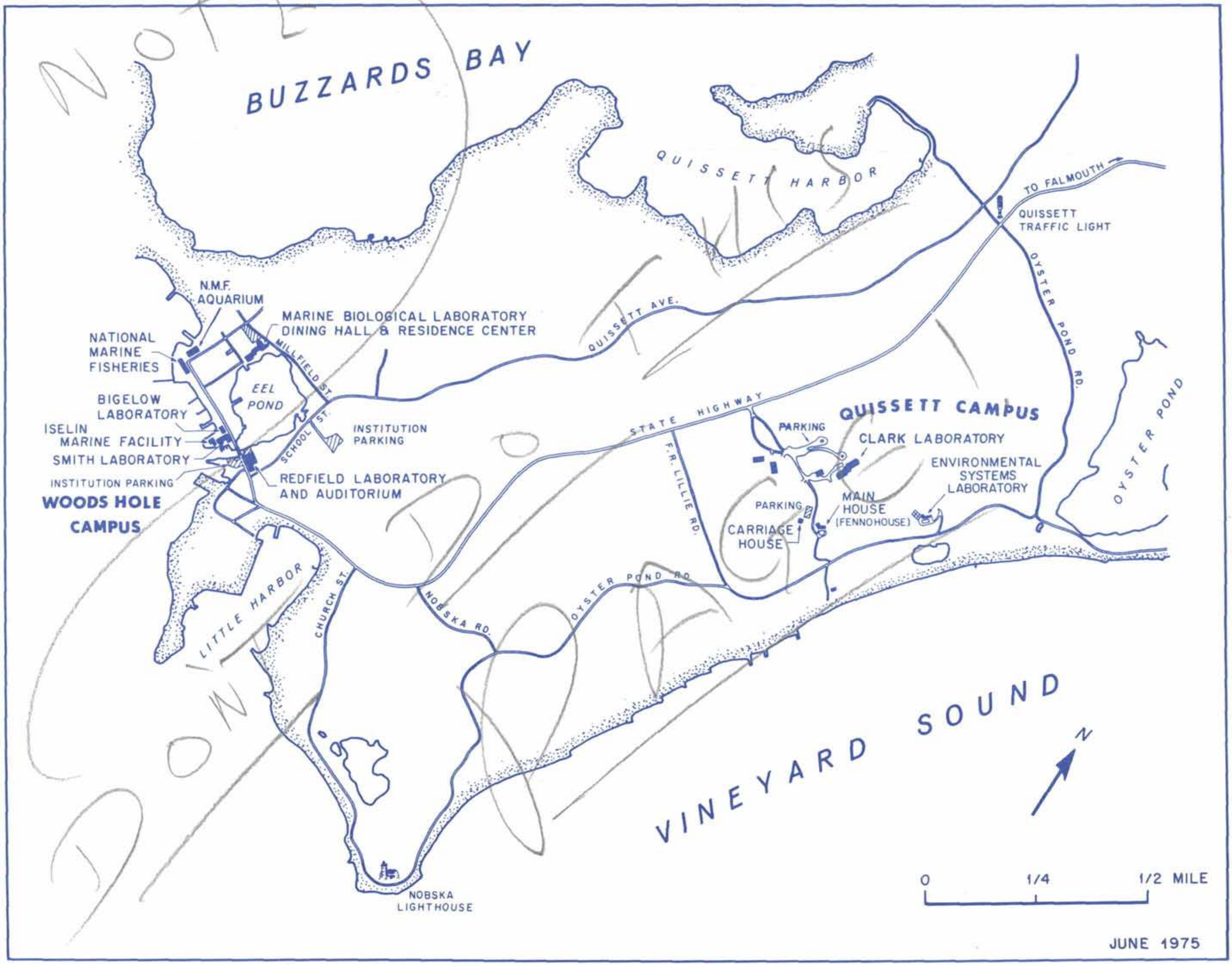
We plan to have a meeting of those interested in work with ALVIN at the Carriage House on the Quissett Campus in Woods Hole on May 24th at 0900. The workshop has had to be set up at short notice so that a report may be presented to the UNOLS ALVIN Review Committee Meeting in June. We can arrange rooms for a limited number at our student center along with lunch on the 24th, but are unable to provide transportation to Woods Hole. We welcome anyone who may be interested in doing work with ALVIN and hope you will be able to offer suggestions even if unable to attend. If you are able to attend, please let us know if you are coming and if you need a room before May 14th. We would like to receive any comments by this date also.

Sincerely,

Fred Grassle

J. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Inst.
Woods Hole, Massachusetts 02543

JFG:jkm


BUZZARDS BAY
QUISSETT HARBOR
TO FALMOUTH
QUISSETT TRAFFIC LIGHT
OYSTER POND RD.
OYSTER POND
N.M.F. AQUARIUM
MARINE BIOLOGICAL LABORATORY DINING HALL & RESIDENCE CENTER
NATIONAL MARINE FISHERIES
BIGELOW LABORATORY
ISELIN MARINE FACILITY
SMITH LABORATORY
INSTITUTION PARKING
WOODS HOLE CAMPUS
EEL POND
MILLFIELD ST.
SCHOOL ST.
INSTITUTION PARKING
REDFIELD LABORATORY AND AUDITORIUM
QUISSETT AVE.
STATE HIGHWAY
F.R. LILLIE RD.
QUISSETT CAMPUS
PARKING
CLARK LABORATORY
ENVIRONMENTAL SYSTEMS LABORATORY
MAIN HOUSE (FENNOHOUSE)
PARKING
CARRIAGE HOUSE
LITTLE HARBOR
CHURCH ST.
NOBSKA RD.
OYSTER POND RD.
VINEYARD SOUND
N
NOBSKA LIGHTHOUSE
0
1/4
1/2 MILE
JUNE 1975

School of Oceanography
Oregon State University
Corvallis, Oregon 97331 (503) 754-3504

15 May, 1976

Dr. J. Fred Grassle
UNOLS ALVIN Workshop
Woods Hole Oceanographic
Woods Hole, Mass.

Dear Fred:

Having been one of relatively few students of biological oceangraphy to participate as an observer on an ALVIN dive, I wish to submit these comments for consideration. I fully agree with the ideas put foward in your letter of 5 May and would like to expand upon them.

I. Use of ALVIN for experimental investigation of ecological stability theory

Area, geologic age, primary productivity, climatic predictability and persistence, and structural texture are all parameters that are important in various systems models concerning diversity and ecological stability (sensu R. May). As ecological policy must be founded on the best of models, and the formulation of such models is intellectually exciting, experimental work must be undertaken. The deep-sea benthos stands as an extreme with respects to all of the parameters that I have listed and is thus an unequaled laboratory.

I thus suggest that a formal program of deep-sea environmental manipulation be undertaken using the ALVIN. Organization of the project must be such that stability theoreticians such as Robert May of Princeton or L. Slobodkin of Stony Brook be given a very major role in the design of experiments. As interest in stability extends throughout general systems theory I beleive that such a project will be of interests to biologists and non-biologists alike.

II. Use of ALVIN for well coordinated investigations of the biological aspects of sediment interface dynamics

All deep-sea geological studies concerned with geochemical cycles, sediment diagenesis, stratigraphy, and other topics have too often been undertaken with the implicit assumption that life processes of benthic organisms are of little consequence. Similarly, too many benthic studies have been conducted by biologists who expediently consider sediment to consist simply of easily quantified particle size classes. Meaningful increase of our understanding of this animal-sediment system can only come from cooperative efforts which extend beyond mere jargon exchange. Biologists and geologists must jointly experience by observation that their objects of study thoroughly intermingle.

I thus also suggest that a formal program of cooperative dives be started so that common research interests and concepts be defined. This can not be accomplished sitting in a meeting room to any fraction of the degree that it can in the ALVIN. I suggest that the program be put in the hands of someone extremely well versed in both biology and geology such as Heinz Lowenstam of Cal Tech. It is of greatest importance that the organizer be a person who can appreciate both biological and geological questions as intellectually exciting undertakings.

Good luck in your efforts to secure funding. I would really hate to see a facility such as ALVIN vanish just as I am finishing school and moving on to my own research. If you desire additional opinions, details, or support (verbal) please write. I shall be here through August and then at the Smithsonian for a year.

By the way of closing; did any of the photos of the salp chains come out? I would like a slide if possible.

Respectfully submitted,

Bob Carney

Robert S. Carney

UNIVERSITY OF MARYLAND
COLLEGE PARK 20742

DIVISION OF AGRICULTURAL AND LIFE SCIENCES
DEPARTMENT OF MICROBIOLOGY
AREA CODE (301) 454-5376

May 12, 1976

Dr. J. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Dear Dr. Grassle:

I appreciate receiving a copy of your memorandum dated 5 May 1976 concerning maintaining support for DSRV ALVIN. I strongly support the utilization of ALVIN in ocean research, however, I should like to request that availability of the ALVIN be made more general, that is, to others than those located in Woods Hole. If it would be possible to provide a certain block of time for which other institutions and individuals could compete, it would be a very strong contribution to marine science, in particular, marine biological sciences, including microbiology.

I wish you success in developing sufficient evidence to compel support of the ALVIN.

I shall be out of the country on a research expedition from May 13-28. If you should require any additional information that I might be able to provide please feel free to contact me after the 28th of May.

Yours sincerely,

Rita R. Colwell

R. R. Colwell
Professor of Microbiology

RRC:rs

WEST INDIES LABORATORY (809) 773-3339
Fairleigh Dickinson University, P.O. Box 4010, Christiansted, St. Croix U.S.V.I. 00820

May 14, 1976.

Mr. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Institution
Woods Hole, Mass. 02543.

Dear Fred,

Your letter of May 5th announcing a Workshop for the DSRV ALVIN arrived at the West Indies Laboratory on May 10th. I was rather upset to see that it had been scheduled for May 24th in Woods Hole, especially since this is the same date that the Annual Meeting of the American Association of Petroleum Geologists is taking place in New Orleans. I suggest in the future you check on major meetings of other professions before setting a date for a workshop on something like ALVIN. The West Indies Laboratory is very definitely planning to request time aboard the ALVIN next year and have put together, I believe, a very good science program to look at both the biology and the geology of the north and west coasts of St. Croix. These dives will be in conjunction with purchased dives to be made by the U. S. Navy. Our science program will entail two to three dives in a large submarine canyon which heads into a coral reef on the north shore of St. Croix. The sediment distribution from this canyon system is extremely important in understanding the overall development of carbonate caps and associated deep sea sediments throughout the Caribbean. In addition to the submarine canyon work which is primarily geological, we are very much interested in determining the ultimate fate of seagrass in order that we might put together the model for a carbonate region. This latter portion of the study will be to augment our present seagrass study which is being supported by the National Science Foundation. We also have additional work completed sponsored by past studies from the Eastward in the canyon system. Another portion will be the joint geological-biological study of the deeper environmental regions around St. Croix to determine the possible effects of deep water dumping.

I hope that in the future the UNOLS group can schedule their ALVIN planning programs so that more people can attend and give more time so that necessary arrangements can be made for people who are not local to the Woods Hole scene to attend.

Sincerely yours,

Robert F. Dill
Director

RFD:dyr

Received Announcement for 6th Annual meeting of UNOLS in WASH. D.C. on 25-26 of May. — Hey Guys lets get together!

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

June 3, 1976

Dr. J. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Dear Fred:

In response to your phone call of June 1st I have prepared the following couple of paragraphs outlining my study plans for using the ALVIN through 1980. Please note that I specifically require the ALVIN because of the depths involved and because in many cases I shall need to find, sample, and even recover specific radioactive waste packages.

EPA Radioactive Waste Management Program
Ocean Disposal

Survey Program Requiring ALVIN:

1977-

*A. Continuation of 1975-1976 studies surveying the deep-ocean radioactive waste dumpsite at 38°30'N, 72°06'W at a depth of 2800m to include: (1) Cesium-137 distribution in sediments and water from deep-ocean point sources (breached containers), (2) bioturbation and its effect on vertical profiling and immobilization of Cs-137, (3) sediment retention properties, (4) deepsea contour currents, (5) characteristics of sediment transport, and (6) recovery of selected waste containers for measurements of metal corrosion and matrix degradation rates.

1977-1978 -

*B. Similar work at the Pacific 1900 m radioactive waste disposal site near the Farallon Islands to compare differences in environmental transpo t and immobilization of Pu-238 and Pu-239,240 released in this site. Comparative studies of bioturbation rates, currents, and biofouling as it effects corrosion rates in shallower water (includes container recovery).

1978-1980 -

*C. Generic studies of up to six candidate deep-ocean disposal sites to prepare technical assessment documents and ultimately a generic Environmental Impact Statement prior to formal statutory promulgation of any designated disposal site areas in the <u>Federal Register</u>.

1978

*D. Possible international study of an internationally-used

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

June 3, 1976

radioactive waste disposal site to be coordinated through the International Atomic Energy Agency and the Nuclear Energy Agency. This could be considered as a technology-transfer program.

Sincerely,
Bob Dyer
Robert S. Dyer (AW-459)
Office of Radiation Programs

*
A,B,and D will all be international studies as a follow-on to the 1976 study which **represents** the first international study with the participation of Japan, Canada, and the International Atomic Energy Agency.

ORGANIC GEOCHEMICAL STUDIES

Robert B. Gagosian and John W. Farrington

Department of Chemistry
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

With future Alvin use we propose to continue our studies of the rates and mechanisms of organic geochemical processes in the sediments and suspended matter at the sediment-water interface. Detailed organic analytical analysis of particulate matter collected from sediment traps and bottom water samples along with surface sediments will be made in order to discern the various diagenetic pathways for biochemicals in the deep-sea. From these measurements we will be able to provide estimates of the fraction of the organic matter reaching the benthos which would be most likely to provide the major portion of energy available to support benthic metabolism.

A series of experiments will also be undertaken in enclosed bell jars at the seafloor using radioisotopically labelled organic compounds in an effort to trace the pathways of organic carbon cycling in the benthos and the rates of these reactions.

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : Fred Grassle DATE: May 26, 1976

FROM : Wilford Gardner (for C.D. Hollister)

SUBJECT:

Hollister's sediment dynamics group could carry out worthwhile scientific studies at bottom stations which are revisited on a regular or semi-regular basis.

From a geological standpoint a bottom station in an area of high current activity is desirable. It would be possible and useful to contrast results from a tranquil area such as DOS#2 with an active area such as the Blake-Bahama Outer Ridge. The possibility also exists that a tranquil area could be found on the top or west side of the BBOR which could be contrasted with an area in slightly deeper water on the eastern boundary of the ridge where erosion is occurring. Depth limitations of ALVIN suggest that the location 30°50'N and 74°25'W might be a place to think about.

The Straits of Florida is another area of interest which has high velocity currents creating massive bed forms and definite erosion resulting from southward flowing water. We would like to do some work there.

1. Bedforms
   Describe, sample, and monitor currents and sediment movement in an area of distinct bedforms. This may include careful placement of current meters on different parts of a bed form to monitor near-bottom flow. Such current meters could be recalled remotely. Time series photography would also be used
2. Benthic boundary layer
   Careful placement of a vertical string of current meters to measure near-bottom curent structure.

   Bottom roughness measurements

   Sampling of water column in the bottom 10 m for suspended sediment characteristics

   Nepheloid layer
   deployment and recovery of sediment traps designed to measure flux of particles and residence time of the nepheloid layer.

3. Rate of variation of animal tracks
   Time lapse photography or revisitng of site with natural or artificial marks in the sediment.

4. Rates of biological mixing of sediments (rate of downward mixing of tracer particles)

5. Erosion and deposition
   Scour and deposits around natural and artificial obstacles

cc: C. Hollister

INSTITUTE of MARINE BIOMEDICAL RESEARCH
University of North Carolina at Wilmington

WRIGHTSVILLE MARINE
BIO-MEDICAL LABORATORY

7205 WRIGHTSVILLE AVENUE
WILMINGTON, N. C. 28401
PHONE (919) 256-3721

May 12, 1976

Dr. J. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Institute
Woods Hole, Massachusetts 02543

Dear Frederick:

I wish to thank you for extending an invitation to me for participating in the proposed workshop on May 24 at Woods Hole for discussing further plans of scientific studies involving the use of DSRV ALVIN. I will not be able to attend this meeting since there is an annual conference arranged by the Sea Horse Institute at Wrightsville Beach, North Carolina to discuss problems pertaining to use of materials in marine environment, specific test results in deep sites and related biological questions of biodeterioration and fouling. This conference begins on the 24th and I have already committed myself for participation. Although I am unable to come I wish to submit some comments in response to your request.

As you know the progress made on studies to understand the biology of the deep-sea animals has been extremely slow during the past decade. Despite the fact that several challenging biological questions still remain unanswered, the biologists are still doing a lot of "shadow boxing" to achieve their goals. There are evidently two approaches to conduct biological investigations at depths beyond the diver's reach. These depths include the extreme stretches of the shelf, the slope, the rise, the plain and the trench. One approach involves in situ studies and another approach focusses on simulated studies. Both efforts are mutually complimentary if comprehensive classes of experiments are carefully conceived and conducted to uplift our knowledge on the biological processes and phenomena in deep ocean, which is the largest biotope on our planet.

Frankly, there needs to be better coordination between the various deep-sea biological efforts that are in progress today. In the Pacific studies scientists have largely emphasized the use of sophisticated remotely operated devices (eg. RUM, CURV III, etc.). In the east coast studies scientists have initiated in situ studies at slope depths with ALVIN during the past years. Perhaps it would be profitable to select designated study sites for more concentrated studies instead of spreading the efforts over several geographic locales.

At our institute we have focussed on development of high pressure aquaria array for performing studies on deep-sea animals to understand their life strategies and physiological adaptations. Quite recently a workshop was organized at the Institute under the chairmanship of Dr. Ralph W. Brauer with participants from various institutions within the nation. This conference addressed the question of a deep ocean simulation facility for performing pertinent biological studies. Presently we are moving toward the development of a deep retrieval system and a simulation facility for long term studies on deep-sea animals. We are currently not in a stage to plunge into any in situ experimental studies involving the use of ALVIN. When a deep simulation facility becomes an operational entity we will be interested to

Dr. J. Frederick Grassle
Page 2
May 12, 1976

use deep submersibles and remotely operated devices in conjunction with our deep-sea biology program. Even though I am unable to attend the ALVIN workshop I wish to submit these comments and look forward to hearing further on the deliberation and recommendations of the workshop.

With best wishes and regards.

Sincerely yours,

Robert Y. George

Robert Y. George
Associate Professor
and
Chairman, Experimental Oceanology Program

RYG/jlf

use deep submersibles and remotely operated devices in conjunction with our deep-sea biology program. Even though I am unable to attend the ALVIN workshop I wish to submit these comments and look forward to hearing further on the deliberation and recommendations of the workshop.

With best wishes and regards.

Sincerely yours,

Robert Y. George
Associate Professor
and
Chairman, Experimental Oceanology Program

RYG/jlf

ALVIN Use in 1978 and Beyond

J. Frederick Grassle, Robert R. Hessler
and Howard L. Sanders

The work proposed for 1977 by Grassle will continue. This includes experiments on recruitment, growth and mortality using boxes of azoic mud, studies of the effects of Turner's wood islands on infauna, photography of hard surfaces, and spatial distribution studies.

In 1978 we wish to initiate a collaborative effort on a larger scale. Free vehicles with the capability of modifying large areas of bottom will be built. Dyes and radioactive markers will be introduced into the bottom in order to study growth rates in animals with carbonate hard parts. Exotic minerals will be spread on the surface of the bottom to measure rates of biological mixing of sediments. With Holger Jannasch we plan to sink a dead whale. We will measure the effects of this additional source of organic matter on the infaunal communities of the surrounding sediments. Other concentrations of food labeled with radioisotopes will be used to trace food chains in infaunal benthic populations. Some experiments are planned where predators and large mobile scavengers are excluded.

The main themes are rates of recruitment, growth and mortality of benthic populations, rates of community succession, and the effects of disturbance on deep-sea bottom communities. These studies will have relevance to the prediction of the effects of deep-sea mining and deep-sea disposal including the search for a disposal area for radioactive wastes.

Proposal to Participate in WHOI Bottom Station
Experiment After 1978
Marine Snow Study
Susumu Honjo and K.O. Emery

The transportation of energy from the euphotic layer to the deep sea bottom involves complex procedures. The form of energy transfer via dissolved and particulate (in classical definition) are unable to explain the growing information of large biomass in the deep sea. A number of investigators suggested that ordinary oceanographic water catching devices such as Niskin bottles have failed to collect the most significant part of input flux. Raining rate of large particles, particularly fecal pellets produced by extremely abundant small zooplankton such as calanoid copepods, can reach the deep sea bottom while a part of them disappeared and the contents of pellets being recycled at various depths in the ocean. The arrival of zooplankton remains has only been observed in box-core samples and in some deep-tow net contents. A sediment trap experiment deployed in many depth-layers of the deep sea column of both the Pacific and Atlantic have been in progress to understand the rôle of large, but rarer, particles as an important vehicle of energy transport.

The other possible vertical transportation mechanism of energy is so called "marine snow". This phenomena was first described by Emery (1952). He assessed the density of distribution in the deep water column using a benthograph. Suzuki and Kato (1953) used the term "marine snow" observed from a Japanese submersible Kuroshio. The marine snow is generally defined as amorphous, flakey aggregates which reflect white light to the normal incandescent light. The size ranges from a half meter in diameter to probably microscopic size. Some are separated from sea water by a sharp boundary but many flakes are not outstandingly demarked from the surroundings. Some observers reported fluorescence. A common characteristic among published literature is the extreme fragilness - they do not maintain the shock or pressure change.

The geographical distribution appears to be somewhat related to the large river discharge. In literature, "snowing" has been reported from the continental shelf area more than the deep ocean. However, Costin (1971) concluded the phenomena is a common phenomena in any part of the ocean. Intense snowing was often observed at the mid oceanic ridge area.

The settling velocity of marine snow is controversial (Terry, 1966). Manheim and Milliman (1967) did not observe the vertical motion of flakes. This was confirmed by many ALVIN pilots for many years. Only Kajihara (1971), using Japanese submersible "Kuroshio", was able to measure the settling velcoity of flakes of approximately 1 mm diameter and reported high speed such as 200 m day^{-1} in the shelf area near Hakodate, Hokkaido. The relevance of Kajihara's observation is somewhat questionable because the local downward advection of sea-water has often been reported in the shallow shelf area, especially when the tidal current was high and in may cause misleadings. The density, size and spatial distribution of marine snow in terms of depth and geography, have not been studied quantitatively except by Emery (1952) and Costin (1971).

The hypothetical role of marine snow is an effective scavenger of chemical elements and molecules which otherwise may not settle to the deep sea floor (Tsunogai and Minakawa, 1976, in press). The food value of marine snow (Tsujita, 1969), although it was denied by Paffenhöfer and Strickland (1970) who reported the Calanus was not maintained by feeding "snow"-rich sea water in the laboratory. It would serve to conclude that marine snow is a very common phenomena in most marine environments, but very little of their oceanographic role has been understood.

We propose to investigate (1) quantity of the distribution of marine snow throughout the water column using a light beam counting technique and relate them to other hydrographic criteria, (2) direct close up observation of representative snowing particles from the submersible. If classification of snow is possible, (3) to answer the question if they are really sinking or not by multidirectional current measurements and eye observation, and (4) to obtain data to understand the life cycle of snow by *in situ* observation.

The marine snow is always reported at Deep Sea Station area. We expect to hit snow anytime whenever diving is underway. A light beam counter, inspired by Emery's experiment in 1952, is essentially an application of Tyndall optics. Colimated electronic strobe light scan water space far enough from submersibles turbulent zone, with parallel beam of 50 cm deep in fan-shape. High resolution photographs are taken from right angle and covers 300 cm x 300 cm area. Such photographs will be taken throughout the water column probably every 25 m (in shallow water, experiment must be done at night). The photo-negatives will be analyzed automatically by a particle analyzing computer to obtain size frequency statistics (Honjo, Emery and Yamamoto, 1973). Application of the DSRV ALVIN is the unique solution to accommodate a large precision optical platform. We have developed a simple "hand lense" optics which enlarge *in situ* objective up to 10 area times to observe the individual snow particles.

Except for some limited numbers of dives which demand full ship time to hover in snow-rich water column, the size distribution analysis experiment can be executed by making use of deadhead descent or ascent for the other scientific mission at the bottom station (such as by biologists). A battery package, which is independent of ALVIN's power source, will be provided to operate powerful beam source.

/

ALVIN SHIPTIME 1978

CARBONATE GEOCHEMISTRY *in situ* pH, Eh, and Dissolution Probe Study

Susumu Honjo

There is a growing consensus that most calcium carbonate dissolution in open sea occurs on the sea floor rather than in the water column (for example, Adelseck and Berger, 1975; Honjo, 1975; Honjo, 1976a,b). The flux of dissolved $CaCO_3$ back into the oceans must be from calcareous sediments which cover a large portion of the deep sea floor (Berger and Winterer, 1974; Biscaye, Kolla and Turekian, 1976, for comprehensive synthesis). Obviously we must greatly upgrade our level of the understanding of the processes which involves the dissolution of carbonates at the lower interface and in the sediment. Laboratory and *in situ* measurements of $CaCo_3$ dissolution rates (for example, Berner and Morse, 1974) suggests the calcareous sediment/pore fluid system should come to equilibrium very soon after burial. However, as is well known, changes in the carbonate chemistry of some water does not conform to the simple stoichiometric alkalinity increase assumed in pore fluid dissolution/diffusion models based on the dissolution rate measured (for example, Siever, Beck, and Berner, 1965; Morse, 1976, in press; Takahashi, 1973).

Thus, questions on what part or depth of sediment carbonate particles dissolve has^ve^ not been answered. One possibility is thin film at the interface (Broecker and Broecker, 1974), throughout considerably thick layer of sediment, pore fluid controlled, or limited to the extent of bioturbation. To understand the actual site of dissolution in terms of sedimentary flux of carbonate, we propose two long-running experiments in a permanent deep station in the Atlantic as well as in a pertinent station in the Pacific.

1) Dissolution probe experiment. Berner/Morse/Honjo's standard calcite particles, assortment of planktonic and benthonic foraminifera, various species of cultured coccoliths, aragonitic particles such as pteropods, calcareous algae in reef environment, diatom, Siever's standard silica, etc., are mounted on the etched surface of inert plastic sheet analogous to "fly paper." The probe is penetrated by the ALVIN's manipulator into sediment as deep as 100 cm. The uppermost portion will be exposed to the water layer directly above the interface. Such probe will be left in sediment at least a year in the Atlantic and probably shorter in the Pacific (dependent upon the undersaturation of water, or depth). The recovered probe will be brought to laboratory and particles are investigated under scanning electron microscope to compare to the standard. The degree of dissolution will be calibrated to the result of laboratory dissolution using pH stat of Berner and Morse (1974) so that the rate of dissolution can be approximated.

2) _In situ_ pH, Eh and other electrolytic measurements. Sea water and pore fluid underneath is multicomponent electrolyte solution involving extremely complex physical chemistry. We have no intention to measure the absolute pH condition of sediment and sea water. However, reliable ΔpH measurements through the bottom viscous layer, interface and in-sediment are urgently necessary to build a flux and dissolution model of calcareous sediment.

DSRV ALVIN will provide an excellent platform to develop such technology. We have requested DSRV ALVIN time to conduct a feasibility test in the PANAMA basin in 1977, but obviously, long consistent concommitment is essential. The idea of maintaining deep sea station is therefore strongly supported. As is well known, the Atlantic and the Pacific Ocean are entirely different in terms of geochemical setting. We definitely need to establish a deep sea station in the Pacific Ocean.

APPENDIX

PARFLUX Phase 2, 1978

Outline of Proposal (preparation underway)

CCD Study by ALVIN on the East Pacific Rise

Understanding of the dynamic relationship between supply and dissolution at the "snow line" of planktonic foraminifera and coccoliths (carbonate compensation depth, CCD) is one of the most essential keys to constructing a good model of the planetary-wide CO_2 cycle. The CCD is as shallow as 3,500 m in the East Pacific Rise area. Therefore, by choosing relevant locations, we should be able to reach true oceanic CCD depth by the DSRV ALVIN. Comparison of geochemical and sedimentological setting below and above the line by choosing pertinent stations along a slope would provide definitive information. The ALVIN can be a unique platform to conduct a great variety of geological, geochemical and biological observations, but to prepare various *in situ* experiments (long and short range) performing as a unique *geochemical laboratory on the sea floor*. At present, the following experiments are planned for the proposed series of dives in the Eastern Pacific, preferably the East Pacific Rise off Mexico, during 1978.

1) Sediment trap experiment to assess the raining rate of large particles at CCD depth.

2) Observation of bottom viscous layer at and deeper than the CCD depth.

3) Observation of biological activity, particularly benthic respiration measurement at CCD depth.

4) Intensive *in situ* research on pteropod ooze (Berner et al., 1976) by DSRV ALVIN at shallower stations. Biogenic aragonite may involve the controlling factor on saturation chemistry of sea water.

5) *In situ* electrolytic measurements, particularly ΔpH stratigraphy in sediment and overlying water. Oxygen and sulfide ion electrode measurements if such technology is available before 1978 (refer to the text of the proposal for 1977 DSRV time).

6) Dissolution probe experiment. A variety of carbonate (Berner/Morse standard calciate, foraminiferan tests, coccoliths, aragonitic samples such as pteropods) and silicate (diatoms, etc.) are mounted on innert plastic surface similar in manner to "fly paper" along the side

of probe. Such probes are planted by DSRV ALVIN at various depths including CCD for some pertinent durations. After recovery, the extent of dissolution is determined by SEM and rate of dissolution is calibrated against the series of standards obtained by dissolving a part of same sample in pH-stat experiment.

7) The ALVIN based core sampling, hydrographic data collection, water sampling by GEOSECS/DSRV instrumentation package (particularly for ΣCO_2 and alkalinity measurement) are planned.

8) Participation of other pertinently related projects is solicited.

MEMORANDUM

To: J. Frederick Grassle

From: H. Jannasch and C. O. Wirsen

Subject: Microbiology

Studies will focus on rates of microbial decomposition of dissolved and solid organic matter under deep sea conditions with emphasis on aspects of ocean dumping of waste materials. The submersible will be needed for operating in situ inoculation and incubation devices on permanent bottom stations as well as in the water column. Radioactively labeled tracer materials will be incubated for periods from several days to more than a year. Experiments in intermediate waters of high and low turbidity will be important for understanding the transport of energy in the form of decomposable organic materials to the deep sea floor. In order to study the fate of bulk material with high sinking rates and its role in sustaining the particular benthic deep sea population of animals and microorganisms, we are seeking the opportunity to deploy the carcass of a stranded whale with the help of the appropriate authorities (National Fisheries Service and National Coast Guard). This major experiment will be done in the vicinity of one of our permanent deep sea stations with the aim to follow the food chain processes and remineralization by various techniques of monitoring and direct visual observation. The normal occurrence and rate of removal of organic matter in the deep sea and the type of microorganisms involved will be compared to those observed at dumping sites of similar depths.

Memorandum

To: Fred Grassle May 24, 1976

From: Paul McElroy
Bolt, Baranek, Newman
50 Moulton Street
Cambridge 02138

Classes of Acoustic Measurements Which Might Be Carried Out

at One or A Series of Bottom Stations From ALVIN

1. Plotting on either a deterministic or statistical basis of details of microtopography.

2. Near-bottom sub-bottom profiling.

3. Reflectivity vs frequency and/or incident angle of bottom sediments in regions of differing fauna.

Such acoustic measurements should be coupled with detailed knowledge of benthic infauna and their effects.

e.g. Microtopography created by burrowing animals.

e.g. Sediment mixing and modification by burrowing and sediment-ingesting infauna.

Site not critical provided it is not homogeneous.

N. B.: Such measurements presuppose completion of Modular Acoustic System for ALVIN.

Lamont - Doherty Geological Observatory | *Palisades, N.Y. 10964*
of Columbia University

Cable: LAMONTGEO
Palisades New York State
TWX-710-576-2653

Telephone: Code 914, Elmwood 9-2900

June 2, 1976

J. Frederick Grassle, Convener
UNOLS ALVIN Workshop
Woods Hole Oceanographic Inst.
Woods Hole, Mass. 02543

Dear Fred,

Reflecting upon last week's meeting at Woods Hole regarding future funding problems of ALVIN, we feel that quite a few positive steps were accomplished. Among the more important advances was the general acceptance by ALVIN users to explore program possibilities that could contribute to a cooperative effort by both users and operators to conceive logical and efficient scheduling of ALVIN that will give maximum number of dives per transit mile and operating days. This most important objective will not only reduce nonproductive lengthy transit legs but will also reduce the cost per dive to the primary underwriters of the program. Not withstanding equipment and weather interventions into the schedule, which have not been really significant this year, the actual cost per dive for these primary funding groups has been inflated far above the advertised cost of $8,500 per day. Much of this disparity in cost accounting is due to a rather shallow process that loses too many days of dive time on long transit legs. No matter how the accounting procedures are presented, all ALVIN users will continue to compute the cost of the program in terms of cost per dive.

We feel that many of the interesting Marine Biology projects presented at the meeting could be combined with valid scientific geological problems not only in the same location as the biological experimental stations but also utilising observations and data that would benefit both disciplines. If we are to use "Rates" as the game word, certainly there are many applications from your studies to sea floor sedimentation studies that would utilise mixing rates, sedimentation rates, bioturbation rates, erosion rates and population rates from both sides of the benthic boundary layer.

As a single example, a major component of deep sea sedimentation rates is surface productivity. Precise measurements of these inter-relationships would have exciting applications to both biologists and geologists.

The Equatorial Current, a high productivity belt in the Eastern Pacific that varies from 1° to 3°N, is marked by a dramatic apparent increased rate of sedimentation as seen in sub-bottom reflection profiles (Fig. 1&2). Even the small-scale Xerox of these CONRAD 13 profiler records show the definite increase in sediment layers beneath the current. Although these lines, from 140° to 106°W, are in an area too deep for ALVIN, we have seen from Precision Depth Records that the ridge crest west of the Galapagos Islands rises high enough to allow bottom sampling by ALVIN. This area (95° to 96°W) should be far enough west so that the terrigenous input from the Galapagos Islands would not obscure the differential sedimentation rate. Inherent in the study is the problem of emplacing two or more stations to measure the differential. Since there are wide perturbations in the North-South boundaries of the current, it would be necessary to place the control station (normal Pacific Deep Sea sedimentation rates) quite far to the north along the same ridge beyond the known, or suspected, limit of increased productivity of the Equatorial Counter Current.

The Eastern Pacific, west of the Galapagos Islands, offers the only deep ocean environment along the equator with depths that complement ALVIN's range. The Atlantic is too deep; east of the Galapagos the unnaturally high current regimes caused by ridges would give results based on topographic control rather than surface productivity differences.

Another area of mutual interest would be the Blake-Bahama outer ridge (Fig. 1). Within a distance of several nautical miles there is a dramatic bottom environment difference (Fig. 3). The deep ocean environment is preserved by transport of terrigenous sediments with the Gulf Stream northward flow of 100 to 300 cm/sec along the western margin of the plateau. The transition zone, along the eastern margin, between erosion and deposition can be reached by ALVIN at depths around 3500m (Fig. 4). This site offers an unusual opportunity to study differential rates and communities within a small area. Once again the biological and geological interests would coincide.

As a simple example, [illegible] sedimentation rates to surface productivity [illegible] the nature of these [illegible] relationships could [illegible] applications to both [illegible].

The Equatorial Current [illegible] the Eastern Pacific that [illegible] by a dramatic upwelling [illegible] in sub-bottom reflectors [illegible]. Even the small scale Xerox of these [illegible] show the definite increase in [illegible]. Although these lines, [illegible] deep for ALVIN, we have seen [illegible] that the ridge crest [illegible] high enough to allow better [illegible] ([illegible]) should be [illegible] that the [illegible] input from the [illegible] differential sedimentation [illegible] the problem of [illegible] the differential. Since [illegible] north-south boundaries of the [illegible] to place the control [illegible] sedimentation rates) [illegible] beyond the [illegible] productivity of the equatorial [illegible].

The eastern Pacific, west of [illegible] offers the only deep ocean [illegible] with depths that [illegible] is too deep; most of [illegible] current regime, [illegible] to topographic control rather than [illegible] differences.

Another area of mutual interest [illegible] Blake-Bahama outer ridge (Fig. 7). Within a distance of [illegible] nautical miles there is [illegible] Terrace (Fig. 8). [illegible] of transport of terrigenous sediment [illegible] northward flow of 100 to [illegible] of the plateau. The transition [illegible] up, between erosion and deposition [illegible] at depths around 3500m (Fig. 4). [illegible] an unusual opportunity to study differential rates and [illegible] in a small area. [illegible] biological and geological interests would coincide.

The sites, southeast of Cape Hatteras should have interest for experimental use; the stations could be occupied during transit legs for both Pacific and Caribbean study programs. Thus, assuming that ALVIN programs will continue to utilise the better weather conditions found in the lower latitudes during winter, the experimental studies would be almost assured of collateral programs that would support an annual occupation of the stations.

The main point we wish to bring up is that the interests of Biologists and Geologists are not mutually exclusive but in fact are complementary. Fauna/sediment relationships are indicators of many factors both within the water column and at the water-sediment interface. We have noted, even over short distances, vertical and lateral, vast changes in faunal populations, species and types. In some cases we see in the Pacific great numbers of a species such as tripod fish which have been rare in the Atlantic. We use these macrofaunal observations as indicators of deep oceanic processes. For example, the tripod fish can be counted upon to give us a current direction; no matter how slight the current, a tripod fish will almost always face into the direction of flow. Stalked sponges are variable; the strong-stalked species will agree with tripod fish, the weaker ones bend with the current. There are zonation differences with respect to bottom types that seem to be more important parameters than depth. A hard-rock outcrop can sometimes be noted not by its obvious appearance but by the stalked filter feeder attached to its surface just below a sediment "dusting" that would normally obscure from our view the lithified sediments.

Our projects of particular interest for geological investigation include Navidad Bank where we started a dive series this spring but were unable to complete the proposed program due to deteriorating weather conditions. As pointed out earlier in the letter, complementary programs should be devised to avoid doubling back on transit legs several times. A series of deep dives along this carbonate platform should be made during the transit leg from the proposed Tongue of the Ocean series to the next logical port which would probably be San Juan.

We are also most interested in the subduction zone problem which can be studied in the Middle America Trench in conjunction with our proposed TRIESTE campaign in 1977. ALVIN is without doubt a more highly maneuverable machine and therefore more adapted to exploration of steep escarpments than TRIESTE and would be ideal for investigating the upper walls of the subduction zone along the west coast of South America.

There is no need to point out the obvious "environmental" applications to these studies. Certainly more support for oceanography is going to come from sources which are concerned with these applications. For example, if we are to bury potentially high contamination objects in the deep ocean would it not be necessary to know whether the bioturbation rate decreases and perhaps ceases if sedimentation rates are very high. In the same vein, Base Line Measurement stations located over large areas in variable environments are going to provide a more valid standard against which measurements of seabed engineering disturbances can be made.

It was a valuable experience to become acquainted with the programs of other ALVIN users at the meeting. I think that the meeting will result in closer cooperation of scientific objectives within the different groups and a more comprehensive scheduling for these future programs. We will be most happy to assist at any time in any way to help keep the ALVIN program in operation. It has been demonstrated that submersibles are no longer in the experimental stage and it would be a setback to oceanographic research for all scientific disciplines to allow the program falter at this time.

Sincerely yours,

Michael Rawson

MR:sah

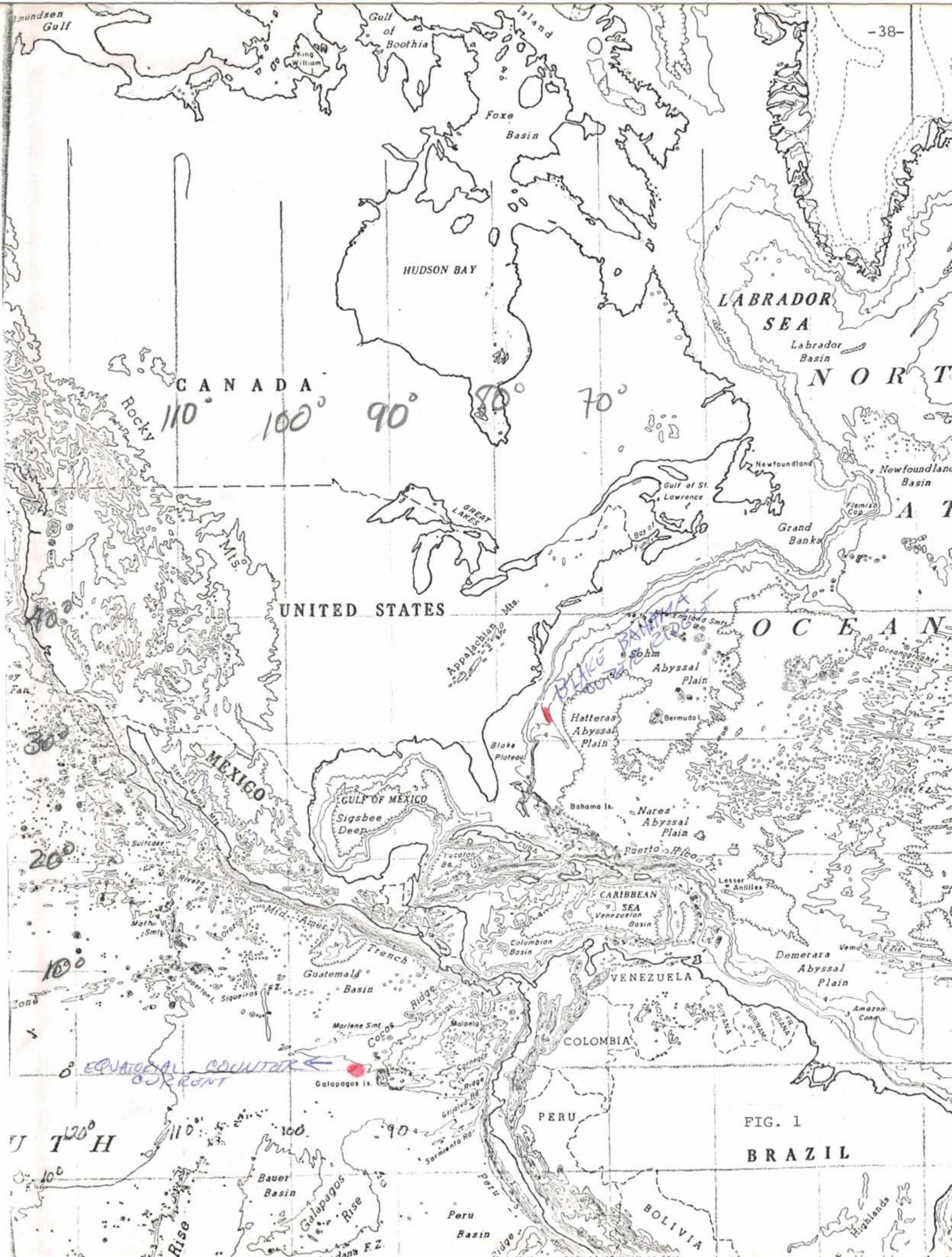
There is no need to [illegible] [illegible] applications to these studies. [illegible] support [illegible] oceanography is only to come [illegible] are concerned with these applications. [illegible] to have [illegible] tentially high contamination objects [illegible] could it not be necessary to know whether the [illegible] and perhaps [illegible] are very [illegible]. In the same vein, [illegible] located over large [illegible] to provide a more [illegible] of useful engineering [illegible].

It was a valuable [illegible] with the progress of other [illegible] at the [illegible]. [illegible] that the meeting will [illegible] of scientific objectives within [illegible] comprehensive scheduling for [illegible]. We will be most happy to assist [illegible] the [illegible] program [illegible] that submarines are no longer in the [illegible] it would be a setback to [illegible] of [illegible] to allow [illegible].

Sincerely yours,

[illegible]

[illegible]



Amundsen Gulf
Gulf of Boothia
King William I.
Island
Foxe Basin
HUDSON BAY
LABRADOR SEA
Labrador Basin
NORT
CANADA
Rocky Mts.
110°
100°
90°
80°
70°
Newfoundland
Newfoundland Basin
Gulf of St. Lawrence
Flemish Cap
Grand Banks
GREAT LAKES
Bay of Fundy
A T
UNITED STATES
Appalachian Mts.
New England Smts.
OCEAN
BLAKE BAHAMA OUTER RIDGE
Sohm Abyssal Plain
Oceanographer
Hatteras Abyssal Plain
Bermuda I.
Blake Plateau
40°
30°
20°
10°
0°
MEXICO
Sierra Madre Mts.
GULF OF MEXICO
Sigsbee Deep
Bahama Is.
Nares Abyssal Plain
Puerto Rico Tr.
CUBA
Yucatan Ba.
Lesser Antilles
CARIBBEAN SEA
Venezuelan Basin
Columbian Basin
Suitcase Smt.
Rivera F.Z.
Mid-Amer. Trench
Orozco F.Z.
Math Smt.
Clipperton I.
Siqueiros F.Z.
Guatemala Basin
Demerara Abyssal Plain
Vema F.Z.
VENEZUELA
Cocos Ridge
Marlene Smt.
Cocos
Malpelo
Carnegie Ridge
COLOMBIA
GUYANA
SURINAM
FR. GUIANA
Amazon Cone
EQUATORIAL COUNTER CURRENT
Galapagos Is.
Grijalva Rd.
PERU
110°
100
90
120°
U T H
Sarmiento Rd.
Bauer Basin
Galapagos Rise
Rise
Peru Basin
Peru
BOLIVIA
BRAZIL
Highlands

FIG. 1

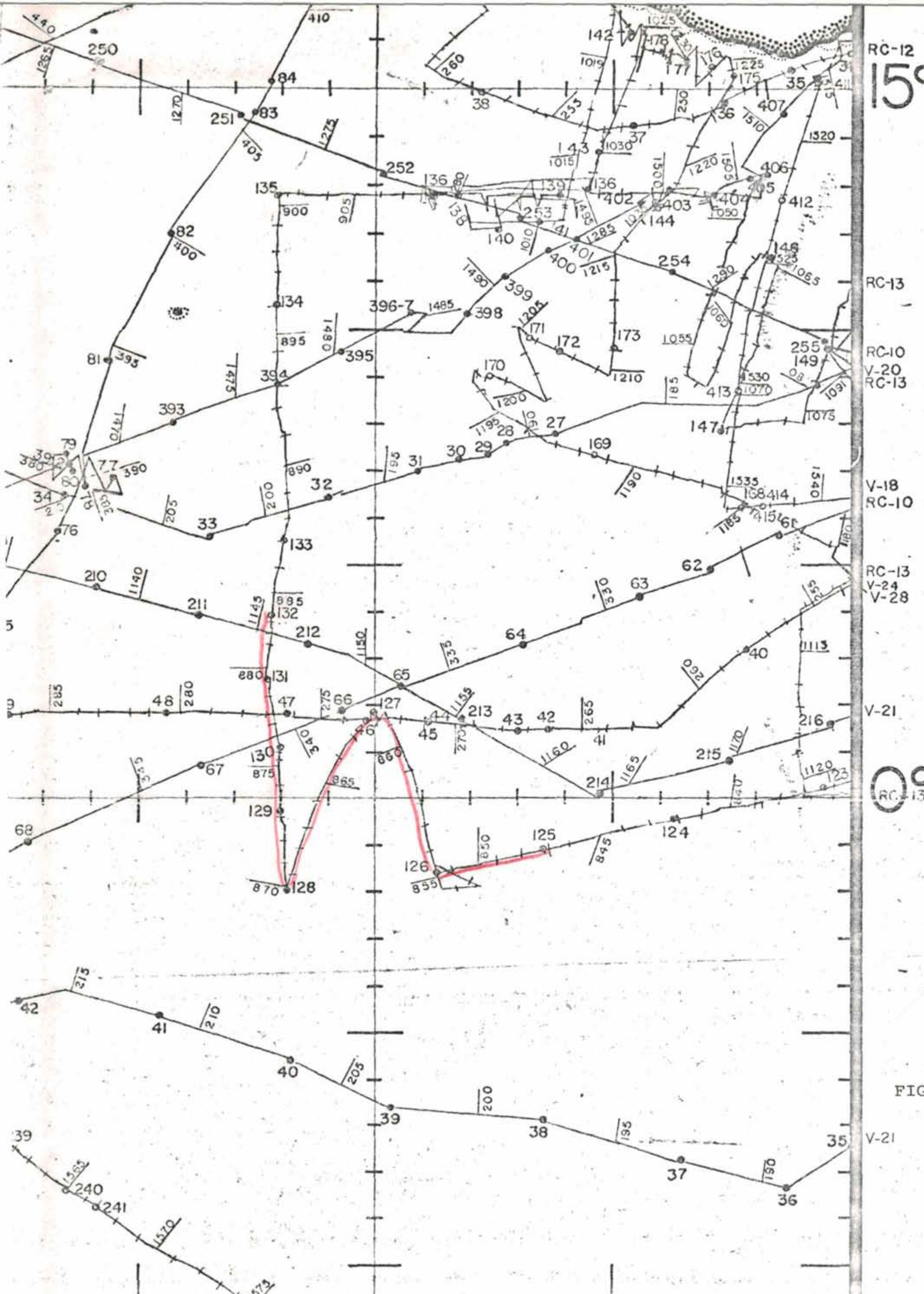
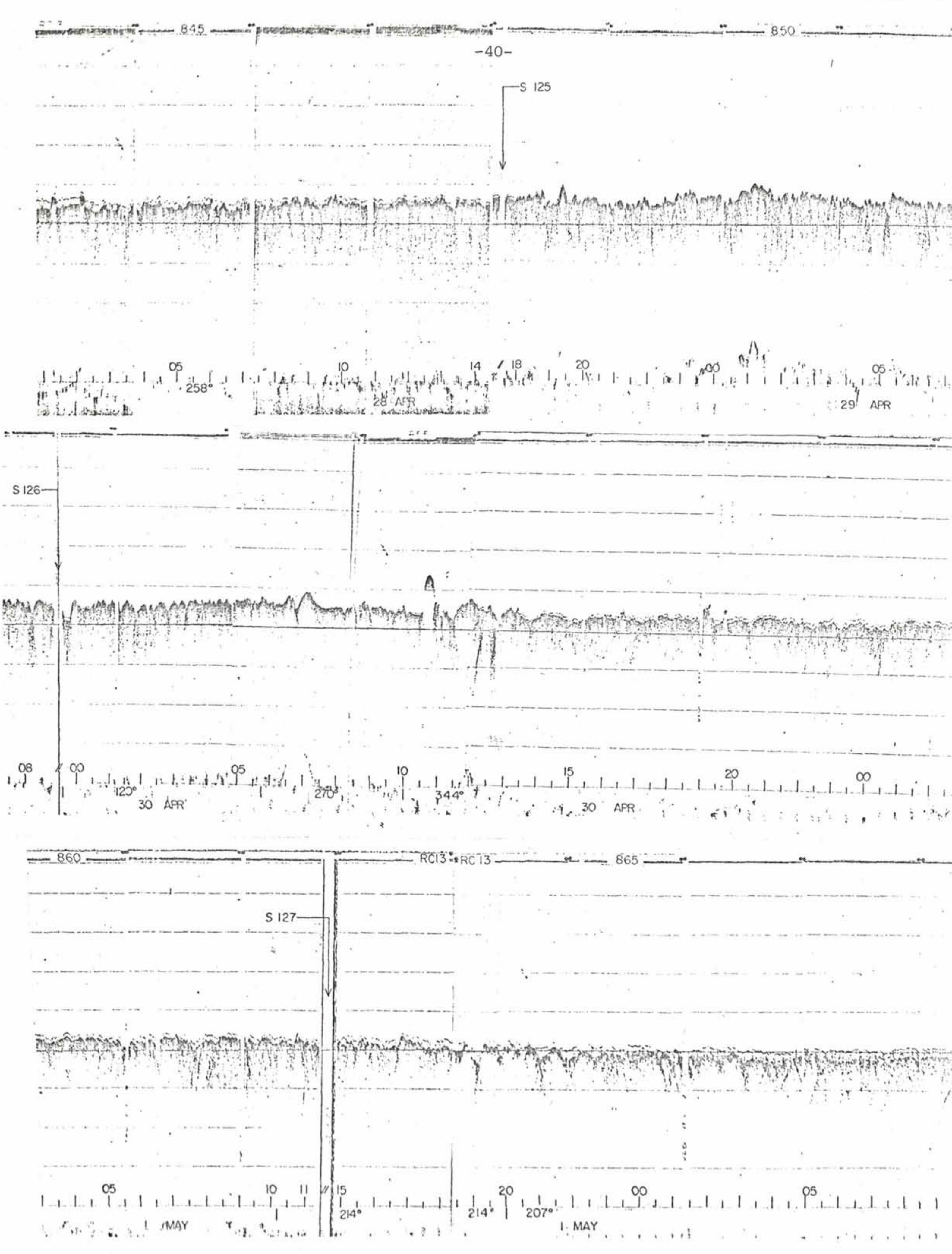
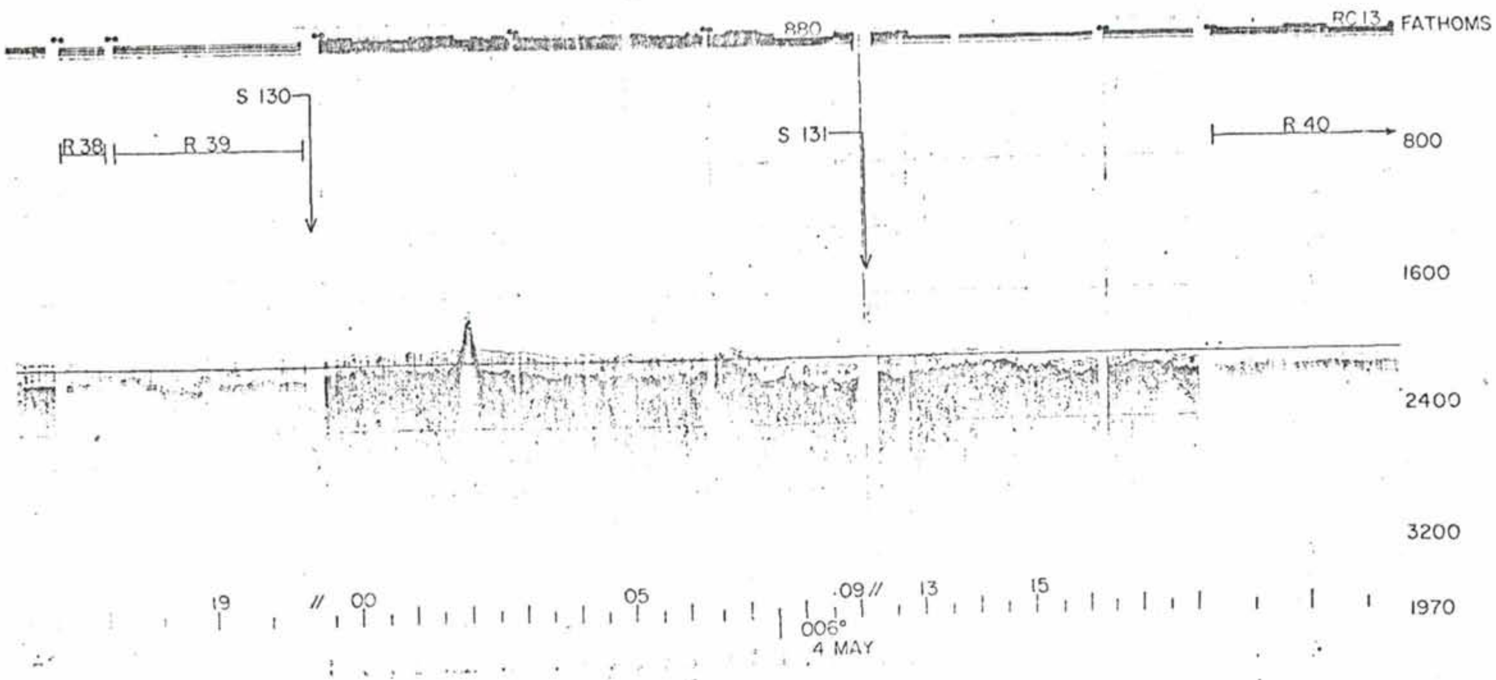
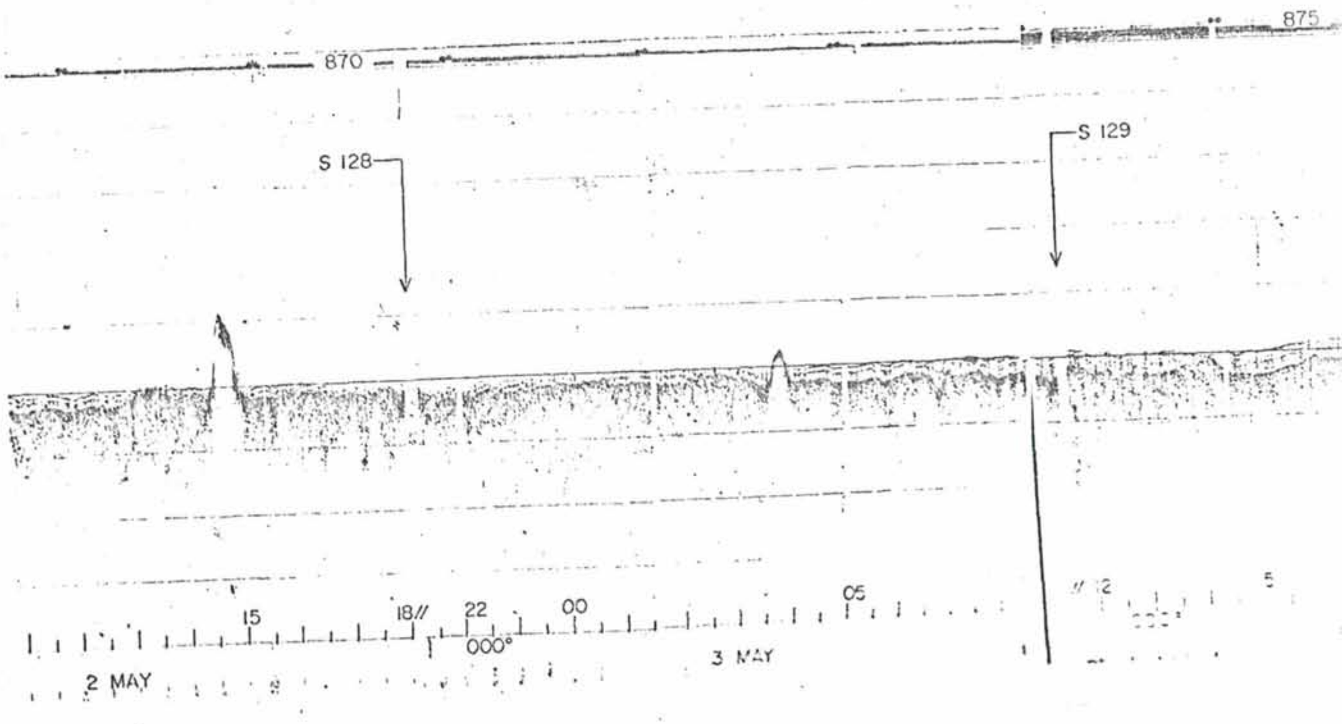

RC-12
15°
RC-13
RC-10
V-20
RC-13
V-18
RC-10
RC-13
V-24
V-28
V-21
0°
RC-13
V-21
RC-11
105°
95°

FIG. 2


845
850
S 125
05
258°
10
28 APR
14
18
20
00
05
29 APR
S 126
08
00
120°
30 APR
05
270°
10
344°
15
20
00
30 APR
860
RC13
RC 13
865
S 127
05
10
11
15
214°
20
214°
207°
00
05
MAY
1 MAY


RC 13
FATHOMS
880
S 130
S 131
R 38
R 39
R 40
800
1600
2400
3200
1970
19
00
05
09
13
15
006°
4 MAY


870
875
S 128
S 129
15
18
22
00
05
000°
2 MAY
3 MAY

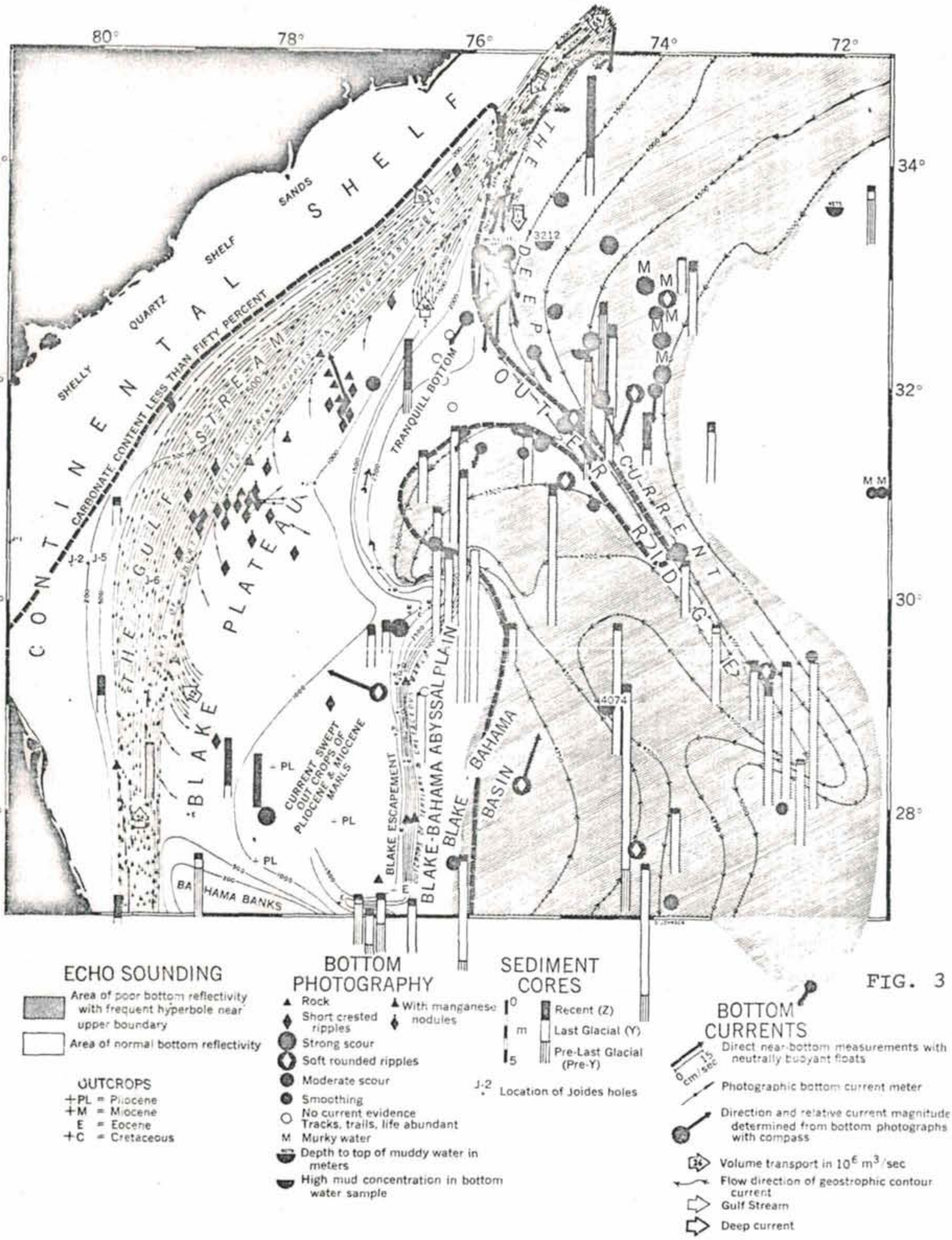
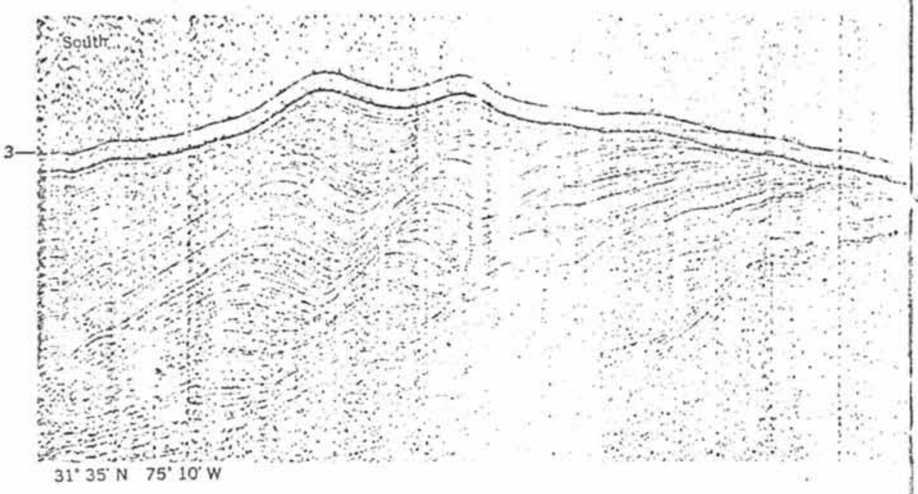


FIG. 3

9.79 Bottom currents, sediments, and echogram character on the Blake Plateau and Blake-Bahama Outer Ridge. Short-crested ripples, manganese nodules, and Tertiary outcrops are found beneath the Gulf Stream which acts as a barrier to seaward transport of continental sediment. The Outer Ridge is formed by rapid deposition from the southerly flowing sediment-laden Western Boundary Undercurrent flowing parallel to the contours. Watery sediments that result from rapid deposition exhibit poor reflectivity.



suggested by Needham, that the red deep-sea sediment found in the continental margin to the south came from this region. The Western Boundary Undercurrent was found to be the process transporting this distinctive red material parallel to bathymetric contours from the continental margin off Nova Scotia to the Bahamas. Recent work on pollen and spores has provided further confirmation (H. D. Needham, D. Habib, and B. C. Heezen. 1969. Upper Carbonniferous palynomorphs as a tracer of red sediment dispersal patterns in the northwest Atlantic. *J. Geol.*, 77:113-120).

23. H. Stommel. 1965. *The Gulf Stream: A Physical and Dynamical Description* (2nd ed.)., Univ. of California Press, Berkeley, 248 pp.

24. B. C. Heezen, C. D. Hollister, and W. F. Ruddiman, 1966. Shaping of the continental rise by geostrophic contour currents. *Science*, 151:502-508.

25. M. Ewing and E. M. Thorndike. 1965. Suspended matter in deep ocean water. *Science*, 147:1291-1294.

26. J. C. Swallow and L. V. Worthington. 1961. An observation of a deep countercurrent in the western North Atlantic. *Deep-Sea Res.*, 8:1-19.

27. The deposits of contour currents and turbidity currents (see Chapter 8) have often been confused. The ideal turbidity current deposit (*turbidite*) is a relatively thick bed, centimeters to meters thick, which grades in particle size from coarse at the base to finer toward the top. Bottom contact is sharp and the top diffuse. Turbidite sand is generally dirty with at least 10 per cent mud occupying the spaces between sand grains. The perfect deposit of the contour current (*contourite*) is a thin, millimeters to centimeters thick, bed of clean, cross-bedded silt. Both upper and lower contacts are sharp and there is little mud between the grains. Since contourites are often derived from turbidites, the two ideal extremes are separated by a complete transitional sequence.

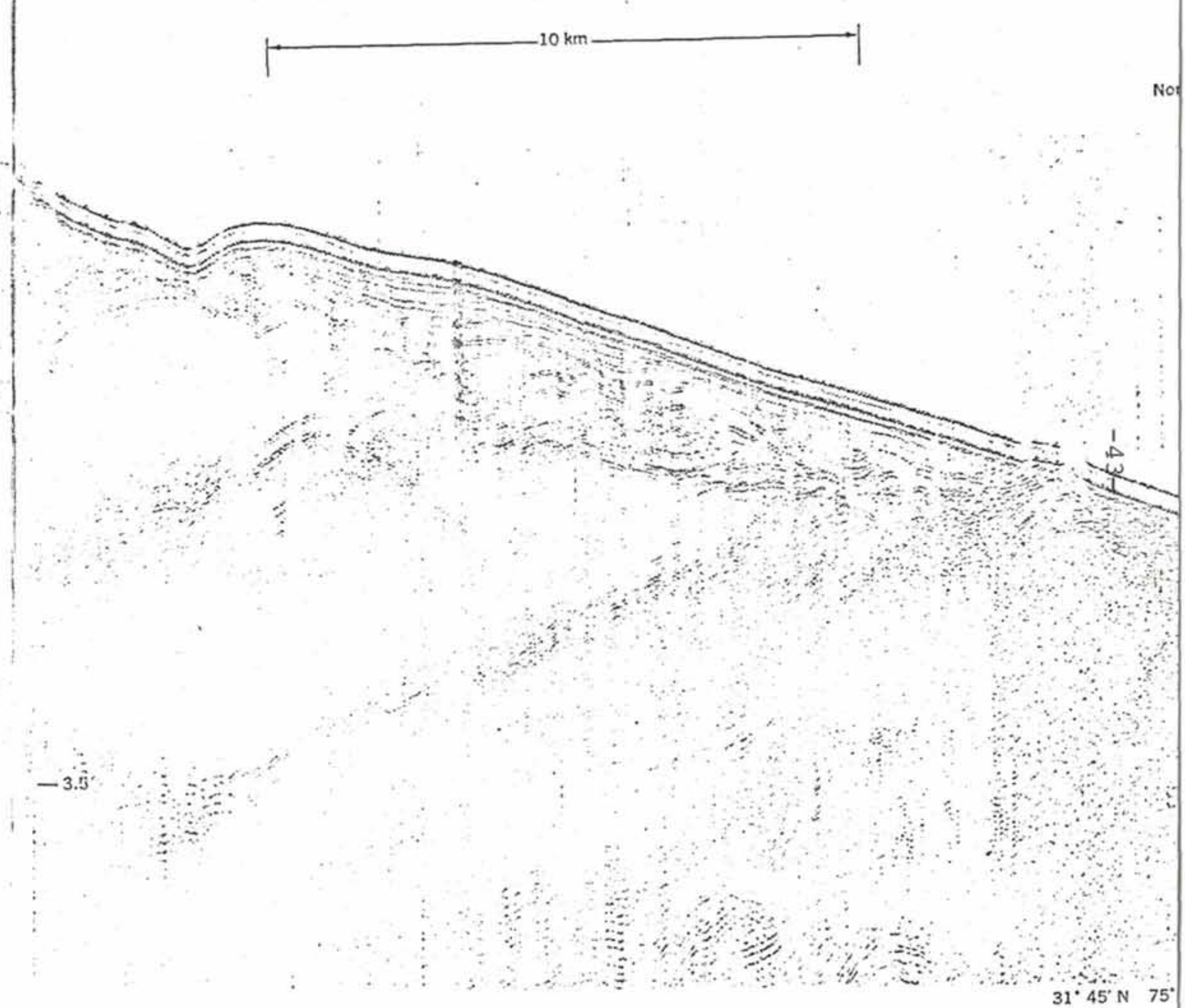


FIG. 4

9.83 Bottom currents have built this migratory sediment drift (Blake-Bahama Outer Ridge) by preferentially eroding (right) and depositing (left) fine muds.

-43-

MEMORANDUM

To: J. Frederick Grassle

From: Gilbert T. Rowe

Subject: Potential ALVIN Use After 1977

Rates of physical and biological processes on the deep-sea floor appear to be extremely slow compared to shallow water. The slow rates of processes in the deep-sea may result from the low rate of flux of organic energy to great depths, and therefore some of my efforts will continue to be directed to discovering and measuring what these rates are. My research in both shallow water and deep water will emphasize the various relationships between the chemical and physical properties of sediments and its biota and the water column. This will include deploying several kinds of experiments and sampling devices. To date, I have used time-lapse cameras and sediment traps. This year we initiate several experiments under NOAA support to determine the erodability of sediments at Deep Water Dumpsite 106 off the coast of New Jersey. The rationale behind the work is a determination of the fate and effects of heavy metals on the deep sea biota. Other work under the same support is concentrated on the interactions between the pollutants and the biota of the water column. Large zooplankton such as salps and jellyfish filter large quantities of particulate matter from the water column and they may function to package pollutants into fecal pellets which have a much higher sinking rate than would be expected from the original particulate matter formed when the waste solutions are introduced into the water column. Experience we have had with nearshore liquid waste precipitates in sea water is very important to an understanding of the fate and changes that the wastes undergo. ALVIN will be useful for similar studies at depths in the open ocean where similar particulates are formed from extant dumping practices.

We have been conducting a study of the zonation of benthic animals in the deep sea using both bottom photography (ship tethered) and conventional sampling techniques (grabbing and trawling). Topographic anomalies such as submarine canyons and trenches are difficult if not impossible to sample with these ship-tethered approaches. We therefore have initiated studies using ALVIN to make such investigations in places where topography and turbidity prevent them. These include the Gulf of Maine, from which we published one paper and a data report, and studies in Hudson Canyon, from which have come several papers on sediment, current and animal interactions. Dave Cacchione, Alex Malahoff and I are presently working up material from the deep extension of the Hudson Canyon onto the continental rise. These studies will be continued in other regions. We are presently summarizing our photographic work in the Mid-Atlantic Bight; our next effort will be analyses of the photographs taken on the FAMOUS expedition and in the Cayman Trough. These will be very useful in our studies of fish and megabenthos zonation and we hope to be able to utilize future ALVIN work in the equatorial regions for similar such studies (my close associate in this work is R. L. Haedrich).

GTR:jp

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : J.F. Grassle, Convener, Alvin UNOLS Workshop DATE: 8 June 1976

FROM : C. Sassaman

SUBJECT: Proposed use of DSRV Alvin in benthic population studies.

Alvin-deployed and free-vehicle baited traps will be used to systematically sample populations of bathypelagic amphipods at two permanent bottom stations in the North Atlantic Ocean. The rate of attraction of amphipods to baited traps will provide data on temporal aspects of niche separation between species of differing size. The rate of population response to systematic trapping and size-frequency distributions will be used to estimate population size, vagility, and the mode of recruitment (adult immigration vs juvenile recruitment) of the component species of the amphipod community. Genotypic analyses of capture animals will be conducted to determine the population genetic correlates of the observed population structures.

A trapping grid will be deployed at one bottom station in conjunction with a labelled bait to measure the directionality of attraction to and departure from a centrally located food source. This array will also measure dispersal distances of amphipods after they have depleted a local resource.

Recent research has suggested that large, mobile carnivores (such as the lysianassid amphipods) play a major role in initiating the breakdown of large parcels of animal matter which reach the sea floor. The rate at which this initial breakdown occurs, and the area over which a given food resource is broadcast may therefore be largely dependent upon the size of amphipod populations, the rate at which they are attracted to these food sources, and the distances and consistencies of direction with which they disperse after the depletion of such a local resource. These rates and distances are the major topics of the proposed research.

UNIVERSITY OF MIAMI

Dorothy H. and Lewis Rosenstiel
SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE

May 13, 1976

COMPARATIVE SEDIMENTOLOGY LABORATORY

FISHER ISLAND STATION
MIAMI, FLORIDA 33139
(305) 672-1840
Cable: UOFMIAMI

Dr. J. Frederick Grassle, Convener
UNOLS ALVIN WORKSHOP
Woods Hole Oceanographic Institute
Woods Hole, Massachusetts 02543

Dear Dr. Grassle:

Thank you for the copy of your letter regarding a workshop to plan future programs for DSRV ALVIN. neither of us can attend the workshop, but we can offer some comments that might be useful.

Although our experience with ALVIN is limited to four dives in the Tongue of the Ocean in April 1975, that was enough to turn up some quite new findings and to convince us that ALVIN opens up a whole new area of research on the sedimentary processes, topography, and diagenesis of the margins of carbonate platforms and shelves. The following paragraphs summarize our findings and indicate the directions and significance of an ongoing program in our area of interest.

As a result of our dives we now appreciate the importance of erosion by turbidity currents in shaping the morphology of the slopes of carbonate platforms. We also documented the interaction of sea-floor cementation with this erosion, both on the slopes and in the axial valley. By integrating the results from our transects we developed a composite three-dimensional view of the topography that makes the detailed bathymetric surveys much more meaningful.

Our study of the specimens of chalk from the cliffs have yielded some quite new and entirely unexpected results. Judging from preliminary age dating, these chalks are surprisingly young and yet they show some dramatic changes in mineralogy like those we know so well from terrestrial environments. We are in the process of confirming these findings and are naturally anxious to examine and sample other areas to gauge the extent of these phenomena. The rapid lithification of pelagic muds plays a major role in the development of the morphology of the slopes. And because ancient chalks like these young ones are a principal petroleum reservoir in the North Sea, our findings have added significance.

An Equal Opportunity Employer

A private, independent, international university

UNIVERSITY OF MIAMI
MIAMI, FLORIDA 33139

May 13,1976

COMPARATIVE SEDIMENTOLOGY LABORATORY
FISHER ISLAND STATION

(305) 672-1840
Cable: UOFMIAMI

Page 2

We are excited by the results from this brief experience and realize that it opens the door to a whole area of additional studies. Firstly, we would like to extend our study of morphology and diagenesis on the slopes to other parts of the Bahamas and especially to greater depths, as for example, on the Blake-Bahama E carpment. In all such future dives we would look for any morphological evidence of faulting or slumping, evidence that can only be produced by direct observation. Secondly, we believe ALVIN can and should be used to monitor sedimentary processes to develop some much needed calibration. Just recently Larry Schumaker told us about the disappearance of an instrument station off New Providence and we would like to follow this lead by establishing a series of surveyed sites in likely areas of sedimentary movement.

We feel that one of the major justifications for continuing research on sedimentation and diagenesis of the margins of carbonate platforms is their relevance to understanding facies anatomy and the distribution of porosity and permeability in comparable ancient platform margins. These ancient margins are the preferred sites for the occurrence of reservoirs for oil and gas and metallic ores.

Sincerely yours,

Schlager
Wolfgang Schlager
Research Associate Professor

Robert Ginsburg
Robert N. Ginsburg
Professor of Sedimentology

RNG:WS:lk

An Equal Opportunity Employer

A private, independent, international university

UNIVERSITY OF MIAMI
Dorothy H. and Lewis Rosenstiel
SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE

4600 RICKENBACKER CAUSEWAY
MIAMI, FLORIDA 33149
(305) 350-7211
Cable: UOFMIAMI

18 June 1976

Dr. J. Frederick Grassle
Woods Hole Oceanographic Institute
Woods Hole, Massachusetts

Dear Fred:

Appended please find a short statement of my proposed future research for ALVIN. I hope this doesn't arrive too late to be included in the package you're putting together for the July committee meeting.

If you need any more information please let me know.

Sincerely,

Jon C. Staiger
Research Associate Professor
Division of Biology and
Living Resources

enclosure
JCS/dsj

An Equal Opportunity Employer

A private, independent, international university

Statement of future proposed research for DSRV ALVIN by Dr. Jon C. Staiger, Research Associate Professor, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

It is proposed to use ALVIN beyond 1977 to conduct research on the distribution and zonation of deep-sea benthic megafauna in the Bahamas. The proposed research can be divided into two projects, to be investigated consecutively.

1) To continue the comparative study of the species composition, distribution, and zonation of the benthic megafauna of the Tongue-of-the-Ocean (TOTO) and Exuma Sound.

This study combines work already underway in TOTO with new work in Exuma Sound. A three-year trawling-based study of the population structure and diversity of the benthic ichthyofauna of TOTO and Exuma Sound, under the direction of Dr. C. Richard Robins, is presently near completion. This study, coupled with a series of ALVIN dives in TOTO in 1975, has produced a large amount of basic knowledge which will enable us to utilize ALVIN's full capabilities as an observation system to further document and refine our conclusions.

Most of the level-bottom area of TOTO (900-1800 m depth range) is dominated by a benthic-fish assemblage that is characterized by 14 species, representing five families. At about 1800 m depth the species composition of this assemblage apparently changes, so that beyond 2400 m depth a different assemblage, representing the same five families, dominates. This transition is seen in both TOTO and Exuma Sound, but it is best documented in Exuma Sound, where there is a larger area of level-bottom at depths greater than 1800 m.

On the New England continental slope a parallel pattern of zonation is seen, but several of the dominant families of fishes and invertebrates are different.

The technique used to study benthic megafauna community composition, diversity, and distribution involves constant-speed observation transects, with each observer tape-recording fish species identifications, numbers of individuals, and time, along with any observations on variation in substrate, current flow, and topography. The efficacy of this method was demonstrated during our 1975 ALVIN dives. In addition to the taped observations, all transects will be recorded photographically, using the external cameras. An odometer wheel will be used to measure minimum distance travelled. Both the tapes and the continuous photographic record will be analyzed for composition, abundance, contagious distribution, and diversity of the benthic megafauna. The field of the fixed 35 mm cameras is much smaller than the area that can be seen from the observer's viewports. In addition, most fishes that swam directly in front of the submersible were also seen from either the port or starboard viewports. For these reasons, I place greater emphasis on the observer's recording of fish identification than on the fixed external cameras. As the invertebrate megafauna is much less motile and far more abundant than the fishes, the 35 mm transparencies afford a more reliable estimate of its composition. The transparencies will be analyzed for species composition, distribution pattern, and dominance of the invertebrate megafauna and the fishes by projecting them on a gridded screen and counting and identifying the organisms present within the grid. Statistical comparisons will be made between all scales of analysis: grid subdivisions, entire slides, transects, and dives. This method is essentially the same as that used by Grassle, Sanders, Hessler, Rowe, and McLellan in their study of benthic megafauna from the Gay Head - Bermuda transect. Tape-recorded data on benthic fishes will be similarly compared, but on the basis of time, rather than photographic quadrat.

2) To study the composition, distribution, and zonation of the

megafauna associated with the upper slope of the Bahama Escarpment (at depths to 3600 m) in the vicinity of 24°N, 75°W (north of the Cat Island/San Salvador area).

The Bahama Escarpment off Cat Island, Conception Island, Rum Cay, and San Salvador drops off from a 1400 m sill to depths in excess of 4500 m. This steep slope is not amenable to conventional trawling and photographic sampling techniques, but can be studied from ALVIN using the same observation transect techniques as for level-bottom analyses.

Research conducted by Drs. Robins and Staiger on shallower steep slopes in the Caribbean Sea, using small otter trawls, has demonstrated the presence of a number of species of fishes whose distributions are apparently restricted to such habitats, at least in the upper Archibenthic Zone of Transition. Our knowledge of the composition and distribution of the megafauna associated with deeper slopes in the tropics is quite poor. Undoubtedly, some elements will be shared with the adjacent fauna of Exuma Sound, but whether the same species dominate and are zoned in a similar manner is a most interesting question.

These two projects are designed to provide basic information which will be an essential contribution to an ongoing, long-term study of the deep-sea benthic communities of the tropical western North Altantic. This long-term program encompasses the University of Miami/National Geographic Society Deep-Sea Biology Project, which terminated several years ago, the current TOTO benthic fish ecology study, and a cooperative program between the University of Miami and the University of North Carolina, now in preparation, to study the ecology of the deep-sea benthic megafauna from the Blake Plateau, the Blake-Bahama Escarpment, and the Hatteras Abyssal Plain.

The Biology of Deep Sea Boring and Fouling Organisms and the Role of Plant Material in Deep Sea Ecosystems

R. D. Turner
Harvard University

This project is composed of two closely related but distinct parts. The first, on wood borers and the importance of plant material in the deep sea, has been in progress for four years. The second, on deep sea fouling, is just beginning.

Part I - Life history and ecology of the Xylophagainae and the contribution of wood and other plant material to nutrition and diversity in the deep sea.

Results of the first experiments involving wood borers showed that they may be very abundant in the deep sea, are capable of reducing a one inch plank to the crumbling stage in about three months, grow rapidly, produce large numbers of young and apparently have cyclic reproduction. In short they are opportunistic, the first established record for the deep sea. I have postulated that their breeding season is tied to the "spring run-off" in high latitudes and the rainy season in the tropics. Following these experiments, when the panels were nearly lost because they broke while being picked up by ALVIN, the panels were enclosed in plastic mesh bags.

The second set of panels retrieved had been exposed in the Tongue of the Ocean, Bahama Islands, for 14 months and some of *Xylophaga* tunnels were over 80 mm in length. The compacted fecal pellets filling the posterior end of the *Xylophaga* burrows had been invaded by capitellid worms which were apparently

feeding on the degraded particles of wood. Many of the burrows also contained crysoptellid and polynoid worms which were feeding on both the capitellid worms and the Xylophaga. Galatheid crabs on the surface were feeding on all three groups. Some of these crabs had crawled under the mesh when they were small enough to do so (the longest dimension was 10 mm) and had reached a length of 45 mm. Many crabs on the outside of the mesh fell off as the panel was pulled from the bottom.

To my knowledge this is the first authenticated food chain for deep sea benthic invertebrates. Continued testing will undoubtedly add to this list. In order to further prove my hypothesis that wood is an important source of nutrient in the deep sea "islands" composed of 12 one cubic foot blocks of wood were placed at the four permanent ALVIN bottom stations (two off Woods Hole and two in the tongue of the ocean). At the time the islands were put down, bottom cores were taken around the islands. These are being analyzed for infaunal invertebrates by Dr. Grassle. Subsequent coring will indicate whether or not the fecal pellets etc. produced by the borers and their "associates" enrich the substrate and affect the abundance, diversity and growth rates of the infaunal animals. On the basis of present evidence I hypothesize that when wood and other plant material is added to the bottom, the increase in diversity and growth will be evident in the epifaunal species and that, after a considerable time lag, the infaunal detritus feeding species will increase in number and rate of growth.

feeding on the dermal particles of wood. Some of the burrows also contained crysocotellid and polynoid worms which were feeding on both the capitellid worms and the *Xylophaga*. Galatheid crabs on the surface were feeding on all three groups. Some of these crabs had crawled under the mesh when they were small enough to do so (the longest dimension was 10 mm) and had reached a length of 45 mm. Many crabs on the outside of the mesh fell off as the panel was pulled from the bottom.

To my knowledge this is the first authenticated food chain for deep sea benthic invertebrates. Continued testing will undoubtedly add to this list. In order to further prove my hypothesis that wood is an important source of nutrient in the deep sea, "islands" composed of 12 one cubic foot blocks of wood were placed at the permanent Alvin bottom stations (two off Woods Hole and two in the tongue of the ocean). At the time the islands were put down, bottom cores were taken around the islands. These are being analyzed for infaunal invertebrates by Dr. Grassle. Subsequent cores will indicate whether or not the fecal pellets etc. produced by the borers and their "associates" enrich the substrate and affect the abundance, diversity and growth rates of the infaunal animals. On the basis of present evidence I hypothesize that when wood and other plant material is added to the bottom, the increase in diversity and growth will be evident in the epifaunal species and that, after a considerable time lag, the infaunal detritus feeding species will increase in numbers and rate of growth.

A series of wood panels (24" x 6" x 1") have been put into the bottom around the wood islands. These will be removed and replaced in sequence each time the islands are visited. They will provide us with dates of settlement and growth rates while the islands serve as a large source of nutrient and "home" for spawning adults.

While diving in ALVIN I noticed a number of epifaunal invertebrates on the rocks and ledges in the vicinity of the islands that were not found on the wood panels. Figuring that wood is not an attractive surface for them I have backed many of the panels with asbestos and some of these are now in place at each of the test sites. This set of panels will contribute to our fouling studies.

Part II - The biology of deep sea fouling.

As indicated above asbestos backed panels are already exposed and the first will be retrieved this year. These panels are set vertically in the bottom but observations from ALVIN suggest that fouling is usually heavier on horizontal surfaces. To test this hypothesis we have designed a rack to hold 12 asbestos panels which will be set out horizontally with both surfaces exposed. These will be set out close to each of the bottom stations and the panels will be removed and replaced in sequence each time the island is visited. This will give us data on time of settlement, growth rates and species interactions. Observations on the extent and composition of the fouling on the racks and the sonar reflectors will also be made each visit

A series of wood panels ([illegible]) have been put into the bottom around the rock islands. These will be removed and replaced in sequence each time the islands are visited. They will provide us with dates of settlement and growth rates while the islandsserve as a large source of nutrient and "homes" for breeding adults.

While diving in ALVIN I noticed a number of colonial invertebrates on the rocks and ledges in the vicinity of the islands that were not found on the wood panels. Assuming that wood is not an attractive surface for them I have backed many of the panels with asbestos and some of these are now in place at each of the test sites. This set of panels will contribute to our fouling studies.

Part II - The biology of deep sea fouling.

As indicated above asbestos backed panels are already exposed and the first will be retrieved this year. These panels are set vertically in the bottom but observations from ALVIN suggest that fouling is usually restricted to horizontal surfaces. To test this hypothesis we have designed a rack to hold 12 asbestos panels which will be set out horizontally with both surfaces exposed. These will be set out close to each of the bottom stations and the panels will be removed and replaced in sequence each time the islands are visited. This will give us data on time of settlement, growth rates and species interactions. Observations on the extent and composition of the fouling on the rocks and the wood panels will also be made each visit and recorded photographically. The first of these racks will be put down on the northern stations in August 1976.

In order to study the vertical distribution of fouling and boring organisms and their free swimming larvae, a series of arrays are planned which will be held up from the bottom with a float. Details of these arrays are now being drawn up. It is planned that the first set will be emplaced during the 1977 TOTO cruise.

These studies will contribute not only to our knowledge of the biology of the species involved but to their importance in relation to man's activities in the deep sea - e.g. fouling of deep sea mooring systems, and protection or destruction of "contained waste" packages. Such systems of testing may also be used as stations to monitor the toxic effects of leakage from "contained wastes" or those of drilling or deep sea mining.

Office Memorandum • WOODS HOLE OCEANOGRAPHIC INSTITUTION

TO : Fred Grassle DATE: 11 May 1976

FROM : Sandy Williams

SUBJECT: ALVIN UNOLS Workshop

A study of the benthic boundary layer is well suited to submersible operations. This work is growing and impinges on several disciplines including P.O. (boundary layer flows, eddy-wall interactions, "bursting"), Marine Geology (sediment transport, topographic working and modeling, pore water exchange), Biology (epibenthic environment, sediment reworking, nutrient sources, dispersal of larvae), Marine Geochemistry (nephloid layers, sediment fluxes), and Ocean Engineering (bottom stresses, erosion and deposition of sediment, stability of sediments as repositories of wastes). Direct observation and selection of experimental sites is important for these studies. For example, current measurements I plan to make within meters of the sediment would benefit by careful deployment in various locations (flat region, crest of 10 meter feature, top and bottom of gully, behind rock, etc.). Engineering development of these current meters could be abbreviated by using ALVIN as deployment, data recording, and recovery system.

I do not plan to use ALVIN now for this work based principally on cost and secondly on scheduling in flexibility and uncertainty. At this stage it is not as important to control the instrument siting as it will be later. Whether the advantage of this control will outweigh the cost depends on the cost. This will be reduced by cooperative work with other disciplines, block funding (which makes the cost less visible) or simply, in my case, by only piggy-backing on fat projects. Long range planning and coordination, as this workshop will do, should help.

Albert J. Williams 3rd

Albert J. Williams 3rd

AJW/kmp