

provided by the Navy and other Federal agencies to pay for the possible scenarios of a SEA CLIFF/ALVIN conversion. Consequently, in answering the following questions, please ignore the potential funding constraints. The working group will be addressing the financial issues after the data is made available and the potential impact these may have on the ongoing operations of the National Deep Submergence Facility.

1. Should the capabilities of both ALVIN and SEA CLIFF be merged so that the result is a 6000 m depth capable submersible?

Yes No Unsure

Comments:

2. Should SEA CLIFF replace ALVIN as the primary research submersible for US scientists?

Yes No Unsure

Comments:

3. Should SEA CLIFF be given to another institution or facility with the desire to operate a manned submersible although federal funding levels for deep submergence science will likely stay level for the foreseeable future?

Yes No Unsure

Comments:

4. Should SEA CLIFF equipment (e.g. manipulators, electronics, sonars, vehicle systems) be transferred to the National Deep Submergence Facility at Woods Hole to enhance ALVIN while the 6000 m SEA CLIFF titanium sphere is preserved for possible future replacement for the existing 4500 m depth rated ALVIN sphere?

Yes No Unsure

Comments:

APPENDIX III

SURVEY RESPONSES 106 QUESTIONNAIRES SUBMITTED April 1997

Category A - Future Directions in Deep Submergence Science (indicate all that apply)

Note: The survey response totals and comments are indicated in parentheses

1. What is your primary field of research? See [Figure 1](#).

- (33) biology ((2)physiology (9)ecology (4)microbiology)
 - (19) chemistry
 - (7) physical oceanography
 - (6) sedimentology
 - (30) marine geology
 - (8) petrology
 - (18) geophysics
 - (13) tectonics/structure
 - (6) engineering
 - (8) other:
 - Marine Archeology
 - Physics
 - Bathymetry
 - Biogeochemistry CNS Cycling
 - Economic Geology
 - In Situ Chemical Sensing Instrumentation
 - Science Education
 - Evolutionary Genetics
-

2. Which area(s) is your research work principally focused on NOW?

- continental shelf/slope - 47
 - abyssal plains - 17
 - mid-ocean ridges - 59
 - transforms - 9
 - trenches - 13
 - seamounts - 15
 - mid-water - 3
 - Other - 14:
 - Deep Basins
 - Hydrothermal areas of sedimented ridges
 - Hot Spots - Oceanic Islands
 - Cold Seeps
 - California Borderland Basins
 - Coastal and Open Ocean
 - Arcs/Back Arc Basins
 - Island Flanks
 - ROV/AUV Technology/Capabilities
 - Ridge Flanks
-

3. Which area(s) do you expect your research work will be concentrated in the next 10 years? [Figure 2](#) summarizes the results of questions 2 and 3.

- continental shelf/slope - 53
- abyssal plains - 15
- mid-ocean ridges - 55
- transforms - 12
- trenches - 18
- seamounts - 23
- mid-water - 17
- Other - 15:
 - Deep Basins
 - Neritic Zones
 - Cold Seeps

- California Borderland Basins
- Coastal and Open Ocean
- Arcs/Back Arc Basins
- Hot Spots/Oceanic Islands
- Continental Slope/Rise/Abyssal Plains of Passive Margins
- Island Flanks
- ROV/AUV Technology/Capabilities
- Ridge Flanks

4. How many times (cruises) in the past 5 years have you used deep submergence vehicles for your research? See [Figure 3](#) and [Figure 4](#).

ROV/tethered vehicles?

- Jason - 19
- ARGO II - 6
- ARGO - 1
- DSL120 - 7
- ATV - 12
- ROPOS - 20
- VENTANA - 6
- MPL Deep Tow - 3
- MPL Control Vehicle - 5
- HBOI ROVs - 5
- Minirover - 1
- Scorpio - 2
- Voyager - 1
- Phantom HVS4 - 14
- TOSS (NAVO) - 1
- NURP ROV - 1
- Heat Flow Probe - 1
- Scampi - 1
- Name of Vehicle not indicated - 6
- None Used - 54

Manned submersibles?

- ALVIN - 115
- SEA CLIFF - 11
- TURTLE - 14
- NAUTILE - 12
- SHINKAI 6500 - 10
- PISCES V - 13
- PISCES - 3
- MIR - 1
- DELTA - 1
- SDL-1 (Canadian Navy) - 7
- NR-1 - 7
- Johnson SEA LINK - 38
- Name of Vehicle not indicated - 8
- None Used - 23

5. What is the maximum depth range that deep submergence vehicles (all types) available to US

scientists should have in terms of your future science requirements for the next 20 years? See [Figure 5](#).

- 3000m - 11
- 4500m - 26
- 6000m - 36
- 7500m - 12
- 9000m - 13
- 6500m - 1
- 11,000m - 1

Summary of Comments:

It was commented that this is a difficult question to answer since there is a big trade off of depth versus weight, power, etc.

6. Do you foresee that there is and will be a need for human-occupied submersibles to accomplish scientific missions in the depth ranges given below? See [Figure 6](#).

	CRITICAL			NOT IMPORTANT	
1500-3000	1(76)	2(20)	3(7)	4(3)	5(2)
3000-4500	1(52)	2(31)	3(10)	4(3)	5(2)
4500-6000	1(27)	2(13)	3(24)	4(5)	5(2)
6000-7500	1(10)	2(10)	3(22)	4(18)	5(21)
7500-9000	1(4)	2(8)	3(20)	4(18)	5(30)

Summary of Comments:

Comments were mixed and samples are summarized below:

HOVs are critical: There is no adequate substitution for human presence. Given an almost equal cost, experimental work has better chances with HOV. Some instrumentation still requires manned operations and a scientist on site for real time assessments. The need for manned submersible is a “key” component to any deep sea research program. Work in the Western Pacific needs the greater depth capability. With emphasis on “observatories” studies (coastal or mid-ocean ridges) human-occupied subs are still needed down to 4500m until ROVs are capable of comparable manipulation of experiments. HOV combinations with ROV are envisioned.

HOVs are not Important: Human endurance in small cramped space is limited to about eight hours; this makes human presence at depths greater than 4000m difficult given transit times in today’s vehicles. Tele-presence needs improvement especially with regard to video, but is clearly the way to go for the deepest deep-sea exploration and experimentation. ROV capabilities are more important at the depths greater than 4,500m. A combination of manned submersibles with depth capability to 6000m and unmanned vehicles to ~7500m should meet almost all of our research needs and still be financially reasonable. It was suggested that the deepest diving submersibles (manned and unmanned) should be a shared international resource. Available Japanese, Russian, and French manned vehicles should be used for 4500-6000 work.

7. On a scale of 1 (critical) to 5 (not important), how important is it to your present or future research to have a human-occupied submersible capable of working between the depths of 4500 and 6000(+) m? See [Figure 7](#).

CRITICAL				NOT IMPORTANT	
1(18)	2(20)	3(25)	4(17)	5(20)	

Summary of Comments:

HOV is critical: A US platform with a proven performance record is needed. It is essential as a nation that we not lose the 6km capability. Because much of scientifically interesting seafloor falls between 4500 and 6000 m, this direct observation function is critical. While ROVs and AUVs can replace many of the functions of manned submersibles, direct observation of the seafloor is critical for many biological and chemical studies of soft-sediment habitats. Work in the Western Pacific is >4500m deep and work on mid ocean ridges has axial depths in the 4000-5000m range. Tectonics/petrology studies of transforms and ridge-transform intersections will also require submersible depth capabilities in this range. Extensive fine-scale manipulations, to date, can best be carried out only by manned submersible; without this capability, work at 4500-6000m depths is limited.

HOV is not important: A 4500m HOV depth capability is sufficient. Most deep tasks can be handled by ROVs. Many aspects of this research support are already covered by ROVs.

8. To what extent could your current and future science objectives at depths greater than 4500 meters be accomplished by human operated vehicles (HOVs), remotely operated vehicles (ROVs) or autonomous vehicles (AUVs)? See [Figure 8](#).

HOV-	100%	75%	50%	25%	less than 10%
	25	18	20	12	9
ROV-	100%	75%	50%	25%	less than 10%
	20	22	30	12	6
AUV-	100%	75%	50%	25%	less than 10%
	6	7	6	18	34

Summary of Comments:

The HOV offers sampling capability and an in situ observation (3D visualization) that is not yet possible with other vehicles. Bottom time of HOVs, however, were noted as a limitation. Both HOVs and ROVs are needed to do the job adequately. High resolution detailed sonar mapping benefits from the unlimited power on an ROV tether, but detailed sampling and seafloor instrument set-up is better done from an HOV. Most ROVs are too light to do good coring. ROVs and AUVs are adequate for camera and bathymetry surveys.

Many surveys indicated that not enough is known about AUVs to rate them. AUVs are not yet proven. However, there was one comment that an AUV such as ABE should be incorporated in the National Deep Submergence Facility. It provides an electromagnetically quiet platform for near-bottom magnetics studies, as well as survey flexibility, duration, and efficiency that currently are not available with HOVs and ROVs.

Category B - Disposition of the US Navy Submersible SEA CLIFF (see [Figure 9](#))

The cost of carrying out the work required to implement solutions associated with the questions below is unknown at this time. Navy moneys traditionally budgeted to support their submersible program are not likely to be provided to operate SEA CLIFF. Fiscal aspects of the problem (i.e. conversion costs) are currently being evaluated by WHOI and the Navy. It is still uncertain at what level funds will be provided by the Navy and other Federal agencies to pay for the possible scenarios of a SEA CLIFF/ALVIN conversion. Consequently, in answering the following questions, please ignore the potential funding constraints. The working group will be addressing the financial issues after the data is made available and the potential impact these may have on the ongoing operations of the National Deep

General comments from surveys regarding Category B questions:

- It is impossible to ignore funding constraints! The cost-benefit assessment is essential in discussing options.
 - SEA CLIFF's capabilities and characteristics were unknown to many surveyed and as a result there were many "unsure" responses.
-

1. Should the capabilities of both ALVIN and SEA CLIFF be merged so that the result is a 6000 m depth capable submersible?

Yes	No	Unsure
47	17	38

Summary of Comments:

Although many surveys indicated "yes" to merging ALVIN and SEA CLIFF, there was a great deal of uncertainty.

Yes, Merge SEA CLIFF and ALVIN: Efforts should be made to obtain an HOV 6000m depth capability for the National Deep Submergence Facility. A 6000m depth capability is needed for work in the W. Pacific.

Unsure about Merging SEACLIFF and ALVIN:

- The approach should be to preserve ALVIN by cannibalizing SEA CLIFF, since ALVIN is the more mature, effective system. None of the capabilities (operational or scientific) of ALVIN should be compromised. SEA CLIFF is much less valuable and capable as a sea floor research tool than ALVIN. Thus if the process of merging the two vehicles produced a hybrid which has fewer capabilities than ALVIN, that would not be good. If the hybrid had all of ALVIN's capabilities plus greater depth capability, that would clearly be an improvement. If the best equipment is selected in the merge and if the resulting vehicle would be operated as ALVIN is, then "yes." Power issues are critical; time on bottom must be maximized.
- Certain capabilities are based on cost and this information is needed to make a recommendation. A hull change may take the sub out of service for too long a time with respect to ongoing science programs.

Do not merge SEA CLIFF and ALVIN:

- The 4500m capability should be kept intact. It will be needed more than the 6000m capability in the near future (~10 years).
 - This approach is recommended only if SEA CLIFF cannot be operated reliably by another institution (e.g., HURL). Two vehicles are more versatile. Both submersibles should be maintained. Modernize SEA CLIFF, make it a science platform, and operate it separately.
 - If funding allowed, it would be ideal to upgrade ALVIN to the same depth capability or build a new vehicle -- if for no other reason than to have a viable US rescue capability. What is needed is a new generation of HOV submersibles; smaller, lighter and less logistically challenging.
 - ROVs and AUVs hold more promise than increased capability to put a human at 6000m. Use money to replace Jason with an ROV designed for science research.
 - This effort is beyond the capabilities of the DSOG at WHOI. If it is going to be undertaken it should be elsewhere, or under a new and revitalized DSOG management, and with a revitalized team and a long term commitment from the sponsors. Since a DSOG restructuring is unlikely, or that a revitalized funding commitment is in the cards, this level of effort is impractical.
-

2. Should SEA CLIFF replace ALVIN as the primary research submersible for US scientists?

Yes	No	Unsure
7	53	40

Summary of Comments:

Surveys overwhelmingly indicated that SEA CLIFF SHOULD NOT replace ALVIN.

SEA CLIFF should NOT replace ALVIN:

- ALVIN is a much more supportable, effective, mature vehicle than SEA CLIFF. If ALVIN can be readily modified for 6000 meter operation by cannibalizing SEA CLIFF, great, but replacing ALVIN with SEA CLIFF would be a disaster for the community! ALVIN has a much higher productivity (dives/year) and has been outfitted specifically for science research.
- SEA CLIFF has suffered extensively from reliability problems (poor track record), while ALVIN continues to be an incredibly productive workhorse. SEA CLIFF is much less capable than ALVIN for seafloor sampling and observing. SEA CLIFF (aside from depth advantage) would require major modification to be as capable as ALVIN. It is too expensive to operate. The sphere is the only useful thing on SEA CLIFF.
- Although there is certain value in diving beyond ALVIN's limits, the problem is one of ALVIN availability not diving capability or depth limits. Simple replacement of ALVIN with SEA CLIFF is very risky, and does not solve the growing problem of insufficient submersible access to US scientists. Two vehicles would add versatility.

Conditional Yes: SEA CLIFF should replace ALVIN if all ALVIN's capabilities and operational procedures/crew are transferred. The reliability and performance record of ALVIN must be continued with a 6000m vessel. Capabilities should be merged so that the net result is just one HOV that can dive to 6km.

3. Should SEA CLIFF be given to another institution or facility with the desire to operate a manned submersible although federal funding levels for deep submergence science will likely stay level for the foreseeable future?

Yes	No	Unsure
24	43	31

Summary of Comments:

SEA CLIFF should be given to another institution or facility:

- U.S. scientists continue to be limited, relative to scientific needs and submersible access. ALVIN is often not available due to logistics of cruise planning. Another DSV for U.S. shelf/slope (east & Gulf) is needed, especially if new funding sources including federal/industrial/commercial are sought. A deeper submergence presence is needed on a more regular basis for Pacific area projects.
- The scientific community as a whole is best served by keeping SEA CLIFF running, especially on a resource base other than UNOLS (e.g., NURP).
- Keep SEA CLIFF alive (without diverting funds from ALVIN), and use its presence as a rationale for ratcheting up submersible funding in the U.S.
- One idea would be to upgrade HURL with SEA CLIFF since they already have funding for Pisces V.
- Competition might be good for WHOI's operation, and it helps relieve the costs of forcing the schedule to be in specific oceans/locals.

SEA CLIFF should NOT be given to another institution or facility:

- Giving SEA CLIFF to a facility that could not support it well would be a huge and perhaps tragic mistake. This is guaranteed to risk the viability of both facilities.
- Unless the institution has the funds in-house for operation and upgrades this option should not be pursued.

- For the time being, we should focus the resources on the WHOI group. Support for ALVIN appears minimal already.
 - If we could find more support, this would be a good idea.
 - Given infrastructure costs, it makes no sense to split things up. Duplication of engineering and expertise would be wasteful.
 - Centralized operation for deep sea research is more realistic.
 - One institution should operate both; however, the Navy may wish to receive bids from Hawaii, for example, if resources of deep-diving should logically be moved from N. Atlantic to N Pacific.
4. Should SEA CLIFF equipment (e.g. manipulators, electronics, sonars, vehicle systems) be transferred to the National Deep Submergence Facility at Woods Hole to enhance ALVIN while the 6000 m SEA CLIFF titanium sphere is preserved for possible future replacement for the existing 4500 m depth rated ALVIN sphere?

Yes	No	Unsure
58	14	26

Summary of Comments:

Transfer SEA CLIFF equipment to the National Deep Submergence Facility:

- Many of the surveys indicated that this would be the most attractive option for a variety of reasons
- This sounds like the best compromise with shrinking support. It leaves the 6000m option open, but doesn't throw away a high productivity resource. Combining the best attributes of ALVIN and SEA CLIFF has many attractions.
 - This option makes the best use of Navy facilities and equipment for academic science and is the most cost-effective.
 - This seems to be the best alternative even though loss of any submersible capability is bad for the entire community.
 - This seems like the do nothing default approach and probably the right approach unless DSOG and the funding base can be revitalized sufficiently to undertake a major revision of ALVIN, including a 6000m capability.
 - ALVIN plus present ROVs can address a larger range of relevant problems than can presently be funded. Therefore, competitive funding of another deep-sea asset is unwise at this time.
 - This seems like a good way to go for the near future and if funding and a good scientific rationale were generated a couple of years hence, it would be appropriate to make the conversion when ALVIN comes due for the next major overhaul.
 - For reference, see the article: Deep Sea Research by Manned Submersible, J.R.Heirtzler and F. Grassle, Science, v. 194, 294-299, 1976

Do NOT transfer SEA CLIFF equipment to the National Deep Submergence Facility:

- This may be a practical short-term solution but it does not address the basic issue that the ALVIN-class vehicles are obsolete... they are very costly to operate ... and should be replaced by HOVs utilizing modern materials and technologies. We need to build a sub that can go to 6000m.
- Both SEA CLIFF and ALVIN should be maintained separately while pushing for additional funding or inventive ways for this to occur, such as porting SEA CLIFF to an already established submergence facility. This options should be pursued only if SEA CLIFF conversion/update is deemed unfeasible. Keeping SEA CLIFF operational separately sounds preferable as long as it does not endanger ALVIN.
- This should be done only after moneys from other agencies are provided to support the vehicle.
- Proceed with merging ALVIN and SEA CLIFF before the opportunity is lost. There will probably not be another such opportunity to bring such a facility on line for many years.

**106 QUESTIONNAIRES SUBMITTED
PRIMARY FIELD OF RESEARCH**

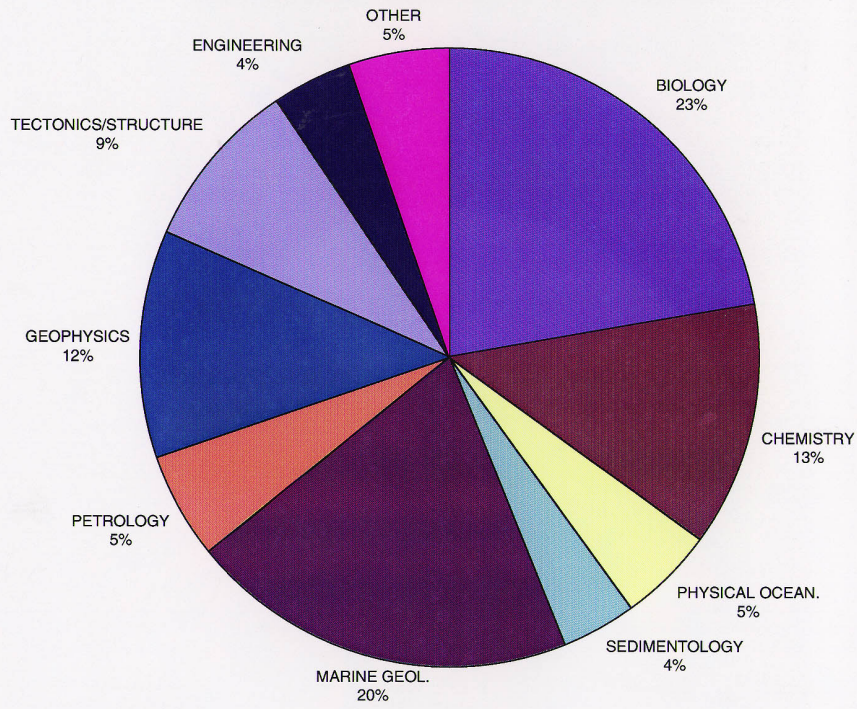


FIGURE 1

**Research Work Areas:
Now and in the Next 10 Years**

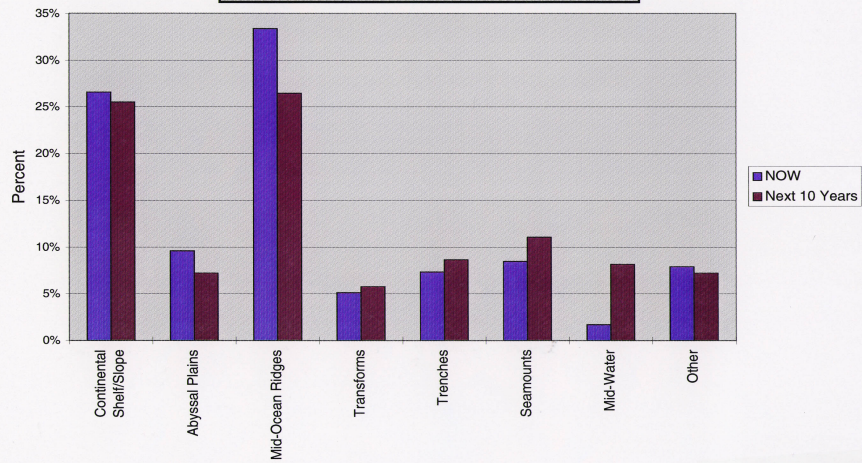


FIGURE 2

ROV/TETHERED VEHICLE USE

VEHICLE	CRUISES
ROPOS	20
JASON	19
PHANTOM	14
ATV	12
DSL-120	7
ARGO II	6
VENTANA	6
OTHER*	28
TOTAL	112

* Twelve other vehicles were listed as being used.

51% of those responding to the survey had not used an ROV

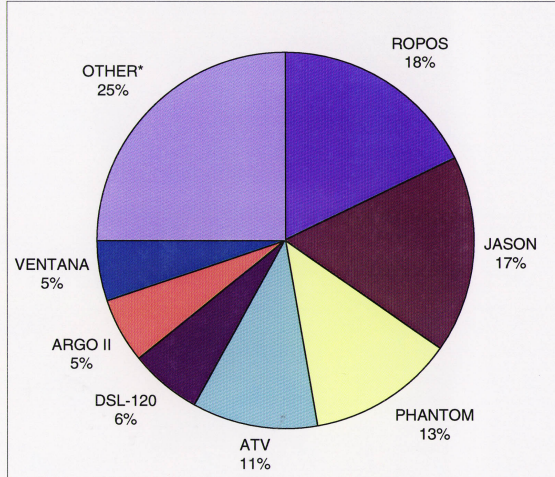


FIGURE 3

HUMAN OCCUPIED VEHICLE USE

VEHICLE	CRUISES
ALVIN	115
SEA LINK	38
TURTLE	14
PISCES V	13
NAUTILE	12
SEACLIFF	11
SHINKAI 650	10
OTHER*	27
TOTAL	240

* Six other HOVs were listed as being used.

22% of those responding to the survey had not used an HOV.

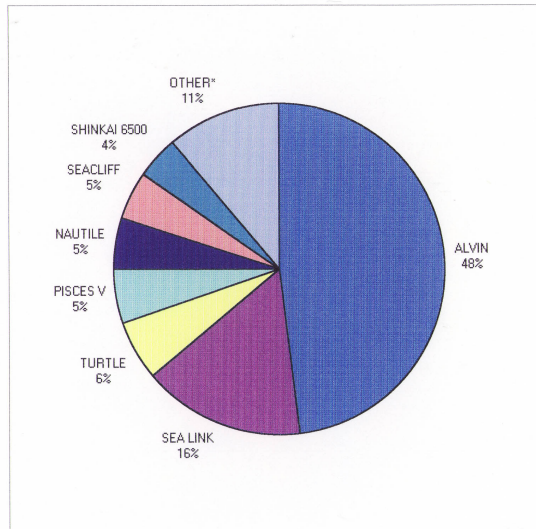


FIGURE 4

MAXIMUM DEPTH RANGE THAT DEEP SUBMERSIBLE VEHICLES SHOULD HAVE IN TERMS OF FUTURE SCIENCE REQUIREMENTS

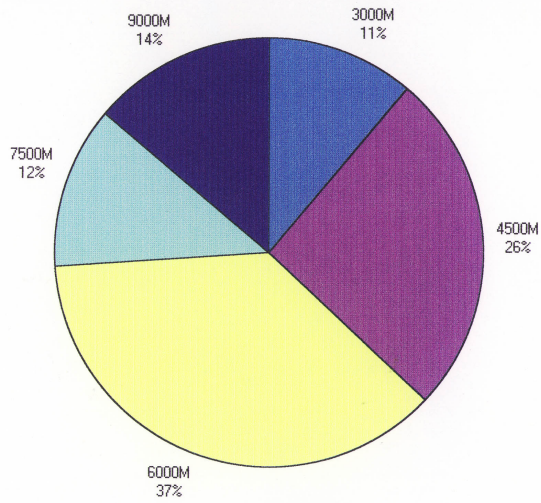


FIGURE 5

NEED FOR HOVs TO ACCOMPLISH SCIENTIFIC MISSIONS IN SELECTED DEPTH RANGES

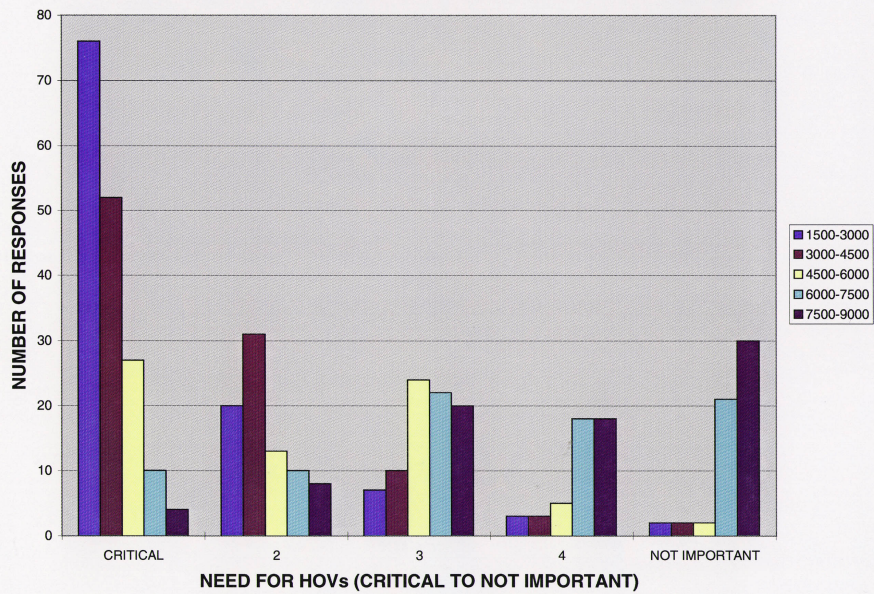


FIGURE 6

**DEGREE OF IMPORTANCE TO HAVE AN HOV CAPABLE OF WORKING BETWEEN THE DEPTHS OF 4500 AND 6000(+)
m (CRITICAL TO NOT IMPORTANT)**

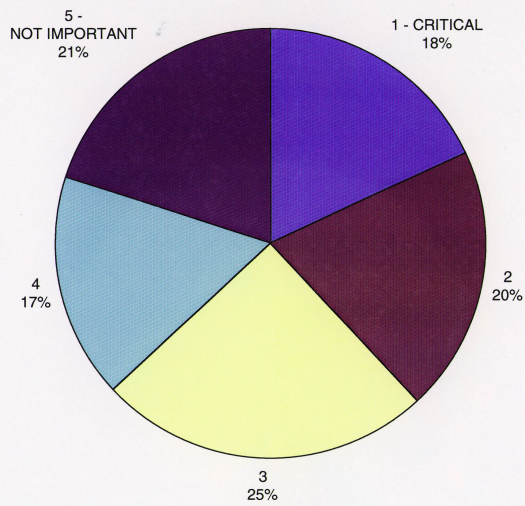


FIGURE 7

**SCIENCE OBJECTIVES ACCOMPLISHED AT DEPTHS >4500M
BY HOVs, ROVs OR AUVs**

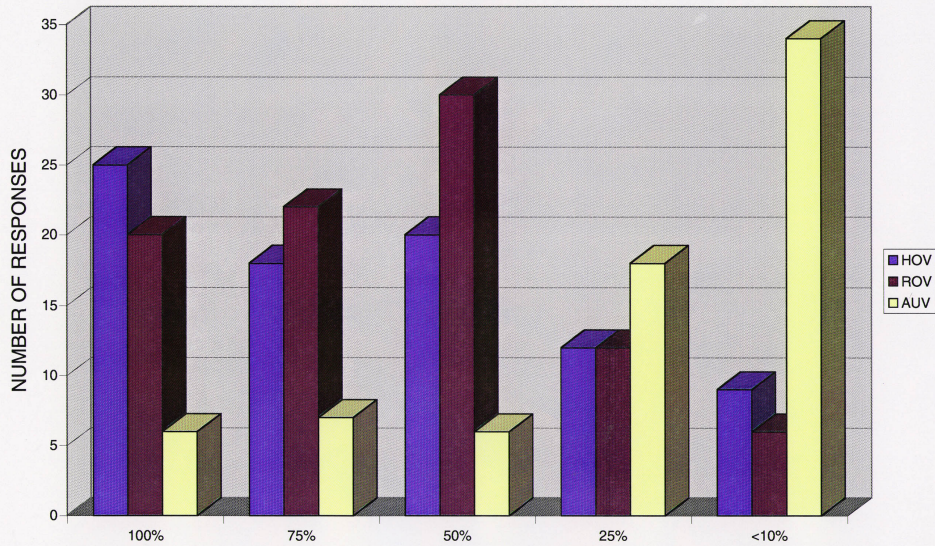


FIGURE 8