THE VIEW FROM A STORIED SUB
The 'Alvin' Off Norfolk, Va.

By R. L. Edwards* and K. O. Emery**

On July 17 and 18, 1967, the authors made 2 dives in DSRV "Alvin," the research submarine of the Woods Hole Oceanographic Institution. The dives were made from the support vessel "Lulu" off Norfolk, Virginia, in 20 to 25 fathoms. During each dive, which lasted nearly 7 hours, we observed closely a series of underwater ridges and their fauna. These were the first dives for both of us and we were not disappointed.

Alvin is a deep-diving research vessel designed specifically for oceanographic research. The funds for construction and operation were provided by the Office of Naval Research. The Bureau of Ships of the U. S. Navy assisted in preparing performance specifications. The Applied Sciences Division of Litton Industries designed and built the sub.

Shape of the Sub

At the surface, Alvin draws 7 feet. It is 23 feet long, has an 8-foot beam, and displaces 15 tons. Submerged, it has a range of 5 miles and cruises at a little more than 1 knot, with a top speed of about 1.5 knots. Its design operating depth is 6,000 feet, where it has a safety factor of more than two. The crew, a pilot and 2 observers, has 4 viewing ports to look through--to see ahead, on either side, and directly beneath the vehicle. The passenger sphere is 7 feet in diameter. It is made of high-strength, 1.33-inch-thick steel. The life-support systems provide for an endurance of 24 hours or more.

Alvin is not large inside. After several hours with a pilot and 2 observers aboard, things begin to feel a bit cramped. The discomforts are minor, however, compared with all the interesting things to be observed outside. And, to help the observers work, the sub is equipped with a tape recorder, television camera, and 2 automatic 35-mm. cameras. Also, each observer can carry a hand-held camera loaded either with color or black-and-white film. The outside cameras produce stereographic pairs and are actuated by a button--or can be set to operate automatically at a desired interval. A box lunch and coffee are provided if the dive is to last long enough.

A Storied Sub

The sub already has made quite a name for itself. During February to April 1966, it made 34 dives off Palomares, Spain, in the search for a lost hydrogen bomb. Alvin found it in 2,800 feet of water on 2 occasions and played a vital role in its recovery.

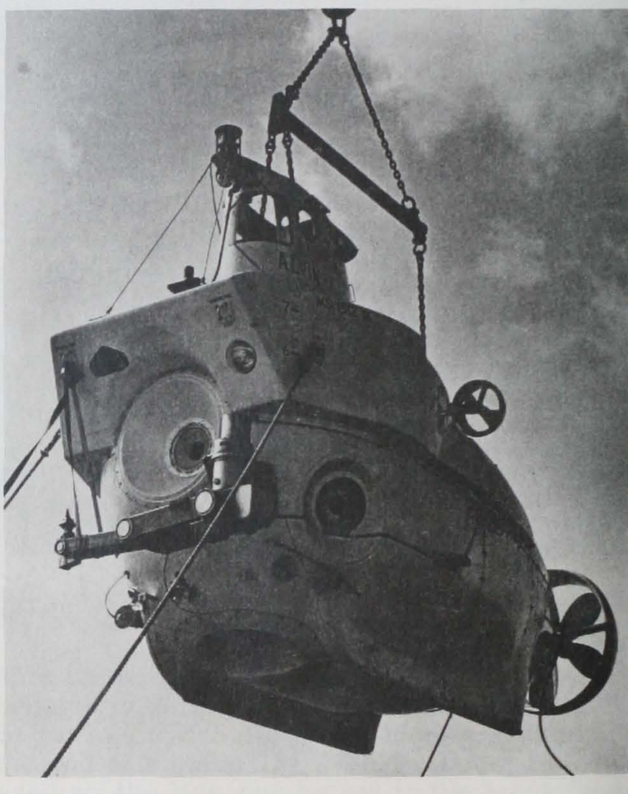

Fig. 1 - DSRV Alvin.

*Fishery Research Biologist, BCF Biological Laboratory, Woods Hole, Mass. 02543.
**Senior Scientist, Woods Hole Oceanographic Institution, Woods Hole, Mass. 02543.
Note: Contribution No. 2142, Woods Hole Oceanographic Institution, Woods Hole, Mass. 02543.

U. S. DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Sep. No. 822

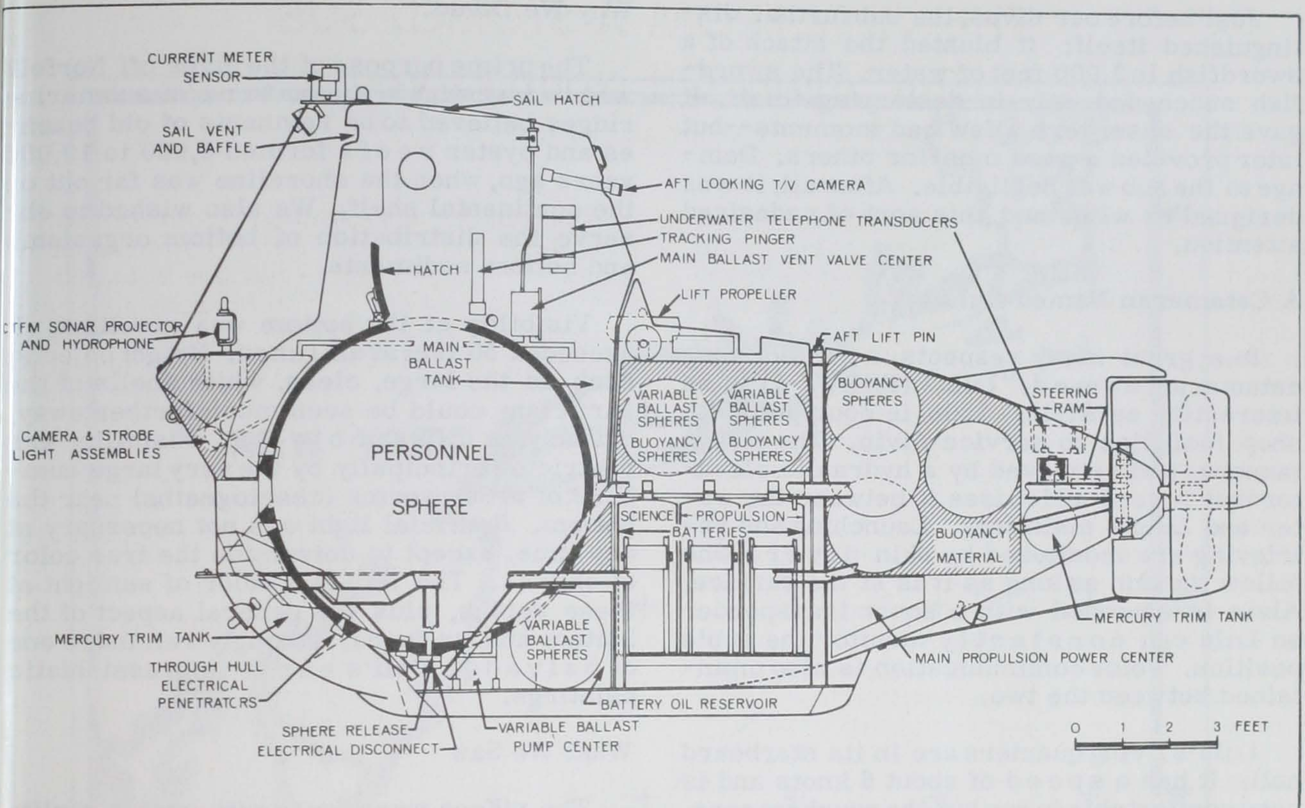

Fig. 2 - Schematic cross-section of DSRV Alvin.

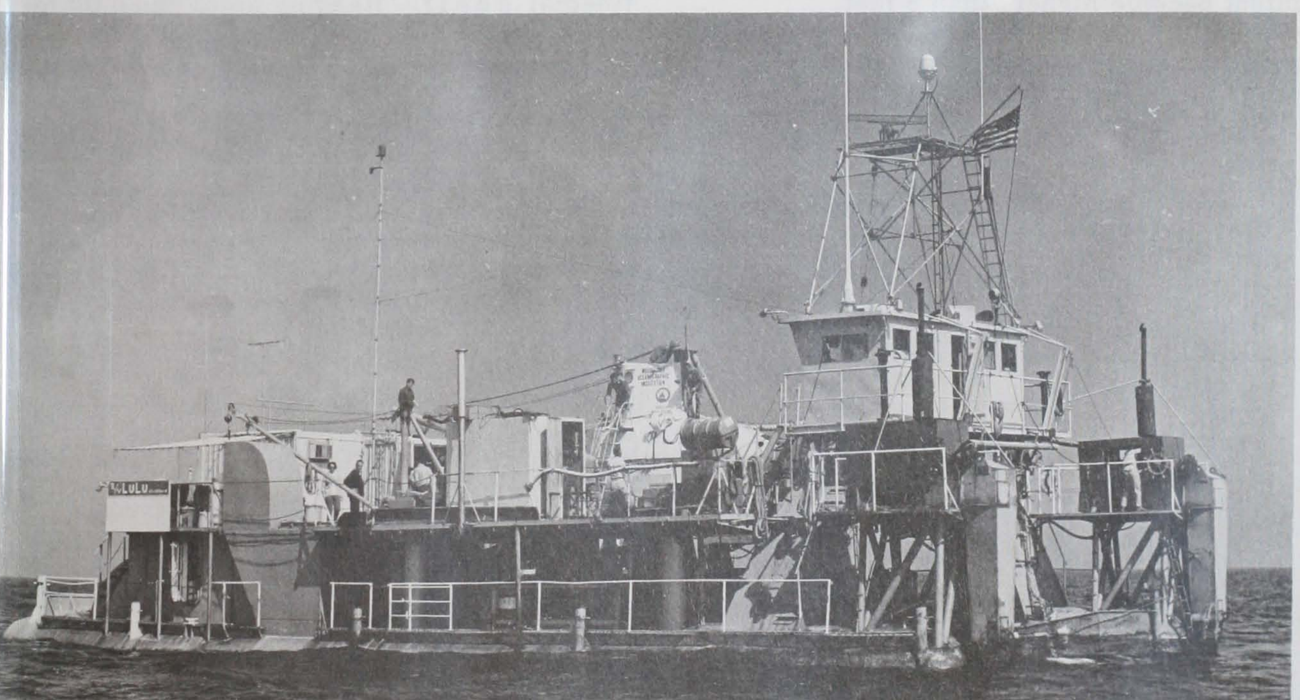

Fig. 3 - Alvin's mothership, Lulu, is a catamaran. Alvin is launched and retrieved from a cable suspended between the hulls. In this picture, Alvin has been raised to working deck.

Just before our dives, the sub further distinguished itself: it blunted the attack of a swordfish in 2,000 feet of water. The swordfish succeeded only in destroying itself. It gave the observers a few bad moments--but later provided a good meal for others. Damage to the sub was negligible. After all, it was designed to withstand this sort of undesired attention.

A Catamaran Named Lulu

In a great many respects, a 96-foot-long catamaran named "Lulu" (DSRVT-1) is as interesting as Alvin. Lulu is equipped with shop facilities to service Alvin. The sub is launched and retrieved by a hydraulic elevator that lowers and raises it between the water and Lulu's main deck. Launching and retrieving are monitored by skin divers who follow the sub as long as it is at the surface. Alvin is equipped with a sonar transponder so Lulu can constantly monitor the sub's position. Voice communication is also maintained between the two.

Lulu's living quarters are in its starboard hull. It has a speed of about 6 knots and is very comfortable in any but the roughest seas. Launching is not attempted when the wind exceeds force 3, or the waves are higher, or might become higher, than 5 feet.

Why We Dived

The prime purpose of the dives off Norfolk was to investigate the nature of submarine ridges believed to be remnants of old beaches and oyster reefs formed 8,000 to 10,000 years ago, when the shoreline was far out on the continental shelf. We also wished to observe the distribution of bottom organisms and bottom sediments.

Visibility at the bottom was excellent. It exceeded 50 feet at all times. Bright objects, such as the large, clean, white shells of the surf clam could be seen much farther away, but only as diffuse objects. Visibility was restricted principally by the very large numbers of arrowworms (chaetognaths) near the bottom. Artificial light was not necessary at any time, except to determine the true color of objects. The bluish color of sunlight at these depths, plus the general aspect of the bottom and its fauna, strongly reminded one of Salvador Dali's early impressionistic paintings.

What We Saw

The ridges were found with oyster shells, as expected. They extended north-south, approximately parallel with the edge of the continental shelf. Ranging up to about 30 feet

Fig. 4 - An ocean quahog graveyard. These are dead shells. It is possible they may overlie a dense bed of living animals.

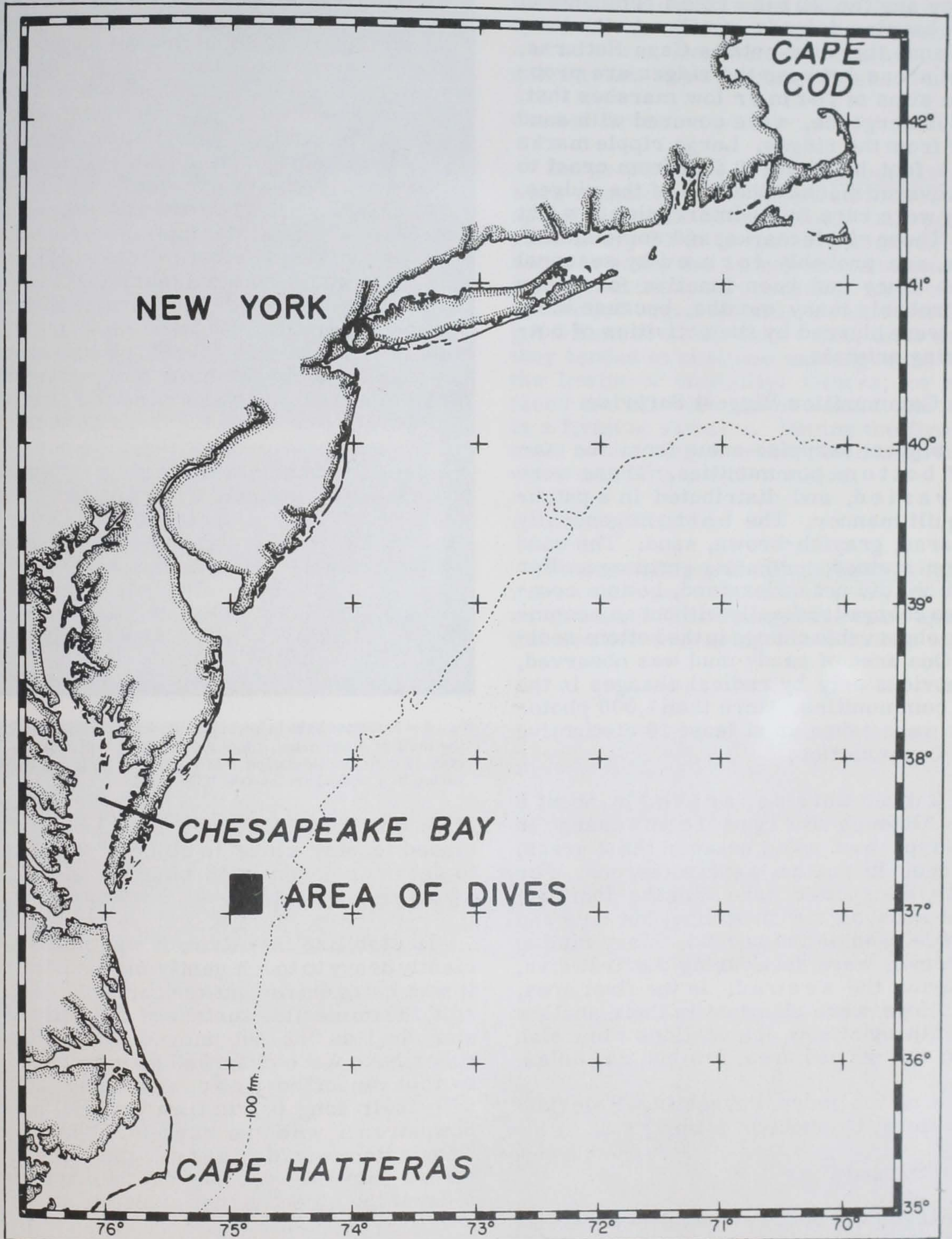

Fig. 5 - Index map showing general location of Alvin dives 205 and 206 made July 17 and 18 on the continental shelf.

above the otherwise nearly flat shelf, they consist mostly of loose coarse sand. Probably they are the submerged remnants of former barrier islands similar to the barrier islands that now outline Cape Hatteras. The flat areas between the ridges are probably the sites of former low marshes that, after submergence, were covered with sand washed from the ridges. Large ripple marks (about 1 foot high and 10 feet from crest to crest) covered much of the tops of the ridges, but they were rare in the intervening low flat areas. These ripple marks, and some smaller ones, are probably formed by seasonal storms. They had been inactive for a long time, probably many months, because their shapes were blurred by the activities of bottom-living animals.

Bottom Communities Biggest Surprise

Our biggest surprise came from the nature of bottom communities. These were many, varied, and distributed in a patchwork-quilt manner. The bottom generally was coarse, grayish-brown, sand. The sand was iron stained, indicating great age. For reasons we did not understand, bottom communities changed radically without an accompanying observable change in the bottom sediment. One area of sandy mud was observed, made obvious only by radical changes in the animal communities. More than 1,000 photographs were taken in at least 10 distinctive bottom communities.

The 2 dives were separated by about 5 miles. Although no significant change in bottom type was noted between the 2 areas, differences in fauna were numerous. For example, the spotted hake was the dominant species seen on the first dive, but only red hake were seen on the second. Many mating cancer crabs were seen during the first dive, none during the second. In the first area, sea scallops were abundant in their shallow holes; although many sea scallops were also seen in the second area, few had dug holes.

Some of the more interesting biological observations, by species, follow.

Red and Spotted Hake

As expected from previous research with the underwater camera, red hake (Urophycis chuss) were almost always closely associated with other objects on the bottom. They were seen frequently with sea scallops, both alive and dead (shells). The larger fish tended to stay close to objects, the smaller to get in or under such things as shells, sponges, or litter.

Fig. 6 - A spotted hake in lower part of picture is cuddled around the shell of a surf clam. Both spotted hake and red hake were seen in such an association. At the top, a large sea scallop is sitting in a typical crater-like hole it made.

To stabilize the Alvin, it was made sufficiently heavy to touch gently on the bottom as it was being driven into the current. As a result, the immediate surface of the bottom was smoothed as the sub moved along. Several times hake were observed swimming quickly to this smoothed area, searching actively with their long pelvic fins for food, heading downstream with the current. When something edible was detected, the fish quickly turned into the current, and then apparently located the object visually and ate it.

The spotted hake (U. regius) behaved in much the same manner but seemed to associate less with other objects on the bottom. One even swam into the cow-catcherlike collecting bin on the front of Alvin and stayed there for more than an hour. Most fish paid little attention to the sub until it came within about 2 feet. Then they tended to move away without any panic or haste.

Silver Hake

Echo-sounder traces usually attributed to silver hake (Merluccius bilinearis) were abundant in midwater before the second dive. When we submerged at 11 a.m., these traces were nearing the bottom. When the sub reached the bottom, small groups of silver hake were seen moving along slowly, mostly within 1 fathom or so of the bottom. Within an hour, at about noon, no fish were observed off the bottom. Single fish only were seen, resting quietly in shallow depressions. They remained that way throughout the dive, which ended at 6 p.m.

There is nothing silver about silver hake in their natural environment. They looked very much like blotched tomcod. Their general color was brownish, with 5 to 7 irregular, darker, vertical bars. All the fins, but especially the 2 dorsal fins, had a luminescent greenish border. When disturbed by the sub, they swam away slowly to another shallow depression and settled down again. The only feeding observed took place at the time of descent, when a few fish appeared to be biting at objects on the bottom. This action was associated occasionally with a quick twist, when the fish "flashed" brightly.

Cancer Crabs

Large cancer crabs (Cancer irroratus) were common. They appeared to have a carapace width of 6 to 8 inches. One occurred about every 30 to 50 feet of travel. Of all the animals seen, the cancer crabs reacted most strongly to the sub's presence. Most of those not buried began to move away when the sub got within 15 or 20 feet. And, once moving, they tended to continue moving away beyond the limits of visibility. Others, for a time, faced the sub with claws raised and spread in a fighting stance. During the first dive, most of the larger crabs, obviously females, were carrying smaller males.

Fourspot Flounder

Fourspot flounders (Paralichthys oblongus) were numerous--one about every 100 feet or so of travel. Two size groups were apparent, the smaller averaging 3 to 5 inches long, the

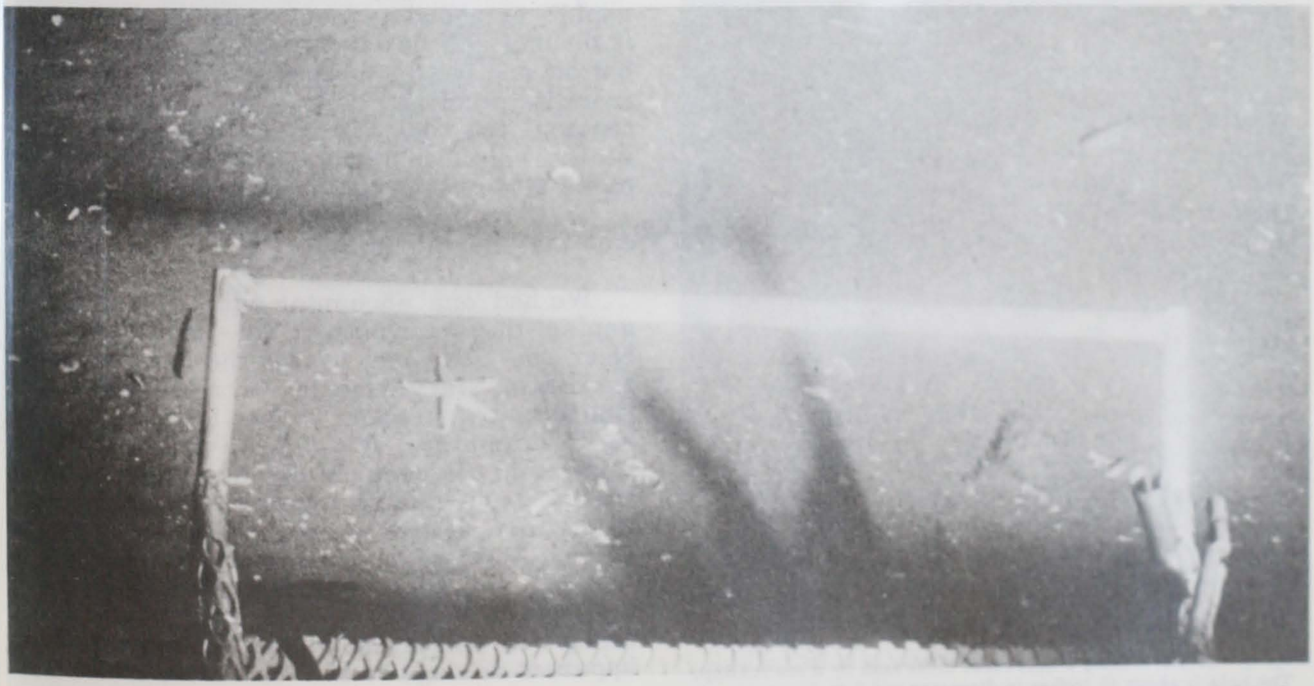

Fig. 7 - Small silver hake resting on the bottom. About noon these fish were seen in midwater; shortly afterward, they settled to the bottom, where they remained in small depressions for the rest of the day.

larger about 10 to 12 inches. They were resting quietly in the bottom, but they were not covered or buried. No buried flounders were seen. A very large number of much smaller flounders, about 1 inch long, also were seen. These small fish occurred every 3 feet or so, and appeared to be fluke (Paralichthys dentatus), not fourspot flounders.

Sea Scallop

Small sea scallops (Placopecten magellanicus), most much less than 1 inch in diameter, were very abundant. Often disturbed by the sub, fish, and crabs, they were seen flitting constantly through the water, usually only a foot or so above the bottom. They moved 3 to 6 feet when disturbed and reminded us very much of small tired butterflies.

In addition to these small scallops, 2 other size groups were apparent. Large scallops, 7 to 10 inches in diameter, appeared at regular and frequent intervals. Medium-sized individuals, about 4 inches in diameter, were infrequent. None of the large scallops showed any tendency to "fly," but the medium-sized individuals were as mobile as the small ones and took off at the slightest provocation.

Fig. 8 - Lobster sharing a hole made in the sand by a sea scallop. The hole is about 15 inches in diameter and 5 inches deep.

Large Sea Scallops

In the first area, very large sea scallops occurred every 20 feet or so. Several were closely observed and judged to be between 10 and 13 years of age. Every large scallop occupied a shallow hold about twice its own diameter. The holes did not have elevated rims and were more than deep enough to completely contain the inhabitant. Scallops were seen turning around in their holds, blowing detritus and fine material out. Even large scallops couldn't "puff" hard enough to blow heavier objects out of their holes, however, and thus many holes were lined with larger shell fragments. In some areas, the sea scallops had clean shells; in others, their shells were incrusted with sponges and other organisms. We noticed that the incrusting organisms were not limited to living scallops, but occurred as well on empty shells and other detritus in the same area.

Surf Clams

Surf clams (Spisula solidissima) were abundant, judging from the very large numbers of shells we saw. There was no visible evidence of this species living within the sediments. One large specimen (about 6 inches wide) was seen "leaping" across the bottom. It had obviously been disturbed by something and was beating a hasty retreat. The clam rapidly extended its foot in such a manner that it thrust itself upward about 18 inches off the bottom and fell to the bottom 2 or 3 feet away from its starting point. At its maximum extension, the foot was about $1\frac{1}{2}$ times as long as the shell. The foot was retracted much more slowly than it was extended.

And the "Sea Monster"

We had one encounter with a strange organism that we dubbed the "Sea Monster." Near the bottom, during the first descent, Alvin pilot Marvin McCamis called our attention to an object about 25 feet long and 6 inches in diameter. It was undulating slowly in midwater. He secured our sea monster with the sub's mechanical hand and brought it close to the port. It was a chain of unusually large salps. The individual salps were about 5 inches long, paired, and aggregated into a long chain of pairs. We dragged the chain along with us for more than an hour without apparent damage to it. We released it when we needed the claw to pick up some rocks.

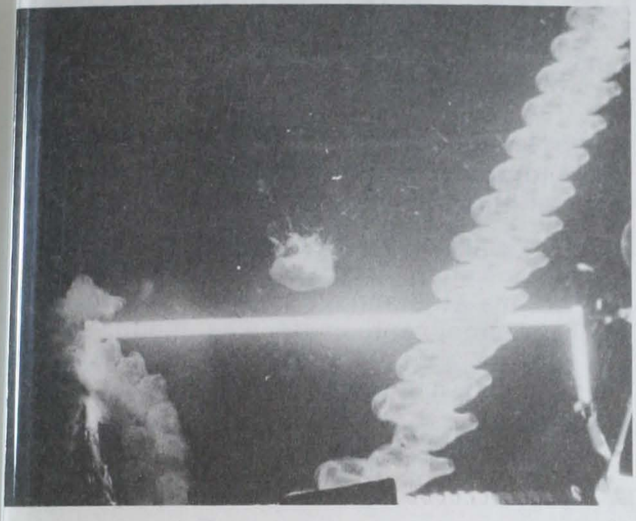

Fig. 9 - "Sea monster" and jellyfish. The sea monster is a giant salp common in these waters but seldom seen in chains this long.

Fortunately, we had sufficiently good photographs to identify the organism as Salpa vagina, a species common in these latitudes.

Sub's Value in Research

What use does a sub have in fishery research? No one expected that we would have even half the visibility we enjoyed on these dives. Sometimes we observed the behavior of fishes from considerable distances. It was apparent that all species paid little if any attention to the sub until it got very close. It is reasonable to suppose that worthwhile observations could be made on most or all groundfish species. Some possibilities include a study of haddock spawning behavior, territorialism of redfish, and the diurnal vertical migrations of hake.

One couldn't miss the "butterflies." Sea scallops up to 3 or 4 inches are extraordinarily mobile and, even under conditions of limited visibility, they could easily be seen. A sub would make the ecologic study of the sea scallop a comparatively easy matter, and surveys of sea scallop concentrations for the commercial fleet would be practical and feasible.

Over the years, all biologists who have studied the early life history of the haddock have noted that small haddock tend to be more abundant in those areas where the jellyfish Cyanea also was abundant. On our dives, Cyanea was seen frequently near the bottom. Small fish, apparently all gadids, were associated with some of them. Direct observations on the relationship between haddock and Cyanea could readily be studied from a sub.

Track of the Otter Trawl

Several times during our 2 dives, we observed what must have been the "tracks" of otter trawls and scallop dredges on the bottom. Studies of the direct effects of trawls and dredges on the bottom could be carried out with comparative ease in a sub. Until much faster vehicles are available, however, there is little justification for using one to observe the action of trawl gear directly. Even with maximum visibility, relatively great speed and maneuverability would be required to keep up with such gear--and to avoid the real possibility of accidental entanglement.

Just as the present generation of submersibles has only limited value for direct observation of moving trawl gear, so operations also would be difficult in strong currents, especially along some parts of the New England coast.

Alvin was made sufficiently "heavy" on our dives to minimize the effect of the currents (up to a half knot) by just setting it on the bottom. Control was excellent so long as we were heading upcurrent. During maneuvers, such as turning around to get a second look at some object, the current could be troublesome. Control of these vehicles requires a trained and delicate touch.