Ocean 11

The Abyss

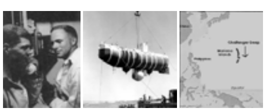
Overview

Man's exploration of the moon and regular shuttle flights into Earth orbit has led many of us to believe that all we have left to discover is "out there", beyond the confines of our planet. Yet the oceans continue to dish up new and vast arenas of exploration, continuing to surprise and intrigue us with its strange and "alien" landscapes.

The discovery in 1977 of hydrothermal vent communities and giant tube worms emerges as one of the most exciting finds in recent years. Heretofore completely unknown, these communities represent a whole new form of life, making their living on the stuff of the Earth rather than the sun, like most Earth organisms. Over 300 new species have been identified, all, of whom base their survival, in one way or another, on a wily group of bacteria known as chemoautotrophs.

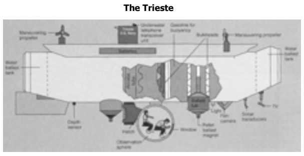
The bathyscaphe *Trieste* reached the deepest spot in the ocean in 1960.

On January 23, 1960, U.S. Navy Lt. Don Walsh and Swiss scientist Jacques Piccard took the bathyscaphe *Trieste* to the bottom of the Challenger Deep of the Marianas Trench, the deepest spot on Earth. They achieved the record depth of 35,800 feet.

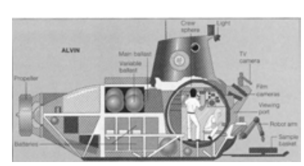


Video: Voyage of the *Trieste*

The Trieste



Alvin



The Next Wave

With over 3,000 dives logged in 30 years of underwater exploration, Alvin remains the major workhorse of deep-ocean exploration. But there's only one Alvin, and oceanographers waiting in line to go down have been yearning for another type of ride.

They're about to get one. A sea change in design and engineering is spawning a new generation of research subs. But these vessels leave their pilots on the surface, operating either by remote control, or on their own, using even more sophisticated computers. Robot subs could hasten the end of what Alvin team veteran Robert Ballard, of the Institute for Exploration, calls "the hunter-gatherer stage of oceanography."

Vehicles operated through remote control, called ROVs, stay attached to a mother ship by an umbilical-like tether that feeds power to propel the craft and runs cameras and mechanical arms. One or more pilots with a joystick steer the vehicle from the surface and watch its progress on a video screen.

At the Monterey Bay Aquarium Research Institute, scientists used ROVs to study the 6,300-foot-deep canyon just offshore. And the institute's brand-new Tiburon has been getting its sea legs. Designed with science in mind, Tiburon can stay buoyant at depth without using its thrusters, a plus for delicately approaching a hydrothermal vent chimney or an elusive creature. Tiburon can descend to 13,000 feet, nearly three times deeper than the institute's first ROV, Ventana, and is equipped to collect twice as many specimens. The new sub also features a stiff tether armored with 12,000 pounds of steel and inter-changeable, science-specific toolsleds for conducting measurements or taking samples. Tiburon launches from the middle of the twin-hulled

Western Flyer, a new vessel that could ply the entire eastern Pacific for expeditions featuring round-the-clock ROV research.

The big drawback to ROVs is the tether, which, like a dog's leash, restricts how far the craft can wander. That's why some oceanographers are excited about another new development: unmanned and untethered subs that ultimately won't need a ship to launch or retrieve them or a costly support crew standing by.

"You can literally drop them over the side and sail away while they do the job," says Monterey Bay's Bruce Robison.

These self-sufficient explorers, known as autonomous underwater vehicles, or AUVs, rely on internal computers and sophisticated software that instructs a sensor-laden vehicle to gather and relay certain data. AUVs could conceivably stay tied to a submerged hitching post or moored to a surface buoy until called into action.

"AUVs are very patient and very dumb," says Al Bradley of the Woods Hole Oceanographic Institution. "They don't get bored."
And that's got researchers pretty excited, for AUVs can free them from tiresome tasks such as mapping the ocean floor. The "flybys" needed to map have all the excitement of lawn mowing, and the autonomous subs would do it more quickly and with more attention to detail than easily distracted human pilots would. Other tasks suited to AUVs include tracking schools of fish or deep-diving whales and tracing a pollution trail to its source.

One of the newest vehicles is Woods Hole's Autonomous Benthic Explorer. The 10-foot-long sub has three separate cigar-shaped bodies housing its payload and buoyancy system, a design that minimizes pitching and rolling at depth. It can drift with a current, climbing over obstacles encountered on the bottom, and retrace its course. Another up-and-coming bottom-dweller is Odyssey II, an 8-foot-long yellow torpedo rub by the Massachusetts Institute of Technology's Sea Grant Program. Earlier this year, it searched for giant squid off the coast of New Zealand. Another MIT craft, Robo-Lobster, mimics the crustacean's acute senses to guide the craft along a chemical plume emitted from a hydrothermal vent or leaking radioactive waste.

Still, AUVs don't have all the answers. Their navigation skills need fine-tuning, their batteries run out, and they're just never going to have the human intuition and binocular vision critical for serendipitous discovery. Robison, who has manned many submersibles, points out that robot explorers can't ask such vital research questions as "What the heck is that?"

So the call of the sea that has lured sailors for centuries continues to draw people into the deep, whether inside Alvin, in the bubble-shaped Deep Rover built by designer Graham Hawkes, or in his latest endeavour, *Deep Flight*, a sleek, missile craft that he plans to pilot 36,000 feet down to the bottom of the Challenger Deep in the western Pacific's Marianas Trench.

Source: Earth, Aug97, Vol. 6 Issue 4, p26, 8p, 9c.

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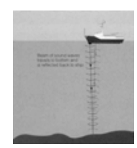
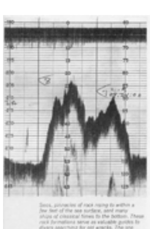


Echo sounders sense the contour of the seafloor by beaming sound waves to the bottom and measuring the time required for the sound waves to bounce back to the ship. If the round-trip travel time and wave velocity are known, distance to the bottom can be calculated. This technique was first used on a large scale by the German research vessel *Meteor* in the 1920's.



Videos: Bathymetric Mapping

27 minutes

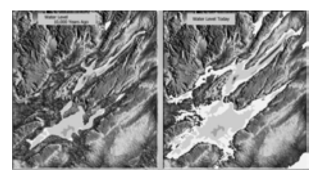
Questions from the video: Bathymetric Mapping

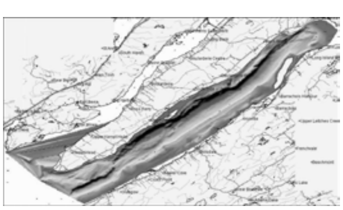
1. The Bedford Institute is now famous for what kind of mapping?
2. Where is this technique being carried out?
3. Give two reasons why this is important.
4. During the war, what would assemble in Bedford Basin?
5. How many ships would gather?
6. What determined their speed of travel?

7. Why was good visibility considered to be a "curse"?
8. What is the name of the naval dive ship?
9. What does this ship have on board?
10. To what depth do each of these travel?
11. What bottom time is there at 180 feet?
    Why?
12. What was the major danger in diving the wreck of this tanker?
13. What is the name of this ship?

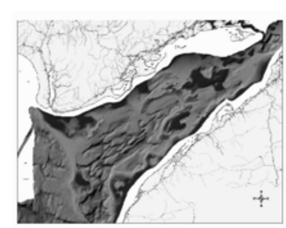
Video: Swiss Flight 111

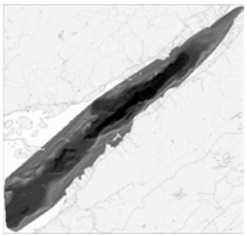
Multi-beam Bathymetric Mapping



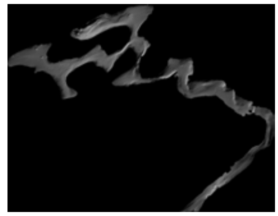


East Bay

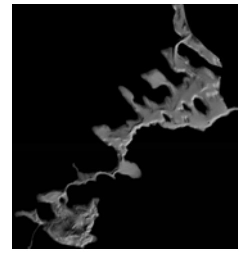




Eskasoni Harbour



St. Peter's Harbour



Bedford Institute of Oceanography

Dartmouth, Nova Scotia

Undersea Canyons

Rivers, tides and winds deposit sediment onto the continental shelf. Sediment builds up and forms a thick layer. Then, suddenly, part of this layer collapses. When this happens, the sediment mixes with water and forms a soup-like mixture. Because it is denser than the surrounding water, it flows more rapidly down the canyon. On its way, it erodes the walls and floor of the canyon. This makes the canyon larger.

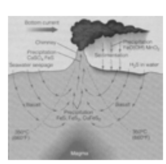
This turbidity current can have a speed of 50 kph at the mouth of the canyon. The Hudson River Canyon, which is larger than the Grand Canyon, was formed in this manner.

These submarine canyons on the continental shelf play a major role in moving sediment from the continents into the deep oceans.

Another type of undersea canyon is called a trench. It forms where one tectonic plate slides under another plate. Trenches are formed in the deep ocean and have very steep walls. The Marianas Trench is about 11 kilometres deep and is found in the Pacific Ocean.

A rift is the name given to the deep, v-shaped canyon that runs down the mid-ocean ridges. It forms where the tectonic plates move apart. New ocean floor forms at the rifts.

Hydrothermal Vent



Seawater enters the fractured seabed near an active spreading center and percolates downward, where it comes into contact with rocks heated by a nearby magma chamber. The warmed water expands and rises in a convection current. As it rises, the hot water dissolves minerals from the surrounding fresh basalt. When the water shoots from a weak spot in the seabed, some of these minerals condense to form a "chimney" up to 20 metres (66 feet) high and 1 metre (3.3 feet) in diameter.

As the water cools, metal sulfides precipitate out and form a sedimentary layer down current from the vent.

Bacteria in the sediment, in the surrounding water and within specialized organisms make use of the hydrogen sulfide in the water to bind carbon into glucose by chemosynthesis.

This chemosynthesis forms the base of the food chains of vent organisms.

In 1977, scientists aboard the submersible Alvin, exploring five thousand feet below the surface of the Pacific, saw large, four-foot-tall tube worms, some with bright red plumes, living around a hydrothermal vent. Later laboratory investigation revealed that the unusual worms had no digestive system but instead contained about 285 billion bacteria per ounce of tissue! In this sunless world, a type of sulfur-loving bacteria was the worms' food source. Clouds of bacteria, appearing white in the lights of the sub, were able to use hydrogen sulfide as an energy source. In most other food chains, plants convert carbon dioxide into food using sunlight during photosynthesis. These peculiar bacteria were able to convert hydrogen sulfide into food during chemosynthesis. Also found around the vents, feeding on the water rich in chemosynthetic bacteria, were certain kinds of clams and mussels. At this great depth and pressure, some species of octopus prey upon these shelled invertebrates. But, when the hot water and chemicals coming from the vent slow down to a trickle, the animals disappear.

In the past twenty years, more than three hundred species have been identified in this unique environment. Similar vent organisms have been discovered at the base of the continental shelf, where the ocean water is sulfide-rich, but not hot, as in the hydrothermal vents. These "cold seeps," as they are called, illustrate how little we know about the productivity of the ocean bottom. As far as scientists can tell, hydrothermal vents and cold seeps have not yet been affected by human activities.

Riftia, large tube worms (pogonophorans) that contain masses of chemosynthetic bacteria in special interior pouches.

The Lost City

Scientific team finds "Lost City" during deep-sea tour of Atlantic.

Oceanographers patrolling the mid-Atlantic in a miniature research submarine have stumbled onto a spectacular deep-sea garden of hot springs and towering spires they nicknamed the 'Lost City'.

"If this were on land," Duke University geologist Jeff Karson said, "it would be a national park."

The scientists spotted the formations on December 4, more than 3,200 feet below the frigid, stormy Atlantic during a month-long expedition to explore a submerged mountain. They said some of the ghostly white mineral formations soar 180 feet - the tallest undersea spires ever seen. Collectively, they cover an area larger than a football field on the flanks of a 14,000-foot mountain known as the Atlantic Massif at 30 degrees north latitude.

The formations have risen over eons as the result of the accumulation of minerals dissolved in hot water bubbling up through fissures known as thermal vents. They occur where plates in the Earth's crust collide and grind. In these black ocean depths, some of the pinnacles resemble stalagmites in a cave while others look like dribble-sand castles on the beach. Ledges, or flanges, of the crusty, feathery crystals jut from the spires like mushrooms.

Most vents occur at points where the crust is much younger than a million years old.

The water from the vents is relatively cool at 160 degrees. The structures are composed of carbonate minerals and silica. Iron and sulphur-based minerals form most seafloor hot springs deposits.

Rocks in the rugged area were formed in the Earth's hot mantle and pushed several miles up to the seafloor along active faults.

Unlike vents in the Pacific the mid-Atlantic vent field shows relatively little complex life.

The scientists saw dense, floating mats of microorganisms but little else. "Why we did not see clams, mussels or shrimp is a mystery to me," Kelley said. "The microorganisms that live within these fields may be very different."

Video: The Abyss

31 minutes

SOME FACTS ABOUT LIFE IN THE DEEP OCEAN

- The upper 100 metres of the water column is considered the sunlit zone.
- Seventeen percent (17%) of all known animal species on Earth live in the ocean. Of these marine species, only two percent (2%) live in the upper water column – the rest live just above, on, and in the bottom sediments.
- Light is considerably reduced between 600 and 1000 feet depth. Animals inhabiting this mid-water have large eyes, a variety of light organs and are usually silvery gray, black, purple or red in color.

Animals which live in the deepest parts of the ocean are dirty white or colorless, have reduced (or absent) eyes and many have bioluminescent (light-producing) organs.

They must rely on senses other than vision to find food and mates and to associate with other animals.

•Deep-sea animals have low metabolisms and move slowly, often using a "float-and-wait" method for catching prey. They do not experience seasonal or annual changes in temperature or salinity of the surrounding water.

•Almost all areas of the deep sea have enough oxygen to support life. It comes from water in the Arctic or Antarctic which becomes so cold that it sinks and flows along the bottom of the ocean.

•Deep-sea animals have several sources of food – migrating larvae of animals which live in shallower depths, bodies of marine mammals and fish, marine snow and bacteria which produce food using chemosynthesis.

•Chemosynthesis is similar to photosynthesis, which all green plants on the surface of the Earth use to make sugar compounds from the sun's energy and carbon dioxide. Deep-sea bacteria use sulfur as the energy source to produce food.

Body tissues of deep-sea fish tend to have more water and less fats and proteins – they are more jellyfish-like than fish-like.

Sound travels four times faster (4798 feet per second) in water than air.

Marine Snow is made up of particles which are formed in the upper layers of the ocean – fecal pellets, bodies of planktonic organisms and other organic compounds. These clump together and fall to the bottom of the ocean.

Many deep-sea animals have large mouths and recurved teeth – when food comes along they don't want to lose it! Some have also developed body parts that dangle and look like bait and may produce light to attract prey.

Black Sea Dragon

Angler Fish