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DIVING AT THE SCRIPPS INSTITUTION OF OCEANOGRAPHY

In the summer of 1949, Conrad Limbaugh, a graduate student in zoology at the University of California's Scripps Institution of Oceanography, made what he believes may have been the first aqualung dive for scientific purposes undertaken in the United States. It was a relatively tame affair.

"I entered the water and swam out through the breakers underneath the Scripps pier," Limbaugh recalls. "I carried a five-tine spear. I swam through a school of queen fish and then out to a school of jack mackerel. Along the bottom I noticed a number of sand dollars sitting edgewise in the sand. Then I came upon an angel shark buried in the sand. This was the first I had seen of an angel shark and didn't recognize it. I prodded the nose of the shark with the spear. It didn't seem to mind. I lifted its head free of the sand and got an idea of how large an animal it was and its shape and it just sank back into the sand." He managed to get one tine of the spear through the shark's leathery hide. The creature shrugged this off and swam easily away.

Limbaugh, then 25, had been skin diving for 13 years. As a student of marine fishes, he at once realized that the aqualung was slated to become an extremely important tool to the ocean scientist. He returned enthusiastically to shore and set about initiating the first systematic use of the gear in scientific studies at Scripps and also proselytizing and teaching other adventurous students and technicians.

The first scientist to join him was Andreas Rechnitzer, a fellow zoology student, who took to the new tool with immediate zest.

Limbaugh is a sandy-haired, blue-eyed man with the husky, smooth-muscled build of a swimmer who has both speed and generous powers of endurance. He is enormously serious about diving and about fishes; in regard to other matters, he is easy-going and humorous. His usual dress is the beach boy's bright shirt and worn cotton pants. He is an amateur painter of some ability, and

has painted the underwater world in which he has spent so much time.

Limbaugh has taught scores of others the use of self-contained underwater breathing apparatus (SCUBA) and has had the thrill of pioneering scientific underwater exploration at one of the spots in the world where such knowledge is most eagerly sought and most thoroughly appreciated, for The Scripps Institution of Oceanography is the oldest institution for oceanographic research and teaching in the United States and the largest in the world.

The Scripps divers have explored and described one of the world's uniquely beautiful and scientifically interesting underwater landscapes.

This is the area just off the southern California coast. There are three chief elements: the narrow, steep-sided rock gorges of the La Jolla Submarine Canyon and its tributaries; the almost flat, sand-bottomed "desert" off the beaches, and the submarine jungles of the giant kelp, Macrocystis, that, like some great sunken hedge, border the coast a few hundred yards offshore.

Deeply incised into the gentle slopes of ocean floor off the California coast is a series of underwater canyons. One of them, Monterey, is just about as steep and as deep as the Grand Canyon of the Colorado. The La Jolla Submarine Canyon, the province of the Scripps divers, is more modest in scale. Running out to sea for 20 miles, it loses its identity in the San Diego Trough at a depth of about 1500 feet. The heads of its branching tributaries lie only a few yards north of the Scripps pier and one can reach water 50 fathoms deep no more than half a mile from shore.

Francis P. Shepard, a professor of geology at Scripps, is one of the world's authorities on submarine canyons. At his instance, the canyon has been systemtically explored from the surface, by use of echo-sounding gear, for many years. Some time ago a suited diver descended into the canyon

and took excellent photographs. Shepard's group was one of the first at Scripps to make use of aqualung-equipped divers.

The diver can go where sound cannot. Many of the declivities of the canyon are so narrow--a diver can touch both walls with his arms spread out--that they return confusing echoes to the ship. Some of the walls are vertical, some even overhang. Ledges and rocky outcrops are silted over with the rain of sediment from above which collects in great semi-solid masses in the bottom, to be flushed out to sea occasionally in some great periodic movement that no diver has ever been lucky enough to see. Such "sweeping out's" of the canyon floor have sometimes coincided with the occurrence of earthquakes; others have not. To get more information on this, one of the geology student-divers has installed specially designed recording apparatus on the floor of the canyon, hoping to record the magnitude of the bottom currents. Periodically, the sediment at the bottom of the canyon -- sand, squid eggs, streamers of kelp, dead eel grass, a few beer cans, empty paint cans, fish skeletons, as itemized on one dive by Charles Fleming -- travels out through the canyon to the floor of the San Diego Trough.

The presence of the steep, rocky walls gives scale to the dives, according to diver Earl Murray. "You get a greater sensation of the depth there." The divers travel up and down the sheer walls of the canyon with the ease of a fly at a windowpane.

The upper part of the canyon cuts into the shelf where the water is less than 50 feet deep.

It was in the canyon that Limbaugh captured the small fish that he and his mentor, Carl L. Hubbs, plan to name after Captain Cousteau.

From the shallow canyon heads, the gullies descend sharply and combine into Scripps Submarine Canyon, which joins other such to form the great La Jolla Submarine Canyon. Divers have gone to depths of approximately 300 feet, but

the greater depths must of course still be explored acoustically.

Light attenuates rapidly in the canyon. "You notice the walls change color as you descend from one depth to another," Ramsey Parks III says. "It's like walking into a dark movie house looking for a seat. In a while your eyes become accustomed to the light change and you can see fairly well."

Life is rich on the canyon walls. Andreas Rechnitzer estimates that the rocky outcrops are encrusted to a depth of about eight inches. "Scallops, that you find there, are able to detect the presence of a diver," he says. "Several times when we have approached within about five feet, we could see the scallop close and then not reopen, until presumably we were out of sight."

The living creatures in the canyon are predominantly mollusks and worms, Limbaugh says. "There are small stony corals and a large number of sea fans. In the very upper parts of the canyon, where there is sufficient light, down to a depth of 85 feet, we find a profuse vegetation, though not nearly so dense as in other rocky regions. During the winter the temperature is much the same all the way down from the surface, but in summer the surface layers are much warmer. The presence of this cold water so near shore means that Scripps biologists can often collect cold-water flora and fauna that otherwise they might have to travel hundreds of miles for. The light in the canyon is absorbed rather rapidly because of the narrow walls and the turbidity of the water, the visibility ranging from six inches up to 100 feet on rare occasions. Usually in the deeper water below the warm layers the water is much clearer. On the upper rims of the canyon, in the sand, large fish such as halibut, are observed, as are other sand fishes, rays, and angel sharks.

"There is generally a green cast to things in the canyon. Some of the sea fans which are fuschsia in color appear violet. The pink sea fans look white. The bright orange Garibaldi, which occasionally gets down into the canyon, appears yellow, and the pink band on the sheepshead appears white.

"The divers observe marks on the walls of the canyon where life begins to determine how much sediment has gone down the canyon."

Less spectacular than the looming canyons are the "deserts" of the sea floor. These almost level reaches of sand are marcelled by the waves into a pattern of gentle undulations. The study of these patterns is the province of the Division of Shore Processes at Scripps, which employs its own diver, Earl Murray, to observe and photograph the sea floor.

Murray, 27 and the father of two, spent seven years in the Navy, largely on submarines. He had some diving training in the Navy. His chief non-scientific diving pursuit is the quest for the black sea bass. Murray weighs 168 pounds; his quary frequently trip the scales at even 200 pounds. They equal his six feet of height.

"Your first trips out on the sand, you say it is very dry and void of life," Murray says. "Drab and uninteresting. We have some difficulty getting some people to dive out there because they get bored with it. But the more you study it, and when you get down close to it, you see it is just teeming with life. There is an abundance of little shellfishes that are in just a busy game of life on the sand. As the sand moves in and out with the seasons it uncovers and creates a habitat for different little fish. There are giant sea pansies and sea pens and sea cucumbers down deeper and your large halibut and diamond turbot and other fish that live in the sand and little shellfish and hermit crabs and sharks -- the sluggish angel sharks and the giant blue sharks and numerous little stingrays. These last, Murray says, "fly around like little birds." And there are crabs, "crabs that look like ping-pong balls and little ones that are covered with growth that are hard to see. There's a little octopus that builds his home out of sea shells. He's a very timid little fellow, but always pleasant."

Beyond the deserts lie the wavering tan forests of kelp. The giant kelp, macrocystis, grows from a small holdfast anchored to a rock or other hard surface. "Macrocystis" means large bladder, and refers to the apricot-sized, gas-filled floats of the plants. Macrocystis grows in relatively shallow water, at depths of 35 to 100 feet. The surface portion has been harvested for many years, forming the basis of a thriving industry, as it supplies the substance algin which has pharmaceutical applications and is also used in food.

The kelp beds act as a barrier to small, choppy wind waves and can be seen from shore as a smooth, brownish band of water paralleling the land.

Over a hundred species of fish have been studied in the kelp beds. In the Jack-and-the-beanstalk forests of the kelp, a diver can hover for minutes over a fish as he studies its habits, can wind in and out of the kelp as he seeks, with an underwater butterfly net, to capture a specimen.

There is constant movement in the kelp as the long, limp fronds respond to the surge. Plants appear yellow-brown against the blue background of the water outside the beds. The stems of the plant are only one-fourth to one-half inch in diameter and as much as a hundred or so feet long. At the surface the long stems flatten out to form a canopy.

Some of the fishes of the kelp have so evolved that their bodies blend well either in shape or in color with the background.

A diver can hold onto a stem of the kelp to keep himself motionless. As he does so he shakes "kelp dust" which settles to the bottom. This "kelp dust" is comprised of millions of minute marine plants called diatoms, the most abundant plant in the ocean. It settles on the bottom to form "sand rust."

Kelp is the resort of many kinds of fishes; senorita, kelp perch, kelp fishes and kelp bass.

The kelp forests are more beautiful than the coral wonderlands of the tropics, according to Charles Fleming, who has seen both.

Tall, balding, blue-eyed "Chuck" Fleming was an ardent spearfisherman until he became more interested in observing the creatures of the ocean. He has a large and colorful collection of seashells. He studied engineering and psychology in college. He has been skin diving since he was 12. Much of his early skin diving was done in Lake Michigan and other freshwater bodies.

"The coral is beautiful for about a week," Fleming says, "and then because it is immoveable it becomes very boring. Your reefs are almost all the same, you fish almost all the same; as a result you don't even look at these things after, I'd say, two weeks of diving in the tropics."

"But the kelp is always in motion. And the floor is interesting. You have some boulders which are as big as a normal one-story, four-room house, that the kelp grows on. There is some sandstone and some conglomerate, and these make very beautiful and weird water-eroded shapes. The colors of the rocks themselves are varied."

Frank Snodgrass, an engineer in the Division of Waves and Currents, is 35. At present he is the Chairman of Scripps' Board of Divers. Snodgrass is 5 feet 9 inches and weighs 180 pounds. Snodgrass' chief underwater hobby is the pursuit of the succulent halibut, which, he says, is probably the simplest of all fishing.

Snodgrass, who has used the aqualung at Guam and Wewak and the Barbadoes, agrees: "One of the best spots is on the seaward side of San Clemente Island (offshore from southern California). The bottom there was white sand. There were large outcrops of boulders and large rocks and lots of caverns and then from the top of the rock outcrops were the large kelp plants."

"It is something that should be painted," says Thomas Mahnken, an illustrator who has just started diving. "My ambition is to take oil paints down there and try to slap some colors on, just the colors that are down there."

At present there are approximately 25 qualified divers at Scripps and 10 students in training. Limbaugh's first informal instructions to his buddies have blossomed into a fairly formal course, complete with stringent physical examinations, homework, and carefully supervised pool and ocean training. A few years ago, information was scarce or non-existent. Now there is a reliable body of it, and it is constantly being added to. "Every diver who has done any diving at Scripps has contributed in one way or another to build up the present diving rules," Limbaugh says.

Scripps is at present the only campus of the University where SCUBA diving is allowed. A University committee under the chairmanship of Charles D. Wheelock, Acting Director of the University's La Jolla-based Institute of Marine Resources, has drawn up a compendium of rules governing diving which has been suggested for all-University use; pending more widespread adoption, they are in effect at Scripps today.

About 50 persons start SCUBA training each year, Limbaugh says. Only about 30 complete the course. Enrollment is generally restricted to students and employees of the Institution. Divers are subjected to pre-training preparation. It is at this stage that most of the failures occur.

The pre-training preparation consists of the following steps.

The diver must:

1. Obtain a certificate that he has passed, within 12 months, a physical examination for qualification equivalent to that for participation in intramural swimming. (Student Health Service Medical Record Classification A).

Successfully perform the following tests or their equivalent in the presence of a member of a certifying board consisting of five experienced divers.

(a) Swim 1,000 feet in pool.

(b) Swim 1,000 feet without fins in the ocean.

(c) Enter and leave the surf without fins.

(d) Swim in a rip current.

(e) Swim underwater without fins for a distance of 75 feet, without surfacing.

(f) Swim underwater without fins for a distance of 125 feet, surfacing not more than four times.

(g) Demonstrate swimming with snorkel and fins with and without face mask.

(h) Surface dive to a depth of 18 feet.

(i) Recover a 10-pound weight from 10 feet.

(j) Carry a 10-pound weight 75 feet using fins.

(k) Surface dive to a depth of 10 feet and recover a swimmer.

(l) Carry a swimmer 75 feet at the surface.

(m) Pick up a struggling swimmer.

(n) Give artificial respiration (arm lift/back pressure).

3. Pass an oral or written examination given by the certifying board to demonstrate knowledge of the following:

(a) How the various pieces of diving equipment function, and their care.

(b) The physics and physiology of SCUBA diving.

(c) The causes, signs, symptoms, prevention, and first aid for the following:

(1) Near drowning
(2) Air embolism
(3) Carbondioxide excess
(4) Exhaustion
(5) Respiratory fatigue
(6) Oxygen poisoning
(7) Nitrogen narcosis
(8) "Bends"
(9) Carbon monoxide poisoning

(d) The diving rules and precautions:

(1) Your diving certificate must be valid.
(2) Your special medical certification for diving must be valid.
(3) Your SCUBA has been overhauled and certified within six months.
(4) Your air supply conforms with the provisions under paragraph 11.
(5) Don't dive if:

(a) You don't feel well.
(b) You have a cold or your sinuses seem congested.
(c) You feel tired or sleepy.
(d) You have indulged in recent excesses of food or drink.
(e) You do not have a buddy.
(f) Conditions seem dangerous.

(6) Plan the dive with your buddy.

(a) Duration of dive including decompression times in relation to air supply in SCUBA.
(b) Depth of dive
(c) Signals to be used
(d) Specific task
(e) Emergency measures
(f) Special equipment for the task and for safety.
(g) Be prepared to take the necessary steps to reach a physician in a medical emergency.

(7) Observe wave and current conditions before every dive.
(8) Sight a gage showing air pressure in tanks.
(9) Recheck SCUBA operation before entering water including operation of reserve air valve.
(10) Check quick release for jettisoning weights and SCUBA.
(11) Make certain you have adequate flotation gear.
(12) Dive with fins.
(13) Carry a knife when working around lines.
(14) Use a protective suit when diving in cold water.
(15) Never use ear plugs while diving.
(16) Do not dive deeper than the depth for which you are certified.
(17) Have means, except as allowed under training provisions, to determine your depth at all times.
(18) Wear a watch if there is a possibility you may need decompression.
(19) Adjust weights to give you neutral buoyancy.
(20) Dive with a buddy:
(a) Keep in touch with your buddy by sight.
(b) Use a buddy line at night or in dark or murky water.
(c) Surface when separated.

(21) Stop descent or ascent immediately if your ears or sinuses hurt.
(22) Do not hesitate to terminate the dive because of fatigue or reaction to cold. Retain an adequate reserve of strength for ascent and for the surface swim.
(23) Ascend immediately if you sense any unusual perfomance of SCUBA.
(24) Ascend immediately if you lose contact with your buddy.
(25) Don't rise faster than 25 feet per minute or faster than the small bubbles from the SCUBA.
(26) During ascent, breathe relaxedly.
(27) Keep a log book of all dives.
(28) After dive rinse gear with fresh water and hang it up to drain and dry.
(29) Always handle compressed air tanks with great care. A charged tank can become a dangerous rocket if the stem is broken.
(30) Collapse of a camera case, flashbulb, etc. at 50 ft. depth may cause a damaging shock. Pressure test new apparatus before going down with it.
(31) Until you have gained extensive diving experience, steer clear of piling, snags, boat propellers, entangling plants, rays, sharks, sea lions, porpoises and whales.
(32) Spear guns are as dangerous as firearms and should be treated with equal caution both above and under water.
(33) Infection is likely to occur from contamination of open cuts unless you wash all cuts with soap and fresh water or disinfectant soon after diving. Fish skin and spines often carry bacteria which may cause skin infections such as boils and carbuncles.
(34) Don't dive in waters polluted with sewage unless you have been immunized recently against typhoid and paratyphoid.

Classes are given about five times a year and are usually limited to less than 12 students. These men spent eight hours in classroom work, eight hours in the swimming pool, and eight to sixteen hours in the ocean in their two-week training course. At the end of the time, if successfully ~~they are~~ certified to dive to 25 feet. To qualify for deeper levels, additional supervised dives must be made; by the time he is working at 130 feet, the diver will have completed some 50 dives with experienced men. If his partners notice that he is not diving properly, not obeying the rules, or even is simply accident-prone, the diver is limited to a specific depth or disqualified completely. Divers can be disqualified by the five-man Board of Divers, which decides whether the diver should be allowed to dive, how deep, and if there should be other restrictions.

The psychological condition of the diver is very important. However, a man's emotional stability is not easily measured with simple tests. Scripps finds it impossible to get competent men to evaluate each diver as he goes to greater and greater depths and it is impossible to have each diver constantly analyzed; therefore, it is left up to the members of the Board to determine whether the diver is following safe practices. If not, he is warned. If he continues, his diving permit is limited or completely revoked.

Refresher courses are occasionally given the more experienced divers.

At present, the divers average about four dives a month. However, some of them dive 18 times a month. According to our log charts (each Scripps dive is meticulously documented), the dives average 23 minutes each and most of the diving is between 70 and 80 feet. Few dives are made below 150 feet, although on one occasion the divers probably exceeded 300 feet. During the past four months, only 11 divers made dives greater than 130 feet. About 900 dives were made by divers at Scripps during the past eight months. Approximately 66 eight-hour working days are spent each year under water. Diving has become such an important tool in the marine sciences that the marine ecologist who doesn't dive can be compared to a blind ornithologist.

Under this regime, accidents of major importance have been rare and there have been no fatalities. However, since steel and rubber cannot change a terrestrial animal to a marine creature, small accidents -- laceration, close calls, and things of that sort -- are inevitably frequent.

Because of the rather thorough training, a diver is considered in less danger diving at moderate depths than he is in driving in city traffic.

Waves born of the long winds that stir the vast Pacific can cause strong rip currents that carry divers to sea and retard their swimming toward shore. The diver may surface to find that a sudden fog has blotted out the shoreline

or his tending boat. The increasing human population of California has been reflected in the dangerous pollution of some favorite diving spots.

One of the increasingly important hazards of diving off California is the presence of other divers. "It's not uncommon to meet up with a stranger (equipped with a spear) swimming a hundred feet below the surface," Limbaugh says. And fishing boats which drive off sea lions with rifle fire have on occasion mistaken a diver's masked head for the shiny muzzle of a sea lion, although no divers have yet been wounded by rifle shot.

The large animals in the ocean present a minor problem. There has been one fatal shark attack on the coast, and a number of less serious shark attacks; however, none was to Scripps personnel. Sea lions have occasionally attacked divers. The largest of our spiny fishes, the black sea bass, is harmless. Sting rays are common and present a hazard to the diver if he wades out from shore.

Cold water can be such a problem to the diver that he will make ill-judged decisions just in order to escape the cold. The waters off La Jolla never become tropically warm, although they also rarely go below 55° Fahrenheit. Several of the divers problems, for instance, nitrogen narcosis, seem to be more apparent under our cold working conditions. Diving suits are worn by most of us. The wet-type suits are preferred. A diver waiting at a decompression stage will at times surface before he should because he is not capable of taking the cold.

The large forests of algae hamper the novice diver, but the old hand has little difficulty, only rarely becoming entangled and easily extracting himself. Each summer we have numbers of large jellyfish, sometimes 25 feet long. Their stings are of a minor nature. Scripps divers do for some reason or other develop boils. A solution for this problem has not been worked out yet.

Keeping-in

Training has not been particularly stressed, although it is mentioned during the schooling that a normal amount of sleep and food are necessary and that you shouldn't drink to excess. Smoking isn't mentioned, but probably only about a fourth of the divers do smoke.

The Scripps divers have had their share of narrow escapes. There was the time Fleming and Limbaugh, in the early days of diving at Scripps, were in the canyon trying to pick up a few lobster for dinner. Limbaugh was at one end of a boulder, Fleming at another. Limbaugh lifted his end to make it more convenient for him to take a lobster, rolling the boulder over on Fleming's arm. Then Limbaugh started to swim ahead. "If he hadn't heard my grunting and turned around," Fleming said, "I'd probably be down there still." "I looked around," Limbaugh remembers, "and there was Chuck sort of looking mad and grinning at the same time."

One sort of close call that has happened several times, to several different divers, is the failure of the attending boat to follow the divers' bubbles.

Limbaugh describes such a dive on the outer edge of the kelp beds: "There was a strong wind and a moderate swell. The three of us followed down one of the giant kelp stalks to the rocky bottom. The sandstone was covered with large sea urchins about eight to ten inches in diameter. I found a rare fish, one of the fringeheads, of which there have been probably no more than a dozen specimens ever taken, and we have taken three-quarters of them in our diving. This one was in a little hole in a rock. I caught another little fish, a sculpin about four inches long, very brilliantly colored in pink and browns and whites, by chasing him into an eight-ounce bottle and closing the bottle. Ramsey Parks speared a sheepshead weighing about 15 pounds. We also picked up a number of abalone, red and pink and a little one known as the northern green abalone and placed these in a burlap sack. We completed our dive in about 25

minutes. Andy Rechnitzer indicated by hand signal -- his hand drawn across his throat -- that his throat was cut; in other words, he was nearly out of air and it was time to surface. The three of us surfaced very slowly. There was no boat. We could see it about three-quarters of a mile away. However, we didn't know whether it was being blown or the man had lost his oars or what was wrong and we couldn't get his attention. I gave the order to drop our weight belts and when we did the boys were much relieved. We asked Ramsey to drop the sack of abalone. However, he was reluctant to drop the fish he had speared. Then we began our swim toward shore.

Our route lay through a bed of Macrocystis. The swim was about three-quarters of a mile. The tough kelp tends to entangle one while swimming at the surface. It took about two hard hours to swim ashore. I had only a half a suit and I had tanks that were not buoyant. I overcame this partially by pushing the tanks under water to the point where air was forced through the regulator and into my rubber suit, ballooning it up and adding to my buoyancy. The man in the boat was still looking for us three hours later when another Scripps boat got to him. He had lost our bubbles in the first few seconds we were down."

There have been several other such incidents.

As for large animal attacks, Scripps divers have experienced none. Their only shark encounter was a sportive one:

Snodgrass, Limbaugh, and two Navy divers were working on a project for Scripps's Visibility Laboratory. They saw a forty-foot whale shark at the surface. Formidable in size and fearful in appearance, the whale shark is by nature a lazy, plankton-eating creature. Limbaugh persuaded the group to "board" the shark. "We climbed all over it," he recalls. "It was accompanied by a large number of pilot fish and over the body there were a large number of shark suckers, a small fish with a suction cup on top of its head. I saw the

whale shark open its mouth. I was curious to see what was inside. I looked in and saw it was black. I placed my hand inside to feel the texture and accidentally placed my hand on a shark sucker and this startled me."

"The whale shark wasn't even aware we were about," Snodgrass says. "He was about eight feet across and a dull grey in color, with white spots. You could swim up and grab his tail or one of his fins and hold on as long as you could hold your breath. He would pull you along without apparently being even fully aware that you were there. Eventually he would sound and you had to let go, but shortly after he would surface again. By that time we would be back in the boat. We would row over, jump in the water and take another free ride."

As its potentialities are more thoroughly explored, SCUBA diving has come to play an increasingly important role in the scientific program of the Scripps Institution. The Division of Shore Processes uses the tool extensively. Reference stakes have been set offshore, allowing periodic measurement of sand level. Ripple marks are observed visually and are photographed. Sand samples are taken.

The use of diving in the study of the submarine canyons has been mentioned.

The aqualung was used indirectly in microbiological studies. The divers collected diseased fish by aseptic methods. Bacteria were then taken from the lesions on the fishes and cultured and, later, healthy fish infected with them.

Divers are making light measurements underwater.

The botanists have used divers to measure the growth rates of organisms. This is done simply by putting out plastic or metal plates and inspecting them at intervals to determine what plants are growing there and how fast. These carefully tended gardens under the sea hint at the possibility of future commercial exploitation of the technique by planting substrate on which hekp and other plants

Divers have been extremely useful in wave studies. Frank Snodgrass, who has a degree in engineering, has led a group of men installing various wave instruments along the coast, primarily for the study of long-period waves. Instruments can be placed more accurately and maintained more easily by using divers than can be done from the ship.

One of the less agreeable assignments of the divers has been the task of observing sewer outfalls. California cities face a sewage disposal problem of great proportions and Scripps scientists have been asked to advise on it. "The sewage coming up out of the outfall was like a big, black umbrella," Earl Murray says of one such dive.

The divers often collect fishes for the Institution's aquarium. An angel shark is taken by looping a rope around his tail. The diver then hastily gets out of the way of the threshing animal as it is hauled up to the skiff.

SCUBA has proved enormously useful to the marine biologist. Limbaugh's studies of the fish life of the kelp beds depended almost exclusively upon the use of such gear. Indeed, diving has nearly revolutionized fish collecting. "In a trip to the Channel Islands," Limbaugh says, "we were able in a two-week period to collect more than half of the known species of fishes found on the coast of California. A good percentage of these could only have been collected by the use of SCUBA."

The most important method of collecting fishes is with a fish-suffocating chemical known as rotenone. This common insecticide is mixed with sea water to a heavy paste. The diver descends and spreads the paste about the crevices. The paste forms a cloud in the water, which suffocates the fish. The divers collect most of the fishes from the bottom, although some come to the surface, where they are collected directly from boats. As many as 50 species have been collected at one time in the southern California waters. Spears are used for the larger fish, which do not succumb to rotenone as readily as small ones.

Small fishes are individually collected with small nets or with bottles.

Direct observations made by divers are of course invaluable in the study of fishes. Ichthyologist-divers, for example, have carefully studied the Garibaldi, a marine damsel fish that looks like an outsized goldfish and is common in shallow waters off southern California. The Garibaldi, the divers have found, cultivates a small garden of very short red seaweeds which he keeps cropped to about half an inch in height. The female deposits her eggs on these seaweeds. The male fiercely protects his nest, as other males are likely to eat the eggs.

A small fish with the wonderful name of "sarcastic fringehead" is common near San Diego. Before the advent of man on the coast, the sarcastic fringehead made its home in empty sea shells. But modern technology works its miracles on the bottom of the ocean as well as on land: now the sarcastic fringehead prefers the beer bottles and beer cans littered on the sea floor. In San Diego Harbor it is not difficult to gather up a dozen of these fishes by stopping up the opening in the cans with one's finger. Several of the sarcastic fringeheads have been moved, beer-can home and all, to the Scripps aquarium. The male spends a good share of life with his head emerging from the opening, which he pugnaciously defends.

One of the beginning divers at Scripps is 40-year-old Theodore Walker, biologist whose current project is work on the means by which fishes orient themselves, particularily the lateral line. He has taken up diving to get out into an environment where he will not be hampered by the acoustic restrictions encountered in a laboratory. The lateral line, he thinks, is an underwater acoustic detecting device probably peaked in the subsonic range of frequencies corresponding to the propulsive movements of fishes.

The divers often bring their observations of fish behavior to Walker. They have noted many times that the fish orient themselves to the bottom although

the bottom may in some instances be the overhanging roof of a cave. Against a vertical canyon wall, they will be in a perpendicular position. Any explanation of the fact, Walker says, is largely conjecture. In a general way, however, he thinks that the fish orient themselves to the bottom visually with the idea of detecting any displacement a current would cause. "If you move the bottom, the fish will move." Diving, says Walker, "is a wide-open field to anyone who is interested in the reactions of fish. Certainly one is apt to get a very bad idea about the importance of vision to fish from sticking around a laboratory. When you go out into diving and run into some of the visibility problems it is quite apparent that much of the time a fish doesn't have too good a view of things. That seems to me to stress the function of the lateral line and other structures. And I've been impressed by the intensity of local ocean currents. I suspect that knowledge of the currents and either taking advantage of them or avoiding them plays quite an important part in the lives of many fishes."

Andreas Rechnitzer, Danish by [illegible], one of the first divers at Scripps, is a student of zoology. At present he is working on studies of the blood serum of surf perches and sea perches. He lives to collect specimens that many times he could not obtain by seining or [illegible] line. Rechnitzer has used diving gear in several other of his projects.

The "completely different world" 60 to 100 feet down fascinates biochemist Wheeler North. At the moment North is studying a cold-water marine anemone that though it lacks eyes responds in its own primitive way to light. North is interested in determining the mechanism. Most of the year the surface waters at La Jolla are too warm for the animal. A few can be found at a depth of 100 feet. North would like to start a colony of the anemones on a canyon wall and compare their growth with that of a group he has in the laboratory.

North's anemone differs from the common kind. Its tentacles are so numerous and slender that the creature looks rather like a ball of cotton, he says.

To the submarine canyons every winter millions of squid come to spawn. John McGowan, a diver and student of marine invertebrates, and Limbaugh have spent many hours documenting the event. The squid are found at a depth of 45 to 150 feet. Large schools of squid will hover over a patch of sand, swimming with their fins. Then they will pair up and, still schooling, will jet the sand away in a rimmed, circular depression. In these they deposit the eggs. The eggs are encapsulated in a covering about the size and shape of a ladies' fountain pen, each capsule containing about 300 eggs. The male will attach himself to the female, blushing bright red (at this depth, appearing brownish-black). The male pushes the female into the sand or into the mass of newly laid eggs and the female extrudes the capsule and attaches it to the sand. After spawning, both die and the canyons become beds of rotting squid. The egg-cases, which looking like a strange snowfall on the ocean floor, continue to grow until they are about two and a half times their original size. As they grow they become incrusted with brown diatoms. The smell of the decaying adult squid can be noticed on shore.

Limbaugh has taken 16-millimeter color films of the spawning, underwater ballet in muted browns and whites.

With the squid comes their predators, the sea lions, marine birds by the hundreds of thousands, whales, many fishes, crabs and lobsters. Even the sessile sea anemones share in the feast. Later, when the larval squid hatch, smaller fishes come to feed on them.

South of San Diego, the divers have observed the sluggish elephant seals of Guadalupe Island, off the Mexican coast. They saw no adults in the sea (the great one-ton bulls were guarding their harems ashore) but did see some pups, if the word can be attributed to creatures that weigh 800 to 1000 pounds.

Limbaugh and other divers were making underwater movies. A pup swam up and had to be pushed away with a camera. Then one came up behind Limbaugh and took the top of his head in his mouth. "First I thought there was some seaweed brushing against my head," Limbaugh recalls. "Then it felt warm and I felt the points of his teeth. I reacted quickly." He put the camera between himself and the animal. The sea elephant had not broken the skin. He did, however, bite the camera, but caused no damage.

Rechnitzer, Limbaugh and other divers have participated in the recovery of a number of Indian artifacts offshore from La Jolla. How these grinding bowls and pestles came to be in the sea has not been determined. Some were found 90 feet deep and nearly a half mile offshore. Some archeologists say that the artifacts may be as much as 5,000 years old. Such bowls have been found at several sites along the southern California shore. Rechnitzer has cataloged those found at Scripps.

Not all the Scripps diving has been done in southern California. The most notable exception was that performed on the Institution's Capricorn Expedition to the South Pacific in 1952-53. Divers on Capricorn were Robert B. Livingston, Associate Professor of Physiology, Medical School, University of California, Los Angeles; Robert F. Dill, Oceanographer, U. S. Navy Electronics Laboratory; Willard N. Bascom, Research Engineer; Walter H. Munk, Professor of Oceanography; Philip E. Jackson, Research Assistant; and John B. MacFall, Photographer.

Dives were made at Ocean Island, a pinpoint island near the equator, over Alexa Bank, a submerged atoll, in the Fijis, the Tonga Islands, Samoa, Tahiti, and the Marquesa. At Pago-Pago, Samoa, the divers located a sunken Navy tanker in 163 feet of water.