1

Sleuthing the Depths: The Science of Underwater Forensics

Curious and enterprising individuals have been going to the ocean floor for centuries to explore sunken vessels and salvage the treasure, weapons, and other valuables hidden within them. These adventurers gained an edge in the seventeenth century when the invention of the first primitive diving bell enabled them to reach greater depths. Despite this capability, there is no record that anyone ventured below the surface to investigate the cause of a sinking until the wreck of the USS *Maine* was first explored in 1898.

Part of the challenge facing would-be deep-sea detectives was depth; even with new technology that allowed them to dive deeper, it usually wasn't deep enough. During the early twentieth century, inventors were constantly improving diving suits to increase the depths divers could safely reach. Though the invention of SCUBA, or the self-contained underwater breathing apparatus, freed divers from a dependence on air hoses and lifelines, 200 feet or so remained the practicable depth. As most of the ocean floor lies thousands of feet below that depth,[1] deep-lying wrecks continued to be unreachable, and the causes of sinkings—including evidence of potential crimes—remained undetected.

The manned submersible, pioneered by the redoubtable Jacques-Yves Cousteau in the 1950s, greatly extended the range of non-military underwater operations. Cousteau's *Soucoupe Plongeante,* or *Diving Saucer,* could descend to 1,350 feet with a pilot and a scientist-observer on board. The success of the *Diving Saucer* led to a proliferation of other submersibles, especially in the United States.

---

1. The average depth of the ocean floor is estimated at 16,000 feet. This calculation takes the ocean floor's uneven surface into account; it is studded with lofty peaks and ridges and seamed with vast trenches measuring 3 to 7 miles in depth

One of the most notable submersibles is *Alvin,* owned by the U.S. Navy and operated by the Woods Hole Oceanographic Institution (WHOI). Extensively repaired and rebuilt every three years, *Alvin* can now safely dive to 14,750 feet thanks to a new super-strong titanium hull.

To aid in underwater exploration, submersibles typically carry powerful searchlights that illuminate the pitch-black depths, cameras (both still and video) that log a pictorial record, and a mechanical arm that can be equipped for a range of uses—collecting biological specimens, taking core samples of bottom sediments or rocks, and retrieving delicate archaeological artifacts from ancient shipwrecks.

Though marvelous, submersibles have limitations. They are very expensive to build ($15 to 20 million for a high-performance analog of *Alvin)* and to operate (currently anywhere up to $45,000 per day). And the rental includes not only the actual working time but also every moment that the submersible is at sea—whether on a dive, or lashed to the deck of a mother ship, or support vehicle, on its way to the work site.

Another drawback of the submersible is its crew space. To maximize strength, the pressure hulls of submersibles (the areas where the humans are contained) are usually built as spheres. To economize on construction costs and prevent the vessels from becoming unmanageably heavy, these spheres are kept rather small. As a result, after an hour or so, the occupants become uncomfortable in the cramped space. They also become very chilly, as power from the batteries is needed to drive the submersible and operate its mechanical equipment and cannot be spared for a heater. The pressure hull also becomes dripping wet inside as the moisture in the occupants' breath condenses on its walls.

Finally, submersibles are designed for slow speeds. While a snail-like pace is absolutely necessary for careful scientific observation, it also means that submersibles take a long time to travel to the sea floor and equally long to return. A typical dive takes six to eight hours, most of which is spent traveling to the bottom and back to the surface. Moreover, because they are powered by batteries, submersibles have limited ranges and operating times. They cannot travel to a work site under their own power but must be transported on the deck of a full-sized ship. (The fee for renting the ship is added to the submersible's operating costs.) And if something goes wrong, the lives of the pilot and any observers may be lost. On *Alvin*'s 308th launch, for instance, the support cables failed, and the pilot and two scientists on board barely managed to clamber out the escape hatch before the little sub sank to the bottom 5,000 feet below.

Alvin first came to the public's attention early in 1966, when a U.S. Air Force tanker plane and a B-52 bomber carrying nuclear weapons collided in midair over the Mediterranean off the port of Palomares, Spain. An H-bomb fell into the ocean; recovering it was a matter of the greatest urgency. Experts feared that in time the seawater would corrode the bomb's casing and trigger a nuclear reaction, sending a deadly rain of radioactive water and sediment over southern Spain.

The approximate position of the bomb was known since a shocked Spanish fisherman had seen it fall near his boat—he thought it was half a man's body dangling from a parachute. But the bottom was a crazy jumble of steep-sided ravines, abrupt rises, and near-vertical precipices. Regular sonar could not detect an object as small as the bomb, and towed sonar could not cope with the rugged topography of the sea floor.

Faced with this problem, the U.S. Navy decided to use a team of four submersibles, including *Alvin,* to find the bomb. It took two months of searching before *Alvin* had success; it discovered the missing H-bomb, its parachute still attached, on a steep, muddy slope nearly 2,500 feet down. *Alvin*'s pilot attempted to anchor a lift line in the mud so that a larger and more powerful companion submersible, *Aluminaut,* could attach it to the bomb, but the cable pulled loose. Then *Alvin* tried to snag the bomb's parachute harness with its mechanical claw. This maneuver also failed. After several more jury-rigged attempts at retrieval, the bomb slid 300 feet farther down the slope. At last, the navy sent down an unmanned, remote-controlled underwater recovery vehicle, or *CURV. CURV* was essentially an open frame with floodlights and television cameras to guide its operators on the surface and a set of powerful, motor-driven jaws to grab the bomb. *CURV* managed to raise the bomb to 200 feet below the surface. There a team of SCUBA divers working near their depth limit was able to attach additional lifting cables for the last stage of the recovery.

CURV was an early example of the ROV or remotely operated vehicle. Popularly called a *robot sub,* an ROV is actually neither. It is not a true submarine because it has no enclosed hull. It is simply a framework that carries motors, a control unit, and other electronic equipment, plus whatever cameras and manipulative paraphernalia the mission directors choose to load for a particular mission. And it is most definitely not a robot because it cannot operate on its own. It is controlled by humans on board a mother ship on the surface, and it gets its signals and its electric power through a slender cable called an *umbilical* or a *tether.* Typically, one operator pilots the ROV while the other controls the cameras, mechanical claws, and other equipment.

ROVs have a number of advantages over manned submersibles. To begin, they are significantly cheaper to build and operate. Since they do not carry humans into the depths, they need no pressure hull. Beside the vehicle itself, a typical ROV includes a tether, a winch, a handling system, control and maintenance vans, spare parts, a generator, and special tools. The price for the complete package ranges from $10,000 for a light, nonindustrial ROV to upwards of $5 million for a deep-water salvage-capable model—a good deal less than the $15 to 20 million it would cost to build a new *Alvin.* Currently, the cost of renting an ROV can run from $3,000 to $20,000 per day, depending on factors such as its size, the complexity of the accompanying equipment, and the number of operators it requires.

Another advantage of ROVs is their ability to undertake risky missions—exploring the inside of a wreck's hull, for example. It is too dangerous to perform such maneuvers with humans on board since it is all too easy for any submersible (or ROV, for that matter) to become wedged fast or entangled. Unlike manned submersibles, whose power and air supplies are limited, ROVs can stay submerged and on the job around the clock. And the operators sit in relative comfort in the van on the mother ship's deck rather than in the cramped and near-freezing pressure hull sphere. The renowned Dr. Robert Ballard, finder of the *Titanic* and veteran of a multitude of dives, says he would much rather be dry, warm, and with room to stretch out on the deck of the support vessel than be chilled and cramped in the pressure hull of a submersible.

ROVs are also incredibly versatile. They are used every day to inspect offshore oil-drilling rigs and undersea pipelines. With the proper manipulators, they can insert bolts and tighten them down (or the reverse); attach shackles and lifting cables to wreckage so that it can be winched up to the surface; cut metal; weld steel; drill bedrock for core samples; dig sea-floor trenches for pipelines and communication cables; and gently lift archaeological objects from the sediments in which they have been buried for centuries.

Many materials go into the construction of an ROV. The framework is either aluminum or steel; to guard against corrosion, the aluminum is coated with sealer and paint, while the steel is protected by zinc anodes. (Sometimes PVC tubing is used for light, non-industrial ROVs.) Manipulators and other special instruments may be crafted from titanium or other very durable materials, and the electronic components, sealed in waterproof casings, are made from silicon and ceramics with powdered-metal leads. Syntactic foam provides near-positive buoyancy, so an ROV that weighs more than a ton on land weighs just 100 to 200 pounds in the water. The slight negative buoyancy keeps the ROV from having to fight its way to operating depth; the light submerged weight reduces the load on the tether.

An ROVs size depends on the type of work it is designed to do. Deep Ocean Engineering's *Firefly,* which is designed to inspect the underwater portions of nuclear power plants, is about the size of a microwave oven and weighs only 10 pounds. The *VideoRay,* frequently used to locate the drowned victims of boating accidents and cars and trucks in deep water, measures 14 x 9 x 8.5 inches and weighs a mere 8 pounds. The navy's *Deep Drone 7200,* used for salvage-and-recovery work to a depth of 7,200 feet, measures 9.25 x 4.6 x 6.17 feet, roughly the size of a subcompact car turned on its side. (The navy does not give its weight). *CURV III,* another navy salvage-and-recovery vehicle, has a depth capability of 20,000 feet and weighs approximately 6.5 tons. It can lift 2,500 pounds. The navy does not furnish its dimensions to the public.

ROVs were originally developed by the U.S. Navy in the 1960s to recover spent practice torpedoes and dummy bombs from training areas off the California coast. The oil-drilling industry soon recognized their value for a variety of underwater tasks and developed them further. To this day, ROVs are mainly used in offshore oilfields. However, they have also been found useful for locating and recovering sunken ships and crashed aircraft, as documented in later chapters.

Although ROVs are the workhorses of undersea investigation, there are times when a diver still does the job better. For delicate, close-up maneuvering, the human hand still cannot be beaten. When visibility is bad, it may be necessary to photograph evidence at very close range. Here again the diver is superior to the remotely controlled vehicle.

Special breathing mixtures enable divers, whether helmeted or SCUBA, to go beyond the usual 200-foot working limit for brief tours of duty. But for deeper water, the armored diving suits first developed in the late 1920s and early 1930s have come into their own. The great advantage of these armored suits is that the air inside remains at normal surface pressure; when surfacing, the diver does not have to undergo a lengthy decompression process. The technical term for these suits is *monobaric,* or *atmospheric diving suits* (ADS, for short). The ADS has worked well at depths to 1,000 feet, and greater depth capability is on the horizon. Looking much like swollen bugs from science-fiction illustrations with domed visors and backpacks attached, these rigid-bodied suits permit the movement of the diver's arms and legs by means of rotating joints. This advance was made possible when high-tech materials were developed to seal those joints from the crushing pressure of the water. There are different variants on the armored suit: the JIM suit, the Newt suit, the SAM suit, and the WASP suit. The WASP is even more surrealistic than its competitors. Without jointed legs—or any kind of legs at all—it resembles a man-sized pupa with arms. It has been upgraded to a depth capability of 2,000 feet.

For working with tools, all these rigs have mechanical grabbers where their "hands" should be; the diver operates this machinery from inside the suit. While the other rigid suits permit the diver to walk on the bottom, the WASP suit is meant to "fly" in the water, maneuvered by a set of electrically powered thrusters. The JIM suit has been used to retrieve valuable anchor chains lost by tankers at 375 feet and salvage a crashed helicopter off Plymouth, England, at a depth of 325 feet. The WASP suit even appeared on TV's *60 Minutes II* after a diver used it to recover a sunken hoard of Nazi counterfeit money from the 348-foot-deep Lake Toplitz in the Austrian Alps. An ROV located the money—fake British ten-pound notes—at 200 feet. After soaking for 55 years, the paper was so disintegrated that the ROV's mechanical claws could not grasp it. But a diver in a WASP was able to recover a sample large enough for conclusive forensic analysis.

Another technique used is saturation diving, based on the principle that once working depth is achieved the amount of gases dissolved in a diver's blood does not increase, regardless of the length of the dive. In practice, the diver might be exhausted and chilled to the bone after as little as fifteen minutes of work. But with saturation diving, the diver returns to a pressurized habitat on the sea floor; there it is possible to strip off heavy, cumbersome gear, warm up, take a shower, read, listen to music, eat, and sleep before going out to work again. Experience has shown that a saturation diver can work four times longer than a conventional diver at a given depth and accomplish much more. Another advantage of saturation diving is that the diver does not have to undergo the stress of decompression after every sortie. American businessman-investigator Gregg Bemis has used saturation divers in his explorations of the World War I British liner *Lusitania.*

At a depth of 300 feet, a diver can use the habitat for up to two weeks before returning to the surface to go through decompression in a shipboard chamber. Two weeks is the limit because long exposure to high pressure does nasty things to the human body: bones are eventually weakened, and the nervous and circulatory systems can be damaged, for example. A variation on this system is to house the habitat on the support ship's deck; the diver makes trips to and from the bottom in a small pressure chamber and enters and exits the habitat through an airlock much like the ones in space labs.

How great is the pressure of the water, exactly? At sea level, the pressure of the atmosphere is approximately 14.7 pounds per square inch, the weight of a column of air reaching from ground level to the topmost fringes of the atmosphere. But water is much denser than air, and at a depth of only 33.8 feet the pressure is two atmospheres. Another atmosphere's worth of pressure is added for each 33.8 feet descended. At 1,000 feet below, the pressure is equivalent to 435 pounds pressing on every square inch of a body or an object, as if it were being squeezed by a giant's hand. At 13,460 feet, the depth at which the British bulk carrier *Derbyshire* lies, the pressure is 2.9 *tons* per square inch. Such pressure is difficult even to imagine.

Pressure is the great enemy of all undersea work, posing dangers to submersibles, ROVs, and divers alike. The pressure of the depths accelerates the speed at which metal is corroded by salt water, magnifying hidden flaws and sometimes causing cracks in the vessel and its equipment.

For divers, the dangers are multiple. They must be supplied with air whose pressure is equal to that of the surrounding water at any given depth. Otherwise, the pressure of the water prevents divers from breathing even at a relatively shallow depth and crushes him or her at greater depths. There have been numerous cases of "squeeze," in which the diver's suit suddenly loses pressure, causing the luckless diver's body to be forced up into the suit's rigid helmet by the external pressure of the water. Needless to say, no diver has survived this experience.

In another scenario, when the diver breathes ordinary air under pressure, nitrogen dissolves in the blood and body fat. Should the pressure be lowered suddenly (if the diver returns to the surface too quickly, for example), the dissolved nitrogen comes fizzing out like the gas in a bottle of soda that has been shaken. In this condition, called *the bends,* nitrogen bubbles block blood vessels and lodge in the joints, causing agonizing pain and contortions and sometimes unconsciousness and death. And nitrogen presents yet another peril to the diver: *nitrogen narcosis,* or rapture of the depths. Here the diver becomes woozy and disoriented and loses touch with reality. SCUBA divers suffering from nitrogen narcosis have been known to swim down into the depths when they meant to return to the surface.

Jacques-Yves Cousteau attempted to avoid this danger by breathing pure oxygen. But he found that, under pressure, oxygen is a violent poison. So deep-sea divers still needed a replacement for nitrogen. Helium was one answer. This gas dissolves very little in the body, and a helium-oxygen mixture, or *heliox,* came into vogue. This combination works safely but with two drawbacks: the diver gets chilled more rapidly, and the voice is affected so that it sounds like Donald Duck's. At 1,000 to 1,500 feet, helium becomes dense enough to adversely affect the diver's breathing; some divers compensate for this problem by using a hydrogen-oxygen mixture, or *hydrox,* despite its dangerously explosive nature. A more recent development is *trimix,* a blend of oxygen, helium, and nitrogen that the diver can adjust to suit changes in depth. The deeper the body goes, the less oxygen it requires, so divers will dilute the helium-oxygen mixture with nitrogen as required, despite the danger of the bends. Since helium can also form bubbles in the bloodstream, extreme care must be taken when diving to greater depths.

With all of the tools and techniques described above at their disposal, deep-sea detectives are called upon when a tragedy at sea (or in a deep lake) must be investigated. Government safety agencies want to establish the cause of a shipwreck in order to prevent future accidents, and insurance companies want to make sure that foul play and fraud were not involved. Since governments can afford only limited investigative corps, and insurance companies cannot afford them at all, such operations are typically contracted out.

In a typical search-and-recovery operation, the wreckage is initially located with sonar, a piece of equipment without which locating deep-lying objects would be impossible. Fittingly, the invention of sonar was inspired by a marine tragedy: the 1912 sinking of the *Titanic.* The Canadian-born Reginald Fessenden, who had worked for Thomas Edison in the United States, realized that the amount of time it took for a burst of sound to bounce back off an object gave a measure of distance. (It was already known that sound travels at a fairly constant speed.) This echo principle even worked at night or in heavy fog, when visibility was nil. Fessenden's original "pinger" was nothing more than an oversized buzzer, but if the *Titanic* had been equipped with such a device the officers and crew on duty could have avoided colliding with the fatal iceberg.

Water is an even better conductor of sound than air, and by 1914 true sonar was invented. A pinger mounted underwater on a ship's hull sends out periodic bursts of sound, which are reflected off solid surfaces and picked up by hydrophones, or waterproof microphones, also on the hull. Another device converts the elapsed time into the ship's distance from the target. During World War I, England and France used sonar to locate lurking German submarines. By the mid-1920s, most of the world's navies were using it. Oceanographers began using sonar, too, since it turned out to be an excellent depth finder—much more accurate than the traditional method of using a weighted line. Its precision made it useful for mapping the ocean floor. Though sonar can be "fooled" by a number of things, such as fluctuating water temperatures, turbulence, turbidity, changes in salinity, and even layers of plankton or large whales, it is still the most reliable tool available for its purpose.

In time, sonar came into use for locating wrecks. Sonar can look straight down, forward, or to the sides. At present, side-scan sonar is the first tool employed by a search-and-recovery team. In this type of sonar, the sound-wave emitters face outward at an angle so that they cover a wide swath of sea floor, from about 1,640 to 4,920 feet on either side of the carrier. Sonar follows a rule of thumb: the lower the frequency, the larger the range, and the less distinct the resulting image. Low-frequency sonar (also called *low-resolution sonar)* is useful for locating large objects, but for fine detail high-frequency (or *high-resolution)* sonar is required; it covers a much smaller area—about 330 to 3,300 feet. The low-frequency sonar is often used for the initial search; then high-frequency sonar is used for positive identification. Some claim high-frequency sonar is able to read the raised lettering on an automobile's license plate from a distance of 200 yards.

The sonar may be mounted either on the support ship itself or on a *towflsh* (also called a *sled),* which is actually a sonar-carrying framework towed behind the ship. The sonar images are relayed to the support ship's control center, where they are recorded on paper and also converted to visual images by sophisticated computers. Once a likely object is found on the bottom, an ROV armed with side-scan and forward-scan sonar plus TV and still cameras is sent down to investigate. The ROV homes in on the presumed wreck and sends data back to the control center, which is located in a van on the support ship's deck.

If the object is indeed a wreck—and the right one[2]—the ROV begins the process of collecting evidence, which usually takes more than one dive. To facilitate an easy return to the wreck, the ROV will drop a pinger on the bottom near its target to signal the precise position.

The ROV's first task is to take hundreds of still photographs[3] and shoot extensive film footage of the wreckage and its distribution. These images are then evaluated in a shoreside laboratory. Naval architects and engineers pore over images of the wreck itself and from the distortion of the metal they calculate how the ship or aircraft failed. Images of the wreckage's distribution—which can number in the hundreds or sometimes thousands—are painstakingly pieced together into a mosaic of overlapping shots. An analysis of the resulting composite image can tell the photo interpreters whether the vessel, typically a cargo carrier, broke up at

2. Not all objects on the sea floor are wrecks; the sonar may well pick up boulders or ledges. Furthermore, some areas of the sea floor, such as the White Sea off the northern coast of Russia where the submarine *Kursk* went down, are so littered with shipwrecks that the right one can be difficult to pick out.
3. For still photographs, black-and-white film is the standard choice because it is faster than color film, making it ideal for dark conditions on the sea floor.

the surface or on its way down to the bottom. To the layperson, a steel ship is a solid, sturdy structure that looks invulnerable, but in fact its own weight, plus the weight of the cargo, impose unimaginable stresses on the hull as it sinks, and few wrecks reach the bottom intact. Cargo may be scattered far and wide; the pattern of its distribution provides clues to the cause of the sinking.

The investigative mission may call for retrieval of physical, as distinct from photographic, evidence. For example, a piece of hull plating with the ragged edge of a fracture may be brought to the surface for inspection. In this case, the ROV cuts the piece loose with a torch or abrasives, then attaches the tortured metal to a toggle on the end of a cable. The evidence is then hoisted to the surface by a winch or crane on the support vessel. Alternatively, the item recovered may be a section of piping, scorched wiring, or seat-cover fabric from a downed airliner. Small items such as these may be placed in a mesh basket, which is then winched to the surface. ROVs themselves do not have a great lifting capacity, although in some cases they will bring evidence to the surface in a basket they carry on board.

The recovered physical evidence—say a piece of distorted hull or hatch cover or the twisted hinge of a loading ramp—is first examined for what the experts call *gross morphologies:* that is, changes in structure visible to the naked eye. Is the metal bent inward or outward? Is it torn? dented? holed? rusted through? The next step is to put the sample under the microscope. But first it must be cleaned. A clean surface is typically achieved through *electropolishing,* a process best described as electroplating in reverse. Where electroplating adds a thin layer of metal to the object being plated, electropolishing removes a thin layer of metal from the object being polished, and the process takes off surface impurities and dirt and leaves a smooth surface—smoother than if the object had been polished by machine. The sample is then treated with nitric or sulfuric acid to bring out the grain structure.

Next an expert looks at the object under an electron microscope (an optical microscope does not give high enough magnification) and determines whether the failure was ductile or brittle. In a ductile failure, the metal is literally pulled apart—it looks irregular under the microscope. When a part is exposed to tension greater than it is designed to handle, a ductile failure results. With a brittle failure, the metal looks flat under the microscope. This type of failure occurs when accumulated stresses weaken the metal until it breaks.

For those who know what to look for, the size of the metal grains can also tell a story. Basically, the smaller the grains, the stronger the metal. Under repeated stress, the small grains gradually coalesce into larger grains, which weaken the metal. "Large," of course, is a relative concept, and even large grains cannot be seen with the naked eye. In the laboratory, metal samples may also undergo mechanical tests to determine their strength and resistance to deformation and chemical analysis to determine whether they contain the proper elements in the proper proportions. The type and extent of corrosion are also evaluated.

If already corroded, metal samples must be protected from further deterioration while making the journey from the wreck site to the lab. It is essential to prevent oxygen from coming into contact with them. To this end, a sample is typically placed in a container of deaerated water (deaeration removes oxygen and other dissolved gases from water, rendering it much less chemically active). Sometimes the sample is packed in a vacuum container instead. The depth at which the wreck lies affects the rate and extent of corrosion. Deep water contains less oxygen than surface water and is therefore less corrosive. However, iron-eating bacteria can invade a wreck even in deep water, as they have with the *Titanic.* These bacteria produce *rusticles*—icicle-like drip formations of mushy iron compounds—which slowly destroy the steel.

Search-and-recovery operations, in addition to collecting and analyzing evidence from the depths, involve slow and deliberate work. The process can take weeks, months, or longer—but it usually yields conclusive results, not to mention healthy doses of danger and drama.

One of the most fantastic stories in the history of deep-water search-and-salvage operations is Project Jennifer, which involved the recovery (on behalf of the CIA) of a Soviet Golf-class submarine that had sunk in some 16,500 feet of water 750 miles northwest of the Hawaiian Islands. Soviet subs of this class were diesel-powered, but this particular one carried the latest nuclear-tipped missiles. It was of the greatest importance to U.S. intelligence to secure the wrecked sub and harvest its secrets; it was equally important to the Soviet Union to prevent the sub from falling into the hands of the "capitalist hegemonic power."

Though they searched frantically for it, the Soviets had no idea where their lost submarine was. The United States had a fairly close approximation of its resting place, however; its listening stations in the Pacific had been tracking the vessel and noted the area in which its transmissions ceased. The U.S. spy sub *Halibut,* supposedly used for oceanographic research, was deployed to the mid-Pacific location deduced by U.S. intelligence. *Halibut's* sonar, in combination with a sonar sled towed by the navy surface vessel USS *Mizar,* determined the sub's precise location.

Although the CIA was anxious to get hold of the codebooks, missiles, and other paraphernalia K-129 (the identification number of the lost Soviet sub) was carrying, it waited six years before acting, confident that its Soviet rivals would not get there first. In the interim, the navy contacted the reclusive billionaire Howard Hughes and convinced him to commission a specially built search-and-recovery ship. The vessel, quite unlike anything that had ever been seen before, was named the *Glomar Explorer.* It measured 619 feet in length and 116 feet in breadth at its widest point. Its horsepower and speed remain classified. In the middle of the hull was a huge "moon pool" surmounted by a tall derrick similar to the ones used in drilling for oil. The derrick would lower a giant five-fingered grab to clutch the submarine and then raise it to the surface.

The *Glomar Explorer* was to operate under a cover story that it was mining manganese nodules from the depths of the Pacific Ocean. There was, in fact, a good deal of interest in these sea-floor mineral deposits at the time. Its real purpose, of course, was quite different. The ship was built under unbelievably strict secrecy. According to one account, any government employee who visited the construction area had to assume a false name and change into a disguise at a safe house some distance from the project. Additionally, one of the planning offices could be reached only through a secret door concealed by a wall locker on wheels.

In 1974, President Gerald Ford authorized the mission, and the *Glomar Explorer* proceeded to its station without incident. To lend authenticity to the cover story, manganese nodules from the Blake Plateau off the southeastern coast of the United States were handed out to the crew's families and friends. The strange-looking ship arrived at its station and began its recovery operation on July 4, 1974. Guided by sonar and kept in position by thrusters (the ocean was far too deep to permit anchoring), the *Glomar Explorer* slowly lowered a long string of oil-field drill pipe through its derrick. When the pipe was out of sight beneath the water's surface, CIA operatives attached the grab, whose existence had been kept secret.

The grab was close to its target when the operator lost control, causing it to strike the sea floor next to the sub's hull. Since it was so close, the operator raised the grab slightly, maneuvered it over the sunken submarine, and lowered it successfully. Very slowly, the operator began to raise the grab and its 3,000-ton payload. When the sub came clear of the sea floor, the added weight sank the *Glomar Explorer* 7 feet lower in the water.

Suddenly, a Soviet "trawler," almost certainly fitted with spying gear, appeared and started circling the *Glomar Explorer.* While the onboard mission chief pondered what action to take, the Soviets decided the Americans were probably wasting their money on another pretentious and ill-conceived project. After coming so close to the lost submarine, the Soviet trawler simply sailed off.

When the submarine with its coveted load of knowledge was just 5,000 feet from the surface, three of the grab's five claws, probably weakened by their impact with the sea floor, broke off. Only partly supported, the sub broke in two. According to the story that the CIA has chosen to share with the public, only the front 38 feet of the vessel were saved; the remainder sank back to its ocean grave. But the recovered portion supposedly held K-129's codebooks and two of its nuclear missiles, plus the bodies of six to eight crew. According to some reports, a third nuclear missile slipped from the craft and fell back to the seabed. It was a purported tense moment on the *Glomar Explorer* as the crew waited for a deadly explosion. But the warhead settled harmlessly on the ocean's bottom.

The recovered Soviet crew were given a formal burial at sea in English and Russian; the mission organizers had provided copies of the ceremony in Russian. The ceremony was videotaped and presented years later to Russian President Boris Yeltsin as a goodwill gesture. As for questions about the sub itself—how did it sink? how did the CIA preserve the salvaged intelligence material? how was that material used?—that information is known only to a privileged group of investigators. It has never been made public.

◆ ◆ ◆

Thanks to submersibles, ROVs, and skilled divers, virtually no place in the sea is now beyond reach. For the first time in history, determining the causes of devastating maritime disasters, whether accidental or acts of sabotage, is within the bounds of underwater forensic science. Deep-sea detective work has come into its own.