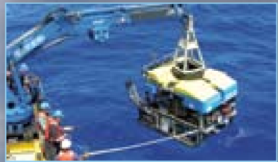
VESSELS & VEHICLES

OF THE WOODS HOLE OCEANOGRAPHIC INSTITUTION



A rare event in Woods Hole: all three WHOI-operated, deep-ocean vessels—*Knorr* (foreground), *Oceanus* (left), and *Atlantis* (rear)—are in port.

Woods Hole Oceanographic Institution Vessels & Vehicles

In order to understand the ocean, you have to get in the middle of it. Traditionally, researchers have used ships to photograph the depths, to drop floats and drifters into the currents, and to collect samples of water, rock, and marine life. In recent years, the observing tools have evolved to include human-occupied submersibles, remote-controlled vehicles, and autonomous robots. Soon researchers will deploy arrays of instruments connected to shore by submarine cables—or via satellite from ocean moorings—to deliver continuous, real-time data on ocean processes to a scientist's desktop.

But even as technological advances allow researchers to monitor the seas from shore-based labs, they rely on sophisticated ships to get a firsthand look at the environment and to carry their tools and instruments into it. Woods Hole Oceanographic Institution (WHOI) operates a range of vessels and vehicles in support of such efforts.

WHOI is a member of the University-National Oceanographic Laboratory System (UNOLS), a consortium of 62 U.S. academic institutions and national laboratories. Those partners coordinate scientific expeditions aboard 26 federally supported research vessels.

WHOI currently operates three ships for UNOLS, and the Institution also owns and operates a coastal research vessel for work in Northeastern waters. Each of these floating laboratories comes with a range of sonar and bottom-mapping equipment, sampling gear, diving and small-boat launching facilities, and meteorological sensors.

As host institution for the National Deep Submergence Facility, WHOI operates and maintains the nation's deepest-diving human-occupied vehicle (HOV), *Alvin*. For four decades, the submersible has brought scientists to the deep seafloor, allowing them to explore a sunless world of extreme pressures and unique creatures.

The ships and *Alvin* submersible are complemented by remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs). ROVs are tethered to a support ship by fiber-optic cable and controlled by pilots on the surface. AUVs are untethered robots that are dispatched on programmed missions. Both types of vehicles can remain submerged much longer than HOVs, making them ideal for surveys and mapping.

The following pages provide a glimpse of the principal vessels and vehicles operated—and sometimes built—by WHOI scientists, engineers, and crew members.

Photo by Doug Weisman. Front cover photo by Craig Dickson, WHOI

R/V *Atlantis*

The research vessel (R/V) *Atlantis* is owned by the U.S. Navy and operated by WHOI for the oceanographic community. It is one of the most sophisticated research vessels afloat, and it is specifically outfitted for launching and servicing the *Alvin* human occupied submersible.

Delivered to Woods Hole in April 1997, *Atlantis* was built with six science labs and storage spaces, precision navigation systems, seafloor mapping sonar, and satellite communications. The ship's three winches, three cranes, machine shop, and specialized hangars were specifically designed to support *Alvin* and other vehicles of the National Deep Submergence Facility (page 21).

The ship carries a complement of 36 crew members, science technicians, and deep submergence group members, as well as a scientific party of 24 men and women for as long as 60 days. Because *Atlantis* is constantly going where *Alvin* is needed for exploration, the ship operates in all of the world's oceans and is rarely seen in Woods Hole. In recent years, the ship and sub have spent most of their time exploring underwater volcanoes and hydrothermal vents in the Pacific Ocean.

Atlantis is part of a class of similar Navy-owned research vessels designed and built by Halter Marine of Pascagoula, Mississippi. Her sister ships are R/V *Thomas G. Thompson*, operated by the University of Washington, and R/V *Roger Revelle*, operated by the Scripps Institution of Oceanography. *Atlantis* is the only vessel designed to support both *Alvin* and general oceanographic research.

Atlantis is the namesake of WHOI's first research vessel, a 142-foot, steel-hulled, ketch-rigged ship that sailed 299 cruises and more than 700,000 miles for ocean science from 1931 to 1966. The Institution's flagship and symbol was the first American ship built specifically for research in marine biology, marine geology, and physical oceanography. The space shuttle *Atlantis* was named for the original WHOI research vessel.

Specifications:
Range: 32,000 kilometers (17,280 nautical miles)
Speed: 20.4 kilometers/hour (11.0 knots) cruising
Length: 83.2 meters (273.2 feet)
Beam: 16 meters (52.5 feet)
Draft: 5.2 meters (17 feet)
Laboratory space: 327 sq. meters (3,517 sq. feet)
Gross Tons: 3,180

Christopher Knight, WHOI

R/V *Atlantis* is the only vessel in the U.S. research fleet designed to support the *Alvin* submersible.

R/V *Knorr*

The research vessel *Knorr* is owned by the U.S. Navy and operated by WHOI for the ocean research community. *Knorr* is best known as the ship that supported a team of WHOI and French researchers in 1985 as they discovered the wreck of the RMS *Titanic*.

Launched in 1968, delivered to Woods Hole in 1970, and completely overhauled in 1991, R/V *Knorr* has traveled more than a million miles—the equivalent of two round trips to the Moon or forty trips around the Earth. The ship's anti-roll tanks and ice-strengthened bow enable it to work in all of the world's oceans and to the edges of the polar regions. The ship can carry a crew of 24 and a scientific party of 32 to sea for as long as 60 days.

Knorr was designed to accommodate a wide range of oceanographic tasks, with two instrument hangars and eight scientific work areas; a fully equipped machine shop; three oceanographic winches; and two cranes. *Knorr* is equipped with sophisticated navigation and satellite communication systems, as well as unique propulsion systems that allow the ship to move in any direction and to maintain a fixed position in high winds and rough seas.

In 2006, the ship was refitted to support a new "long-coring" system that can extract 46-meter (150-foot) sections of ancient sediment from the seafloor. Weighing nearly 11 metric tons (25,000 pounds), the new piston-coring system is the longest in the U.S. research fleet (twice as long as existing systems). *Knorr* and its long-corer will allow scientists to sample deep sediments that are rich with historical information about the oceans and climate.

R/V *Knorr* was named in honor of Ernest R. Knorr, a distinguished hydrographic engineer and cartographer who was appointed Chief Engineer Cartographer of the U.S. Navy Hydrographic Office in 1860. He was one of the leaders of the Navy's first systematic charting and surveying effort from 1860 to 1885.

Specifications:
Range: 22,200 kilometers (12,000 nautical miles)
Speed: 20.4 kilometers/hour (11.0 knots) cruising
Length: 85 meters (279 feet)
Beam: 14 meters (46 feet)
Draft: 5 meters (16.5 feet)
Laboratory space: 256 sq. meters (2,756 sq. feet)
Gross Tons: 2,518

Tom Kleindinst, WHOI

Knorr has logged more than one million miles in the name of science, one of only two ships in the current UNOLS fleet to have travelled that far.

R/V *Oceanus*

The research vessel (R/V) *Oceanus* is owned by the National Science Foundation and operated by WHOI. The ship has been used extensively in recent years for studies of the Gulf Stream and the Deep Western Boundary Current, of climate change, and of harmful algal blooms (popularly called "red tides").

Oceanus is a mid-sized research vessel designed for expeditions lasting two to four weeks. The ship spends most of its time working in the North Atlantic, with occasional trips to the Mediterranean, South Atlantic, and Caribbean. It is the WHOI-operated vessel you are most likely to see in Woods Hole.

Oceanus was delivered to Woods Hole in November 1975, and the first scientific voyage was undertaken in April 1976. The ship is operated by a crew of 12 and accommodates a scientific party of 19 for up to 30 days at sea.

The ship underwent a major mid-life renovation in 1994, which included the construction of a new deck house and new pilot house, along with increases in laboratory space and accommodations for scientists. Outfitted with three winches and a crane, the ship is often used for deploying oceanographic buoys and moorings and for hydrographic surveys, though it is capable of supporting all types of chemical, biological, and geological studies.

The ship was designed by John W. Gilbert Associates of Boston and constructed by Peterson Builders of Sturgeon Bay, Wisconsin.

The name of the ship is drawn from Greek mythology. The Titan Oceanus, father of the river gods and sea nymphs, was represented as a great stream of water encircling the Earth. Oceanus was believed to be the source of all bodies of water.

Specifications:
Range: 12,900 kilometers (7,000 nautical miles)
Speed: 20.4 kilometers/hour (11.0 knots) cruising
Length: 54 meters (177 feet)
Beam: 10 meters (33 feet)
Draft: 5.3 meters (17.5 feet)
Laboratories: 110 sq. meters (1,185 sq. feet)
Gross Tons: 298

Tom Kleindinst, WHOI

Oceanus is the North Atlantic workhorse of the WHOI fleet, and it has been used extensively in recent years for studies of the Gulf Stream and related ocean circulation systems and for monitoring harmful algal blooms (also known as "red tides").

R/V *Tioga*

The newest member of the WHOI fleet is R/V *Tioga*, an aluminum-hulled coastal research vessel that serves ocean scientists and engineers working in the waters off the Northeastern United States. *Tioga* is owned by Woods Hole Oceanographic Institution.

Launched in 2004, this small, fast research boat was designed and outfitted for oceanographic work close to shore. Speed allows *Tioga* to operate in narrow weather windows, meaning researchers can get out to sea, complete their work, and make it back before approaching foul weather systems arrive.

Tioga can accommodate six people for overnight trips—including the captain and first mate—and up to 10 people for day trips. The boat is equipped with water samplers, a current profiler, and an echo-sounder, used by scientists to conduct sea-floor surveys. *Tioga* has two winches, including one with electrical wires to collect real-time data from towed underwater instruments. Buoys can be deployed using the A-frame on the stern, which is similar in size to those on WHOI's large ships.

Since its delivery to Woods Hole in April 2004, *Tioga* has been used to collect water samples during harmful algal blooms ("red tides") and oil spills; to recover autonomous "gliders"; to test and deploy new instruments; to tag right whales with monitoring instruments; and to provide an introduction to ocean sampling techniques for undergraduates and graduate students. The boat has made dozens of trips to WHOI's Martha's Vineyard Coastal Observatory.

Designed in part by Roger Long Marine Architecture of Cape Elizabeth, Maine, *Tioga* was engineered and built by Gladding-Hearn Shipbuilding of Somerset, Massachusetts.

The name *Tioga* comes from an Iroquois word meaning "swift current." It is also a Seneca name meaning "the meeting of two rivers."

Specifications:
Range: 650 kilometers (350 nautical miles)
Speed: 33 kilometers/hour (18 knots) cruising
Length: 18.3 meters (60 feet)
Beam: 5.2 meters (17 feet)
Draft: 1.5 meters (5 feet)
Laboratory space: 18.5 sq. meters (200 sq. feet)
Gross Tons: 53

Tom Kleindinst, WHOI

The nimble and speedy *Tioga* mostly plies the waters around Cape Cod, though it has worked as far south as New Jersey.

Alvin

WHOI operates the U.S. Navy-owned Deep Submergence Vehicle *Alvin* for the national oceanographic community. Built in 1964 as the world's first deep-ocean submersible, *Alvin* has made more than 4,200 dives. It can reach nearly 63 percent of the global ocean floor.

The sub's most famous exploits include locating a lost hydrogen bomb in the Mediterranean Sea in 1966, exploring the first known hydrothermal vent sites in the 1970s, and surveying the wreck of RMS *Titanic* in 1986.

Alvin carries two scientists and a pilot as deep as 4,500 meters (about three miles) and each dive lasts six to ten hours. Using six reversible thrusters, *Alvin* can hover, maneuver in rugged topography, or rest on the seafloor. Diving and surfacing is done by simple gravity and buoyancy—water ballast and expendable steel weights sink the sub, and that extra weight is dropped when the researchers need to rise back up to the surface.

The sub is equipped with still and video cameras, and scientists can also view the environment through three 30-centimeter (12-inch) viewports. Because there is no light in the deep, the submersible must carry quartz iodide and metal halide lights to illuminate the seafloor. *Alvin* has two robotic arms that can manipulate instruments, and its basket can carry up to 680 kilograms (1,500 pounds) of tools and seafloor samples.

Due to numerous upgrades made over the years, *Alvin* remains state-of-the-art. (For instance, a new robotic arm was installed in 2006.) The sub is completely disassembled every three to five years so engineers can inspect every last bolt, filter, pump, valve, circuit, tube, wire, light, and battery—all of which have been replaced at least once in the sub's lifetime.

The sub is named for Allyn Vine, a WHOI engineer and geophysicist who helped pioneer deep submergence research and technology.

Specifications:
Length: 7.1 meters (23.3 feet)
Beam: 2.6 meters (8.5 feet)
Height: 3.7 meters (12.0 feet)
Weight: 17 metric tons (35,200 lbs.)
Operating Depth: 4,500 meters (14,764 feet)
Dive Duration: 6-10 hours
Speeds: 0.8 to 3.4 kilometers/hour (0.5 to 2 knots)
Max. Cruising Range: 5 kilometers (3 miles)
Life Support Duration: 72 hours for 3 people

Dan Fornari, WHOI

Built as the world's first deep-ocean submersible, *Alvin* has made more than 4,200 dives and can reach 63 percent of the global ocean floor.

Jason/Medea

Jason is a remotely operated vehicle (ROV) designed and built by WHOI's Deep Submergence Laboratory to allow scientists to have access to 98 percent of the seafloor without leaving the deck of a ship.

Jason is a portable, two-body ROV system. A 10-kilometer (6-mile) fiber-optic tether delivers electrical power and commands from the ship through *Medea* and down to *Jason*, which then returns data and live video imagery. Suspended in the water above *Jason*, *Medea* serves to isolate *Jason* from the movements of the ship, while providing lighting and a bird's eye view of the ROV during seafloor operations.

Jason is equipped with sonar imagers, water samplers, video and still cameras, and lighting gear. *Jason*'s manipulator arms collect samples of rock, sediment, or marine life and can place them in the vehicle's basket or on "elevator" platforms that float heavier loads to the surface.

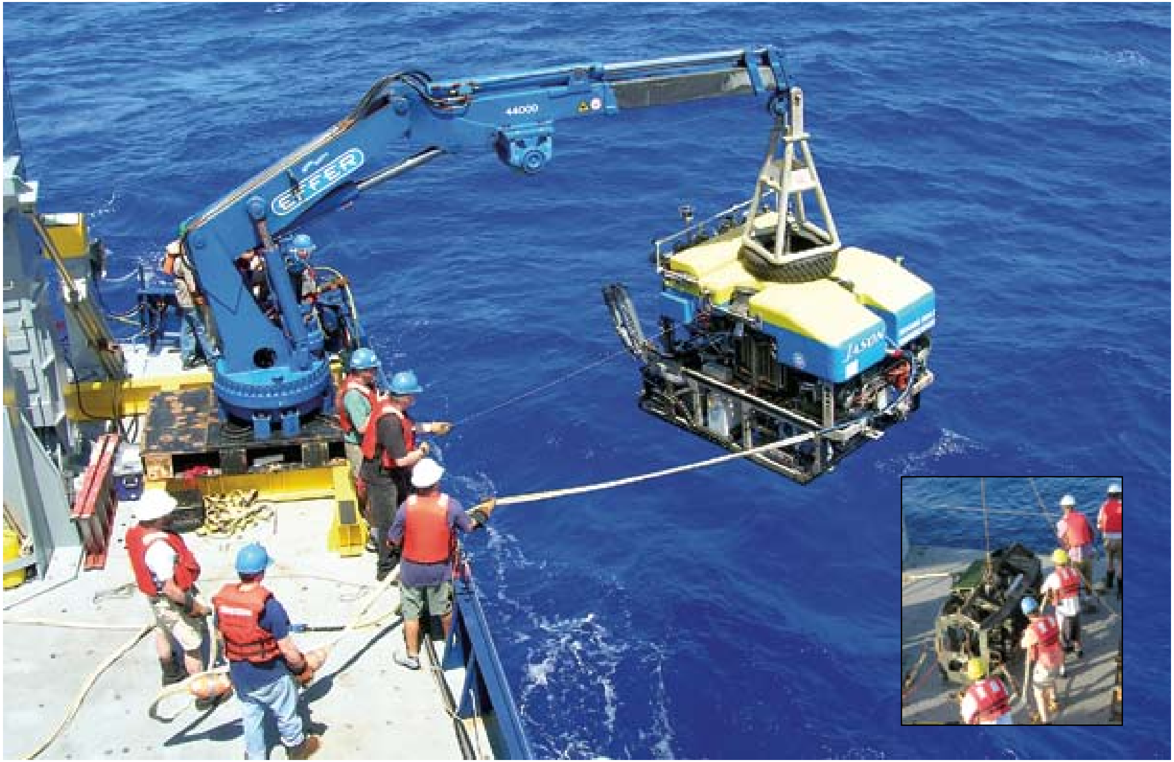
Pilots and scientists work from a control room on the ship to monitor *Jason*'s instruments and video while maneuvering the vehicle. The average *Jason* dive lasts 21 hours, though operators have kept the vehicle down for as long as 71 hours.

Jason was first launched in 1988, and the system has been used for hundreds of dives to hydrothermal vents in the Pacific, Atlantic, and Indian oceans and in the Mediterranean Sea. ROV *Jason* is now in its second generation, with a sturdier, more advanced vehicle having been launched in 2002.

The ROV also has had a successful side career in underwater archaeology. A prototype version named *Jason Jr.* was used to survey the wreck of RMS *Titanic,* and the fully developed *Jason* visited a 1,600-year-old Roman trading ship in 1989.

Jason and *Medea* are named for the adventurous ocean explorer of Greek mythology and for his wife.

Specifications:
Depth Capability: 6,500 meters
Dimensions: 3.4 meters (134") long, 2.4 meters (96") high, 2.2 meters (88") wide
Weight: 3,675 kilograms (8,100 pounds)
Tether: 20 millimeters (0.8") diameter, neutrally buoyant
Maximum Vehicle Speed: 1.5 knots forward, 0.5 knot lateral, 1.0 knot vertical
Propulsion: Six brushless DC electric thrusters, 250 lbs of thrust



Photos by Tom Bolmer, WHOI

Though ROVs have been used extensively by the oil and gas industry for several decades in shallower depths, *Jason* and *Medea (inset)* was the first ROV system to be adopted and extensively used by ocean researchers.

Autonomous Benthic Explorer

The Autonomous Benthic Explorer (ABE) is a robotic underwater vehicle used for exploring the ocean to depths of 4,500 meters (14,764 feet). It was the first AUV used by the U.S. scientific community. ABE is often used in tandem with *Alvin* or *Jason* surveying large swaths of ocean floor to determine the best spots for close-up exploration.

ABE is designed to perform a pre-programmed set of maneuvers, using its five thrusters to move in any direction, hover, and reverse. The AUV excels at surveys of the shape of the seafloor (bathymetry), its chemical emissions, and its magnetic properties. ABE is particularly valuable in rugged terrain. Onboard sensors tell the vehicle how deep it is and how far it is off the ocean floor, and the AUV calculates its horizontal position by contacting a system of acoustic beacons (transponders) set out in fixed locations.

Since its launch in 1996, ABE has made more than 200 dives, surveying an average of 16 kilometers (10 miles) per dive. The vehicle has been used to locate, map, and photograph many deep-sea hydrothermal vent sites and volcanoes. Geologists use ABE's magnetic readings to understand the evolution of the Earth's crust.

Some observers believe ABE looks like the *Enterprise* from the *Star Trek* science fiction series. The shape helps the vehicle remain stable in deep-sea currents. Most of ABE's flotation resides in the top two pods, with instruments and other gear housed in the bottom. The separation of buoyancy and mass makes ABE resistant to pitching and rolling. The resemblance to Captain Kirk's space ship is coincidental, but ABE's design team did stencil "NCC 1701"—registry number of the fictional *Enterprise*—on the hull for fun.

Specifications:

Dimensions: 3 meters (9.8 feet) long; 2 meters (6.6 feet) wide; 2.5 meters (8.2 feet) high

Weight: 550 kilograms (1,213 pounds)

Operating range: 20-40 kilometers (10.8 to 21.6 nautical miles) and 14-20 hours

Energy: Lithium ion batteries (5 kilowatts/hour)

Survey speed: 0 to 1.4 knots

Eben Franks, WHOI

The space-aged looking ABE was one of the first autonomous, robotic vehicles used for deep-ocean exploration.

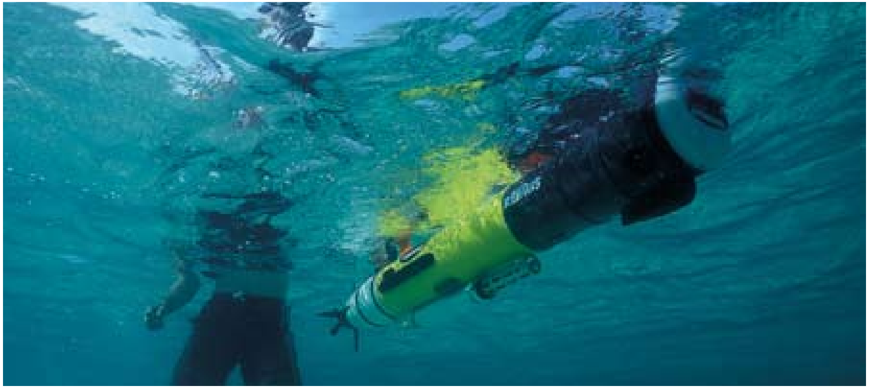
REMUS

Invented by engineers in the WHOI Oceanographic Systems Lab, Remote Environmental Monitoring Units, or REMUS vehicles, are low-cost autonomous underwater vehicles (AUVs) designed to be operated with a simple laptop computer.

Initially conceived for coastal monitoring, the torpedo-shaped vehicles are now used as platforms for a wide variety of instruments at a variety of depths. (Larger versions of REMUS vehicles can reach 600, 3,000, and 6,000 meters depth.)

They are particularly well suited to surveying and mapping tasks, traveling methodically over an area like a lawnmower to sample key ocean characteristics.

REMUS uses a propeller and fins for steering and diving. To determine its position, REMUS transmits a coded ping to an underwater transponder and listens for a reply.



Chris Linder, WHOI

The lightweight design of the typical REMUS vehicle facilitates launch and recovery by just a few researchers in a small boat or from a dock or beach. Because it is small, REMUS can easily be transported in a car, air shipped as baggage, or commercially shipped overnight. During Operation Iraqi Freedom in 2003, the U.S. Navy used REMUS vehicles to detect mines in the Persian Gulf harbor of Um Qasr. (Navy officers said they preferred REMUS AUVs because each could do the work of 12 to 16 human divers, and they were "undeterred by cold temperatures, murky water, sharks, or hunger.") Another REMUS—known as the Tunnel Inspection Vehicle (TIV)—was specifically adapted to survey New York City's Delaware River Aqueduct for leaks.

Seabed

Developed and built by engineers in WHOI's Deep Submergence Laboratory, *Seabed* is an autonomous underwater vehicle (AUV) that can hover over seafloor targets like a helicopter or "fly" slowly in shallow to moderate water depths. The vehicle was designed as a low-cost imaging platform and as a test bed for technologies required for future ocean observatories.

The vehicle can descend to depths of 2,000 meters (6,500 feet), enabling it to explore the continental shelves in most of the world's oceans. *Seabed* is particularly well suited to collecting sonar maps and photographs of the seafloor, even in rugged terrain. The AUV has been designed specifically to further the development of underwater color imaging, photo mosaicking, and three-dimensional image reconstruction. *Seabed* also includes sensors for measuring currents and water properties.

With multiple thrusters, *Seabed* can independently control its heading, speed, and depth. The vehicle has two hulls, with most of the weight in the lower hull and flotation in the upper hull; the large separation between its centers of mass and buoyancy make it capable of coming to a complete stop, moving slowly, and even moving backwards—critical traits for precise surveys of underwater sites.

Since its inception, *Seabed* has been used in support of marine archaeology, benthic research, coral reef studies, geology and geophysics, and marine chemistry.

Brian Bingham, Franklin W. Olin College of Engineering

Gliders

Gliders are autonomous underwater vehicles (AUVs) that change their buoyancy and use wings to produce forward motion. They are robotic, diving floats that slowly move up and down across the sea in a saw-toothed pattern to study currents, water chemistry, and biology.

Gliders have no external moving parts or motors; instead they move by pumping ballast—mineral oil, water, wax—in and out of bladders in the hull. This pumping action changes the volume of the glider, making it denser or lighter than the surrounding water. The vehicles are steered by wings on the tail and hull or by shifting weight (such as batteries) inside the hull.

Researchers direct these AUVs to glide in certain directions and to variable depths, and then to surface periodically. Satellite phones and Global Positioning System receivers are used to determine the vehicle's location, to send data, and to transmit commands. Since gliders navigate by dead reckoning, these satellite conversations often include course corrections.

Gliders can carry a variety of sensors to monitor the ocean for weeks to months. They are often used to measure the temperature, salinity, and clarity of water, which allows oceanographers to derive information about circulation. When optical and acoustic sensors are added, they are used to explore the relationships between ocean physics and biology.

WHOI research teams have helped develop two types of gliders—*Slocum* and *Spray*—which are named for Joshua Slocum, the first man to sail around the world alone, and for his boat. These gliders have been used to cross and survey the Gulf Stream and Monterey Canyon.

Paul Fucile, WHOI

Benjamin Carr, WHOI

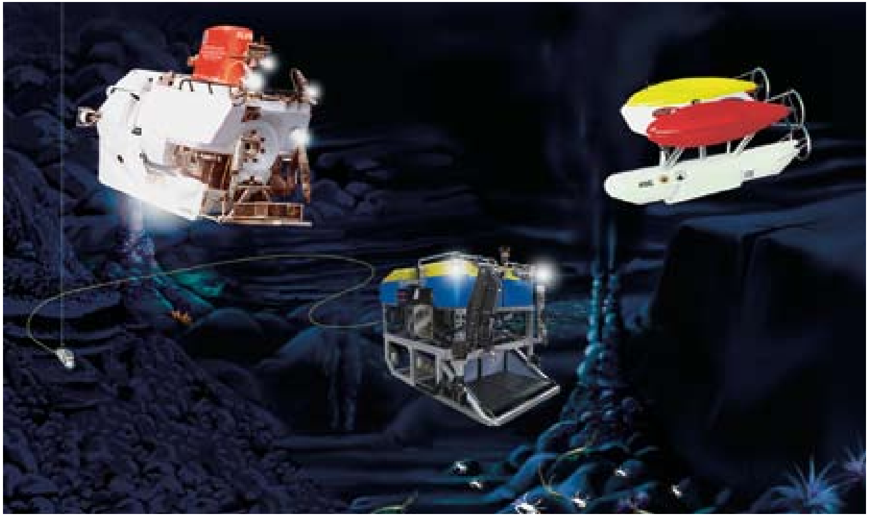
National Deep Submergence Facility

Since 1974, WHOI has operated deep-sea exploration vehicles for the benefit of the entire U.S. oceanographic community. The National Deep Submergence Facility (NDSF), hosted at WHOI, is a federally funded center that operates, maintains, and coordinates the use of three vital deep ocean vehicles:

· the human occupied submersible *Alvin* (page 12)
· the remotely operated vehicle *Jason/Medea* (page 14)
· the Autonomous Benthic Explorer ABE (page 16).

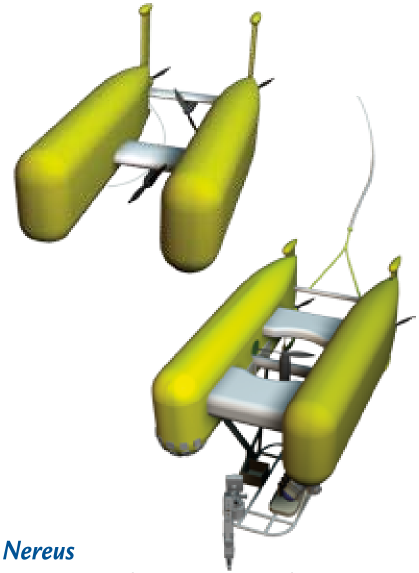
More than half of our planet is covered by water that is at least two miles deep. The unique vehicles of the NDSF carry humans and a virtual "human presence" beneath those deep waters and down to the largely unexplored seafloor. Whether diving 4,500 meters (14,700 feet) or remaining submerged for several days, each vehicle offers unique tools to explore the mysteries beneath the ocean's surface.

The NDSF is sponsored by the National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration. The operation is managed by WHOI and overseen by the University-National Oceanographic Laboratory System (UNOLS), an organization of 62 academic institutions and national laboratories involved in marine research.



E. Paul Oberlander, WHOI

Coming Soon



Nereus

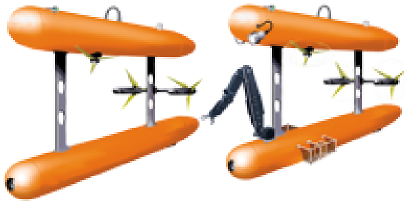
Now in development, the *Nereus* hybrid remotely operated vehicle (HROV) will be able to reach the deepest parts of the ocean—from 6,500 meters to 11,000 meters (21,500 feet to 36,000 feet), depths currently unreachable by ocean researchers worldwide.

While working at sea, engineers will be able to transform *Nereus* from an autonomous, free-swimming vehicle (for wide-area surveys) to a tethered vehicle (for close-up investigation and sampling of seafloor rocks and organisms). The battery-operated vehicle will be equipped with sonar, a magnetometer, instruments for measuring water properties, and a mechanical arm for gathering samples.

Researchers plan to use *Nereus* to explore remote, difficult-to-reach areas, including the seafloor under the Arctic ice cap. One of the HROV's early missions, likely in 2007 or 2008, will take it to Challenger Deep, a portion of the Mariana Trench located in the Pacific Ocean at 11,000 meters (more than 35,000 feet), the deepest known part of the ocean.

Jaguar and *Puma*

Two deep-diving versions of the *Seabed* autonomous underwater vehicle (page 19)—dubbed *Jaguar* and *Puma*—are being developed to look for hydrothermal vents under the ice of the Arctic Ocean in the summer of 2007. *Puma* will be an autonomous "bloodhound," using specialized sensors to survey wide areas, "sniff out" vent plumes, and follow them back to their source. Once a vent is found, a "hummingbird" AUV—*Jaguar*—will hover in place and use cameras, sonar, and a manipulator arm to map, image, and sample the area.



Sentry

The successor to the ABE vehicle (page 16) is the *Sentry* AUV, which is faster, has greater depth capability, and is capable of longer deployments. Test dives with *Sentry* were completed in 2006, and engineers are now working to install scientific sensors comparable to what is available on ABE. *Sentry* is slated to join the National Deep Submergence Facility in 2008.

New human occupied submersible

After more than four decades of exploration with the famed *Alvin*, (page 12) scientists and government agencies have decided it is time for a new human occupied vehicle. WHOI engineers and scientists, in partnership with colleagues at several institutions, are now designing a new submersible that can dive to 6,500 meters (21,325 feet) and reach 99 percent of the seafloor. By comparison, *Alvin* can dive to 4,500 meters (14,764 feet) and reach 63 percent of the seafloor.

Funded by the National Science Foundation, the next-generation submersible will dive and ascend faster, allowing more time on the ocean floor. Once completed in 2009, it will have improved viewports for the pilot and observers, more interior space, and an increased ability to carry equipment and samples. The vehicle also will include high-speed data transmission capabilities and variable ballast systems for mid-water studies.

Illustrations by E. Paul Oberlander, WHOI

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WHOI conducts research around the world in oceanography and ocean engineering and is the largest private, nonprofit marine research and higher education organization in the U.S.

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