Designing Modular Unmanned Landers To Better Observe Life in the Deep Ocean
The Medusa Landers are Compact, Reconfigurable Platforms For Unobtrusive Deep-Sea Observation

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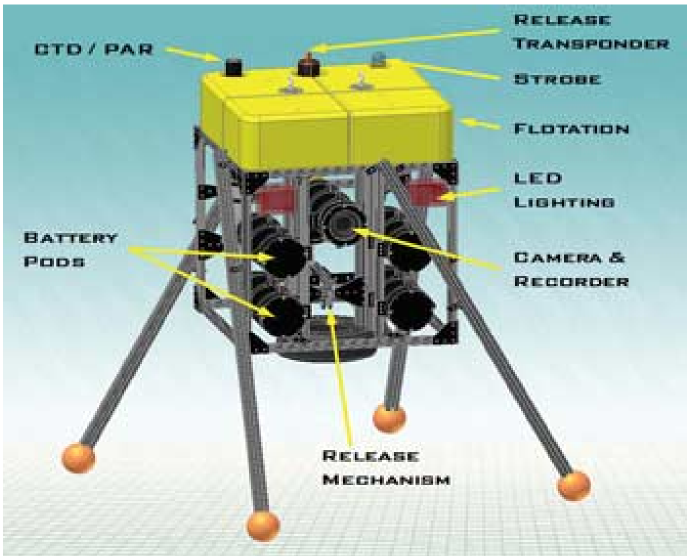
Observing deep-sea fauna is a challenging undertaking, particularly given the types of tools and platforms that are typically used for the task. Deep-sea photography has provided valuable glimpses of this inaccessible realm since 1940, but video of life in real time presents a number of challenges that scientists are only just beginning to effectively overcome.

The distribution and behavior of life in the deep sea is dramatically altered by the bright lights, loud thrusters and strong electrical signatures of most remotely operated vehicles (ROVs), autonomous underwater vehicles and submersibles. Many midwater ecosystems are still sampled using archaic fishing nets that either fail to catch what is there or severely damage it in the process. Furthermore, these tools generally operate over a period of several hours at a time, never fully allowing deterred animals to adjust to their presence and return to the site of interest. In fact, the disruptive presence of such devices in these otherwise dark, silent, remote areas of our oceans has led many in the scientific community to wonder how much marine life we have still not yet seen and how valid our observations of deep-sea ecosystems really are using such tools.



Design Features

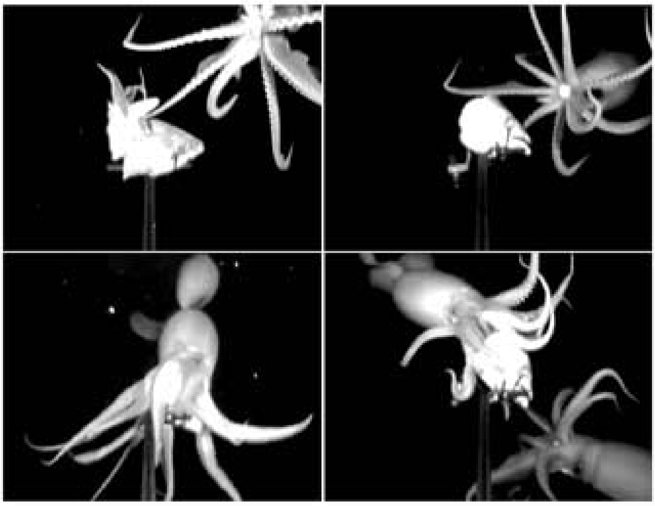
Building on previous work in the development of systems for unobtrusive deep-sea monitoring, scientists and engineers at The University of Queensland (UQ) and Harbor Branch Oceanographic Institute (HBOI) set out to design a low-cost, modular, reconfigurable unmanned platform for longer-term unobtrusive recording of deep-sea life. The design requirements included: low cost; ability to withstand a long deployment time (days to weeks); a deepwater rating (2,000 meters); a compact, lightweight form-factor; ability to operate on the bottom or in midwater; easy, inexpensive deployment requirements (launch and recovery possible from small vessels, without the need for ROVs or submersibles); full-motion video and audio recording capability; unobtrusive lighting; a low acoustic and electrical signature; a reconfigurable mounting frame; and accommodation for ancillary instruments and payloads.

The result was Medusa, a lander that consists of a 26-inch cubical anodized aluminum frame with syntactic foam flotation on top. The frame design allows for modularity and easy integration of new and custom sensor packages and provides a vast array of connection and mounting options.

Another benefit of the “bolt-together” frame is the ability to disassemble the system into a small shipping configuration if needed. It can then be reassembled without any special tools on site. An acoustic release and ranging transponder is also included to allow for the release of a sacrificial drop-weight for recovery, as well as simple range-location of the unit when deployed.

The main video camera is typically an ultralow-light nonintensified black and white charge-coupled device. Other cameras, including full-color, can be interchanged for daytime deployments in shallow water or anywhere the use of white light is not an issue. Full-motion video is recorded in MPEG-4 format to a solid-state hard drive with the capacity for several days of continuous recording time (longer when periodic or triggered recording is used). The camera and video recorder are housed in a 2,000-meter-rated aluminum housing with a conical acrylic viewport.

Lighting is provided by low-cost, epoxy-encapsulated light-emitting diode (LED) arrays, which can be manufactured in virtually any color profile. For unobtrusive monitoring, far-red LEDs at 690 nanometers are used, as they have been shown to be undetectable by the visual systems of most known deep-sea fauna, but offer far better penetration and illumination in seawater than infrared lighting. For simulated bioluminescence experiments, blue-green LEDs at 470 nanometers are used. For shallow applications, or where bright lights are not an issue (for instance when recording full-color video), daylight-spectrum 6,500 kelvin white LEDs are used.



Two-meter-long Humboldt squid attack Medusa during midwater deployments over the Peru-Chile Trench. The lander was in drifter mode, baited and floating at 700 meters over a 7,800 meter depth.

Power comes from lithium-ion battery pods in dry aluminum housings. Each pod contains the Li-ion packs as well as charging and power-regulation circuitry. A typical deployment configuration consisting of two battery pods will power the Medusa system continuously for several days, or longer with periodic or triggered recording. Additional battery pods can be added and daisy-chained for longer deployments or payloads with higher power demands.

A self-logging ancillary instrument package is also included, consisting of conductivity, temperature and depth and photosynthetically available radiation sensors. Other instruments, such as a hydrophone or dissolved oxygen and pH sensors, can be added.

Finally, a deepwater strobe and radio or satellite tracking beacon is mounted in the foam pack to allow easy location at the surface.

Launch and Recovery

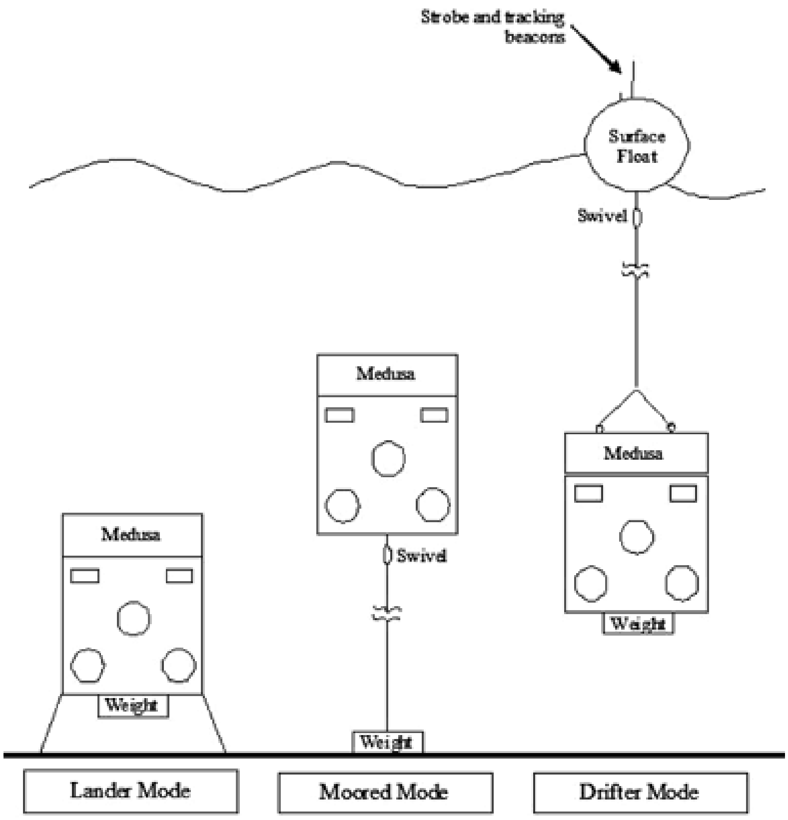
Once fully rigged, Medusa weighs approximately 300 pounds in air. Therefore, it is possible to deploy the system from a small vessel of opportunity with a couple of deck hands or a small davit. The system can be deployed in one of three modes: as a benthic lander, midwater drifter or midwater mooring.

In benthic mode, four legs with ball-feet are added to the system, along with a sacrificial drop-weight composed of concrete, sand or steel. The large separation of its center of gravity and center of buoyancy makes Medusa extremely stable. It can be rolled off the back of a heaving ship upside down without a problem; field trials have shown that the system will right itself almost immediately, in as little as 10 feet of water, and will remain level on uneven bottom terrain, even when not all legs are touching the seafloor.

In midwater-mooring mode, the legs are removed and polyvinyl chloride fins are added to keep Medusa pointing up or down-current. A length of line is added between the main frame and the drop-weight, allowing the unit to float freely off the bottom.

In midwater-drifter mode, Medusa is also configured with fins and a drop-weight, but is suspended from a simple surface float on a length of line. A radar reflector, strobe and a radio frequency or satellite beacon for tracking purposes are attached to the surface float.

In all cases, the unit can be easily deployed over the side of a small vessel or placed precisely on-site if an ROV or submersible is available. Once deployed, the unit is left unattended and records video and data automatically. Recording is typically continuous, and with new generations of large-storage-capacity hardware, it can easily manage this task for several days. Future enhancements will allow both scheduled and sensor-triggered recording. Recovery is accomplished from the surface vessel by triggering the acoustic release to drop the sacrificial weight using a small overboard transducer. The unit then returns to the surface and is recovered with light deck gear, such as a hook-pole, small davit and capstan winch.



The three Medusa deployment modes.

Field Deployment Highlights

In 2010, three Medusa systems were constructed for UQ and the Ocean Research and Conservation Association (ORCA). A series of field deployments were performed off of the Florida Keys, Australia and South America. Further deployments are scheduled this year off the coasts of Australia and Brazil and in the Gulf of Mexico. Deployments were conducted on various vessels, including a seven-meter aluminum rigid-hull inflatable boat, a 20-meter dive boat and a 90-meter oceanographic research vessel. Deployments were conducted in all three modes and yielded excellent results.

From these few initial deployments, it is evident that many elusive species are present in the deployment areas and were undisturbed by the Medusa landers. For example, six-gill sharks and Humboldt squid have been filmed a number of times before, but always using bright lights, to which these animals react. The Medusa uses far-red light, which allows scientists to view these animals homing in on and attacking the lander's bait in their natural way, relying on senses other than sight, such as olfaction and mechanosensory systems (vibration senses), to locate the food.

Conclusions and Future Work

A new unmanned instrumentation and video-recording platform, Medusa, has been designed to unobtrusively observe deep-sea fauna down to 2,000 meters.

It is apparent from early results that the Medusa landers are very capable systems for unobtrusive deep-sea exploration and observation.

HBOI plans to construct more Medusa landers to continue to lower costs and expand the number of these systems being used in the field. Additionally, researchers plan to add enhanced features, such as motion-triggered recording, extended video recording time, acoustic recording and an expanded ancillary sensor suite.

Acknowledgments

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