A DEEP DIVING REMOTELY OPERATED VEHICLE
FOR RESEARCH IN THE PACIFIC

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The University of Hawaii is the only United States academic institution with a permanent deep manned presence in the Pacific Ocean. The Hawaii Undersea Research Lab (HURL) has been operating the 2000-m Pisces V submersible for over four years, and to maximize the efficiency of manned bottom time, HURL has acquired a RCV-150 remotely operated vehicle (ROV) to be used as a surveying, sampling and mapping tool. The RCV-150 system was originally designed for operations in the oil fields. A total of 10 vehicles were built, of which four are still in operation. The HURL ROV is equipped with a color video camera mounted on a pan-and-tilt assembly. There are six individually controlled, variable-intensity lamps, and dual five-function manipulators. An obstacle avoidance sonar is standard on all RCV-150 vehicles. Additional color video and 35-mm still photographic cameras can be fitted to the vehicle as required. Manned submersible operations will concentrate on exploration, location, and marking of suitable sampling sites on the seafloor. The ROV’s role will be threefold: 1) the vehicle must locate and sample areas visited by the Pisces V; 2) the vehicle will survey future areas of interest for use in planning submersible dives; and 3) the ROV will deploy and recover scientific instrumentation. The RCV-150 is currently being modified for operations to 2000 m, matching the depth capability of the Pisces V. Both the ROV and the submersible will be permanently installed on the dedicated research vessel R/V Kalumaki.

INTRODUCTION

The University of Hawaii is the only United States academic institution with a permanent deep manned presence in the Pacific Ocean. HURL has been successfully operating the Pisces V, a three-man submersible, for several years. In an effort to maximize the efficiency of manned bottom time, HURL acquired the RCV-150 (Figure 1), a remotely operated vehicle system for use as a scientific surveying, sampling, and mapping tool. This system will be deployed daily during the submersible’s maintenance periods. Thus, the Pisces V and the RCV-150 will be used alternately, around the clock.

The standard RCV-150 system was originally marketed as an offshore service ROV for the petroleum industry. The 1000-m operational depth and the precise handling of this particular vehicle made it the ROV of choice in the offshore support industry for several years. These same criteria also made the RCV-150 a highly desirable mid-water and near-bottom platform for use in scientific investigations. The HURL vehicle is being modified so that it may be used as a complimentary system alongside the submersible at water depths up to 2000 m.

LOW COST ROV’s FOR SCIENCE

HURL initially investigated the possibility of using a low-cost remotely operated vehicle (LCROV) in its science program. Low-cost ROV’s have evolved from “swimming eyeballs” to sophisticated observational and sampling platforms since their inception in the early 1980’s (Stewart and Auster 1989). The expectations and demands of the scientific community have compelled manufacturers and operators to incorporate a multitude of sampling, sensing, and navigational equipment. The new generation of LCROV is often equipped with accessory cameras, CTD’s,
sonars, laser scaling devices, and short baseline navigation systems. The Benthos Mini-Rover and the Deep Ocean Engineering Phantom series, in particular, have established excellent track records in the academic community as reliable, shallow-water sampling, observational, and data collecting tools.

Figure 1. The Hawaii Undersea Research Lab's RCV-150 remotely operated vehicle. The vehicle is equipped with four thrusters, six variable-intensity lights, a 5-function manipulator, and a color video camera on a pan-and-tilt unit located behind the glass dome.

The evolution of maximum operational depths of LCROV's has paralleled that of accessories. The early LCROV's were limited to depths of a few hundred meters. As the scientific community became more aware of the usefulness and adaptability of LCROV's to research applications, the demand for access to greater depths became a driving force in the industry. The greatest obstacle to reaching deeper into the ocean with LCROV technology was the amount of thrust needed to maneuver the vehicle with the increased drag caused by longer and, in some cases, thicker umbilicals. Fiber optic technology allowed for the development of thinner and lighter umbilicals to carry increased amounts of data to the surface, and more power to the vehicles at depth, using cables of comparable diameters. Today, LCROV's routinely carry out scientific operations to 300-m (1000-ft) depths.

Similarly, the cost of a new LCROV has become more sophisticated as well. A new vehicle with an enhanced depth capability and an array of high-tech equipment may cost well over $250,000.
LCROV OR ROV?

A LCROV system was tested in Hawaiian waters during August 1988 to allow HURL to evaluate its performance and to provide HURL personnel with operational experience. A standard LCROV equipped with a low-light ICCD camera was used to observe bottomfish behavior for the Hawaii Cooperative Fisheries Unit at the University of Hawaii (Haight and Kelly, in prep). The research was conducted at depths up to 125 m on Penguin Banks off the west coast of Molokai. Several fish count transects and stationary counts were successfully conducted over the course of the cruise. Several shortcomings, however, were noted. Of particular concern was the maneuverability of the vehicle at greater depths and the limited ability of the vehicle to perform manipulative tasks. Strong bottom currents and 2-meter seas sometimes prevented the vehicle from executing the most simple tasks effectively. The open ocean test of a LCROV, while meeting its scientific objectives, compelled HURL to investigate the performance and acquisition of an industrial ROV system for use in its research program.

HURL participated in a series of test dives conducted by Harbor Branch Oceanographic Institution to showcase their science-dedicated Hysub 40 ROV (Clark et al. 1990). This industrial work vehicle was brought from the oil fields and modified for scientific sampling and underwater research. The vehicle can operate to depths of 1000 m, and carries a photographic/video camera, sonar system, and a navigation beacon as standard equipment. The vehicle has been redesigned to accept an accessory science tool package which incorporates a programmable five-function manipulator and a rotary bin sampler similar to those of the Johnson Sea Link I and II. This science package is designed to be easily reconfigured to carry other tools depending on the needs of a particular investigator. Cruise participants were encouraged to suggest specific tasks to be executed by the vehicle and to evaluate the performance of this own sampling gear when deployed by the ROV.

The week of test dives proved that the vehicle performed well even under adverse sea conditions. Standard sampling tools were successfully operated, and several new tools provided by their manufacturers were assessed. More importantly, however, the magnitude of scale between the use of LCROV's and large, industrial-work-type ROV's in executing scientific objectives was realized. It was apparent that to conduct the type of research HURL supports, a capable, professional, work-type ROV system would have to be acquired.

THE HURL ROV SYSTEM

In early 1990, HURL purchased the RCV-150 line of ROV's from Honeywell, Incorporated. Included in the purchase was a complete vehicle, a winch/A-frame handling system, two launching garages, a control van complete with redundant power supplies, control consoles, and an extensive inventory of spare parts and engineering documentation. The HURL ROV was equipped with a Newvicon low-light black-and-white camera mounted on a pan-and-tilt assembly. There are six individually-controlled, variable-intensity 250W lamps, and dual five-function manipulators. An EDO obstacle avoidance sonar is standard on all RCV-150 vehicles. Color video and 35-mm still photography equipment can be fitted to the vehicle as required. Sampling tools and instrument packages are mounted on the launching garage for deployment by the ROV at depth. Similarly, samples recovered by the vehicle are deposited and secured in receptacles on the launching garage for transport to the surface.

Engineering is underway to convert the HURL RCV-150 to a 2000-m research ROV. Many of the original components of the system were designed for operations to 2000 m, including the structural members and flotation packages. To accommodate the new cable design, the vehicle telemetry system is being converted from RF radio to fiber optic transmission. The new fiber optic umbilical cable will provide ample power to the vehicle and launching garage, and increase the data transmission capabilities of the system while maintaining the current cable diameter of less than 2.5 cm. This will allow scientists to use high data rate instruments at depth for in situ monitoring and sensor data collection. Instead of redesigning a transportable deployment system capable of handling over 2000 m of armored cable, the system will be permanently installed on the main winch and A-frame deployment system of the submersible support ship R/V Kaimikai.
The electro-optical cable will have a multi-function capability. In addition to ROV operations, it will be used to deploy towed photographic and video systems and television grab samplers, using duplicate fiber optic telemetry units. The 2000-m depth capability also matches the depth rating of the *Pisces V*, allowing the ROV to be used as a standby submersible rescue vehicle as well.

**SUMMARY**

The RCV-150 will be the deepest diving ROV in the United States available to scientists on a regular basis. The scientific value of using remote systems in oceanographic and limnological studies has been proved over the last decade by the advent and rapid technological advance of LCROV systems. Likewise, large ROV systems like the RCV-150 will become more important to the scientific community because of their ability to power, carry, deploy, and recover sophisticated tools and sampling devices. Fiber optical data links allow not only the transmission of broadcast-quality video from the seafloor, but open wide the multifaceted, in-situ monitoring and data-gathering capabilities of the ROV. Payload capacities of large ROV systems will become more of a concern to ocean scientists as they continue to push the capabilities of ROV technology. The use of sample baskets, interchangeable tool trays, and other sampling receptacles increases dramatically the total ocean floor capability of garaged ROV systems.

The combination of the RCV-150 and the *Pisces V* aboard the R/V *Kaimikai* will allow HURL to conduct scientific investigations more effectively than with either system alone. Moreover, manned bottom time can be better planned and utilized if the ROV is used to explore for unique dive targets or conduct routine sampling operations. In our operational scenario, manned submersible operations will concentrate on exploration, location, and marking of suitable sampling or instrument package sites on the seafloor. The role of the ROV is threefold: 1) the vehicle reoccupies and samples selected sites visited by the submersible; 2) the ROV surveys areas of interest for use in planning future submersible dives; and 3) the ROV is used to deploy and recover single or multiple instrument packages to and from the seafloor.

**LITERATURE CITED**


Haight, W. and K. M. Kelly. In prep. In-situ observation of commercially important deepwater snappers using a remotely operated vehicle.