Going the Distance: Use of Diver Propulsion Units, Underwater Acoustic Navigation, and Three-Way Wireless Communication to Survey Kelp Forest Habitats

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Abstract

Here we describe a kelp forest survey technique using an underwater acoustic navigation system coupled with diver propulsion units (DPUs). The surveys characterized kelp forest habitats and macro-biota along the inshore sections of five routes proposed for deploying temporary underwater seismic cables in San Luis Obispo County, California. The total distance surveyed was nearly 5 km (3 mi) over a period of five days. Survey depths ranged between 18 m (60 ft) and 3 m (10 ft) MLLW. Acoustic transponders set to transmit separate acoustic frequencies were attached to temporary drop buoys, and using GPS were sequentially positioned up to 200 m apart along the cable routes. The acoustic signals received by a transponder interrogator unit on a DPU enabled the lead diver to accurately navigate from one transponder to the next and to record predominant habitats and macro-biota while en route. A dive buddy with a video camera mounted to a second DPU videotaped sections of the cable route while also transiting. For safety and improved communication, we used a wireless 3-way communication system with full face masks. Using typical kelp forest survey protocols, such as meter tapes and swimming compass courses underwater, would have been especially difficult over these depths and distances.

Keywords: kelp forest habitat characterizations, SCUBA, underwater navigation, videotaping

Introduction

This study was conducted to characterize benthic habitats and macro-biota in kelp forests along the San Luis Obispo County, California coastline where the routing of five temporary seismic cables with geophones is proposed as part of a high energy nearshore seismic survey (Figure 1). Our habitat characterization work using SCUBA and based on direct observations and video documentation was completed along the cable route sections passing through kelp forests. A continuation of the same cable corridor extended offshore into deeper water where the habitat characterization and videotaping was completed using a remotely operated vehicle (ROV). The inshore characterizations needed to be completed using SCUBA because the tethered ROV could not be operated in the dense forests of giant kelp (Macrocystis pyrifera) and bull kelp (Nereocystis luetkeana) that were common inshore. The proposed offshore and inshore sections of the cable routes were aligned to occur on sand flat habitat where possible, based on substrate maps prepared from multi-beam sonar surveys. However, rocky habitat that is colonized more densely with invertebrates and kelp could not be avoided in many areas, particularly inshore where kelp forests predominate. The total distance to be surveyed using SCUBA was nearly 5 km (3 mi), along a 3 m (10 ft) wide corridor centered on the planned cable alignments. Survey depths extended to 18 m (60 ft) mean lower low water (MLLW) and underwater horizontal visibility distance was often limited (<4 m, [<15 ft]).
Completing surveys in kelp forests using SCUBA along transects to characterize benthic habitats and macro-biota can be challenging, especially when transects (typically meter tapes on reels) must be deployed according to specific start and end coordinates. Deploying transects from a boat in kelp forests is generally not possible, due to propeller entanglement with kelp and interference from surface and mid-water kelp fronds that prevents the meter tapes, or even weighted lines, from sinking to the bottom. The typical option is then to deploy the meter tapes using SCUBA on headings underwater using a dive compass. This method can work well if the transects are relatively short (i.e., <50 m, 164 ft), but dive compass navigation can be inaccurate and difficult if underwater horizontal visibility is limited and if currents are swift moving. Divers also need to re-wind the tapes back to the starting point, which results in added bottom time, air consumption, and fatigue.

Due to the long distances and precise routes that needed to be surveyed, we instead used a combination of a wireless underwater pinger-receiver navigation system, diver propulsion units (DPUs), 3-way wireless underwater communication, and SCUBA to navigate accurately in straight lines over these long distances. Survey data included direct observations of substrates, habitat types, and macrofauna, and a videotape record of the proposed cable corridors.
**Methods**

The underwater observations and video were completed by a team of two SCUBA divers working with a 2-person boat crew that also functioned as a second dive team. The research vessel was a 28-ft Munsen craft equipped with dual GPS systems and a precision depth finder. Divers used an underwater navigation system to ensure that they followed directly along the proposed geophone alignment corridors. Alignment coordinates were provided by the Pacific Gas and Electric Company.

The underwater navigation system consisted of acoustic transponders/pingers (RJE International Model ATT-400) attached to temporary buoys (Figure 2). Each was set to transmit a unique frequency. A transponder interrogator unit (pinger receiver, RJE International DTI-300, Figure 3) was monitored and operated by the lead diver. The transponder interrogator displayed the bearing and distance from the interrogator unit to the transponders/pingers within an accuracy of one meter.

![Figure 2. Pinger and drop buoy system used to maintain the pinger directly above the drop buoy anchor.](http://archive.rubicon-foundation.org)

The work along each cable route began with the boat crew positioning the transponders on temporary buoys at specific locations along the cable route, starting at a pre-determined offshore point near the -18 m (-60 ft) MLLW isobath. Two or three transponders were then set at distances no greater than approximately 200 m (656 ft) apart along the cable route towards shore using an onboard GPS-based software navigation system for positioning (Figure 4). Each diver used a hand-held DPU (Seadoo VS) on which either the transponder interrogator unit or video camera was mounted (Figure 3). Divers descended to the bottom at the starting buoy from where they began navigating and completing observations. Because each pinger had a unique sending frequency, the divers were able to continue from point to point along the cable route without surfacing, depending on air consumption. As the team proceeded, the lead diver wrote observations on a pre-printed underwater data sheet, noting the
distance to the next pinger as a method to provide a navigational fix on any features of interest. The diver operating the video camera recorded representative habitat features and biota at various points along the cable route. Both divers used DTS full face masks with integrated communication hardware for wireless communication between the divers and boat crew.

Figure 3. Underwater navigation and videotaping system consisting of a diver propulsion unit (DPU) equipped with an RJE International DTI-300 transponder interrogator and another with a Bonica Snapper HDDV/1080P HDDV video camera.

The surface support vessel followed the dive team as they proceeded underwater towards the shore. The cable routes were surveyed into the shallowest depths indicated on the alignment maps or to the shallowest depths that were considered safe for the divers, based on swell height and underwater visibility, and safe for boat operations.

Results

We completed all of the planned work over five days in August 2011, which consisted of noting and videotaping representative habitats and macro-biota within and proximate to kelp forests. The total distance covered was nearly 5 km (3 mi). Two dive teams of two people working each day could complete 1 km (0.6 mi) of cable route surveying using a total of 4-6 72 ft³ SCUBA tanks per day. The total combined bottom time to complete all of the work was 14 hours.

The observations did not reveal apparent alternative routes in the areas of kelp forests to align the seismic cables over sand versus rock. The substrates on all but one of the routes were predominantly boulder and moderate relief bedrock with stands of giant kelp, bull kelp, and the subcanopy kelp *Pterygophora californica*. Kelp canopy, at the time of our survey, was largely absent along one route, due to the seabed being largely sand and eroded sandstone. None of the surveyed routes included sensitive macro-invertebrates, such as gorgonians, hydrocorals, or emergent abalone that would be disturbed by deploying or retrieving the geophones.
Discussion

Our work presented here focuses on the survey methodology we used to characterize and document kelp forest habitats. The pinger-receiver underwater navigation system was invaluable for the divers to maintain accurate positions along the cable routes. This methodology was also very efficient. Fourteen hours of total bottom time was expended to complete all the work. The amount of time that would have been required to complete the same work otherwise, using the more conventional method of deploying and retrieving meter tapes and navigating according to compass headings, would have taken several times longer to accomplish. Also, because much of the work was at depths up to 18 m (60 ft), surfacing for re-orientation was not practical. The pinger navigation system allowed the divers to remain near the bottom and travel on specific headings over long distances (~200 m [656 ft]).

Figure 4. Inshore cable route and waypoints used for deploying pinger drop buoys.

Although we used a wireless 3-way communication system for diver-diver/diver-boat/boat-diver communication, we rarely needed to talk to each other once the surveys were in progress. Conventional hand signals were generally sufficient for communication between the divers, and the boat operator used the diver’s bubbles to track their progress and follow along. However, the wireless communication system was used occasionally, and would have been especially important had an emergency situation arose.
The DPUs also helped to conserve air, reduce diver fatigue, and therefore reduced the number of tanks that would have otherwise been needed, including total dive time, number of divers, and number of dive days. Surface intervals for changing tanks and repositioning pinger units were sufficient to keep the divers within no-decompression limits. The DPUs were also useful on the surface, as the divers could more easily and rapidly approach the dive boat, versus the boat operator having to carefully maneuver the boat to pick up divers.

The methodology we used to complete our kelp forest habitat characterization allowed us to obtain descriptive information on the general characteristics of the benthic habitats and macro-biota along the seismic cable routes surveyed. More detailed biological information could have been collected if the underwater navigation system was used in a quantitative (quadrat-type) sampling design, but this would have added significantly more bottom time and survey days. The navigation system we used is not limited to subtidal biological surveys. For example, the same equipment and methodology can be used in search efforts where areas need to be canvassed in a systematic fashion and to readily locate underwater targets that have a pinger attached.

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