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Canadian Imaging and Sampling Technology for Studying Marine Benthic Habitat and Biological Communities

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ABSTRACT

The systematic mapping of marine benthic habitat and biological communities requires specialized oceanographic instrumentation. During the past ten years, as part of research programs investigating the effects of mobile fishing gear and offshore hydrocarbon development, Canadian scientists and engineers have developed a suite of tools for imaging and sampling seabed habitats over different spatial scales. Towcam is a towed vehicle which collects continuous but low-resolution video imagery of the seabed over a large area (i.e. 1-10 km transects). Campod is an instrumented tripod equipped with two video cameras and a 35-mm camera with 250-frame capacity. It is deployed while the ship is on station, or slowly drifting, and collects both general reconnaissance video and high-resolution imagery from a small area of the seabed. A hydraulically operated videograb, which uses the same conductor cable and winch as Campod, collects sediment and organisms from an area of 0.5 m^2. Video cameras allow the operator to select the exact area of seabed to sample and to ensure that the grab closes properly. These three instruments are briefly described and examples of their application on the continental shelf off eastern Canada provided. These and comparable tools used by other ICES countries, when used in conjunction with acoustic survey tools (multibeam, seismic, sidescan, RoxAnn, QTCview, etc.), make possible the classification and mapping of marine benthic habitat and biological communities over large areas.

INTRODUCTION

Sustainable management of marine resources requires information on the classification and spatial distribution of benthic habitat and biological communities. A considerable amount of the necessary information can be obtained using acoustic survey tools such as multibeam bathymetry, seismics, sidescan sonar, RoxAnn and QTCview. However, there also is a need for tools to collect video and photographic imagery, as well as samples of substrate and organisms, at representative locations on the seabed. This information is needed to groundtruth substrate properties inferred from acoustic tools and to describe detailed habitat structure and biological communities. The many advantages of imaging methods in benthic ecological studies have been summarized by Rumohr (1995).

During the past ten years, Canadian scientists and engineers at the Bedford Institute of Oceanography (BIO) have designed and constructed a unique suite of specialized tools for imaging and sampling the seabed over different spatial scales. This equipment was developed in house because of the close working relationship between BIO's environmental scientists and engineering community. While originally designed primarily for a broad spectrum of integrated environmental impact studies, these tools are now being applied to the classification and mapping of benthic habitat and communities. This paper briefly describes three of these tools as they are currently being used. Further information can be obtained by contacting the authors.

TOWCAM

Towcam (Fig. 1) is a towed vehicle which collects continuous but low-resolution colour video imagery of the seabed over a large area (i.e. transects many kilometers in length). It was designed as a more dependable replacement for BRUTIV (Rowell 1997). It is towed at a constant altitude (generally about 2 m which gives a field of view about 1 m wide) above the seabed at a speed of about 2 knots (i.e. about 4 kilometers an hour).

The aluminum towfish is of open construction with adjustable wings to generate a depressing force and a pair of pendulum rudders for roll stability. It is fitted with a Sony XC-999 colour video camera, a pair of 500 watt quartz halogen lights, and an acoustic altimeter. It is towed on approximately 500 m of ¾ inch double armoured galvanized conductor cable (South Bay) that is spooled on a 50 HP Swann winch. The effective maximum operating depth is approximately 200 m. All electrical power is supplied from the surface so there is no limit on tow duration. Towfish weight is 110 kg while length is about 2 m (including bridle). A transponder is attached to the towfish and its exact location over the seabed determined using a Trackpoint II acoustic tracking system.

Constant altitude above the seabed is maintained by adjusting the amount of cable paid out. This is currently controlled manually by a scientist in the ship's laboratory who observes towfish performance on computer and video monitors. A closed loop control system for the winch has been designed in order to maintain a constant altitude automatically. This was successfully tested in 2000 and is expected to be operational next field season. Real time video imagery is displayed in the laboratory. It is also displayed on the bridge to assist the quartermaster in ship handling. Video imagery and navigation data are recorded on DVCAM digital tape for later analysis. Data on towfish behaviour are recorded on a PC. Notes of interesting features, referenced to time code and GMT, are recorded to assist subsequent analysis of the tapes.

Analysis is done ashore by viewing the videotapes and extracting the desired information. Different methods can be used. In some cases, it is useful to analyze an entire transect while in others it is more useful to analyze imagery within a particular time interval. Regardless of the methods used, resolution of the imagery will depend upon the altitude of the towfish off the bottom, the towing speed, and the quality of available processing equipment. Static video images can be captured and imported into various image analysis systems, but the resolution of these images is less than high quality photographs.

Towcam has proven to be an excellent tool for conducting general reconnaissance surveys on the scale of kilometers. It provides continuous imagery over large spatial scales. The video imagery can discern major habitat features such as substrate and bedforms, fish, and large epibenthic organisms such as crabs, sea cucumbers, scallops, starfish and sand dollars (greater than about 10 cm). Towcam is non-destructive and has the potential to carry other sensors such as sidescan sonar and a digital still camera. It can be used over any kind of seabed (e.g. mud, sand, gravel, cobble, boulder, bedrock, etc.) as long as the relief is relatively low and the water is not turbid. Towcam has the potential to become an excellent stock assessment tool for commercial fisheries such as scallops.

CAMPOD

Campod (Fig. 2) is a light-weight instrumented tripod equipped with video and still cameras. It was designed with an open profile and wide stance to minimize disturbance to the seabed. Campod is deployed while the ship is on station, or slowly drifting, and collects high-resolution imagery from a small area the seabed.

A Sony XC-999 colour video camera is mounted obliquely to provide a forward-looking, wide-angle view while drifting over the seabed. A downward looking Sony 3-CCD high-resolution video camera is mounted on the central axis of the frame. It provides wide-angle, zoom and macro adjustment to allow both broad coverage and close inspection of the seabed. Illumination for the video cameras is provided by a pair of 500 watt quartz halogen lights. A 35 mm Nikon F4 still camera (with a 250 exposure film pack) and two high speed flashes (Quantum Q powered by turbo-batteries) are also mounted on the frame. The length of the legs is adjustable and at present the size of the photographic image is approximately 37 by 52 cm (0.2 m^2) when Campod is landed on the seabed. Weight of the assembled package is 340 kg and height is approximately 2 m. Because of its relatively light weight, substantial wire angles can develop on deeper deployments so a Trackpoint II transponder is attached to provide accurate positioning of the imagery.

The entire Campod system includes laboratory controls, sliprings, a customized 50 HP winch, approximately 500 m of 1.25 inch Kevlar conductor cable (South Bay), and a large diameter sheave block. During deployment and retrieval of Campod, an operator on deck controls the winch. However, when the seabed comes into sight on the monitor, control of the winch is taken over by a scientist in the laboratory. The usual operating procedure is to slowly drift for a few minutes with Campod suspended just above the seabed to assess general bottom properties with the video cameras. Then, Campod is landed on features of particular interest to obtain higher resolution video imagery and take still photos. If desired, and current and wind conditions are suitable, it is possible to drift considerable distances (on the order of 500-1000 m). A video monitor is also placed on the ship's bridge to assist the quartermaster with ship handling. Video imagery (from either the oblique or downward looking cameras as determined by the scientific operator) and navigation data are recorded on DVCAM digital tape for later analysis. Notes of interesting features, referenced to time code and GMT, are recorded to subsequent analysis of the tapes.

Analysis of the imagery is done ashore. Video tapes are analyzed using methods similar to those used for viewing Towcam tapes. However, the resolution is much better. After processing, the still photographs are digitized and burned to CD. Images are then analyzed on PC using Adobe Photoshop. Resolution can be enhanced by manipulating the contrast, brightness, colour and grain of the image. It is also possible to magnify the image and resolve features on the order a few millimeters (e.g. observe small isopods on sponges). Such post-processing of CD images greatly improves the resolution of biological and physical features, and allows the examination of species-microhabitat associations in an undisturbed state.

Campod has proven to be an excellent tool for obtaining high-resolution video and photographic imagery of benthic habitat and epibenthic organisms. The oblique video camera provides general reconnaissance information, especially on long drifts. More detailed imagery can be obtained by switching over to the downward looking high-resolution video camera. Even more detail can be obtained from the still photographs. Except for the small footprint when it lands, Campod is non-destructive so that time series observations can be made at a given location. It has also been used to carry other equipment for benthic boundary layer studies such as optical backscatter sensors, a silhouette camera and a water sampler (Milligan et al. 1998). Campod can be used over any kind of seabed (e.g. mud, sand, gravel, cobble, boulder, bedrock, etc.) regardless of relief, including steep walls of submarine canyons.

VIDEOGRAB

The videograb (Fig. 3) is a hydraulically-actuated bucket grab equipped with video cameras (Schwinghamer et al. 1996, Rowell et al. 1997). It was designed to minimize disturbance to the sampling area and to provide the scientific operator the ability to visually select the precise sampling area on the seabed, close and open the bucket remotely, and verify that the bucket closed properly prior to recovery. Videograb is deployed while the ship is on station. It collects high-resolution video imagery from a small area of the seabed as well as a sample of sediment and associated organisms. The advantages of video-assisted grabbing have also been recognized by Mortensen et al. (2000).

The video equipment is very similar to that used on Campod. A Sony XC-999 colour video camera is mounted obliquely to provide a forward-looking, wide-angle view while drifting over the seabed. A downward-looking Sony 3-CCD high-resolution video camera is mounted directly above the open bucket and provides imagery of the seabed about to be sampled and closure of the bucket. It provides wide-angle, zoom and macro adjustment to allow both broad coverage and close inspection of the seabed. Illumination is provided by a pair of 500 watt quartz halogen lights. Large fins align the videograb with the current and counteract any tendency to rotate. The bucket is closed hydraulically (takes about 40 sec), and the area sampled is 0.5 m^2. Sampling depth is on the order of 10-25 cm and at full penetration the sediment volume is about 100 L. The weight of the videograb is 1136 kg and the height is approximately 2.5 m. In most deployments, wire angles are small and ship position (end of the crane boom) serves as a reasonable proxy for sample location. However, a Trackpoint II transponder can be attached for more accurate positioning if needed.

The videograb uses the same laboratory controls, sliprings, winch, cable and block as Campod. It takes about 30 minutes to switch the cable from one package to another. Because of its greater size and weight, more crew members are needed to handle the videograb on deck. During deployment and retrieval of the videograb, the winch is controlled by an operator on deck. However, when the seabed comes into sight on the monitor, control of the winch is taken over by a scientist in the laboratory. The usual operating procedure is to slowly drift for a few minutes with the videograb suspended just above the seabed to assess general bottom properties with the video cameras. Then, it is landed on features of particular interest. Once landed, the open bucket is poised 20 cm above the bottom. By paying out slack cable, the videograb is decoupled from the motion of the ship and high-resolution video of the seabed is recorded looking through the open bucket. Closure of the bucket simultaneously closes a retractable lid which reduces (but does not eliminate) washout of the sample during recovery. Careful shiphandling is necessary to keep the vessel over the videograb while it is on the bottom. If the operator is not satisfied with the landing site, the videograb tips over, or the bucket does not close properly, the videograb can be lifted off the seabed, the bucket opened hydraulically, and another landing site selected. A video monitor is also placed on the bridge to assist the quartermaster in ship handling. Video imagery and navigation data are recorded on DVCAM digital tape for later analysis. Current operating depth is limited by cable length to about 500 m.

Video tapes are analyzed ashore using methods similar to those for viewing Campod tapes. Sediment samples are sieved, preserved in formalin and processes ashore using standard procedures (Kenchington et al. 2000).

The videograb has proven to be an excellent tool for collecting samples of sediment and associated epifaunal and infaunal organisms with minimal disturbance. It works well over a wide spectrum of substrate types ranging from mud to gravel, although several attempts are often required to get complete closure in gravelly sediments. The associated video imagery provides information on the undisturbed habitat from which the sample is collected as well as information on the quality of the sample. It leaves a relatively small footprint (a few square meters) and so can be used to make time series observations at a given location. The videograb can also carry a dynamically responding underwater matrix system (DRUMS™) to provide information on small-scale structural properties of surficial sediments (Schwinghamer et al. 1996, Schwinghamer et al. 1998).

EXAMPLES OF APPLICATION

All three tools have been successfully used in studies of the effects of hydrocarbon drilling wastes on continental shelf benthic ecosystems (e.g. Muschenheim and Milligan 1996). They also have been successfully applied to a series of three controlled experiments investigating the impact of mobile fishing gear on the benthic habitat and communities of offshore fishing banks (e.g. Kenchington et al. 2000, Rowell et al. 1997, Schwinghamer et al. 1996, and Schwinghamer et al. 1998). On a more operational scale, the videograb was successfully used to recover wreckage from the Swissair crash site off Nova Scotia. Campod has also been used to confirm the identity of interesting sidescan targets such as shipwrecks.

These tools are now being used for mapping benthic habitat and communities at various locations on the continental shelf off Nova Scotia. The prime areas investigated so far are the Gully, a large submarine canyon just east of Sable Island, and the Northeast Channel between Georges and Browns Banks. These mapping surveys are being conducted collaboratively with geologists from the Geological Survey of Canada, Atlantic (also at BIO), and the exact sampling transects and stations are selected to target specific features of interest using multibeam bathymetry and sidescan data. Campod has proven very useful for studying the abundance and distribution deep water corals. The videograb was recently used successfully to collect live specimens of deep water horny corals attached to large rocks.

The successful application of these tools requires precise navigation (i.e. dGPS, Trackpoint II acoustic tracking system, etc.) so that the location of imagery and samples is known within a few meters. In habitat mapping applications, it is important to be able to plot the data on other georeferenced data sets such as multibeam bathymetry and sidescan sonar.

To date, we have done little work on habitat classification like that done by Kostylev et al. (2000), but the information needed to do so is being collected by these tools. It is expected that this equipment, with proposed improvements, will play an important role in carrying out the proposed Canadian seabed resource mapping program (SEAMAP)(Anon 1999).

PROPOSED IMPROVEMENTS

Numerous improvements are being considered for these tools. Towcam is currently limited to a depth of about 200 m because of the length of the existing cable. We are exploring the possibility of obtaining a longer, fiber-optic cable to extend the operational depth range down to at least 500 m. This will most likely require an entirely new winch. Plans are also underway to add a high-resolution digital still/video camera(s) to the towfish. Stronger lights are also being considered so that the towfish can fly higher off the seabed and image a larger area. Both Campod and videograb are currently limited to an operational depth of less than 500 m. It is necessary to increase this depth to at least 1000 m for studies in submarine canyons and the continental slope, and this will require a new cable and probably a new winch. It has been suggested that we extend the legs on Campod so that photographic images when landed are larger to improve the quantitative assessment of biological communities (i.e. larger sampling area). We are also exploring the possibility of reducing the closure time on the videograb bucket to improve operation in high current situations.

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Figure 1. Photograph of the Towcam fish (1999 version) being deployed off the stern of the C.C.G.S. *Hudson.*

Figure 2. Photograph of Campod being deployed from the C.C.G.S. *Hudson* near the Hibernia oil platform on the Grand Banks.

Figure 3. Photograph of the videograb (equipped with DRUMS™) being recovered by the C.C.G.S. *Hudson.*