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Underwater Video Sleds: Versatile and Cost Effective Tools for Habitat Mapping

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Abstract

Underwater video sleds are useful to researchers through their capabilities in substrate mapping, acoustic groundtruthing, fish habitat research, reconnaissance mapping, and applications to fish stock assessment. Sleds can be designed to suit a variety of substrates and seafloor conditions. Typical camera sled designs include bottom contacting and bottom tending or sleds suspended in the water column. In general, underwater video sleds are easily modified and accessorized with lasers, lights, altimeters, tracking systems, and other electronic devices. Sled costs range from a few thousand dollars for a simple drop camera to hundreds of thousands of dollars for a state-of-the-art system. The trade-offs between design simplicity and potential data products are inevitable and result in difficult choices. Advantages of video sleds over other visual observation methods include portability, simplicity, low cost, resilience to extreme conditions, and ease of maintenance. However, video sleds can observe only small swaths of seafloor, can be difficult to track accurately, and have limited utility for examining small or detailed features. Although data are relatively easily obtained from most platforms, distilling what is observed on the screen to an accurate number in a spreadsheet is often time consuming and difficult for any underwater video technology. The importance of visualizing the objectives, data needs, statistical methods, and model application prior to choosing an underwater video sled or survey design cannot be overemphasized.

Introduction

Underwater video sleds and cameras have been applied to many important problems in fisheries and habitat research. There have been applications to substrate and vegetation mapping (Harper et al. 1998, Grizzle et al. 2005, Stevens and Connolly 2005), groundtruthing acoustic mapping (Cochrane and Lafferty 2002, Rooper and Zimmermann 2007), target fish identification for acoustic surveys (Somerton and Glendhill 2005; J. Boldt, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, 2007, pers. comm.), fish-habitat association studies (Cailliet et al. 1999, Williams and Leach 1999, Rooper et al. 2007), estimating fish abundance (Lauth et al. 2004b, Morrison and Carbines 2006), and estimating stock assessment parameters (Lauth et al. 2004a).

Here I review three basic designs for underwater video sleds, examine important features of the mapping technique and study area to consider when choosing a design, address the major technological topics to consider when designing an underwater video sled, and examine the important considerations in terms of sled capabilities and cost when designing a sled for a specific study.

Figure 1. **Typical bottom-contacting camera sled design. This camera sled, which was used to measure flatfish density in shallow water near Kodiak, Alaska (Spencer et al. 2005), has a low-light black-and-white analog camera with a surface feed through a coaxial cable and uses only ambient light. Photo courtesy of Mara Spencer and Al Stoner, Alaska Fisheries Science Center, Newport, Oregon.**

A primary consideration when designing an underwater video sled is the clear definition of study objectives, desired data, analyses that will be conducted, and specific problems associated with the study area. For example, a project using underwater video to assess flatfish abundance in soft-bottom areas would have very different data requirements (accurate estimate of area swept, video suitable for species identification, scaling lasers to assess size of specimens, etc.) from a project designed to groundtruth acoustically derived habitat maps (accurate positioning, video suitable only for habitat designation, ability to avoid seafloor obstacles, etc.). For this reason, the camera sled should be designed to collect the appropriate data for meeting the project objectives.

Sled designs: bottom contacting

The most commonly used design for underwater video sleds is a bottom-contacting system (Fig. 1). This type of sled maintains contact with the seafloor while being towed

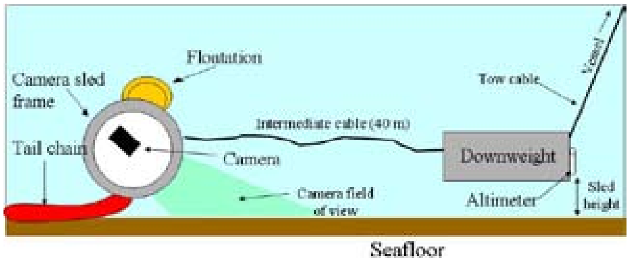


Figure 2. Diagram of a typical bottom-tending camera sled showing details of downweight (or depressor weight), altimeter, camera, and tail chain placement. This diagram is based on the Towed Automatically Compensating Observation System (TACOS) developed by Barker et al. (1999) and built by Harold Zenger, Alaska Fisheries Science Center, Seattle, Washington.

over the substrate. These sleds typically use skids or runners and are heavily weighted to keep them in contact with the seafloor. The size of these sleds is limited only by the ability to deploy and retrieve them successfully at sea, and they can be designed small enough for deployment from a small vessel (Spencer et al. 2005). On bottom-contacting sleds the cameras are typically mounted facing forward within the sled frame to protect the video equipment from damage.

The major advantage of a bottom-contacting sled over other sled designs is the platform stability. Since the sled is in contact with the bottom while being towed, the field of view of the video camera is usually determined by its height off the bottom (size of sled), camera lens characteristics, and camera angle of incidence with the seafloor. All of these items are easily measured on a bottom-contacting sled. Additionally, accessory equipment such as acoustic sensors are easily added without much modification to the basic design. Bottom-contacting sleds can be useful for many different types of projects and data collection needs, including habitat mapping applications. The major limitation of this sled type is that, although they work well in areas with smooth, soft, or gently sloping seafloors, when the bottom is irregular, rough, or rocky, they can easily get fouled on obstacles because their ability to come off the bottom quickly is usually limited by their heavy weight.

Sled designs: bottom tending

The second commonly used sled design is a bottom-tending sled (for example see Barker et al. 1999). The bottom-tending sled is suspended just off the seafloor by the counterbalance of weight and buoyancy (Figs. 2 and 3). The sled is designed with a heavy tail chain that results in a slight negative buoyancy in the water. Thus, when the sled is deployed, the tail chain drags on the bottom and, depending on the balance of buoyancy versus tail chain weight, the unit can be tuned so that it achieves neutral buoyancy at a specified distance off the bottom (in this case 1-2 m). A downweight, or depressor weight (Fig. 2), is often used to stabilize the sled from undulations caused by sea surface conditions. This makes bottom-tending sleds more accommodating in rough seas. The sled is typically towed at slow speed or allowed to drift with prevailing currents. Cameras are generally mounted looking forward or downward within the sled frame. As with bottom-contacting sleds, the size of the unit is limited only by retrieval and deployment ability and they are typically large enough that accessory equipment and sensors can easily be added to the frame.

Figure 3. A bottom-tending camera sled, the Towed Automatically Compensating Observation System (TACOS) being deployed from a fisheries research vessel in Seguam Pass, Alaska. The picture shows the position of camera (Tritech Osprey CCD color camera), parallel lasers, and halogen lights (1500 W total illumination) mounted on the sled. Photo courtesy of Harold Zenger, Alaska Fisheries Science Center, Seattle, Washington.

The advantage of this type of system is that it can be designed to work over rough or rugged seafloor. Because the sled is designed to be almost neutrally buoyant and only lightly contacts the seafloor (through the tail-chain only), its height can be adjusted quickly. This means the unit can come off the seafloor quickly if an obstacle is encountered. In addition, in some applications, the downweight can be fitted with a downward facing altimeter to measure distance of the sled off the seafloor or an altimeter pointing forward to perceive obstacles in front of the sled. With real-time altimeter output at the surface, the sled driver can respond to obstacles before the underwater camera components on the sled are put in danger.

The complexity of the design of bottom-tending sleds is their major disadvantage. In order to collect data over rough and rugged bottoms, this type of video sled is usually equipped with both real-time video and altimeter feeds to the surface. This increases the complexity of both the sled and topside electronics as well as the cabling and winch needs for the research platform. Data from the altimeter and

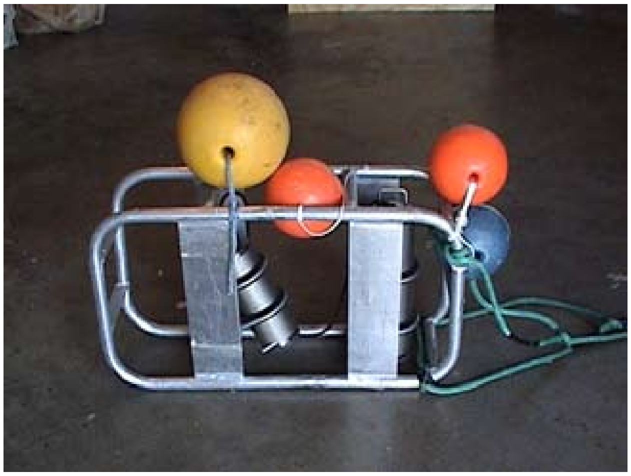


Figure 4. Drop camera system developed by Craig Rose and Scott McEntire at the Alaska Fisheries Science Center, Seattle, Washington. The camera is an off-the-shelf progressive scan camcorder linked to a strobe lighting system. Lights and camera are self-contained, power is supplied by batteries, and both are housed in titanium tubes. Photo courtesy of Scott McEntire.

camera need to be transmitted up the cable to the driver of the sled and power is typically transferred down to the sled to run cameras, lights, and altimeters. Also a substantial amount of tuning of the system is required to calibrate the sled to maintain a constant height off the seafloor. Adjusting the combination of weight and flotation to achieve neutral buoyancy at a set height off the bottom usually requires substantial field testing.

Sled designs: drop cameras

Drop camera systems are typically the simplest of sled designs (Lauth et al. 2007; Fig. 4). These cameras are usually light enough to be deployed and retrieved by hand or through simple hydraulic systems (such as small winches or power blocks). Simple drop camera systems may not have either weight or counterbalancing flotation measures used in the bottom-contacting or bottom-tending sled designs. Additionally, they are usually not towed along the seafloor, but instead are drifted with the current or anchored at a specific site on the seafloor. The camera is typically mounted within a sled frame needed to prevent damage to the unit. Drop cameras can usually be designed to be self-contained so that external power sources for lights and cameras can be replaced by battery power and video or image recording can be captured onboard.

An advantage of a drop camera system over the previous sled designs is its portability and simplicity. Drop cameras can be designed small enough to be handled aboard all sizes of research vessels and can be designed so that specialized equipment, such as dedicated winch systems, are not needed. This makes drop cameras especially useful from vessels of opportunity (such as commercial fishing vessels) and for exploratory research (Lauth et al. 2007).

Because of their small size, drop camera systems have reduced drag relative to bottom-contacting and bottom-tending sled designs. In areas of high currents, this can be a distinct advantage since the camera can reach the seafloor rapidly upon deployment with less weight attached. The size of cable or line can also be smaller with the lighter drop cameras, also reducing drag and increasing portability. Where the terrain is extremely rugged, drop camera systems with live video feed to the surface and a quick responding winch may be necessary in order to navigate seafloor obstacles (Lauth et al. 2007).

The major disadvantage of drop camera systems is the simplicity of data that can be collected from this platform. Typical at-sea conditions often make it difficult to maintain video contact with the seafloor since drop cameras have limited ability to self-regulate their depth. Wave action at the surface, as well as the speed of prevailing currents, each affect the quality of the video produced much more with drop cameras than with other designs. Simple drop cameras are also designed without accessory items such as lasers, altimeters, etc., which further limits the types of data collected.

Study site and mapping methodology

In seafloor habitat mapping applications, underwater camera sled designs are often influenced by both the type of mapping technology to be used and the expected features of the seafloor. Some prior knowledge of the expected seafloor complexity, rugosity, and hardness is useful when designing an underwater video sled. As described in the previous sections, not all types of sleds are appropriate for all types of seafloors. Besides seafloor complexity, a number of other physical characteristics should be considered in the sled design including current speeds, water depth, slope, and hardness of the seafloor.

Seafloor mapping is commonly carried out using video observations, grab samples, or acoustic methods. The most efficient method for creating large-scale seafloor maps utilize acoustic methodologies. In deepwater applications the devices typically used are single-beam echosounders (Ellingson et al. 2002), sidescan sonars (McRea et al. 1999, Rooper and Zimmermann 2007) or multibeam echosounders (Kostylev et al. 2001, Rooper and Zimmermann 2007). The acoustic maps are then groundtruthed to determine the habitat type using other technologies such as underwater video or grab samples. The principles of groundtruthing acoustic data can vary depending on the analysis method used. Two approaches to combining groundtruthing data and acoustic data can be described as "top-down" and "bottom-up" (Fig. 5). Top-down approaches are more commonly used and rely on a statistical method to cluster or group the acoustic data into areas of similar backscatter pattern (Cochrane and Lafferty 2002, Cutter et al. 2003). The seafloor characteristics are then

Table 1. List of basic camera sled components with some examples of high, medium, and low cost options. Also listed is common optional equipment used for measuring seafloor features, sled navigation, and tracking the camera sled.

Basic component	Low cost option	Medium cost option	High cost option
Camera	Black and white analog	Camcorder in housing	HD camcorders and high resolution cameras
Lights	Ambient lighting	Halogen lights in housing	HID lighting
Deployment and towing equipment	Nylon line or light cable	Armored cable with conducting wires and winches	Fiber-optic cable and winches
Power source	Battery		Vessel connection
Additional options			
Tracking systems	Layback angle		Pinger and hydrophone systems
Measuring systems		Parallel lasers	Stereo video
Navigation	Altimeter	Real-time video	Forward-looking acoustics

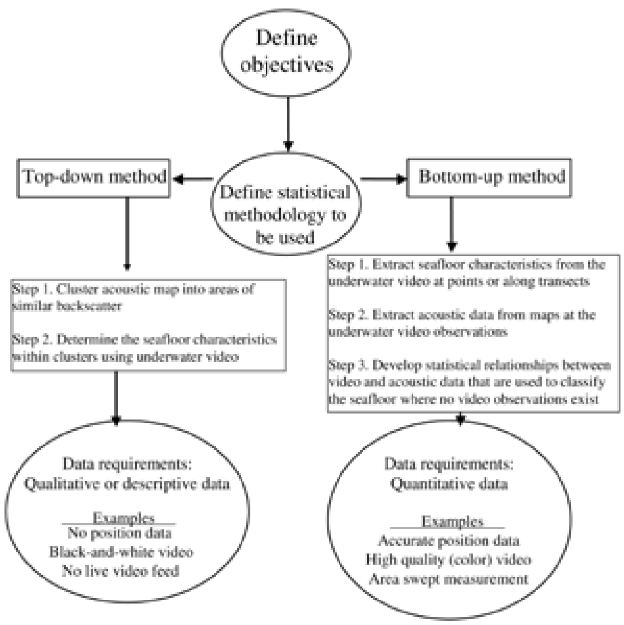


Figure 5. Schematic of process for developing and initializing a design of an underwater video sled based on defining objectives, determining the statistical methods that will be used in the analyses, and refining the data types needed to fit the methods.

determined by examining the groundtruthing data collected by the underwater video within the cluster, and the cluster is assigned the habitat type that is observed on the video. In a bottom-up approach, the data collected from the video groundtruthing are linked directly to the acoustic characteristics overlying the video path using a statistical model (Hewitt et al. 2004, Rooper and Zimmermann 2007). This model is then used to predict the seafloor characteristics in areas where only acoustic data are collected. Although both of these methods can provide accurate habitat maps, the groundtruthing data requirements from video are much different for the two methods.

In the case of top-down methodology, the data requirements for groundtruthing may be only a small number of samples within each cluster to determine the dominant habitat type in areas of similar acoustic characters. This in turn may only require a drop camera lowered to the seafloor to collect these samples. There may be little requirement for quantitative data. For example, accurate tracking of the underwater camera sled may not be required, since only a sample from within an area of similar acoustic return is needed.

In the case of bottom-up methodology, significantly more data may be required. In order to develop a statistical relationship between acoustic data and camera groundtruthing, more accurate knowledge of the position of the camera relative to the specific point on the acoustic map may be necessary. In turn, these analysis requirements should guide the development of the underwater video sled so that the correct data for the technique are acquired. Using a bottom-up approach will undoubtedly require more thought in the design and expense than the top-down approach. A rough seafloor application may limit the designs that can be used relative to an application on a smooth bottom. Visualizing the data products needed to complete the habitat map, and having a general idea of the type of seafloor that will be encountered prior to designing the underwater video sled, will facilitate the best use of funds and technology to address a particular habitat mapping application.

Technological considerations

The technical considerations for designing an underwater camera sled are numerous. The basic components that must be attached to the sled are listed in Table 1. For video camera work, the most important components of each sled are the frame, the camera and recording system, the lighting system, and the deployment and towing mechanism. For sled frames, the shape, strength, and materials used should all be appropriate to the study site characteristics and the data needs. As described previously, the basic sled shape can be determined by the type of seafloor expected to be encountered. Most of the sleds designed for work in Alaska waters have been made of various thicknesses of aluminum tubing (ranging from ½ to 3 inches in diameter). A sled composed of aluminum has many advantages in marine applications including being relatively lightweight, resistant to corrosion, high strength, and easy to manufacture or modify. However, aluminum can be expensive compared to other materials and more difficult to repair.

Camera and lighting systems must be compatible with one another, meaning the lighting system must provide adequate lighting for the camera. Traditionally, camera sled lights have been limited to filament type lamps in waterproof housings, which are susceptible to failure from vibration or contact with underwater objects. In more recent years, advanced lighting systems such as halogen, gas discharge, HID, and LED lights provide a more robust and dependable light source that requires less power for an equivalent amount of light at the sled. A number of commercial manufacturers produce underwater lights in housings rated to 6,000 m. There are innumerable options for cameras as well, although the technology incorporated into cameras and recorders marketed to the marine industry tend to lag behind many off-the-shelf consumer systems. These range from black-and-white cameras requiring little lighting to high resolution color cameras. Typically these cameras send the video signal to a recorder mounted on the sled or at the surface through an electromechanical cable.

It is common to use standard off-the-shelf video cameras installed in underwater housings for some applications. These systems are convenient because the video is recorded at the camera and it can be powered by batteries, which can eliminate the need for video and power connections to the surface. Using off-the-shelf technology also allows utilization of high-definition camcorders mounted inside an underwater housing. These units may require more light than specialized underwater cameras, but using a camcorder housing can provide the flexibility to easily change units as technology progresses or as cameras fail. Either of these camera options can be recorded to digital formats, although using a camcorder in a housing may be more straightforward. The length of the cable over which the signal is transmitted is a limiting factor for analog video, unless it is amplified at the source or converted to a more efficient format for transmission. A final consideration that can be important in choosing a camera system is choosing one with the capacity for capturing clear still-frame images. A camera that uses progressive scan, rather than interlaced video, produces much nicer still-frame images (Fig. 6).

The deployment, towing, and retrieval systems must also be accounted for in sled design. For the larger units (most bottom-contacting and bottom-tending), a specialized winch with an electromechanical or fiber-optic towing cable and corresponding slip-ring is required. Smaller drop cameras can utilize manual deployment systems using only nylon rope or a strong cable. Large winches with hydraulic

Figure 6. A comparison of still frame captures from analog video with interlaced frames (top panel) showing rockfish in boulder field, and digital video with progressive scan (lower panel) showing flatfish buried in fine sediment. Lower panel photo courtesy of Scott McEntire, Alaska Fisheries Science Center, Seattle, Washington.

or specialized electrical power requirements may limit the type of vessel from which a camera system can be deployed. Although tying into an existing hydraulic or electrical supply is relatively easy, it increases the cost and vessel requirements for a study.

Accessory equipment to consider

For habitat mapping applications, tracking systems, altimeters, and parallel lasers attached to the sled are useful. The ability to track the underwater video sled during data collection can be useful to avoid obstacles, keep the unit on a survey trackline, and provide position information for producing habitat maps. For groundtruthing habitat maps using a bottom-up approach to classification, accurate tracking of the video sled is necessary. In cases where the accurate position of the sled is not vital, tracking may be accomplished using the layback angle of the towing cable. Where accuracy is important, tracking is usually accomplished with an acoustic pinger attached to the sled sending position information to a hydrophone mounted on the research vessel. Commercially available software packages can then calculate the offset of the underwater sled from the position of the research vessel and the ship's global positioning system.

Altimeters can easily be mounted on underwater camera sleds or on downweights in front of the sled (Fig. 2). These can provide important feedback for navigating the camera sled to avoid collisions with the seafloor. Knowing the height of the camera sled off the seafloor can also enable researchers to calculate the area of seafloor viewed in the video.

In most cases, seafloor mapping techniques involve estimating the amount of each type of habitat encountered (i.e., Rooper and Zimmermann 2007). Using the percentage cover of the different types of habitats is a simple alternative where the area swept does not need to be known. For estimating the amount of each habitat type and scaling habitat features, it is important to have some measure of the size of the camera field of view or to have a mechanism for measuring features observed in the video. One alternative to resolve this issue is to use a bottom-contacting sled for which the camera is mounted a known distance off the seafloor (Lauth et al. 2004b). Using this method, the amount of seafloor in view can be continuously known based on the height, camera lens characteristics, and angle of incidence of the camera to the seafloor. Scaling lasers are often used on sleds that do not maintain a constant height off the seafloor. Using parallel and crossing lasers set a known distance apart, the area of seafloor viewed can often be measured (Kocak et al. 2004), although this can be difficult in complex habitats. Calibrated stereo-video (requiring two cameras) is also an option that can provide very accurate measurements of objects in the camera field of view, but this method requires significant additional analysis time (Harvey et al. 2004).

Recent advances in technology have allowed mounting of additional accessory equipment on larger underwater camera sleds. These have allowed for collection of additional data useful to habitat mapping. For example, a bottom-contacting sled used by researchers at the Alaska Fisheries Science Center has been outfitted with a DIDSON acoustic camera system (Moursund et al. 2003). This acoustic camera system affords the researchers a larger field of view than a traditional video camera (C. Rose, Alaska Fisheries Science Center, 2007, pers. comm.). Images are received from up to 9 m away from the focus of the acoustic camera, while the field of view of a standard underwater camera is only about 3 m width (although this varies with water depth, turbidity, etc.). The resolution in acoustic cameras is less than with video cameras, but there is no requirement for underwater lighting for illuminating the seafloor.

Because video sleds can be designed to be fairly large sized, many other types of accessories can be added to them, enabling collection of a wide spectrum of data types. Traditional fisheries acoustics instruments can be mounted on a camera sled, as well as current meters. Instruments to measure other habitat components such as phytoplankton, zooplankton, water salinity, and water temperature can also be easily mounted to an underwater camera sled (Fig. 7).

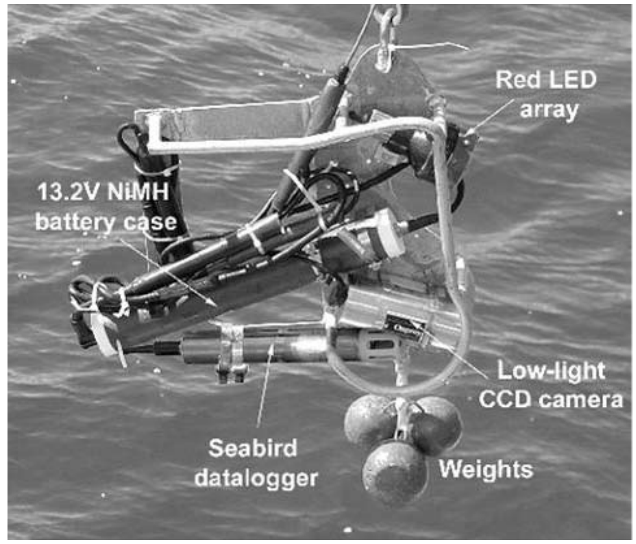
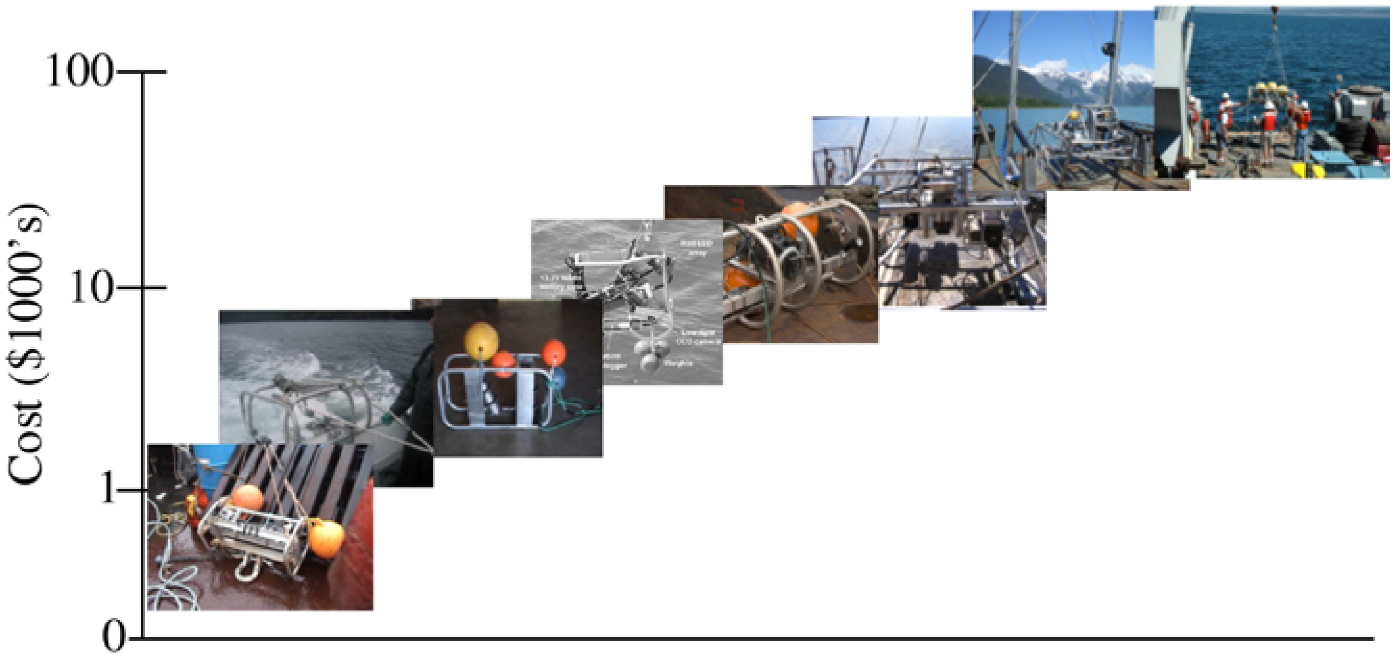


Figure 7. Drop camera system developed by Bob Lauth, Alaska Fisheries Science Center Seattle, Washington. The camera system utilizes a low-light camera and red LED lighting system. The system is battery powered, and a coaxial cable provides a real-time video stream to the surface. A Seabird microbathythermograph data logger records depth and temperature during deployment (reprinted from Lauth et al. 2007).

Cost of sled designs

As a general rule, the cost of a camera sled increases exponentially with the technology that is attached to it. Fig. 8 shows the approximate cost of eight camera sleds currently used for underwater research in Alaska, with the corresponding technologies that are utilized in their design. At the lower end of the spectrum ($1,000s) are drop cameras with cameras and lights powered by batteries. Also in this price range are cameras used for shallow water applications where ambient light can be utilized. In the middle cost category ($10,000s) are bottom-contacting, bottom-tending, and drop camera designs, which use specialized winch systems or have relatively expensive accessory equipment. In the upper cost category ($100,000s) there are sleds that have fiber-optic connections and provide extremely detailed pictures of the seafloor (Fig. 9).

The major drivers of cost for these eight examples are the quality of images obtained, tracking systems, winch and cable requirements, and the ability to measure seafloor features. An important cost determinant that may not be apparent in the design of a camera sled is the type of technical support required to operate the system. For fiber-optic, hydraulic, and some electromechanically based systems, technicians



Sled design type	Drop camera	Bottom contacting	Drop camera	Drop camera	Bottom tending	Bottom contacting	Bottom contacting	Bottom tending
Camera type	Analog underwater CCD	Analog underwater CCD	Progressive scan (camcorder)	Analog underwater CCD	Analog underwater CCD	Progressive scan (camcorder)	High resolution digital	High resolution digital
Lighting system	Halogen	Ambient	Strobe	Red LED array	Halogen	Strobe	Strobe	HID lighting
Deployment system	Light line or cable	Light cable with coaxial connection to camera	Light line or cable	Electric winch and electro-mechanical towing cable	Hydraulic winch and electro-mechanical towing cable	Hydraulic winch and heavy towing cable	Electric winch and fiber optic towing cable	Electric winch and fiber optic towing cable
Power source	Battery	Battery	Battery	Battery	Vessel (110 V)	Battery	Vessel (220 V)	Vessel (220 V)
Measuring capabilities/equipment	—	—	—	—	Parallel lasers	—	—	Parallel lasers

Figure 8. **Eight camera systems currently being used for habitat research in Alaska, listed by increasing estimated cost. System descriptions and photos (from left to right) courtesy of Scott McEntire, Mara Spencer, Scott McEntire, Bob Lauth, Harold Zenger, and Craig Rose (all of Alaska Fisheries Science Center, AFSC), Gregg Rosenkranz (Alaska Department of Fish and Game), and Bob McConnaughey (AFSC).**

Figure 9. Still image captured via fiber-optic connection to bottom-contacting camera system developed by Gregg Rosenkranz (Alaska Department of Fish and Game, Kodiak). The system utilizes a GigE Vision camera (1360 by 1024 pixels), four strobe lights, and a telemetry bottle mounted on the sled in separate pressure housings. Image data from the camera are sent to the towing vessel via an armored fiber optic tow cable over a gigabit Ethernet; the sled is towed at 3.5 knots and the camera collects images at 4 frames per second. Red laser points in the photo are 10 cm apart. Photo courtesy of Gregg Rosenkranz.

with special skills may be needed to build, deploy, and maintain the camera system on at least an annual basis.

Comparisons to other methods

Compared to other platforms for capturing underwater video for habitat mapping purposes, such as AUVs, ROVs, and manned submersibles, camera sleds hold some distinct advantages. Camera sleds can be designed to be very small and portable, allowing for easy shipping to a study site or use off of a wide variety of research platforms. The technology needed to create a simple camera sled is easily accessible to the untrained professional. One of the most important advantages of using camera sleds over other technologies is the cost. A simple camera sled can be constructed, deployed, and maintained for significantly less cost relative to an AUV, ROV, and manned submersibles. Well-designed camera sleds are also resilient to damage from hitting objects on the seafloor and other harsh conditions at sea because the important components (cameras, lights, etc.) are contained within a protective frame. Camera sleds can also be designed to be more resilient to high currents than ROV or manned submersibles. When components are simple, camera sleds can be easily maintained and updated with technological advances (i.e., moving to high definition from analog cameras) or with changing project objectives (i.e., from mapping applications to fish density estimation).

Recognizing the disadvantages of camera sleds for habitat mapping applications is important. Compared to manned submersibles, camera sleds have very small viewing swaths. It is fairly easy to control the position of ROVs and manned submersibles to examine specific objects; however, fine control of camera sleds is virtually impossible in all but the shallowest depths. In mapping applications, camera sleds have limited ability to discriminate between substrates such as sand and mud. In order to get an accurate classification of fine sediments, sleds must be combined with other types of sampling such as sediment grabs. With ROVs and manned submersibles, it is possible to collect these sediments using manipulator arms. These limitations can reduce or eliminate a camera sled's utility for a specific habitat mapping project.

Summary and conclusions

There are many trade-offs between total cost and the quality of data that must be considered when designing a camera sled. The most important consideration may be the need for qualitative or quantitative data. Designing a sled to collect qualitative data is much cheaper than the requirements for quantitative data. It is also important to consider the cost associated with completing the video or image analysis. The time needed to complete video analysis can exceed the time of actual video collection by an order of magnitude (Tissot 2008). Also, the cost of the research vessel or platform and level of technological support needed to maintain the sled throughout the data collection process must be considered. The logistics and cost of carrying out field research with an underwater video camera of any kind can be complex and difficult.

As a general rule, when considering a habitat mapping project using a video sled it is important to define the objectives early in the process. This will help to define the statistical methods that will be used in the analyses, which in turn will determine the data types needed to fit the methods. Finally, consider the limitations and characteristics of the study area to be mapped and then design an underwater camera sled to collect the appropriate data for the habitat mapping project.

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