SeeStar: an open-source, low-cost imaging system for subsea observations

François Cazenave, Chad Kecy, Steven H.D. Haddock; Monterey Bay Aquarium Research Institute

Abstract

Scientists and engineers at the Monterey Bay Aquarium Research Institute (MBARI) have collaborated to develop SeeStar, a modular, light weight, self-contained, low-cost subsea imaging system for short to long-term monitoring of marine ecosystems.

SeeStar is composed of separate camera, battery, and LED lighting modules. Two versions of the system exist: one rated to 300 meters depth, the other rated to 1500 meters. Users can download plans and instructions from an online repository and build the system using low-cost off-the-shelf components.

It utilizes an easily programmable Arduino based controller, and the widely distributed GoPro camera. The system can be deployed in a variety of scenarios taking still images and video and can be operated either autonomously or tethered on a range of platforms, including ROVs, AUVs, landers, piers, and moorings.

Several Seestar systems have been built and used for scientific studies and engineering tests. The long-term goal of this project is to have a widely distributed marine imaging network across thousands of locations, to develop baselines of biological information.

System Description

Housings

- 1500m depth rated, off-the-shelf aluminum housings manufactured by Group B inc,
- 300m depth rating, very low cost, easy to manufacture PVC housings

Camera module:

- uses go-pro Hero 3/3+
- camera is controlled by Arduino based microcontroller.
- can be programmed for time lapse photo or video using Arduino based microcontroller

Light module:

- uses off-the-shelf flashlight
- 7000 lumens, wide beam
- Controlled by camera module

Battery module:

- 14.4VDC, 4500mAh NiMH rechargeable battery pack
- capable of 3000 images, or 3 hours of video

Cost:

- Total cost of components: $2500

Applications

SeeStar is a very versatile imaging system that can be used for various applications: ROV, AUV, lander, pier, mooring, diver, etc. Below are a few examples.

Fishery surveys in Monterey Bay

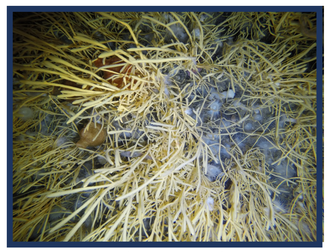
SeeStar was used for several fishery surveys in Monterey. The system was mounted to a tripod and lowered to the seafloor for a few minutes in numerous locations from depths ranging from 30 to 70 meters. The camera was programmed to record video. Dozens of locations were surveyed.

SeeStar was mounted on a tripod and lowered to the seafloor from a ship.

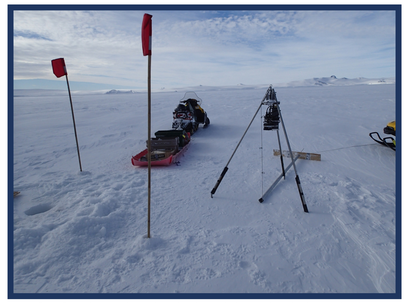
Rockfish photographed by SeeStar in Monterey Bay.

Benthic survey in Antarctica

As part of an ecological survey in McMurdo Sounds, Antarctica, Dr. Stacy Kim, of Moss Landing Marine Laboratories, deployed two SeeStar systems. The systems were mounted on specially designed tripods with spring loaded legs that could fit through a 10” hole in the sea ice. The tripods were lowered to the seafloor, to a depth of 200m, using a line. They were deployed for a duration of two months and recorded 1 image of the seafloor every 20 minutes.



The sea floor, McMurdo Sound, Antarctica, at 200m depth.



SeeStar is ready to be deployed through a hole in the ice.

Wave Glider deployment

SeeStar was mounted to a Wave Glider (autonomous, wave-powered surface vehicle). The purpose of was to see the effect of waves and wind on the vehicle during a 20-day deployment at sea. The camera took one image every 5 minutes.

One of over 5,000 images captured by SeeStar during a 20-day deployment on a Wave Glider.

Open Source Design: Build you own SeeStar

The design of SeeStar is protected by a Creative Commons Attribution-ShareAlike 4.0 license: anybody is allowed to copy, modify, and commercialize the design.

Most of the components are available off-the-shelf and assembly requires minimal technical skills.

Plans, assembly instructions, users manuals, 3D models, software can all be downloaded on the SeeStar repository:

https://bitbucket.org/mbari/seestar

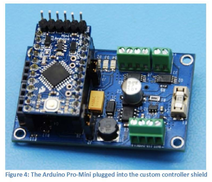


Figure 4: The Arduino Pro-Mini plugged into the custom controller shield

Figure 12: Exploded view of SeeStar camera module

Assembly Instructions

Attention was paid during the design of the SeeStar II Imaging System in order to minimize the need for specialized tools and parts. A few simple tools are all that is required to assemble the SeeStar camera module.

Tools and Parts Needed for Assembly

1. All parts for camera module (See appendix 11)
2. Flathead screwdriver, small
3. Phillips screwdriver, medium
4. Set of small Allen wrenches
5. Wire stripper (covering 20AWG to 24AWG)
6. Wire cutters
7. Needle nose pliers
8. Soldering iron & solder
9. O-ring grease (Type 55 MolyKote, Parker O-lube, or similar)
10. Four plastic standoffs (Male-female type, ½” long, 4/40 thread)
11. Four stainless steel allen screws (1/4” long, 4/40 thread)

Hero Bus Cable Assembly

The Hero bus cable connects the Controller Shield to the GoPro Hero camera. Only two pins are used: pin 12 (mode button) and pin 30 (ground). For the fabrication of the cable assembly, a specialized high pitch 30-pin connector is needed to plug into the Hero Bus on the camera. This is a low level signal and 24 AWG wire can be used. Extra care should be taken when soldering the wires onto the pins of the Ridax connector due to the tight pitch of the pins. The receiving connector on the Controller Shield is a 2-pin 0.025” square post socket. The other end of the cable needs only be attached to two straight pins like the one shown in Figure 6.

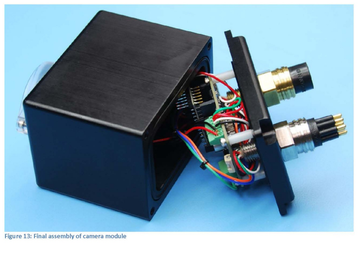
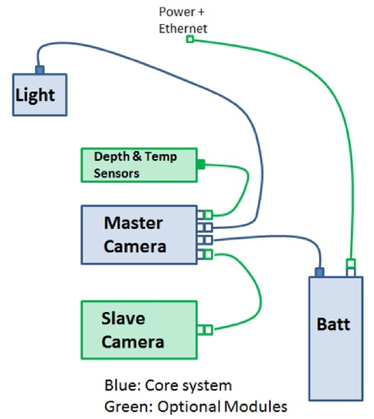


Figure 13: Final assembly of camera module

Excerpts from the SeeStar assembly manual that can be downloaded free of charge.

Next generation SeeStar

We are currently developing SeeStar III which will be a far more capable imaging system. First, the gopro camera will be replaced by a higher quality imager, especially suitable for low light imaging. Seestar will be able to support external sensors to log environmental data such as pH, oxygen, temperature, and depth. Data will be synchronized and recorded alongside the images or video. Other optional features may include a second camera module for stereo imaging and the use of a tether for real-time video. We envision SeeStar III as a modular system to which the user can add or remove subsections as needed by their particular science requirements. For example, by adding a tether with live view, SeeStar III can be deployed in near shore environments with video being streamed and recorded manually. Or, particular sensors can be added to give the science user contextual data to give a more complete picture of the conditions being recorded.



Block diagram of the next generation SeeStar

Acknowldegements

THE David & Lucile Packard Foundation

We thank the David and Lucile Packard Foundation for their generosity in funding work at MBARI.