SeeStar: an open source, low-cost and modular camera system for subsea observations

François Cazenave, Steven Haddock, Chad Kecy, Mike Risi (Monterey Bay Aquarium Research Institute).

Time series of biological data are often difficult to establish using automated instruments and methods. Phenomena like jellyfish blooms, seastar wasting syndrome, urchin barrens, and other ecosystem changes all require photographic data to document. One way to generate these datasets is through camera deployments, as is often done in terrestrial research. Imaging systems that can operate in challenging marine environments, though, are often expensive, bulky, or unable to provide illumination that is synched with the image capture.

To solve these problems, we have developed SeeStar, a modular, light-weight, self-contained, low-cost imaging system which can be deployed in a variety of scenarios and on a variety of platforms, including ROVs, AUVs, towed nets, piers, moorings, and even on landers beneath sea-ice. Originally designed to image macroplankton, SeeStar has turned out to be a useful tool for a wide range of applications, from monitoring experiments on the seafloor, to recording video from an autonomous underwater vehicle (AUV).

SeeStar draws from off-the-shelf components as much as possible and openly available software and schematics. It is composed of a camera module, a battery module and a lighting module. The housings are made of 3” schedule-40 PVC pipe (3.5” outside diameter), and polycarbonate windows, which are inexpensive and readily available materials. Very little machining is required to manufacture the housing, while assembly and maintenance require only basic tools. The lighting module has an optional anodized aluminum housing to dissipate heat during applications when the light must stay on for a long time (e.g. video). The system is rated to 300m depth.

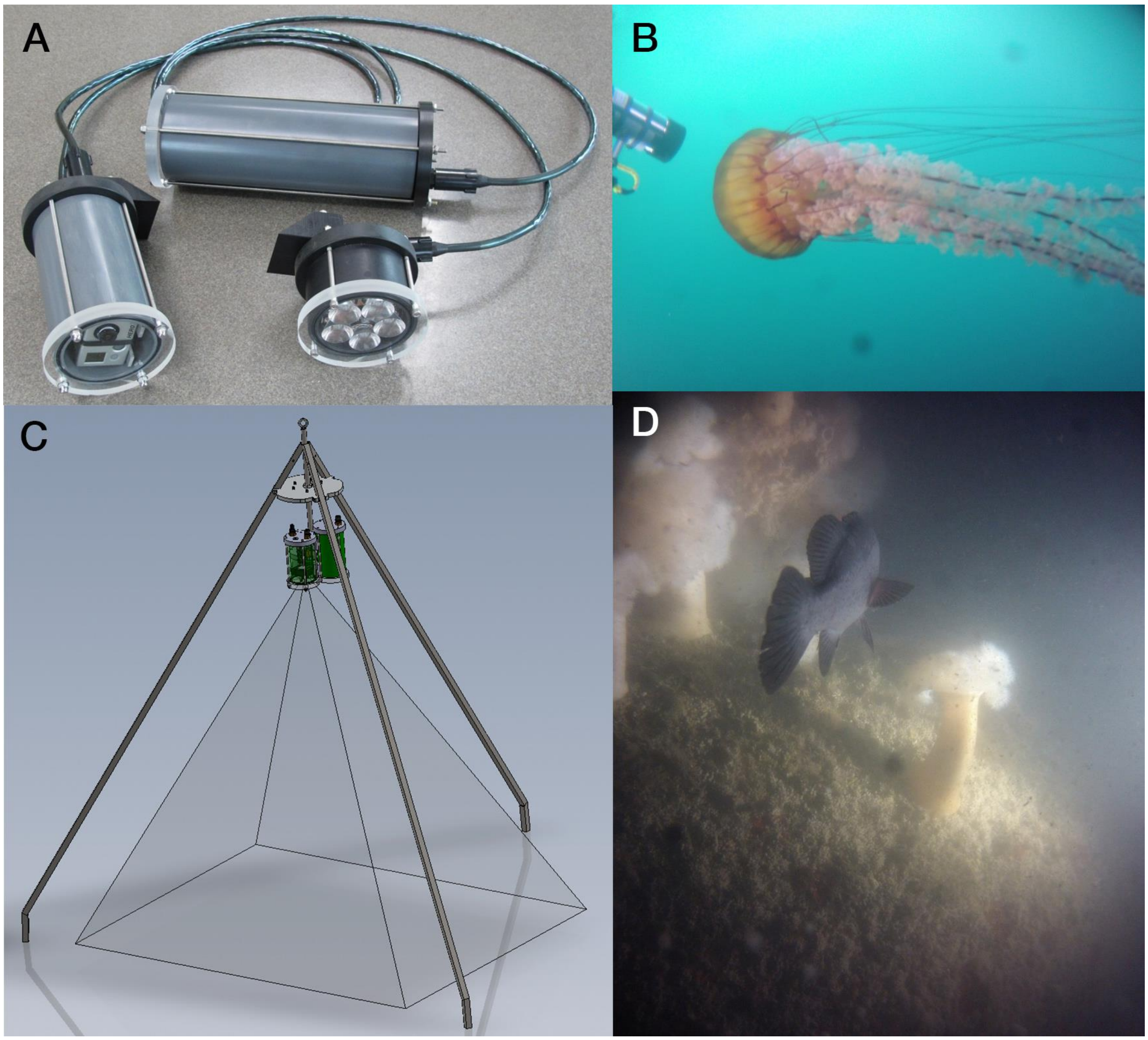
The camera housing as currently configured contains a Gopro Hero 3+ camera, controlled by a custom controller board. This board is responsible for powering both the camera and the lighting module, so that they can be synchronized. It operates from the main battery bus voltage and provides the lower voltages needed by both itself and the camera. The onboard PIC24 microcontroller communicates directly to the camera and is responsible for all system control. The controller board also features a flash memory device for data storage, a real-time clock and watch battery for accurate time keeping, and RS232 transceiver for off-board serial communication of commands. The images are stored on a SD card and can be downloaded via a USB port or wirelessly.

The light module exists in two versions, with 5 or 9 LEDs and with outputs of 2000 and 3675 lumens respectively. The LEDs are mounted on a custom metal core printed circuit board. The battery housing contains 16 NiMH rechargeable batteries for a nominal bus voltage of 19.2 volts. For extended deployments, alternate power sources can be utilized such as larger secondary batteries or primary batteries

In order to make this technology easily accessible and inexpensive to anyone, all design documents and tutorials are posted online. Engineers are currently working on improvements to the system and investigating the possibility of using other cameras with higher resolution.

The system was tested extensively in Monterey Bay and used for several experiments. For example, it was deployed on a reef, at 20m depth, collecting 2000 images over 3 days. It was deployed with an ROV to a depth of 300m, and it was mounted to a long-range AUV for week-long deployments. A one-year deployment under the sea ice in Antarctica is planned for the coming year. Long-term installations on several piers as part of the Ocean Observing System Network are also being prepared.

This paper will describe the design of the system, including mechanical engineering, electrical engineering, and software. It will describe some example of applications and provide a preview of future improvements to the system.



A: The SeeStar system includes a battery module (top), a camera module (left) and a light module (right).

B: Picture of a jellyfish taken with SeeStar while mounted on ROV Ventana in Monterey Bay.

C: A special spring loaded tripod has been developed to deploy SeeStar through a 10” hole in the sea ice in Antarctica

D: Rock fish on a reef in Monterey Bay, at 20m depth.