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Extended abstract

Development of a deep-water camera system capable of deployment on fishing gear

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Deep-water camera development

Between 2006 and 2014, the Australian Antarctic Division (AAD) undertook an extensive study into the vulnerability of benthic habitats to impact by demersal fishing gear, including otter trawl, demersal longlining and pots (Welsford et al., 2014). A major component of the study was to examine the fishing 'footprint' of the different gear types to determine the extent of their interaction with benthic habitats. This was comparatively easy to estimate for trawl gear, but required that the lateral movement of demersal longlines and the drag of pots be quantified. A variety of mechanical and electronic methods, including inertial sensors and drag wheels, were trialled, but ultimately it was determined that only underwater video could provide the visual evidence of movement that would satisfy critics of the study.

The benthic impacts camera system (BICS) was developed to meet a very specific set of requirements. The camera would need to be simple to operate, small enough to be attached to each of the gear types, be able to function to at least 2 000 m depth, have its own light source and autonomously record several hours of footage to capture the hauling event of fishing gear.

The BICS consisted of four pressure housings (two LED lamps, a camera and a main housing containing the battery, control electronics and a digital video recorder), which could be mounted in different crash frames for each gear type. The crash frame for mounting the camera to demersal longline was the most difficult to design. Ultimately, a cylindrical frame with a spring-loaded articulated arm was developed. The arm could fold down to fit through the small shooting window of the longline vessels. At depth, a hydrostatic release operated, freeing the articulated arm, deep-sea floats then raised the crash frame so that the camera had a view along the line (Figure 1).

The longline crash frame was also used to attach the camera to pots and alternative frame designs were developed to allow the camera to be attached to the headline of otter trawl nets and to the beam of a beam trawl (see Kilpatrick et al., 2011).

The modular construction of the BICS allowed alternative cameras to be used. Although colour cameras were available, in most cases monochrome cameras were used for their superior sensitivity and dynamic range in low-light conditions. The BICS was successfully used to gather footage from each of the gear types and allowed the quantification of lateral movement of demersal longlines and the drag of pots on the sea floor (Figure 2).

One of the findings of Welsford et al. (2014) was that benthic taxa such as gorgonians, demosponges and bryozoans which sit relatively high above the sea floor and are brittle or tear, had much greater probability of suffering lethal or sub-lethal damage than smaller in-fauna and soft-bodied invertebrates which are often buried in soft sediments. The study recommended further developments of the camera, including an upgrade of the video technology and to expand the sampling of under-represented ecoregions in the Southern Ocean such as East Antarctica.

By 2015, video camera technology had significantly advanced. Small and relatively inexpensive action cameras like the GoPro ® had entered the market. These cameras are fully digital and capable of recording and storing many hours of footage on board, eliminating the need for additional recording hardware. They also have markedly better resolution, higher sensitivity under low-light conditions and a larger dynamic range. The availability of commercially manufactured pressure housings simplified the process of protecting the camera. With a concurrent improvement of LED lighting, new deep-water camera systems could be considerably more compact than the original BICS yet with improved capabilities. The new AAD deep-water camera system comprises three small pressure housings: a housing for an LED light at the top (derived from an inexpensive bicycle light), an electronics and battery housing in the middle section and a commercially produced pressure housing (Group B Inc. Go Benthic) containing a GoPro Hero 4 Silver action camera at the bottom (Figure 3).

The footage obtained using the GoPro-based system is a significantly higher quality than was possible with the previous camera system. Recording was now in colour at full HD resolution (1920 × 1080 pixels), at a higher frame rate and with lower levels of illumination. One notable improvement was the marked reduction in back-scatter from particles in the water, which made the video footage appear much clearer. A further benefit was that the GoPro could be configured to capture 12 mega-pixel still images (Figure 4) at regular intervals, which are far superior to frame grabs from motion video.

The latest development of the AAD deep-water camera system consists of a single housing, designed to withstand 3 000 m depths. The housing is machined from acetal plastic, with high density polyethylene bumpers at each end (Figure 5). Internally, the same GoPro camera and LED lamp have been used, however, the battery capacity has been doubled, resulting in up to eight hours of continuous operating time. A comparison of the features of each generation of the cameras is listed in Table 1.

At present, a combination of camera systems are deployed from Australian fishing vessels in the toothfish fisheries at Heard Island and McDonald Islands, Macquarie Island and in the Ross Sea and East Antarctica. They have also been deployed from French vessels in the Kerguelen Islands fishery and from British vessels in the southeastern Atlantic.

Development of video analysis software

Although only a few seconds of footage or even a still image is required to expand our understanding of seabed type and the presence or absence of large structure-forming ecotypes, the current version of the AAD deep-water video camera can capture up to eight hours of video on each deployment. Much of this footage is repetitive, but occasionally larger organisms move into view. As it is not practical to view all of the footage in real-time, AAD is currently developing software which can process the video files and quantify pixel differences which indicate movement between successive time periods of video. This information is plotted as a histogram of relative movement against time (Figure 6). The user can then move through the video file to the appropriate time stamp to determine whether the movement that was indicated might have related to an event of interest.

Development of new camera systems has allowed collection of data from new fisheries and areas, building on the work of Welsford et al. (2014). Continuing this work in future will provide more opportunity for both mapping the habitat of previously unseen sea floor as well as allowing the assessment of risk posed by fishing activities on sea floor ecosystems.

The designs of both of the recently developed cameras, and the source code for the video analysis software, can be made available to researchers on request to AAD.

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References

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Welsford, D.C., G.P. Ewing, A.J. Constable, T. Hibberd and R. Kilpatrick. 2014. Demersal fishing interactions with marine benthos in the Australian EEZ of the Southern Ocean: An assessment of the vulnerability of benthic habitats to impact by demersal gears. Final Report FRDC project 2006/042. Australian Antarctic Division: 258 pp.

Table 1: Comparison of features of the three generations of AAD deep-water video cameras.

	Benthic impacts camera system	AAD deep-water video system V1.5	AAD deep-water video system V2.0
Depth rating	>2 000 m	~2 600 m	~3 000 m
Weight in air (incl. crash frame)	23 kg	6 kg	14 kg
Camera	Analog colour or monochrome lipstick camera (520 TVL resolution)	GoPro Hero 4 Silver or Black (up to 4K resolution)	GoPro Hero 4 Silver or Black (up to 4K resolution)
Video file format	MPEG2, 720 × 576 px, 25 fps	MP4, 1920 × 1080 px, ~30 fps	MP4, 1920 × 1080 px, ~30 fps
Recording time	~8 hours	~ 4 hours	~ 8 hours

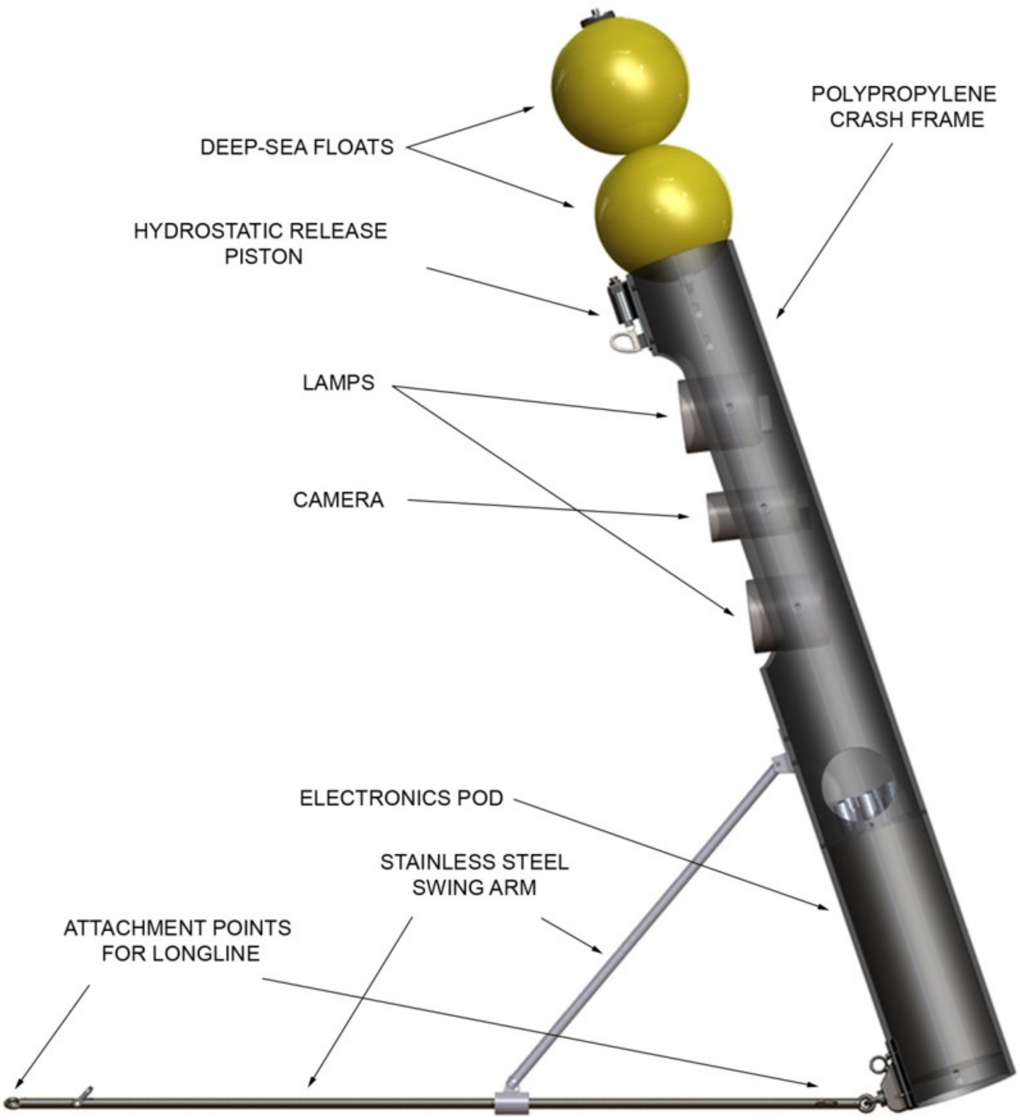

Figure 1: The BICS installed into the demersal longline crash frame. The arm of the crash frame is in the open position allowing the camera a view along the line.

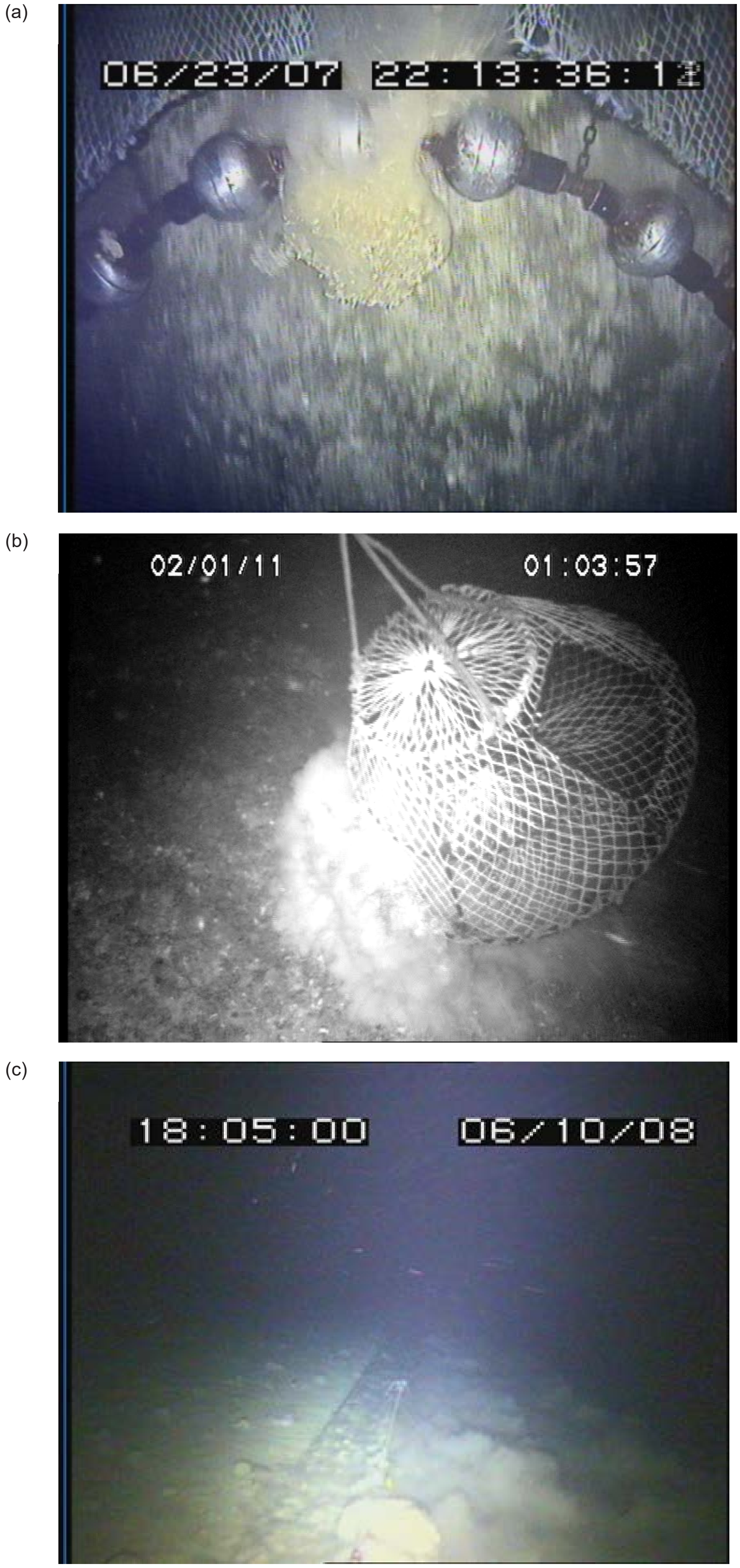

Figure 2: Examples of video screen captures from the BICS, taken from cameras attached to each of the three gear types: (a) demersal trawl, (b) pot and (c) demersal longline.

Figure 3: AAD deep-water camera system, version 1.5.

(a)
(b)
(c)

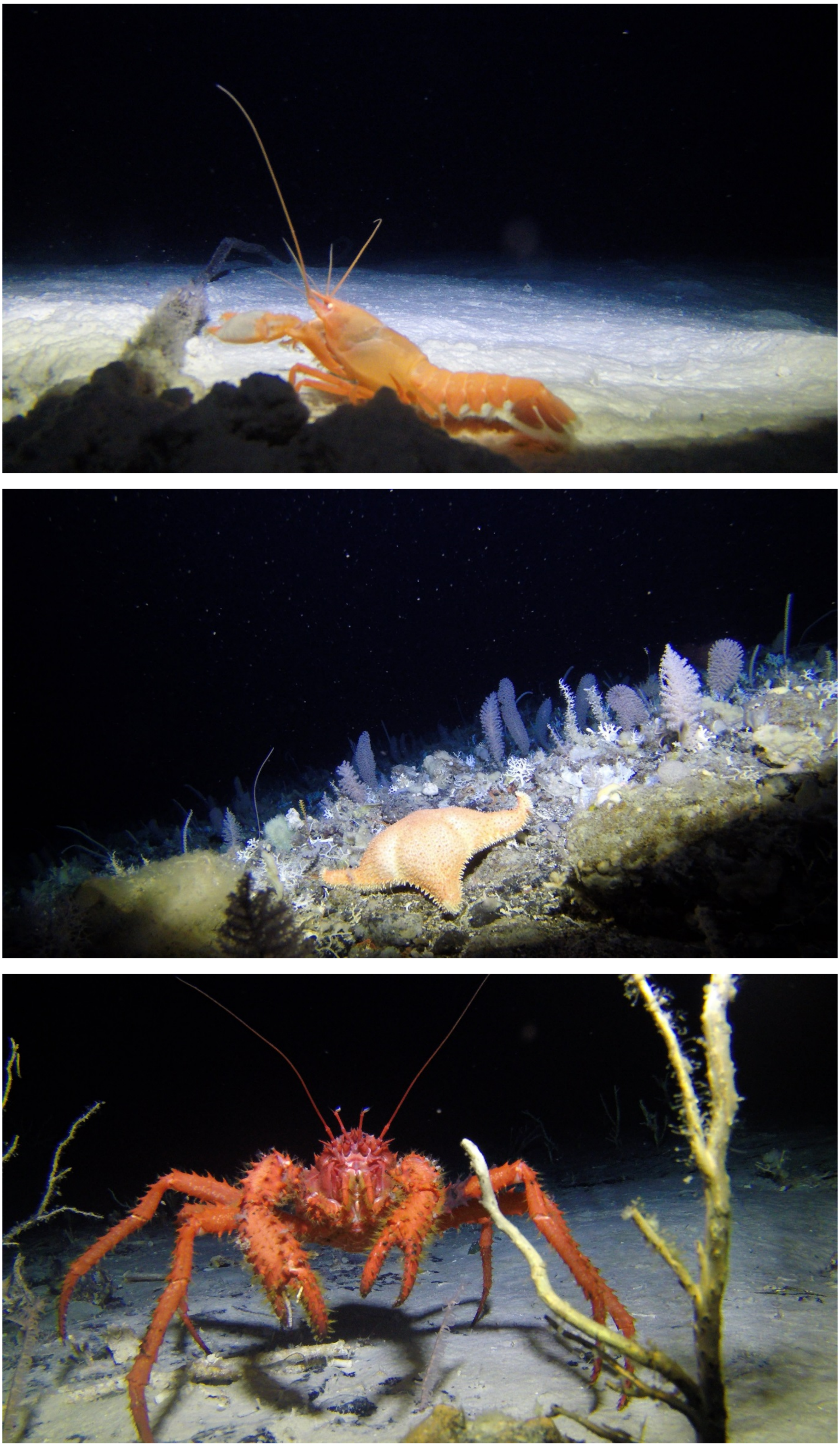

Figure 4: Examples of still images from the AAD deep-water camera: (a) Bellator lobster (*Thymosides grobovi*), (b) seastar (*Porania antarctica*), (c) king crab (*Paralomis aculeata*).

Figure 5: Version 2 of the AAD deep-water camera system.

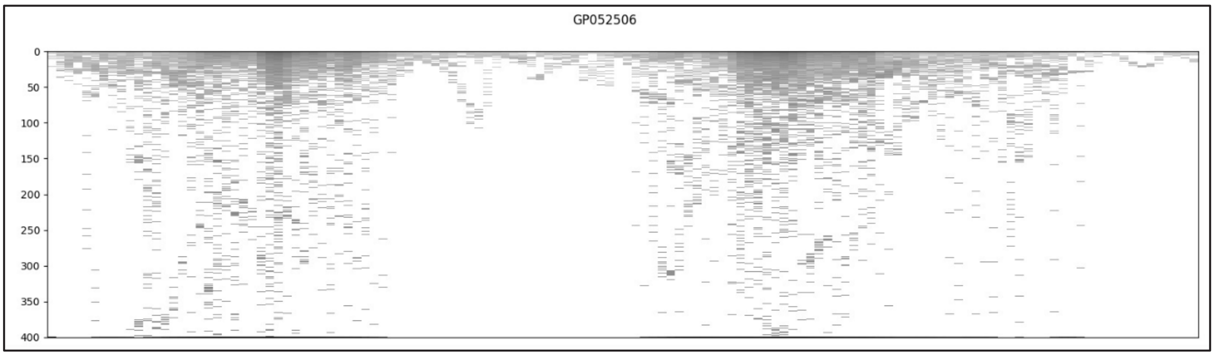

Figure 6: Histogram of relative movement between successive time periods of video. The video timestamp is plotted on the x-axis and relative pixel differences are plotted on the y-axis, in descending order. Periods of comparatively little movement are indicated near the top of the histogram, with periods showing greater movement towards the bottom.