Baited underwater video methodology testing: improvement of still photo image quality

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By:

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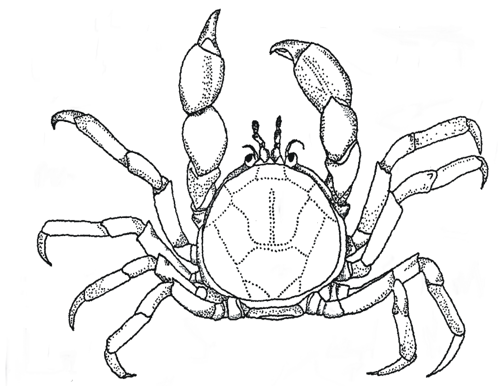

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1.0 Introduction

Baited underwater video (BUV) was developed by Willis and Babcock (2000) in response to difficulties in accurately sampling a fish species whose behavioural reactions to divers vary markedly between sites. The authors stated that fish feeding by visitors to the Leigh Marine Reserve resulted in snapper exhibiting diver-positive behaviour at some sites, while elsewhere in the reserve they were wary of divers, and outside the reserve they actively avoided divers. Willis and Babcock (2000) stated that the use of a remotely deployed sampling method eliminated this source of bias.

BUV methodology has seldom been used in New Zealand or elsewhere, but has potential for use in areas where diver counts are difficult or dangerous. Davidson and Richards (2005) applied the technique at two marine reserves in Nelson/ Marlborough and reported difficulties when using the traditional BUV methodology in low visibility conditions (i.e.< 4 m horizontal distance). This problem had not been encountered in northern New Zealand where water clarity distances were considerably higher. In response, Davidson and Richards (2005) suggested changes to the methods that potentially enabled BUV to be applied successfully in low water clarity conditions. The authors did not however, have time or resources to test the new methods at that time.

The aim of the present small scale study was to test the new methods suggested by Davidson and Richards (2005). In order to test the suggested methodological changes, we collected video footage and photo frames in (a) the laboratory situation and (b) in a variety of water visibilities along the Abel Tasman coastline within the Tonga Island Marine Reserve. Photo frames were "grabbed" using the standard methodology from video footage, however, additional frames were "directly captured" from the underwater camera using new methodology. The quality of these images was compared between the two methods to determine if improved image quality could be achieved.

We conclude the report with discussion as to how the new methodology could be used as part of a monitoring programme for Pohatu Marine Reserve, a reserve that traditionally has low water visibility (Davidson *et al*. 2001). Occasionally Pohatu and control sites are subjected to good water clarity, however, these events occur seldom and are usually short in duration. It is hoped that existing BUV methodology can be adapted using the new methods for use in lower visibility conditions that are often present at

Pohatu and particular other marine reserves in New Zealand.

2.0 Methods

BUV data were collected in the laboratory and from the field. Laboratory video and still images were collected under relatively dark conditions. A variety of objects including the reference stand were captured in images using the old and new methods.

Field data were collected on the 13th December 2005 from three sites located in the Tonga Island Marine Reserve (Figure 1). Field sample sites were selected to provide a variety of water visibility conditions. At each site, water depth was recorded and linked to the photo frames and video for later analysis.

The BUV system used in the present study consisted of an Ikelite EV-CAM Hz colour camera mounted on a modified alloy tripod 115 cm above the substratum facing straight down (Plate 1). A commercial bait holder (containing 400g of canned fish cat food) was attached to the square base of a stand attached to the tripod so that it lay near the centre of the camera's field of view. The base reference stand was exactly 400 mm square allowing spatial calibration of digitised images and accurate estimation of the lengths of fish responding to the bait (Willis and Babcock 2000, 2001; Willis *et al.* 2000; Davidson and Richards 2005).

One 30 minute deployment was made on soft, or combinations of soft and hard, substrata at each field site. When deployed on soft substratum, the camera was placed immediately adjacent to or within 5 m of the reef habitat. The BUV assembly was lowered to the sea floor from an aft- and stern-anchored vessel.

Directly captured photograph images were collected over a 25 minute period, followed by collection of a 5 minute video tape. The baited station was monitored on a LCD screen on board the survey vessel using a Sony DC-TRV25E PAL 1 mega pixel fully digital colour camera.

Laboratory and field collected still images collected using the two capture methods were compared and discussed with respect to ease and accuracy of analysis.

Plate 1. BUV apparatus consisting of a modified tripod with attached reference square and commercial bait container.

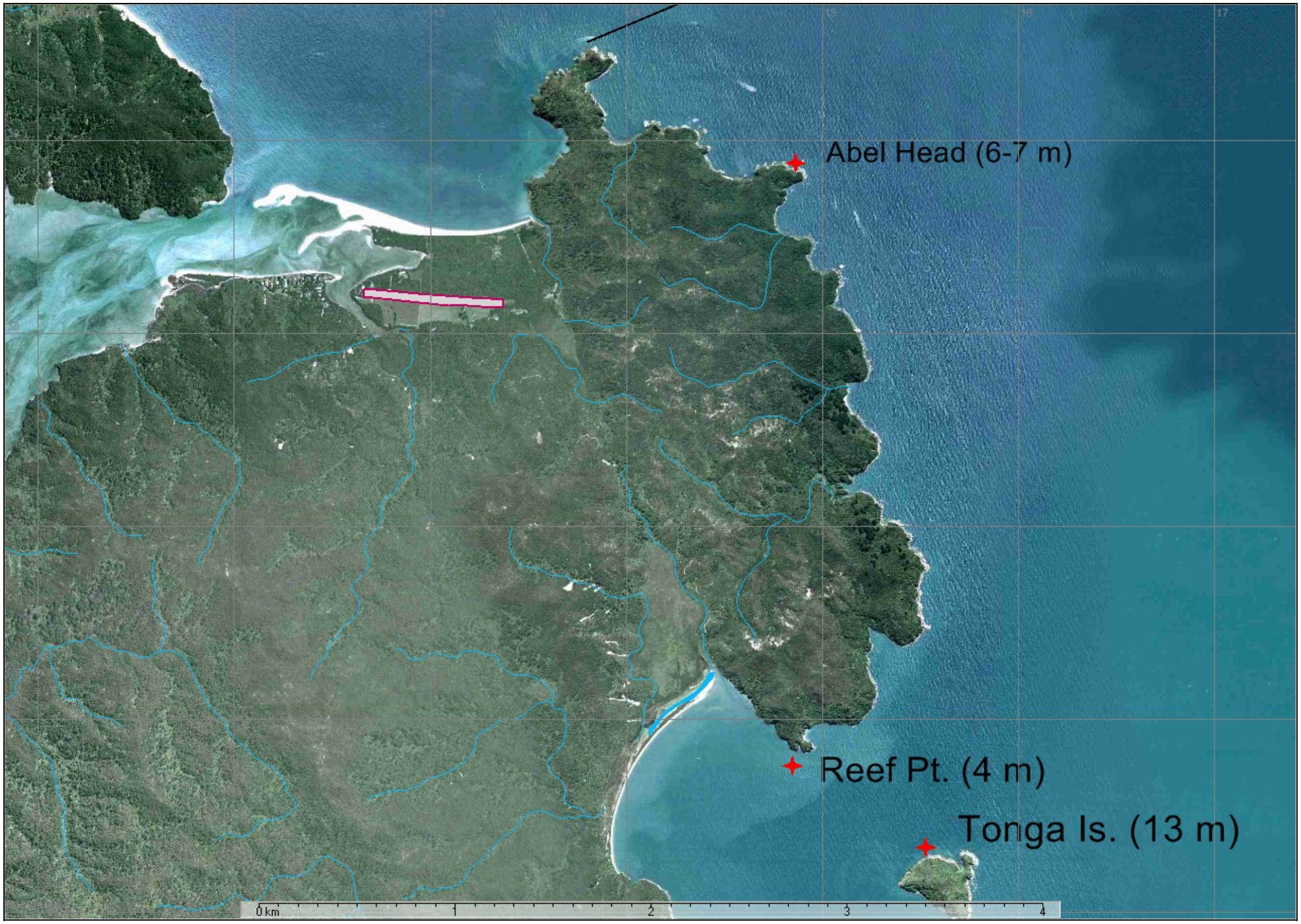


Figure 1. Location of BUV sites (red stars) and their depths within the Tonga Island Marine Reserve.

3.0 Results

3.1 Laboratory images

All images collected from the laboratory are distorted as the camera lens is designed for underwater situations. These images are however, useful in understanding the differences in image quality obtained by the two methods as fewer variables such as water clarity and depth need to be considered.

A 1 minute 42 second video was collected in the darkened laboratory. A total of nine images were frame grabbed from the digitised video footage while a total of nine still photographs were directly captured from the underwater camera.

Photographic images collected directly to the camera were between 142 and 149 kilobytes compared to 397 kb for the images grabbed from the digitised video footage. The dimensions of the images collected directly from the camera were larger (640 x 480 mm) compared to the images collected from the video (352 x 288 mm) (Photos 1 and 2).

At the original photograph dimensions obtained using the two methodologies, the images appear similar. When the images are enlarged to a standard size (15 x 11 cm) to enable measurement of fish, it is clear that the photograph collected from the digitised video tape is of considerably lower quality (Photo 4) than the photograph collected directly from the camera (Photo 3).

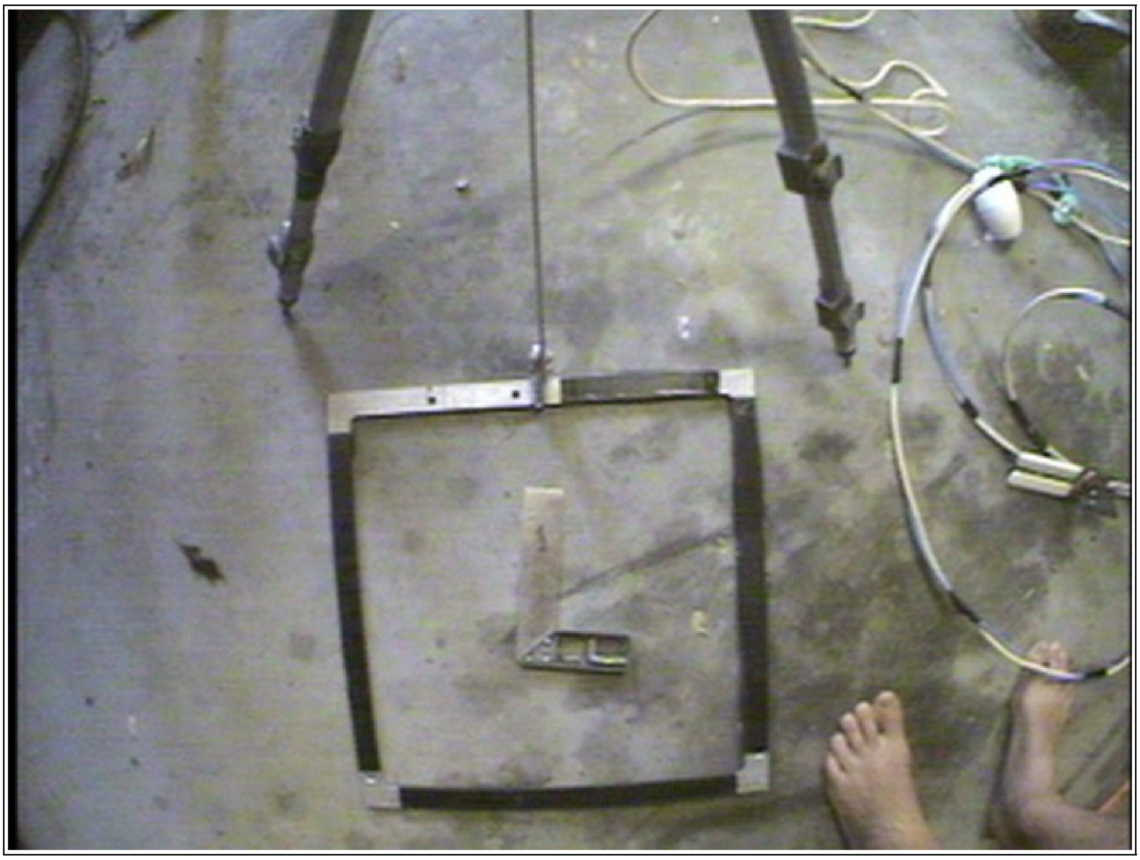
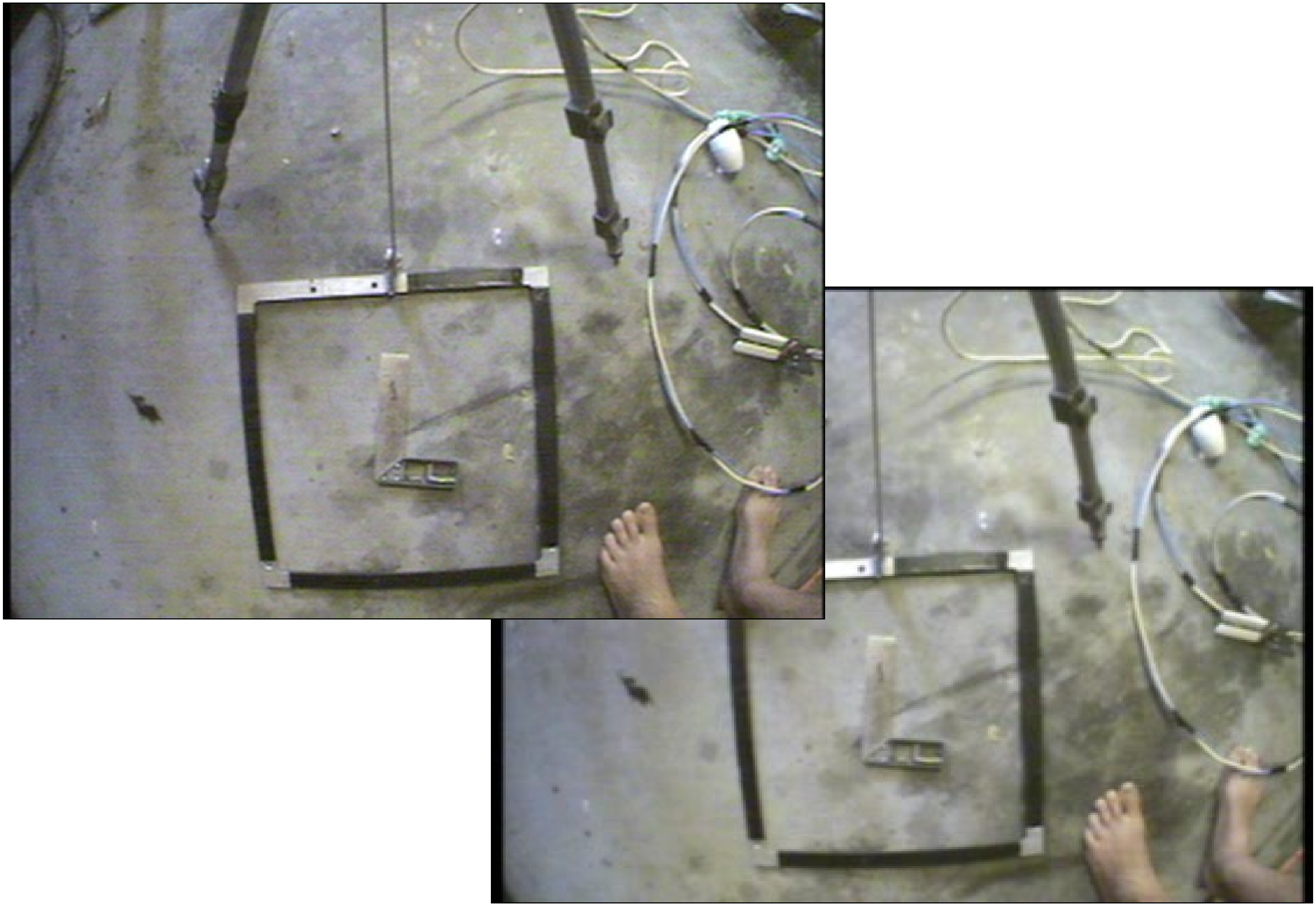


Photo 1. Raw image captured directly from underwater camera.

Photo 2. Raw image frame grabbed from digitised video footage.



Photos 3 (left) and 4 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph.

3.2 Field collected images

The three sites in Tonga Island Marine Reserve provided a variety of water clarity conditions enabling a comparison between images collected using direct capture and traditional video footage frame grab. During the field work, Abel Head had the best water clarity followed by Tonga Island and lastly Reef Point where water visibility was poor (<3 m estimated distance) (Table 1).

Table 1. Summary of sample sites within Tonga Island Marine Reserve.

Site	Depth (m)	Water clarity	Frame capture	No. photos
Abel Head	6-7 m	5-6 m	Direct capture	21
			Video frame grab	7
Tonga Island	13 m	3-4 m	Direct capture	29
			Video frame grab	5
Reef Point	4 m	2.5-3 m	Direct capture	19
			Video frame grab	9

Photographic images collected directly to the camera were between 121 and 130 kilobytes compared to 397 kb for the images grabbed from the digitised video footage. The original dimensions of the images captured directly from the underwater camera were larger (640 x 480 mm) compared to the images frame grabbed from the video (352 x 288 mm) (Photos 5 and 6, 11 and 12, 17 and 18).

At the dimensions obtained using the two methodologies, the images appear similar. When the images are enlarged to a standard size (15 x 11 cm) to enable measurements of fish, it is clear that the photographs collected from the digitised video tape are of lower quality (Photos 8, 14 and 19) compared to the photographs captured directly from the camera (Photos 7, 13 and 18). Once images have been enhanced using Adobe Photoshop, the differences between image quality become greater. This is especially apparent for the low water clarity sites at Tonga Island (Photos 15 and 16) and Reef Point (Photos 21 and 22). The video grab images appear fuzzy and the location points for the tip of the fish head and the tail are poorly defined. In contrast, the direct capture images are sharper and the fish head tip and tail tip are easier to identify on the screen.

The same photograph enhancement process was applied to all photographs using Adobe Photoshop. For the very poor water visibility photos collected from Reef Point, the level of enhancement possible was greater for the direct capture photos compared to the video frame grabbed image (i.e. Photo 21 versus 22), however, both images are unsuitable for fish measurements due to the poor water clarity.

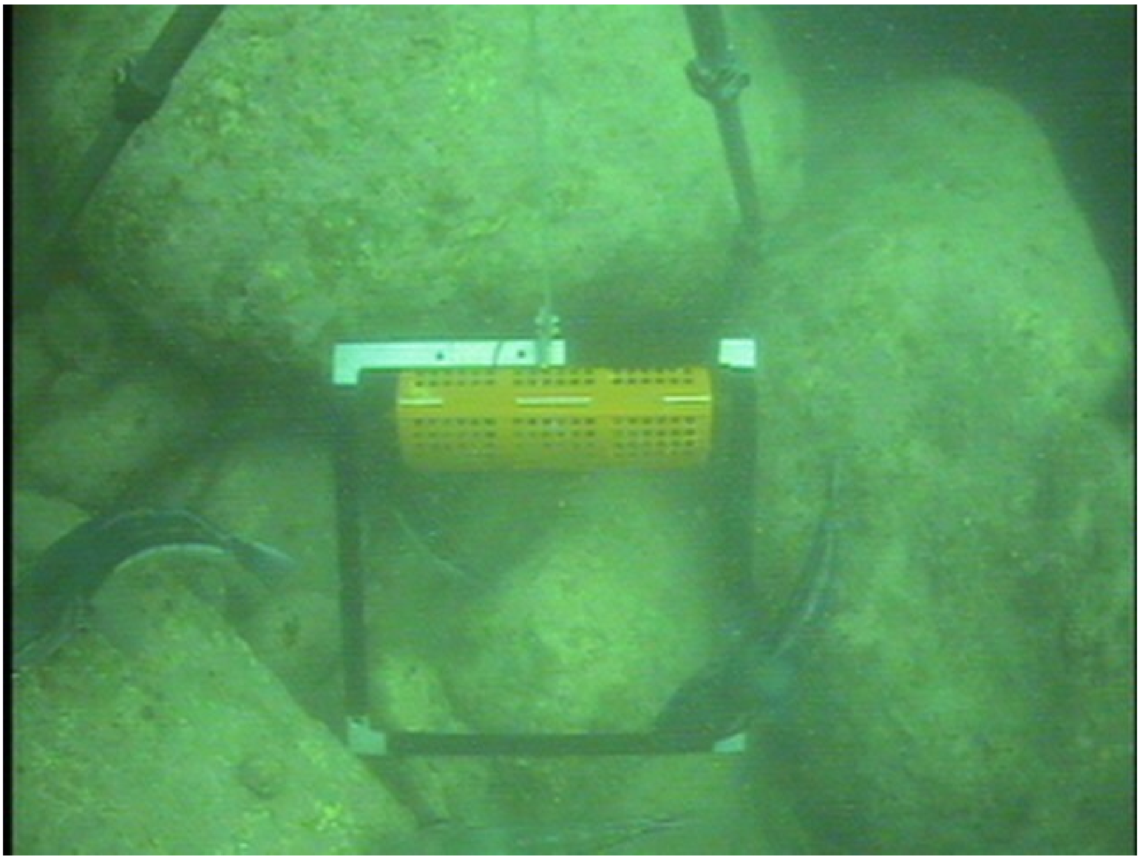


Photo 5. Direct capture (not edited) showing two blue cod at Abel Head.

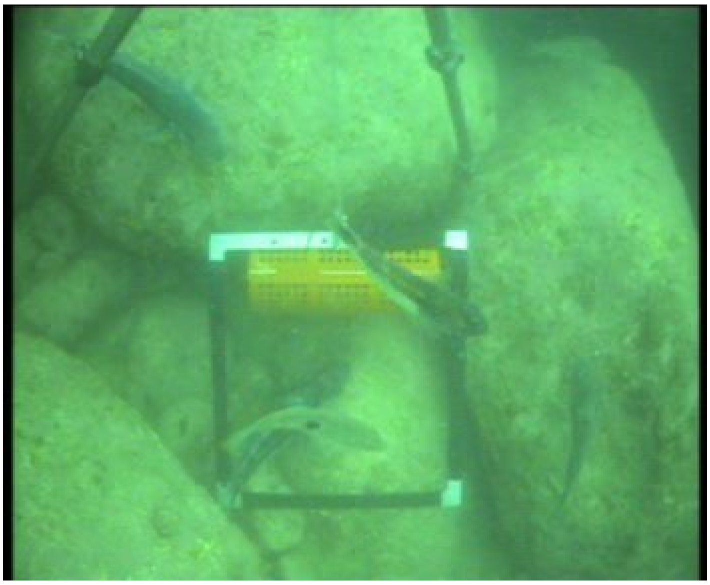
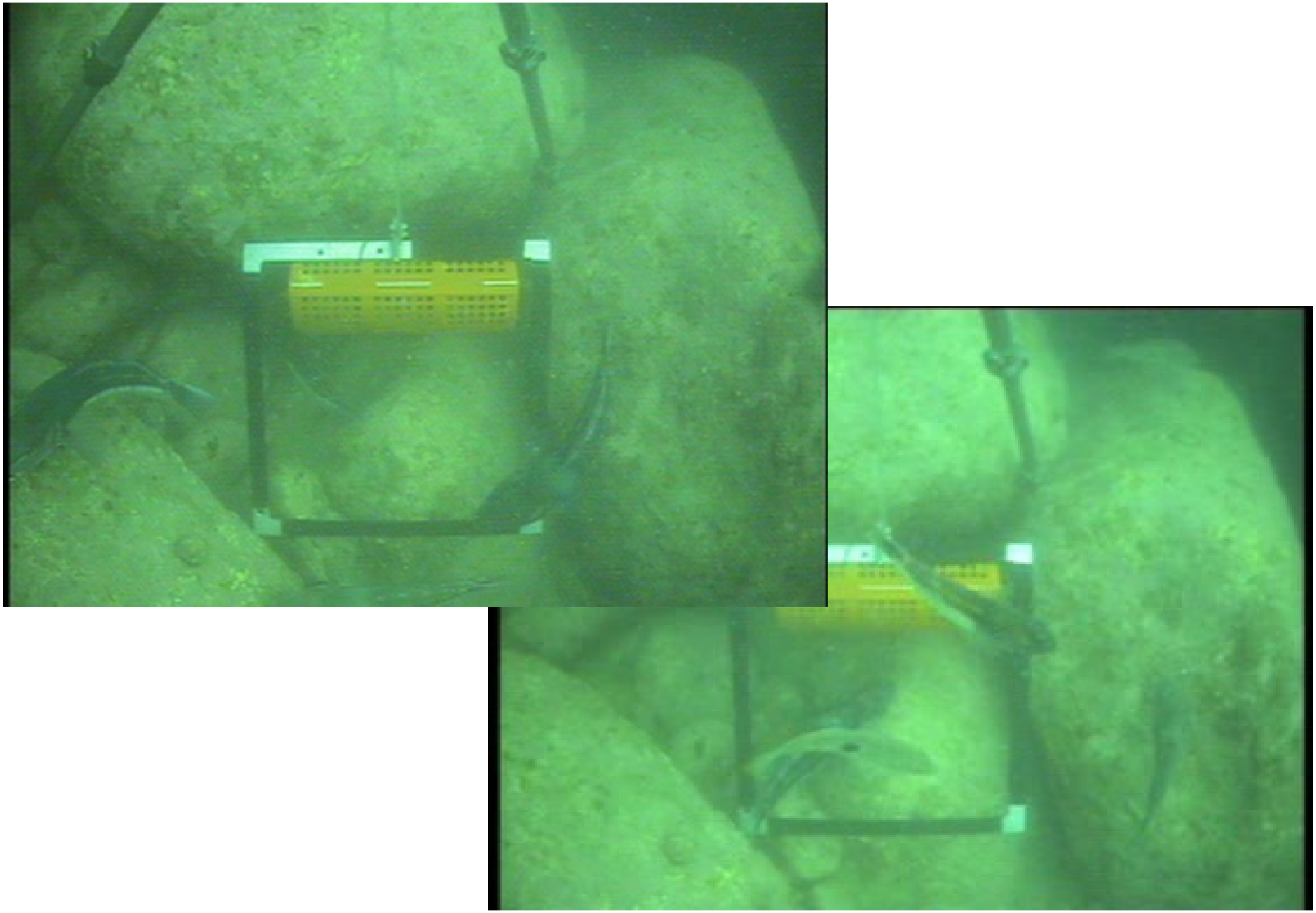
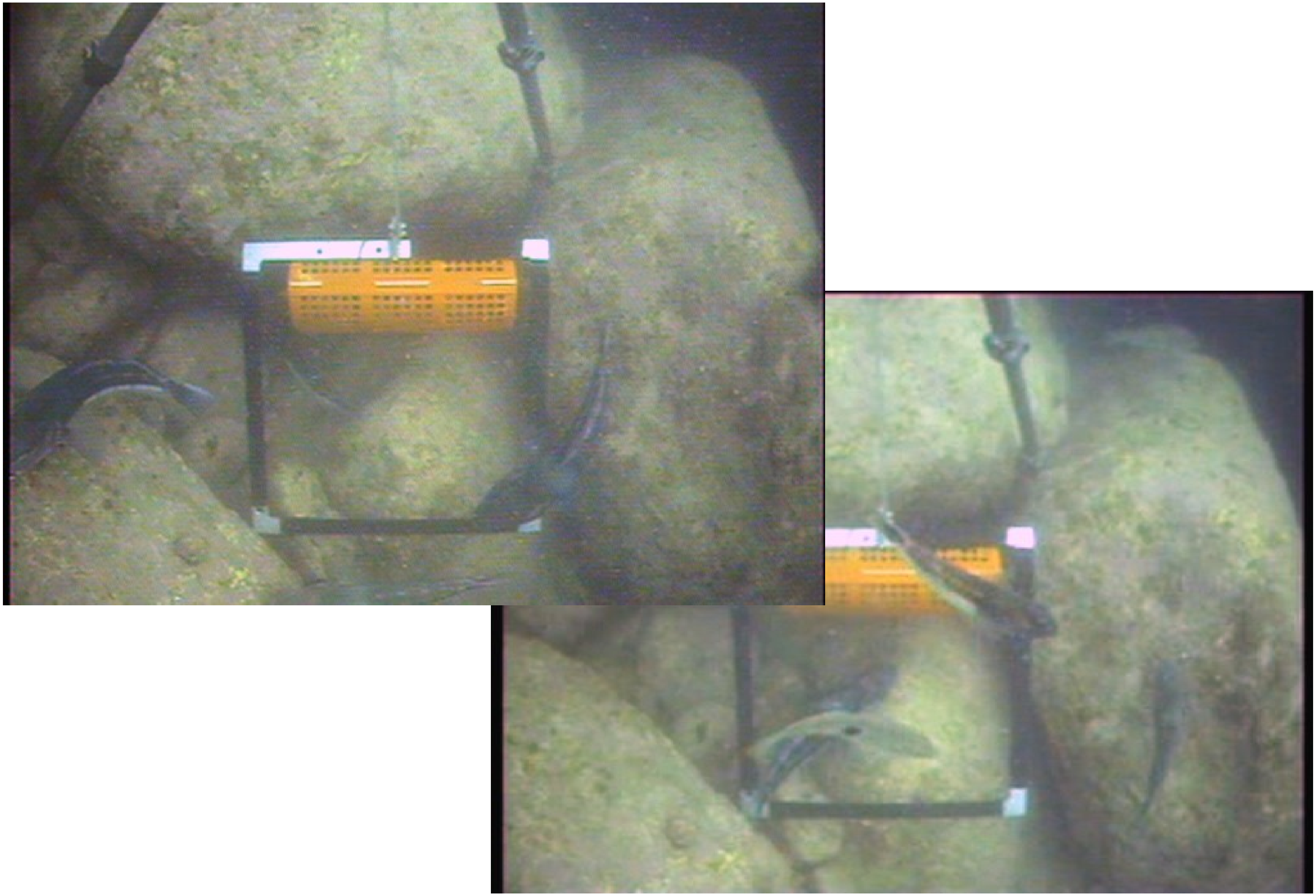


Photo 6. Video tape frame grab (not edited) showing four blue cod and spotty at Abel Head.



Photos 7 (left) and 8 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Abel Head. No image enhancement.



Photos 9 (left) and 10 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Abel Head. Images have been enhanced using Adobe Photoshop.

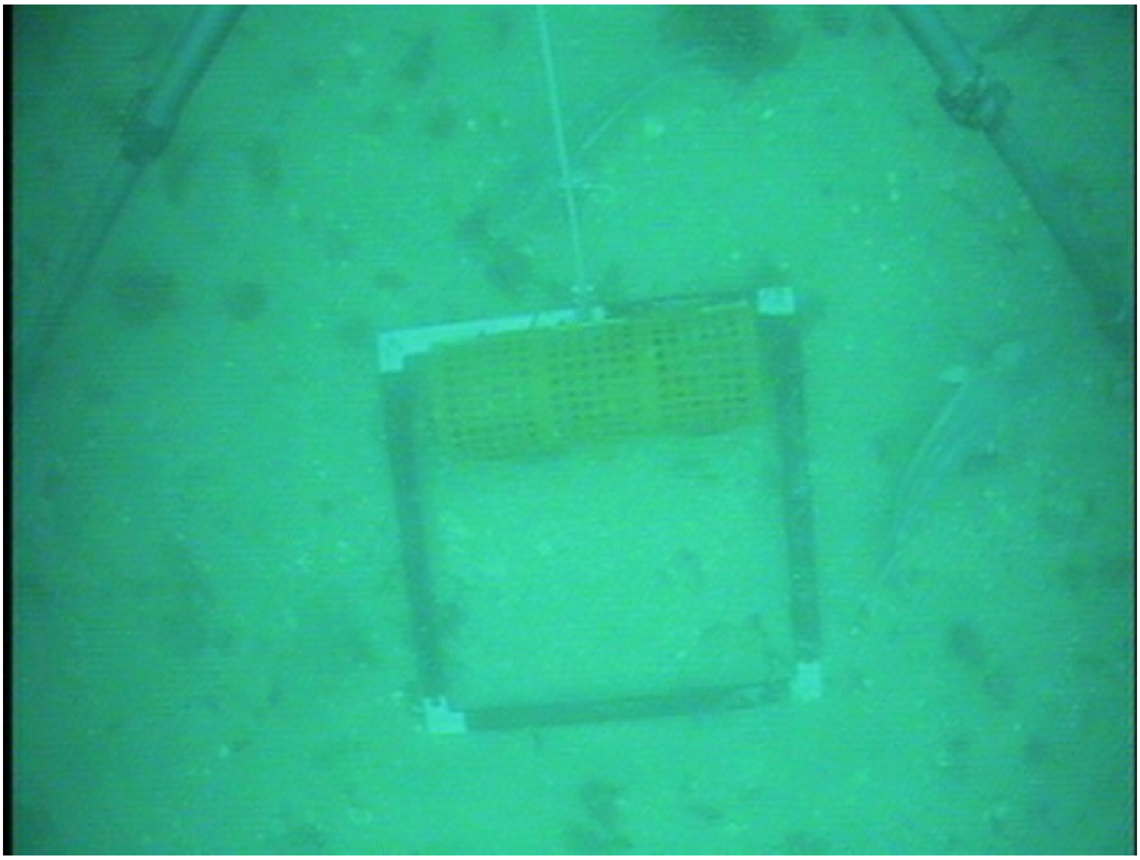


Photo 11. Direct capture (not edited) showing two blue cod at Tonga Island.

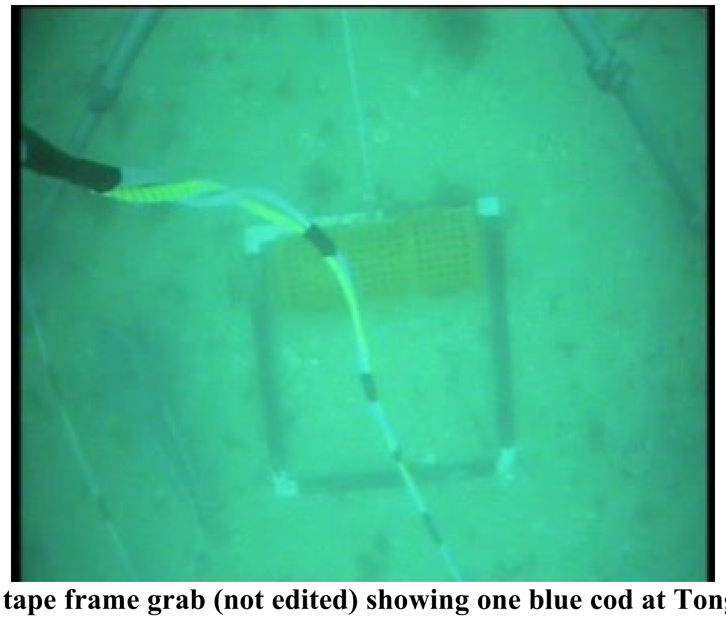
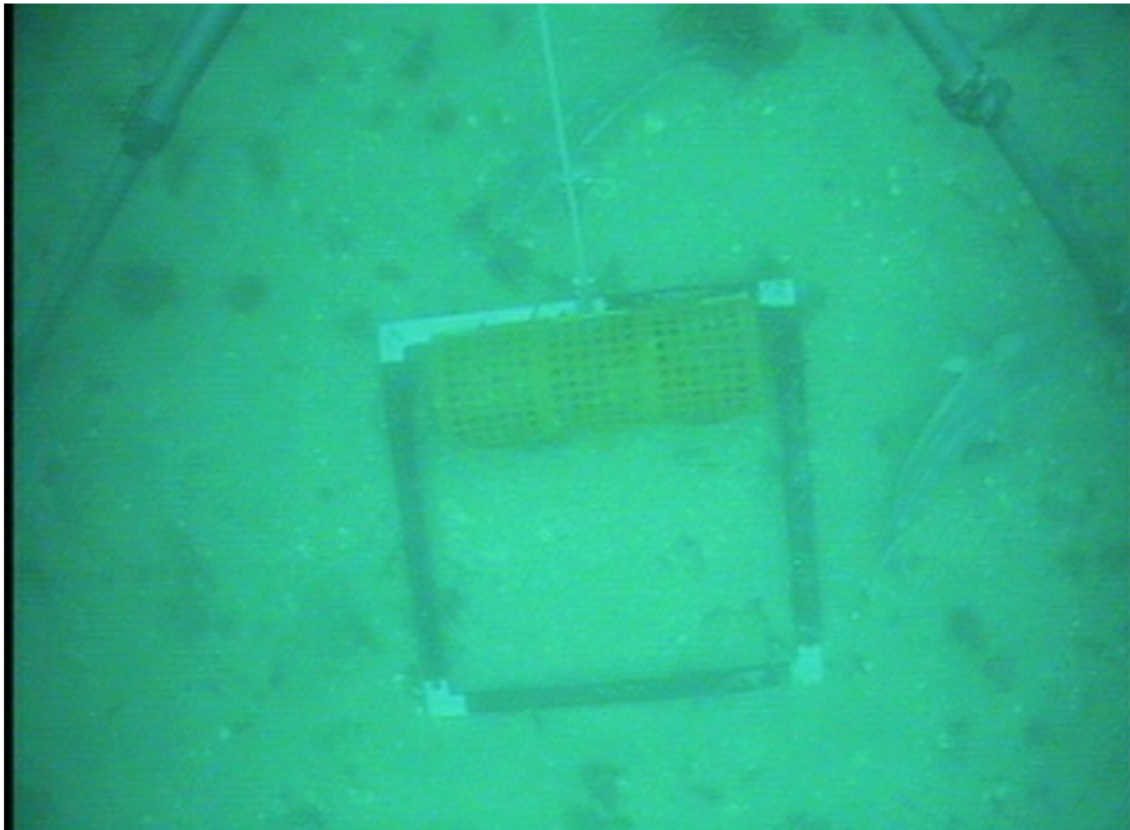
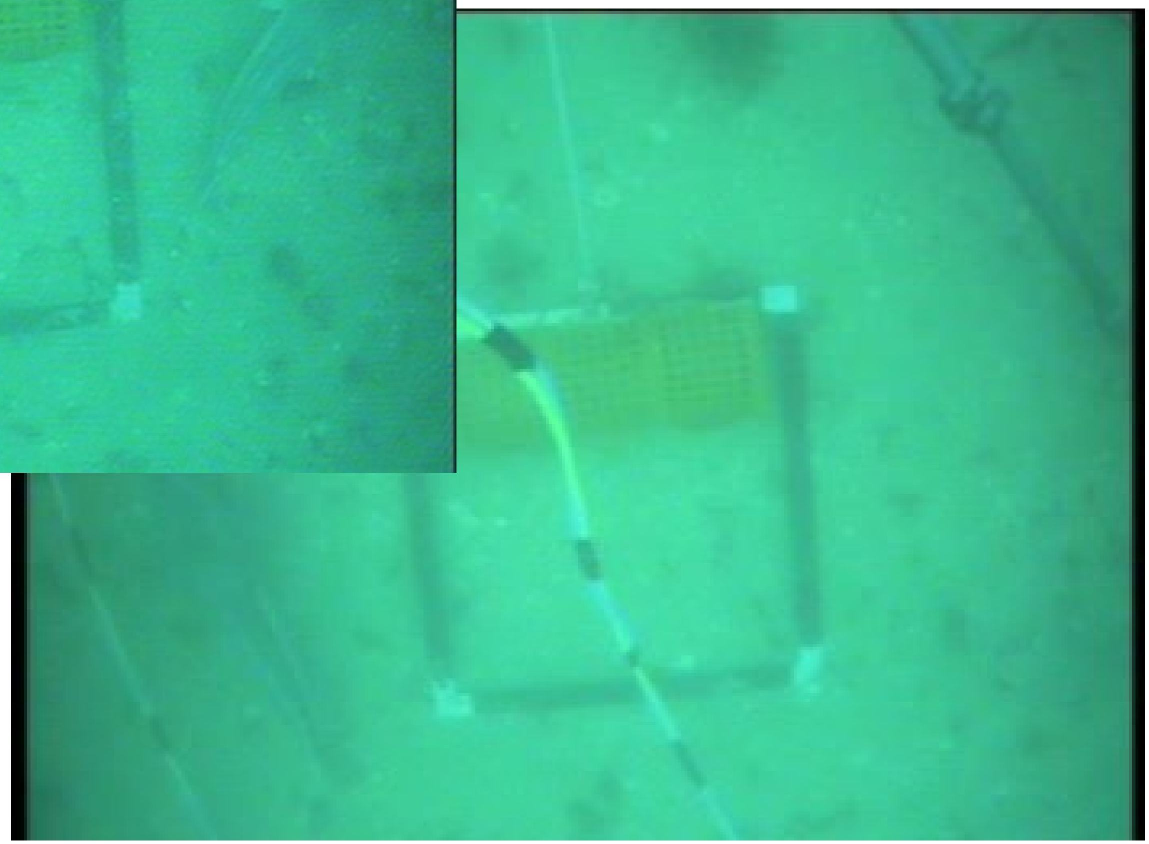
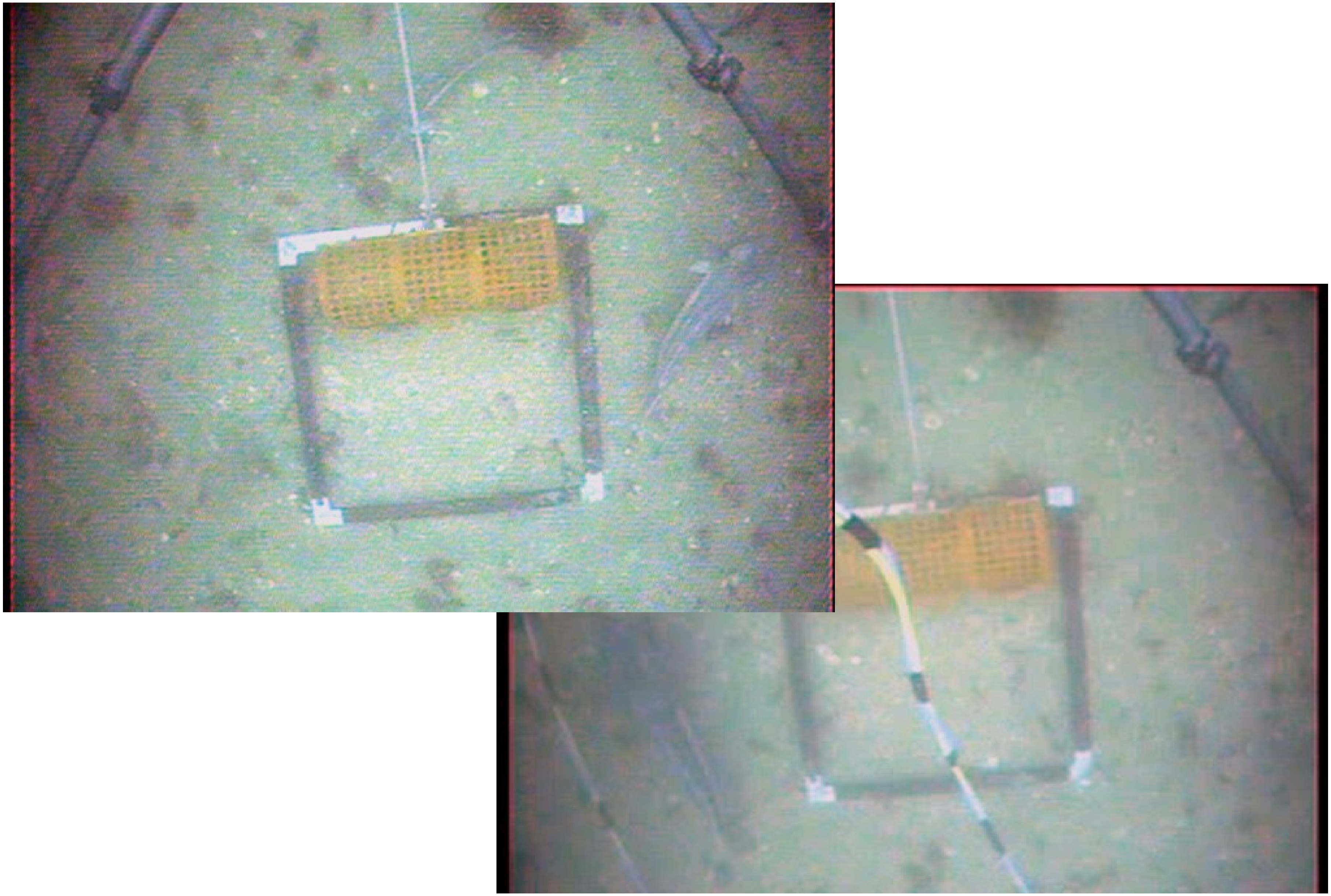


Photo 12. Video tape frame grab (not edited) showing one blue cod at Tonga Island.





Photos 13 (left) and 14 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Tonga Island. No image enhancement.



Photos 15 (left) and 16 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Tonga Island. Images have been enhanced using Adobe Photoshop.

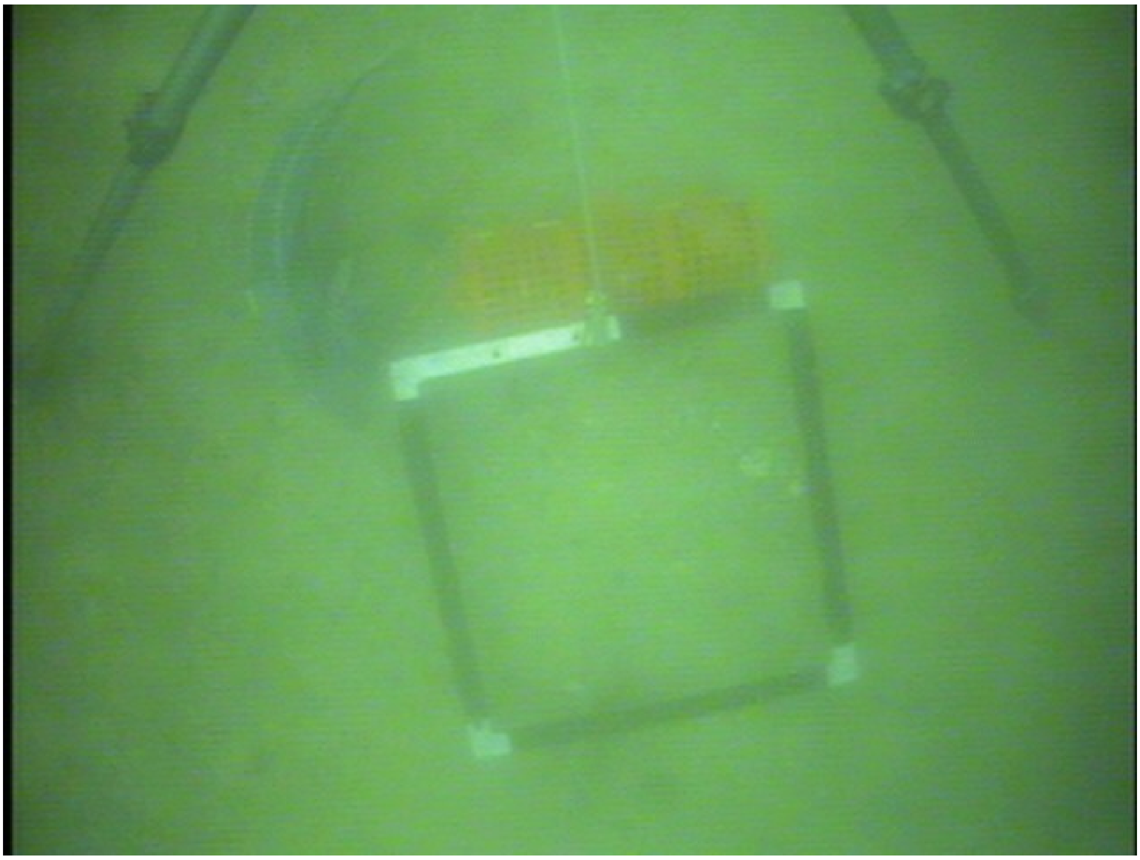


Photo 17. Direct capture (not edited) showing one blue cod at Reef Point.

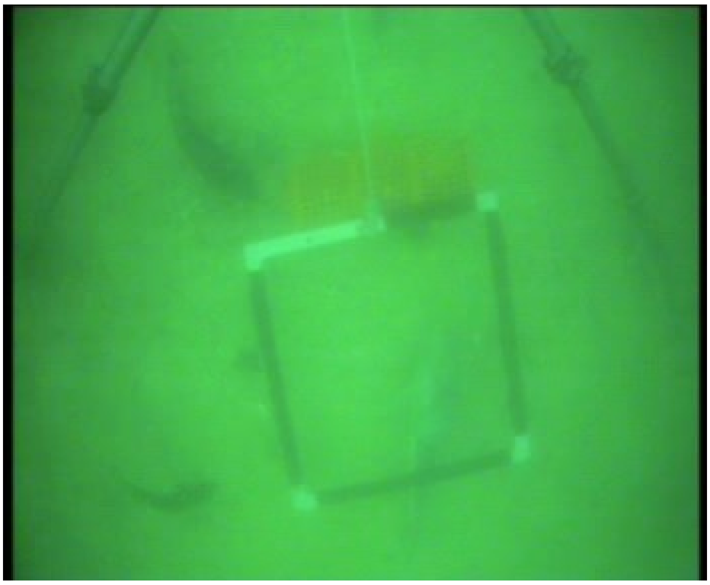
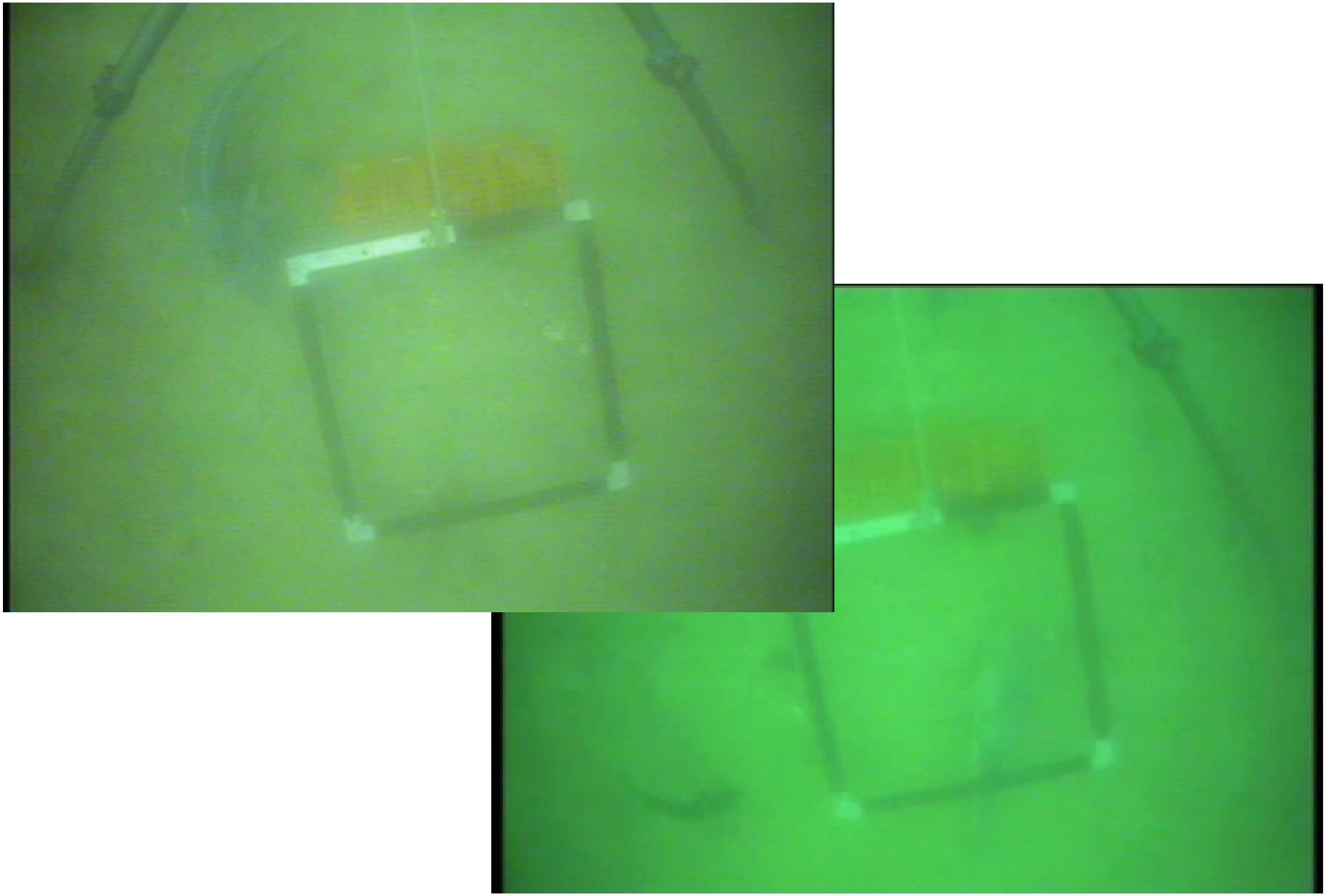
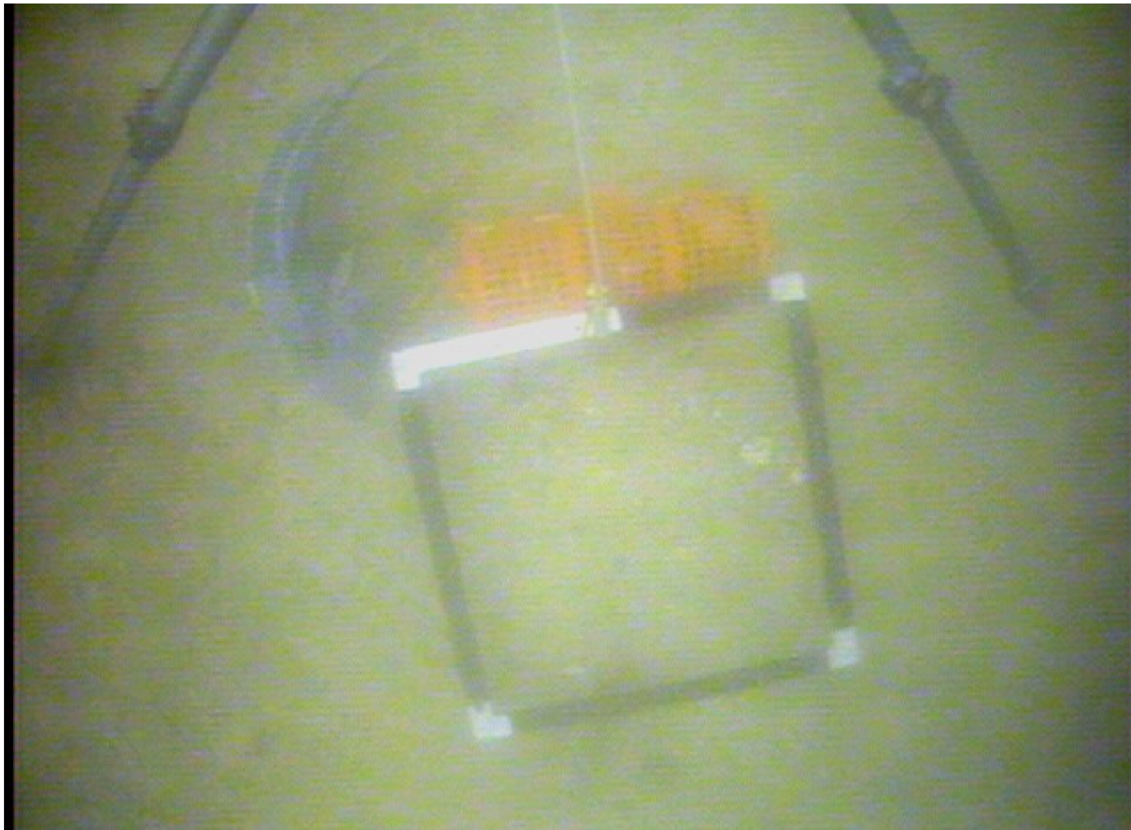


Photo 18. Video tape frame grab (not edited) showing three blue cod at Reef Point.



Photos 19 (left) and 20 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Reef Point. No image enhancement.




Photos 21 (left) and 22 (right). Direct capture (left) at original image size, video capture (right) enlarged to same size as direct capture photograph collected from Tonga Island. Images have been enhanced using Adobe Photoshop.

4.0 Discussion

4.1 Why use BUV methodology?

The use of BUV methodology has a variety of advantages over other methods used to sample fish size inside and outside marine reserves. Other methods include underwater diver estimations of fish length, stereo underwater camera, lasers, and catch, measure and release.

The advantages of BUV include:

- Fewer field staff and no need for divers thereby reducing cost and logistical issues.
- Without requiring dive equipment, field staff can be quickly mobilised and can travel with greater ease and greater distances to take advantage of optimal water clarity for BUV field work. Without the need for diving equipment and a reduced staff requirement, the time taken to travel to field locations is reduced and simplified.
- A large number of sites can be sampled in a relatively short period thereby maximising the amount of data that can be collected during good water visibility periods. Once the boat is anchored at each sample site, the time taken to collect data is 30 minutes. During this time, both direct photo images and video footage can be collected. No diver surface intervals are required, therefore each site can be sampled consecutively.
- Fish length data is relatively accurate and can be used to compare against fish lengths obtained using other methods such as diver fish length estimates.
- Some fish species are diver negative, but will be attracted to BUV stations (e.g. snapper).
- Digital image data can be taken away from the field and analysed at a later time.
- Using the new methodology, the time taken in the laboratory to process data will be reduced.

Disadvantages of BUV are:

- the time required to process images is relatively large compared to the time taken to collect field data. This time makes this method relatively expensive compared to underwater fish transects and catch, measure and release methods.

- large cod will often chase smaller cod from the BUV station creating a potential bias towards large individuals.

- some species such as butterfish may not respond to the BUV station.

4.2 Comparison of image quality using the old and new methods

Laboratory photographs

The images obtained from the digitised video appear fuzzy compared to the images captured directly from the underwater camera. The fuzzy appearance of the images frame grabbed from the video is worsened by enlarging image to a size where fish can be measured.

Field photographs

The same image quality and sharpness issues were apparent for the field collected photographs. The contrast between the two methods was more dramatic for the images collected from poor water clarity conditions compared to cleaner water captured images.

The fuzzy image appearance when combined with low water conditions makes measurement of fish difficult and inaccurate. For accurate fish measurements, it is optimal if images can be enlarged on the computer screen. Poor quality photographs mean that image size must be kept small to enable fish measurements. Better quality photographs allow for on-screen enlargement and better accuracy of fish measurements. Measurement of fish is particularly difficult if the tail is not clearly defined. Fish tails are relatively transparent and the tip of the tail is impossible to accurately gauge when photographs are fuzzy.

Clearly BUV techniques work best in very clean water. Under these conditions, the fish presence, fish species, and the tip of the head and tail can be determined and used to measure each individual fish. When BUV is used in poor water conditions, it is important that image quality is as high as possible. This will reduce measurement error and reduce the number of fish that cannot be measured in any screen. This is particularly important for smaller fish that are often more difficult to measure compared to larger individuals.

4.3 Methods comparison

Traditional BUV methodology

The traditional BUV methodology involves the collection of video tape footage in the field from the underwater camera. This footage is digitised using Nero Vision Express 2 or similar in the laboratory at a later date. Digitised video is then replayed on a PC. The elapsed times from the start of the deployment to the first arrival of blue cod, snapper, tarakihi and blue moki is recorded. Individual still photograph frames are grabbed approximately every 30 seconds using Nero Show Time software or similar. Frame captures can be delayed from 1 to 4 seconds in an effort to photograph fish close to the benthos or in an alignment that reduces measurement error. The still images are used to measure fish using on-screen calibrated measuring software.

New methodology

The new methodology involves the collection of video footage collected directly onto a laptop via a fire-wire connection out of the surface video camera that is itself receiving images from the underwater camera (Photo 23). Still images can be frame grabbed from this video footage at a later date if required and video footage can be viewed at any time in the future. While video footage is being collected, frame captures can be collected at 30 second intervals directly from the underwater camera and stored on a memory stick held in the surface video camera.

This new methodology collects all of the data collected using the traditional methodology (see above), but has the added advantage of providing better quality images captured directly from the underwater camera onto the memory stick.

Computer analysis

Individual lengths of particular reef fish are measured using three-point calibration on images imported into Sigma Scan Pro5 or similar. Measurement error using this method is typically < 20 mm (Willis and Babcock 2000). Not all fish in each photo frame can usually be measured as some fish will often be obscured by others while some will be at oblique angles to the camera or too high above the benthos. Only fish that are well presented to the camera and close to the benthos should be measured.

Photo 23. Collection apparatus consisting of a line feed from the underwater camera (blue cable) feeding an Ikelite power and data manager, feeding a Sony video camera where still images are captured onto a memory stick. The video camera is connected to the laptop via a fire-wire cable allowing direct capture and immediate digitising of video footage.

4.4 BUV for density calculations

BUV has been used an an indices of fish density (Willis and Babcock 2002). There are potential biases when using this method for fish density calculations. BUV acts as a fish attractant resulting in an accumulation of fish around the station. As a result, many fish will be repeat sampled resulting in a misleading scale of fish abundance. Davidson and Richards (2005) often observed little difference in the number of blue cod at control sites compared to reserve sites while collecting BUV data, especially at sites where blue cod were common. At Long Island-Kokomohua Marine Reserve the UVC data collected over a period of 10 years from the same sites used by Davidson and Richards (2005), have shown that blue cod were more abundant within the reserve compared to control areas (Davidson 2001, 2004). It is therefore not recommended that BUV data be used as a method for calculating fish abundance.

Acknowledgments

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