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Hull Camera: Preliminary Design and Testing of its use for Assessing Biofouling on Small (<12 m) Recreational Vessels

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Hull Camera: Preliminary Design and Testing of its use for Assessing Biofouling on Small (<12 m) Recreational Vessels

Executive Summary

This report documents the preliminary design and testing of a hull camera for assessing biofouling on recreational vessels less than 12 m in length. There were two aims: firstly, to establish a preliminary design for an easy to use camera system which would allow less accessible areas of a vessels hull to be viewed, and secondly, to undertake preliminary testing of its usefulness. The hull camera was tested on four different vessel hull types: round, deep vee, tunnel and yacht. An assessment of the degree of biofouling on these different hull types was initially made with waterline inspections then repeated using the hull camera. These results were then compared. The hull camera was found to provide a clearer picture of the real level of biofouling of these vessels, which was underestimated by waterline inspection. The hull camera was shown to be useful for the assessment of recreational vessel less than 12 m long and to have the potential to become a useful tool in the monitoring of non indigenous marine species in the recreational sector.

Acknowledgments

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Justin McDonald is thanked for his help in developing this project and useful discussions during its testing. Nick Konzewitsch and Scott Evans are thanked for their assistance in developing the camera set up and Nick is also thanked for helping with the field testing of the hull camera. Neil Dorington is thanked for allowing access to the vessels inspected at the Hillarys Boat Harbour.

1.0 Introduction

Biofouling is the growth of organisms on an underwater surface. These organisms can include: biofilms of bacteria, cyanobacteria and diatoms; filamentous green algae and turfing red and brown algae; sessile organisms such as sponges, tube-building polychaetes, bryozoans, bivalve molluscs and ascidians; and mobile organisms such as nudibranchs, amphipods, isopods, crabs, molluscs and fish. Currently in Australia the degree of biofouling on vessels is described by three levels, primary, secondary and tertiary (Commonwealth of Australia, 2007). The primary biofouling layer occurs first and is characterised as a surface layer composed of bacteria and microscopic and filamentous algae which results in a slimy film. Continual submersion of a vessel leads to the development of a secondary layer of biofouling. This secondary layer builds upon the primary layer and includes organisms such as encrusting animals (e.g. barnacles, bryozoans, and polychaetes), turfing algae (e.g. coralline algae), amphipods and hydroids (Commonwealth of Australia, 2007). The final layer is the tertiary layer which develops on top of the secondary layer and consists of larger animals such as sponges, tunicates, macro algae, mussels, crabs and sea stars (Commonwealth of Australia, 2007). Biofouling can affect the functioning of a recreational vessel by increasing drag and subsequently increasing fuel costs, damaging the paint and hull where they are attached and clogging pipes, motors and propellers which can lead to engine damage. Another, potentially more serious consequence of biofouling, is the translocation and introduction of non-indigenous marine species (NIMS) to a new region.

Non-indigenous marine species (NIMS) are organisms that have moved from their natural environment to another area. Many NIMS remain inconspicuous and innocuous, however, they can potentially threaten human health, economic, social and cultural values as well as the marine environment, subsequently being referred to as marine pests. NIMS have also been identified as one of the most significant threats to biodiversity (Carlton and Geller, 1993). It has been estimated that 10,000 different species are being translocated around the world within ballast water each day (Carlton, 1999).

Although it is well recognised that large commercial vessel are major potential vectors for the introduction of NIMS, smaller recreational vessels also pose a threat. As an example, it is almost certain that an ocean-going yacht was responsible for the introduction of the black-striped mussel (*Mytilopsis sallei*), an extremely invasive marine pest, introduced into Darwin Harbour in 1999 (Hayes *et. al.*, 2007). This introduction posed a serious threat to the pearling industry ($225 million value of production in 1998) and cost more than $2 million to eradicate (CRC Reef, 2004). Such an introduction into Western Australia's waters remains a potential threat given that there were 102,059 recorded recreational vessels in 2003 (Kinloch *et. al.*, 2003).

Recreational vessels come in a variety of sizes (e.g. a kayak to a luxury motor boat) and a variety of shapes (e.g. flat bottom, round hull, deep "V" hull and tunnel hull). The hull of a recreational vessel has areas which may have some protection from water flow, thus providing small niches where biofouling can establish. However, the distance and speed travelled, whether it remains in or is regularly removed from the water and the length of stay at a destination, all affect the likelihood of a vessel becoming infected by NIMS. For example yachts tend to be predominantly used for leisure activities which involves slow cruises, visiting different distant destinations with marinas and bays where they may remain for substantial periods of time. As yachts have fixed keels they tend to remain either anchored, moored or berthed within the marina or bay. As a result their hull is in constant contact with the water. These bays or marinas may be within or close to an international port facility, increasing the yachts susceptibility to be fouled by NIMS brought in by international trading vessels. Further, if the yacht already has established NIMS the longer stop over durations may increase the likelihood of the yacht translocating the NIMS. In contrast smaller power boats typically only move about in localised areas moving quickly between destinations, with greater velocity potentially helping dislodge growth on their hulls due to increased drag on the organisms. However, these smaller power boats are able to access the vast majority of inshore locations and therefore potentially aid in translocation of NIMS.

The Australian Quarantine and Inspection Service (AQIS) currently use a combination of waterline and pole-mounted camera inspections to determine the biofouling risk of internationally cruising vessels < 25 m. Cameras are used to complement the waterline inspections as an inherent short coming of the waterline assessment is a lack of evidence of increased biofouling in areas below the waterline. This may skew the assessment in favour of not finding secondary/tertiary biofouling and hence passing of vessels that should otherwise be failed. These two methodologies were reviewed by URS (2007) who noted that initial waterline inspections may not be a reliable indicator of biofouling on other areas of the hull, and that the waterline inspection may significantly underestimate the extent of hull biofouling. Other problems which can greatly affect the reliability of waterline inspections include: poor water clarity limiting the depth which can be viewed; and that viewing is limited by wharf access.

2.0 Project aim

This project targeted recreational vessels less than 12 m in length. It was not the purpose of this paper to duplicate the role of AQIS and their monitoring modus operandi (i.e. < 25 m long commercial vessels) but rather to undertake preliminary testing of a hull camera prototype for recreational vessels under 12 m and to determine whether the hull camera could have a useful role to play in assessing the degree of biofouling on this sized vessel.

The aim of this project was twofold. Firstly to establish a preliminary design for an easy to use camera system which would allow less accessible areas of a vessels hull to be viewed and secondly to undertake preliminary testing of its usefulness. Within this second aim a comparison of biofouling ratings from waterline inspection results and hull camera results are also presented. However, it should be noted that this report is not trying to assess whether the defined categories of primary, secondary and tertiary biofouling are appropriate to determine if the vessel or its biofouling pose a threat in terms of introducing non indigenous marine organisms.

3.0 The hull camera system setup

Two telescopic poles were joined via a hinge which allowed a range of flexibility between 0° to 180° to be achieved. The telescopic poles allowed increased access to difficult positions underneath the vessel hulls and allowed the camera to reach further under the hulls. A Scielex industrial camera was mounted on the end pole (Figure 1). This camera was a 0.01 lux colour video camera, waterproof to 600 m and encased in 316 marine grade stainless steel housing with a mounting arm. A 30 m cable connected the camera to a video recorder, an Archos 605 wifi (Figure 2). An external battery was used to run the camera and the video recorder. The camera was also attached to the pole via a hinge which allowed a certain degree of angular positioning, again to assist with viewing difficult to get to places. The field of view of the camera was 24 x 24 cm with a minimum focal distance of 15 cm. A 15 cm spacer was attached to the camera to ensure the distance to the hull was consistent (Figure 3).

Figure 1. Photograph showing the use of the hull camera from the jetty. The join between the two poles (circle) can be seen, this allowed better access to the hull and other difficult to get to areas e.g. propeller. Photograph Sam Bridgwood.

Figure 2. Image showing the video camera (1) (minus the pole) and the video recorder (2) encased in the pelican case. Note the length of the cable is much shorter in this image than was used for the field testing. Image accessed from: http://www.scielex.com.au/products/products_14.html.

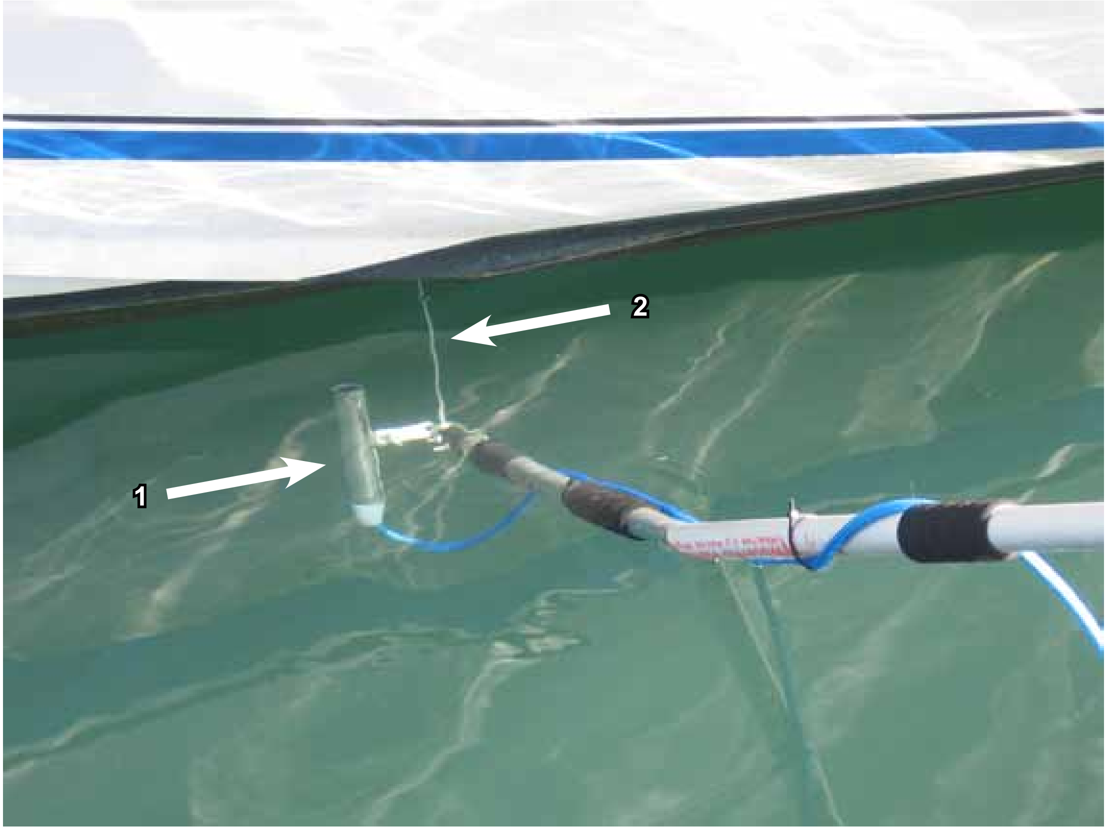


Figure 3. Picture showing the hull camera at work. The arrows are pointing out (1) the camera and (2) the 15 cm spacer used to ensure the camera is at the best focal distance. Photograph Sam Bridgwood.

4.0 Testing of the hull camera

As this was a preliminary testing of the hull camera only three replicates, of four different shaped boat hulls, were assessed, including two power boat hulls shapes and two wind powered hull shapes. The power boat hull shapes were round bottom (Figure 4A) and deep vee (Figure 4B). The two wind powered were tunnel (i.e. catamaran Figure 4C) and a standard yacht shape (Figure 4D). Particular areas of the hull, depending on the shape, were targeted for assessment. Where possible the same areas were used for the waterline and hull camera assessments. These areas included the bow, midship, stern, keel body, keel bottom, propeller, propeller shaft, rudder and marlin board.

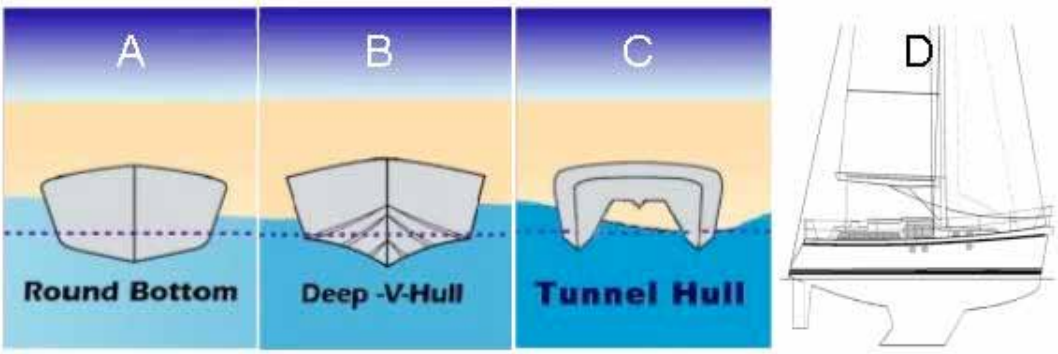


Figure 4. Image showing the hull types assessed for biofouling by both waterline inspection and hull camera. Image A and B represent the power boat hulls, whilst C (catamaran) and D (yacht) represent the predominantly wind driven vessels. Images A, B and C were accessed from: http://www.boatus.org/onlinecourse/reviewpages/boatusf/project/info1b.htm. Image D was accessed from: www.radford-yacht.com/dsn058/dsn058.html.

Initially a waterline inspection was undertaken assigning one of the three levels of biofouling (primary, secondary and tertiary) to a vessel. A fourth category was used when assessment wasn't possible, i.e. unknown/unable to assess. The vessel was then re-assessed using the hull camera video footage. Examples of the differing levels of biofouling for the different areas of the hull assessed by hull camera are given in Figures 5 – 8. These still images were extracted from the video footage.

Each vessel was given an overall biofouling score (averaging all areas assessed) as well as scores for the individual target areas. The results from the waterline assessment and the re-assessment from the hull camera were compared for the overall biofouling score and then for individual areas to determine if results from waterline inspections could be improved with the use of a hull camera i.e. was there a difference in biofouling levels. All vessels assessed were penned at the Hillarys Boat Harbour.

Primary

Secondary

Tertiary

Figure 5. Examples of all three biofouling levels captured by the hull camera on the vessels hulls.

Secondary

Keel body Keel bottom

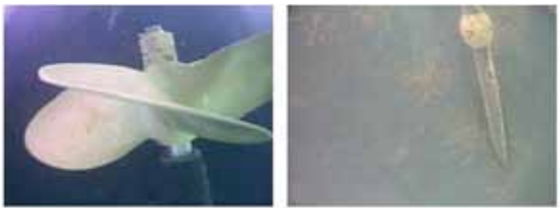
Tertiary

Keel body Keel bottom

Figure 6. Examples of secondary and tertiary biofouling levels captured by the hull camera on keels.

Primary

Propeller | Propeller shaft



Secondary

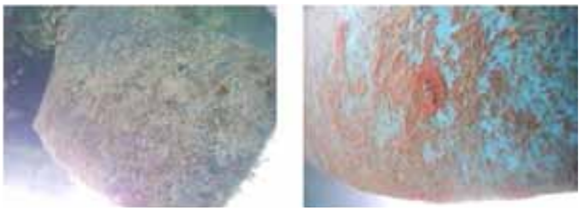
Propeller | Propeller | Propeller | Propeller shaft

Tertiary

Propeller | Propeller | Propeller

Figure 7. Examples of all three levels of biofouling captured by the hull camera on propellers and propeller shafts.

Secondary



Tertiary

Figure 8. Examples of secondary and tertiary biofouling levels captured by the hull camera on rudders.

5.0 Results

The results from this preliminary study indicate that waterline inspections tended to underestimate the overall biofouling score of a vessel when compared to the results from the hull camera. The results were as follows:

Round hull: one vessel would have had its biofouling underestimated if only waterline inspection had been used, in this case it was rated as primary rather than secondary.

Deep vee hull: two vessels would have had their biofouling underestimated if only waterline inspection had been used. One of them being rated as primary instead of secondary and another secondary instead of tertiary.

Tunnel hull: all three vessels would have had their biofouling underestimated if only waterline inspection had been used. Two of them were rated secondary instead of tertiary and one primary instead of secondary.

Yacht: all three vessels would have had their biofouling underestimated if only waterline inspection had been used. Two of them were rated as primary instead of secondary and one secondary instead of tertiary.

Results for individual areas highlight the gap in the assessment of biofouling if only made based on waterline inspections. For three of the boat hull shapes (deep vee, tunnel and yacht) very few of the different areas assessed actually showed agreement between the biofouling scores for waterline inspections and the hull camera (Figure 9). The round hull showed the best agreement between the two biofouling methods, however there was still a 44 % underestimation of biofouling scores (Figure 9).

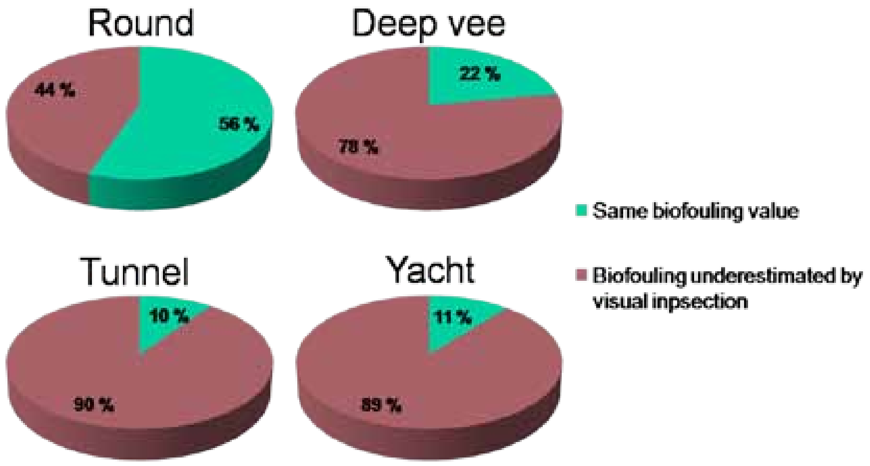


Figure 9. The percentage of agreement between biofouling values for waterline inspections and the hull camera.

6.0 Discussion and recommendations for future work

The first aim of this report was to develop an easy to use camera system which would allow access to areas of a vessel hull not able to be viewed during a waterline inspection. This was achieved with the hull camera set up described herein. This camera and pole system allowed the land-based user increased viewing of all hulls, thereby increasing the number of areas able to be targeted for biofouling inspections. Images captured by the hull camera were of a high quality (see Figures 1 - 3 and 5 - 9). Thus biofouling surveys using the hull camera could be completed on site, with simultaneous recording of biofouling values as they are viewed on the video screen, as well as offsite from the recorded video using post analysis techniques. The advantage of video is that it provides a permanent record of biofouling which can be re-visited at a later date, offering the ability to re-use captured imagery for further analysis or comparisons over time.

The second aim was to undertake preliminary testing of its use. Although testing of the hull camera was only on a limited number of vessels, results did indicate a large discrepancy between the biofouling values determined from waterline inspections compared to the hull camera. Typically, the hull camera resulted in higher biofouling values compared to waterline inspection, thus indicating that the hull camera would be of value for this type of work.

As these trials were only undertaken on penned vessels, future work should investigate the ease of using the hull camera on vessels moored in open water i.e. the user on a small boat rather than a fixed platform. Other uses of the hull camera could include assessing the biofouling of jetties, other mooring facilities and navigational markers. Future work could include increasing the resolving capacity of the hull camera i.e. looking at genus or species of the organisms rather than the three broad biofouling levels. Further investigations could address whether there is a relationship between vessel type and biofouling, thus developing a vector risk which could be assigned to different hull types. This could be achieved by having vessels lifted out and weighing the biofouling mass for different hull types. Possible improvement to the hull camera system could include the use of a Remote Operated Vehicle (ROV) with a mounted camera, effectively removing the pole. This would allow the user greater freedom and manoeuvrability to access different areas on the vessels hull. ROVs are already in use for larger commercial vessels and platforms however, smaller, cheaper options are available and would make the process of assessing recreational vessel hulls more streamline. With further funding the Biosecurity group at the Department of Fisheries, Western Australia, would have the capacity to undertake these types of investigations.

Ultimately an extension of the hull cameras application to undertake biofouling assessments would be its ongoing use in public marinas as a monitoring tool for the detection of non-indigenous species and hence an early detection system for marine pests.

7.0 References

Commonwealth of Australia (2007). Marine Pests Website. Accessed online 17th August 2009. http://www.marinepests.gov.au/marine_pests/marine_pests_as_biofouling.

Carlton, J. T. (1999). The scale and ecological consequences of biological invasions in the world's oceans. In Invasive species and biodiversity management. Sandlund, O.T., Schei P.J. Viken A, (eds). Dordrecht, Kluwer Acandemic Publishers. pp 195-212.

Carlton, J. T. & Geller, J. B. (1993). Ecological roulette: the global transport of nonindigenous marine organisms. Science 261: 78-82.

CRC Reef. (2004). Introduced species in tropical waters: current state of knowledge, March 2004. Published by CRC Reef Research Centre Ltd.

Hayes, K. R., Gunasekera, R., Patil, J., Sliwa, C., Migus, S., McEnnulty, F., Dunstan, P., Green, M & Sutton, C. (2007). Empirical validation: Small Vessel Translocation of Key Threatening Species. Stage II – *Undaria pinnatifida*. Final report for the Australian Government Department of Environment and Heritage. CSIRO Division of Marine Research. Hobart. Australia. pp 60.

Kinloch, M., Summerson, R. & Curran, D. (2003). Domestic Vessel Movements and the Spread of Marine Pests. Risks and Management Approaches. Published report by Bureau of Rural Sciences (Department of Agriculture, Fisheries and Forestry) to the National Oceans Office, Canberra. pp 168.

URS (2007). Review and Evaluation of the Biofouling Protocol for Vessels Less than 25 m in Length. Unpublished report to the Australian Quarantine and Inspection Service by URS Australia Pty Ltd Perth. pp 149.