# Memo

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| To | Phoenix Hale<br>Freshwater Technical Advisor – Biosecurity<br>Department of Conservation Te Papa Atawhai |
| Date | 11 April 2024 |
| Subject | Camera Positioning System (CPS) for submerged macrophyte detection module |

## 1. Introduction

Department of Conservation Te Papa Atawhai (DOC) operates a freshwater pest species management programme that aims to reduce the spread of invasive freshwater species throughout Aotearoa New Zealand. Pest species management and surveillance is often difficult and costly, and the development of new methods and tools is critical to reduce barriers, costs, and implement effective management of these pests.

Since FY2021/22, DOC has partnered with National Institute of Water and Atmospheric Research Taihoro Nukurangi (NIWA) to support the development of a remote detection system for submerged macrophytes to facilitate surveillance and monitoring of control operations in lacustrine ecosystems. In FY2022/23, initial field testing of NIWA's prototype detection module was undertaken in Lake Whakatipu and the Kawarau River, for the automated detection of lagarosiphon (*Lagarosiphon major*) (Clements et al. 2023). The prototype equipment performed as expected, and a list of improvements was developed to progress towards a fully operationalised automated detection system.

The system operates by submerging a video camera to a depth of c. 1 m from target submerged species. Video from the camera is streamed to an AI (Artificial Intelligence) detection system that has been developed to process this data in real time to automatically detect the presence and geo-locate target species, in this case lagarosiphon. To progress towards a field-ready deployable system, in FY2023/24 NIWA was contracted by DOC to develop a system to enable the current camera setup to be automatically raised or lowered in the water column towards targets, to maximise detection efficacy and avoid collisions with the river or lakebed or other obstacles in the water column.

These developments are part of a wider workplan that is proposed to enable a field-deployable system that can be used by DOC and other agencies to improve surveillance and monitoring of control operations of submerged invasive species.

## 2. Methods

Following NIWA's 2022/23 experiments (Clements et al. 2023), which used a motorised depth pole (https://power-pole.com/micro) with manual human input to raise or lower the camera system in the water column, NIWA suggested that it was likely possible to automate this system and develop a Camera Positioning System (CPS) that could sense obstructions using acoustic signals to activate the motor driven pole, to automatically lower or raise the camera. This would allow more efficient field deployments of the automated detection system.

Therefore, NIWA has implemented the following developments to move from manual to automatic positioning of the motorised depth pole:

1. To avoid the problem of the standard motor driven pole rotating (and hence the submerged camera) as it is driven up or down, the original 2 m long round profile carbon-fibre pole was substituted with a square aluminium 2.5 m long rod to raise and lower the camera system (Figure 1 and Figure 2).
2. To prevent the motor from driving the rod beyond its intended range, end stops were added. The first was electronic, intended to tell the computer when the rod had reached its fully up or fully down limit and stop the motor. The second was a physical stop at each end.
3. To enable the transition from round to square rod, and to house end-limit switches that are activated by magnets embedded in the rod, we designed and 3D-printed some fixtures.
4. To minimise costs, we developed and added the new CPS application software and hardware to the existing automated detection module (Figure 3). We programmed the computer to 'electronically assert' the previous manual button inputs.
5. To sense a rising lake or riverbed or other obstruction in the water column, a Ping2 acoustic depth sensor (https://bluerobotics.com/store/sonars/echosounders/ping-sonar-r2-rp/) was integrated, with specified range 0.3 to 70 m and a beam measurement width of 25 degrees, mounted at the bottom of the rod. A 3D-printed fitting was used to attach this sensor to the rod. This enabled the sensor to tilt through an angle of 90 degrees (Figure 1 and Figure 2).
6. Initial tests of the CPS were carried out at NIWA's Christchurch Rating Tank (flume) at Kainga (southern bank of the Waimakariri River). The flume is a 50 (Length) x 2 (Width) x 2 (Deep) metre tank filled with water. It has a movable car that straddles the tank and can tow instruments at programmable speeds. With the CPS mounted on the rating car (Figure 1) we introduced obstacles to the tank to simulate a rising lake or riverbed. Initial field testing of the CPS also occurred in the Kawarau River near Queenstown in March 2024, with the CPS mounted on a jet boat (Figure 4 to Figure 6).


**Figure 1:** Left – The Camera Positioning System (CPS) equipment mounted on the rating car in the flume. Right – The modified motorised rod that raises and lowers the GoPro video camera.

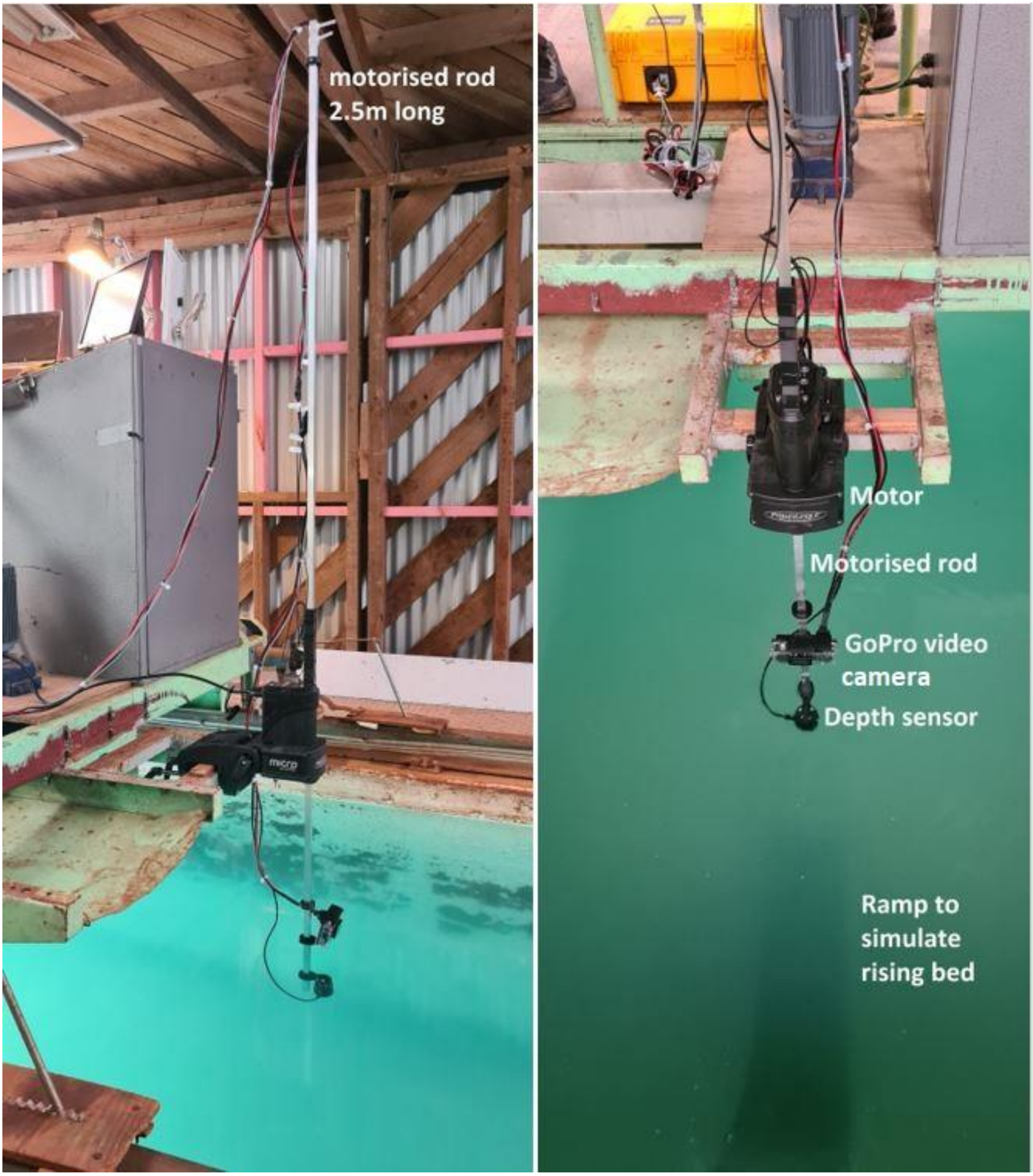


**Figure 2:** Left – Relative size of the 2.5 m long square aluminium rod driven by pinch rollers inside the motor module. Right – The acoustic depth sensor senses the simulated rising bed, and the system automatically raises the rod with the attached camera. *Refer to videos in memo report folder, embedded in power point: CPS_videos_for_milestone_1_of_2.pptx*

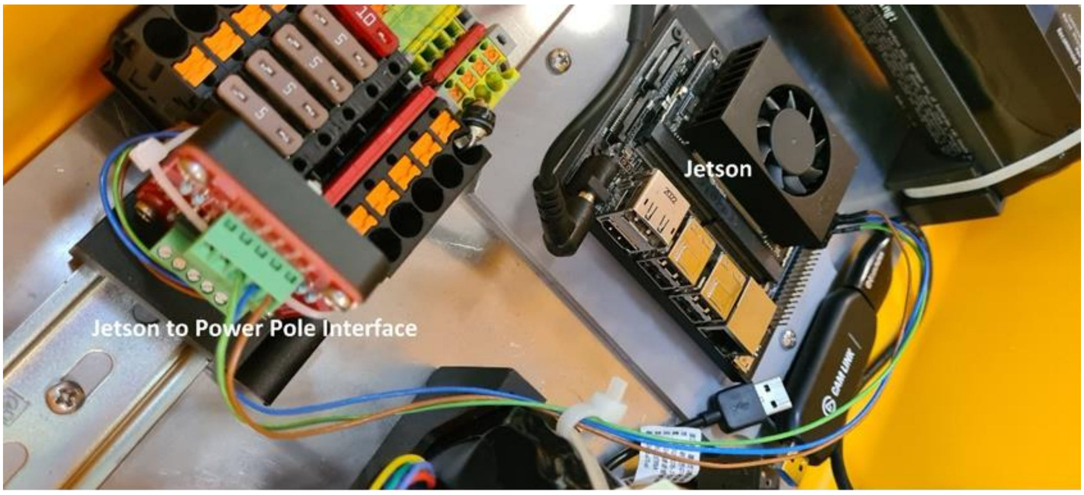




**Figure 3:** Top – Camera Positioning System (CPS) hardware and (middle) application software embedded in the existing detection module. Bottom – The test system simulating a rising bed with a flexible ramp.

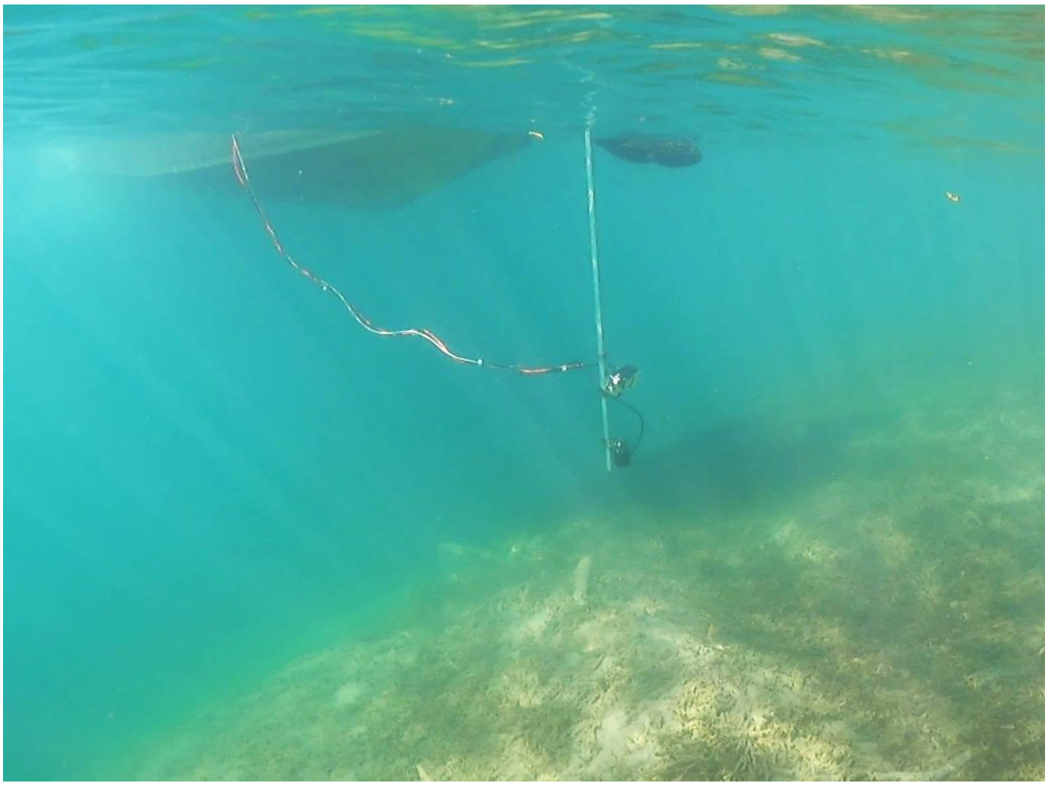

**Figure 4:** Initial trial of the CPS in the Kawarau River, March 2024. Underwater view of the rod-mounted GoPro camera approaching a rising riverbed.

**Figure 5:** Initial trial of the CPS in the Kawarau River, March 2024. Underwater and topside view of the GoPro camera approaching the river edge.


**Figure 6:** Initial trial of the CPS in the Kawarau River, March 2024. Rod-mounted GoPro approaching and detecting two instances of lagarosiphon, with date, time and GPS location displayed and recorded. *Refer to videos in memo report folder, embedded in power point: CPS_videos_for_milestone_1_of_2.pptx*

### 3. Results

The initial phase of development of the CPS system has demonstrated that the camera system can be automatically (without human input) raised and lowered in the water column integrating hydroacoustic technology, this has not been demonstrated previously.

- Substituting the original 2 m long round profile carbon-fibre pole with a square aluminium 2.5 m long rod eliminated pole rotation and therefore optimises image collection quality for use by the automated detection module.
- The mechanical and electronic stops worked as expected in both the flume and field trials.
- The 3D-printed fixtures worked well.
- Using the computer to 'electronically assert' the Power Pole's buttons worked but gave rod-travel increments that were much coarser than we had anticipated and require, this aspect needs further refinement to accurately set the camera position from targets and obstacles.

### 4. Discussion

**System design**

We would have preferred to retain the original, more-flexible carbon-fibre material rod, and while it can be made in square section, it cannot be made small enough to suit the mechanical roller feed in the current motor system. Hence, we used the aluminium rod. Aluminium, while less flexible than carbon-fibre, may be more robust. However, if the rod were to collide with something solid it would bend and likely not be of further use. We could provide a hinging system so that, if all else fails, the rod can simply hinge up/backwards. During future field trials it will be good practice to carry a spare rod. We could use longer rods for lake work, although we would need to investigate rod and camera stability at faster boat speeds. If this were a limiting factor, we could consider other rod designs.

We may be able to revert to the larger-section tube, more-resilient carbon-fibre rod, if we could accommodate the larger size within the pinch rollers of whatever motorised system we progress with, following this initial prototype. A larger rod size may then enable the cables to be fed down through the rod to give them protection, reduce drag and be less likely to catch on weed or other snags. It would need a flexible fitting at the top end to protect the cables as they exit the rod (e.g., like that on the EFM300 Electric Fishing Machine developed by NIWA). The excess cable would also need to be 'managed' during rod movement.

We could achieve finer motor control by driving the motor directly, by accessing the power input, and feed it via a H-bridge (e.g., like NIWA's irrigation gate controller technology). We would make the up/down increments much finer by turning on the motor for a shorter time (per increment) compared to the 'out of *our* control' time interval integrated in the off-the-shelf Power Pole product. To provide some degree of positional feedback we would embed magnets along the rod at intermediate positions.

**System performance**

Because the rating tank has a water depth of 1.75 m and is made of concrete, testing the acoustic equipment was more constrained than we had anticipated and there was some ambiguity in the results. However, more meaningful results were obtained in the open water trial in the Kawarau River, which demonstrated that the developed CPS can automatically raise and lower the camera system in the water column without human input.

While we may experiment with cameras with zoom capability in the future, the CPS system will still be required particularly in more challenging turbid environments. We are currently using off-the-shelf GoPro cameras which are compact, readily available, and relatively inexpensive. We also intend to deploy up to three GoPro's on a boom to extend swathe areas being surveyed. The CPS system that we have developed in this project could be modified to support these potential enhancements.

## 5. Conclusion

In this project we have developed a CPS system and demonstrated that the prototype can automatically raise and lower a video camera in the water column to improve the detection accuracy of our previously developed automated detection module.

In future work we intend to redesign the CPS application software to run in a standalone system rather than controlling it with the Jetson computer used in the current detection module. A forward-looking acoustic sensor/s should also be added to further sense obstructions in the forward facing direction. We could use contextual information from these sensors to help reduce any false triggering of the rod driving motor that might result from using a single sensor.

As we add additional cameras, increase frame rates, increase the number of models running on the automated detection module to detect multiple species, operate at greater boat speeds etc. we need to identify and overcome any limiting factors of the detection system, including both the CPS and the detection module.

## 6. Next steps

We have built and demonstrated an automated CPS system that can be further developed. However, to progress towards a fully operationalised automated detection system, we primarily need to focus on improving detection precision of the detection module by developing and evaluating field detection algorithms and detection rates. This is a known and achievable task.

We recommend as next steps:

- Field testing the developed automated detection system for lagarosiphon, initially in Lake Whakatipu and the Kawarau River where imagery has been collected and used in the development of the current algorithm system. We would then test the system in other clear water environments (e.g., North and South Island lakes, specific lakes to be determined) where imagery data has not been used in algorithm training to determine detection rates in these situations.

- Exploring a consortium funding approach from authorities responsible for freshwater and marine biosecurity in New Zealand to enable this solution to be rapidly advanced and adopted.

## 7. Acknowledgements

Thanks to the Department of Conservation Te Papa Atawhai for their support of this project. Brendon Smith (Mechanical Engineering Technician, NIWA) provided mechanical advice and designed and 3D-printed the fixtures. Hayden McDermott (skipper) and Inigo Zabarte-Maeztu (NIWA) provided field assistance.

## 8. References

Clements, D., Bulleid, J., Preston, G. (2023) Invasive macrophyte remote detection research - 2022/23. NIWA memo report to DOC. June 2023.