JNCC Report 728

Video methodologies for deep water surveying of Queen conch (*Strombus gigas*): A comparison study in Turks & Caicos Islands

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Summary

Queen conch (*Strombus gigas*) remains one of the most important fishery resources in the Wider Caribbean Region, but growing demand has led to problems of over-fishing, illegal landings and declines. In Turks & Caicos Islands (TCI), queen conch is the second most important commercial fishery, supporting a large export trade (> $3.5 m USD per year) as well as a domestic market. Previous underwater visual surveys using only scuba divers have not had the resources, such as large enough research teams and funding, to access deeper depths where conch may be present, resulting in incomplete stock assessments being formed. However, such data must be as comprehensive as possible for resulting fisheries management plans to be fully effective.

As part of an EU ReSEMBiD (Resilience, Sustainable Energy and Marine Biodiversity) funded project focussing on sustainable management of the queen conch fishery in TCI, novel underwater visual surveys of queen conch are being completed on the Caicos Bank: an expansive underwater plateau south of the Caicos Islands. In this study, two methodologies that could provide a more time and cost-effective way to survey deeper depths than divers can safely reach were compared: the established towed video array method (TVM) and more novel underwater drone (ROV). Due to surveying conditions and time limitations, the scope of this study was restricted to a qualitative comparison of the two survey methods. The results of this are summarised within this report.

From the results of this brief comparison study, it is clear that careful consideration should be taken to determine whether the current cost, complexity and upkeep of an underwater ROV, with all the functions required to perform transect surveys for queen conch, is justified by the benefits one could provide: such as the ability to survey a wider range of habitats without risk of environmental damage, and reduced personnel required for transport and operation. If funding is limited, the TVM currently appears to be the most suitable option for the monitoring of queen conch at depth

This report is intended to be used as an initial guide to inform queen conch density and abundance survey planning in the Wider Caribbean Region: especially if looking for a time and cost-effective way for surveying at depths greater than can be safely reached by scuba divers. The results will also inform ongoing monitoring efforts in TCI, both under the current ReSEMBiD-funded project and beyond, in efforts to ensure the ongoing sustainable harvest of the species. It should be acknowledged that whilst this analysis goes partway towards fulfilling the original mandate to compare two novel underwater survey methodologies, the undertaking of additional quantitative comparison studies and further comparisons with other ROVs on the market, would provide a fuller picture for those considering undertaking similar conch surveys.

Contents

1 Introduction

Queen conch (*Strombus gigas*) remains one of the most important fishery resources in the Wider Caribbean Region, but growing demand has led to problems of over-fishing, illegal landings and declines. Unfished deep-water adult populations of queen conch are considered critical spawning stock refugia (Apeldoorn 1997; Boman *et al*. 2021) but are challenging to study using dive surveys due to safety considerations and practical limitations. Underwater video methods like the towed video method (TVM) from Boman *et al.* (2016) have proven to be effective for surveying larger areas and deeper waters for conch in the wider Caribbean region for the last decade and have been compared against other established methods such as the use of scuba divers (Cruz-Marrero *et al*. 2020). However, recognising the TVM methodology has not changed since it was designed (van Rijn 2013), and considering recent technological advances in remote operated vehicles (ROVs) for taking underwater videos, there is now a need for comparison between established TVM and novel ROV methods in the surveying of deep-water queen conch populations.

Past assessments of queen conch abundance in the Turks and Caicos Islands (TCI) have indicated a decline in the nation's queen conch fishery, as well as key knowledge gaps still forming a barrier to a complete stock assessment being formed. With funding provided by the EU through its Resilience, Sustainable Energy and Marine Biodiversity fund (ReSEMBiD), novel underwater visual surveys are being undertaken for queen conch in TCI to inform an updated, robust and more extensive stock assessment and future management plans for the fishery. To achieve this, surveys must also be undertaken at depths greater than previously achieved using scuba divers only.

In TCI, the TVM methodology that was effectively utilised for surveying conch in other Caribbean nations, such as Saint Eustatius (Boman *et al*. 2016) and Anguilla (Izioka *et al*. 2016), will be employed: recognising that this has already been established as a cost-effective method to enable surveying at deeper depths than conventional dive surveys. A short method comparison survey between camera tow and underwater drone technologies will also go on to inform the remainder of the project's survey work, as well as inform other Overseas Caribbean Territories intending to undertake conch population surveys in future. This report outlines the specifications and operation of the two methods compared in TCI, and a qualitative analysis of the costs and benefits encountered with each method.

This report is intended to be used as an initial guide to inform queen conch density and abundance survey planning in the Wider Caribbean Region: especially if looking for a time and cost-effective way for surveying at depths greater than can be safely reached by scuba divers.

2 Methods

2.1 Monitoring methods

To inform current underwater visual surveys for queen conch density and abundance studies in TCI and future monitoring efforts in the wider Caribbean, an established methodology was compared in the field to a potential novel methodology. Here, the towed video array (TVM) and a mid-range remotely operated vehicle (ROV or underwater drone) are compared for their potential to carry out belt transects on the seabed at depths of 10 m to 60 m. A brief overview of specifications and operational procedures of each method are introduced in this chapter.

It is important to recognise that only one ROV was assessed in this study, and a number of other options are available on the market depending on survey budget. This study can therefore be used as a basic indicator of how other similarly priced ROVs might perform for undertaking conch surveys but is not a definitive assessment of the potential use for all ROV options.

2.1.1 Towed video array

The hovering towed video array (TVM) was initially built and tested in St. Eustatius (Van Rijn 2013) and consequently calibrated (Boman *et al.* 2016) and adopted to survey the deeper waters of Anguilla, Saba Bank and St. Eustatius (Boman *et al.* 2021). The original design was based on methods described in Stevens (2003) and Sheehan et al. (2010) while adapting it to be a cost-effective and practical solution that can be built, operated and maintained in a tropical island setting. For that reason, the frame is constructed using polyvinyl chloride (PVC) piping (Figure 1) that is commonly used in plumbing, and a rope tether is attached to the frame using hose clamps and shackles. All items required to construct such an array should be available at local hardware stores, and parts can be adjusted to whatever is available locally. Cameras and lasers needed for the TVM can be purchased online.

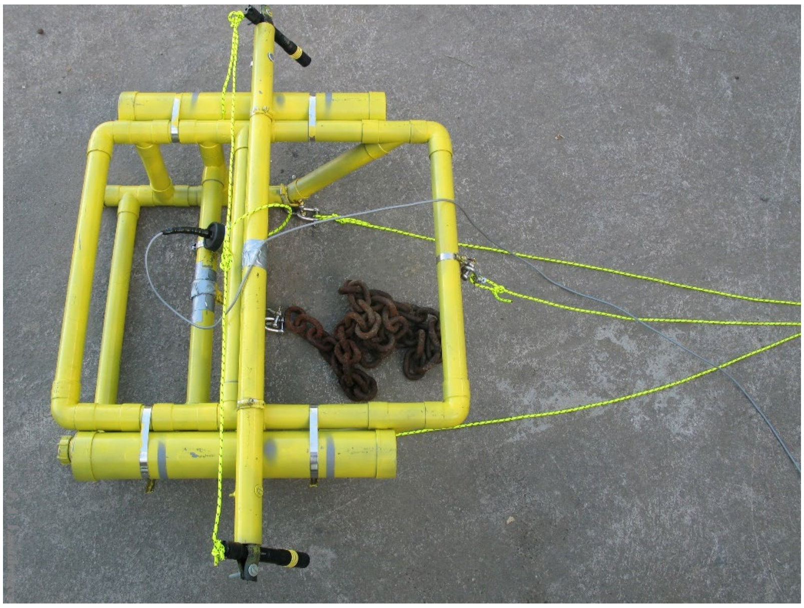

Figure 1. Original towed video array as constructed on St. Eustatius (© J.J. Lastdrager).

To enable use for surveys, a drop camera is necessary to provide the on-board operator with information on the array, via a portable monitor, that allows them to adjust for changes in depth and avoid high-relief and vulnerable habitat such as coral reef. A second camera is also required to record video footage of the transects surveyed. Two green lasers are also mounted on the frame, one metre apart, to indicate the width of the belt transect in recorded video footage.

To ensure the TVM is located correctly in the water column for seabed surveying, two sealed, air-filled PVC pipes are attached to the upper frame for slight positive buoyancy. The weight of the drag chain then sinks it towards the seabed and allows it to hover. At ±10 kg drop weight also keeps the frame in a horizontal position and absorbs some of the surface motion from the boat. Both the drag chain and drop weight are attached using strong fishing line tied in a loop (50 to 90-pound test): this is necessary as if these parts get firmly caught on the bottom, the fishing line will break before the frame or tether does and all parts can be retrieved safely. The setup as deployed in the water can be seen in Figure 2.

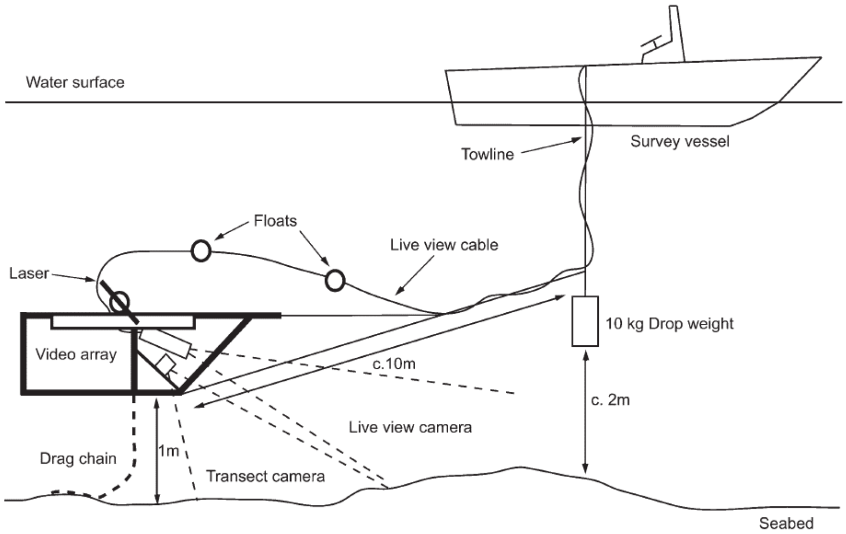

Figure 2. Setup of the towed video method (Boman *et al*. 2016)

A team of two to three people is required to operate the TVM correctly and undertake successful transects, and several steps must be carried out just before and during deployment from a survey vessel. Firstly, the frame is *filled* with water to allow it to sink in the water column, and the drag chain and drop weight are attached. The boat is then navigated upwind of the intended transect. With lasers and cameras turned on and the video recording camera (such as a GoPro) recording, the boat engines are put in neutral and the array is deployed with the drag chain, ensuring all lines are free. The drop weight is then lowered until it touches the seabed, then taken up by 1.5 metres before tying to a cleat. At this point, the start of the transect is marked on a GPS device. During the transect, the live view of the seabed from the drop camera must be monitored constantly to avoid collisions and adjust for changes in depth. After the TVM has covered the intended transect distance the end of the transect is marked, the array is retrieved, and the GoPro recording is stopped. Batteries must be checked and changed before new transects are undertaken, and following a survey day, all parts of the TVM must be rinsed thoroughly with freshwater to maintain the equipment and increase its longevity.

For this study undertaken in the Turks and Caicos Islands, all parts to construct the array were purchased at a local hardware store (Do It Center, Providenciales) and the cameras, portable monitor and lasers were purchased online. The frame was fitted with a live view camera attached to a 300ft cable (Deep Blue Pro, Ocean Systems, Inc. Everett, WA) and a transect camera (GoPro Hero 9; GoPro, San Mateo, CA). Two green lasers (Orca D560-GL; Orcatorch technology limited, Baoan, China) were used to indicate the width of the belt transect.

2.1.2 Seadrone PRO

The last decade has seen remotely operated vehicles (ROVs or underwater drones) become increasingly advanced and available to consumers of all kinds. As a result, ROVs are more frequently being used for small-scale environmental monitoring projects, like coral reef surveys in the Dutch Caribbean (E. Meesters, personal communication, 9 June 2022). This small-scale comparison study explored the potential of the Seadrone PRO ROV (Seadrone

Inc; Palo Alto, CA) for queen conch surveys, in comparison to the established TVM (Boman *et al.* 2016).

The Seadrone PRO (Figure 3) was selected for use in queen conch surveys in TCI due to its modular design, long battery life (~3 hours), depth lock capability, and laser scalers. Three sets of rechargeable batteries were required to allow for roughly nine hours of continued operation. Additionally, a doppler velocity logger (DVL) was purchased as an add-on to lock the ROVs distance to the seabed whilst undertaking transects. As with the TVM, it is necessary to record the length and width of the video transect to quantify the surveyed area and thus calculate conch density. Therefore, the laser scaler module was also purchased for the quantification of the belt transect width.

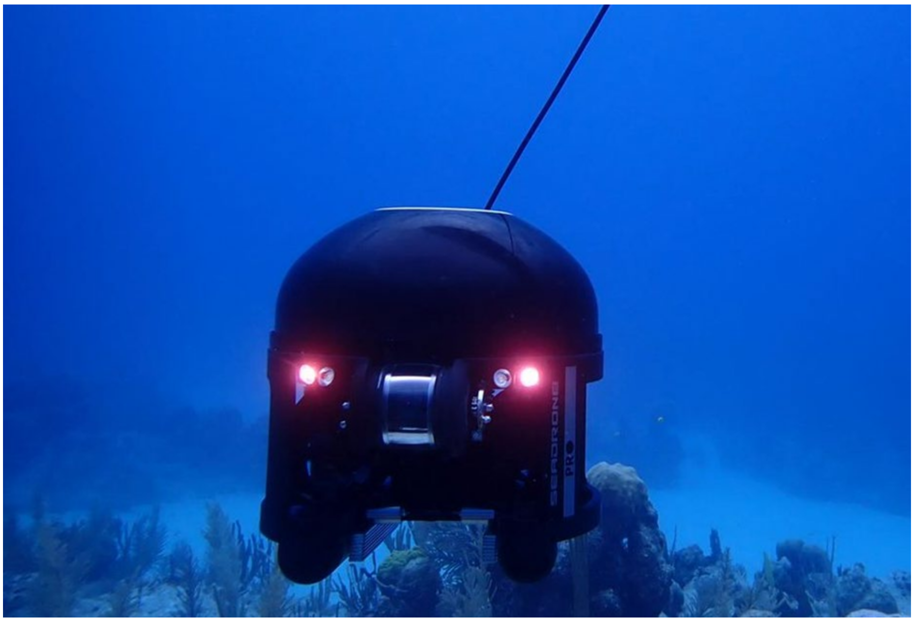

Figure 3. The Seadrone PRO is a remotely operated vehicle designed for inspection and monitoring.

The Seadrone PRO package (Seadrone Inc; Palo Alto, CA) consists of the ROV unit, cable reel, and an Apple iPad (Cupertino, CA) for operation via an app. Set-up and instruction manuals are provided, with further support and tutorials available on request.

Several steps have to be taken to safely and successfully operate the Seadrone PRO ROV. When on a boat in an open-water environment, anchoring or mooring before operation is the safest option, whilst also ensuring a stable and decluttered platform is available to operate from. The iPad provided connects to a Wi-Fi unit on the cable reel, and the app provided allows for viewing of live footage from the camera and operation of the ROV. Once the Wi-Fi is connected, the ROV compass and internal systems must be calibrated and checked before deployment. The operation of the Seadrone PRO from a boat requires two to three people to undertake belt transect surveys. One person operates the ROV using the controls on the iPad or controller provided, while another person manages the cable from the reel, which can be done by the boat captain or a third person. It is important to ensure that enough cable is released into the water for the ROV to move freely. Following a survey day, the ROV must be rinsed thoroughly with fresh water following the manufacturer’s instructions to maintain the equipment and increase its longevity.

The Seadrone PRO was shipped directly to the Turks and Caicos Islands and only a large storage and rinse container was purchased locally (Do It Center, Providenciales).

2.1.3 Video analysis

Video footage from both the TVM and Seadrone PRO is analysed manually by reviewing the footage and counting queen conch individuals within the laser points defining the transect width (Figure 4). It is important to distinguish between live and dead conch, which is determined based on visual cues such as position, shell damage, tracks on the sea bottom and any observed movements. Footage can be paused to confirm sightings and assess visual cues, and live individuals are then recorded in an Excel spreadsheet with associated transect data.

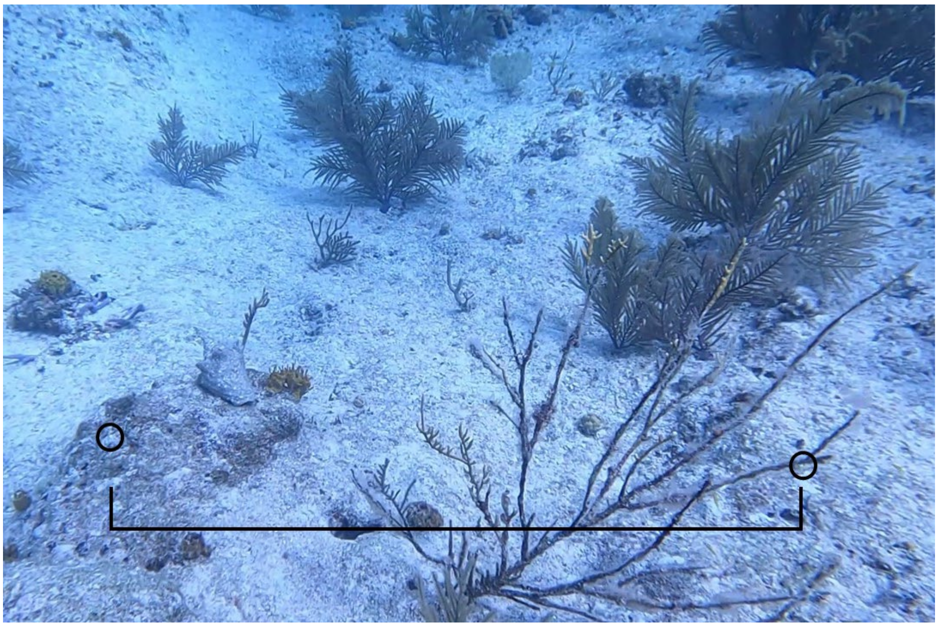

Figure 4. Snapshot of TVM footage, with a queen conch present within the one metre transect width, indicated by the black line. Laser points are shown within the circles.

2.2 Method comparison study setup

2.2.1 General comparison

The aim of the study was to carry out a full comparison of the TVM and ROV in order to inform upcoming and future survey work for conch studies. From the initial tests with both methodologies, undertaken both on land and at sea, a qualitative comparison was made on a number of general points.

2.2.2 Survey transect comparison

The next step involved undertaking a 500 metre long transect at sea for both methods separately. For a successful qualitative comparison of both methods in the water, the aim was to undertake both transects in a similar habitat and depth with queen conch present. This would allow for a more effective comparison of how well conch could be identified from the respective video footage. Unfortunately, due to weather conditions and time limitations experienced during the study, no ROV transects containing conch were successfully undertaken, and as such the qualitative in-water comparison of the two methods was restricted.

The final step was to deploy both methods at the same time and actively follow the TVM with the Seadrone PRO in an attempt to survey the same 500 m transect (Figure 5). This was the most logical sequence, as the TVM is a passive towed object and therefore would not be able to follow the Seadrone PRO. To achieve this, the Seadrone PRO needed to be controlled to follow the TVM closely and preferably capture the lasers of the TVM in its own video footage. This would allow for a qualitative and potentially quantitative comparison of the two methods if conch were present in the transect. Unfortunately, due to conditions and time limitations experienced during the study, no comparison transects containing conch were undertaken. As such, the scope of this method comparison study remains qualitative only and the results are presented as such.

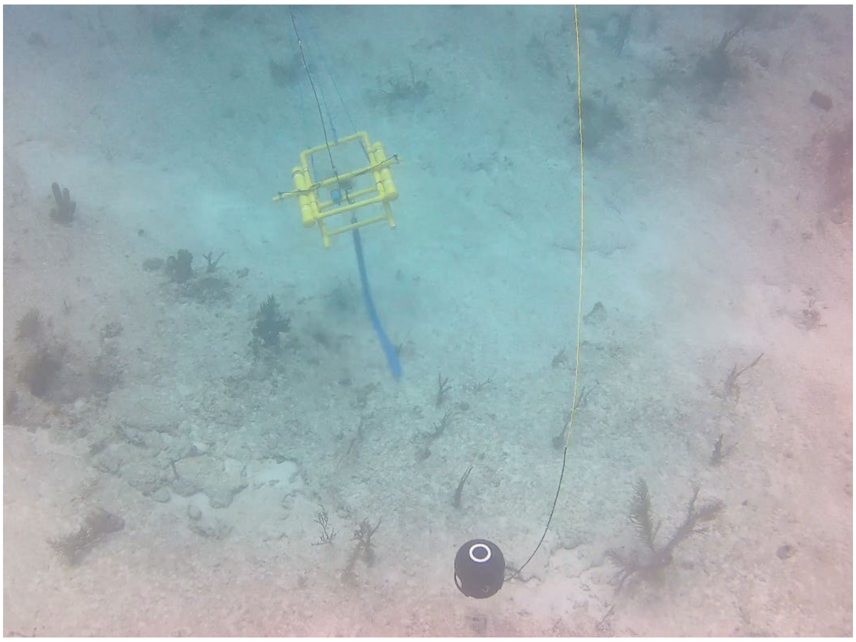

Figure 5. At-sea transect comparison setup. The TVM is being passively dragged by the survey vessel with the current, whilst the ROV is being actively controlled to follow the same transect line directly behind.

3 Results

3.1 General comparison

3.1.1 Ease of use

The Seadrone PRO requires no construction and minimal set-up time, whereas the TVM has to be built from scratch with the need for technical skills. Once ready for use at sea, the TVM, with guidance, is relatively simple to deploy and operate as it is a passive method (the array drifts behind the boat with the current). Conversely, the ROV requires more training time and a higher skill level to effectively operate it underwater for monitoring purposes. Within the time available to undertake this study the survey team were not able to attain a full understanding of the ROV, its functions and how to handle it correctly, which hampered progress made with this method.

3.1.2 Portability

The SeaDrone PRO ROV and cable reel are fully portable and designed to be carried by one operator. The drone is compact (30 x 30 x 32 cm) and weighs 10 kg, whilst the cable reel weights 5 kg. Both are designed to be taken as a carry-on on a commercial plane, with the TSA-approved 90 Wh batteries also allowing for deployment at-sea without the need of a surface power system. Conversely, the TVM was designed to be used on a single island, and not with air travel in mind. It requires surface power for the live view camera, and once assembled, it is bulky (80 x 100 x 30 cm) and weighs roughly 12 kg, with the tether adding an additional 8 kg. The frame and tether need to be carried by two operators and are considered oversized check-in luggage for most airlines.

3.1.3 Durability

The durability of both the TVM and SeaDrone PRO will be decreased by sun exposure and saltwater corrosion over time. Generally, moving parts experience the biggest strain and therefore need most maintenance. The TVM has no moving parts and the two cameras are protected by the PVC array. The Seadrone PRO has several moving parts, including four propellors and movable lasers, which other ROVs would also have in their design. Although the build quality on the Seadrone PRO is of a very high standard and designed to withstand corrosion, it can be expected to require more maintenance than the TVM over a long period of time. The manufacturer has accounted for this by making all the water exposed parts replaceable by users through use of a “modular” drone design.

While the tether of the TVM remains under the surface whilst in use, that of the Seadrone PRO floats. In the unfortunate event that another boat passes over the line and cuts the tether, the ROV could be lost, or at best the tether damaged. The reason the tether floats is to minimize entanglement with objects on the seafloor, which appeared to work well during initial tests. If the TVM gets stuck on an object on the seafloor it will most likely involve the drag chain or the drop weight. These items are attached to the frame and tether by a strong fishing line, so they break when forces become too high. If this happens the TVM will rise off the bottom and can be retrieved using the tether.

3.1.4 Maintenance

Most parts of the TVM can be replaced easily with items found at most hardware stores or online. The drop camera is the most difficult component to replace, due to the limited suppliers available and the general expense (including any associated shipping costs). With the Seadrone PRO, the modular design intends for repairs to be relatively easy for any user in any location, and tutorials are provided for assistance with any repairs. Nevertheless, as parts may need to be replaced more frequently, maintenance of an ROV could be regarded as more time consuming and potentially complex for any given user. Once the warranty expires, any repairs may also become more expensive. Warranty information should be considered before any purchase of an ROV, as well as the two cameras required for the TVM: as once any warranty period ends, repairs may become far more costly.

3.1.5 Costs

The TVM is considered a cost-effective method for queen conch surveying due to its relatively simplistic design and relative availability of components. The most expensive items to purchase for construction of the TVM are the drop-camera (to guide the array with a live-view of the seabed) and GoPro or similar high-quality underwater camera (to record video footage of the transect for analysis). Costs can therefore be impacted by the make and model of cameras purchased for the array; however, it must be considered that lower cost components may compromise video quality attained. Costs are also impacted by the prices encountered for parts purchased locally: options may be limited which can impact the final price. For this study, the total cost of components to build the TVM frame, which were purchased within TCI, was $824.16. The drop camera was imported from the United States and cost $1,950, including shipping. All other technical components were purchased in the

UK and taken to TCI in airline hold luggage, and cost the equivalent of $931. In total, the cost of components for construction of the TVM came to the equivalent of $3,700.

Underwater ROVs range widely in cost and technical specification. Low-end drones with limited functionality start from $1,000, whilst high-end options can easily exceed $50,000. The SeaDrone PRO can be considered a mid-range ROV which, at the time of this study, was purchased for $17,917 with the inclusion of built-in lasers and depth-lock capabilities. It should be noted that the locator module add-on, which would allow for GPS tracking of the drone and programming of pre-set transect routes, would result in an additional cost of $7,299. However, this module can be added to the ROV at a later date if available budget does not allow for initial purchase, as was the case for this study.

3.1.6 Potential uses

Because of its simplistic design the potential uses of the TVM are limited. The method lends itself to seabed monitoring on relatively smooth substrates only, as undertaking video transects in more complex or sensitive habitats would become too difficult if the operator is required to constantly adjust the length of the tether to avoid obstacles. The versatility of the Seadrone PRO is much higher once the operator is fully comfortable with the use of the controls. When optimized it could be used for seabed monitoring on more complex and rough substrates as controls are sensitive and immediate. Additionally, this and other similar ROVs could be used for a much larger range of tasks, including port and customs inspections, ship hull monitoring, coral reef monitoring, and fish surveys.

3.1.7 Environmental impact

The TVM includes a drag chain which is essential in its construction: the weight of the drag chain sinks it to the seabed and allows the TVM to hover at the appropriate depth for video footage to be taken. The chain touches the seabed and moves with the current as the TVM is pulled forward by the boat. This is the only part of the array that has the potential to physically impact the seabed environment. To reduce risk of the chain impacting any sensitive species or habitats, the TVM must not be operated over coral reefs, and in other areas the operator must be vigilant and reduce the tether length or end the transect if any sensitive species or habitats come into view on the live-view monitor. The Seadrone PRO, as with other similarly designed ROVs, has no components touching the seabed at any point during its operation, if controlled effectively. If a depth-lock mode is engaged, this could further reduce risk of hitting the seabed. The risk of physical environmental damage is therefore likely to be less if using a ROV in comparison to the TVM and can be used in a wider variety of habitat types.

3.1.8 Health and Safety

When surveying in an open-water environment safety is of great importance. No major safety concerns were identified when operating either the ROV or the TVM. However, during TVM trials in TCI, the location of the power supply at the stern of the vessel used resulted in the operator being in the full sun for long periods of time whilst in use. To alleviate health and safety concerns resulting from sun and heat exposure, it would be best if an on-boat power source were available in a location allowing for operation in the shade.

3.2 Survey transect comparison

3.2.1 Transect routing

During the test transects undertaken in TCI, the depth lock and laser functions of the ROV were not yet correctly configured for use. The Seadrone locator function, which would allow for GPS tracking of the drone, was not budgeted for within the project, so was also not available for use at the time this study was undertaken. Without these functions it proved challenging to conduct quality transects with the Seadrone PRO. The operator had to keep a course on the survey vessel compass, manage height above the seabed, avoid bigger obstacles and adjust for current whilst driving the drone forwards along its transect. If all functions listed above were available, the operator should be able to program transects to be taken automatically by the drone, and simply monitor for errors, which would result in much simpler operation. Conversely, while using the TVM, the operator only has to monitor the height above the seabed and look for bigger obstacles, so operation is much simpler. However, low wind conditions can result in TVM transects taking longer than those of ROVs such as the Seadrone PRO, as the TVM passively moves with the current.

3.2.2 GPS tracking

A handheld GPS is used to mark the start and end points of the TVM transect. This allows the operator to keep track of the length of the transect. Simultaneously, the timestamp of the waypoints is used to indicate how far into the GoPro recording the transect starts and when it stops: thus, which footage should be included in the video analysis. The Seadrone ROV offers a GPS locator module that allows the recording of the location of the ROV which would be necessary to record the length of the transects. This module could not be purchased within the scope of funding available, so its effectiveness could not be tested within the scope of this study. It is worth considering the purchase of this or a similar module for any ROV to increase its suitability for conducting belt transects. In the case of the Seadrone ROV, the range of the locator module is only 300 metres and can be less when obstacles are in the way, thus surveys should be adjusted to work around these limitations.

3.2.3 Video quality

In the comparison studies conducted in TCI, video quality from the Seadrone PRO camera (as configured out of the box) was inferior to that of the GoPro Hero 9 used on the TVM. The main reason for this appears to be the difference in megapixels (MP): while the GoPro used has 20 MP, the Seadrone PRO camera has 2 MP. As a result, video footage appeared comparatively blurry with low colour contrast (Figure 6). Whilst no conch were recorded with the ROV, it is assumed that the video quality would make video footage analysis for queen conch monitoring purposes more challenging. The Seadrone PRO does have a function to adjust the focus of the camera, but unfortunately, it was not possible to test this adjustment fully in the timeframe available to conduct this study.

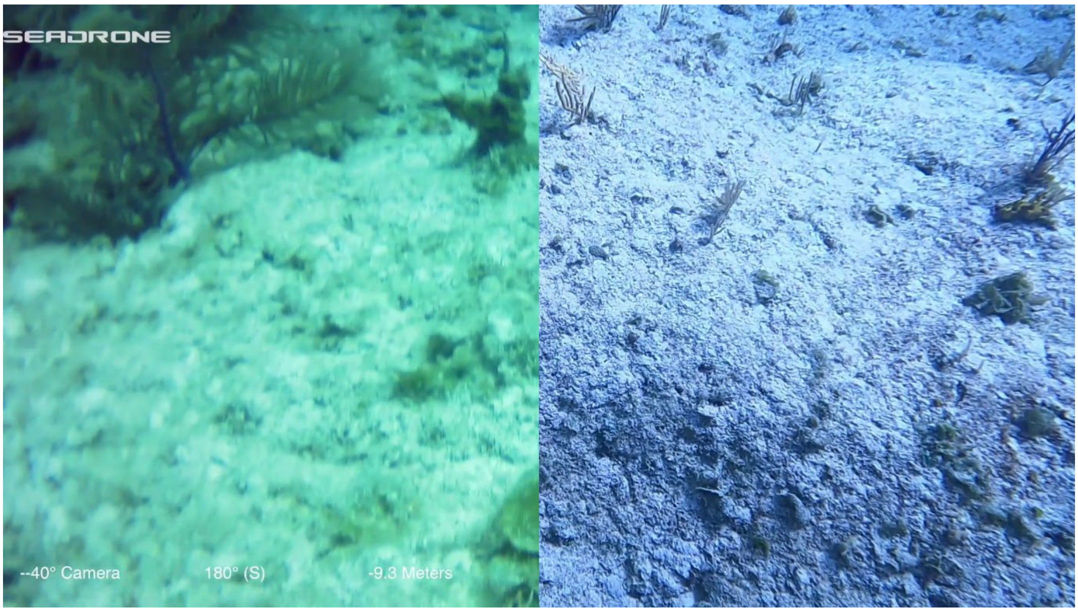

Figure 6. Comparison of video stills from the Seadrone (left) and the GoPro on the TVM (right), taken at a comparable depth and conditions

3.2.4 Laser

The lasers on the TVM are mounted one metre apart: the appropriate distance for the determination of the transect width (see Figure 1). The Seadrone PRO has the lasers mounted 10 centimetres apart and therefore a grid overlay (provided as part of the controller functions) is required to determine the correct placement of the drone within the water column for the required transect width. During the transect tests the laser-module on the ROV was not functioning correctly, and we were not able to test its functionality. However, the manufacturer provided instructions on how to achieve a one metre transect width with the lasers on the ROV, which could be trialled for effectiveness in the future.

3.2.5 Depth lock

To keep the TVM hovering at the correct depth for transects to be conducted, a drag chain and drop weight is used as shown in Figure 2. On the Seadrone PRO an electronic system, the doppler velocity logger (DVL) and software, is used to lock the height above the seabed. This system was not functioning at the time of this study: therefore, we were not able to test if this system works well during transects to maintain the required distance to the seabed for the intended transect width. This function should become available with the next update of the SeaDrone app so could be tested in the future.

4 Discussion

While the Seadrone PRO ROV used in this study shows great potential for future use, it cannot be used in the current configuration to conduct monitoring transects for queen conch comparable to those that can be achieved by the TVM. As such, the TVM is currently identified as the most suitable and cost-effective method to survey conch at depths greater than can be safely reached by scuba divers.

Without fully functioning lasers, depth-lock and GPS locator-module, the Seadrone PRO cannot be used for monitoring transects, as the area surveyed cannot be effectively determined for calculating queen conch densities. Furthermore, the video quality as seen in this study would likely cause difficulties in identifying live conch in video analysis. However, one solution could be to mount a GoPro to the bottom of the ROV to record higher quality video footage if required. The other key concern that a passive vessel could damage the floating tether or the ROV itself could be minimized by flying a diving flag on the vessel during operation. Once these factors have been addressed and the necessary systems and functions are in place and operable, the survey team will need to invest several more days in testing the Seadrone PRO before it can be used for queen conch surveys. In its current capacity, the ROV can instead be used for inspection of moorings, specific sites or conch aggregations.

The key limitations experienced with the TVM are portability between islands and the inability to survey more complex and fragile habitats due to the requirement for a drop weight in its design and function. Nevertheless, the method can be used in its current configuration to survey deeper waters for queen conch around the Turks and Caicos Islands: specifically on the Caicos bank, where much of the substrate is sandy and there are no large variations in depth or structure along transects.

With more time and resources, the monitoring potential of the Seadrone PRO could surpass that of the TVM for deep waters. The model used in this study is only one of a number of options available on the market at a similar price which promise functions such as depth lock, laser pointers and GPS tracking, and the technology and options available in the field of underwater ROVs is expanding and improving rapidly at present. In future, ROVs are also likely to be a more affordable, and will likely be a beneficial tool not only in the monitoring of queen conch populations but for many other species, including those economically important to Turks and Caicos Islands and the wider Caribbean, such as the spiny lobster (*Panulirus argus*) and coral reefs. However, at the time of this study, it would appear that careful consideration should be taken to determine whether the current cost, complexity and upkeep of an ROV with all the functions required to perform transect surveys is justified by the benefits it could provide, such as the ability to survey a wider range of habitats without risk of environmental damage, and reduced personnel required to transport and operate it. With limited funding, the TVM currently appears to be the most suitable option for the monitoring of queen conch.

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