Deep Sea Monitoring using ROV Technologies in the San Andres, Providencia and Santa Catalina Archipelago, Colombian Caribbean

Monitoreo de Aguas Profundas Utilizando Tecnologías ROV en el Archipiélago de San Andrés, Providencia y Santa Catalina, Caribe Colombiano

Surveillance en Haute Mer Utilisant les Technologies de ROV dans les Archipels de San Andres, Providence et Santa Catalina, dans les Caraïbes Colombiennes

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ABSTRACT

In the Seaflower Biosphere Reserve (RB) marine ecosystems at depths over 40 meters have been little studied, this generates information gaps that affect the conservation processes and recognition of the population dynamics of marine species. The local company SEPIAROV SAS, developed an ROV-type technology focused on the reduction of the necessary logistics, enabling its application in research exercises, called SEPIA that solves the need to evaluate deep ecosystems, reducing efforts and increasing background time. More than 20 prototypes were developed, applying agile technology development methodologies in order to adapt the operational capabilities of the SEPIA ROV to monitoring. Currently, thanks to the inter-institutional work that integrates the state through the Departmental Government and the CORALINA Environmental Corporation, the academy with the National University of Colombia, the private company SEPIAROV SAS and the community. SEPIAROV is being implemented in projects such as the monitoring of coral reefs, distribution of queen conch and lionfishes, in the latter identifying individuals between 50 and 89 meters deep, developing methodologies that allow to optimize the dive time and the results obtained. The SEPIAROV initiative has worked hand in hand with Macondo lab innovation, laboratories of the Simón Bolívar University, in order to boost technology innovation for the marine research community, with versatile tools that meet the needs of deep ecosystem research, key and invasive species in the islands of San Andres, Providence and Santa Catalina which have gained high importance in recent years.

KEYWORDS: ROV, deep sea monitoring, prototyping, queen conch

INTRODUCTION

The queen conch *Lobatus gigas* belonging to the Gastropoda class, is distributed from eastern Florida to the coasts of Venezuela, going down to Brazil, it is highly appreciated for its nutritional value and the beauty of its shell, being essential for the Caribbean communities since ancient times, as an important part in diet, culture and tradition (Aldana 2003, CORALINA 2016). It has been the second fishery by economic importance in the Caribbean after the spiny lobster *Panulirus argus* (Brownell and Stevely 1981, Stoner et al. 1992, Theile 2001), actually a lot of people still subsist thanks to the commercialization of this species. Although it is an important resource, there has been a notable decrease in its populations due to natural and anthropic pressures, which highlight overfishing, pollution, loss and degradation of ecosystems, ocean acidification and increase in water temperature, a consequence of global climate change. In Colombia, the main fishery is developed in the Archipelago of San Andrés, Providencia and Santa Catalina and represents an important source of income for fishermen (Prada and Castro 2009).

The ability of the snail to inhabit up to 100 m deep and indications of population migration at depths greater than 30 m where the fishing effort is less than in the shallow reef has been reported. The use of technologies capable of monitoring these depths is possible with ROVs (Underwater remotely Operated Vehicles), which can efficiently obtain relevant information on the status of deep queen conch populations and the mesophotic ecosystems that they can inhabit.

The SEPIA ROV has been developed thinking on a low cost, high efficiency, easy to use and updatable technologies that allow to explore the deep ecosystems surrounding the Archipelago of San Andres. Since 2016 more than 20 prototypes and its IPs were registered and it was in 2019 when the first queen conch survey was made with successful results, the methods used were based on the shallow standard queen conch monitoring which have been done for more than 15 years all around in the Archipelago.

METHODOLOGY

The archipelago of San Andrés, Providencia and Santa Catalina, from the jurisdiction of Colombia, includes three small inhabited islands (San Andrés, Providencia and Santa Catalina), and seven banks and coral cays located between 11° 30' and 16° 30' N and 78° 28' and 82° 00' W with an approximate extension of 250.000 km^2 of territorial sea and exclusive economic zone. The archipelago was recognized by UNESCO as the Seaflower Biosphere Reserve in 2000 and a large extension of it (65.000 km^2) was declared in 2005 by the Ministry of Environment, Housing and Territorial Development as a multiple-use marine protected area (MPA) and as an integrated management district (DMI-AMP) in 2014 by the Ministry of Environment and Sustainable Development (CORALINA 2019).

Based on historical queen conch monitoring on the shallow reef platform of three islands: San Andrés, Providencia and Roncador, stations were established in areas surrounding them where individuals of the species were found, these stations being generally of depths greater than 30 m. The *L. gigas* individuals were observed by means of videotransects of maximum 20 minutes' duration, using an ROV which navigates at an average maximum speed of 2 knots and with capacity to reach depths of up to 100 m (Figure 1). During the tours data from the substrate, depth, number of individuals and age class (adults or juveniles), immersion time, reproductive behavior and presence of other species of mollusks, crustaceans and fish (lionfish) inside or outside the transect was taken.

To achieve successful results, related ROV characteristics such as speed and time, compass, video and capacity to reach up to 100 m were turn into an easy to use and replicable methodology which solves distance, wide of focus and the shallow water conch surveys comparison on the ROV navigation and recording.

Classification by age class among adult and juvenile individuals was carried out taking into consideration the presence of the lip. Only those individuals who had the observable shaped lip were classified as adults, while juveniles are those individuals who do not have a lip. Population estimates by age class were calculated from the equations proposed by Medley (2008) and others described below:

Density (conch/ha) per station: $ds = \frac{Ns}{A}$, where **Ns** is the total queen conch found in that station and **A** is the total surveyed area per station (ha).

Surveyed Area (ha) per station: $A = \frac{(t*S*w)}{10000}$, where **t** is effective the diving time (s), **S** is the average diving speed (m/s) and **w** is the transect wide (m) the later based on the wide of the focus adjusted to be 4 m wide.

RESULTS

In San Andres from September 22nd to October 10th 2019, they have monitored 10 stations on the island of San Andrés. Among which, only three individuals have shovel snail individuals, therefore, the population density is very low. The average total density was 2.84 (± 1.5 SE) conch/ha being 1.6 (± 1.07 SE) of adults/ha and 1.25 (± 1.25 SE) of juveniles/ha. (Table 1). In Providencia and Santa Catalina between October 18th and 23rd 2019, monitoring was carried out in Providencia and Santa Catalina. A total of 31 dives were made, of which 28 corresponded to ecosystems where individuals of *L. gigas* potentially inhabit. The stations with more queen conch were found in the east and west of the islands, which correspond to few frequent fishing sites and too deep to capture them,

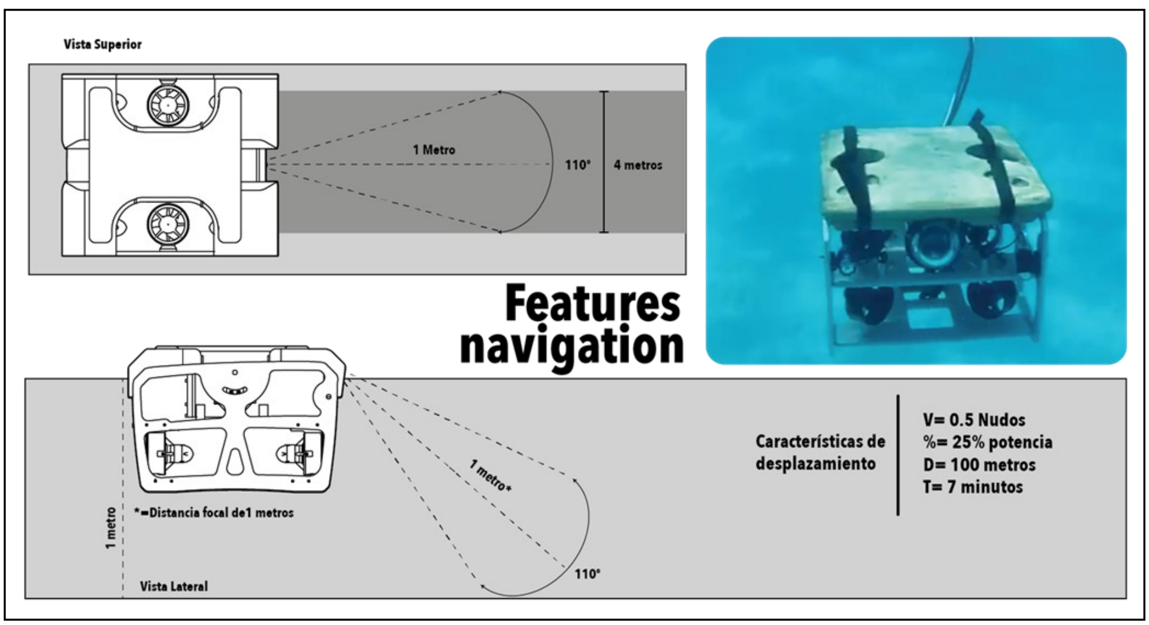

Figure 1. Navigation of the ROV during the queen conch surveys.

Table 1. Population densities of the deep-sea queen conch in the San Andres, Providencia and Santa Catlina Archipelago, 2019.

	SAN ANDRÉS			PROVIDENCIA			RONCADOR		
	Adults	Juveniles	Total	Adults	Juveniles	Total	Adults	Juveniles	Total
Average density ind/ha	1.60	1.25	2.84	62.30	23.30	85.59	53.24	26.02	79.26
Standard Dev.	3.38	3.94	4.75	157.56	44.20	193.92	113.41	58.90	168.68
Standard Error	1.07	1.25	1.50	28.77	8.07	35.40	20.71	10.75	30.80

respectively. Reproductive behavior and egg masses were observed between 28 and 46 m. The average total density was 85.59 (± 35.4 SE) conch /ha being 62.3 (± 28.77 SE) of adults/ha and 23.3 (± 8.07 SE) of juveniles/ha. Finally, between August 31st and September 8th 2019 the monitoring was conducted in Roncador. 30 dives were performed in total, of which corresponded to 24 ecosystems where individuals potentially live *L. gigas*. Stations reached depths between 22 and 90 m, being most individuals over 30 m deep. In addition, reproductive behavior was observed as copula and production of egg masses. The most inhabited ecosystems included sandy bottoms with proximity to octocorals, sponges and corals with little coverage of macroalgae and cyanobacteria. The average total density was 79.26 (± 20.71 SE) conch/ha being 53.24 (± 20.71 SE) of adults/ha and 26.02 (± 20.71 SE) of juveniles/ha.

The results indicate that the population density of queen conch adults in Providencia and Roncador at depths > 30 m are greater than the 50 individuals/ha predicted by the Allee effect (Courchamp et al. 1999), where the probability of that individuals have successful reproductive encounters is possible and where, less than 40 individuals * ha^{-1} spawning can even be compromised as is the current case for San Andres.

It is believed that deep-sea queen conch adult populations provide significant recruitment into shallow-water (< 25 m) stocks (Boman et al. 2016, Aldana 2019) and therefore there is a priority to protect them from fishing activities, since they replace the populations that can be extracted. In the Bahamas, Stoner and Sandt (1992) explained how fishing with SCUBA manages to reduce the queen conch populations of waters around 30 m to approximately > 1 adult * ha^{-1}. However, and considering that a pilot of the stations has been carried out to monitor the deep-sea conch populations, the realization of more dives that include depths between 30 and 100 m, will allow to find the places where some of the adults reproduce and maintain a stock of juveniles observed in more superficial waters. In addition, comparison and support in monitoring studies of the species in shallow waters like the ones performed regularly in the archipelago for more than 15 years, as well as the geomorphology of the islands, could help to identify these areas and access channels that allow the movement of juveniles and adults at different depths.

The distribution of individuals in the body of water is greatly influenced by the type of substrate / ecosystem, the quality and temperature of the water (which during the monitoring ranged between 28° C and 31° C), reproduc-

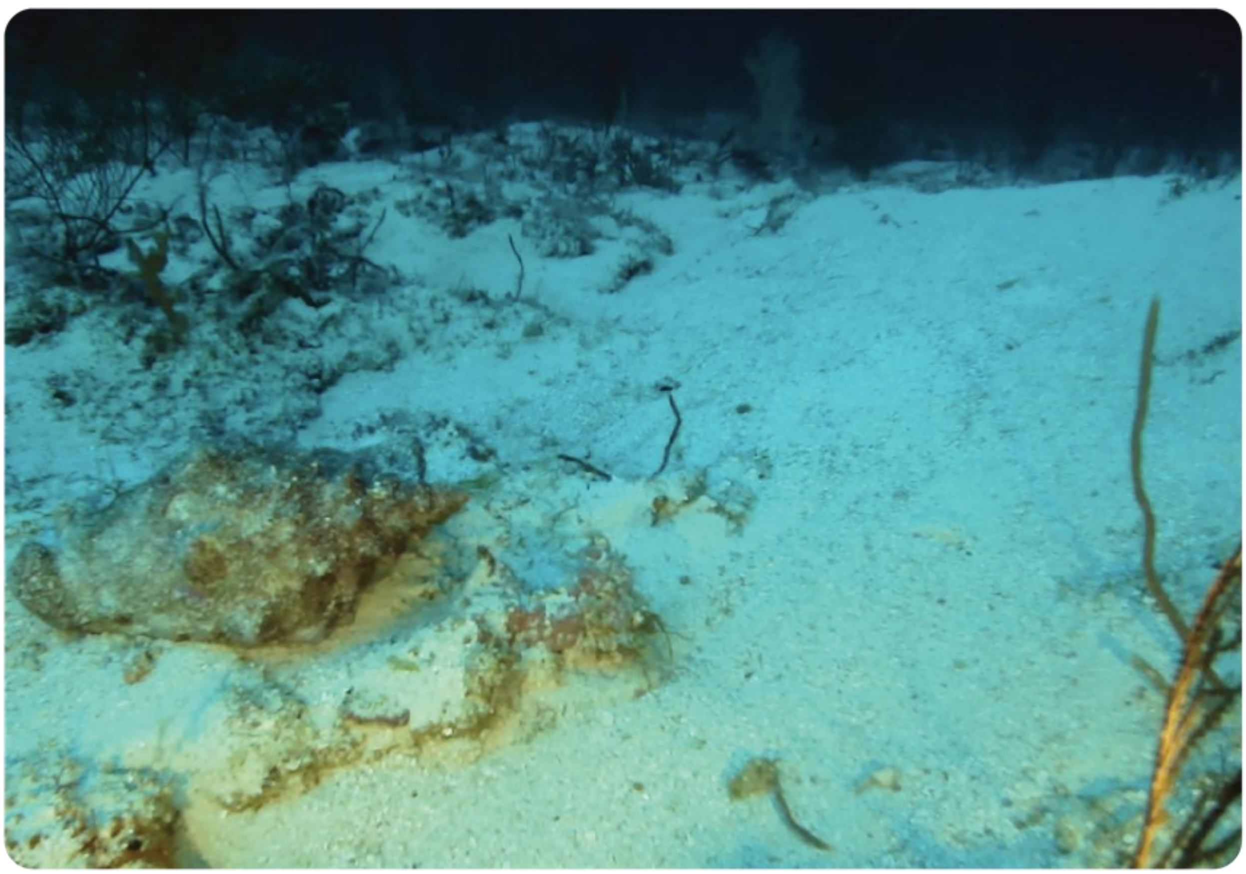

Figure 2. The deepest queen conch, Roncador 87 meters depth ,Abril.

tive aggregations, predation, especially due to fishing pressure, among others (Posada et al. 2000, Boman et al. 2016, Azcarate and Rojas-Archbold 2018, Aldana 2019). In Roncador and Providencia, the highest adult densities were found in sandy bottom ecosystems with proximity to coral patches or scattered coral heads, similar to those reported by Glazer and Kidney (2004), Vallès and Oxenford (2012) and Boman et al. (2016), but being characterized as organisms that inhabit sandy bottoms, these tend to avoid sites with large gravel-type particles. Juveniles were found at depths > 50 m and up to 87 m, despite being characterized by predominantly inhabiting shallow water (< 1 5 m), where they are exposed to being illegally extracted (Figure 2).

When comparing the population densities obtained in depth monitoring with the latest report in each of the islands, more adults * ha^{-1} are observed in each site, being five times higher in Providencia, both results being 2019 with a difference of one month between the monitoring carried out. On the other hand, the total density at depth in Roncador is half of the 2007 report taking into account that in that year 187 juveniles were found in shallow waters, this is related to the wide area of shallow reef platform that it possesses, providing ecosystems suitable for the development of juveniles of *L. gigas* (Forbes et al. 2016) and for the development of the legal and illegal queen conch fishery in the sand bank. However, San Andrés has maintained low conch densities since the declaration of the closure of the fishery more than 10 years ago without apparent recovery (Azcarate et al. 2018). So far the populations that inhabit deep-sea waters seem to follow the same pattern, which could be due to the strong pressure of illegal fishing exerted on juveniles that inhabit shallow waters near the coast and their effect on the generational relief with adults.

As conclusions the monitoring of the queen conch populations is possible with ROV technologies that are currently compact, accessible and easy to operate for research purposes. The densities found are high and are related to the monitoring carried out in shallow waters, making it possible in the future to generate permanent stations and in greater numbers to evaluate the distribution and abundance of this species in the water column.

A crucial management objective for the conservation of *L. gigas* should be to maintain the densities of adults in deep waters to ensure their natural reproduction. This is why the protection of individuals in deep water should be promoted once the key areas for their reproduction and larval dispersion are identified with the implementation of conservation actions and the prohibition of the development of fishing gear for their extraction, as they suggest Prada and Appeldoorn (2015).

In order to make adequate estimates of population densities, it is important to distinguish between not only juveniles and adults but live and dead and include such data in future analyzes. Likewise, the consignment of the depths at which each conch is found allows, in deep monitoring, to infer patterns in the vertical distribution behavior of the species. And so the devices and methodology are currently being developed to obtain biometric data of the individuals of *L. gigas* that inhabit deep waters, information that will be used to carry out population analysis and biomass estimation in the monitored places.

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