

Development of an Evaluation Method of the Queen conch (*Strombus gigas*) Resources in Guadeloupe and Application to Eight Marine Sites in the Archipelago

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ABSTRACT

The queen conch (*Strombus gigas*) is an intensively exploited species all over the Caribbeans and particularly in the Guadeloupean archipelago. Considering the local economical importance of this species and the threats on the regional stock, the Regional Fisheries Committee is initiating a study aiming to achieve a first assessment of the Guadeloupean stock variation. A simple methodology allowing the evaluation of the densities of the queen conch using an underwater towed camera was developed in order to be freed from logistical and financial diving constraints. This first step allowed us to operate the settlements of this method through a first estimation of stocks densities in eight sites, from the Grand Cul-de-Sac Marin to Marie Galante. This protocol offers the advantage of sampling large surfaces in reasonable time and for a moderate cost. The experimental average density was estimated about 37.52 conches/ha, with a minimum of 12.9 conches/ha and a maximum of 65.1 conches/ha, for a total sampled surface of 47,700 m². The study reveals that large areas are needed to evaluate the state of this resource whose distribution is very dynamic and heterogeneous. This reliable and easily implemented method is strictly necessary to estimate the exploitable stock of Queen conches on a large scale and at every depth it could be found. This process will be applied to the evaluation of the stocks of Queen conches in the archipelago, and more broadly applied to the monitoring of other exploited resources. It was first applied for the determination of the initial state of a bay of Marie Galante, which will be the site of a future fishing reserve project.

KEY WORDS: *Strombus gigas*, stock assessment, Guadeloupe

Elaboración de un Método de Evaluación de los Recursos del Caracol Rosa (*Strombus gigas*) en Guadalupe y Aplicación a Ocho Yacimientos del Archipiélago

El Caracol rosa (*Strombus gigas*) es una especie intensamente explotada en todo el Caribe, particularmente en el archipiélago de Guadeloupe. Frente a esta acta y considerando la importancia del mercado que genera este recurso, el CRPMEM Guadalupe inicia un estudio para estimar las variaciones de densidades de esta especie en el archipiélago. Proponemos una metodología que permite estimar las densidades de Caracol rosa con una cámara submarina remolcada, con el fin de librarse de coacciones logísticas y financieras de la sumersión en buceo. Este trabajo inicial permitió la validación de este método, así como una primera estimación de las densidades de Caracol rosa en ocho yacimientos en el lagon del « Grand Cul-de-Sac Marin » y en la isla de Marie Galante. Este protocolo ofrece la ventaja de otorgar muestras de grandes superficies con costo accesible. La densidad promedio observada es 37,52 ind/ha, con un mínimo de 12,9 in/ha y un máximo de 65,1 ind/ha, para un total de 47 700 m² investigados. El estudio demuestra la necesidad de mostrear superficies anchas para estimar el estado de tal recurso, cuya repartición es heterogénea y fluctuante. Este método, fiable y simple, parece ineludible para estimar las existencias explotables de Caracol rosa a una escala ancha así como a todas las profundidades de repartición de este recurso. Este método se aplicara para la evaluación en curso de las poblaciones de Caracol rosa en el archipiélago y adaptado para estimar otros recursos explotados. En el caso de Marie Galante, esta tecnica permitió el establecimiento del estado inicial de las poblaciones antes de la colocación de un proyecto piloto regional de acantonamiento de pesca para recuperar las poblaciones de Caracol rosa.

PALABRAS CLAVES: *Strombus gigas*, estimación de poblaciones, Guadalupe

Mise au Point D'une Méthode D'évaluation des Ressources en Lambi (*Strombus gigas*) en Guadeloupe et Applications à Certains Gisements de L'Archipel

Le lambi (*Strombus gigas*) est une espèce intensément exploitée dans toute la Caraïbe et notamment dans l'archipel guadeloupéen. Face à ce constat et aux vues de l'importance du marché que génère cette ressource, le CRPMEM Guadeloupe initie une étude visant à estimer les variations de stock de cette espèce dans l'archipel. Pour répondre à cette problématique, nous proposons une méthodologie permettant d'évaluer les densités de lambi à l'aide d'une caméra sous-marine tractée, dans le but de s'affranchir des contraintes logistiques et financières de la plongée en scaphandre autonome. Cette première approche a permis la mise au point de cette méthode, ainsi qu'une première estimation des densités de lambis dans les 8 sites d'échantillonnage situés dans le Grand Cul-de-Sac marin et à Marie-Galante. Ce protocole offre l'avantage d'échantillonner de grandes surfaces en peu de temps et à moindre coût. La densité moyenne mesurée est de 36,9 ind/ha avec un minimum de 13,2 in/ha et un maximum de 65,1 ind/ha, pour un totale de 47 712,15 m² échantillonnés. L'étude démontre la nécessité d'échantillonner de très larges surfaces pour évaluer l'état d'une telle ressource dont la répartition est hétérogène et fluctuante. Cette méthode fiable et simple à mettre en œuvre se pose comme incontournable pour estimer le stock exploitable de lambi à une large échelle ainsi qu'à toutes les profondeurs où se rencontre cet animal. Cette méthode sera appliquée à l'évaluation en cours des stocks de lambis dans l'archipel et adaptée au suivi d'autres ressources exploitées. Dans le cas de Marie Galante, cette dernière a permis la réalisation de l'état initial préfigurant la mise en place d'un projet pilote régional de cantonnement de pêche.

MOTS CLÉS: *Strombus gigas*, évaluation, stock, Guadeloupe

INTRODUCTION

The marine invertebrate *Strombus gigas* (Linnaeus, 1758) has a long history of supporting subsistence and commercial Caribbean's fisheries, as it is relatively easy to catch and highly nutritious (Doran 1958, Mulliken 1996, Sadler 1997). Recently, the increase in economic demand due to the increase in population and in tourism's activities encouraged the development of commercial fisheries. Today, the *S. Gigas* is supposed to be the second most exploited resource after the spiny lobster in the Caribbeans (Aiken *et al.* 1999, Aiken *et al.* 2006, Theile 2001). Thus, a variety of measures has been taken in many areas to prevent the overfishing of Queen conch stocks (Appeldoorn 1994).

In Guadeloupe part of the French West Indies, the practice of queen conch fishing is regulated by the prefectural by-law of 2002, which limits conch fishing to professional fishers. This activity is thus authorized from the 1st of October to the 31st of December, from a depth of 0 to 25 meters. It is extended to the 31st of January beyond a depth of 25 meters. Each captured conch must present a well-flared shell lip and a minimum fresh meat weight of 250 g.

As the queen conch is a valuable resource, illegal captures are very common in the areas dedicated to Guadeloupean fisheries. Until 2007, there was no monitoring program surveying the *Strombus gigas* landings or the densities of the local population. The only existing monitoring program is the one conducted by the National Park of Guadeloupe in the Protected Marine Area of the "Grand Cul-de-Sac Marin", a program that began in 2005 (Mége and Delloue 2007). But this survey is carried out on transects of 600 m² of sea-grass bed by professional scuba divers in accordance with the French labor code. The *Strombus gigas* is known to be widely spread on various types of substrate and within depths ranging from 0 to 100 meters, so stock-monitoring programs must consider conch heterogeneous spread on wide areas.

The scope of this paper is to present the first step of a simple methodology developed by the CRPMEM Guadeloupe, allowing the evaluation of queen conch densities with as few logistical and financial constraints as possible (Chalifour and Scolas 2008). Our purpose is to design a standardized protocol in order to estimate queen conch densities and their fluctuations to provide a better management of our regional *Strombus gigas* stocks.

MATERIAL AND METHODS

The queen conch has been widely exploited over years in the Guadeloupean archipelago. The first step of our project was to identify the actual localization of the fisheries, and the fishing gear that they used. Thus, a survey was accomplished by the CRPMEM staff in March 2008. All the collected data were summarized in a Geographical Information System project under the "GV SIG 1.1" freeware (Chalifour and Scolas 2008). Through

this GIS a Guadeloupean conch stock monitoring protocol was elaborated and tested on eight sites identified as actual conch fishing areas and in the PMA of the "Grand Cul-de-Sac Marin" (Figure 1).

In each site, randomized transects were conducted with an underwater towed digital camera. We used a PANASONIC 1/3" CCD camera, providing a resolution of 752 x 582 pixels (Figure 2). A special casing was designed for the protection of the equipment and for its stabilization.

On each site, two randomized transects are realized for each depth scale of 5 meters between 0 to 25 meters (0 - 5; 5 - 10; 10 - 15; 15 - 20; 20 - 25 meters), when the seabed profile allows it. The positions of the transects are recorded with a GPS system. Two parallel laser pointers are placed on each side of the camera creating a reference point for the determination of the span of the field of analysis. Digital movies were then simultaneously recorded and viewed on a portable media player Arcos 7, with a 7" screen and an internal hard-drive.

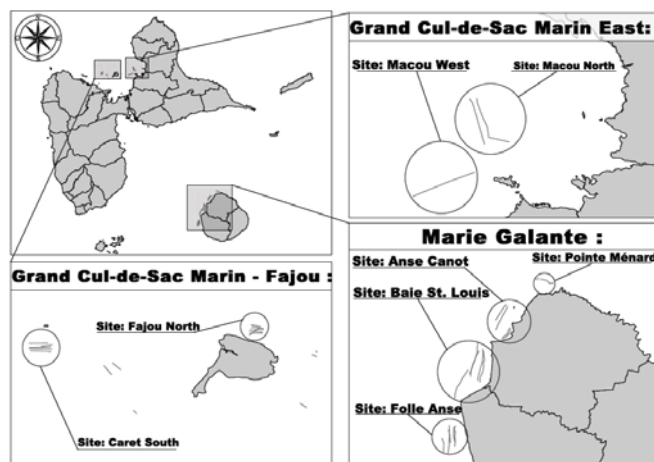


Figure 1. Map of Guadeloupe and the 8 sampling sites surveyed by the CRPMEM Guadeloupe in 2008.

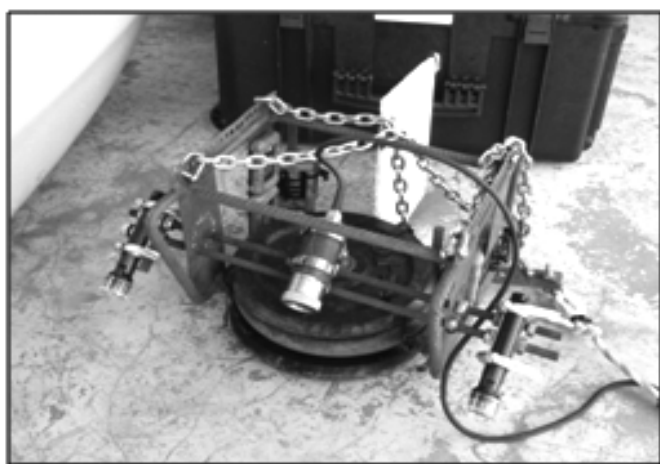


Figure 2. Picture of the casing designed to protect and stabilize the equipment during towed transects.

Four of the eight monitored sites are on the west coast of the Marie Galante island in the Guadeloupien archipelago: “Pointe Ménéard,” “Anse Canot,” “Baie de Saint Louis,” and “Folle Anse”. The part of the Marie-Galante coast has the widest island shelf of Marie Galante, with various types of substrate and habitat. The other sites are situated in the Grand Cul-de-Sac Marin lagoon on the north coast of Guadeloupe: “Fajou North” (MPA); “Caret South”; “Macou North” and “Macou West”.

Thus, recorded videos are analyzed by two operators via the BSplayer 1.37 freeware. The area of each filmed transect is determined. Conches are counted. Then, conch densities by depth and by site are calculated. The recorded data will be compared with future monitoring programs in order to perceive stock variation in the conch fisheries of Guadeloupe. This data could also provide information about conch density by type of substrate (Chalifour and Scolan 2008).

Future data will be statistically tested in order to estimate inter-annual stock variations in the conch fisheries of Guadeloupe, providing information for stock management and regulation adjustment.

RESULTS

Over the course of our tests we encountered 176 Queen conches and surveyed over 47,700 m² (4.77 ha) through 29 transects ranging from 196 to 2069 meters long and between 0 and 15 meters deep. Transects numbers, sites and areas are given in Table 1.

These transects allowed us to improve our video acquiring protocol. The main goal was to monitor Queen conch stocks living between 0 and 25 meters of depth, where the *Strombus gigas* is fished by free diving. Thus, two transects are realized for each area comprised between

isobaths of 0, 5, 10, 15, 20 and 25 meters, when the sea bed profile allows it. During this, the camera must be towed about 1.5 meters above the seabed by a boat at a constant speed of 2.778 km/h (1.5 nautical miles/hour). Each transect is plotted every minute via a GPS system, during its 15 minutes' duration.

These tests allowed the adaptation of the structure designed to fieldwork conditions. Additional ballast has been placed on the structure to increase its stability. The final weight of the prototype is about 22 kg.

Video analysis for Queen conch count is simultaneously realized by two people, at a viewing frame/sec. speed five times slower than the original film speed. Non-interpretable film sequences are truncated before the final analysis. Our tests showed the difficulty to perceive the laser pointers light for depth comprised between 0 and 15 meters, where sunlight intensity was too high.

The first results of our tests are given Table 2. The density observed range from 12.9 conch per hectare for “Macou North”, to 65.1 conch per hectare for “Caret South” (Figure 3). The global mean density was about 37.52 Queen conch per hectare of monitored seabed.

DISCUSSION AND CONCLUSION:

The camera prototype designed by the CRPMEM staff has completed its role. The film transects allowed an estimation of Queen conch stocks in eight sites. These tests constitute the first step in future Guadeloupien queen conch stocks assessments. These tests met difficulties concerning the reading of the light of the two laser beams, difficulties caused by the intensity of the sunlight between 0 and 15 meters of depth. The field of view was then extrapolated with the “ImageJ” freeware (Chalifour and Scolan 2008).

Table 1. Transects realized by the CRPMEM Guadeloupe in 2008.

Site	Fajou N.	Caret S.	Macou N.	Macou W.	Baie St. Louis	Anse Canot	Pointe Ménéard	Folle Anse
Date	29/04/08	30/04/08	02/05/08	02/05/08	05/05/08	06/05/08	06/05/08	07/05/08
Transect n.b	5	5	1	1	6	4	2	5
Depth (meters)	0-5m	0-5m	0-5m	0-5m	0-15m	0-10m	10-15m	0-15m
Length (meters)	1325.3	2071.2	1311.9	1818	8400.02	3425.68	785.07	4102.1
Area (m ²)	2264	3072	2325	2999	17881.54	8032.93	1708.21	9429.47

Table 2. First results of the CRPMEM's designed protocol during 2008.

Station	MPA	Grand Cul-de-Sac Marin			Marie Galante			
	Fajou North	Caret South	Macou North	Macou West	P.te Ménéard	Anse Canot	Baie St Louis	Folle Anse
Sites	Fajou North	Caret South	Macou North	Macou West	P.te Ménéard	Anse Canot	Baie St Louis	Folle Anse
Area (square meters)	2264	3072	2325	2999	1708.21	8032.93	17881.54	9429.47
Counted conch	3	20	3	9	10	44	57	33
Density	13.2	65.1	12.9	30	58.5	54.8	31.9	35

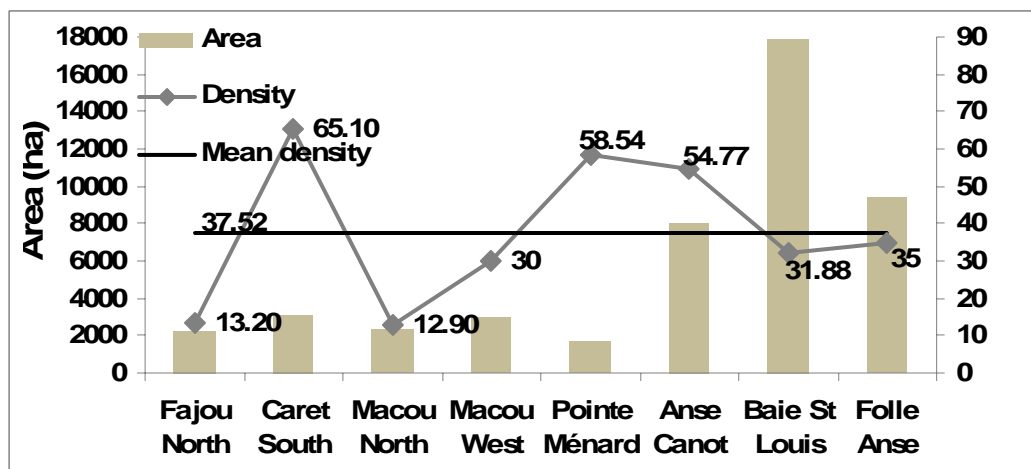


Figure 3. Queen conch density and area surveyed per site in Guadeloupien archipelago.

One of the main benefits of this method is that it is easily applied with little human resource. Only three people are needed to realize transects: one pilot, one camera-positioning operator, and one image-recording and GPS-plotting operator whereas scuba-diving transects require at least four professional divers (according to the French working regulations).

Densities of the sampled sites seem to be low as a decline of reproduction could be noticed when it falls below 50 conchs per hectare (Anonymous 1999). So queen conch populations monitored in “Fajou North”, “Macou North”, “Macou West”, “Baie de Saint Louis” and “Folle Anse” may be threatened. According to the results a fishing reserve would be established in the site of the “Baie de Saint Louis” for Queen conch and white sea urchin population management (Chalifour 2008).

Queen conch densities monitored through scuba diving transects realized in the Grand Cul-de-Sac Marin’s MPA, have ranged from 33.33 to 166.67 conch/ha during the 2008 survey whereas our protocol has shown 13.2 conch/ha for the same site (Simone Mége, Réserve Naturelle Marine du Grand Cul-de-Sac Marin, personal communication). This difference could be due to the difficulty to see smaller conches on sea-grass bed, a difficulty that is also common with towed divers transect (Wood and Olsen 1983, Glazer and Berg 1994, Berg and Glazer 1995). Those densities could also be explained by the fact that conches were observed in a sea-grass bed in 0 to 15 meters of depth during the beginning of the local mating season, which takes place in deeper sandy areas.

Results provided by our protocol are very similar to those found in other Caribbean fisheries (Table 3). The final step would be to validate this protocol with transects realized both with the towed camera and with scuba divers, allowing the estimation of the difference between filmed conch density and observed density.

Another benefit of this method is that the data collected and stored could be used for various monitoring

programs: sea-grass bed monitoring, habitat quality estimate, macro fauna monitoring, lost and ghost fish-traps hunting. Accordingly, video transect must be recorded with data comprising the date, the position, and the filming conditions. These precautions will allow anyone to reuse these data for any other management program.

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Table 3. Queen conch density monitored in other Caribbean areas *via* other protocols.

Place	Density (conch.ha ⁻¹)	Méthode	Fishing ground statut	References
Puerto Rico				
West coast	8.49	Variable length transects	overfished.	Mateo, 1997
Est coast	7.49			
Jamaïca (Pedro's Bank)				
Traditional (0-10m)	89.09	Quadras on transects	Sustainable	Appledoorn, 1995
Industrial (10-20m)	144.46			
External zone (20-30m)	276.97			
Belize	14.6	Variable length transects	Overfished	Appledoorn & Rolke, 1996
Honduras (Caycos Cochinos)	14.6	Variable length transects	Overfished	Tewfik et al., 1998
Bermuda	0.52	Towed divers	Overfished and closed since 1978	Berg et al., 1992b
Florida, Keys				
High density periods	4.08	Towed divers	Overfished and closed since 1985	Glazer & Berg, 1994
Low density periods	0.44			
General	1.54	Towed divers		Berg & Glazer, 1995
US Virgins Islands				
St-Thomas/St-John	9.76	Towed divers	Overfished	Wood & Olsen, 1983 Friedlander et al., 1994
St-Thomas/St-John	12.25	Scooter	Overfished	
Venezuela (Los Roques)				
Protected area	2 130	Quadras	Overfished and total closure	Weil & Laughlin, 1984
Fished area	900	Quadras		Weil & Laughlin, 1984
General	1 210	Fixed length transects (3m x 60m)		Bastidas & Rada, 1998
General	18.78	Variable length transects	Over fished and total closure	Schweizer & Posada, 2006
North-east	34.74			
South-west	52.34			
Bahamas (Exuma Cays)				
Protected Bank	53.60	Variable length transects Towed divers	Some overfished areas	Stoner & Ray, 1996
Protected Shelf	96.00			
Iles Turks et Caicos				
Fished area	277	Belt transects with fixed length (6 x 60m)	Overfished MPA in 1993	Béné & tewfik, 2003
Protected area	555			
St Eustatius Marine Parc, Antilles Hollandaïes	430	Scooter	Limited captures	Davis, 2003
Guadeloupe, Grand Cul-de-Sac Marin	100	Fixed length transects (2 x 2m x 150m)	Intensely fished	Mege & Delloue, 2007