Size-Maturity Indicators in Queen Conch (*Strombus gigas*) of Port Honduras Marine Reserve, Belize: Strengthening Management for Improved Fisheries Sustainability

Indicadores de Talla Versus Madurez en Caracol Rosado (*Strombus gigas*) de la Reserva Marina de Port Honduras, Belice : Fortaleciendo la gestión para mejorar la sostenibilidad de la pesquería

Indicateurs Taille - Maturité dans Lambi (*Strombus gigas*) de Réserve Marine Port Honduras, Belize : Renforcement de la Gestion pour l'Amélioration de la Durabilité de la Pêche

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EXTENDED ABSTRACT

Introduction

Queen conch (*Strombus gigas*) is a large gastropod found throughout the Caribbean, where it is a food source and economically important export product (Randall 1964). *S. gigas* has been overfished in many regions, and its international trade is now regulated under CITES. Until recently, Port Honduras Marine Reserve (PHMR) enjoyed a relatively stable population, regulated by the national shell length limit of 17.8 cm (7 inches) or market clean meat weight $\geq$ 3 oz (85g), a 3-month closed season during reproductive season, and full protection in Replenishment Zones; measures intended to protect immature conch from harvest before reproducing. However, TIDE fisheries independent density data indicates a continuous decline in population with diminished reproduction during reproductive seasons since 2013 (Foley 2013). Fisheries-dependent catch surveys indicate PHMR fishers are complying with the shell length limit, yet the proportion of catch with lip thickness < 9 mm (minimum maturity threshold in other studies) increased from 30% in 2009 to 90% in 2012. Evidence suggests lip thickness is a more reliable proxy indicator of maturity (Avila-Poveda and Baqueiro-Cárdenas 2006, Stoner 2012), but also that maturity relationships vary by habitat on a local level and regionally (Appledoorn 1988, Stoner and Schwarte 1994), and that therefore relationships determined from studies in other areas cannot be applied to PHMR conch. PHMR is a dynamic inshore environment with significant freshwater input, giving rise to habitats and feeding behaviors distinct from the Belize barrier reef. Such relationships therefore need to be determined locally. This study aims to determine the most reliable proxy indicator(s) of maturity in *S. gigas* specific to Port Honduras Marine Reserve (PHMR), southern Belize. Recommendations are made based on relationships between shell length, lip thickness, lip width, total meat weight, market clean weight and operculum dimensions, for revisions to the legal size limit definition to achieve long-term sustainability of *S. gigas* in Belize while meeting economic needs of fishers and associated livelihoods.

Methodologies

To understand seasonal dynamics in maturity of male and female conch, sample collection was divided into three seasonal phases. Phase I (late open season) February - March 2015, Phase II (closed season) July - August 2015, and Phase III (early open season) November - December 2015. Samples were obtained from sites in the General Use Zone of PHMR known to be good conch fishing grounds. The target sample size was 150 per phase, recording sex, shell length, lip thickness, lip width, operculum length & width, operculum length:width ratio, unprocessed weight and market clean weight. Gonadosomatic Index (GSI) was calculated as the ratio between gonad weight and total unprocessed meat weight. For histology analysis, each sample was scanned on a compound light microscope for gonadal structures to classify samples by sex and maturity stages following Stoner's (2012) gonadal maturity index, ranging between no germ tissue, immature, early developing, late developing, spawning capable and regressing. Maturity derived using both GSI and histological methods were compared with physical metrics for males and females. Polynomial regression was used to determine statistical significance for GSI relationships. Logistic regression was used to determine significance of lip thickness:gonadal maturity index relationships in males and females. Results from Phase 1 and 2 comparisons between physical metrics and GSI, and Phase 1 histological comparison are presented here, with the full study due to be complete in February 2016.

Results

GSI — A clear relationship was observed between lip thickness (LT) and maturity, particularly for males. GSI:LT regression: males - Phase 1: $r^2 = 0.42$; Phase 2: $r^2 = 0.41$; females - Phase 1: $r^2 = 0.26$, Phase 2: $r^2 = 0.26$). There was no relationship observed between shell length (SL) and GSI maturity (males - Phase 1: $r^2 = 0.02$; Phase 2: $r^2 = 0.001$; females - Phase 1: $r^2 = 0.00$, Phase 2: $r^2 = 0.11$) (Figure 1). Relationships between meat weight (unprocessed & market clean) and GSI are stronger than for SL but weaker than for LT. No clear relationships were observed between GSI and any operculum

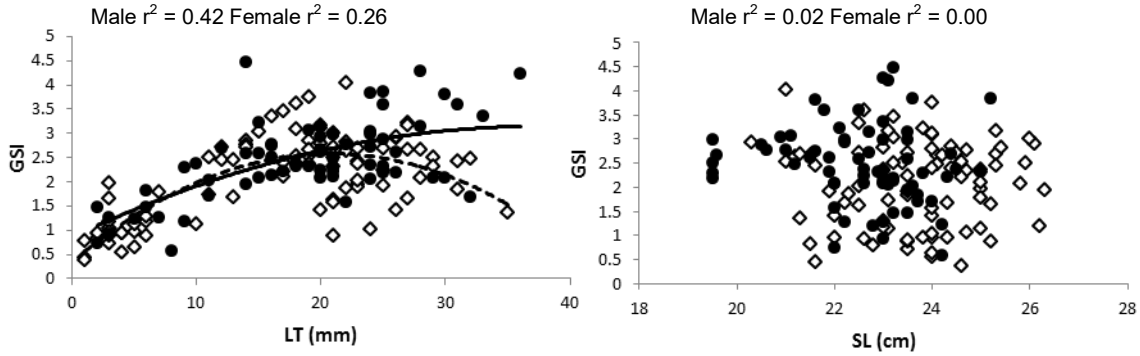

Figure 1. Phase 1 Male (black) & female (white) LT and SL vs GSI. Polynominal regression lines: males solid, females dotted. Phase 2 results very similar.

measurements, nor lip width.

Histology vs LT: — ***Males*** - Phase 1 histology reveals spawning capable males comprise 66.7% of 15 - 20 mm LT class, and continue to increase thereafter, comprising 84.2% of the 20 - 25 mm LT class, 85.7% of the 25 - 30 mm LT class, and 100% of those > 30 mm LT. Males are therefore mostly spawning capable by 20 - 25 mm LT in Phase 1 (Figure 2). ***Females*** - the female spawning capability threshold is less clear in Phase 1. All stages of development are evenly spread among 10-30mm LT classes. Immature are not seen above 25mm LT, but no dominance of spawning capable specimens in highest LT classes. Logistic regression indicates a stronger relationship between LT and histology maturity index for males (p = 0.0004) than females (p = 0.02) during Phase 1, with > 80% probability that males > 25 mm LT are or have been spawning capable (Figure 2).

Discussion

Initial results from GSI and histology demonstrate a clear relationship between LT and maturity for males. The female spawning capability threshold is less clear in Phase 1 histology. This may be due to being outside the reproductive season, with females possibly not exhibiting spawning capability until Phase 2 (reproductive season). Phase 1 results indicate that the shell length limit is not adequately protecting immature and developing conch from being harvested. Many female legal-sized conch are vulnerable to harvest in Phase 1. This could partly explain recent stock declines. Conch are of serious concern as overall maturity of the stock is decreasing rapidly based on lip thickness (Stoner et al. 2012), yet this trend appears to be masked by the current shell length based minimum size limit. Shell length regulation alone is therefore not achieving its

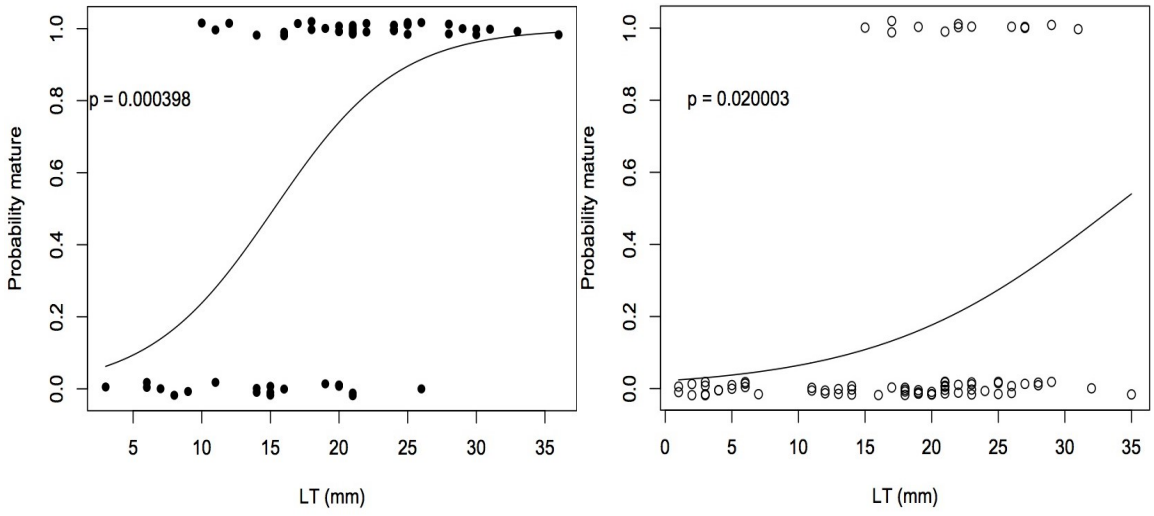

Figure 2. Phase 1 logistic regression of lip thickness for a) males; b) females. Samples were divided into 2 groups – Group 1 spawning capable & regressing, Group 2 no germ tissue, immature, early developing, late developing. Strong relationship for males, less clear so far for females, probably need to wait for Phase 2 (reproductive season) to observe maturity index in females.

intended management objective of protecting immature conch from being harvested during open season (Avila-Poveda & Baqueiro-Cárdenas. 2006), posing a threat to the sustainability of conch in PHMR. Urgent changes are therefore needed to incorporate lip thickness into size limit regulations.

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