An Assessment of Conch Morphology on the Island of Saint Lucia and Possible Future Management Implications

Una Evaluación de la Morfología Concha en la Isla de Santa Lucía y Posibles Impuestos Futuros de la Gestión

Une Évaluation de la Morphologie Conchante sur L'île de Saint-Lucie et des Possibles Implications de Gestion Future

ALLENA JOSEPH[1], PETRONILA POLIUS[1]*, IAN HORSFORD[2], SHANNA EMMANUEL[1], PATRICIA HUBERT- MEDAR[1], HILROY SIMON[2], and MITSUHIRO ISHIDA[3]

[1]*Department of Fisheries, Pointe Seraphine, Castries, Saint Lucia, West Indies.*
**petronila.polius@govt.lc*
[2]*FisheriesDivision, Point Wharf Fisheries Complex, St. John's, Antigua, West Indies.*
[3]*Japan International Cooperation Agency, Point Wharf Fisheries Complex, St. John's, Antigua, West Indies.*

ABSTRACT

Queen conch morphology assessment was carried out along the North and West of Saint Lucia's coast. The activities and analysis of data from sampled population helped to achieve the following objectives:

i) Develop baseline morphometric data with respect to conch for Saint Lucia;
ii) Determine if there were spatial variability in regards to conch morphology;
iii) Examine length-weight relationships for various maturity stages (juvenile, sub adult, adult and old adult);
iv) Develop national-derived conversion factors for different levels of processed conch meat; and
v) Appraise current management regimes (e.g., minimum size / weight).

For the pooled adult conch, shell length and shell lip thickness differed significantly along the coast and among fishing areas in Saint Lucia ($p < 0.05$), where conch from the west coast were larger and greater lip thickness than conch in the north. Analysis of sampled adult conch further underpins the fact that queen conch exhibit sexual dimorphism as female queen conch are significantly larger and weighed more than male conch ($p < 0.001$).

Variations in sexual dimorphism and spatial variability among adult conch have implications for management regimes, as larger female conch may be favored over male conch; similarly the differences between the sexes with respect to the size at sexual maturity and the current legal minimum size. Recognizing the variations or changes that exist in the life history of the queen conch, conversion factors for various processing grade of conch revealed that there is a significant difference between the various process grade to nominal weight among the different stages of conch maturity ($p < 0.005$).

The results from the assessment highlights the need for the strengthening of current management approach, considering one that is multifaceted, and based on participation and cooperation to ensure that the conch fishery is sustainable.

KEYWORDS: Queen Conch, co-management, conversion factors, morphology, biological assessment

INTRODUCTION

Queen conch represents one of the most valuable demersal resources in the region and is second only to the spiny lobster in fisheries value to the Caribbean Region (Chakalall and Cochrane 1997). In the majority of the countries of the Wider Caribbean, fishing consists of small canoes 7 - 10 m long powered by outboard engines, carrying 1 - 4 divers. Fishing trips for conch are mainly daily, in which fishing lasts approximately 6 - 8 hours.

In Saint Lucia, conch is exploited commercially all year round by over 40 fishers at depths ranging from 24 m to 30 m. They operate out of open wooden and fiberglass pirogues ranging in length from 7 - 10 m powered by outboard engines of 115 - 250 hp. Fishers of this resource can be divided into part-time and full-time. Full-time fishers conduct dives on average four times each week, alternating harvesting and rest days whilst part time fishers operate twice each week (Joseph, [2001]). An average of 100 - 500 individual conch are landed per trip. Conch is sold at an average cost of US$7 - 8 per pound, with landing estimated at 43 tonnes per annum.

Saint Lucia is party to the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). Queen Conch (*Strombus gigas*) is listed in Appendix II of the CITES Convention. Queen Conch is also listed in Annex III of the SPAW Protocol (Protocol concerning Specially Protected Areas and Wildlife) for the Cartagena Convention, of which Saint Lucia is also a party, calls for Parties to "adopt adequate measures to ensure the protection and recovery of species", "to regulate the use of the species" and to "formulate, adopt and implement plans for their management and use".

In terms of conservation measures, the Fisheries Regulation Cap 7.17, prohibits: harvests of conch of less than 180 mm total shell length, less than 1 kg total weight and less than 280 g meat weight not including digestive glands. In addition, these regulations restrict harvesting of immature conch defined as individuals without a flared lip. The Fisheries Regulations also make provisions for a closed season but to date, this management measure has not been implemented.

While queen conch are believed to be distributed around the island of Saint Lucia, only two populations (one in the north and one in the south) have been identified. Although suitable queen conch habitat is available in several bays and back-reef areas, queen conch are seldom found in these shallow water areas (less than 9 m) (CITES 2012, Brownell and Stevely 1981). The nearshore populations are considered overexploited, and consequently fishers now target deeper waters (depths ranging between 25 - 37 m) stocks using SCUBA (CITES 2012).

Most recent research with respect to conch in Saint Lucia (Conch Resource Assessment Study, King-Joseph et al 2008) revealed that:

i) Conch were usually landed already de- shelled, and as such, maturity data for conch landed was not available to the Department of Fisheries,
ii) Two distinct populations of conch were located in Saint Lucia waters. Most present day fishers did observe significant differences between conch from the south and from the north of the island, and
iii) Conch from the south were found to contain less meat per unit of total conch weight than conch from the north.

Additionally, in March 2013, at the Sixth Meeting of the Conference of the Parties to CITES, several decisions were adopted to promote regional cooperation on the management and trade of queen conch. Among the actions called for in these decisions, range states were encouraged to adopt the recommendations stemming from the meeting of the Working Group on Queen Conch. These actions include:

i) The development of national plans for queen conch management and conservation,
ii) Develop and adopt conversion factors to standard-ize data reported on catch and trade of meat and other products of queen conch, and
iii) Collaboration on joint research programmes.

In light of the fore mentioned, the specific objectives of this research were to:

i) Develop baseline morphometric data with respect to conch for Saint Lucia,
ii) Determine if there were spatial variability in regards to conch morphology,
iii) Examine length-weight relationships for various maturity stages (juvenile, sub adult, adult and old adult),
iv) Develop national-derived conversion factors for different levels of processed conch meat, and
v) Appraise current management regimes (e.g., minimum size / weight).

METHODOLOGY

Queen conch were sampled from three sites along the West and North of coast of Saint Lucia (Figure 1). Sampled sites comprised of traditional fishing sites and were sampled by research personnel and commercial conch divers. The geographical coordinates, mean depth dived, and habitat characteristics were noted. All conch encountered during dives were sampled.

Conch were sexed, where possible, and their maturation stage determine according to the following criteria derived from Appeldoorn (1988):

i) Juvenile (J) - Queen Conch without a flared shell lip,
ii) Sub adult (SA) - Queen Conch with flared shell lip starting but not fully developed; lip thickness < 5 mm,
iii) Adult (A)- Queen Conch with flared lip fully developed and minimal shell erosion; lip thickness ≥ 5mm, and
iv) Old Adult (OA) - Queen Conch with shell characterised by a thick lip (> 5mm), heavy erosion and fouling.

From each sample, the following morphometric data were collected:

i) Shell length – length of the shell from the apex of the spire to the end of the siphonal canal,
ii) Lip thickness – thickness of the shell lip measured in the mid- lateral region, roughly 40 mm inward from the end of the lip,
iii) Nominal weight – weight of intact animal, including shell,
iv) Tissue weight – weight of intact animal, after removal from shell,
v) “Dirty” meat weight – weight after removal of shell and digestive glad (visceral mass), and
vi) “Clean” meat weight – weight after removal of shell, digestive gland (visceral mass), mantel collar, operculum, radula, and digestive tract.

All weights were to the nearest 1 g. Lip thickness was measured to the nearest 0.1 mm while the shell length was measured to the nearest 1 mm using calipers. Conch meat was extracted from the shell by making a small hole in the fourth whirl of the spire and removing the columnar muscle from the central axis using a knife.

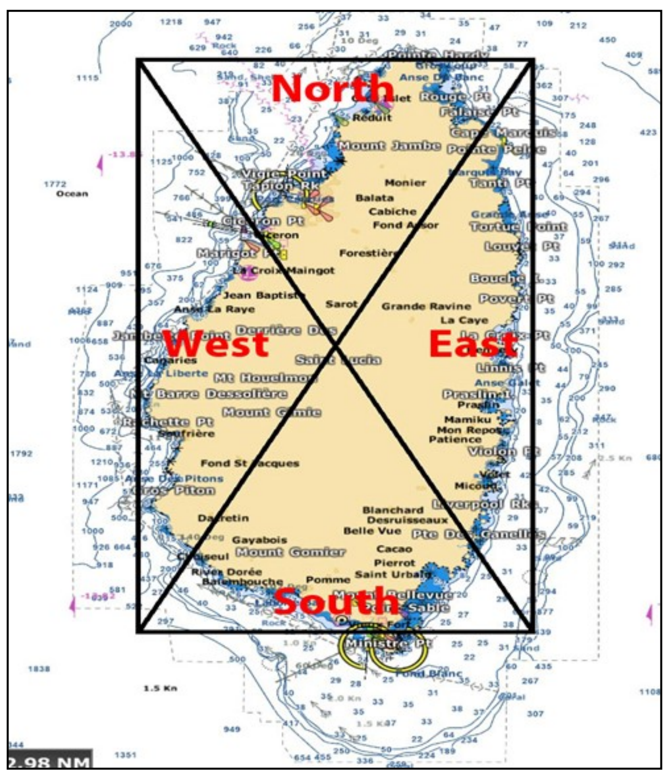

Figure 1. Map indicating how the areas sampled for queen conch were classified in general reference to the coastline of Saint Lucia

Statistical analyses were conducted using SPSS 15.0 for Windows. Simple linear regression was used to investigate the relationship between nominal weight and different levels of processed meat. To determine the relationships between shell dimensions and weights, simple linear regression was used on common log transformed data. Separate analyses were made for the various maturation stages and were only grouped to address statistical issues in certain cases (e.g., sub-adult and old adult grouped with adult due to small sample size). Conversion factors were estimated per maturation stage by calculating a conversion factor per sample for each processing grade or level. Analysis of variance was used to determine if morphometric means and conversion factors for the maturation stages were significantly different.

RESULTS

A total of 477 conch specimens were collected (81 juveniles, 31 sub adults, 361 adults and 4 old adults) from the north and west coast of Saint Lucia at depth ranging from 80 - 100 ft (24 - 31 m).

For pooled adult conch (i.e., sub adult, adult and old adult), shell length differed significantly along sampled coasts and among the fishing areas in Saint Lucia, $p < 0.05$ (Figure 2). The mean shell length for pooled adult conch from the west coast of Saint Lucia was larger than that for north coast (235 mm versus 232 mm).

The age of conch with a flared shell lip can be estimated with some degree of accuracy by measurement of lip thickness (Appeldoorn 1988). Lip thickness, as an indicator of relative age since maturation, differed significantly between the sampled coasts $p < 0.05$, where conch from the west coast were slightly younger than those from the north coast of Saint Lucia, measuring 14.3 mm versus 16.7 mm, respectively (Figure 3).

Adult female conch were significantly larger and weighed more than male conch, $p < 0.001$. Females were 3% larger than their male counter parts (Figure 4). Although being statistically significant, the actual difference in mean shell length between sexes were moderate (236 mm versus 229 mm).

Additionally, the mean "dirty" meat weight of sampled female conch was significantly higher (307 g) than male conch (281 g) (Figure 5). However, most sampled conch were larger than the 180 mm legal minimum shell length and weighed more than 280 g.

The relationship between shell length and tissue weight evolves with maturity, with the regressions for sub adults and adults shifting above that for the juveniles; the steeper slope for juveniles (ignoring old adults due to limited samples, n = 4) indicated greater weight gain per unit (Figure 6).

For all regressions, old adults had a higher adjusted coefficient of determination than any other maturation stage. Regression for old adults accounted for as much as 85% of the variance that can be explained by the regression model; regression for sub adults and adults accounted for 36% and 31% respectively. Regression for juveniles accounted for 79% of the variance. The decrease in the goodness-of-fit of the regression models (as indicated by the coefficient of determination R^2) from juveniles to adults, was due to the cessation of shell length growth as juveniles developed into sub adults the adults, with the onset of the flaring and thickening of the shell lip.

Due to the aforementioned changes in the life history of the queen conch (cessation of shell length growth, flaring, and thickening of the shell lip, etc.), conversion factors for the various processing grade to nominal (live, including shell) weight differed significantly among maturity stages $p < 0.005$ (Figure 7). The conversion factors for the various processing grades are summarized in Table 1.

DISCUSSION AND CONCLUSION

Pooled adult conch from the west coast of Saint Lucia were significantly larger (shell length) than those from the north coast ($p < 0.05$). In terms of lip thickness, conch from the west coast were significantly older than those from the north coast $p < 0.05$. Variation in conch size with respect to location is consistent with research findings in Antigua (Horsford et al. 2013), Bahamas (Stoner et al. 2012), Barbados (Bissada 2011), Mexico (Aldana-Aranda & Frenkiel 2007) and Honduras (Alexander et al. 1998). While Stoner et al. (2013) expressed that the reasons for variations in queen conch size and lip thickness among referenced study sites are unknown, it was concluded that the differences may be associated with nutritional environments, water temperature, and overall growth rates, and as such, are site specific.

Adult conch exhibited sexual dimorphism, with females being 3% larger than male, $p < 0.001$. This difference between the sexes has implications for the size at sexual maturity (i.e. females maturing at a larger shell length). Most conch, whose sex was determined during this research were larger than the legal 180mm shell length and 280 g meat weight (Figure 4 & 5). Horsford et al. (2013), recognizing the morphological differences in conch, concluded that one of the implications of having regulations based solely on a standard minimum size (i.e. a standard shell length and a corresponding standard meat weight), is that this approach would not afford proper protection for large juveniles in situation where there are morphological differences with respect to location. This view is particularly relevant seeing as while the option for setting specific size limits for specific areas would address the problem, this would not be viable given that there are no designated fishing zones (except for marine managed areas, in the case of Saint Lucia) and fishers may not necessarily limit their efforts to specific areas. Therefore, increasing minimum shell length regulations from 180 mm could result in a differential selection between the sexes since conch exhibited sexual dimorphism (Horsford et al. 2013). The conclusion is further supported by research conducted on the islands of Antigua and Barbuda which confirmed that in the case of commercial fishing trips, the sex ratio of the allowable catch (minimum meat weight of 225 g), was favoring the harvesting of females [X^2 (1, n = 711) = 4.26, $p < 0.05$], with 53.9% of the sample being female (Horsford et al. 2013). Hence, increasing the shell length to exclude the landing of meat from large juvenile

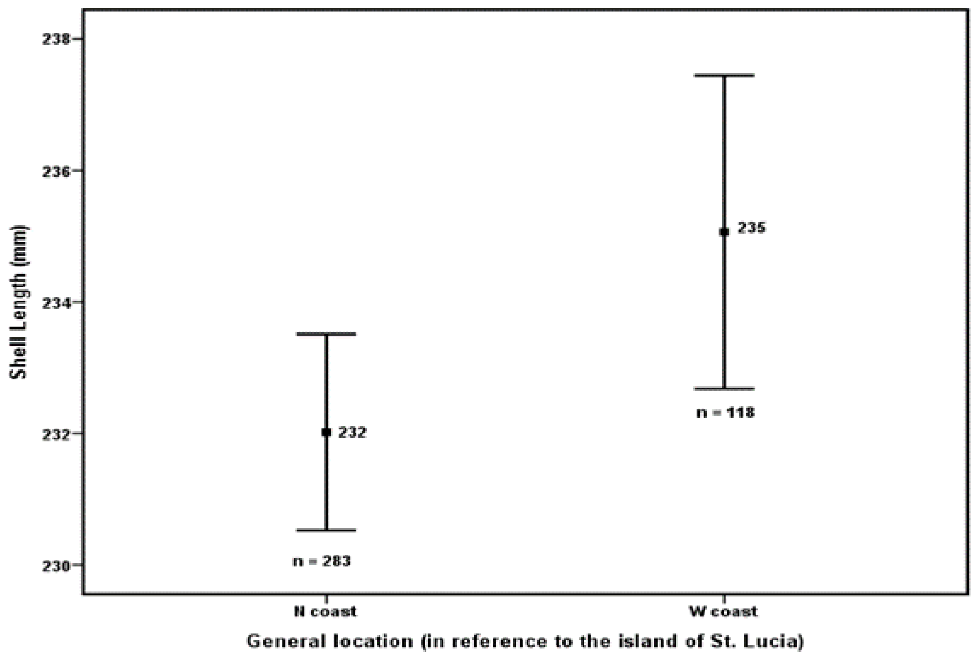

Figure 2. Mean shell length of pooled adult queen conch (ie sub adult, adult and old adult) from the coast of Saint Lucia. Error bar is for the 95% confidence interval and n = sample size.

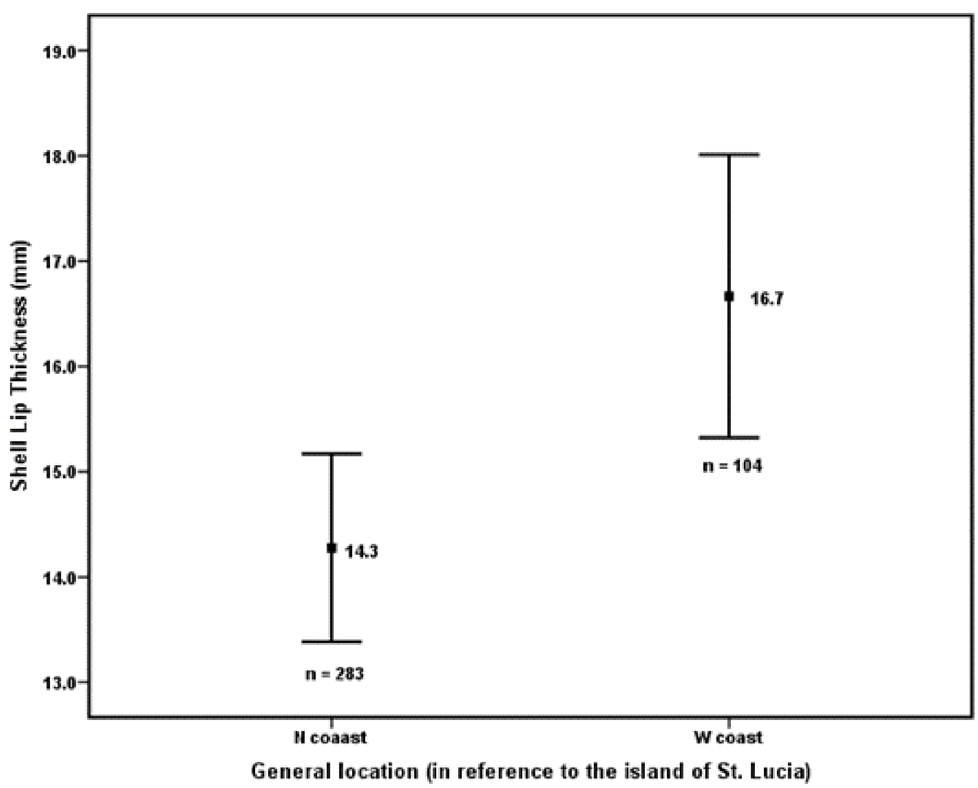

Figure 3. Mean shell lip thickness of pooled adult queen conch (i.e. sub adult, adult and old adult) from the coast of Saint Lucia. Error bar is 95% confidence level and n = sample size.

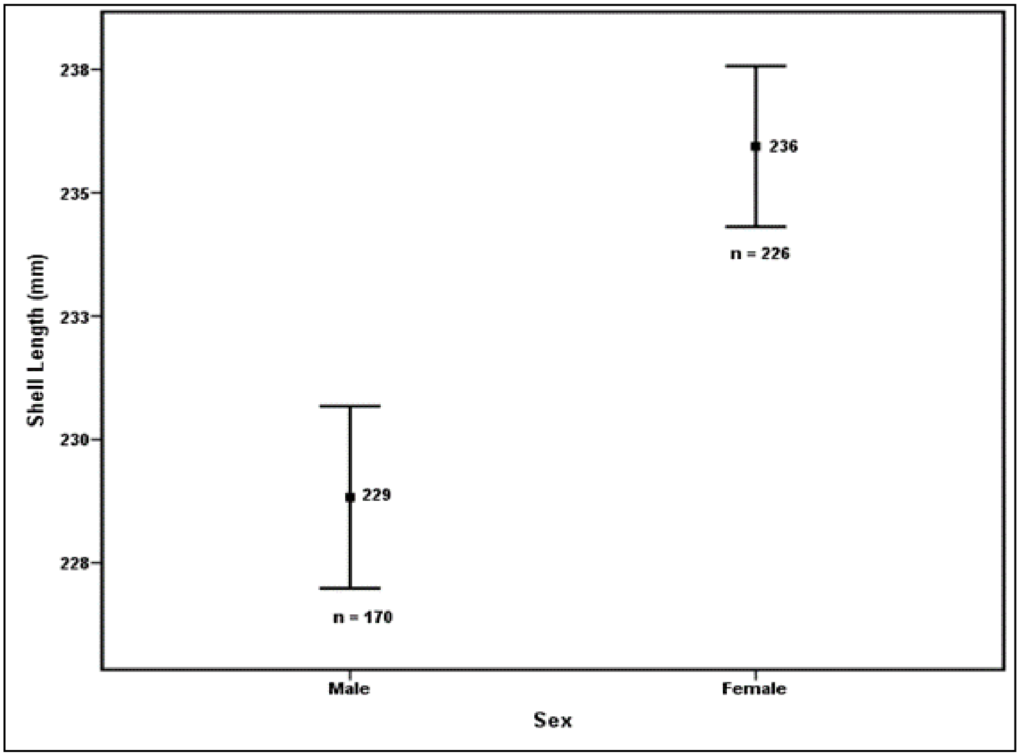

Figure 4. Mean shell length by sex for pooled adult queen conch (i.e. sub adult, adult and old adult) from the island of Saint Lucia. Error bar id 95% confidence interval and n = sample size.

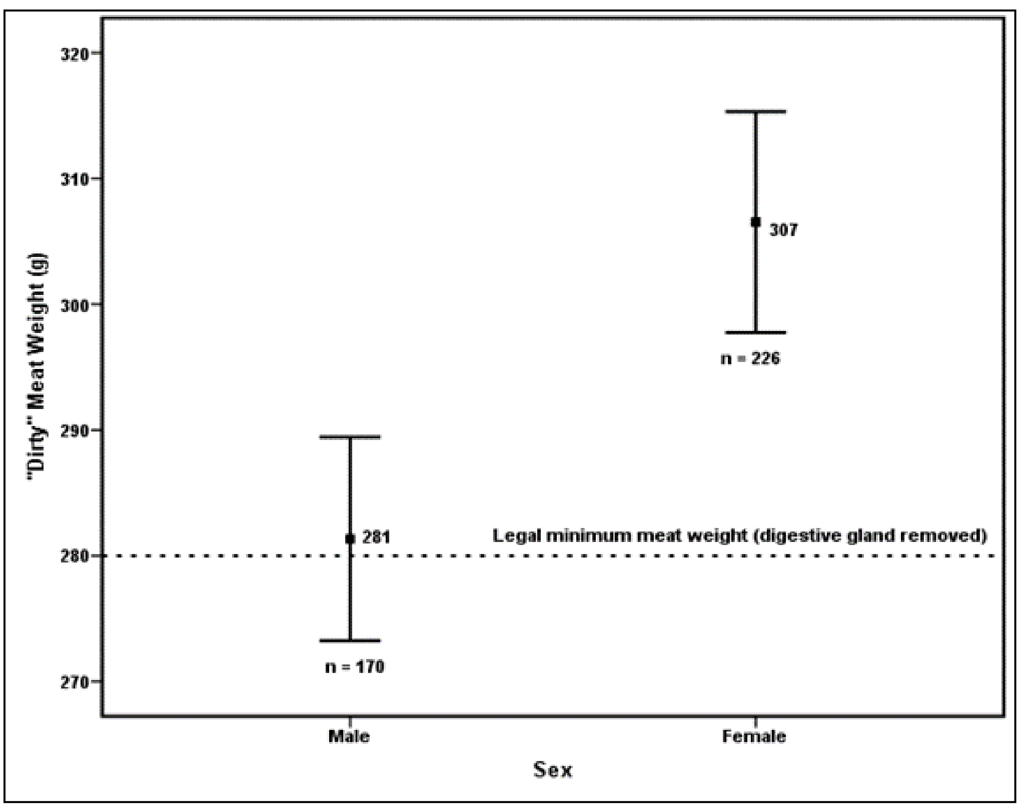

Figure 5. Mean "dirty" meat weight by sex for pooled adult queen conch (i.e. sub adult, adult and old adult) from the island of Saint Lucia. Error bar is 95% confidence interval and n =s ample size

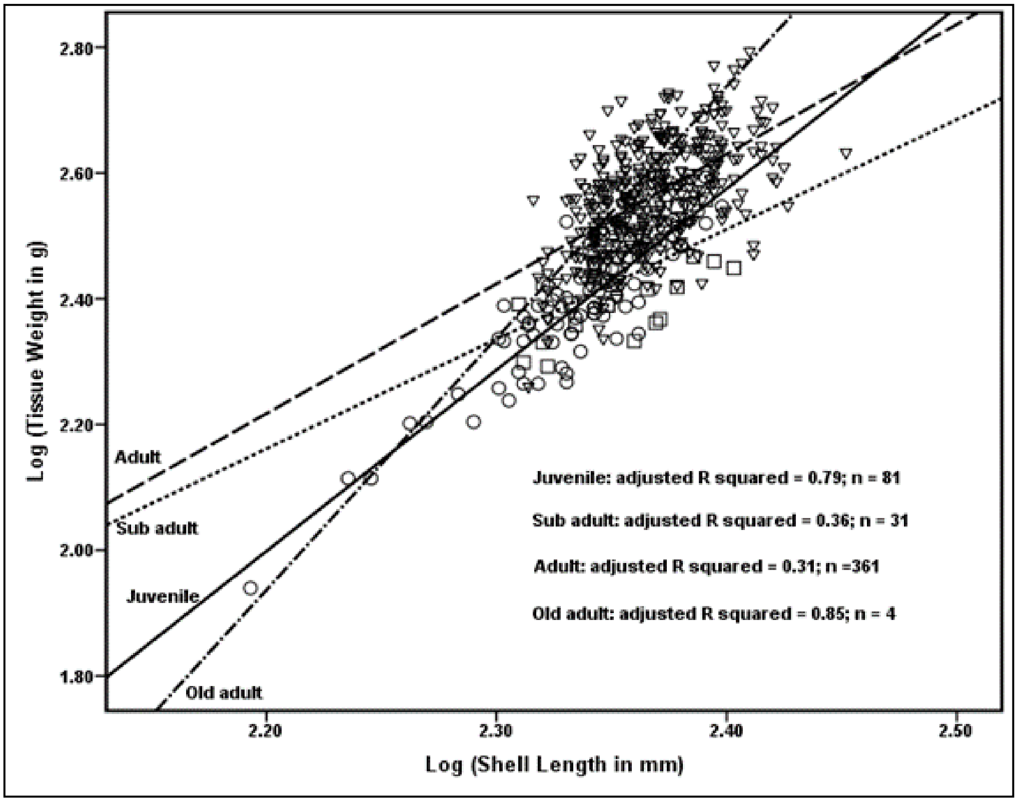

Figure 6. Shell length-tissue weight relationship for juvenile, sub adult, adult and old adult queen conch from the island of Saint Lucia

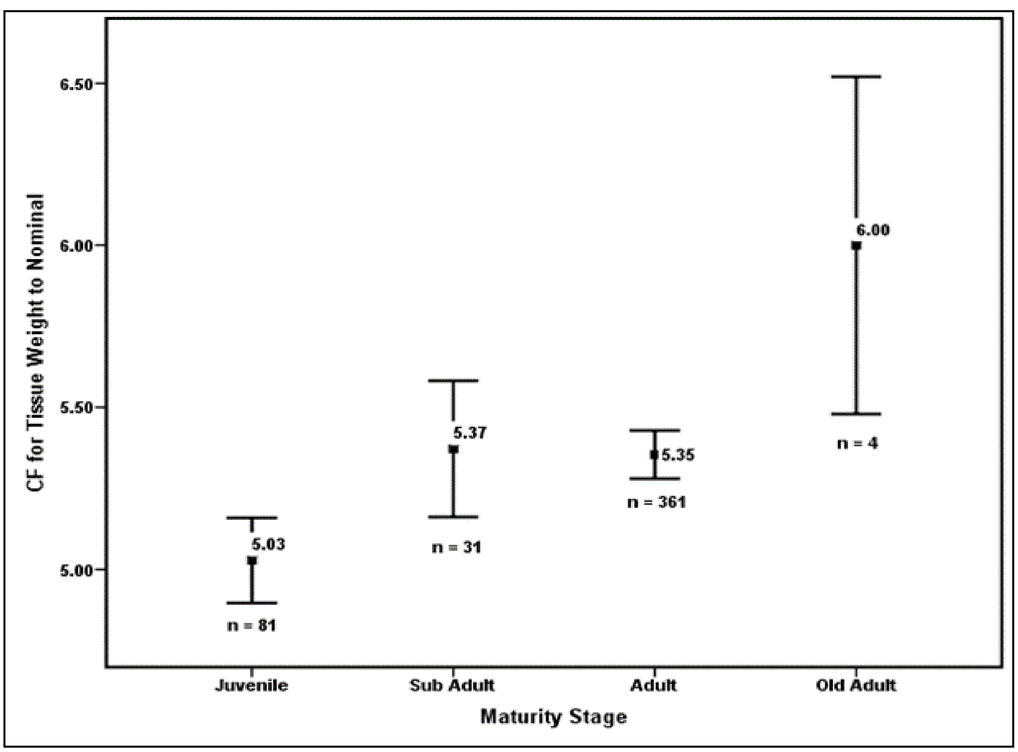

Figure 7. Conversion factor (CF) for tissue weight (i.e., weight of intact animal after removal from shell) to nominal weight for the various maturity stages for queen conch from the island of Saint Lucia. Error bar is 95% confidence interval and n = sample size

(without shell) would further skew the sex ratio of the catch. For Saint Lucia, conch is normally landed as "dirty" meat, where the shell and visceral mass are removed.

In terms of length-weight relationships (Figure 6), shell length and tissue weight varied significantly across maturation stage, with the regression for the sub adult, adult and old adult shifting above that of the juveniles. The steeper slope for the juveniles, when compared to the other maturation stages, is an indication of the greater weight gain per unit increase of length, at this stage. With the cessation of shell length growth at maturity (Appeldoorn 1988) and the bio-erosion of the shell with age, old adults growth are geared towards thickening the lip and shell, while soft tissue mass is being lost with age (Horsford et al., *In press*). The cessation of shell length growth in maturity is responsible for the decrease in the goodness of fit of the regression models from juvenile to sub adult to adult.

Estimation of catch data is basic information for fishery management and for population models used to determine stock status. In the queen conch fishery, the main commodity is the meat fillet, a product resulting from different types of processing, which vary from country to country. Differences in the processing meat affects the estimation of conch catch data, therefore there is a need to determine and apply conversion to catch data so that landings can both estimated with less error and made comparable across the region. It was noted that the conversion factors differed significantly among maturation stages, $p < 0 .005$ (Table 1). While the establishment of statistically valid conversion factors is essential for transforming all processed conch into nominal weight, making data series consistent throughout the years and comparable among countries of the region (Aspra et al. 2009), the use of a single conversion factor for the species is problematic due to the significant differences among maturation stages. Horsford et al. (2013) and Stoner et al. (2012), recognizing that the size at maturity of queen conch may change with time and with fishing pressure, inter alia, as has been observed for the commercially harvested volutid gastropod *Zidona dufresnei,* as well as for queen conch in the said studies, recommends that the demographics of the queen conch population should be monitored over time to ensure that the reference points have not shifted as it relates to applying conversion factors.

There is no *one size fits all* or any perfect management solution to address the complexities associated with conch morphological variances, fisheries regulations that are responsible for managing queen conch stocks vary from country to country and are sometimes based upon objective biological information, like population models, and the differences of age or size at maturity. As such, accepting the fact that queen conch exhibit significant morphological variances with respect to location, sex, and maturation stage, the only viable option for successful management is a multifaceted approach. The Department of Fisheries recognize that the existing legislation needs to be strengthen to allow for strong management measures. Options available include a combination of minimum size restriction (shell length, meat weight, and lip thickness) as well as other measures such as protected areas, closed season and or closed areas, and "limited entry" through the use of special permits.

It is expected that the work which has started with past assessments and this study would continue on to future research focusing on sites on the south coast of Saint Lucia, broadening the depth range to include shallow sites (< 24 m). This would ensure all variability with respect to the conch population are captured. Morphometric studies should endeavor to collect data on the various habitat types encountered as this information, as reflected in other similar studies, is critical towards identifying ecologically

Table 1. Conversion factors to nominal weight for queen conch sampled from the coast of Saint Lucia.

Level of Processing	Group	Sample Size n	Mean Conversion Factor
Tissue Weight	Juvenile	81	5.03
	Sub adult	31	5.37
	Adult	361	5.35
	Old adult	4	6.00
"Dirty" meat weight	Juvenile	81	6.35
	Sub adult	31	6.74
	Adult	361	6.61
	Old adult	4	7.71
Clean meat weight	Juvenile	81	9.80
	Sub adult	31	10.16
	Adult	361	10.27
	Old adult	4	11.73

important conch habitat (nursery areas, spawning areas, etc.) as this is valuable for designing the sampling regime for density based conch surveys. Additionally, the conch fishery is thought to be one of the areas of Saint Lucia fishery where the potential exists for a close and successful collaboration between fishers and the Fisheries Department. It provides an opportunity to demonstrate how rapid, precautionary, participatory action can provide an adequate basis for management until more definitive scientific information becomes available (Aiken et al. 1999). The approach to this study required one of a collaborative and participatory effort between fishers and the Fisheries Department, and as such, encouraged the progressive inclusion of co-management strategies not only at the pre-implementation phase but throughout. However, the success and approval of such measures should be actively sought at both the community and policy level so as to effect change with the hope of rebuilding stocks.

ACKNOWLEDGEMENTS

This study was funded by the Japan International Cooperation Agency (JICA), the Fisheries Department, Ministry of Agriculture, Fisheries, Natural Resources, Physical Planning and Cooperatives, Saint Lucia, and the Fisheries Division of Antigua and Barbuda. Special thanks to the conch fishers of Gros Islet particularly; Ellick Prospere, Gilbert Bruneau, Marcellus St. Ange, Dwight Gilbert, Williamson St. Ange, Christopher Polius, Clement Cherubin, Tyson Henry, and Earl Lewis for without them this study would not have been possible.

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