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Summary of Queen Conch (*Lobatus gigas*) research undertaken in Anguilla and the implications for current management practices

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ABSTRACT

Prior to 2014 little research had been conducted on the Anguilla conch fishery aside from indirect data collected by the Department of Fisheries and Marine Resources (DFMR) during annual monitoring of reef and seagrass areas, or via generic landing site visits and other observations. Due to a suspected inadequacy of current regulations combined with concerns relating to fishery sustainability, DFMR facilitated two small groups of visiting researchers in 2014 and 2015 to fill this knowledge gap. The work conducted, combined with that carried out recently in neighboring islands, confirmed that the current minimum landing size of 18 cm shell length for *Lobatus gigas* (formerly *Strombus gigas*) is a poor indicator of conch maturity, with up to 94% of individuals of this size still immature. Histological analysis of gonad samples revealed that there is no correlation between shell length and maturity, with the development of a flared lip a much more precise indicator. It was concluded that a lip thickness of 10 mm should replace the minimum shell length legislation in order to move towards a more sustainable fishery. Semi-cleaned meat weight (digestive glands removed), essential to allow assessment of conch chucked by fishers while out at sea, currently set at 225 g was concluded to be sufficient given that meat weight can reduce as conch pass well beyond maturity. By accompanying fishers while harvesting *L. gigas* compliance to regulations seemed good, although it was recognized that this could be due to a researcher being present onboard. From in-water habitat and *L. gigas* abundance surveys a patchy distribution of conch were observed which led to an overall conclusion that the conch fishery in Anguilla is likely to be unsustainable, and so the need for legislative change is urgent. Based on boat activity surveys during the study period it was estimated that 69,190 lbs of semi-cleaned meat is landed per year by the fishery across an active fleet of seven full to part-time vessels (thus excluding recreational or small scale catches). This represents an estimated 6% of the fishable biomass. It is suggested that to ensure sustainability, this fishery should not be developed much beyond its current size and consideration be given to the issuance of special species specific licenses, and the introduction of recreational catch limits. This is especially relevant due to *L. gigas* being listed in 1992 under Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), of which Anguilla is party. It has been suggested that consideration be given to the possibility of conch farming in Anguilla, although the present study found this an unviable option due to a lack of extensive protected shallow water habitats and the difficulty in obtaining hatchery seed or juveniles for culture.

Introduction

The Queen conch (*Lobatus gigas*[1]) is common across most of its range from the Gulf of Mexico, across the Caribbean, and along the north coast of Brazil (Stoner, 2003; Davis, 2005). This large marine gastropod is commercially valuable throughout the region as an important food source and livelihood. Originally artisanal in nature this traditional fishery has become under increasing pressure as export markets develop, similar to those for the spiny lobster fishery. This fishing pressure increase has resulted in diminished population densities over recent decades (Theile, 2001; Stoner *et al*., 2011; Tewfik, 2013; Wood, 2014). Furthermore, the decline of the *L. gigas* population in the Wider Caribbean is thought to be accelerated by the illegal harvest of immature conchs or legal harvest of immature conch protected by outdated legislation (Stoner *et al*. 2012). The harvesting of immature conch in this way leads to a decrease in the reproductive output of the population and a decline in fishery sustainability.

This is thought to be the case in Anguilla, where a small scale conch fishery exists. Despite its small scale, when combined with recreational shallow water harvesting, a large number of individuals are landed annually. The recreational or coastal based catches can be indirectly documented by large conch middens present in certain areas and extensive patches of discarded shells observed while diving (Wynne, pers. obs.). Relative to some of the other nations in the Caribbean Anguilla has somewhat limited conch grounds which raises further questions relating to sustainability. Deeper conch habitats exist beyond safe diving limit, so species conservation is not the primary managerial concern, rather the overfishing of accessible resources leading to adverse livelihood effects and diminishing long-term supply of this important commodity to vendors.

In terms of existing legislation aimed towards fishery sustainability, the Department of Fisheries and Marine Resources (DFMR) consider it outdated and in need of revision, although study was needed to justify this. Currently minimum size limits are based on shell length (18 cm) and weight of meat after removal of digestive glands (225 g). These limits were based on regional recommendations made decades ago, before extensive regional conch research had been conducted. It has been well known for many years that a minimum shell length of 18 cm is insufficient to protect immature individuals; with such limits meaning that up to 94% of a population may still be legally fished before they are mature and had the chance to reproduce (Blakesley, 1977). Such a situation leads to growth overfishing, a situation that has likely been occurring in Anguilla for many years. This type of overfishing eventually leads to recruitment overfishing and stock collapse[2].

Since the late 1980’s it has been known that a more reliable way to judge maturity sizes in *L. gigas* is through the thickness of its flared lip (Appledoorn, 1988). As a juvenile conch grows its shell gets longer, but as maturity is reached this process slows and eventually halts, with shell thickness now beginning to increase. As this takes place a flared lip develops on the outside edge of the shell aperture, which also thickens over time. The thickness of this lip can be measured and is now the widely accepted method of quantifying the age of a conch over shell length; not just because shell length stops increasing, but also as the length of shell can actually reduce with age due to erosion or damage. Initially a lip thickness of 5 mm was seen as appropriate (Appeldoorn, 1996), although subsequent studies in Puerto Rico showed that a high proportion at this thickness were still immature, so an increase to 9.5 mm was adopted (Theile, 2001). Despite this many Caribbean nations either have no flared minimum or still have limits set between 5-9 mm (Theile, 2005). Over recent years evidence is mounting that even 9.5 mm is not adequate to protect immature conch populations (Mueller & Stoner, 2013). New work investigating lip thickness and maturity

[1] Formally classified as *Strombus gigas*

[2] Despite recruitment being from pelagic origin, this statement is based on suspected similar regional fishing pressure

suggests that minimum thicknesses of up to 15 mm may be needed to ensure fishery sustainability is achieved (Stoner *et al*. 2012, Meijer zu Schlochtern 2014).

Confounding this, geographical differences may exist, with *L. gigas* lip thickness at maturity values theorized to vary across its range. For this reason, if possible, it is necessary to base management recommendations not on regional studies, but on work conducted at a more local scale. Thus, when such a study was proposed throughout neighboring islands in 2013, DFMR was keen to participate. With no conch fishery work ever formally conducted on the island, DFMR also requested that visiting researchers undertook a full fishery assessment and population study. This report is a summary of the work which began in 2014 with a three month visit by researchers (Deelen, 2015), and subsequently built upon with a further six month visit in 2015 (Kuramae Izoika, 2016). This latter study combined much of the research from both visits. Data collected by DFMR are also included where appropriate, including measurements taken of discarded harvested (chucked) conch shells on beaches (Wynne, 2007) and in-water survey work (Wynne, 2009; 2017).

The key research objectives set out were to:

[1] Investigate biometric relationships between shell length and flared lip thickness.

[2] Collect gonad samples for regional study of maturity probability versus lip thickness.

[3] Establish the current distribution, abundance and population structure of the *L. gigas* in Anguilla.

[4] Evaluate habitat characteristics determining the abundance and size of *L. gigas* around Anguilla.

[5] Assess the overall current status of the conch fishery in Anguilla.

Methods

Methods used were varied based on the five research objectives. Full methodological details of the work conducted in 2014 can be found in Deelen (2015), and that conducted in 2015 found in Kuramae Izoika (2016). In general there were two main aspects to the work: Fishery assessments and habitat assessments. The fishery assessments involved taking part in fishing trips and collecting catch and effort data. Where possible conch gender was also assessed but this was largely restricted based on logistics. Fishing fleet surveys were also conducted along with semi- structured interviews with fishers. Fishing fleet surveys were undertaken by visiting ports mid-morning when conch fishers would be out fishing if they were to be fishing that day, and counting which boats were still in port. This yielded an activity probability that could be extrapolated across the year based on a reported potential six day working week of the fishers. Habitat assessments were conducted via diving, snorkeling and using an underwater towed video array. The habitat work in 2015 focused on the underwater towed video array method as it yields more data per unit effort and also allows survey work to be conducted beyond safe diving limits. Recently published work by Boman (2016) justifies this method and demonstrates how results do not vary significantly from diver surveys but how it does increase overall survey efficiency.

The collection of gonad samples, although related, fell outside of the fishery assessment and habitat assessment aspects of this work. During peak reproductive season (July-August) conch were collected opportunistically and dissected to ascertain sex and collect the gonad samples that were due to be sent overseas for histological analysis. Towards the end of August however, due to difficulties in dissecting during fishing trips, sample number was still very small and so some dedicated fishing trips using the DFMR vessel were undertaken in an attempt to fill the gap.

Results

Objective [1] – Relationship between shell length and lip thickness

During assessment of conch middens by Wynne (2007), which are thought to have been harvested by hand (often recreationally) and chucked on shore, were predominantly under 18 cm shell length and without a flared lip. The only *L. gigas* measured during this time with a flared lip were over 20 cm. Work conducted by Deelen (2015) measured conch harvested by fishing vessel, and of 484 individuals only four were found with a flared lip under 18 cm (Figure 1).

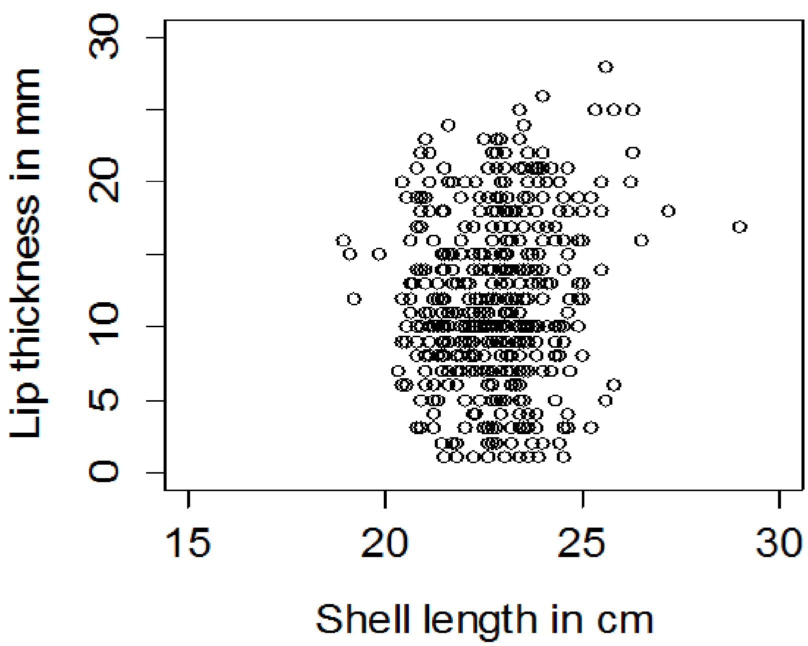

Figure 1: Biometric relationship between shell length (cm) and lip thickness (mm) n=484. Results were obtained during 2014 research visit and measurements taken while on fishing trips. Of special interest is that lip thickness appears to develop across all shell lengths measured, with no linear relationship as might be expected. Graph taken from Deelen (2015). A similar graph illustrating the lack of correlation between lip thickness and shell length can be seen Boman (2017b).

Objective [2] – Maturity probability based on lip thickness

In total 33 gonad samples were collected from male and female conch with a variety of shell length and flared lip thickness. Unfortunately, due to difficulties dissecting conch while on fishing trips, and subsequent problems locating conch with a thick enough lip while conducting trips using the DFMR vessel, the number of samples were not sufficient to produce a size at maturity curve specifically for Anguilla. However, similar studies (Boman *et al*., 2017) undertaken on the neighboring island of St Eustatius (c.80 km distant), suggest that 50% of males are mature with a lip thickness of c.3 mm, and that 50% of females are mature with a lip thickness of c.12 mm (Figure 2).

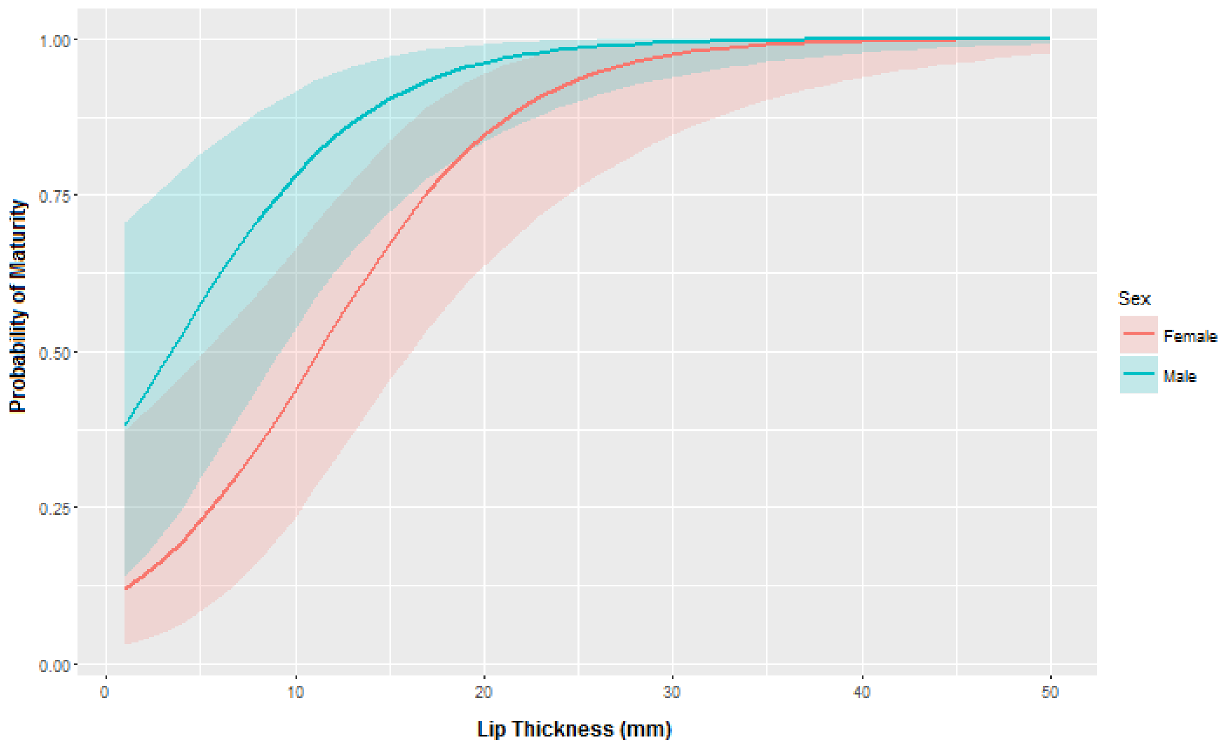

Figure 2: *L. gigas* percentage probability of maturity versus lip thickness (mm) for both male and female conch analyzed in St Eustatius. 50% maturity is c.12 mm for females and c.3mm for males (Boman *el al*., 2017).

Objective [3] – Distribution, abundance and population structure

A distribution map of *L. gigas* densities was constructed through underwater video transects (n = 126) and dive/snorkeling surveys (n = 32) across both researcher visits (Figure 3). During these surveys 155 live adult *L. gigas* were recorded during video transects and 28 during dive surveys. Of the total 158 locations surveyed, four were found to have densities between 201-350 individuals per hectare; six with densities between 101-200 individuals per hectare; five with densities between 51-100 individuals per hectare; seventeen with densities between 26-50 individuals per hectare; and twenty with densities between 1-25 individuals per hectare. The remaining sites had no *L. gigas* present. Four extra transects were also conducted around Sombrero Island, but these were excluded from the analysis in Kuramae Izoika (2016) due to their geographical separation from other sites surveyed. Overall results give a mean *L. gigas* density of 29.05 per hectare (± 5.49), although consideration needs to be given on the random nature of these surveys (i.e. they did not solely focus on known fishing grounds).

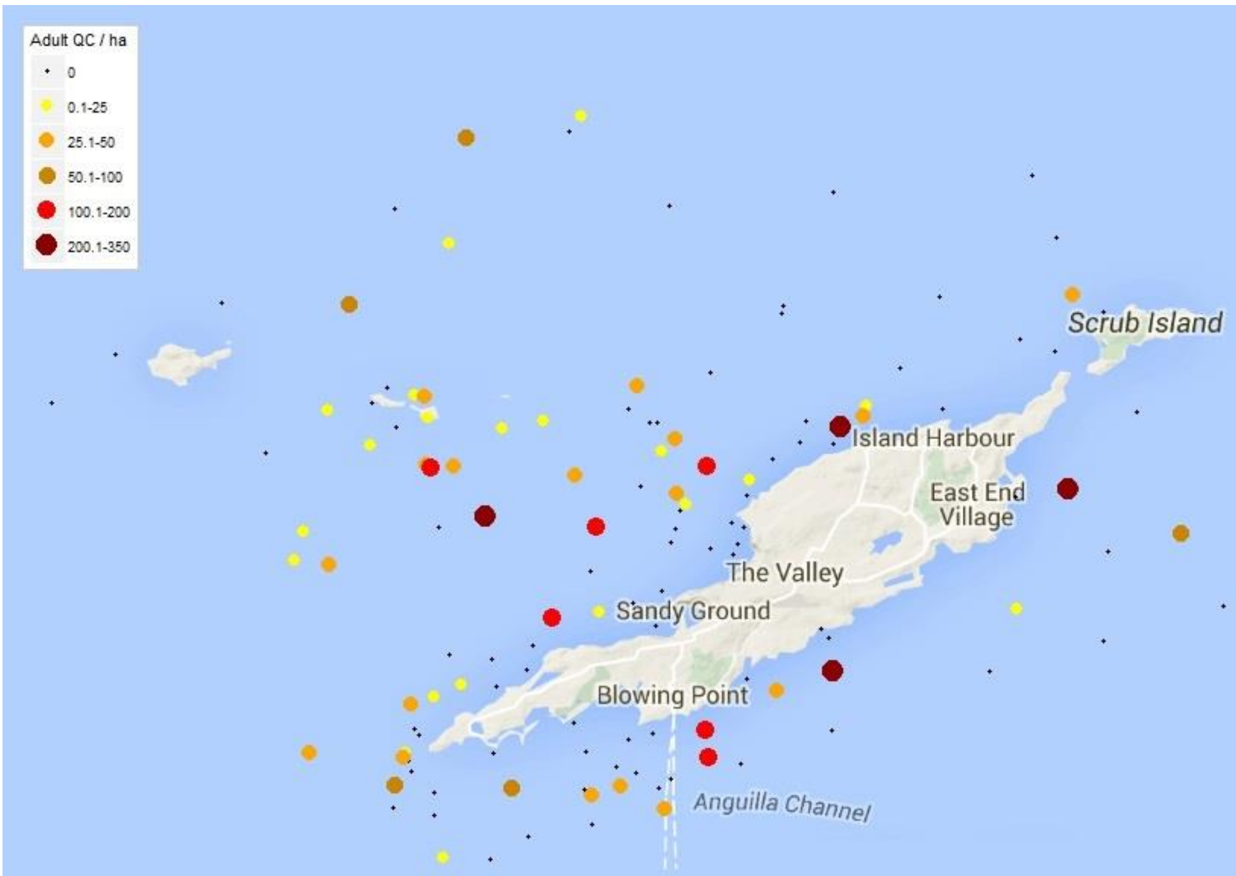

Figure 3: Queen Conch (*L. gigas*) densities established through underwater surveys in 2014 and 2015, split into abundance categories. Map data taken from Kuramae Izoika (2016).

Population structure (based on landed catch) from fishing trips are presented in Figures 4 (shell length) and 5 (lip thickness) conducted during 2015. Mean shell length (n = 994; 554 females and 440 males) was calculated as 22.42 cm (± 0.05) for females and 22.32 cm (± 0.07) for males, with mean lip thickness of 12.85 mm (± 0.24) from females and 13.21 mm (± 0.27) for males. Research from 2014 (n = 486), which did not separate by sex, reported a mean shell length of 22.7 cm and a mean lip thickness of 11.8 mm. Dive surveys conducted in 2014 calculated a mean shell length of 22.3 cm and mean lip thickness of 7.1 mm, although sample size was very small (n = 9). Size estimations are not included from video surveys due to accuracy concerns and inability to measure lip thickness. Reef and seagrass monitoring conducted by DFMR (Wynne, 2009; Wynne, 2017) have found a mixed distribution at the various sites, with habitat characteristics described in the following subsection. DFMR snorkeling work has also identified some areas with a large number of juveniles, for example close to Scilly Cay (Island Harbour), and Sandy Ground (Road Bay).

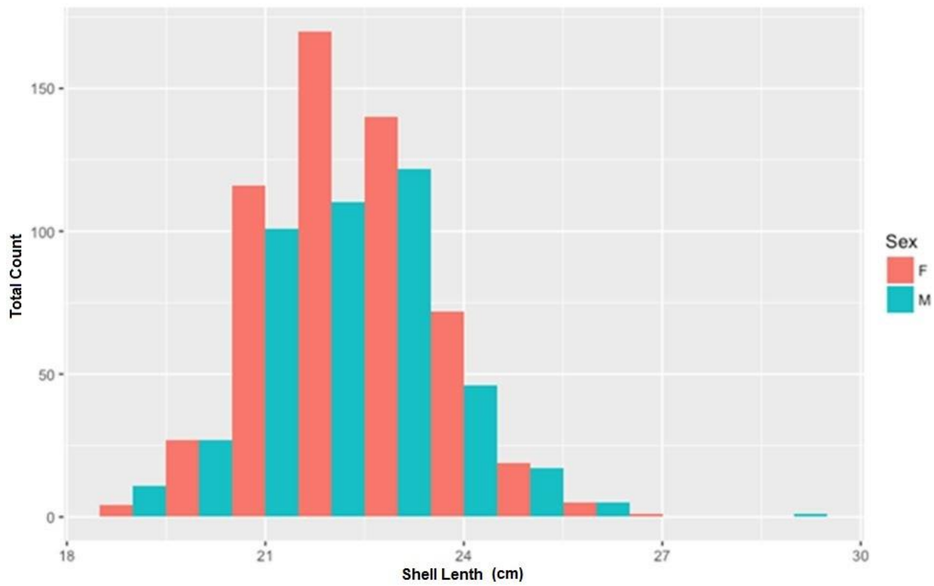

Figure 4: Total count of adult conch shell length slip by sex as measured during fishing trips. Mean shell length (n = 1044; 578 females and 466 males) was 22.4 cm for females and 23 cm for males. Figure modified from Kuramae Izoika (2016).

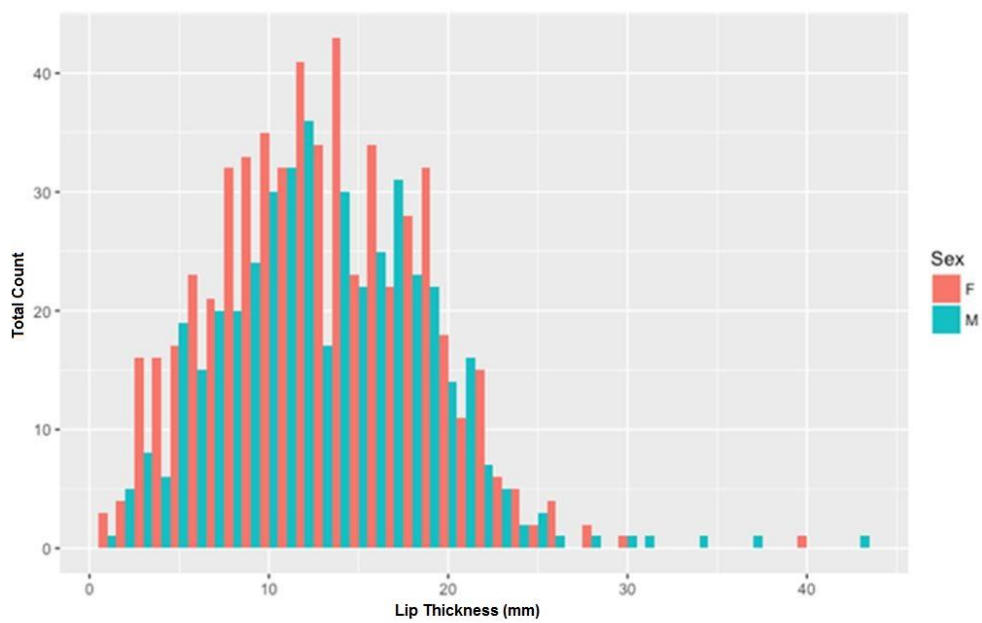

Figure 5: Total count of adult conch lip thickness slip by sex as measured during fishing trips. Mean lip thickness (n = 1044; 578 females and 466 males) of 14.6 mm from females and 12 mm for males. Figure modified from Kuramae Izoika (2016).

Objective [4] – Habitat characteristics

Results from video transects during both 2014 and 2015 found the highest mean *L. gigas* densities per hectare on a mixed (hard/soft) underlying substrate, closely followed by soft underlying substrate, and finally hard underlying substrate (Figure 6). When analyzing benthic associations, seagrass was found to have the highest densities per hectare, followed by a mixed community, with lowest numbers seen on an algal dominated area (Figure 7). In terms of depth (Figure 8) the greatest density of L. gigas per hectare were found at medium depths (15 m – 30 m), closely followed by densities deep depths (> 30 m). Shallow water areas (< 15 m) had by far the lowest densities overall. Dive surveys in 2014 also measured conch shell length and lip thickness, and made inferences relating to habitat categories. These results are not presented here as the conch sample size (n = 9) was too small for meaningful analysis. Reef and seagrass monitoring conducted by DFMR (Wynne, 2009; Wynne, 2017) have found that most of the conch found in seagrass areas are usually juveniles or young adults, with those on sand/rubble areas appearing to consist mainly of young adults to mature individuals. Any conch found on reef areas usually have a well-developed thick lip, although their paucity means they are not often recorded during survey work.

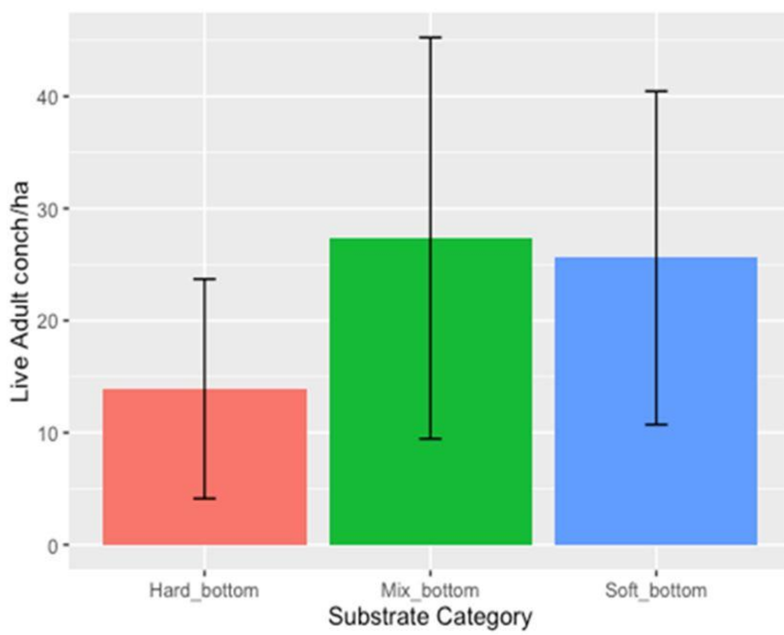

Figure 6: Live adult *L. gigas* mean densities per hectare based on underlying substrate composition. Figure courtesy of Kuramae Izoika (unpublished). Hard bottom refers to areas consisting mainly of rock, boulders or reef plateau, with soft bottom referring to sandy areas and mix bottom a mixture of the two.

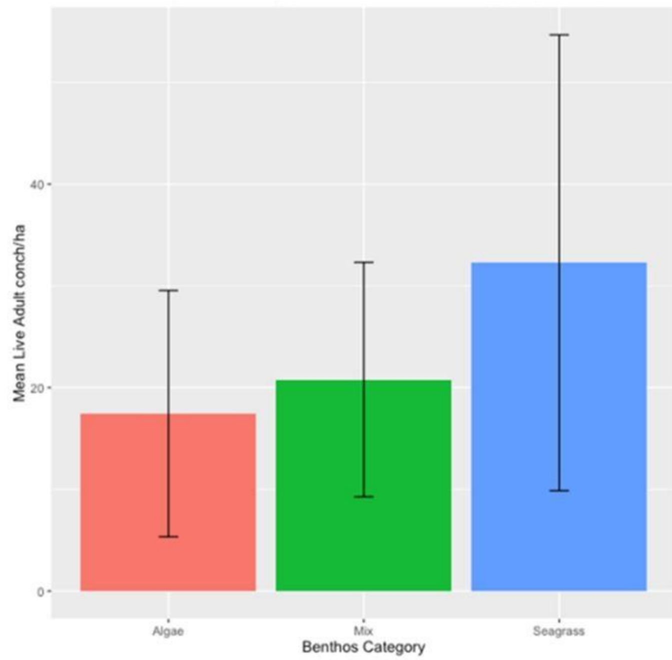

Figure 7: Live adult *L. gigas* mean densities per hectare based on benthic community composition. Figure taken from Kuramae Izoika (2016). Algae refers to areas dominated by algal flats, with seagrass referring to areas dominated by seagrass, and mix a mixture of the two.

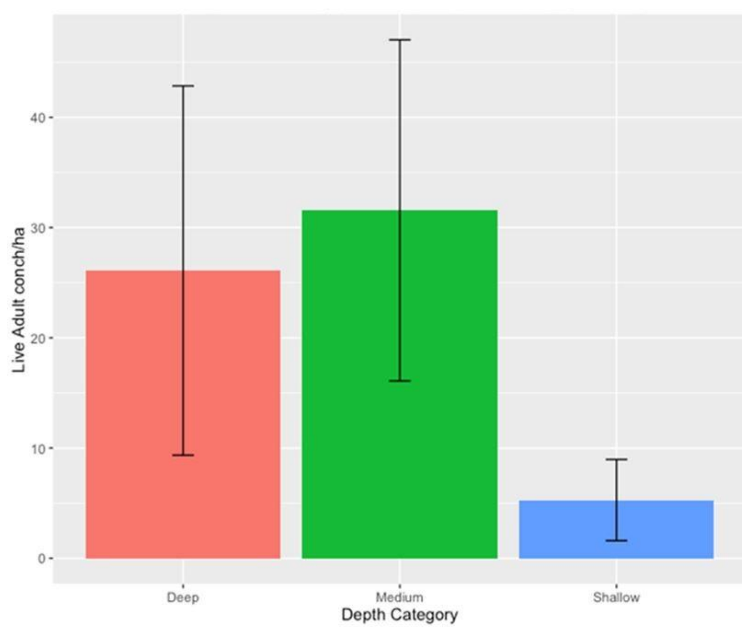

Figure 8: Live adult *L. gigas* mean densities per hectare based on depth of survey. Figure taken from Kuramae Izoika (2016). Deep refers to areas greater than 30 m in depth, with shallow referring to areas less than 15 m in depth, and medium between 15 m and 30 m.

Objective [5] – Description of the conch fishery in Anguilla

Based on fishing trips undertaken during 2014 and 2015 fishers harvest *L. gigas* at a mean rate of 275 conch per trip, usually with a crew of two and by diving using SCUBA[3] to depths not usually deeper than 30 m. Baskets that fit 20-25 conch are filled by the diver and then hauled to the surface by the second crew member. Most fishers chuck their catch at sea and discard the shells, although some do undertake this while at port. The landed conch is considered semi-cleaned with usually only their digestive glands removed. There are currently 7 full time conch boats operating in Anguilla which depart on an estimated 19 trips per month (weather and season depending), although a small number of others may operate on a highly sporadic basis. Based on a potential six day work week (DFMR, pers. obs.), and a mean probability of 23% activity on any given working day, the current research estimates that approximately 507[4] fishing trips are undertaken per year by the fleet. This equates to c.139,496 conch landed annually or an estimated 69,190 lbs. of semi-cleaned meat[5].

The main fishing area for conch is the St Martin Channel (south of Anguilla), a relatively flat area ranging in depth between 18-30 m and predominantly comprised of sand or scattered rubble with a mixed community of sponges and small soft corals. Other areas fished are the more seagrass dominated areas to the north of Anguilla, including (but not limited to) the Seal Island Channel; the Shoal Bay East area; and Dog Island/north of Seal Island reef. It is problematic to accurately categorize these northern areas as much variety exists and habitats can change rapidly in a small area, where a seagrass bed may suddenly become a sand flat with scattered rocks much like the St Martin Channel. It is considered that the primary conch ground in Anguilla is the St Martin Channel as habitat are more uniform in nature and thus more reliable in terms of catch.

Kuramae Izioka (2016) calculated the submerged plateau of Anguilla to be c.200,000 ha, which according to estimates equates to 80,900 ha of potential conch habitat once reef areas and all land masses have been subtracted. A mean of 29.05 *L.gigas* ha^{-1} gives an overall population estimate of c. 2,350,000 individuals. This means the estimated annual catch of the conch fishery is approximately 6% of the total stock.

Discussion

The need for rethinking current legislation

Based on scientific study over recent decades, it has been established that a minimum shell length size for harvest as exists in Anguilla (18 cm) is an insufficient measure for sustainable management of the *L. gigas* fishery as at that size only 94% of individuals are still immature (Blakesley, 1977). Furthermore, this research states that shell length is not a good indicator of *L. gigas* maturity at all, and that lip thickness is by far a more robust assessment tool (Theile, 2001; Stoner *et al*., 2012; Boman 2017a; Boman 2017b). The lack of correlation between shell length and lip thickness (Figure 1), combined with the clear relationship demonstrated between lip thickness and maturity probability (Figure 2) further backs this up. Indeed, based on the life history stages identified by Stoner & Davis

[3] In many countries in the region the use of SCUBA has been banned in order to conserve deep water populations
[4] Unrounded figure is 507.26, which is that used in subsequent calculations.
[5] This assumes the average semi-cleaned (no digestive glands) conch weighs 225 g (legal minimum) or 0.496 lbs.

(2010) an individual with a shell length of 18 cm is not even considered an adult[6]. This presents a strong case for a change in regulations if a sustainable conch fishery is to be achieved in Anguilla, and the need for lip thickness to be the measure used when assessing maturity via a conchs external shell.

Some changes over recent years have taken place in terms of what thickness of lip is considered a sign of a mature conch. To begin with thicknesses of 5 mm were assessed as sufficient, but new evidence suggests that this is not the case with thicknesses of up to 15 mm being suggested (Meijer zu Schlochtern, 2014). Much of this is likely due to some inherent difficulties when measuring lip thickness, especially when lip flare first begins to take place. At this stage, the lip can begin to curl, and ripples perpendicular to the lips edge make accurate measurements difficult to make, with calipers often over-measuring. Thus an individual with a true lip thickness of 2 mm may be inadvertently measured as 5 mm. Such measuring problems do not occur when the thickness increases, and by 10 mm inaccuracies are seldom noted (DFMR, pers. obs.). This ties in well with research conducted primarily in the neighboring island of St Eustatius where it was concluded that there was a 50% chance of a female being mature with a lip thickness of c.12 mm, and for males a lip thickness of c.3 mm (Figure 2). By taking into account the need for prioritizing female protection over males, and also livelihood considerations of the fishers (Figure 5), setting a 10 mm thickness minimum satisfies best the criteria[7]. Livelihood considerations are important as the aim of management is not to place restrictions on a fishery that lead it to become a no longer financially viable option. A lip thickness minimum of 10 mm would mean less than 30% of current catch be left for future harvest while at the same time protecting over 50% of the mature *L. gigas* population. With the current legislation, all catch landed is legal (Figure 4) but only 6% of the mature population is protected, which may well benefit livelihoods in the short term, but the long term projection of such a situation is most probably one of stock collapse.

Changing to a lip thickness limit over a shell length limit is crucial to ensure the future sustainability of the conch fishery in Anguilla. However, conch fishers seldom land their catch in their shells and so another measure is also needed to accommodate this. The lip thickness minimum gives fishers an important guide when harvesting conch underwater, and provides authorities with the tool they need when inspecting boats while out at sea, or during land patrols on beaches where coastal based fishing of shallow conch grounds takes place (and as such the return of live individuals to the sea). However, when the conch is landed on shore by boat it has been chucked and partially cleaned. Currently the semi-cleaned weight limit (digestive gland removed) is set at 225 g. Based on work conducted by Stoner *et al*. (2012) this weight seems sufficient for managerial purposes. With a lip thickness of 10 mm, a mean soft tissue weight of c.280 g was recorded, thus once partially cleaned an approximation of 225 g is likely. It is also not advisable to increase the semi-cleaned weight any higher than it currently is as tissue weight begins to drop as age increases, and so older individuals with very thick lips (> 30 mm) would not be legal. It is interesting to note that this work by Stoner *et al*. (2012) also highlights the current inadequacies of a 18 cm minimum shell length, as at this size the total soft meat (not cleaned) weight is c.175 g. Thus a legal individual in terms of shell length would likely be illegal in terms of meat weight. Using a 10 mm lip thickness instead unifies the two regulations in a much more satisfactory level.

[6] The three life history stages are < 10 cm Juvenile 11-18 cm Intermediate > 19cm Adult

[7] This is a liberal recommendation, with 12 mm more likely to aid sustainability, but livelihood issues exist

Conch distributions and the implications for fishery sustainability

As illustrated by Figure 3, conch distribution is somewhat patchy and seemingly hard to predict, and has likely been heavily influenced by fishing practices. Based on habitat characteristic results their preference for mixed/soft bottom areas is clear (Figure 6), although they are also present, albeit in lower numbers, on hard bottom habitats and can even be found on reef areas. Those encountered on reef areas, and in further offshore areas presumably under less fishing pressure, are generally much older with thicker well developed lips. For example, while visiting Sombrero Island (over 30 km from mainland Anguilla) individuals with the thickest lips across the whole study period were found. During fisheries assessments it is often difficult to tease apart habitat influences from fishing pressure, but the inaccessible nature of Sombrero does suggest that the age of the conch there is a fishing related phenomenon. In closer to shore hard bottom/reef areas older conch with well-developed lips are again more common that surrounding sand/rubble areas or seagrass beds. Their paucity however means these areas do not attract conch fishers and so suggest that *L. gigas* chance upon these areas and remain relatively safe from harvest and so reach ages beyond that expected in other habitats with fishing present. Once again though influential variables are difficult to tease apart, and an alternative reason could be that these areas have been fished out by spear/pot fishers who snorkel while fishing/setting traps and may opportunistically harvest them. The older mature ones may simply be those that have avoided capture. This latter scenario is however made less likely by the fact that if an even distribution of conch originally existed in these areas one would expect an even distribution of lip thicknesses to be present after an essentially random harvesting process.

The results presented in Figure 7 illustrate that the largest number of conch are found in seagrass beds, with fewer seen in mixed or algae dominated areas. These latter categories, although somewhat subjective in nature, suggest an increasing amount of hard substrate. Without size estimations for the conch, it is difficult to corroborate these results with those made during separate DFMR survey work, but it is suggested that the reason for these higher numbers is a propensity for these areas to be dominated by smaller juveniles or intermediate individuals. This can in part be confirmed by the conch middens reported by Wynne (2007), where large piles of chucked conch shells, most of which were undersized or without a developed lip, were found close to the beach in bay areas dominated by seagrass. Also, a large number of juveniles are found in the seagrass beds close to Scilly Cay, and during DFMR fishing trips that aimed to find thick lipped individuals for gonad sampling in the seagrass beds offshore from Shoal Bay East, none were found. In this latter area, not considered by DFMR as a known conch ground, no individuals with a lip thickness above 5 mm could be found. Despite the potential for fishing to be skewing these results and influencing conclusions, it seems unlikely that such patterns could solely be due to it as by chance some thick lipped individuals would have avoided harvest.

By looking at the influence of depth on distribution (Figure 8), similar inferences can be made. Shallow areas, easy for harvesting and accessible by all as they are generally close to shore, have the lowest numbers. Deeper areas that can only be accessed by boat and while using SCUBA equipment have higher numbers. This result may initially be seen as encouraging in terms of fishery sustainability as it suggests that potential grounds still have higher densities than the depleted shallow areas. However, when looking at actual densities in these areas, numbers are actually low[8], as reflected by the distribution map presented in Figure 3. This reverts back to the patchy overall nature of areas with a high density of conch, and the lack of a strong correlation with any of the habitat variables studied. This is perhaps the strongest evidence of a fishing effect, as in the St Martin Channel for example; with such a uniform habitat one would expect a uniform natural distribution. Indeed, while DFMR were conducting fishing trips in search of gonad samples from conch with a well-developed lip, some locations in the St Martin channel chanced upon had many conch (of mixed lip thickness, but mostly < 10 mm), whereas other seemingly identical areas had none whatsoever.

This latter observation, combined with the patchy nature illustrated in Figure 3, suggests that conch fishing in the St Martin Channel has reduced an area once rich in *L. gigas* to one which today only has a scattering of high density patches able to support the current fishery. It is difficult to make exact predictions, but it seems likely that at some point in the not too distant future if fishing practices remain as they do today (or if the conch fleet expands) then the fishery is likely to collapse as it did a few decades ago in Florida. This is also supported by the fact that the annual catch rate is at 6% of the total stock which is close to the maximum fishable biomass of 8% recommended by the Queen Conch expert workshop (CITES 2012). It is essential to change the legislation in an attempt to not let this happen, but this must be backed up by increased surveillance and enforcement of regulations as it is apparent from the evidence contained within the conch middens that even an extremely liberal minimum size is not adhered to by some fishers. These midden results however seem to contradict those collected when researchers undertook fishing trips with local fishers, where no individuals under the current legal minimum size were landed. It is suspected that this is due to the 'researcher onboard' effect, where fishers stick to the legal limits while being observed. A similar situation was suspected while assessing the Spotted Spiny Lobster (*Panulirus guttatus*) fishery in Anguilla a few years ago, where fishers discarded berried females into the sea while being observed, yet berried females were found while measuring catches purchased by local restaurants (Wynne, 2004). Of course, this may also be due to different fishers having different standards, but unfortunately it is counter intuitive and means recommendations made by researchers to decision makers can lead to adverse livelihood impacts. For example, Figure 4 suggests that no landed conch were below current legal size (good level of compliancy), with Figure 5 suggesting that a minimum lip thickness of 10 mm would not adversely affect livelihoods. However, if there are very few 10 mm individuals left in Anguillian waters (aside from in the patches known about to fishers where the researchers were taken), then such a limit, if adhered to, may render the fishery unviable. Also, the 'researcher onboard' effect means actual compliancy is unknown, so changing the limit will do nothing for the sustainability of the fishery unless surveillance and enforcement efforts increase. This is the only way to ensure that the fishery is governed with sustaining legislation and protect the remaining resources for future harvest. If the legislation is changed and not enforced until fishers begin to report a reduction in size and catch then it will likely be too late and most remaining conch will be below minimum lip thickness and so the fishery unable to legally operate at an economically viable level.

[8] 50 individuals per hectare is generally considered the threshold needed for reproduction to occur

Potential for fishery development/conch farming

Based on the discussion in the previous paragraphs it is concluded that it would be unwise to actively encourage the development of the conch fishery at present. In fact, at the discretion of the Minister of Fisheries, it may be wise to consider specific licenses permitting conch fishing (with provision for a limited recreational bag size[9]) and limit the number of those granted to the current size of the conch fishing fleet. However, if some room for expansion is deemed necessary, and again at the discretion of the Minister of Fisheries, the following needs consideration: With an estimated rounded annual landing rate of 140,000 conch across only seven vessels, and bearing in mind that some vessels land over double the mean of c. 20,000 conch per vessel per year (the highest being estimated as over 54,500 conch per year), the addition of one extra vessel has the potential to increase landings by almost 40%[10]. Such increases would quickly push the fishery over the 8% recommended fishable biomass and towards a rapid collapse, especially without upgrading the current legislation with regard to lip thickness. Furthermore, based on the fact that during the survey period at least half of the conch fleet appeared less active than expected, it is likely that actual catch is higher than that estimated. If this is the case, the fishery is under even greater pressure and the need for legislative change even more urgent. With this being the case, if a cap limit were to be introduced, a maximum number of vessels for the fishery should under no circumstances be greater than ten, and even then such an expansion is potentially hazardous for the fisheries long term survival.

One potential solution to the situation is conch farming, as has been attempted in the Turks and Caicos Islands. Over the last thirty years, more than $12 million has been invested to try and overcome the complex process involved with farming conch from larval life history stages. Despite this, the operation has yet to achieve its envisaged potential, although it is a popular destination for eco-tourism groups. The main drawbacks to the process, aside from its highly complex nature include: obtaining hatchery seed or juveniles for culture; the large area of shallow water ‘cages’ needed to contain the conch; a long grow out period of three to four years before being of saleable size; high cost of maintaining the facility and the cages (especially after storm events); potential for increasing disease outbreaks and/or nutrient load; and need for land operations also increasing cost. These factors, especially the need for large areas of shallow sheltered water, mean such an operation is not recommended for Anguilla.

[9] In Florida this number has been set at 6 conch per recreational vessel

[10] This figure was arrived at based on 54,500/140,000 = 0.389

Recommendations

- Change current legislation to promote sustainability of the fishery as current 18 cm minimum size is inadequate. Instead, a minimum 10 mm thickness of the adults flared lip is suggested as a measure of 50% maturity.

- Semi cleaned meat weight of 225 g is concluded to be sufficient, although meat weight is not considered a good measure of maturity. Such legislation must be combined with lip thickness regulations and increased surveillance and enforcement.

- As it is operated currently the conch fishery is considered unsustainable without this new legislation and increased surveillance and enforcement.

- Even with new legislation it is not recommended to promote development of the fishery as stocks can unlikely support this. It may be necessary to cap further development by issuing a limited number of specific conch fishing licenses (suggested seven), with regulations in place for a small amount of recreational catch.

- Farming of conch is not recommended as a suitable option for Anguilla for reasons including (but not limited to): a lack of well protected shallow water areas for cages; difficulty in obtaining hatchery seed or juveniles for culture; and a long grow out period combined with a high maintenance cost, especially after storm events.

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