Preliminary Analysis of Size Differences of Queen Triggerfish, *Balistes vetula*, Across Island Shelves and Gear Types in the US Virgin Islands

Las Diferencias Preliminares del Tamaño del Queen Triggerfish, *Balistes vetula*, a Través de las plataformas de la Islas y los Tipos de Artes de Pesca en US Virgin Islands

Les Différences de Taille Préliminaires de la Queen Triggerfish, *Balistes vetula*, à Travers Les Étagères Insulaires et les Types D'engins dans les US Virgin Islands

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ABSTRACT

The Queen Triggerfish, *Balistes vetula,* is one of the most popular commercial fishes in St. Thomas and St. Croix, United States Virgin Islands (USVI). This species can comprise up to 10 - 15% of annual reef fish landings. St. Thomas is located on the Puerto Rican shelf approximately 40 miles north of St. Croix, which is a separate geographic feature on a small, insular platform. Depth of water between the two shelves exceeds 4,000 m. Fishing gear also differs between islands; St. Thomas commercial fishers only use traps while gear use by St. Croix fishers is diverse, using spear guns on SCUBA, traps, or a combination. Monthly samples were collected from fishers on both islands using multiple gear types in order to test for differences in the average size across island shelves and fishing method. When comparing gear types, there was no significant difference in mean lengths found between trap and spear fish in St. Croix, suggesting different gear types may be catching similar size individuals. Across islands, our data shows commercially caught fish in St. Croix are significantly smaller than St. Thomas fish. It is possible this difference among islands is caused by the differing geographical conditions across the shelf types and heavier fishing pressure in St. Croix. If varying islands are landing different sizes, the USVI Queen Triggerfish fishery may need multiple management strategies based on location, taking into account differing physical island shelves and fishing practices.

KEYWORDS: Caribbean fisheries, Queen Triggerfish, *Balistes vetula*, island shelves, commercial fishing gears

INTRODUCTION

Tropical fisheries of the Caribbean region are considered to be small-scale, artisanal operations that target a variety of reef fishes (Garrison et al. 1998, Kojis and Quinn 2006, Ramdeen et al. 2015). Artisanal, multi-species fisheries are often multi-gear fisheries, in order to achieve the desired mix of species (Munro and Smith 1984). Trap fishing is one of the oldest fishing methods and is widely used in the Caribbean, representing a large part of fishing effort and landings (Stevenson and Stuart 1980, Munro 1983, Gobert 1998, Garrison et al. 2004, Hawkins et al. 2007). Other common fishing techniques in the Caribbean region include linefishing, the second most practiced method of reef fish exploitation, and spearfishing, which has become an important economic activity (Munro 1983).

The United States Virgin Islands (USVI) reef fish fisheries are an example of a small-scale, multi-gear, and multi-species enterprise. Fishers operate from small open vessels, between 4 - 6 m in length, use relatively inexpensive gear, and sell their catches directly to consumers or local markets (Munro and Smith 1984, Ramdeen et al. 2015). This United States territory consists of three islands, St. Thomas, St. John, and St. Croix, each with a long history of fishing (Fielder and Jarvis 1930 as cited by Kojis and Quinn 2006). St. Thomas and St. John are located on the Puerto Rican shelf approximately 64 kilometers north of St. Croix, which is a separate geographic feature on a small, insular platform. Depth of water between the two shelves exceeds 4,000 meters. The shallow portion of the shelf extending off St. Croix is much smaller and deeper waters are typically less than 3 miles from shore whereas in St. Thomas/St. John the shelf drops off about 11 - 13 km from the coast (Kojis and Quinn 2006). Therefore, the northern USVI islands have a total fishable area that is almost 5 times greater than in St. Croix (Kadison et al., *In review*). This means that most fishing in St. Croix is limited to shallower reefs, which has influenced the gear types utilized by the commercial fishery.

Historically, trap fishing was the primary gear of the USVI, but as economic conditions and technology improved, fishers expanded their fishing ranges and diversified into gear types such as spearfishing on SCUBA, netting, and linefishing (Kojis and Quinn 2006). While traps are still the principle fishing gear in St. Thomas/St. John, they have become less important in St. Croix. This is due to two reasons:

i) Even though economic conditions and technology improved, the proximity of the shelf edge to the coast of St. Croix spurred an increase in linefishing for deep water pelagics and snapper, instead of increasing the number of traps and
ii) The shallow, insular shelf made deployed traps susceptible to hurricane damage.

When Hurricane Hugo passed in 1989, many fishers chose not to replace lost or damaged traps and switched to other gears such as line fishing, netting, and spearfishing on SCUBA (Kojis and Quinn 2006). Trap fishers still operate in St. Croix, although not as many as historically (Bryan 2015). For these reasons, St. Croix's fisheries have more gear types while St. Thomas/St. John primarily use lobster and fish traps to catch multiple reef fish species.

Reef fish fisheries are typically dominated by a few species (McClanahan and Mangi 2004). In the USVI fishery, parrotfish (23%), snappers (14%), triggerfish (10%), surgeonfish (8%), and grunts (8%) are the most common species, with groupers (9%) and lobsters (8%) also comprising an important part (Ramdeen et al. 2015). However, differences exist between St. Thomas/St. John and St. Croix in terms of catch composition. Parrotfish are more frequent in catches of St. Croix while larger groupers are more common in St. Thomas/St. John. The triggerfish landings category has traditionally included both filefish and triggerfish, making it difficult to know landings of individual species before 2011 (McCarthy 2012). We know that one of the most popular species within that category is Queen Triggerfish, *Balistes vetula*, the focus of this study. Nicknamed Ol'wife by local fishers, this species is targeted across all three islands. Landings of triggerfish, which was a category including both Queen Triggerfish and filefish species, ranged from 70,000 - 100,000 lbs per year in St. Thomas/St. John and between 22,000 - 30,000 lbs per year in St. Croix (McCarthy 2012). Since species specific landings data became available in the 2011 - 2012 fishing year, Queen Triggerfish landings in St. Thomas range from 26,000 - 45,000 lbs per year (SEDAR 2016); however, this information was not accessible for St. Croix. Commercially, *B. vetula* is caught solely by traps in St. Thomas/St. John and by traps and spearfishing on SCUBA in St. Croix.

Fundamental differences exist between these different gear types that cause them to have varying effects on reef resources (Frisch et al. 2012). Traps are efficient small boat gear, catch a wide diversity that are not caught with other gear, and can be left out for days if conditions for retrieval are unfavorable (Stevenson and Stuart 1980, Garrison et al. 1998, Kojis and Quinn 2006). However, due to their unselective nature, traps can accrue large amount of bycatch, or non-target species, and can damage bottom habitat when dropped on reefs (Hawkins et al. 2007). Fishing pressure from traps has greatly impacted Caribbean fish assemblages across multiple islands (Hawkins et al 2007). Historically trap fishing, particularly in the USVI, contained primarily groupers and snappers up until the 1980s when herbivores such as parrotfish and surgeonfish began to dominate the catch, which is indicative of overexploitation (Garrison et al. 1998, Garrison et al 2004). Balistids have also appeared to decline in catches since the 1960s (Garrison et al. 1998). Linefishing has similar impacts in that it also produces large amounts of bycatch, up to 65% in some cases, and can cause habitat damage through lost fishing line and hooks (Frisch et al. 2008).

Spearfishing, on the other hand, has a high selectivity because there is minimal to no bycatch of non-target species and results in minimal gear loss (Frisch et al. 2008). Spearfishers choose which fish to shoot, making it less likely that undersized, undesirable, or protected fishes will be taken (McClanahan and Mangi 2004, Frisch et al. 2008). This fishing method is also considered to have an efficient catch per unit effort (CPUE) due to its selectivity (Frisch et al. 2008). However, intense spearfishing can cause declines in the density and mean size of target species despite size and catch limits (Frisch et al. 2012), especially when SCUBA is utilized. Spearfishing on SCUBA is legal in regions around the world, including Chile, some states of Australia, and locations in the Indo-Pacific (Lindfield et al. 2014). It is also legal in the USVI, but is only employed commercially in St. Croix. Using SCUBA increases the CPUE and expands the area of the water column and the depth at which fishes can be exploited (Lindfield et al. 2014). Spearfishing and traps impact fisheries resources differently, with distinctive issues and concerns. However, due to a lack of specific information pertaining to each gear type, some fishing methods are managed together despite their varying impacts (Frisch et al. 2008). This calls for studies comparing the differences in targeted species between gear types, such as size and age differences in order to determine if certain parts of a population are more vulnerable from one gear type over others.

Since Queen Triggerfish are a popular food fish and are targeted in the USVI, research efforts need to focus on addressing important questions regarding the fishery and provide data to inform management bodies. Currently, no regulations are in place other than annual catch limits (ACLs) for Queen Triggerfish. However, some reef species such as Yellowtail Snapper, conch, Spiny Lobster, and parrotfish have size limits, seasonal openings, and closed areas. Additionally, there are species such as many groupers that are illegal to take, such as Nassau and Goliath groupers. Two of the unanswered questions regarding the USVI fisheries are whether or not the two distinct island shelves that contain St. Thomas/St. John and St. Croix have separate populations of *B. vetula* and how different gear types are targeting this species. As stated above, differences exist in the impacts of the different fishing gear types and we expect that each type will target reef resources differently. The goal of this study was to determine if differences in sizes exist between Queen Triggerfish caught in St. Croix and St. Thomas. We also compared sizes between trap and spear caught Queen Triggerfish in St. Croix. We hypothesized that the average size of Queen Triggerfish would be larger in St. Thomas than in St. Croix. We also hypothesized that size differences exist between trap and speared Queen Triggerfish in St. Croix. This study presents preliminary size differences in *B. vetula* across the separate island shelves of the USVI and across gear types utilized by commercial fishers.

METHODS

Study Location and Fishery

The USVI is located in the northeastern Caribbean between the Caribbean Sea and the North Atlantic Ocean, approximately 64 km east of Puerto Rico. It consists of three islands: St. Croix, St. Thomas, and St. John with a total estimated human population of 103,574 (CIA 2016). St. Croix is the largest of the three islands with an area of approximately 220 square kilometers (Stoffle et al. 2009) and a flatter terrain than the second largest St. Thomas, which is 80 square kilometers and more mountainous (Platenberg and Boulon 2006). The third and smallest island is St. John, two-thirds of which is the Virgin Islands National Park.

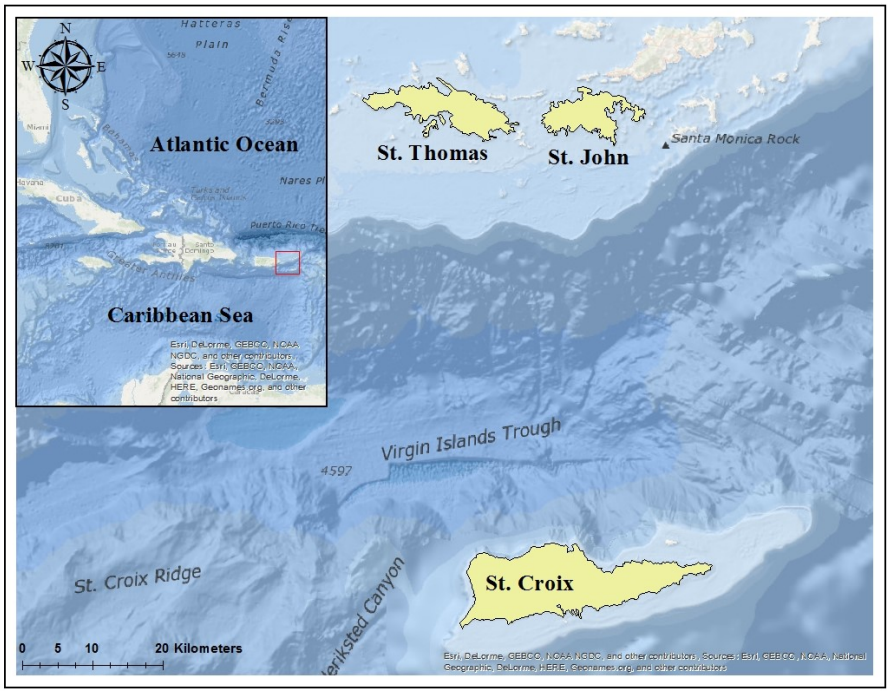

Figure 1. Map of the United States Virgin Islands.

Fiedler and Jarvis conducted the first comprehensive survey of fishers in the territory in 1930. Since then, the population of the USVI has quintupled but the number of fishers has remained about the same (Kojis and Quinn 2006). As of 2010, St. Thomas/St. John had 187 licensed fishers while St. Croix had 214 licensed commercial fishers (Kojis and Quinn 2011). However, not all registered fishers actively fish, although they still hold commercial licenses (Kojis and Quinn 2011). St. Thomas/St. John fishers have been fishing longer and are more likely to be full time fishers than those in St. Croix (Kojis and Quinn 2006). Since the initial survey of commercial fishers in 1930, a continual decline has occurred in the number of licensed commercial fishers as a proportion of the USVI population (Kojis and Quinn 2011). Fish catches are usually marketed whole, gutted, scaled, and iced; they are commonly sold at the landing site of the fishers, but are also sold along the road out of a truck, at fish markets, and to local restaurants (Kojis and Quinn 2006).

Data Collection and Analyses

Queen Triggerfish samples were purchased from local fishers on St. Thomas and St. Croix between July and October 2016. No fish were purchased from St. John. In St. Croix, samples were purchased from spear and trap fishers to compare sizes across gear types. Samples in St. Thomas were only purchased from trap fishers as the island does not have any commercial spearfishers. I met with fishers before they took their catch to market, to ensure no sorting had occurred.

All fish samples were kept on ice until processing. Processing consisted of measuring fish to the nearest millimeter (mm): standard length (SL), fork length (FL), and total length (TL) using the upper lobe of the caudal fin. Total length is not always a reliable representation of a Queen Triggerfish's size as the lobes of the caudal fin are thin, greatly elongated, and easily damaged, especially when caught in traps. This meant that some individual fish did not have a total length measurement. Additionally, standard length was not taken for some samples due to differences in data recorders. Therefore, only fork lengths were compared across gear types and islands.

Fish collected belonged to one of three groups based on how and where they were caught: St. Thomas (STT) trap, St. Croix (STX) trap, and St. Croix (STX) spear. In order to determine if mean size (mm FL) differed among the three sources of fish samples, we used a one factor ANOVA. A post-hoc Tukey test was used for pairwise comparisons and all statistical tests were deemed significant if $p < 0.05$. Additionally, a Kolmogorov-Smirnov (K-S) test was conducted to compare size frequency distributions.

RESULTS

A total of 229 samples were collected with 131 trap fish from St. Thomas, 43 trap fish from St. Croix, and 55 speared fish from St. Croix (Figure 2). The mean size (and range) for each group was 334 (216 - 435), 297 (206 - 357), and 305 (228 - 391) mm FL, respectively. Mean size varied significantly among the three sample sources ($F = 15.63$, $df = 228$, $p < 0.001$). Post-hoc comparisons indicated that STT trap samples were significantly larger than STX trap and STX spear samples. No difference was detected in mean size between STX trap and STX spear fish samples.

Size frequency distributions differed significantly between STT trap and STX trap samples (K-S test: $Z = 0.43$, $p < 0.001$) and between STT trap and STX spear samples ($Z = 0.33$, $p < 0.001$) with STT trap fish having a larger proportion of large samples. No difference occurred in distributions between STX sample sources (Figure 3).

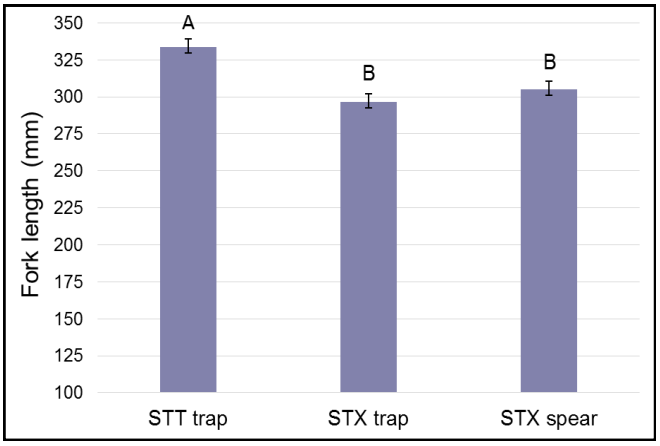

Figure 2. Fork length in millimeters of commercially caught Queen Triggerfish based on island and gear type. St. Thomas = STT and St. Croix = STX. Letters represent significance based on a post-hoc Tukey test.

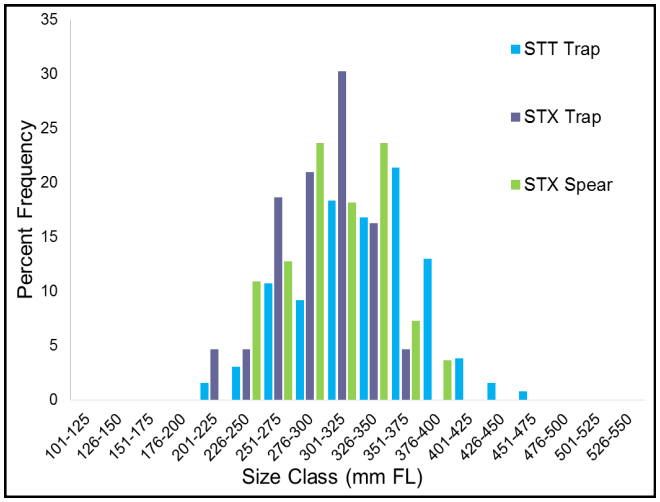

Figure 3. Size frequency distributions of commercially caught Queen Triggerfish based on island and gear type. St. Thomas = STT and St. Croix = STX.

DISCUSSION

Based on preliminary size data, it appears that island shelf has more of an influence on Queen Triggerfish size than the commercial fishing gears. Queen Triggerfish were on average larger in St. Thomas than in St. Croix, regardless of the gear type they were caught with. There are multiple reasons why this difference might exist in the fishery. The distribution and population dynamics of a species are influenced by numerous factors, including substrate type, food availability, water depth, and water movement (Lowe-McConnell 1987), which are in part determined by the shelf characteristics associated with each island (Walsh 1988). There is a possibility of two distinct populations of this species within the territory which are subjected to differing hydrological conditions influencing growth. Growth is also influenced by the food availability of the shelf (Jones 1986); St. Croix has less total fishable area than St. Thomas and consequently less area for a fish's population to forage over. Lastly, the level of recruitment to the population in St. Croix may differ compared to St. Thomas since less shelf area could also mean less viable areas for reproductive strategies such as spawning (Kadison et al. in review). These factors might limit the size of Queen Triggerfish in St. Croix, whereas individuals in St. Thomas do not experience these limitations.

However, the differences in gear types used and their exploitation intensity between the northern USVI islands and St. Croix could also explain these findings. This study shows that individual Queen Triggerfish lengths across islands follow the same trend seen for groupers and snappers in the territory (Kadison et al., *In review*). The narrower and shallower shelf of St. Croix makes it more vulnerable to intense fishing efforts, especially when fishing strategies like spearfishing are employed. It is well known that spearfishing has a very efficient CPUE and a high selectivity, which is only increased when used on SCUBA (Frisch et al. 2008, Lindfield et al. 2014). It has also been shown that intense spearfishing can cause declines in the density and mean size of target species (Frisch et al. 2012), which is why this fishing methodology has been banned in certain parts of the world (Lindfield et al. 2014). Some fishers in St. Croix have stated that "divers spear everything" and there are less fish along the shorelines and nearshore reefs as a result (Kojis and Quinn 2011). In comparison, the St. Thomas shelf has more fishable area in depths greater than 25 meters than St. Croix (Kadison et al., *In review*), which is why no level of commercial spearfishing in the northern USVI has been established and traps are still the favorable fishing gear. This is one possible explanation for smaller Queen Triggerfish sizes in St. Croix, because the shelf is under heavier fishing pressure due to the gear types utilized. So even though there were no significant differences between the fishing methods, the gear types utilized in the commercial fishery must be taken into account and may be a factor driving size differences across islands.

Another explanation is fishers in the territory target plate or pot size fish, which are cooked and served whole; however, this demand for a certain size range is created by the customers. It could be that the customer preference differs across islands which would influence which Queen Triggerfish sizes fishermen target. For example, one partic-

ular spearfisher in St. Croix explained that he observes Queen Triggerfish close to or smaller than 220 millimeters in length but he does not spear them because the effort to shoot small individuals is not profitable or desirable to customers (Bobby Thomas, personal communication). We have also observed through diver surveys larger Queen Triggerfish of sizes that are not appearing in the St. Croix catch. Similarly, trap fishers in St. Thomas have stated that they throw some fish back because they do not think they will sell, most likely because the size is either too small or too large. This could be why the highest frequency of sizes was between 250 - 375 mm, while no fish from any group was less than 206 mm or greater than 453 mm (Figure 3).

While these preliminary results allude to a bigger trend in the fishery between islands, there are certain limitations that should be acknowledged. Firstly, Queen Triggerfish were only purchased from a small proportion of the total number of commercial fishers and only in particular areas of each island. The dispersed nature of the small-scale fishery in the territory made it difficult to systematically collect from all areas and all fishers, which should be considered in future studies that rely on fishery dependent data. Additional anecdotal information should also be collected from the fishers who are providing samples, such as what is the desirable size fish and what specific depth of water they are spearing or deploying traps in. This information should be included in future research in order to elucidate specifics about how fishers are targeting reef resources and where the most fishing pressure is concentrated.

The task of monitoring small-scale, artisanal Caribbean fisheries is difficult, but even more so in multi-island entities such as the USVI (Ramdeen et al. 2015). It is clear that the disparate island shelf geography and fishing methodologies are influencing the exploitation of Queen Triggerfish. However, it is important to consider that not just one of the factors discussed above may be the cause of the size differences, but it is more likely that a combination are the reason for the results presented here. Currently, the USVI fisheries are managed as a single unit and more studies based on fishery dependent data are needed to understand the appropriate management strategy, which may require the territory being split into distinct fisheries units. This study, in addition to Kadison et al. (*In review*), demonstrates the need for tailored management of the USVI's fisheries that takes into account the physical and spatial differences of island shelves and different exploitation levels of commercial fishing gears.

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