Thesis for the Degree of Master of Fisheries Science

The trend in Schoolmaster Snapper (*Lutjanus apodus*) catches in Haiti

By

Jean Woody AMAZAN

The World Fisheries Graduate School

Pukyong National University

February 22, 2019

The trend in Schoolmaster Snapper (*Lutjanus apodus*) catches in Haiti

아이티 Schoolmaster Snapper (*Lutjanus apodus*) 어획량의 추세

Advisor: Prof. Saang-Yoon Hyun

By

Jean Woody AMAZAN

A thesis submitted in partial fulfilment of the requirements
for the degree of

Master of Fisheries Science

in the World Fisheries Graduate School,
Pukyong National University

February 22, 2019

The trend in Schoolmaster Snapper (*Lutjanus apodus*) catches in Haiti

A thesis

By

Jean Woody AMAZAN

Approved by:

(Chairman) Prof. A. Dale Marsden

(Member) Prof. Jin-Koo Kim

(Member) Prof. Saang-Yoon Hyun

February 22, 2019

Table of Contents

List of tables

List of figures

List of abbreviations

CPI: Consumer Price Index

EEZ: Exclusive Economic Zone

FAO: Food and Agriculture Organization

K: Growth rate

L. apodus: *Lutjanus apodus* (Schoolmaster snapper)

L. campechanus: *Lutjanus campechanus* (Northern red snapper)

L. griseus: *Lutjanus griseus* (Grey snapper)

L. purpureus: *Lutjanus purpureus* (Southern red snapper)

L_{inf}: Asymptotic length

L_m: Length at maturity

L_{max}: Maximum Length

L_t: Length at age t

M: Natural mortality

Max D: Maximum Depth

Min D: Minimum Depth

P: Probability

S.E.: Standard Error

t_0: Age at Length zero

t_0: Age where length is zero

TL: Total Length

t_m: Age at first maturity

t_{max}: Life Span

USD: US dollar

VBGE: Von Bertalanffy growth equation

W_{inf}: Asymptotic weight

W_t: Weight at age t

The trend in Schoolmaster Snapper (*Lutjanus apodus*) catches in Haiti

Jean Woody AMAZAN

The World Fisheries Graduate School,

Pukyong National University

Abstract

An investigation was conducted to analyze and determine the substantial difference in the trends observed between the capture of the Schoolmaster Snapper (*Lutjanus apodus*) and that of other members of the genus Lutjanus collected from 1950 to 2014 in Haitian waters. To carry out this study, reconstructed catches data of these species were collected, processed and analyzed. Considerations were made based on the landed value per tonne, the asymptotic length and weight and their location in the water column in order to make comparisons amongst each species. *Lutjanus apodus* proved to be the least caught in Haitian fisheries. Their landed value per tonne was low compared to *L. campechanus* and *L. purpureus*, but higher than that of *L. griseus*. This difference in landed value per tonne between *L. apodus* and *L. griseus* is explained significantly in that, *L. apodus* appears to have a brighter

color than that of *L. griseus*, which gives them a higher market value. However, the length and weight of *L. apodus* are lower than those of other species belonging to the genus Lutjanus. This may have been a contributing factor to the low catch compared to other species. In addition, they are closer to the surface than other species, given their position in the water column, so they would be more likely to be captured by non-motorized traditional gear with low catch capacity. This work was done on speculative and hypothetical arguments. It would have been beneficial for this study to have access to more precise and adequate data to estimate trends in different population sizes of these species to provide additional explanations for differences in annual catch trend.

1 Introduction

This paper presents an analysis of the annual catch trend of species belonging to the genus Lutjanus in Haiti covering the period of 1950 to 2014. According to Ramdeen et al. (2012), the fishing sector is not prioritized by the Haitian government, as it is the case of several other Caribbean islands. The management of the fisheries sector in Haiti is difficult as a result of the use outmoded laws (e.g. Fisheries Act of 1959) which do not necessarily address the issues affecting the sector (Mateo & Haughton, 2003). Neither fisheries management authorities nor fishers comply with fisheries management rules (Ramdeen, et al., 2012). This has led to complications in the collection of accurate fisheries data, essentially catch data (Ramdeen, et al., 2012), which plays a key role in informing policy for developing fisheries management tools and strategies (Pauly, 1998). Additionally, financial resources and adequate institutional capacity are lacking for effective enforcement of the fisheries laws (Mateo & Haughton, 2003). With this challenge, work required to rebuild a catch database from the fisheries of Haiti and Navassa Island has been undertaken from the catch recovery method of Zeller (Zeller, et al., 2007; Pauly & Zeller, 2015). Data in the S*ea Around Us Project* gives a comprehensive picture of Haitian capture fisheries (Pauly & Zeller, 2015). The data

makes it possible to trace the annual catch of Lutjanus species, which forms the basis of this study.

Schoolmaster Snapper (*Lutjanus apodus*) was considered for this study (Figure 1). It was selected based on its association with a group of fishes with brightly colored pigmentation (colored fish) which have a high market value in Haiti (FAO, 2005). Additionally, preliminary observations of the collected data showed that the catch of *L. apodus* appears to be the lowest compared to other Lutjanus species. This informed the likelihood of possible extinction of this species and stimulated the interest of investigating the possible reasons for this observation.

Therefore, this study seeks to highlight and understand the substantial difference in trends observed between the catch of the Schoolmaster Snapper (*Lutjanus apodus*) and those of other members of the genus Lutjanus over the study period mentioned above.

2 Literature review

2.1 Schoolmaster Snapper fish

2.1.1 Description

Lutjanus apodus belongs to the Family Lutjanidae (Snappers), which belongs to the order Perciformes (Froese & Pauly, 2018). Its pectoral fins are long and can extend to the anus (Allen, 1985). According to Lindeman et al. (2016), they can measure up to 62 cm in length. It is a commercially valuable fish and forms part of the recreational fishery (Allen, 1985).

Figure 1. Schoolmaster Snapper (*Lutjanus apodus*) (SEO, 2015)

L. apodus are gonochoristic fish, which means that males are different from females. Spawning occurs in calm waters away from the reef of the coast areas (Roocker, 1995). A data sheet of the Schoolmaster Snapper (*Lutjanus apodus*) is presented in Table 1, from Allen (1985) and Froese & Pauly (2018).

Table 1. Data Sheet of the Schoolmaster Snapper (*Lutjanus apodus*) (Allen, 1985; Froese & Pauly, 2018)

Common name	Schoolmaster Snapper
Scientific name	*Lutjanus apodus* (Walbaum, 1792)
Class	Actinopterygii
Order	Perciforms perch-likes
Family	Lutjanidae (Snappers)
Genus	Lutjanus
Environment	Fresh, Brackish and Marine
Reproductive guild	Non guarders
Growth rate (K)	0.350 $year^{-1}$
Asymptotic Length (L_{inf})	36.6 cm TL
Age at Length zero (t_0)	-0.45 years estimated from L_{inf} and K.
Natural mortality (M):	0.77 $year^{-1}$ Estimated from L_{inf}, K and annual mean temp. = 28 °C
Life Span (t_{max}):	8.1 years Estimated from L_{inf}., K and to.
Age at first maturity (t_m):	2 years
Length at maturity (L_m):	21.2 cm TL
Maximum Length (L_{max})	79.1 cm TL
Asymptotic Weight (W_{inf})	878.7 g

2.1.2 Distribution

L. apodus is considered to be the most abundant of the snappers found in the coral reefs of Caribbean waters (Randall, et al., 1983). They are usually found in tropical and subtropical waters, especially around the coast (Martinez-Andrade, 2003).

Adult *L. apodus* are usually found in the shallow waters of coastal areas, which are partially warm and clear (Lieske & Myers, 1994). Juveniles can be found in brackish waters and also in deep sandy areas with or without seagrass, and also on muddy bottom areas of lagoons or mangroves. These fish usually inhabit the roots of mangroves (Figure 2).

Figure 2. Schoolmaster Snapper fish schooling in habitats of mangrove roots (Brandon Cole, n.d)

Additionally, the Snappers can occupy different positions in the water column depending on their size (Roocker, 1995). However, with a particular attachment to mangrove root habitats, they may be victims of anthropological activities, particularly coastal zone construction. Also, the impacts of climate change may negatively affect coral reefs which can have adverse consequences on the species (Lindeman, et al., 2016).

2.1.3 Feeding Habit

L. apodus are carnivorous, with their food consisting mainly of worms, fish, gastropods, crustaceans (shrimp, crab, decapods), and cephalopods (Allen, 1985). These fish are opportunistic predators as they target small organisms during the day and catch larger prey during the night (MacDonald, et al., 2009). Their diet varies depending on the stage of their life cycle. Juvenile forms feed on crustaceans, while adults feed mainly on other fish (Roocker, 1995). They normally travel in groups as an adaptation of defense or protection in the event of a possible predator attack (Dickinson & Koenig, 2017).

2.2 Life history variables of fish

Fish life history variables play an important role in population dynamics studies (Martinez-Andrade, 2003), which gives them a major role in the management of fisheries resources

and many other natural resources. These variables have a great influence on the development of species and are therefore essential for their long-term exploitation (Pauly, 1998).

Life history variables can in itself be a strategy consisting of a set of variables that are adapted to each other in response to particular ecological variations (Roff, 1992). Such a strategy does not apply to isolated individuals, but on populations where species interact. However, one of the key elements of a strategy is the variance between individual models (Stearns, 1976). This variance is the product of selection that acts on particular organisms. Indeed, environmental variables greatly influence life cycle strategies by directly influencing life history variables of populations. Relevant environmental variables may include prey availability, temperature, breeding sites, shelter, competitors and predators (Stearns, 1976).

These variables help to improve our understanding of natural selection and the expression of genetic variation in response to environmental factors (Livingston, 1988). It highlights the constraints between the reproductive and demographic variables such that there is an adaptation or development of an adaptation strategy to different environments. These constraints can be physiological, phylogenetic, ecological or demographic (Winemiller & Rose, 1992).

2.3 Spatial variation according to the feeding habits of Snappers

It can be inferred from the dietary habits of fish that the growth of the fish is closely related to the quantity and quality of the food they consume (Martinez-Andrade, 2003). One of the most common techniques for studying dietary habits in a species is the identification of the types of foods that are present in the digestive tract content with the volume or weight represented by each (Roocker, 1995). This technique makes it possible to understand the food choice of fish and has made it possible to develop the theory of the optimal search for food by a fish. This theory contributes to the comprehension of the choice between different food sources by a fish (Arthur & Pianka, 1996).

Optimal food search theory applies to fish because they are continuously growing throughout their life cycle. At each stage of the life cycle of the fish, it must adapt to a mode of feeding, from which a strategy of search of food is developed (Martinez-Andrade, 2003). Livingston (1988) and Gerking (1994) state that, *"the optimal foraging strategy does not consistently apply throughout the life cycle of a fish species, so adjustment is required during ontogeny"*. According to Livingston (1988), migratory coastal fish can undergo trophic changes throughout their life cycle depending on the appropriate food type for each stage, and also a sharing of food resources with other species in other habitats.

The Lutjanus species are often considered as opportunistic carnivores with a propensity for nocturnal feeding (Martinez-Andrade, 2003). In the analyses of the diet of some species of snappers belonging to the genus Lutjanus, it was found that they consumed fish followed by crustaceans, then gastropods, cephalopods and finally plankton (Martinez-Andrade, 2003). Typically, snappers feed from the surface to a depth of about 500 meters, yet some adult species cannot reach 100 meters to feed (Roocker, 1995). Parrish (1987) reports that it is difficult to determine exactly the dietary habits of the species at depth because there is a loss in the contents of the digestive tract due to regurgitation during the expansion of fishes that are transported to the surface.

2.4 Capture Fisheries in Haiti

2.4.1 Characteristics of fishing in Haiti

Fishing activity in Haiti is mainly artisanal with an open access system. The species targeted by fishers are generally demersal fish, which represents about 33% of landings (FAO, 2005).

Fishers in Haiti use three types of vessels: boats or canoes with keel from 3 to 6 meters; flat-bottomed boats from 3 to 5 m in length; and wooden canoes from 3 to 4 m in length, with an average of about 7000 fishing boats (JICA, 2011). Fishing in Haiti is also

categorized by various gears with simple passive fishing characteristics (JICA, 2011), such as Z-shaped traps, nets, beach seines and accessories. Other fishing gears such as monofilament nets, fixed gillnets and trawls as well purse seines with very fine mesh and length varying between 300 and 700 meters are also used. A boat of 6 to 8 meters long accommodates a crew of 6 to 8 fishers (JICA, 2011).

Moreover, in terms of capacity, fishing boats can be motorized or non-motorized. The non-motorized are wooden canoes and flat-bottomed canoes, propelled by paddles or oars. The motorized boats contain a motor of 15 to 25 horsepower and measure about 6 meters (JICA, 2011).

According to Mateo and Haughton (2003), the average catch of a fishing unit (fishers and artisanal fishing gear) fluctuates between 3 and 5 kg per trip and can operate from 125 to 150 hours per year. In terms of capture, ground fish are caught by gillnets or trammel net, and beach seines are used in the catch of Snappers and other species in the same area (JICA, 2011).

2.4.2 Fish classification

Fishery products are classified into three categories in Haiti, depending on their value in terms of production (mainly for export), packaging and destination (FAO, 2005). The first category products include lobster, shrimp, conch meat and octopus (FAO, 2005). The second category includes fish with brightly colored pigmentation

(e.g. Family Lutjanidae, Serranidae, and some pelagic species such as jacks, barracuda, etc. (FAO, 2005). These are the fish of medium to large size, for some big markets of large urban centers. The last category includes small pelagic fishes, which are second-choice fish for local markets, whether fresh or processed or shipped to urban markets after salting or drying (FAO, 2005).

2.4.3 Fish market

The export market is the primary market because it attracts revenue for high value products such as lobster and shrimp, and a little less conch meat (*Strombus gigas*) and octopus (FAO, 2005). These products can be found in the menu of some of the more elite restaurants of the capital and provincial cities. The second market mainly concerns first class of fish with brightly colored pigmentation such as Lutjanidae, Serranidae, etc. and some pelagic species such as lemon trees, barracudas, etc. (FAO, 2005).

3 Thesis statement

The annual catch trend of *Lutjanus apodus* in Haiti compared to other species of the same genus (Lutjanus) is low. This may result from the fact that *Lutjanus apodus* has a low landed value, length and body weight lower than other species of the same genus.

4 Methodology

This study applied statistical data analysis to the annual catch, the landed value, the length, the body weight and the positions occupied in the water column level of different species belonging to the Lutjanus genus in Haiti. We collected data to examine:

a) The annual catch trend of Lutjanus species in Haiti from 1950 to 2014;
b) The landed value per tonne per Lutjanus species caught in Haitian waters;
c) The body length and weight of Lutjanus species that may affect the determination of their landed value; and
d) The positions occupied in the water column level of different species belonging to the Lutjanus genus in Haiti.

These were important to understand the trend in catches observed for *L. apodus* and those of the other Lutjanus species taken from 1950 to 2014.

4.1 Annual catch data of Lutjanus species in Haitian territorial waters

To analyze the trend in the capture of Lutjanus species in Haiti we used reconstructed annual catch data from Ramdeen et al. (2012). Information available on government websites and publications, in particular, their fisheries department or corresponding agencies, both online and in printing documents, are

the primary source of information for rebuilding catches (Pauly & Zeller, 2015). To reconstruct data on capture fisheries in Haiti, Ramdeen et al. (2012) proceeded to the following steps:

a) human population and the population of fishermen were estimated

The human population was estimated from the Haitian population statistics extracted from *Populstat* (Lahmeyer, 2006) *www.populstat.info* for 1950 and from the World Bank from 1960 to 2010. Linear interpolation was used to derive the missing values in the data. These processed data were used in the calculation of total seafood demand from 1950 to 2010 to estimate subsistence catches as well as the proportion of fishers in the total population.

Data on the number of fishers in Haiti were available for six different years between 1942 and 2006, from different sources (Ramdeen, et al., 2012). Direct linear interpolation from available data as an anchor to estimate data for all years from 1942-2006 was used. From the last anchor point (2006), Ramdeen, et al. determined the proportion of fishers in the population and used this fixed figure to estimate the number of fishers from 2007 to 2010.

b) Haiti's artisanal and subsistence catches were estimated

The total artisanal fishery catch in Haiti was estimated from the data described in point a) by dividing the catches reported by FAO (based on information reported by the Ministry of Agriculture of Natural Resources and Rural Development MARNDR / Haiti) by the number of fishers reported for the corresponding year. Ramdeen

et al. (2012) calculated the catch per unit effort (CPUE) of artisanal fishers and four CPUE values (for 1942, 1957, 1976 and 2006) were estimated and then linearly interpolated to derive CPUE for 1950 through 2010. The reconstructed estimate of total artisanal fisheries catches in Haiti from 1950 to 2010 was obtained by multiplying the CPUE by the number of fishermen estimated each year (Ramdeen, et al., 2012).

According to Moal (1977) and FAO (1981), Haitian fisheries are mainly based on subsistence catches, but data on subsistence fisheries in Haiti were not readily available (Ramdeen, et al., 2012). Subsistence catches in Haiti were estimated from a national nutritional study conducted by Sebrell et al. (1959), who cited an average fish consumption of 2.92 kg per person per year^{-1}. Ramdeen et al. (2012), estimated the total demand for seafood by multiplying the annual population by 2.92 kg per person^{-1} per year^{-1}. This calculation gives a total demand for seafood from which import and aquaculture data were subtracted to obtain the national marine catch demand (Ramdeen, et al., 2012). Since the import data varies and is unreliable, the marine capture demand was calculated as a guide only, which made it possible to derive an assumed average per capita seafood subsistence rate of about 1 kg·person·year (Ramdeen, et al., 2012). It was then assumed that subsistence capture rates were 25% higher in the 1950s and 25% lower in the 2010s. Ramdeen et al. (2012) applied a seafood subsistence rate of 1.25 kg per person per year in 1950 and 0.75 kg

per person per year in 2010, interpolated linearly between these two rates of per capita national subsistence, and then multiplied by the annual population size to arrive at the estimate of subsistence catches from 1950 to 2010 for Haiti.

c) The composition of the capture fisheries of Haiti and Navassa Island was estimated

Detailed quantitative data on the catches of Haiti and Navassa by species were not readily available. Therefore, Ramdeen et al. (2012) used the FAO breakdown for years with the most taxonomic categories as a starting point. The proportion of total catches by group from 1995 to 2010, given that 1995 was the first year that all groups had a non-zero value was calculated, and then these proportions applied throughout the period 1950 to 1995 to the total reconstructed catch.

To further disaggregate the catch into different taxa, Ramdeen et al. (2012) used quantitative and qualitative catch data from Zacks (1998). He analyzed three captures of ten different fishers using several traditional gears (bamboo traps, gillnets, hooks and lines, and crossbows) from June to August 1995 in Luly, Haiti (Zacks, 1998).

For Navassa Island, Miller et al. (2008) estimated three scenarios for annual landings of fish, lobster and queen conch. These estimates were based on extrapolations of landings observed in 2004 and 2005 on the number of cruises made each year in Navassa. By the fact that fish caught in Navassa and landed in Haiti

is already treated (head and viscera are removed), Miller et al. (2008) applied the FAO conversion factors (2.0 and 2.5) to estimate fresh whole catches landed each year in different fishing scenarios of 150, 99 and 45 trips. They had taken the minimum total landed catch and assumed a zero discharge rate that gave a conservative average estimate of 31 tonne / year^{-1} (Miller, et al., 2008), and that Ramdeen et al. (2012) applied each year, from 1970, to reconstruct the minimum catches of fish from the island of Navassa.

To detail the catches of Navassa Island, Ramdeen et al. (2012) used the count of species caught in fishing boats observed on Navassa Island from October to November 2002 by Miller et al. (2008). These were converted to weight using the common weight of the species in *FishBase* (www.fishbase.org, accessed January 2012) and a trap fishery survey at Pedro Bank (Hartsuijker, 1982; Ramdeen, et al., 2012).

The full breakdown of species by artisanal sector and subsistence sector is presented in the Appendix Table A 6 and Appendix Table A 7. Annual catch data, once collected, were subjected to statistical analysis to assess the difference in catch between *L. apodus* and other Lutjanus species using a Student's t-test.

4.2 Comparison of the landed value per tonne per Lutjanus species caught

In order to understand the economic behavior of fishers taking part in fishing activities around the world, Sumaila et al. (2007) created a global ex-vessel fish price database based mainly on secondary data from governmental agencies, web sites, and published literature (e.g., the FAO, the OECD Bureau of Statistics, the European Commission, South East Asia Fisheries Development Center (SEAFDEC), FAO-Globefish, and several national fisheries and statistical agencies) (Sumaila, et al., 2015). A database of raw price data was compiled, and an interpolation method was applied to estimate missing values to ensure that all catch records from the *Sea around Us project* global catch database (Watson, et al., 2004) regardless of taxon, country and year were assigned prices (Sumaila, et al., 2007).

These price data are then used by Pauly and Zeller to estimate landed value by species (Pauly & Zeller, 2015). Landed values are presented in US dollars to provide a uniform basis of comparison. Real prices were determined using local consumer price indices (CPI) obtained from the World Bank to convert nominal local prices into real prices (in USD) for the year 2010 (Sumaila, et al., 2015).

In order to compare prices between different species of the Lutjanus genus caught in the Haitian waters, the annual value of landings (in USD) was divided by the annual catch (in tonne) of

each species. This was then subjected to statistical analysis to assess the difference between *L. apodus* and other Lutjanus species using a Student's t-test.

4.3 Comparison of body length and weight of Lutjanus species that may affect the determination of their landed value

The difference in the life cycle parameters can influence the economic importance of individual species and have an obvious impact on the dynamics of fish populations (Martinez-Andrade, 2003).

Size or weight of fish is often considered as a key factor in the determination of its price in commercial fisheries (Fabian & Mikko, 2013). According to Asche and Guillen (2012), larger fish are more expensive, which allows them to identify size as a major determinant of fish prices. The pricing based on the size of the fish can be influenced by the effect of the supply by considering that within each species, the bigger fish tend to be rare, which makes them potentially more desirable and therefore more expensive (Fabian & Mikko, 2013). Also, Walters and Hilborn (1992) argue that fish-size pricing has a great influence on the optimization of capture fisheries. Therefore, this led to consider body length and weight of the Lutjanus species in order to compare them with each other.

A search for information concerning the life history variables of Lutjanus species has been done in the *FishBase data set* of (Froese & Pauly, 2018).

The life history variables that have been considered are: Asymptotic Length (cm) TL and the Asymptotic weight (g). They are components of the Von Bertalanffy growth equation (VBGE):

- $L_t = L_{inf}(1\text{-}exp[-k(t\text{-}t_0)])$ and
- $W_t = W_{inf}(1\text{-}exp[-k(t\text{-}t_0)])^3$.

With L_t: length at age t, L_{inf}: asymptotic length, K: growth rate per year and t_0: hypothetical age at zero length, W_t: Weight at age t, W_{inf}: Asymptotic weight.

- Asymptotic length (L_{inf}): It is the length in centimeters that a fish of a given population can reach if it grows indefinitely (Fishbase Glossary, 1995).
- Asymptotic weight (W_{inf}): It is the average weight that the fish of a given stock would reach if they were to grow for an infinitely long time (Fishbase Glossary, 1995). $W_{inf} = aL_{inf}^b$. Values for "a" and "b" for each particular species can be obtained from (Froese & Pauly, 2018)

These life cycle variables have been taken into account as they are likely to influence the landed value of fish.

4.4 Spatial variation according to the feeding habit of the Lutjanus species

The spatial variation of fish is related to their dietary habits as they grow. Emphasis was placed on the spatial variation (space occupied in the water column) of each species in order to estimate as far as possible how the catch of the different species of Lutjanus is affected by the different types of fishing gear used in Haiti. A search in the literature on the different positions occupied by each species in the water column level was made to compare them with respect to *L. apodus*. This comparison has been useful to the extent that we can speculate on the catchability of certain species depending on the type of fishing gear used. In Haiti they are of two types (motorized and non-motorized) (JICA, 2011).

5 Results and discussion

5.1 Results

5.1.1 Annual catch data of Lutjanus species in Haitian's water

Annual catch data for four species belonging to the genus Lutjanus were analyzed. The species used in the analysis included *Lutjanus apodus* (Schoolmaster Snapper), *Lutjanus campechanus* (Northern Red Snapper), *Lutjanus griseus* (Gray Snapper) and *Lutjanus purpureus* (Southern Red Snapper). All of these species belong to the "Associated reef mean fish (30 - 89 cm)" function group and the "Perch-like" trade group of Pauly and Zeller (2015). The annual trend of *L. apodus* catches was compared to the average annual catch trend of other species belonging to the genus Lutjanus (Figure 3).

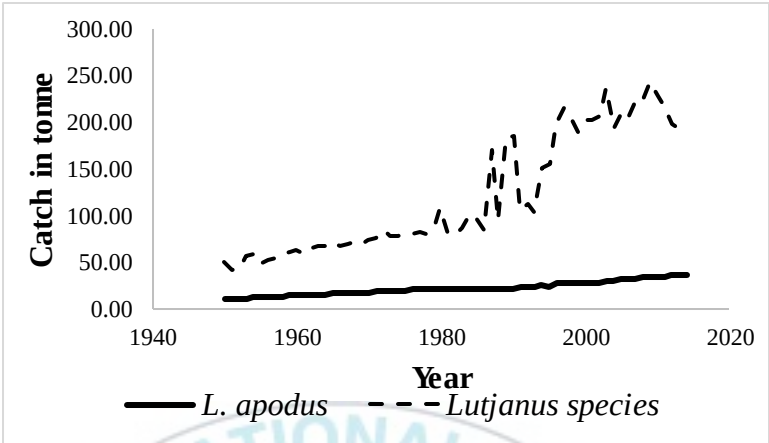

Figure 3. Annual catch trend in tonne of *L. apodus* against the mean annual catch trend of the other species belonging to the Lutjanus genus in Haiti

The value calculated for the correlation coefficient between the two annual trend catches was 0.916 depicting a positive strong relationship between them. In Figure 3, the trend in the annual catch of both cases (*L. apodus* and Lutjanus species) was similar showing for each a growth, but the slope of each trend were different. Figure 4 shows the trend in annual catch for each species belonging to the genus Lutjanus.

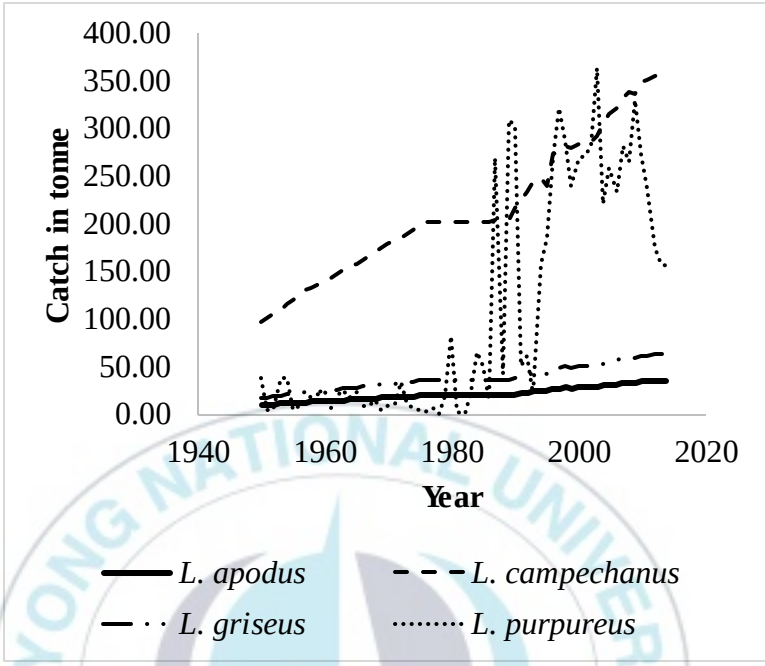

Figure 4. Annual catch in tonne of different species of the Lutjanus genus in the water of Haiti

Statistical differences in annual catch between species are presented in Table 2. The mean annual catch of *L. apodus* is statistically significantly different from other species and is the lowest compared to the other species.

Table 2. Statistical comparison of the annual catch data for *L. apodus* and the other species for 1950-2014 (sample size = 65). S.E. = Standard Error.

Species	Average	S.E.	P value (t-test)
L. apodus	21.1	± 0.9	8.9×10^{-32}

L. campechanus	215.5	± 8.9	
L. apodus	21.1	± 0.9	1.2×10^{-15}
L. griseus	38.0	± 1.6	
L. apodus	21.1	± 0.9	1.1×10^{-7}
L. purpureus	107.3	± 14.8	

The annual catch of *L. apodus* is lower than that of other species of the genus Lutjanus. This could be explained by:

i. fishers being less interested to capture *L. apodus*; and/or
ii. a difference in the life cycle variables for each species.

This brings us to the following sections which will deal with the considerations mentioned above.

5.1.2 Comparison of the landed value per tonne per Lutjanus species caught in Haitian water

The result of the calculations is presented in Figure 5. The statistical analyses are presented in Table 3.

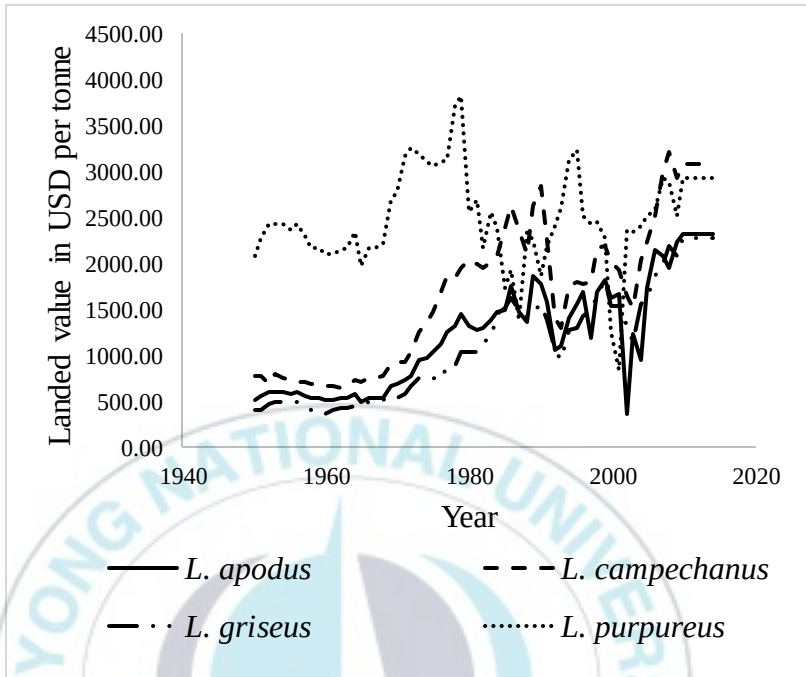

Figure 5. Landed value per tonne per Lutjanus species caught in Haitian waters from 1950 to 2014

Table 3. Statistical analysis of the different in landed value per tonne between other Lutjanus species and *L. apodus*, calculated using data shown in Figure 5. S.D. = Standard Deviation, S.E. = Standard Error, Sample size = 65 and, there is a significant difference for a P value < 0.05.

Species	Mean	S.D.	S.E.	t statistic	P value
L. campechanus	462.1	307.9	38.2	12.1	$3.4x10^{-18}$
L. griseus	-99.5	207.3	25.7	3.9	$0.3x10^{-3}$
L. purpureus	1279.8	727.5	90.2	14.2	$1.9x10^{-21}$

5.1.3 Length and body weight of Lutjanus species that may affect the determination of their landed value

The life cycle variables that were considered are those for the four species belonging to the genus Lutjanus whose annual catch data are available in the *Sea Around Us Project* for Haiti (Pauly & Zeller, 2015; Froese & Pauly, 2018). Figures 4 and 5 show respectively the body length and the body weight of the different species taken into consideration in the study. Compared to other species of the Genus Lutjanus; *Lutjanus apodus* has the lowest values for asymptotic length and body weight.

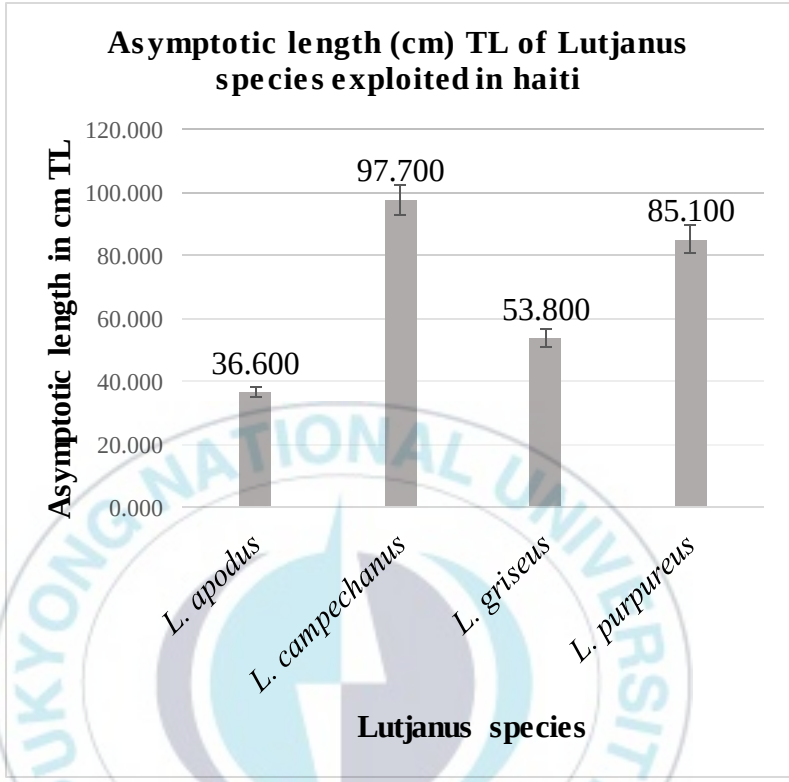

Figure 6. Comparison of the body length within Lutjanus species in Haiti

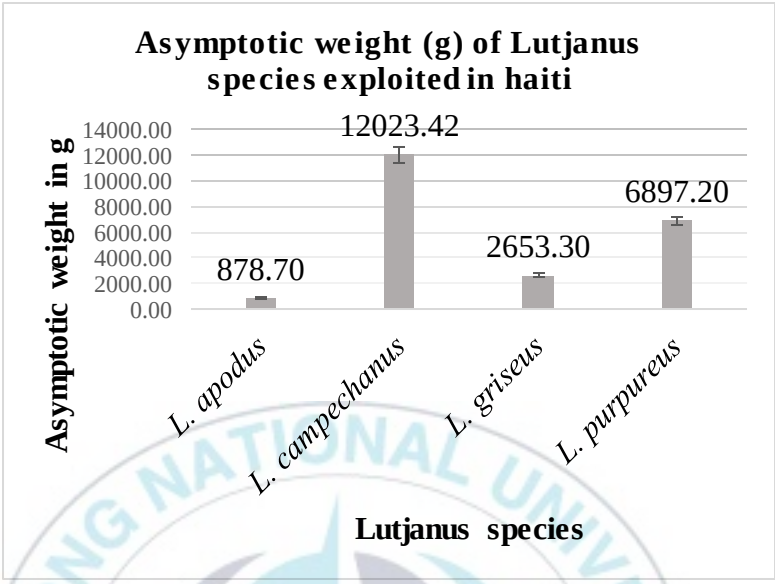

Figure 7. Comparison of the body weight within Lutjanus species in Haiti

5.1.4 Spatial variation according to the feeding habit of the Lutjanus species

The spatial distribution of *Lutjanus apodus* and the other Lutjanus species is presented in Table 4. This table presents for each species: the average asymptotic length, the minimum depth, and the maximum depth reached according to which individuals species move for their prey.

Table 4. Spatial distribution in the water column of *L. apodus* and the other species. With L_{inf} = Asymptotic Length; Min D = Minimum Depth, Max D = Maximum Depth

Scientific Name	L_{inf}	Min D	Max D
Lutjanus apodus	36.6	2	63
Lutjanus campechanus	97.7	10	90
Lutjanus griseus	53.8	5	180
Lutjanus purpureus	85.1	70	120

5.2 Discussion

Based on the annual catch reported in section 5.1.1 *Lutjanus apodus* has the lowest annual catch compared with other Lutjanus species exploited in Haiti. This deduction is made on the basis of data available from studies by Zacks (1998) and Miller et al. (2008). The Zacks (1998) study examined three separate catches of ten fishers from June to August 1995 in Luly, Haiti, while that of Miller et al. (2008) used the number of species caught aboard fishing vessels observed on Navassa Island from October to November 2002. These studies were conducted in specific locations, over a limited period of time and from limited observations (Zacks, 1998; Miller, et al., 2008) that may not reflect the reality of the whole country between 1950 and 2014. This was an obstacle, and it would have been preferable if more data had been collected for the annual catch of these species for a more accurate and specific outcome.

With regard to the result obtained for the landed value per tonne per species in section 5.1.2, the targeting of the species seems to have shifted towards those which generate the most income for the fishers. It was found that for *L. campechanus* and *L. purpureus*, landed values are larger, ranked in order of importance of capture than those of *L. apodus* and *L. griseus*. However, even if the catch of our target species *L. apodus* is lower than that of *L. griseus*, the landed value per tonne for *L. apodus* is greater than that for *L. griseus*. Such a difference between the price per ton of each of them could be explained by the fact that *L. apodus* seems to be more

colorful than that of *L. griseus* and that Haitians are very interested in fish with very colorful pigmentation.

When considering asymptotic length, *L. apodus* has the lowest values as well as value for asymptotic weight. This shows that *L. apodus* is not the most targeted species in capture fisheries in Haiti when weight and length variables of other Lutjanus species are taken into account. This explains why the annual catch trend of *L. apodus* is the smallest among the other species. In the same approach, the difference in size of species may have an influence on the selectivity of the fishing gears. All indications are that it is difficult to access data on gear specifications in Haiti.

In addition, given the differences in the position of species at the water column level, the difference in annual catch trend could be related to the type of fishing gear used. According to the JICA report (2011), the capacity of motorized fishing gears is greater than that of non-motorized. Knowing that the smaller species (*L. apodus* and *L. griseus*) are closer to the surface (Table 4), they are likely to be captured by non-motorized fishing gear, which could give them a lower catch in terms of mass, especially since *L. apodus* is smaller in size, that explains its low catch in relation to *L. griseus* and the other species.

Larger species tend to be deeper or farther away from the coast and are likely to be captured by motorized gear, those with greater capacity (JICA, 2011). This explains the reason why the

catch of these species appears to be greatest compared to other species (*L. apodus, L. griseus*).

Still, it should be noted that studies leading to the disaggregation of catch data for species caught in Haiti have been limited in terms of space and time (Zacks, 1998; Miller, et al., 2008) which makes it difficult to conclude with more certainty the deductions made in this study.

6 Conclusion and recommendations

Based on the findings of this study, a substantial dissimilarity in the slope of the different trends has been observed. The annual catch trend for *L. apodus* is the weakest compared to other species of the genus Lutjanus. A possible explanation for this is that *L. apodus* is not the most targeted species in fishing activities in Haiti. This may be partly because of the landed value per tonne per species. Landed value per tonne for *L. campechanus* and *L. purpureus* are larger, ranked in order of importance of capture but those of *L. apodus* and *L. griseus* are quite different. Even if the catch of *L. apodus* is lower than that of *L. griseus*, the landed value per tonne for *L. apodus* is greater than the landed value per tonne for *L. griseus*. This difference between them may be explained by the fact that *L. apodus* seems to be more colorful than that of *L. griseus* and that Haitians are very interested in fish with brightly colorful pigmentation. In addition, the length and weight of the body of *L. apodus* are the lowest compared to other Lutjanus species exploited in Haiti. Variation in size between species may play a role in the difference in the annual catch trend between species while being based on the selectivity of fishing gear.

Given differences in the position of species at the water column level, the trend difference in annual catches may be related to the type of fishing gear used. Knowing that the smaller species (*L. apodus* and *L. griseus)* are closer to the surface (Table 4), they

would probably be captured by non-motorized fishing gear, which gives them a lower catch in terms of mass, especially since *L. apodus* is smaller, which explains its low catch compared to *L. griseus* and the other Lutjanus species.

Larger species tend to be deeper (Table 4) or further away from the coast and are likely to be captured by motorized gear, those with greater capacity (JICA, 2011). This may explain why catches of these species seem to be larger than those of other species (*L. apodus*, and *L. griseus*).

This work has been carried out on speculative and hypothetical arguments, since estimates of the annual population size of Schoolteacher Snapper (*Lutjanus apodus*) and other species of the genus Lutjanus exploited in Haiti have not been established. It would have been beneficial for this study to have access to data to estimate population size trends for these species to provide additional explanations for the difference in the trend of their annual catches.

In order to have more meaningful and accurate fisheries data to work with, it would be advisable for the Haitian competent authority in charge of fisheries to assist in the provision of real time and up to date data for conducting fisheries assessments and analyses in the future.

A revised enforceable regulatory framework in the fisheries sector should be put in place to sustainably manage and regulate fishing activities.

It is recommended to conduct further study to compare *L. apodus* with other species. Finally, additional studies are recommended to determine the full extent and socio-economic importance of the fishery in Haiti, as well as the status of the target species in the capture fishery.

7 Acknowledgements

I thank first and foremost God who gave me the aptitude required to carry out this study in Master of Fisheries Science. I thank the Korean government for offering me the opportunity of this scholarship through the World Fisheries University (WFU) of Pukyong National University (PKNU). I thank all the staff of World Fisheries University, the professors who tutored me during this Master Programme (Christopher L. Brown, Aminur Rahman and A. Dale Marsden). Many thanks and appreciation goes to the evaluation committee of my thesis (A. Dale Marsden, Jin-Koo Kim and Saang-Yoon Hyun) which helped me to present an acceptable thesis work. My gratitude goes to my family and friends who have helped me from near or far to accomplish this task.

8 References

Allen, G., 1985. FAO Species Catalogue. Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date. *FAO Fish. Synop.,* 6(125), p. 208.

Arthur, R. & Pianka, E., 1996. On optimal use of a patchy environment. *The American Naturalist,* 100(916), pp. 603-609.

Asche, F. & Guillen, J., 2012. The importance of fishing method, gear and origin: The Spanish hake market. *Marine Policy,* Volume 36, p. 365 –369.

Brandon Cole, n.d. *Marine Photography by Brandon Cole.* [Online] Available at: https://sharkswhalesdolphins.photoshelter.com/image?&_bqG=8&_bqH=eJzzDjUJzPL1t4x0cszTdSkzKfUNN0ksSfIN1PW1MjKwMjWwMjQAAivPeJdgZ9vg5Iz8_JzcxOKS1CLt4LzEgoLUIjWwVLyjn4ttCZAdGuwaFO_pYhsK0pbu6xroFpjmbOjuqxbv6BxiW5yaWJScAQAvKSPy&GI_ID= [Accessed 10 11 2018].

Dickinson, J. & Koenig, W., 2017. *Animal social behaviour.* [Online] Available at: https://www.britannica.com/topic/animal-social-behaviour/The-how-and-why-of-social-behaviour [Accessed 10 11 2018].

Fabian, Z. & Mikko, H., 2013. Is size-dependent pricing prevalent in fisheries? The case of Norwegian demersal and pelagic fisheries. *ICES Journal of Marine Science,* 70(7), p. 1389–1395.

FAO, 1981. *Aquaculture development and coordination programme. Aquaculture development in the Caribbean. Report of a mission to Antigua, Haiti, Jamaica, Montserrat and St. Lucia, June-July 1980,* Rome. 95 p.: FAO.

FAO, 2005. *Food and Agriculture Organization of the United Nations.* [Online] Available at: http://www.fao.org/fi/oldsite/FCP/fr/hti/profile.htm [Accessed 15 9 2018].

Fishbase Glossary, 1995. *Fishebase Glossary.* [Online] Available at: https://www.fishbase.de/glossary/Glossary.php?q=age+at+first+maturity [Accessed 05 11 2018].

Froese, R. & Pauly, D., 2018. *FishBase. World Wide Web electronic publication..* [Online] Available at: www.fishbase.org [Accessed 07 11 2018].

Gerking, S., 1994. *Feeding ecology of fish,* USA: Academic Press.

Hartsuijker, L., 1982. *Trap fishing survey of Pedro Bank (Jamaica),* Jamaica: Fisheries Division, Ministry of Agriculture.

Hilborn, R. & Walters, C., 1992. *Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty.* New York: Chapman and Hall.

JICA, 2011. *Final country repport: Haiti,* s.l.: s.n.

Lahmeyer, J., 2006. *POPULATION STATISTICS (Populstat): historical demography of all countries, their divisions and towns.* [Online] Available at: http://www.populstat.info/

Lieske, E. & Myers, R., 1994. *Collins Pocket Guide. Coral reef fishes. Indo-Pacific & Caribbean including the Red Sea,* s.l.: Haper Collins Publishers.

Lindeman, K. et al., 2016. *utjanus apodus. The IUCN Red List of Threatened Species.* [Online] Available at: https://www.iucnredlist.org/species/155152/726254 [Accessed 9 11 2018].

Livingston, R., 1988. Inadequacy of species-level designations for ecological studies of coastal migratory fishes. *Environmental biology of fishes,* 22(3), pp. 225-234.

MacDonald, J., Shahrestani, S. & Weis, J., 2009. Behavior and space utilization of two common fishes within Caribbean mangroves: implications for the protective function of mangrove habitats. *Estuarine, Coastal And Shelf Science,* Volume 84, pp. 195-201.

Martinez-Andrade, F., 2003. *A comparison of life histories and ecological aspects among snappers. (Pisces: Lutjanidae)".* Louisiana: LSU Doctoral Dissertations. 2271..

Mateo, J. & Haughton, M., 2003. *A Review of the Fisheries Sector of Haiti with Recommendations for its Strengthening,* Belize: CARICOM Fisheries Unit, Princess Margaret Drive, P.O. Box 642.

Miller, M. W., Wiener, J. W., McClellan, D. B. & Stoffle, B., 2008. *Preliminary effort and yield estimates from the Haitian Fishery at Navassa Island,* Punta Cana: 60th Gulf and Caribbean Fisheries Institute Proceedings.

Moal, R. A., 1977. Developpement des peches traditionnelles en Haiti. *SCET International,* p. 121.

Parrish, J., 1987. *The trophic biology of snappers and groupers. p. 405-463. In: J. J. Polovina and S. Ralston (eds.) Tropical snappers and groupers,* Boulder: Westview Press.

Pauly, D., 1998. Rationale for reconstructing catch time series. *EC Fisheries Corporation Bulletin,* 11(2), pp. 4-7.

Pauly, D. & Zeller, D., 2015. *Sea Around Us project. Catch reconstructions: concepts, methods and data sources. Online publication (www.seaaroundus.org).* Vancouver: University of British Columbia..

Ramdeen, R. et al., 2012. Reconstruction of total marine fisheries catches for Haiti and Navassa Island (1950–2010). *Sea Around Us Project, Fisheries Centre, University of British Columbia,* pp. 37-46.

Randall, D., Hoar, W. & Donaldson, E., 1983. *Fish physiology.* s.l.:Academic Press.

Roff, D. A., 1992. The evolution of life histories; theory and analysis. *Chapman & Hall,Great Britain,* p. 535.

Roocker, J. R., 1995. Feeding ecology of the Schoolmaster Snapper, Lutjanus apodus (walbaum), from Southwestern Puerto Rico. *Bulletin of Marine Science,* 56(3), pp. 881-894.

Sebrell, W. H. et al., 1959. Appraisal of Nutrition in Haiti. *The American Journal of Clinical Nutrition,* Volume 7, pp. 538-534.

SEO, 2015. *Image Gallery: schoolmaster snapper.* [Online] Available at: http://keywordsuggest.org/gallery/736969.html [Accessed 12 11 2018].

Stearns, S. C., 1976. Life- history tactics: a review of the ideas. *The Quarterly Review of Biology,* Volume 51, pp. 3-47.

Sumaila, R., Teh, L., Zeller, D. & Pauly, D., 2015. The global ex-vessel fish price database. *In. D. Pauly and D. Zeller (eds). Catch reconstructions: concepts, methods and data sources. Online Publication. Sea Around Us (www.seaaroundus.org). University of British Columbia.*.

Sumaila, U. R., Marsden, A. D., Watson, R. & Pauly, D., 2007. A global ex-vessel fish price database: construction and applications. *Journal of Bioeconomics,* 9(1), pp. 39-51..

Watson, R., Adrian, K., Ahmed, G. & Daniel, P., 2004. Mapping global fisheries:sharpening our focus. *Fish and Fisheries,* Volume 5, p. 168–177.

Winemiller, K. & Rose, K., 1992. Patterns of life- history diversification in North. *Can. J. Fish. Aquat.*, 49(10), pp. 2196-2218.

Zacks, M., 1998. *No one owns the sea because it belongs to us all: a socioeconomic and biological study of the fishery of Luly, Haiti. Masters of Arts thesis.* Arcahaie: University of University of Florida. 197 p..

Zeller, D., Shawn, B., Gerald, D. & Daniel, P., 2007. Re-estimation of small-scale fishery catches for US flag-associated island areas in the western Pacific: the last 50 years. *Fishery Bulletin*, 105(2), pp. 266-277.

Year	C (t)	L.V. (USD)	L.V./C (USD/t)
1950	9.45	4838.34	512.00
1951	9.88	5573.81	564.00
1952	10.33	6185.56	599.00
1953	10.78	6479.61	601.00
1954	11.25	6759.65	601.00
1955	11.72	6811.86	581.00
1956	12.21	7339.70	601.00
1957	12.71	7194.79	566.00
1958	13.05	6957.44	533.00
1959	13.40	7127.49	532.00
1960	13.74	7133.23	519.00
1961	14.09	7300.56	518.00
1962	14.45	7629.21	528.00
1963	14.81	7953.23	537.00
1964	15.18	8726.87	575.00
1965	15.55	7603.32	489.00
1966	15.93	8472.34	532.00
1967	16.31	8740.69	536.00
1968	16.69	9080.69	544.00
1969	17.08	11288.88	661.00
1970	17.46	11945.54	684.00
1971	17.85	13190.75	739.00
1972	18.24	14223.31	780.00
1973	18.62	17692.95	950.00
1974	19.02	18468.78	971.00
1975	19.43	19970.49	1028.00
1976	19.84	22224.13	1120.00

1977	19.83	25039.25	1263.00
1978	19.81	26128.30	1319.00
1979	19.80	28783.81	1454.00
1980	19.79	26257.44	1327.00
1981	19.78	25380.46	1283.00
1982	19.78	25872.35	1308.00
1983	19.78	27431.49	1387.00
1984	19.77	29002.32	1467.00
1985	19.75	29452.52	1491.00
1986	19.86	34853.62	1755.00
1987	19.95	29565.66	1482.00
1988	20.02	27193.50	1358.00
1989	20.09	37479.28	1866.00
1990	21.15	37471.56	1772.00
1991	22.10	34924.81	1580.00
1992	22.96	24545.58	1069.00
1993	23.87	26118.92	1094.00
1994	24.26	34184.06	1409.00
1995	23.44	36468.05	1556.00
1996	26.89	45664.99	1698.00
1997	27.02	32103.85	1188.00
1998	27.55	46399.17	1684.00
1999	27.68	50399.65	1821.00
2000	27.35	44662.65	1633.00
2001	27.88	46696.74	1675.00

2002	27.89	9818.09	352.00
2003	27.94	34724.66	1243.00
2004	28.58	27124.16	949.00
2005	29.82	51856.21	1739.00
2006	30.83	66509.67	2157.00
2007	31.62	65743.37	2079.00
2008	32.47	63243.32	1948.00
2009	33.22	73991.67	2227.00
2010	32.97	76854.69	2331.00
2011	34.28	79913.50	2331.00
2012	34.51	80444.77	2331.00
2013	34.75	80992.25	2331.00
2014	34.98	81535.67	2331.00

9 Appendices

9.1 Annual catch data of exploited Lutjanus species in Haiti from 1950 to 2014 (Pauly & Zeller, 2015)

9.1.1 Schoolmaster snapper (Lutjanus apodus)

Appendix Table A 1. Annual catch data of exploited *Lutjanus apodus* species in Haiti from 1950 to 2014. With: C = Catch in tonne; L.V. = Landed Value in USD (Pauly & Zeller, 2015)

*9.1.2 Northern Red Snapper (*Lutjanus campechanus*)*

Appendix Table A 2. Annual catch data of exploited *Lutjanus campechanus* species in Haiti from 1950 to 2014 With: C = Catch in tonne; L.V. = Landed Value in USD (Pauly & Zeller, 2015)

Year	C (t)	L.V. (USD)	L.V./C (USD/t)
1950	96.39	74122.97	769.00
1951	100.80	77315.89	767.00
1952	105.33	72467.10	688.00
1953	109.97	88415.92	804.00
1954	114.72	85353.83	744.00
1955	119.59	88017.22	736.00
1956	124.57	87944.46	706.00
1957	129.66	92965.29	717.00
1958	133.14	92268.93	693.00
1959	136.65	93745.24	686.00
1960	140.19	93927.78	670.00
1961	143.76	95166.61	662.00
1962	147.38	94766.91	643.00
1963	151.07	101970.14	675.00
1964	154.81	112389.90	726.00
1965	158.60	114189.80	720.00
1966	162.44	123941.36	763.00
1967	166.33	125748.59	756.00

1968	170.26	131613.29	773.00
1969	174.20	156606.27	899.00
1970	178.14	163528.19	918.00
1971	182.06	170594.43	937.00
1972	186.00	194738.97	1047.00
1973	189.97	238407.78	1255.00
1974	194.01	262492.48	1353.00
1975	198.15	293064.98	1479.00
1976	202.40	340838.78	1684.00
1977	202.22	377539.54	1867.00
1978	202.05	373192.89	1847.00
1979	201.92	395969.39	1961.00
1980	201.83	411325.68	2038.00
1981	201.78	400528.57	1985.00
1982	201.76	392417.08	1945.00
1983	201.73	405076.25	2008.00
1984	201.65	419839.73	2082.00
1985	201.49	481551.73	2390.00
1986	202.57	529917.94	2616.00
1987	203.49	483081.38	2374.00
1988	204.25	430766.64	2109.00
1989	204.87	535941.72	2616.00
1990	215.69	614296.75	2848.00
1991	225.46	508872.23	2257.00
1992	234.20	329994.57	1409.00

1993	243.52	314630.32	1292.00
1994	247.46	432815.32	1749.00
1995	239.06	428869.89	1794.00
1996	274.31	487453.58	1777.00
1997	275.64	494220.86	1793.00
1998	281.04	608451.78	2165.00
1999	282.30	615423.74	2180.00
2000	278.97	561288.85	2012.00
2001	284.36	546544.26	1922.00
2002	284.50	468289.20	1646.00
2003	284.95	429702.99	1508.00
2004	291.53	595605.45	2043.00
2005	304.16	676450.75	2224.00
2006	314.51	790049.74	2512.00
2007	322.55	964425.78	2990.00
2008	331.15	1062000.75	3207.00
2009	338.89	992279.17	2928.00
2010	336.30	1033116.94	3072.00
2011	349.69	1074234.88	3072.00
2012	352.01	1081376.42	3072.00
2013	354.41	1088735.93	3072.00
2014	356.78	1096040.89	3072.00

*9.1.3 Grey Snapper (*Lutjanus griseus*)*

Appendix Table A 3. Annual catch data of exploited *Lutjanus griseus* species in Haiti from 1950 to 2014 With: C = Catch in tonne; L.V. = Landed Value in USD (Pauly & Zeller, 2015)

Year	C (t)	L.V. (USD)	L.V./C (USD/t)
1950	17.01	6922.98	407.00
1951	17.79	7364.55	414.00
1952	18.59	8606.09	463.00
1953	19.41	9392.74	484.00
1954	20.25	9839.18	486.00
1955	21.10	10298.69	488.00
1956	21.98	10771.40	490.00
1957	22.88	10204.90	446.00
1958	23.50	9609.88	409.00
1959	24.12	9959.73	413.00
1960	24.74	9203.11	372.00
1961	25.37	10325.08	407.00
1962	26.01	10897.63	419.00
1963	26.66	11543.29	433.00
1964	27.32	12457.41	456.00
1965	27.99	12930.32	462.00
1966	28.67	14103.57	492.00
1967	29.35	14940.72	509.00
1968	30.05	15233.53	507.00

1969	30.74	17276.59	562.00
1970	31.44	16755.19	533.00
1971	32.13	18956.13	590.00
1972	32.82	21728.84	662.00
1973	33.52	25109.08	749.00
1974	34.24	26327.99	769.00
1975	34.97	26295.77	752.00
1976	35.72	26430.84	740.00
1977	35.69	31545.89	884.00
1978	35.66	31805.60	892.00
1979	35.63	37094.29	1041.00
1980	35.62	37183.86	1044.00
1981	35.61	36854.09	1035.00
1982	35.60	40731.15	1144.00
1983	35.60	42434.75	1192.00
1984	35.59	51243.36	1440.00
1985	35.56	54259.02	1526.00
1986	35.75	58232.35	1629.00
1987	35.91	53720.93	1496.00
1988	36.04	50786.56	1409.00
1989	36.15	52928.95	1464.00
1990	38.06	59531.57	1564.00
1991	39.79	54867.33	1379.00
1992	41.33	43438.10	1051.00
1993	42.97	40481.94	942.00

1994	43.67	55461.15	1270.00
1995	42.19	54800.51	1299.00
1996	48.41	69368.83	1433.00
1997	48.64	73109.21	1503.00
1998	49.60	81633.88	1646.00
1999	49.82	90918.64	1825.00
2000	49.23	75518.98	1534.00
2001	50.18	77379.99	1542.00
2002	50.21	65870.43	1312.00
2003	50.29	57777.59	1149.00
2004	51.45	80669.37	1568.00
2005	53.68	87061.19	1622.00
2006	55.50	103177.86	1859.00
2007	56.92	113385.96	1992.00
2008	58.44	128447.57	2198.00
2009	59.80	124573.14	2083.00
2010	59.35	134658.91	2269.00
2011	61.71	140018.32	2269.00
2012	62.12	140949.17	2269.00
2013	62.54	141908.42	2269.00
2014	62.96	142860.57	2269.00

*9.1.4 Southern Red Snapper (*Lutjanus purpureus*)*

Appendix Table A 4. Annual catch data of exploited *Lutjanus purpureus* species in Haiti from 1950 to 2014 With: C = Catch in tonne; L.V. = Landed Value in USD (Pauly & Zeller, 2015)

Year	C (t)	L.V. (USD)	L.V./C (USD/t)
1950	37.65	78126.38	2075.00
1951	5.35	12216.71	2285.00
1952	5.35	12991.95	2430.00
1953	37.65	91680.83	2435.00
1954	37.65	91793.78	2438.00
1955	3.63	8556.53	2355.00
1956	9.54	23241.09	2435.00
1957	10.60	24303.12	2293.00
1958	19.75	42655.87	2160.00
1959	20.69	44647.66	2158.00
1960	23.29	48973.21	2103.00
1961	5.67	11905.35	2101.00
1962	18.47	39558.34	2142.00
1963	25.26	55050.25	2179.00
1964	17.73	41372.83	2333.00
1965	23.67	46895.61	1981.00
1966	8.69	18763.60	2158.00
1967	8.20	17817.05	2172.00
1968	15.61	34437.71	2206.00

1969	4.46	11945.50	2680.00
1970	7.79	21626.15	2775.00
1971	11.61	36744.64	3166.00
1972	33.56	109006.35	3248.00
1973	10.71	34224.48	3197.00
1974	7.06	21928.28	3106.00
1975	3.79	11591.70	3057.00
1976	2.85	8830.58	3101.00
1977	6.46	20181.34	3126.00
1978	0.57	2108.54	3719.00
1979	18.63	71248.55	3824.00
1980	82.16	211074.35	2569.00
1981	1.41	3787.35	2685.00
1982	1.19	2572.52	2170.00
1983	23.19	59503.30	2566.00
1984	64.71	153812.97	2377.00
1985	51.11	88367.52	1729.00
1986	15.57	30104.54	1933.00
1987	268.93	369772.78	1375.00
1988	42.33	99233.13	2344.00
1989	308.19	693426.79	2250.00
1990	302.71	562427.53	1858.00
1991	51.40	112916.39	2197.00
1992	61.67	148321.35	2405.00
1993	21.67	56330.68	2599.00

1994	158.72	496159.43	3126.00
1995	184.06	593416.25	3224.00
1996	269.76	677361.57	2511.00
1997	321.11	776761.12	2419.00
1998	288.43	709827.86	2461.00
1999	238.75	545059.93	2283.00
2000	268.49	339645.74	1265.00
2001	271.30	227352.26	838.00
2002	281.16	666351.47	2370.00
2003	363.32	853086.41	2348.00
2004	221.43	530986.30	2398.00
2005	258.56	652613.88	2524.00
2006	234.08	604172.24	2581.00
2007	281.62	825145.69	2930.00
2008	265.26	762882.66	2876.00
2009	331.05	835572.21	2524.00
2010	273.53	804191.56	2940.00
2011	237.92	699471.86	2940.00
2012	174.72	513685.77	2940.00
2013	157.90	464233.38	2940.00
2014	156.05	458795.23	2940.00

9.2 Asymptotic length and asymptotic weight of Lutjanus species exploited in Haiti

Appendix Table A 5. Asymptotic length (Linf in cm) and asymptotic weight (Winf in g) of Lutjanus species exploited in Haiti (Froese & Pauly, 2018)

Scientific Name	L_{inf}	W_{inf}
Lutjanus apodus	36.60	878.70
Lutjanus campechanus	97.70	12023.42
Lutjanus griseus	53.80	2653.30
Lutjanus purpureus	85.10	6897.20

9.3 The full breakdown of species by artisanal sector and subsistence sector

9.3.1 Artisanal Sector

Appendix Table A 6. The full breakdown of species by artisanal sector (Ramdeen, et al., 2012)

Taxa	% in 1950	% in 2010
Ablennes hians	0.32	0.24
Acanthocybium solandri	1.25	3.75
Acanthurus bahianus	0.20	0.15
Caranx ruber	9.49	7.12
Chaetodon capistratus	0.52	0.39
Chaetodon sedentarius	0.20	0.15
Clepticus parrae	27.17	20.38
Conger triporiceps	0.28	0.21
Coryphaena hippurus	1.67	5.00
Decapterus macarellus	1.07	0.80
Epinephelus cruentatus	0.64	0.48
Gymnothorax moringa	0.32	0.24
Haemulon aurolineatum	1.67	1.25
Haemulon flavolineatum	0.52	0.39
Haemulon plumieri	1.47	1.10
Hemiramphus brasiliensis	0.48	0.36
Holocentrus adscensionis	1.55	1.16

Holocentrus rufus	1.51	1.13
Inermia vittata	0.44	0.33
Lactophrys spp.	0.20	0.15
Lutjanus apodus	0.20	0.15
Lutjanus campechanus	2.03	1.52
Lutjanus griseus	0.36	0.27
Makiara nigricans	1.67	5.00
Mulloidichthys martinicus	2.98	2.23
Myripristis jacobus	0.64	0.48
Ocyurus chrysurus	0.52	0.39
Priacanthus cruentatus	1.11	0.83
Pseudopeneus maculatus	1.83	1.37
Rhomboplites aurorubens	0.99	0.74
Scombridae	1.25	3.75
Selar crumenophthalmus	5.56	4.17
Sparisoma aurofrenatum	6.95	5.21
Sparisoma chrysopterum	0.52	0.39
Sparisoma rubripinne	0.24	0.18
Sparisoma viride	2.11	1.58
Sphyraena barracuda	1.25	3.75
Sphyraena picudilla	5.20	3.90
Thunnus spp.	1.25	3.75
Tylosurus crocodilus	0.75	0.57
Xiphias gladius	1.67	5.00
Misc. marine fishes	10.00	10.00

	Total	**100.05**	**100.01**

9.3.2 Subsistence Sector

Appendix Table A 7. The full breakdown of species by subsistence sector (Ramdeen, et al., 2012)

Taxa	% for the period 1950-2010
Ablennes hians	0.32
Acanthurus bahianus	0.20
Caranx ruber	9.49
Chaetodon capistratus	0.52
Chaetodon sedentarius	0.20
Clepticus parrae	27.17
Conger triporiceps	0.28
Decapterus macarellus	1.07
Epinephelus cruentatus	0.64
Gymnothorax moringa	0.32
Haemulon aurolineatum	1.67
Haemulon flavolineatum	0.52
Haemulon plumieri	1.47
Hemiramphus brasiliensis	0.48
Holocentrus adscensionis	1.55
Holocentrus rufus	1.51
Inermia vittata	0.44
Lactophrys spp.	0.20
Lutjanus apodus	0.20
Lutjanus campechanus	2.03

Lutjanus griseus	0.36
Mulloidichthys martinicus	2.98
Myripristis jacobus	0.64
Ocyurus chrysurus	0.52
Priacanthus cruentatus	1.11
Pseudopeneus maculatus	1.83
Rhomboplites aurorubens	0.99
Selar crumenophthalmus	5.56
Sparisoma aurofrenatum	6.95
Sparisoma chrysopterum	0.52
Sparisoma rubripinne	0.24
Sparisoma viride	2.11
Sphyraena picudilla	5.20
Tylosurus crocodilus	0.75
Misc. marine fishes	20.00
Total	**100.04**