EFFECTS OF CLIMATE CHANGE AND FISHERIES ON THE DISTRIBUTION OF MARINE FISH IN THE CARIBBEAN COLOMBIAN SEA BASED ON TRADITIONAL ARTISANAL FISHING KNOWLEDGE

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ABSTRACT

Based on their practical experience and traditional knowledge, artisanal fishers have the ability to identify the changes in the distribution of marine species, which seem to be related to climate factors and fishing pressure. Migratory and non-migratory marine fish species occur in the Colombian Caribbean and they are dependent on the regional climatic conditions, which makes them move up or down in the water column. However, according to local fishers, factors such as fishing stressors (both commercial fisheries and artisanal fisheries) also make these species move or vanish in certain areas.

RESUMEN

La presente investigación pretende determinar si ha habido algún cambio en la distribución de especies marinas debido al efecto del cambio climático y la presión de la pesca basado en el conocimiento de los pescadores artesanales del Caribe colombiano. Algunos eventos climáticos como la temporada de lluvia, los vientos y las corrientes frías han cambiado haciendo que algunas especies marinas en este caso de peces desaparezcan por un tiempo y otras se vayan más profundo en el océano. Pero, no solo los factores climáticos tienen un impacto también la presión de pesca hace que algunas especies se vayan desplazado a sitios más profundos y a áreas protegidas.

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1.0 INTRODUCTION

The distribution of marine fish is related to the environmental conditions in the ocean (FAO, 1990), which are altered by the outcome of anthropogenic activities such as climate change and industrial fishing (Dauncey, 2009).

Climate change is affecting biotic and abiotic processes (IPCC, 2001) and is having an impact on organisms, populations, species distribution and ecosystems' interactions (IPCC, 2002), as a result influencing local fisheries (EPA, 2012; Defeo, Castrejon, Ortega, Luhn, Gutierrez, & Castilla, 2013). Global and local shifts have for a number of species changed the time of seasonal life cycles, altered their range and deteriorated their habitats (Cheung, et al., 2009); disrupted their trophic chain (EPA, 2012) and food webs; increased the risk of diseases and the potentiality of extinction (EPA, 2012; Gianrt-Reto, et al., 2002).

The effect of climate change in aquatic ecosystems produces variations not only in the water temperature, but also increases the thermal stratification, alters the flux of nutrients and ocean productivity, triggers the rise of sea levels (EPA, 2012), modifies the precipitation patterns, and boosts water acidification — to name just a few issues—all of which have significant impacts on fish populations and directly affects the abundance of habitat-forming species (Hoegh-Guldberg & Bruno, 2010; IPCC, 2007; Perry, Low, Ellis, & Reynolds, 2005).

Due to the fact that the ocean works as a natural sink absorbing carbon dioxide (CO_2) from the atmosphere (Center for Ocean Solutions, 2014), the IPCC has estimated that so far the ocean "has absorbed about 30% of the emitted anthropogenic CO_2… half of [which have been emitted during] the last 40 years (2014, p. 5)." The IPCC (2014) asserts with high confidence that "since the beginning of the industrial era… the pH of the ocean surface water has decreased by 0.1, corresponding to a 26% increase in acidity (p. 4)." This acidification has a direct impact on the metabolism and calcification of species that need to fixate calcium to build their shells, such as clams, snails, queen conch and coral reefs (Semesi, Kangwe, & Bjork, 2009; Doney, Fabry, Feely, & Kleypas, 2009; Feely, et al., 2004; Brierley & Kingsford, 2009).

One of the most affected ecosystems by the changes in the temperature and ocean acidification are the coral reefs (Cheung, Lam, Sarmiento, Kearney, Watson, & Pauly, 2009; Baker, Glynn, & Riegl, 2008), which contain more than a quarter of the shallow water marine species. These protect coastlines and support fisheries (IPCC, 2007; Baker, Glynn, & Riegl, 2008).

Changes in water temperature not only change the distribution of marine species (Cheung, Lam, Sarmiento, Kearney, Watson, & Pauly, 2009; Perry, Low, Ellis, & Reynolds, 2005; EPA, 2012; Chevaldonne & Lejeusne, 2003; Barry, Baxter, Sagarin, & Gilman, 1995) but also lead to local extinction and changes in species composition (Cheung, Lam, Sarmiento, Kearny, Watson, & Pauly, 2009; Tonn, 2011). Several warm water species are moving north or/and south, experiencing changes in size and altering the productivity of their habitats (Cheung, Lam, Sarmiento, Kearny, Watson, & Pauly, 2009; FAO, 2008; Hoegh-Guldberg & Bruno, 2010).

Ocean warming creates strong thermoclines in the ocean making it difficult for the nutrients to reach the surface and preventing the oxygen to go deeper in the water, which at the same time affect the spring algae/or phytoplankton blooms that provide food for several types of marine organisms (Carpenter, et al., 2008). The alteration of the plankton's productivity and fish distribution will affect commercial fisheries (Le Quesne & Pennegar, 2012; Cheung, Close, Lam, Watson, & Pauly, 2008).

Research has shown how the water temperature and climate influence the volume of marine organisms (Hays, Richardson, & Robinson, 2005; Hughes, 2000), and how changes in hydrology (freshwater runoff) affect the production of commercial fisheries (Brown, 2011; Harley, et al., 2006; Brander, 2007; Blanchard, et al., 2012; Hollowed, et al., 2013) .

In addition to climate change, other anthropocentric activities such as industrial fisheries and overfishing affect ocean productivity, marine ecosystems, ecological processes and fish populations' distribution (Agardy, 2000; FAO, 2003). Fishing practices particularly affect target populations by reducing their abundance, and affecting life history (growth, maturation, potential spawning and recruitment), structure, sex ratio and species composition of the community (FAO, 2003).

Due to overfishing, species of pelagic predatory marine fish (such as sharks, tuna, and cod), as well as the species with commercial value (such as groupers and sardines) have collapsed either locally or regionally (Jackson, et al., 2001; Baum, Myers, Kehler, Worm, Harley, & Doherty, 2003; Musick, et al., 2000; Myers & Worm, 2003), thus altering the food web and communities structure (Baum, et al., 2003).

Of the total global marine fisheries production (79.7 tonnes in 2012[1]), FAO estimated that 80% of fish stocks are being exploited to a certain degree, 28.8% of which "were estimated as fished at a biologically unsustainable level, and therefore, overfished" (2014). As a result, fisheries have shifted from large piscivorous[2] fishes towards planktivorous[3] fishes and small invertebrates (Pauly, Christensen, Dalsgaard, Froese, & Torres, 1998).

FAO (2014) has identified the impacts of climate change and carbon emission as some of the major issues that directly affect the international trade of fishery products. It also recognized the role that small-scale fisheries play in fish production and local trade and the exacerbated effects that climate change and industrial fisheries exert on fishing communities who depend on marine fish for subsistence and commercialization.

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[1]According to FAO (2014), 18 countries account for 76% of the global marine catches, which corresponds to an average of one million ton per year.
[2]Piscivorous: Aquatic species that feeds on fish
[3]Planktivorous: Aquatic species that feeds on planktonic food

Colombian Artisanal Fishers

Even though, industrial fisheries represent 89% of the fisheries production in Colombia, artisanal communities contribute a considerable percentage to the local economy (FAO, 2005). Colombian artisanal fishing communities usually face high levels of poverty, no access to education and training, and unfair competition from large national and international fishing fleets (FAO, 2005; FAO, 2011b). Since Colombian fishers are within or under the poverty line and have limited resources, they normally use small wooden boats or canoes (usually operated with paddles to avoid fuel expenses). This form of transportation limits the fishing range, reducing their access to stocks/species of commercial value. Although it can be expected that small-scale or subsistence fisheries will be largely affected by changes in marine fish distribution and abundance (FAO, 2011b), it is highly uncertain to know the actual impact or long-term consequences of both climate change and industrial fisheries on marine coastal ecosystems.

Two studies have been completed in regards to coastal artisanal fishing communities in the Colombian Caribbean in relation to observed changes, catch and fishing efforts (Garcia, 2010; Castro, Grandas, & Garcia, 2007). Numerous local reports are produced by the governmental agency in charge of fisheries[4] at the national level in conjunction with FAO or other entities. These reports are normally focused on national large-scale production of fish and the impacts to the industry due to declining —or shifting—of

[4]AUNAP –National Authority of Aquaculture and Fisheries

fisheries/stocks of high commercial value (Chavarro, Garcia, Garcia, Pabon, Prieto, & Ulloa, 2008; FAO, 2011b).

In its latest report on the State of the World Fisheries and Aquaculture, FAO highlighted that small-scale fishers and fishing communities hold a disadvantageous position in regards to the government and large-scale industry when it comes to negotiations of management issues (FAO, 2014). As will be discussed later, Colombian fishers and fishing communities are generally stigmatized and marginalized. This research documents the level of awareness of fishers in regards to climate change and the causes of shifting fish populations, as a preliminary approach to enable and promote inclusiveness, voice and participation.

1.1 AREA OF STUDY

Colombia is located in the northern part of South America. The study was conducted in two geographical regions, Providence and Santa Catalina, which is located in the insular Colombian Caribbean, and Taganga, which is near Santa Marta, one of the biggest cities on the northern coast of Colombia (Fig.2).

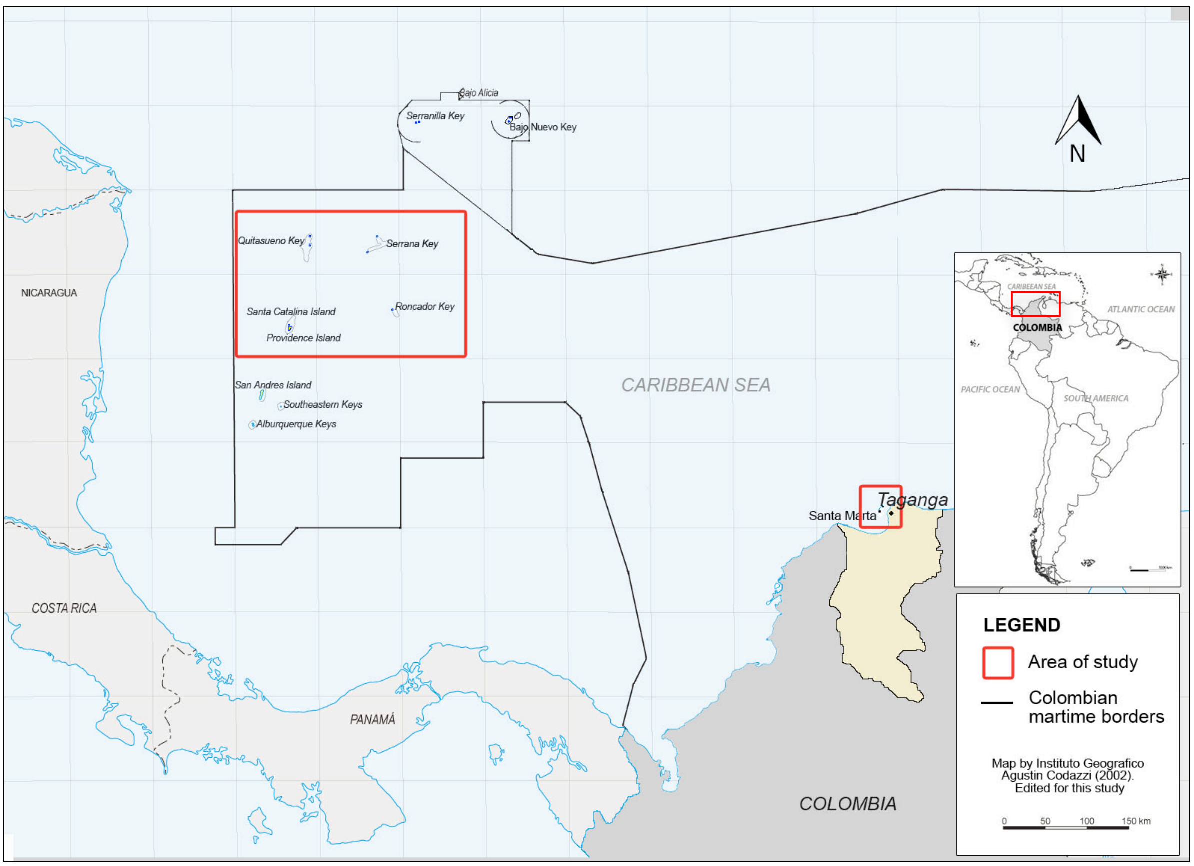

Fig. 2: Location of study areas, Providence and Santa Catalina (part of the San Andres Archipelago) and the fishing village of Taganga (Magdalena Department), Colombian Caribbean.

Providence and Santa Catalina Islands

Providence and Santa Catalina Islands are part of The Archipelago of San Andres, located in the west of the Colombian Caribbean sea, between parallels 13°19’ and 13°24’ of latitude North, and meridians 81°21’ and 81°24’ of longitude West (IGAC, 1986). This Archipelago has a marine area about 350,000 Km^2 (Alcaldia de Providencia y Santa Catalina, 2012). These islands are surrounded by small cays (Fig. 4) such as the Three Brothers Cay, Crab Cay, Bottom House Cay, Basalt Cay y Palm Cay and Coral Reef with a 22 Km long, which are crucial for the Archipelago’s fishing communities (Fig. 3)(Alcaldia de Providencia y Santa Catalina, 2012).

Fig. 3:Overview of artisanal fishers in Providence Island (Photo © 2014 Fabricio Pardo)

The climate in the archipelago is influenced by hurricanes, the tropical convergence zone and fronts of mid and high latitude (CORALINA-INVEMAR, 2012). Due to its tropical location, there are two seasons dry and rainy. The dry season goes from January to April providing only 11% of the total annual rainfall. The driest month is March. The raining season comprise from May to December. October and November are the dampest months (CORALINA-INVEMAR, 2012). The average temperature is 25°C with a near precipitation of 1,500 mm per year (Marquez G. , 1987).

The predominant winds from the east and northeast divide the island in a dry Eastern side and a slightly wetter Western (Marquez G. , 1987).

There are different marine ecosystems in these islands such as sandy beaches, mangrove forests, small marshes, sea grass beds, rocky and coral reefs and shallow reef lagoons (Garzon & Acero, 1983). The reef complex extends from about a mile Southwest of Providence until about 11miles north for a total of 20 km, which it is the second largest in length in the Caribbean (Monsalve, 2003).

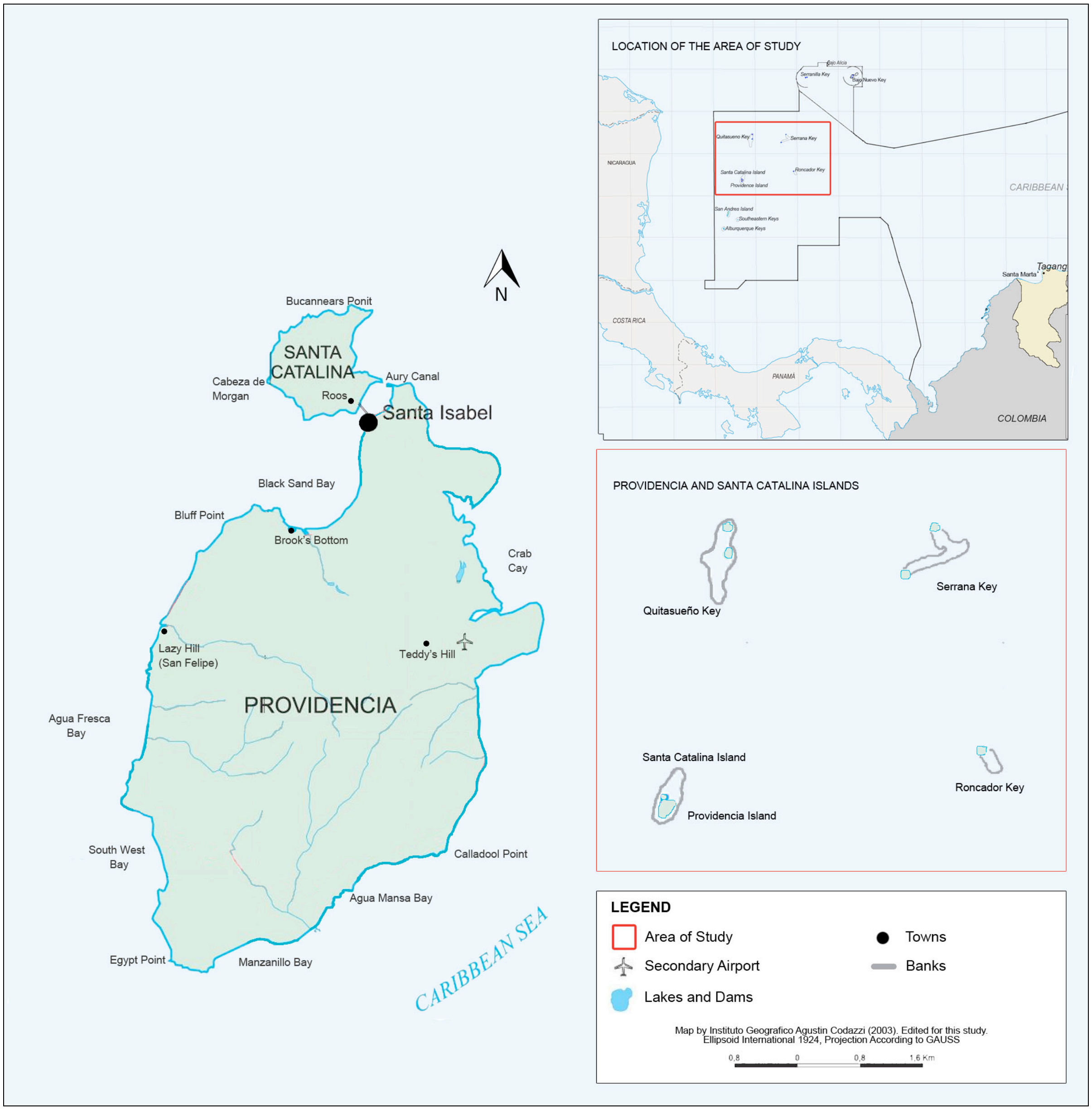

Fig. 4: Providence and Santa Catalina, San Andres Department, Colombian Caribbean

Surface currents in the Caribbean correspond to two bodies of water (the North Equatorial Current the Caribbean and the Guyana Current), which come from different geographical locations and merge to form the current known as the Florida or Gulf Current. Its movement is directed to the west. In the archipelago region, affected by the

Caribbean Current, ocean currents are directed towards the Nicaraguan coast. At San Andres and Providence, the waters are divided by refraction against the Nicaraguan coast and the continental shelf, giving origin to a South Current towards Costa Rica and Panama and a Northern Current towards Honduras (Melendro, np).

Santa Marta

The coastal region of Magdalena department comprises Santa Marta, Taganga and the Tayrona National Park (Fig. 3), and is located between coordinates 11°15’ and 11°22’ N and 73°57’ and 74°12’ W (Diaz, et al., 2000 in Ramirez-Baron, et al., 2010). This region has a dry season between December to April and a rainy season between September to November (Franco-Herrera, 2005).

The dry season is influenced by strong winds from the North and Northeast (Alisios) what causes an oceanic upwelling characterized by the presence of water with temperatures between 21° to 24°C and high salinity 36.5 to 37.2 ppm (Bula-Meyer, 1990 in Ramirez-Baron, et al, 2010).

There is a rainy season with abundant precipitation with a maximum of 270 mm per month. During this time, the water temperature increases up to 29 to 30°C and the salinity decreases (Bula-Meyer, 1990 in Ramirez-Baron, et al, 2010). The temperature for this region is between 20 and 37°C (air) and 21 to 29°C (water) throughout the year (Acosta, 2005 in Ramirez-Baron, et al, 2010). Taganga has a variety of ecosystems ranging from coral aggregations, seagrass to sand bottoms, with organic matter and sediments that come from natural marine processes and anthropogenic waste, stimulating species biodiversity and interaction between the ecosystems (Gaitan-Espitia, 2008)

Fig. 5: Fishing Village of Taganga, Magdalena Department, Colombian Caribbean

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1.2 METHODOLOGY

In total, 18 people were interviewed including artisanal fishers in both locations as well as local researchers who are working directly with fisheries or/and artisanal communities.

In order to collect the data, I used a digital tape recorder during the interviews. I also provided the Informed Consent Form before the beginning of the interview.

This research was framed as an 'empirical qualitative instrumental case study' (Stake, 1995), in order to understand how fishers' communities are experiencing climate change. This framework assumes that by observing local communities, their concerns and constraints, it is analyze to analize an issue, in this case climate change in the context of changing marine populations and its impact in coastal livelihoods. This study was focused on the complexity of the interrelationships between climate change and local fishing communities rather than the data itself.

A set of questions were formulated to enable a conversation that sought to answer — based on the interviewees' knowledge and experience— the question of: "has the distribution of the fish species changed due to shifting climatic factors and/or fishing pressures?

The name of the interviewees has been coded to protect their privacy. Artisanal fishers were coded (AF1 to AF14) and the researchers were coded (FR1 to FR4).

2.0 RESULTS

Fourteen of the 18 interviewees were artisanal fishers (AFs). Their fishing experience ranged from 25to 50 years. In general, fishing was their livelihood and their experience coincided with the age range, thus the most experienced fisher was also the oldest, 76 years old; and the least experienced was 45 years old.

According to the elders, when they were young (and also at the time of their fathers and grandfathers), they would fish to meet their basic needs —for subsistence (AF2, FR1, FR4, AF11) (Marquez A. , 2005). Local people would consume what was available during the season and there was no preference for a species or group in particular (AF1). However, with the arrival of personnel from central Colombia to work on the construction of infrastructure projects (e.g. Providence's dam or the roads in Magdalena), and with the increase in tourism, the demand for certain species increased (AF1). By the 1970s, lobsters, yellow tail (Fig. 6), snapper and hawksbill turtle became highly valued commodities for trade[5] (AF1), not only to supply local needs, but also growing national demand (Marquez A. , 2005). According to AF4, before the 1990s it was still possible to fish between 300 to 400 lb of the target species in a short time ('low fishing effort'), but by the end of the decade the fishing effort increased considerably and the biomass of caught fish would rarely reach 200 lb per day.

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[5]See Appendix 1 for a complete list of fish species caught by artisanal fishers in Providence and Santa Catalina and Santa Marta.

According to scientific records, there are at least 62 species that have been caught by the artisanal fishers in Providence and Santa Catalina Island (Medina, 2004), and 171 species have been reported in Taganga (Santa Marta) (Grijalba-Bendeck, Bustos-Montes., Posada-Pelaez, & Santafe-Munoz, 2012).

Fig. 6: Yellow Tail. (Photo © 2001 Universidad Nacional)

2.1 Factors Affecting the Abundance and Distribution of Fish According to Artisanal Fishers

Species of commercial value include migratory and non-migratory species. In regards to the availability of these species, fishers observed that there was not only a relation between climate conditions and the presence of these species (innate conditions of migration, currents bring certain species), but also noted that there was a difference in terms of abundance of non-migratory species (AF2, AF3, AF4, AF6).

Artisanal fishers of Providence and Santa Catalina relate the abundance of Yellow Tail to the availability of their natural food (AF12); to winds coming from the north that mixes the ocean water with its bottom that releases small organisms that the Yellow Tail feeds on (AF5, AF9); to the currents coming from the North, which bring the Yellow Tail's food (AF4, AF9); and to the flowering of the mango tree (AF8); and the black crab spawning season both of which coincide with the start of the rainy season in mid April (AF10).

The rain patterns have shifted in the Archipelago and Santa Marta, extending the dry season to May and June. AF4 and AF8 affirmed that the usual rain patterns started to change dramatically for the Archipelago in 2010. IDEAM (2014) showed that the precipitation for the months of April and May were well below normal.

One of the interviewees (AF8) in Providence attributed the lack of Yellow Tail this year (2014) due to the lack of rain in the Archipelago. This suggests that shifting rain patterns are modifying the availability of certain species. AF9 claims that the rain cools down the surface water allowing the species to reach the coast.

According to AF8, the rainy season coincides with the spawning and congregation times in most of the species. Therefore, species such as Kingfish or Wahoo, Snappers and Grouper increase their numbers rendering them more vulnerable to setting caught (Bent & Taylor, 2011).

AF4 and AF10 suggested a relation between moon cycle and presence of certain species. AF4 stated that when the moon is full, the tide is higher and this makes species such as Jurel (*Caranx hippos*) appear on the surface and get exposed. AF10 affirms that during the crescent moon, fish tend to eat more. Thus fishing during this time delivers better results.

Although dependent on the currents, elder fishers affirm that during the 1970s and 1980s it was possible to fish Yellow Tail throughout the year. But, from the 1990s the arrival of it was linked to the North wind (AF9). Accounts range from the total disappearance of the species from the fishing sites after 2000 to occasional encounters (AF10).

Data gathered by INPA[6] in 1995 of the industrial and artisanal fish production combined for the San Andres Archipelago shows that the Yellow Tail's biggest production months were April and May, compared to the rest of the year (INPA, 1995). In terms of tonnes of Yellow Tail national production per year, the data available suggest that the species has significantly declined from 1989 (59,000 tonnes) to 2000 (7,900 tonnes) (INPA, 2000).

There are a number of changes that AFs noticed during the last decade. For instance AF13 and AF14 stated that the sea level was higher before; AF3has noticed that the water surface temperature has warmed; and AF5 affirmed that green algae appeared whenever the temperature of the water rose. The inability to fish Yellow Tail has been also attributed to the species moving deeper into the water column due to the warming of the surface water (AF8). Other species have been also noted moving deeper into the ocean (AF2, AF3, AF4, AF5, AF6, AF8, AF13). Some of these species are Black Snapper, Red Snapper, Janpow or Nassau Grouper and other large Groupers. AF2, AF3, AF4, AF8, AF11, and AF13 stated that it was possible to catch more fish during the rainy season because the water was colder, which made the fish to come closer to the shoreline.

Research shows that marine fish are responding to the increasing sea surface temperature by shifting their distribution to deeper water (Cheung & Pauly, 2013) and reaching colder water (Perry, Low, Ellis, & Reynolds, 2005). According to AF9, the Black Snapper was caught before at 90m and now at 160m; The Nassau Grouper has gone

[6]INPA: National Institute of Fisheries and Aquaculture was replaced by the INCODER in 2003 and this agency was also replaced by AUNAP – National Authority of Aquaculture and Fisheries in 2011.

from 290 m to 330m; the Red Snapper from 165 m to 330 m; and some others snappers have moved to 700 m depth.

Corten (1986 in Rijnsdrop, et al., 2009) affirms that climate conditions could interfere with the transportation of the eggs and larvae between nursery and spawning areas (Harley, et al., 2006). FR4 observed that larvae of Mullet (*Mugil* sp.) were still present this year (2014), in Santa Marta, during May due to the strong prevalent winds, when they had normally moved to the pelagic areas after March.

AF13 observed that an unusual cold current from the North that arrived in Taganga on January 2014 brought abundant Cachorretas (***Auxissp***), allowing fishers to catch at least 15,000 individuals. He affirmed that this has happened only once since 2000. AF4 also stated that even though the winds have been a recurrent event throughout his life, in 2011 the winds did not happen in October. This, according to him had devastating effects on the amount of fish he caught that year.

Artisanal fishers have two hypotheses in regards to the diminishing fish stocks. The first one is that they think that the species have been extremely and repeatedly disturbed, therefore the fish would try to find a safe site to live such as protected areas (AF6, AF7). The second one is the increase in the water surface temperature, which makes the fish move deeper in the ocean to find cold water (AF2, AF3, AF4, AF5, AF7 AF8, AF10, AF11, AF12, AF13).

2.2 Fishing Practices and their Effect on the Abundance and Distribution of Marine Species

Campbell and Pardede's (2006) research suggests that particular fishing gears have a direct influence on the structure, biomass and composition of reef fish communities. These gears (see Table 1, on page 23, for gears used in the Colombian Caribbean) target specific families/species exerting a 'fishing pressure' that has a negative correlation with the fish biomass in certain areas (Hawkins & Roberts, 2004; McClanahan & Mangi, 2001).

Studies such as Rueda and Defeo (2003) demonstrated that the use of specialized gears has not only a trophic effect on an area's populations, but also significantly affect the non-target species (by-catch) and the natural conditions of an area (ranging from negative effects on coral reefs to the reduction of dissolved oxygen due to gear's operations) (Rueda & Defeo, 2003; Hawkins & Roberts, 2004; McClanahan & Mangi, 2001).

Interviewees suggested that the fishing gears that impacted fish populations the most were the fish traps (AF2, AF4, AF6, AF8), industrial long lines (AF3, AF4, AF5), harpoons – diving with a scuba tank (AF2, AF4, AF6, AF8). While industrial long lines are used by large vessels (not artisanal fishers), they have a direct impact on local populations.

According to AF3, AF4 and AF5, the hooks destroy anything they touch on the bottom including coral reefs and sea grass beds; catch non-target species (by-catch) as well as targeted species before spawning or during the juvenile stages (undersized individuals). AF3 asserted that the biomass ratio between industrial and artisanal fishers per night is 100:1 respectively. Although the law in Colombia regulates industrial long lines, there is no enforcement and the industrial fisheries continue to target species in restricted areas (AF3, AF4, AF5).

The use of fishing gears is constrained by the transportation capacity. While most AFs own boats with outboard engines, the amount of fuel needed to reach the fishing sites is becoming more expensive (also the Colombian Army controls the amount of fuel that each AF can use, see section 2.3). As mentioned by AF2, AF7, AF12, AF14, and FR2, these sites are falling farther from their usual fishing areas due to decreasing stocks, which makes the fishing efforts longer. AF14 affirmed that in the past he would go just 40 miles from the coast but nowadays he has to travel up to 250 miles to catch considerably less than what he would before.

Table 1: Fishing Gears used by Artisanal and Industrial Fishers in the Colombian Caribbean

According to the interviewees, the following are the most common used fishing gears and their impacts:

- **Fishing lines**:
  - Hooks (Fig. 7)
  - Industrial long line: Set at the bottom of the ocean with baited hooks distributed at regular intervals (up to 10,000 hooks per line, according to AF6). Length varies (frequently 1 km). Frequent by-catch. Used by Colombian and international vessels (AF6 affirms that these boats are coming from Honduras, Jamaica and Cartagena). This gear is prohibited by Colombian law in the artisanal fishing areas and marine protected areas (Law 47 of 1993).
  - Trolling
  - Reel
- Nets:
  - Beach seines
  - Surroundings nets
  - Cage-nets
  - Gillnets and seines
- **Fish traps**: Catches any type of fish and any size. Frequent by-catch (which is discarded –if dead; or returned to the water –if it lacks any commercial value) (Fig. 8)
- **Harpoons**: Extremely selective and effective (when used with a scuba tank). Targets top predator and large species (Fig. 9)

Fig. 7: Hooks. Fishing gear used by artisanal fishers in the Colombian Caribbean (Photo © 2001 Universidad Nacional)

Although most of the interviewees stated that the species structure, assemblage[7] and composition[8] have not changed dramatically during the last 50 years, they noticed that there was a reduction in biomass caught in their usual fishing areas. AF1 stated that half a century ago, AFs were able to catch 400 groupers in one night, which is very rare or virtually impossible nowadays. AF2 affirmed that species such as the Nassau Grouper are recovering, but the King Fish, the Snappers and other Groupers are becoming rare.

[7]Fish assemblage is the term used to describe the collection of species making up any co-occurring community of organisms in a given habitat or fishing ground (FAO, 1997)
[8]See Appendix 1 for a list of species

Fig. 8: Fish Traps. Fishing gear used by artisanal fishers in the Colombian Caribbean (Photo © 2001 Universidad Nacional)

Research has shown that one of the most significant effects of fishing pressure on marine fish is the reduction in size and weight for sexual maturity of targeted species, due to the intensive exploitation of large individuals (Smith, 1994; Marmol & Blanco, 2010). This is exacerbated by the increase in water temperature, which affects the early stages of the fish cycle, resulting in faster maturity time and length shortening (Heino, et al., 2002). AF7 and AF9affirmed that Groupers have reduced their weight from 60 to 20 lb, and Janpow from 120 lb to 40 lb in the larger individuals. Weight and size reduction have an obvious impact on the economic impact on fishers, who 40 years ago caught around 640 lb on a fishing effort versus between 80 to 90 lb today (AF2).

AF1, AF5, AF10 asserted that fishers are constantly looking for new fishing sites, with either the idea of letting the usual site recover or because of total depletion of targeted species. Most of the AFs were concerned with the future of their families and the potential disruption on their way of living. AF1 indicated that they agreed with and valued the mechanisms to sustain the fish stocks by not fishing in the spawning areas, by respecting the closed seasons, and by allowing certain areas to recover. Research such as McClanahan & Mangi (2001) and Labrosse et al (2000) also suggest that those mechanisms to sustain stocks must be complemented with a combination of closed areas and the diversification of fishing gears.

AF6, AF12 and FR2 noted that due to the fishing pressure, species other than fish (that are commercially important) such as the Queen Conch, have moved away from the shoreline. Apparently, five decades ago fishers were able to collect them near to the shore (at around 50 cm deep), but as the demand for this species increased, so did the species up depths reaching the 90 m. Although fishing this species is regulated by a closed season (June 1 to October 31 every year and permanent for the San Andres Archipelago) and area limitations (Accord 0017, 8 May 1990, INDERENA Resol. 0179, 5 May 1995, INPA), because of its high value, every individual found is captured and sold (AF6, AF7, AF12, FR2).

Fig. 9: Harpoon. Fishing gear used by artisanal fishers in the Colombian Caribbean
(Photo © 2001 Universidad Nacional)

2.3 Societal Transformation of Artisanal Fishing Communities in the Colombian Caribbean. The Case of Providence and Santa Catalina and Taganga

It is important to note that in the San Andres Archipelago, each family of AFs would find preferred fishing areas on their own. They would safeguard them as sacred and would not share a location with other individuals outside their families. These locations were passed then from generation to generation as part of the family's wealth (AF1 and AF10). Community members would unite to protect their fishing grounds to protect them from outsiders (AFs coming from continental Colombia or international fleets). In fact, these islands have a separate immigration system from continental Colombia and non-natives cannot work on the islands unless they have been issued a work permit called "the ocre."

The situation in the San Andres Archipelago changed dramatically after the Colombian loss to Nicaragua of 10.7% of its marine territory (nearly 100,000 km^2) in 2012. Due to the closeness of San Andres and Providence to Nicaragua, the two counties have been disputing for over a century both marine and insular territory. But, it was on November 19 of 2012, when the International Court of Justice of The Hague decided to grant Nicaragua with this marine territory (Territorial and Maritime Dispute (Nicaragua v . Colombia), Judgment, I.C.J. Reports, 2012). A year later, on November 20, 2013, the president Juan Manuel Santos, after being highly criticized for his poor preparation and slow response with the Haya, decided to grant —through Decree 2667and as a form of compensation for the economic impact on AFs of this decision— a monthly salary to AFs equivalent to $CA800 per month, until the officially registered 360 AFs would either find new areas to fish or would find a new source of income (Republica de Colombia, 2013). According to AF2, before this Decree, there were around 80 AFs in Providence, but with the new opportunity for an easy income, many non-fishers became fishers. These new fishers —most of them from a younger generation— have begun to employ unsustainable fishing techniques. AF6 stated that "young AFs just care about the present." This situation has clearly created a grudge and a noticeable divide between old and young fishers, especially because some of the old fishers never registered therefore were never granted these funds (AF1). With the arrival of over 200 more AFs to the fishing areas the impact on local stocks is dramatic. There is less fish nowadays than before (AF4 and AF10).

For the Taganga's AFs the situation was different. Taganga was a small fishing village with a road access to Santa Marta, a city that has the third largest port for the Colombian Caribbean. Although the access to Taganga was relatively easy (compared to getting to San Andres), the arrival of tourists and outsiders began around 20 years ago (AF1). AFs from Taganga would use the same fishing grounds and in trying to maximize the profits, every AF would participate in the fishing efforts. The profits were divided equally after a fishing trip (AF13)

Taganga started to change with the arrival of tourists (mostly foreign backpackers), who began to buy front beach properties and raised the housing prices. With more tourism, the demand for fish increased exponentially, not just for Taganga, but also for the Santa Marta area, which became a relatively cheap destination for tourists (AF13). Then, to meet the demand, some AFs began to use fishing techniques such as dynamite or nets with a small size mesh (AF14). Fishing became more difficult and not as lucrative as before. Thus, many transformed their fishing boats into charter boats (AF14). The new generation of AFs are a product of opportunity rather than legacy (AF13). There is also the stigma of being a fisher, who is socially considered to be at the lowest level on the social scale in Colombia (Guerra Curvelo, 2001; Salas, Chuenpagdee, Charles, & Seijo, 2011). Therefore, many AFs' sons prefer to be tourist boat drivers than fishers (AF13).

2.4 Obstacles Faced by Artisanal Fishing Communities in the Colombian Caribbean

Most of the interviewees expressed that they felt a lack of support from the government. AF1 stated that there is a lot of bureaucracy to obtain or renew their fishing permits and boat permits. AF1 affirmed that it was easier to register a boat with an international flag than a national one.

Due to the war against the drugs, the San Andres Port Officials put caps in the gas volume that AFs can use per month. The rationale is to prevent people from selling the fuel for long trips to the North. However, with the depletion of stocks, the distances that AFs need to travel are bigger and the need for fuel greater. Nevertheless, these caps have remained the same (AF1).

The local government[9] set allowances for AFs for fishing. Those fishers based in San Andres have a bigger allowance (25,000 lb per year) compared to those based in Providence (15,000 lbper year). However, fishers can technically fish anywhere, even near Providence. Providence AFs think that this is an unfair advantage to San Andres' fishers (AF7).

There is little to no enforcement in regards to the use of inappropriate or banned fishing gears(AF1 and AF10). For instance, the use of scuba tanks to fish with harpoons is

[9]Colombia has a decentralized governmental system. San Andres and Providence are a department. Departments in Colombia are equivalent to Provinces in Canada.

prohibited by law in the San Andres Archipelago (Law 13 of 1990, Colombian Government) and although it is respected by AFs, on occasions boats from continental Colombia arrive to the area, their fishers use tanks and leave the area being accountable to no one (AF1 and AF3). These fishers report their catch in a coastal port where the restrictions are different from those in the Archipelago (AF7). According to some AFs, on certain occasions there are industrial fishing boats fishing in restricted areas. However, both industrial and artisanal fishers are never fined or suspended (AF6) mostly, because there are no ways to prove it. Although the declining of fish stocks is a complex problem, government officials blame AFs for it (FR2).

AFs are finding during the last couple of years that they are competing with sharks and dolphins for food. According to AF13, this happens when they fish with hooks and they catch something. Then, sharks or dolphins have realized that these are easy prey and they try and steal the fish from the hooks (AF1, AF4, AF10 and AF12).

There is little to no sustainability or environmental information nor education when fishers get their licenses. In order to inform them in regards to the closed season, restrictions, conservation efforts and prohibitions, the government should establish a mandatory course for all applying and renewing their fishing licenses.

The financial incentives of alternative species make it almost impossible for AFs to change their target species of high commercial value. AF5 admitted that even though he is now constantly searching for new fishing sites, he is always looking for the same species that would represent a bigger financial return.

Others have become creative and change the common name of certain species, such as the Parrot Fish to Parrot Snapper or Tilapia. Tourists would buy these with no knowledge of what they are really consuming (FR3).

3.0 CONCLUSIONS

The distribution of marine species is being affected by a wide array of issues. The two main causes seem to be related to conditions arising from climate change and the ongoing fishing pressure. These two causes are exacerbated by governmental decisions, fishing practices (that lead to overfishing) and lack of education/awareness.

Over the past 5 years, the local weather, the rainy season, and front currents have changed dramatically affecting the artisanal fishers in the Colombian Caribbean.

In general, fishers are sceptical about the recovery of fish stocks. They are concerned with the decline of certain species of high commercial importance and the probable inability to sustain their families in a near future.

Certain fishing practices are not only depleting fish stocks but also deteriorating several habitats, such as coral reefs, seagrass bed, sandy bottoms, etc.

Management plans for fish stocks and species of high commercial value should be not only sound regionally but also be synchronized with conservation efforts at the national (and international) level.

In the last 20 years, Colombian artisanal fishers have noticed changes in the populations of fish ranging from number, size and weight of individuals of species of commercial value.

The numbers' reduction and distribution of fish species are influenced by direct (shifting climatic conditions and industrial fishing) and indirect factors (lack of control and enforcement of both local and national governmental agencies).

According to artisanal fishers in Providencia and Taganga, cold-water currents and winds from the North have been historically correlated with the abundance of fish, but these climatic patterns have drastically changed in the last 20 years. This has had an effect on the presence/absence of certain species, such as yellow tail, whose arrival has shifted to different months of the year.

The increase in temperature and the decrease in local sea levels has made certain species to migrate to deeper waters. This movement of species of commercial value has made it more difficult for artisanal fishers to accomplish their fishing efforts and to meet their basic needs.

According to Colombian artisanal fishermen, the pressure that the industrial fisheries have exerted on marine fish stocks has considerably reduced population numbers, and as a consequence some species have either been brought to local extinction or displacement due to the destruction of their habitats.

The lack of governmental controls has allowed illegal fishing vessels and practices to occur in the area.

The decline of marine fish stocks has most certainly been caused by malpractices of both artisanal and industrial fisheries.

The fishing gears that have more impact on the population of marine species are:
Fish traps because it captures all sorts of species and sizes, including juvenile fish, therefore affecting reproduction.
Industrial longline because it catches many untargeted species and deteriorates the seabeds habitats to many demersal species.
Harpoon because no fish escapes it and it targets large individuals, reducing the genetic information.

Species of lesser commercial value have become new targets due to the decrease of species of high commercial value.

Selective fishing makes fishers exert more pressure over certain species (such as groupers), which has an incidence in the local decrease or extinction of these species.

The by-catch, of both artisanal and industrial fisheries needs to be taken into account, since untargeted species are also being affected.

Fishing has been focused on the extraction of large individuals of commercial value, which has had an effect not only on the abundance of species, but also in the reduction of size and weight in local populations. For this reason, smaller and light weighted individuals are mostly captured.

According to the Colombian artisanal fishers, marine fish species have migrated to protected areas to avoid human disturbances.

Through the Decree 2667 of 2013, the Colombian government created a number of undesirable consequences for artisanal fishers. Although the idea was to give incentives to local fishing communities, the lack of knowledge and planning stimulated the appearance of more fishers when the goal was to reduce their numbers. These new fishers with no experience or understanding of fishing are exerting more pressure on already overfished stocks.

The local and national governments should offer support to local artisanal fishers in terms of education (especially concerning to sustainable fishing) and sustainable technologies.

Closed areas and season should be reviewed, created or/and enforced, in order to recover both local populations and habitats.

Fishing in certain areas of national waters should be restricted to local communities and industries. This would avoid conflicts that arise with continental or international fishers and local communities.

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APPENDIX 1

The following lists are an account of the most common fish species caught by the interviewed artisanal fishermen in Providence and Santa Catalina (List 1) and Taganga (List 2). The Taganga list was completed with information provided by a fish researcher (RF4).

List 1. Fish species caught by artisanal fishers in Providence and Santa Catalina Islands

Common Name	SpanishName	Scientific Name
Amber Jack		*Seriolasp*
Barracuda		*Sphyraena barracuda*
Black Fin Snapper		*Lutjanusbuccanella*
Black Grouper	Cherna	*Mycteropercabonaci*
Black Snapper		*Apsilusdentatus*
	Bonito	*Euthynnusalletteratus*
Doctor Fish		*Acanthuruschirurgus*
Dorado		*Coryphaenahippurus*
Grunt	Ronco	*Haemulonsp*
Hog Fish	Pargo pluma	*Lachnolaimusmaximus*
	Jurel	*Caranxlatus*
Kingfish or Wahoo		*Acanthocybiumsolandri*
Mandilos or Brim		*Etelisoculatus*
Nassau Grouper or Janpow		*Epinephelusstriatus*
Old Wife		*Balistesvetula*
Parrot Fish		*Scarussp*
Red Eye Snapper		*Rhomboplitesaurorubens*

Red Fin Snapper		
Red Grouper		
Red Snapper		*Lutjanusporpureus*
	Saltona Negra	*Elegatisbipinnulata*
Sardine	Sardina	*Harengulaclupeola*
Shark	Tiburón	
	Sierra	*Scomberomorussp*
Silk or Yellow Eye Snapper		*Lutjanusvivanus*
Swordfish		
	Tijereta	
Turbet		*Canthidermissp*
White Margate	Margarita	*Haemulon album*
Yellow Fin Snapper		
Yellow Tail	Saltona Roja	*Ocyuruschrysurus*

List 2. Fish species caught by artisanal fishers in the Santa Marta area.

Common Name	SpanishName	Scientific Name
Albacore*	Atún*	*Thunnusalalunga*
	Bonito*	*Euthynnusalletteratus*
	Cachorreta rayada*	*Auxisspp*
	Carite*	*Scomberomorusbrasiliensis*
	Chivo Mapale*	*Cathoropsmapale*
	Cojinuanegra	*Caranxcrysos*
	Jurel	*Caranx hippos*
LongnoseStingray*		*Dasyatisguttata*
Macabi		*Elopssaurus*
	Machuelo	*Opisthonemaoglinum*
	Mero	*Epinephelusitajara*
	Mojarra	*Eugerresplumieri*
	OjoGordo	*Selarcrumenophthalmus*
	Sabalo	*Megalopsatlanticus*
	Sierra*	*Scomberomorus cavalla*
Snapper	Pargo	*Lutjanusanalis*
Snapper	Pargo	*Lutjanussynagris*
Snook	Robalo	*Centropomusundecimalis*

The species listed here are those species of high commercial value for the Santa Marta area. Those with no asterisk continue to have the same commercial importance, but due to the declining in their numbers, other species have become valuable (*)