THE CARIBBEAN SPINY LOBSTER FISHERY IN CUBA:

An approach to sustainable fishery management

by

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ABSTRACT

The Caribbean spiny lobster (*Panulirus argus*) is the most valuable fishery resource in Cuba. Intensive fishing efforts and deterioration of essential habitats have led to overexploitation of this resource over much of its distributional range. In Cuba, the spiny lobster fishery collapsed in 1990, and since then landings have consistently declined. In response to this crisis and with the aim of obtaining the maximum economic benefits from this highly-prized resource, the Cuban Ministry of Fishery attempted to improve the management of this fishery.

The purpose of this study is to identify the biophysical, human and institutional components of the spiny lobster fishery in Cuba and map their interactions to better understand the current management of this fishery and promote its long term sustainability. An exhaustive literature review and an analysis of the current management regulations show that Cuba has met some of the most important criteria that could lead to the long term sustainability of the fishery. The limited access to the fishery, allocation of exclusive territorial rights and quotas, as well as the strict enforcement of the minimum legal size and a lengthening of the closed season have lead many researchers to consider the Cuban fishery as one of the best managed spiny lobster fisheries in the world. Despite these regulations, landings have not increased. This indicates that the lobster population has not recovered from the previous overexploitation.

The management could be improved by providing protection to the lobsters with the highest reproductive capacity through an increase in the minimum legal size to 81 mm carapace length and establishment of a maximum legal size (142 mm CL). More complete socio-economic impact analysis is necessary to better understand the human components of the fishery. This could help illuminate the reasons for illegal lobster fishing, a common problem in the Cuban waters. Additionally, fishermen integration into the fisheries policy-making process is crucial to achieve effective management regulations. A sustainable spiny lobster fishery in Cuba is essential for the recovery of this transboundary resource both in the local waters and in the Wider Caribbean Region.
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I. INTRODUCTION

Once considered food for the poor or bait for other fisheries, the Caribbean spiny lobster (*Panulirus argus*) is now one of the most high-priced luxury seafood items in the United States, Europe, and Japan. This species is valued by humans, not only as a food source but also as a source of revenue and as a source of recreational and aesthetic value (Lipcius & Cobb, 1994; Rudd, 2001). Spiny lobsters support some of the largest commercial fisheries world-wide, while concurrently sustaining small-scale artisanal and recreational fisheries (Butler IV, 2001; Seijo, 2007). However, high demand and market prices can intensify fishing pressure on spiny lobster populations, leading to a need for wise management decisions (Phillips *et al*., 1994).

Some of the same characteristics that make the Caribbean spiny lobster and the other 32 species of the family Palinuridae commercially valuable—large size and abundance—also make them ecologically important (Lipcius & Cobb, 1994). Each of the different phases of the *P. argus* life cycle represents a critical link in the marine food web in each of its different habitats throughout its ontogenetic development, from the open ocean to coastal habitats. Besides serving as prey for sharks, finfish and other marine species, the spiny lobster also serves as a keystone predator upon a diverse assemblage of benthic and infaunal species (Lipcius & Cobb, 1994; Toller, 2003). Its selective predation is apparently responsible for profound effects on species composition and size-frequency distributions of invertebrates such as sea urchins, mussels and gastropods (Lipcius & Cobb, 1994; Partnership for Interdisciplinary Studies of Coastal Oceans, 2007). In southern California, Behrens & Lafferty (2004) found that the healthy kelp forest inside a marine reserve was maintained by an abundant number of the red spiny lobster *P. interruptus*, which
were controlling (preying on) the population of sea urchins (voracious kelp grazers). On the other hand, in a fishing area adjacent to this reserve, with low numbers of lobsters due to fishing pressure, the kelp forest was decimated by abundant sea urchin populations. Consequently, declines in the abundance of spiny lobsters (i.e. keystone predator) due to intense harvesting, may negatively impact the marine community structure through a trophic cascade effect (Colleman & Williams, 2002).

The Caribbean spiny lobster resource is exploited throughout its range in the Western Central Atlantic (from USA to Brazil, and from the Gulf of Mexico to the Antilles islands), supporting the second-most economically important fisheries in the region (Ehrhardt, 2005). Also, the Panulirus argus fishery is considered the largest spiny lobster fishery in the world (Lipcius & Cobb, 1994; Baisre & Cruz, 1994). The major countries harvesting spiny lobster in the region are the Bahamas, Brazil, Cuba, Nicaragua and the United States of America, each with landings above 1,000 tons per year according to national reports submitted to FAO (Cochrane & Chakalall, 2001) (Table 1).

In Cuba, the P. argus fishery constitutes the most valuable single species fishery, accounting for 60-65% of the country’s gross income from fisheries products (Baisre & Cruz, 1994; Claro et al., 2001; Lopez Valdes, 2002). The natural stocks of this species support fisheries in the western central Atlantic region, providing high economic return (estimated ex-vessel value\(^1\) of US $800 million in 2006) and direct employment to more than 40,000 fishers (Toller, 2003; FAO, 2007) with additional jobs at shore-based activities. In the region, only the very large western central

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\(^1\) *Ex-vessel Price.* Price received by fishermen for fish, shellfish and other aquatic plants and animals landed at the dock.
Atlantic penaeid shrimp fisheries surpass these values (Ehrhardt, 2005). Considering the presence of several developing countries in the Wider Caribbean Region, these economic and social benefits offered by the spiny lobster fishery are of considerable importance for the development of the region (Cochrane et al., 2004)

Table 1. Top 15 countries harvesting *P. argus*, as measured by average annual landings from 2000-2007 inclusive, and the percentage of the total average landings (34,578 t) by all countries over the same period of time.

<table>
<thead>
<tr>
<th>Lobster Harvesting Country</th>
<th>Average landings (t) 2000-2007</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahamas</td>
<td>8,211.0</td>
<td>23.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>6,944.3</td>
<td>20.1</td>
</tr>
<tr>
<td>Cuba</td>
<td>6,263.1</td>
<td>18.1</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>4,192.3</td>
<td>12.1</td>
</tr>
<tr>
<td>United States of America</td>
<td>1,954.4</td>
<td>5.7</td>
</tr>
<tr>
<td>Dominican Republic*</td>
<td>1,209.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Honduras</td>
<td>888.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Mexico</td>
<td>833.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Haiti</td>
<td>771.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Venezuela</td>
<td>696.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Belize</td>
<td>520.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Jamaica</td>
<td>394.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Colombia</td>
<td>325.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Turks and Caicos Is.</td>
<td>314.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>167.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* Although Dominican Republic’s average landings is above 1,000 t, the annual lobster production of this country was not consistently above that value during the period 2000-2007.

In Cuba and the rest of the Wider Caribbean Region, the fishery for *P. argus* has evolved from a small undercapitalized fishery to a large, economically important, heavily capitalized fishery since the mid-1990s (Hunt, 1994). This increased fishing effort is reflected in the total landings for the region that steadily increased from about 2,000 metric tons (mt) whole weight in the mid
1950s to about 29,000 mt whole weight in the early 1980s (Figure 1). However, after reaching an average of 36,055 mt from the mid-1980s until 1995, regional landings decreased 55% in the 2000s (Ehrhardt et al., unpub.). This decreasing trend is an indication that most of the local fisheries reached full exploitation status during that time, while many others were already considered as overexploited (Cochrane & Chakalall, 2001). For example, in Cuba spiny lobster yields declined after the landings peaked in 1985, primarily due to intensive exploitation and negative impacts to spiny lobster habitats (Baisre, 2004; Baisre & Cruz, 1994). Unsustainable fishing practices can put this valuable marine resource at risk and threaten the livelihoods and food security of many people. For these reasons, it is necessary to responsibly manage the spiny lobster fishery in the FAO Western Central Atlantic Fishery Commission (WECAFC) region in order to ensure the sustainability of its stocks and the social and economic benefits that it provides.
The Caribbean spiny lobster is a common tropical and sub-tropical species in the Wider Caribbean Region (Cervigon et al., 1993). It inhabits shallow coastal areas, mainly associated with coral reef assemblages. Cuba’s extensive insular shelf hosts abundant coral reef, seagrass beds, and mangroves, providing suitable habitats for one of the greatest Panulirus argus stocks in the Caribbean region. The Cuban shelf is close to its maximum exploitation (Claro et al., 2001). According to the most recent regional workshop organized by the WECAFC spiny lobster ad hoc group (2006) the spiny lobster stock in Cuba is considered fully-exploited (Cochrane & Chakalall, 2001). Since the decline in Cuba of the lobster production around the mid-1980s, the Cuban Ministry of Fishery has tried to improve the economic efficiency and management of
fisheries through stricter measures and new regulations (Baisre, 2004). Nevertheless, as in many other coastal regions of Latin America and the Caribbean, a lack of resources has hindered the implementation and enforcement of these regulations (Charles et al., 2007). Though the fishery experienced a slight increase in production after these regulatory efforts, the spiny lobster stock has not yet recovered from overfishing (Cruz, 1999; Ehrhardt et al., unpub).

The prevailing oceanic currents in the Wider Caribbean Region contribute to the dispersal of those marine species with a planktonic larval stage across many national boundaries. It has been hypothesized that the spiny lobster larval recruits found in Florida originate in other waters from the Caribbean region, including Cuba, and are carried to Florida by the Gulf Stream and the Florida Current (Stockhausen et al., 2000; Claro et al., 2001a). Hence, some countries “downstream” in the oceanic current path will depend on the spawning populations located in the “upstream” countries for at least part of their recruitment (Claro et al., 2001a; Cochrane & Venema, 2001). The inter-connection of the P. argus stock or stocks by the drift of their pelagic larvae creates a strong ecological link among the countries in the region, and a need for close cooperation in the responsible management of the species (Claro et al., 2001). Therefore, a sustainable spiny lobster fishery in the Cuban waters would have a positive impact on the status of this shared marine resource on the rest of Wider Caribbean Region.

The recovery of a marine resource that is fully exploited or overexploited, such as the Caribbean spiny lobster, depends on the design of effective management strategies to achieve a responsible use of that resource. These strategies need to be based on the best available information. Having a complete understanding of the biophysical environment of the species (e.g. life history,
behavior, habitat and meteorological phenomena) is crucial but not sufficient to fully devise these management regulations. It is also necessary to understand the human and institutional components that interact, directly or indirectly, with the resource (Orbach, 1980). Only then we will be able to develop an effective fishery policy that can successfully guide or change the human behavior towards a sustainable use of that resource.

Because sustainable fisheries depend greatly on good governance, improving the management of the fisheries in Cuba is essential. The purpose of this study is to identify the three ecological subsystems (biophysical, human, and institutional) and map their interactions to establish the total ecology of the Caribbean spiny lobster (*Panulirus argus*) fishery in Cuba. This analysis will provide a better understanding of the current spiny lobster fishery management process and its shortcomings, as well as take an opportunity to make some recommendations to achieve a sustainable status at the national and regional level.

The following review examines the life history of the spiny lobster (*P. argus*) to provide information to improve the management of this resource by focusing on the protection of the most valuable life stages of this species. Second, by analyzing those environmental and oceanographic features of the Wider Caribbean Region, I present reasons to support the need for regional collaboration. Finally, to provide a full understanding of the governance of this marine

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2 Total Ecology of the coastal environments: it explains the human and non-human components of the coastal environment and their inter-relations. The later includes the biological, physical and chemical components of a coastal environment. The former has two broad sub-components: (1) the human constituencies (the people who live on, use, or otherwise are concerned in their beliefs or behaviors with the coastal environment, including the scientific community); and (2) the humans who constitute the policy and management institutions, whose decisions and actions from the policymaking process affect directly the behavior of the coastal constituencies and indirectly the non-human components of the environment (Orbach, 1995).
resource, I provide background on the political and socio-economic factors that shape the fisheries of the spiny lobster in Cuba and the rest of the region.
II. METHODS

Critical Literature Review

I conducted a thorough research and analysis of the existing literature on the three subsystems (biophysical, human, and institutional) of the ecology of the Caribbean spiny lobster fishery in Cuba.

A great deal of research and regulatory effort has been put into the recovery of the declining spiny lobster populations by the Cuban government and many other Caribbean countries. Given the economic significance of this species, many studies have been made on its life history, ecology and fisheries to ensure sustainability of the stocks and to continue/and or increase the profitability of the fisheries (Phillips, 2005; Saul, 2004). Furthermore, the large size and frequently dense populations of spiny lobsters combined with their presence in shallow waters, makes them relatively easy to study (Phillips et al., 1994; Butler IV, 2001).

Lobster biology and management of the lobster fishery in Cuba are well-documented in Cruz et al. (1990), Baisre and Cruz (1994), Cruz (1999), de León et al. (2005), Baisre (2004), Puga et al. (2005) and Piñeiro et al. (2006, 2007 and 2007a). The first descriptions of spiny lobster off the Cuban coast were made by the Portuguese Manuel Antonio Parra seventeen years before Latreille (1804) described the species Panulirus argus and Panulirus guttatus in the Atlantic (Cruz, 2003). Since then the number of scientific research pertaining to Caribbean spiny lobster in Cuba has increased along with the economic importance of the species. Information at the regional level on the assessment of the Caribbean Spiny Lobster has been collected and widely
presented at several workshops and meetings organized by FAO\textsuperscript{3} under the auspices of the Western Central Atlantic Fishery Commission (WECAFC), the Gulf and Caribbean Fisheries Institute and other international institutions.

I conducted a literature search in English- and Spanish-language publications on the most significant aspects of the Caribbean Spiny lobster ecology and fishery. When possible, I also communicated with Cuban scientists and managers to ascertain the future direction of fisheries management in Cuba, since new fishery regulations are emerging as the Cuban fishing industry changes along with the current political and socio-economic situation in Cuba. Information was gathered primarily from the most recent publications made by Cuban and international researchers in peer-reviewed scientific journals. The Cuban legislation, such as the Decree Law 164/1996 on Fishing Regulations and other ministerial resolutions, were obtained from readily available Government documents published at the “The Official Gazette” of the Republic of Cuba\textsuperscript{4}. Nongovernmental sources, including published reviews relating to management, official and unofficial publications (newspapers, popular and fishing magazines like “Mar y Pesca”) were especially helpful as secondary sources.

The total spiny lobster landings available for the entire Caribbean region including Cuba were obtained from the data recorded (from 1950-2007) on FAO Fishstat database (FAO, 2007a). This database contains capture production statistics (the volume of fish catches landed) by country or

\textsuperscript{3} FAO: Food and Agriculture Organization of the United Nations  

\textsuperscript{4} “The Official Gazette” of the Republic of Cuba is the official instrument, recognized by the constitution, of normative publicity. The Ministry of Justice is the responsible of its publication and the guardian of the gazette central archives. (URL: http://www.gacetaoficial.cu/html/que_es.html, visited on November, 2008)
territory, species item, FAO Major Fishing Area and year (FAO, 2009). In Cuba, fishery data has been recorded since 1935, but it was not available for this study. The lobster annual landings from 1935-1949 were estimated from a graphic representation of the lobster catches published by Baisre (2004). To observe the historical development of the Caribbean spiny lobster fishery in Cuba and in the entire region, a third degree polynomial trend line was added to time-series of landings using Microsoft Office Excel 2003.
III. BACKGROUND

The Caribbean spiny lobster fishery in Cuba

The most valuable target species in Cuba is the Caribbean spiny lobster (*Panulirus argus*), which accounted for approximately 17% of total near-shore catches in the period from 1996 to 2000 (Claro *et al.*, 2001; Baisre, 2004). For its high economic value *P. argus* is called in Cuba the “queen of the seas” (Carrobello & Rabassa, 2006).

The commercial exploitation of the spiny lobster probably began in the Gulf of Batabanó (southwest coast of Cuba), in the early part of the XX century (Baisre & Cruz, 1994). Currently, this same area is the most important lobster fishing area in Cuba, contributing 60% of the total national catch. The southeastern area of the Cuban shelf contributes between 20-25% of the catch, while the rest (15%-20%) is caught along the northern coast (Claro *et al.*, 2001).

The fishery has a typical pattern with two catch peaks, one immediately at the commencement of the open seasons (June) and then during the winter mass migrations (generally around November) (Baisre & Cruz, 1994). The former provides 50% of the national lobster catch.

- **Fishing gear and vessels**

There is a diversity of fishing gears in the fishery, but the principal types of gears are (See also Appendix B):

- the artificial shelters (known as pesqueros in Cuba and casitas cubanas in Mexico),

- trap-like nets (jaulones de corrida),
- the “liftable artificial shelter” (pesquero levable: several artificial shelters attached with a line that it is used to raised them out of the water).

Claro et al. (2001) and Baisre (2004) illustrate a full description and diagrams of the different gears.

According to Puga et al. (2005) there are about 143,000 artificial shelters, and about 12,200 “jaulones de corrida” traps, although it is not clear if this is at the national level or only within the Gulf of Batabanó. The artificial shelters are more commonly used in the southern coast (Cruz & Phillips, 1994). In the northern coast unbaited traps, often used in combination with the artificial shelters, are the most common type of gear (Joyce, 1997).

In several publications I found conflicting reports of the numbers of fishing vessels and fishermen in this fishery. According to Baisre (2004) there are about 1,250 fishermen and 240 vessels operating from twenty ports (eleven on the southern coast and 9 on the northern) at the national level). Also, there are divers that fish the spiny lobster in the port of Casilda, Trinidad city, in the south of Cuba (Baisre, 2004). However, information about the depth and diving or snorkeling gear these divers use is not available in the published literature. Puga in Ehrhardt et al. (unpub.) mentions that in Cuba, the number of vessels was reduced from 310 in 1980-1989 to 198 in 2007. There is either inconsistency in the data published, or these numbers are changing very rapidly. Thus, it is very difficult to have a sense of the current number of vessels and fishermen —and thus any measurement of fishing effort— in the lobster fishery in Cuba.
• Socio-economic aspects of the fishery

The spiny lobster fishery in Cuba provides employment to around 9,000 people, as represented here in the following set of tables. Table 2 represents the number of people employed in the lobster fishery (directly in the fishery and in land operations) according to Puga and de León (2003).

Table 2. Human resources associated directly and indirectly with the lobster fishery in Cuba. (Source: Puga & de León, 2003). (Note: the original source of this table did not define any of these terms. I assumed that the numbers refer to the amount of employees in each of the different sectors of the fishery. The term industry may refer to the processing plants, and workers may refer to those involved with the construction and repairs of boats and fishing gear, but it is very difficult to ascertain what working groups they actually encompass)

<table>
<thead>
<tr>
<th>Sectors of the fishery</th>
<th>Number of human resources employed per sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishermen</td>
<td>1,280</td>
</tr>
<tr>
<td>Lobster collection centers</td>
<td>253</td>
</tr>
<tr>
<td>Vessels to transport lobster and fishermen</td>
<td>144</td>
</tr>
<tr>
<td>Industry</td>
<td>1,091</td>
</tr>
<tr>
<td>Administration and Services Division</td>
<td>3,031</td>
</tr>
<tr>
<td>Workers</td>
<td>3,319</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,118</strong></td>
</tr>
</tbody>
</table>

The lobster fishery in Cuba is a very profitable activity. For example, Puga *et al.* (2005) calculated USD $9 millions of total cost for the lobster fishery in the Gulf of Batabanó for the year 2002 (Table 3). This value is very low compared with its high annual profit of USD $46
millions, equivalent to the 83% of its total revenue. Similar high returns for the entire lobster fishery in Cuba were reported by Puga & de León (2003).

Table 3. Economic results of the spiny lobster fishery in the Gulf of Batabanó for the year 2002 (Source: Puga et al., 2005).

<table>
<thead>
<tr>
<th>Economic Parameters</th>
<th>USD$ year$^{-1}$ (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>55.87</td>
</tr>
<tr>
<td>Variable cost</td>
<td>2.93</td>
</tr>
<tr>
<td>Fixed cost</td>
<td>2.91</td>
</tr>
<tr>
<td>Processing cost</td>
<td>3.63</td>
</tr>
<tr>
<td>Total cost</td>
<td>9.46</td>
</tr>
<tr>
<td><strong>Profit</strong></td>
<td>46.41</td>
</tr>
</tbody>
</table>

---

- **Exports and Market**

There are about 30 centers in the country to collect the lobster and keep them alive until they can be distributed to 9 processing plants. They then are preselected according to their quality, size and weight to be processed into different marketable products. Cuba is trying to increase the quality of the lobster products in order to obtain higher prices (Adams et al., 2000). For this the Ministry of Fishery (MIP abbreviated from Ministerio de la Industria Pesquera in Spanish) is planning an investment to improve the technological conditions in the collection centers and in the fishing gear used (Carrobello & Rabassa, 2006).

More than 60% of the catch is processed as pre-cooked whole lobsters (Puga & de León, 2003). The lobster is also marketed as whole but uncooked (31% of the total lobster landings), tails and
alive. Live lobster is the product with the highest market value. La Coloma, in the Pinar del Rio province, is the main supplier of these lobsters, which are usually held for 72 hours in a collection center in Mariel, Havana, before being sent to the airport to be distributed to the international market.

Ninety percent of the total lobster harvested in Cuba is exported to Japan, Europe and Canada, with an average price of US$ 12/kg. During the years 2000-2004, Cuba exported to the international market an annual average of 4,500 metric tons, generating around USD $70 million per year (Holmyard & Franz, 2006). This accounts for over 60% of the country’s annual income from fisheries (Puga & de León, 2003). No lobster is provided from the MIP to the Cuban population. Part of the annual export revenue is utilized for importing lower-valued fish products for local consumption (Adams et al., 2000).
IV. RESULTS AND DISCUSSION

A. Biophysical components

A.1 Wider Caribbean Region

The Caribbean spiny lobster (*Panulirus argus*) is distributed throughout the Wider Caribbean Region, from Brazil to Bermuda and North Carolina, USA (Cervigon et al., 1993). The Wider Caribbean Region as defined in the Regional Seas Program of the United Nations Environmental Program (UNEP) comprises the insular and coastal States and Territories of the Caribbean Sea, the Gulf of Mexico, and part of the northwestern Atlantic Ocean extending out to the island of Bermuda (UNEP, 1983) (Figure 2).

![Figure 2. The Wider Caribbean Region and the maritime boundaries demarcating the Exclusive Economic Zones of the States and Territories. Note: the Caribbean spiny lobster is mainly associated with the coral reefs, thus its distribution corresponds with the locations of this marine ecosystem (Source: modified from Burke & Maiden, 2004).]
The Wider Caribbean (also referred in this document as the Caribbean region) is a semi-enclosed body of water consisting of several deep basins separated by relatively shallow sills and extensive system of insular and continental shelves such as those of Belize, Cuba, and most notably The Bahamas (UNEP 2004). These wide coastal shelves and warm tropical waters create ideal conditions for the formation of significant extensions of coral reefs (e.g. the Meso-American Barrier Reef System, the second longest barrier reef in the world), seagrass beds and mangroves (Burke and Maidens, 2004). These marine ecosystems are essential habitats for the different life stages of the Caribbean spiny lobster (Cruz et al., 2001). They also support an exceptional diversity and endemcity of marine organisms.

The climate in the region is mainly tropical, with a distinct wet season around June through November and a dry season (December – May). The persistent easterly trade winds are temporarily interrupted during the period of December-February when cold fronts migrate from north to south affecting the westernmost areas of the Caribbean Sea (Heileman, 2007). During the wet season the tropical waves that move westward can develop into depressions, tropical storms, and hurricanes. A distinctive hurricane season extends from June to November, but the worst months for Cuba traditionally are September and October (two out of three hurricanes that have hit the island have landed in those months) (CubaNews, 2008). In the Caribbean region the frequency of these natural events increased three times more during the period 1995-2005 than in the previous years, with Cuba showing the highest frequency (1.09 hurricanes/year) (FAO-

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5 Essential fish habitat: means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Act, 16 U.S.C. 1801 et seq).

6 The Caribbean islands (the Bahamas, the Lesser Antilles, and the Greater Antilles) and Mesoamerica are considered as biodiversity hotspots by Conservation International (2007). Within their marine ecosystems, the level of marine endemcity is high, with nearly a quarter of the 60 species of corals and 1,500 species of fish being endemic (Heileman, 2007).
OSPESCA, 2006). The strong winds and waves associated with these meteorological phenomena have negative impacts on the coastal and marine ecosystems by causing suspension of sediments in shallow waters and breaking corals, sponges and mangroves trees (Salazar-Vallejo, 2002; Wulff, 2001; Wulff, 1995).

Strong and persistent easterly trade winds determine the continuous flow of water from east to west through the Caribbean Sea (Mahon, 2008) (Figure 3). Part of the North Brazil Current flows northwestward along the northeastern coast of South America, forming the Guiana Current when it reaches French Guiana. The Guiana Current receives other contributions to its water flow from the North Equatorial Current after it enters the Caribbean Sea through the passages between the Lesser Antilles (Smith et al., 2002). The water then continues westward as the Caribbean Current, the main surface circulation in the Caribbean Sea (Gyory et al., 2008). The currents then follow a movement from the south-east to north-west in the Yucatan Basin. In the Gulf of Mexico a clockwise flow (known as the Loop Current) joins the Yucatan Current and the Florida Current going to the east again through the Straits of Florida. Then the Florida Current, which receives waters from the Antilles Current, stretches all the way up to Cape Hatteras where it becomes the Gulf Stream.

7 For a more detailed description of the surface current patterns in the Wider Caribbean Region visit the web-based ocean current reference site: http://oceancurrents.rsmas.miami.edu/caribbean/caribbean.html
Because most of the marine plants and animals in the Caribbean have a planktonic larval phase, lasting from several weeks to more than a year, their dispersion is determined in great part by the prevailing oceanic currents (from south-east to north-west) in the Wider Caribbean Region (Stanley, 2003). These larvae could be transported long distance by the currents across different maritime boundaries, establishing ecological interconnections among different areas (Robert, 1997; Pineda et al., 2007). This has great significance for the management of these shared resources, since local populations may be affected by processes occurring elsewhere in the region. The larvae drifting in the ocean can also be retained in offshore gyres created by counter currents, meanders and eddies. Some of the conspicuous gyres in the region can be found off the coast of Nicaragua, Costa Rica, and Panama, in the Gulf of Honduras (Harborne et al., 2001), and clockwise gyres off the south of Cuba (Claro et al., 2001) and north of the Bahamas. These
oceanographic features have a significant role in the retention of larvae contributing to the recruitment of the local stocks (Ehrhardt et al., unpub.; Burke & Maidens, 2004).
A.2 Cuban shelf

• Biophysical characteristics of the Cuban marine shelf

The Republic of Cuba, the largest island in the Wider Caribbean Region, consists of the main island and many smaller islands, including the Isle of Youth (Isla de la Juventud) and 4,195 islets and keys (Nuñez-Jiménez, 1982) (Figure 4). All these islands, forming the Cuban archipelago, are located on an extensive insular shelf (67,831 Km² including all the islets and keys, and 53,126 Km² of marine area solely) (Claro, 2006). Cuban national waters are delimited in accordance with the articles of the Law of the Sea Convention, which Cuba signed in 1984, as follows:

• Territorial Sea (Decree Law 1/1977)-12 miles (from the baseline)
• Contiguous Zone (Decree Law 158/1995)-24 miles (12 miles after the territorial sea)
• Exclusive Economic Zone (Decree Law 2/1977)-200 miles (from the baseline)

Figure 4. The Cuban archipelago and its insular shelf (green color). The wider shelf areas are marked by the letters A-D. The solid line represents the boundary of the territorial waters,
and the dashed line is the boundary of the Cuban Exclusive Economic Zone. (Source: Claro, 2006).

In the Cuban shelf there are four distinctive shallow and wide areas separated by areas of narrow shelf (Figure 3). These are bordered on its outer edge by extensive stretches of fringing keys and coral reefs that protect shelf waters and restrict interactions between them and the adjacent seas. Thus, the levels of biological productivity are high inside the insular shelf compared with the poor waters of the surrounding open oceans (Joyce 1997). Because of their productivity these areas are the main fishing zones in Cuba.

- **Fishing Zones**

The Cuban shelf is divided in different zones according to their economic relevance for the fishing industry (Rey-Santos et al., 2008). These zones are defined by the Ministry of Fishery on the Decree Law 164/1996 “Fishing Regulations”. The four marine areas with shallow and wider shelves (Figure 4: Zones A, B, C and D) are designated as **zones of great economic interests**, where commercial fisheries are primarily authorized (Regulaciones Pesqueras de Cuba 164/1996). These zones represent 95% of the marine catch and almost 100% of the coastal fisheries in Cuba (Baisre, 2004). Conversely, the narrow shelf areas are **zones of lesser economic interests** and are mainly open for recreational and subsistence fisheries (Regulaciones Pesqueras de Cuba 164/1996a). Only other relevant commercial fishing activities take place in a few bays located outside the zones of great economic interests (e.g. Cienfuegos harbor, Nuevitas, and Nipe Bay) (Baisre, 2004).

Inside all these fishing areas there are also **closed zones** (Zonas de Veda) established by the Ministry of Fishery in collaboration with the Ministry of Science, Technology and the
Environment, where all fishing activity is totally prohibited in order to protect the patrimony and the natural resources (Regulaciones Pesqueras de Cuba 164/1996b). Other marine areas in Cuba are designated as **zones under special regime of use and protection** in which the fishing activities are regulated by special resolutions dictated by the Ministry of Fishery (Regulaciones Pesqueras de Cuba 164/1996c).

A brief description of the four zones of great economic interests is provided here; they appear according to their significance to the fishing industry. Greater detailed depictions of the physical and oceanographic features of these areas are presented in Claro *et al.* (2001), Baisre (2004) and Claro (2006).

i. **Southwestern region**

This region, known as the **Gulf of Batabanó (Zone B)**, goes from Cabo Francés to Playa Girón. It is not only the largest (20,850 km$^2$) but also the most economically important fishing zone in Cuba. The long reef lines, numerous keys and islets from the **Archipelago Los Canarreos** (including the Isle of Youth) bordering the Gulf of Batabanó form a massive costal shallow lagoon (with averages of only 6-7 m deep).

The coral reefs present on this archipelago, along with those in the archipelago Jardines de la Reina (in the southeastern region), although still threatened by overfishing, are among the best preserved reefs in the Caribbean region (Guinotte *et al*., 2003). With the aim of protecting these fragile ecosystems and the high biodiversity present in them, the Ministry of Fishery declared the
marine area southeast of the Zapata Swamp as a closed or “no-take zone” (Figure 5) (Regulaciones Pesqueras de Cuba 164/1996c). Other marine areas of the archipelago Los Canarreos that have great importance for the tourism industry (around Key Largo del Sur, and close to Punta Francés in the Isle of Youth) are considered as zones under special regimes of use and protection (Estrada et al., 2004). Ultimately, sustainable fisheries and tourism depend on the good preservation status of the marine and coastal ecosystems (Houck, 2003; Lindeman et al., 2003).

![Diagram of coastal areas](image)

Figure 5. Two coastal areas where fishing activities are controlled according the articles 21 and 22 of the fisheries regulations (164/1996). (Adapted from Estrada et al., 2004).

Some of the country main fishing ports (e.g. La Coloma, Batabanó and Nueva Gerona) are located on this southwestern zone of the Cuban shelf. The Gulf of Batabanó is Cuba’s major
lobster fishing ground, providing two thirds of the total national lobster catches (Claro et al., 2001). Other important fishery resources are shrimp, and some demersal (e.g. grunts, snappers, and porgies) and pelagic fishes (e.g. sardines and jacks). The great abundance of lobsters and finfishes in this zone is due to extensive complexes of seagrass, mangrove and patch reef habitats present in the Gulf of Batabanó.

ii. Southeastern region

This region (Zone A) is the second most extensive area in the Cuban shelf (18,000 km²). Along with the Gulf of Batabanó it is one of the most important fishing zones in Cuba. It extends from Cabo Cruz (on its eastern limit) to Punta de María Aguilar (on the west). This long and wide shelf, fringed by the Archipelago Jardines de la Reina, encompasses the Gulf of Guacanayabo (on the east) and the Gulf of Ana María (on the west). Along the coastal margin, both gulfs present extensive lagoons and estuaries fed by several rivers including the two largest in Cuba: the Cauto and Zaza rivers. On these typical coastal lagoons and estuaries is where the main shrimp fishery occurs. Other estuarine species (e.g. mullets and mangrove oysters), reef fishes and spiny lobster are also caught on this region. However, marine landings of these estuarine-dependent species have drastically declined over the last decade because of reduction in nutrient and sediment inputs from land-based sources due to river damming (Baisre & Arboleya, 2006).

The largest zone under special regime of use and protection (or fishery reserve) in both Cuba and in the Caribbean region was established in 1996 within the archipelago Jardines de la Reina, at Doce Leguas Keys. This fishery reserve is only accessed by the company Avalon, a public-private joint venture between the Cuban government and an Italian company, and a few
authorized Cuban lobster boats. Long distances from land (80 kilometers, or 50 miles),
government regulations and the constant vigilance of this company have provided protection to
the diverse ecosystem and marine species within the archipelago Jardines de la Reina. Recent
studies have demonstrated the effectiveness of the protection and management of this marine
area where fish abundance and size of the economically important species are higher inside this
area than in the adjacent fished areas (Partnership for Interdisciplinary Studies of Coastal
Oceans, 2008; Pina-Amargos, 2008).

iii. Northeastern region

The northeastern region (Zone D) extends along the north-central coast from Punta Hicacos to
Cayo Sabinal and encloses several macrolagoon systems with many islands, islets, and keys that
form part of the Archipelago Sabana-Camagüey. The northeastern region is the main fishing
area for finfish in the entire country, with fish landings representing 34% of the total national
finfish production and with a yield per shelf surface unit of 0.856 t/km$^2$ (Claro et al., 2001).

Zone D is the shallowest area in the Cuban shelf (average 2-3 m) which makes it very
susceptible to terrestrial runoff and vulnerable to fishing activities. The hydrology of this area
has been affected by the damming of the main rivers that flow into it. Also, the exchange
between the inshore and offshore waters has been altered and limited by the construction of
causeways to connect several keys of the Archipelago Sabana-Camagüey and with the main
island, in order to make them accessible for tourism. This has disrupted the water circulation
inside the northeastern region causing negative impacts on its macrolagoons and mangroves
ecosystems (Alcolado et al., 1999; Claro et al., 2001). Consequently, the fish biomass production
in this region has decreased (Claro et al., 2000), since these ecosystems are essential habitats for the development of juveniles of important commercial species.

iv. Northwestern region

The northwest coast (Zone C), with the narrowest shelf and smallest area, is the region delimited by Cabo San Antonio, on the west, and Punta Gobernadora on the east. It covers an area of about 3,945 km² including the Gulf of Guanahacabibes, the fringing keys and reefs of the Archipelago Los Colorados, and the Bank of Sancho Pardo. Also, spawning aggregation grounds such as Corona San Carlos, that are important for different species of snappers and groupers are found in this region. Pelagic bony fishes, sharks, and some reef fishes are the major fisheries resources of this region. The spiny lobster is also found in this zone but it is less abundant than in the other regions of the Cuban shelf, accounting for only 2-3% of the national lobster catch (Claro et al., 2001).

• Hydrological characteristics

The mean water flows off the southern and northern coasts of Cuba are westerly. This circulation pattern may contribute to the dispersal of larvae produced on Cuba’s outer reefs towards the downstream areas in Florida, USA (Claro et al., 2001b). There is also a complicated system of cyclonic and anticyclonic circulation off the southwestern Cuban shelf (Figure 6).
The occurrence of such a diverse system of eddies and gyres are important for understanding the lobster and fish recruitment processes. These recirculation systems are the main physical mechanism for the retention of eggs and larvae produced both by local spawning populations near the Cuban shelf edge and those produced “upstream” in the Caribbean region (Cruz, 1999; Claro et al., 2001). They also contribute to the transport of the spiny lobster postlarvae (pueruli) from the open ocean to the coastal waters.

Figure 6. Large-scale oceanic circulation around Cuba (Source: Claro et al., 2001).
A.3 Caribbean Spiny Lobster Ecology

The Caribbean spiny lobster (*Panulirus argus*) is a decapod crustacean in the family Palinuridae (Appendix A). It is generally agreed that the terms spiny lobster and rock lobster are interchangeable to refer to some 40 species of clawless lobsters from this family (Lipcius & Cobb, 1994), but for the purposes of this study they are considered separately. Therefore, the terms spiny lobster or lobster it is used on this document to refer to *Panulirus argus*, the Caribbean spiny lobster.

*P. argus* is a common tropical and subtropical species in the Wider Caribbean Region. The greatest spiny lobster stocks are principally located on the larger continental shelves of the region: Brazil, Honduras-Nicaragua, Belize-Mexico, Florida, the Bahamas and Cuba (Ehrhardt, 2005). During its ontogenetic development this species undergoes several habitat shifts, utilizing a variety of marine ecosystems (Phillips *et al.*, 1980; Acosta & Butler, IV 1997).

**Life History**

There are five major phases within the life cycle of the Caribbean spiny lobster (Lipcius & Cobb, 1994): (1) the adult (> 80 mm, CL), (2) eggs carried by female lobsters and released near open ocean waters, (3) planktonic and pelagic phyllosoma (with 11 larval stages), (4) puerulus (postlarval stage) which is a transitional swimming phase that goes from oceanic to neritic habitats, and (5) the juvenile phase. The juvenile phase has been further subdivided by Cruz and Bertelsen (2008) in (5a) post-puerulus or solitary juvenile algal phase that swims towards shallow seagrass habitats and settle in structurally complex algal habitats, (5b) gregarious juvenile shifting from algal to crevice shelters (rocky holes, sponges, and corals) (National
Oceanic and Atmospheric Administration, Florida Keys National Marine Sanctuary, 1996), and (5c) older juvenile or pre-recruit phase (50-79 mm CL) which migrates from the nursery grounds (nearshore hard-bottom habitats) to deeper offshore hard-bottom adult habitats.

One of the most remarkable and distinctive features of the palinurid lobsters life history involves mass migrations into deeper water locations or alongshore (Lipcius & Cobb, 1994). *P. argus* migrates in queues (single file lines with up to 64 individuals) by maintaining contact between the antennules of one individual and the anterior walking legs of another. Migration will begin after the arrival of cold fronts or hurricane as an avoidance mechanism of the physically stressful environmental conditions (severe drop in water temperature, high northerly winds of up and large sea swells) (Baisre, 2004). During this time lobsters vulnerability to fishing activity increases given that they are easier to catch outside their shelters.

Water temperature is an important abiotic factor that influences the growth, development and survival of *Panulirus argus* (Marx & Herrnkind, 1985). This species is generally found where minimum monthly water temperatures exceed 20 °C (68 °F), since optimal growth occurs in temperatures of 26 - 28°C. Rapid decline of water temperatures below 10 °C (50 °F), may cause death of postlarvae and molting lobsters (Marx and Herrnkind 1985). If water temperatures exceed 32 °C (89.6 °F) lobsters may experience rapid growth but poor survival (Aiken, 1980; Witham, 1974).
• Reproduction

Seasonality

In Cuba, the Caribbean spiny lobster reproduces throughout the year, with peaks of mating activity during June-July (Cruz & Phillips, 2000). The spawning season is more intensive during March through May, when the greatest numbers of berried females⁸ occur (Cruz & de León 1991). A secondary spawning peak takes place in September, produced by larger mature female lobsters with carapace length (CL) between 90-119 mm (Cruz & Bertelsen, 2008).

Size at first maturity

The smallest berried lobster captured in Cuba was 67 mm carapace length (Arce & deLeón, 2001). However, the size where 50% of females carry eggs (size at onset breeding, also known as size at first maturity) varied from 79 to 81 mm CL in the Cuban shelf. “Knowledge of the size at onset breeding is important for determining the percentage of females which contribute eggs to the population pool (Cruz & Bertelsen, 2008).”

Cruz and Bertelsen (2008) present convincing evidence that larger lobsters are the most reproductively important individuals. Larger females produce more clutches per breeding season showing that female fecundity is a function of the carapace length. These larger females also may have multiple spawning, producing at least two broods separated by three or four weeks. Larger males are capable of mating more often, with more females and produce larger spermatophores than smaller males which may increase fertilization rates (MacDiarmid & Butler

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⁸ Berried females: females bearing fertilized eggs (characterized by a bright orange color) adhere to hook-like setae of the pleopods located on the lobster abdomen.
Therefore, the protection of these large individuals is necessary in order to have a positive impact on the reproductive output of the lobster stock.

• **Larval dispersal and recruitment**

Spiny lobster is a marine resource with transboundary\(^9\) larval dispersal (Munro *et al.*, 2004). During a period of 6 to 10 months the planktonic larvae are transported by the oceanic currents from the spawning areas to the settlement habitats (Figure 2). These sites are not necessarily in the same marine shelf or country. Because of the long duration of this larval phase and the current flows on the Caribbean region, many lobster populations may serve as source of larvae for other areas (Cochrane & Chakalall, 2001).

This mix of larvae from different origins contributes to the theory of a pan-Caribbean lobster population. This has been supported by studies of the genetic structure of *P. argus*, which have demonstrated a high level of gene flow among different sites (Venezuela, Panama, Bermuda) inside the Caribbean region (Silberman & Walsh, 1994). Genetic diversity equivalent to that expected between species or subspecies has only been found between Brazil and the rest of the Caribbean region (Sarver *et al.*, 1998). Although there is high likelihood that these are two biologically distinct stocks, still there is a lack of genetic heterogeneity and therefore of lobster population subdivisions inside the single wider Caribbean stock (Cochrane *et al.*, 2004). This has

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\(^9\) The FAO definition of shared fish stocks includes all fish stocks that cross the boundaries of a costal state EEZ into neighboring EEZs and/or adjacent high seas, along with those stocks found exclusively on the high seas (Munro *et al.*, 2004). Among the shared stocks, *Panulirus argus* is considered as a Transboundary Stocks since its larvae cross the EEZ boundary of one coastal state into the EEZ of one, or more, other coastal states (considering that most of the Caribbean region is basically covered by numerous EEZs and small areas international waters can be found).
implications for the management of the lobster population at the regional level, since any action in the waters of one country may have consequences on the lobsters of other Caribbean nations.

The arrival of puerulii to the coastal regions in the Caribbean occurs throughout the year, although with a variable pattern in different geographic areas. For example, in the Cuban archipelago and the Mexican Caribbean a larger peak of pueruli settlement have been observed in October, but in the Florida Keys the recruitment is concentrated in February-March (Cruz & Bertelsen, 2008).

The puerulii become juveniles settling into shallow nursery areas for the next 6-8 months. Then the juveniles move away from the nursery grounds towards deeper hard-bottom areas closer to the edge of the shelf, eventually recruiting to the adult habitats (lobster fishing grounds). This juvenile pre-recruit phase is found in the adult habitats in Cuba with a mean size of 76.8 mm CL, mainly during March-May. Because the fishing season in Cuba opens in June, right after recruitment, and because of the high exploitation rates that have decimated the larger adult lobsters, most of the lobster landings are made up of new recruits (Baisre & Cruz, 1994). Therefore, the recruitment process plays a prevailing role on the annual production of the spiny lobster fisheries (Ehrhardt et al., unpub.).

The success of the recruitment process is limited in part by the availability of suitable nursery habitats (Lipcius & Cobb 1994; Butler IV et al. 2005). Some of the main factors that are negatively impacting the lobster recruitment habitats in Cuba include:
- reduction of natural runoff and nutrients inputs from land-based sources in the coastal waters due to river damming affecting the productivity of the habitats (Baisre & Arboleya, 2006; Baisre, 2006). There may also be associated changes in salinity that affect the lobster larvae and their prey (Ehrhardt et al. unpub.).

- changes in the habitat structure by the impact of major hurricanes (Cruz & Baisre 1994; Wulff, 1995; Salazar-Vallejo, 2002). Blanco (2007) reported the detachment and washed off to shore of many sponges after the passage of the category four hurricanes Michelle, Lili and Isidore in 2001 and 2002.

- coastal zone development and pollution causing loss and degradation of seagrass beds (Arias-Schreiber et al., 2008; Sarver et al., 1998; Sarver et al., 2000; Silberman et al. 1994), mangroves, and coral reefs (Claro et al., 2001).

- overfishing and use of destructive fishing gear are threatening two thirds of Cuba’s coral reefs (Burke & Maidens, 2004).

Recruitment could be also affected by an overexploitation of the parental stock. The adult lobster population (spawning biomass) could be reduced to the point that the number and size of the individuals left will not have the reproductive capacity to replenish itself (recruitment overfishing), hence threatening the continued existence of the resource and the fishery (Lobsterconservation.com). Therefore, when seeking to sustain viable and profitable fisheries it is crucial to implement a combination of management regulations that protect the inshore nursery habitats and the spawning population (Ehrhardt et al., unpub.).
B. Human Components

The human components of the fisheries go beyond the people who catch the fish (Orbach, 1980; Bavinck et al., 2005). The processing, distribution and consumption of the seafood products caught by the fishermen interconnect many other individuals with the fishing activities (Thorpe et al., 2005). There are also those who build and repair boats and fishing gear. Even the families of the fishermen and the community where they live are also influenced by the fisheries. When other users of the natural resource and the marine environment (e.g. divers, recreational fishermen and scientists) are also considered, the list is large and the interactions among the users are extremely complex.

In order to continue to derive social and economic benefits from the marine ecosystem, fisheries depend on a healthy stock of the resource it is exploiting. This requires a sustainable management of the fishing activities, which means changing, organizing and regulating the human interactions with the fisheries (Thorpe et al., 2005). Hence, any changes in the fisheries, through management or otherwise, will affect the fishermen and just about anyone who influences and has a stake in the various processes that take fish from their ecosystems all the way to consumption (Orbach, 1980). For this reason it is necessary to recognize the different human components and understand their behaviors, as well as the socio-economic and political context in which their interactions with the fisheries take place.

This section is an attempt to identify some of the main human components of the lobster fishery in Cuba. Some general figures of the human components are presented in the overview of the
lobster fishery in Cuba described in the background section (e.g. number of fishermen and indirect jobs provided by the fishery) (Table 2). In comparison to the literature found regarding the biological and institutional components, very few studies were found describing at least some characteristics of the lobster-fishing communities in Cuba. The following discussion is limited to the fishermen lobster fishery in Cuba and the consumers, as well as some of the dynamic interactions among them.

- **Commercial fishermen**

About 1,250 lobster fishermen work for commercial fleets that are owned and controlled by the Cuban government (Baisre, 2004). These fishing fleets, depending on where they fish, are grouped inside 15 provincial fishing associations around the Cuban coast, (Adams et al., 2000). Some of the most important lobster-fishing communities La Coloma, Batabanó and Gerona are located inside the most productive fishing zone, the Gulf of Batabanó.

A study of the coastal communities in the south of Pinar del Río was recently conducted by Piñeiro et al. (2007 a). These authors describe that the low density population of these communities is concentrated in small towns and coastal settlements in proximity to the fishing ports, where the lobster fishery is the main economic activity. Recent changes in the duration of the closed season (a lengthening from 3 to 5 months) had negative impacts on the economy and social behavior of this coastal area. A reduction on the number of fishing days affected the total income received by the lobster fishermen. Consequently, the profits in those communities decreased during the months when the fishery used to take place. This may have contributed to worsen the already limited quality of life that characterized these communities, consequently
contributors to the migration problem already observed in these coastal residents - who move to
the capital of Pinar del Rio province in search of other alternatives to improve their livelihoods (Piñeiro
et al., 2007a). These authors also suggested that the negative economic impact caused
by this fishery management decision may create an incentive for the illegal fishing of lobsters in
the area. This chain of events indicates certain economic dependence of these communities on
the lobster commercial fishing. The degree of this dependence needs to be determined in future
studies.

According to Piñeiro et al. (2007a) these coastal communities do not have a clear understanding
of the interactions that exist between the lobster population and the other components of the
coastal and marine ecosystems. In addition, they do not fully comprehend the fragility of these
ecosystems. For these reasons they do not realize that human activities to the other elements of
the ecosystem (e.g. cutting mangroves and pollution) have an impact on the status of the lobster
population and consequently on their economies. These authors recommended to increase the
environmental awareness of these coastal communities as well as to identify their needs and
interests.

The reports describing the socio-economic aspects of the fisheries do not include any description
of the demographic characteristics of the lobster fishermen. Joyce (1997) mentions that the
Ministry of Fishery officials have become concerned about the age of the fishermen and are
attempting to attract young people to this industry, implying that they are of advanced age.
However, no explanations were presented on why the lobster fishery is not being considered by
the younger generation as a livelihood. The mechanisms through which new fishermen are recruited to the lobster fishery are also not reported.

There used to be conflicts among lobster fishermen, from different provincial fishing associations, that shared an extensive fishing area (Baisre 2000, 2004). The artificial shelters and traps set up by a group of fishermen were harvested by others, thus increasing the effort and cost of the first group. Such inter-vessel competition was reduced by establishing a spatial division of the fishing zones and allocating exclusive territorial rights\(^\text{10}\) (concessions) to each provincial fishing association (Figure 7a) (Baisre, 2004) Then an association subdivided its allocated territory among its fishing fleets (Figure 7b). No further conflicts have been reported after the implementation of this allocation system. Neither have interactions with other users of the same marine areas (e.g. finfish fishermen and tourism). Information on the mechanisms used to enforce this territorial division and the role the lobster fishermen play on it should be further researched and if proof to be that effective it could be used as example in other countries.

\(^{10}\) The exclusive fishing territories in Cuba were not allocated based on a ministerial resolution therefore they were established by an act of fact and not by an act of rights. The division of the exclusive territories were negotiated first among the conflicting fishing fleets that shared an extensive fishing grounds, and then among the provincial fishing associations (Baisre, 2004).
Figure. 7. Territorial division of the lobster fishery into exclusive fishing zones and subzones, in the Cuban shelf (a), and inside the Gulf of Batabanó, Zone B (b). The main fishing associations are represented with a black dot. (Source: (a) Adapted from Joyce, 1997; (b) Adapted from Baisre, 2004).
Consumers

Fisheries are conditioned by the socio-economic and political context where they take place (García & Graigner, 2005). The consumer group of the lobster fishery in Cuba is determined by the market of the lobster products and by group of people with different economic backgrounds.

In Cuba 90% of the lobster is exported to the international market and the other 10% is sent to the tourism sector (Puga & de León, 2003). Therefore, there is no lobster supplied to the local market. This creates a high internal demand for the lobster products.

This high demand, along with the high value paid for spiny lobster products by Cubans and by tourists, stimulates an illegal lobster fishery. During March, 2009 the price of a lobster tail in the black market was about CUC $2 or USD $2.16 (several sources, personal communication), while the restaurant prices vary between USD $20-$35. Even when the tourists can afford eating lobster at these high prices, they would obviously prefer to pay for the illegal lobster that is ten times less expensive.

The average salary in Cuba is $20 a month. Thus, an average Cuban worker would not be able to afford buying lobsters at the price that it is currently sold in the tourism facilities. Selling

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11 On March 2008 President Raul Castro's government lifted the ban on Cubans staying at resort hotels reserved exclusively for foreigners (Reuters). Before this date Cubans did not have access to the places where lobster was legally sold.
12 Cuban Convertible Peso (CUC). CUC $1.00 = USD $1.08, and Cuban Peso $1 = 1/24 of a CUC. The exchange rate for the Cuban Convertible Peso was last updated on April 17, 2009 from The International Monetary Fund.
illegal lobsters also provides an additional source of income that could supplement the monthly fixed salary of an average Cuban.

While in my research I did not find any records of the number of illegally harvested lobsters, illegal fishing is a common activity in Cuba (Figure 2).

Figure 2. Illegal fishermen in the Gulf of Batabanó, caught by the fishing inspector who is ordering them to remove the gear (jaulon) out of the water and return to shore. (Source: Fuentes-Rodriguez, 2008).

There are also other factors that contribute to this illegal activity. Both private and recreational lobster fisheries are totally prohibited (Joyce, 1997); fishing licenses for lobster is only given to the commercial fleets. The lobster is a resource of relative easy access. It can be found in shallow waters and close to shore facilitating the access, either by small boats or by swimming with snorkeling gear from the coast. It is also requires simple and inexpensive fishing gears (e.g. hooks or traps).
Surveillance and monitoring of the illegal fishing activities in the extensive Cuban shelf is not an easy task, especially with the limited resources that the Fishing Inspection Office has (Fuentes-Rodriguez, 2008). I could not ascertain the current sanctions for those individuals that are caught by the authorities fishing lobster illegally. Usually the fees are based in Cuban Pesos (the currency in which the Cuban workers get paid their salaries). If they are not high enough then they are not acting as a disincentive, because an illegal fisherman can return to the water and catch a few more lobsters to compensate this loss.
C. Institutional

Fisheries Policy in Cuba

According to the Cuban socialist system, the State (Cuban government) organizes agencies and institutions to be in charge of administering the means of production. The Ministry of Fishery is the Government agency that since 1975 has been totally responsible for all fisheries policy, planning, management, regulation, and production\textsuperscript{15} (Joyce, 1997). Thus, the Cuban state-owned fisheries are managed under a fairly high centralized system, different from what occurs in most of other countries (Adams \textit{et al}., 2000; Claro \textit{et al}., 2001)

\begin{itemize}
  \item Contribute to the national food security by providing a constant supply of seafood with good quality and at an attainable price for the Cuban population.
  \item Obtain revenues by exporting highly valued fisheries resources to the international market.
\end{itemize}

Achieving a sustainable exploitation of the marine fisheries resources is among the premises of the Cuban fishery strategy. However, Cuba mentioned at the regional workshop FAO-OSPESCA (2006) that a sustainable fishery of the already limited marine resources in the Cuban shelf would not provide a significant increase on the catch levels. Consequently, the MIP is considering the development of aquaculture (on land and at sea) as the main and quickest

\textsuperscript{15} During the elaboration of the current document (on March 2, 2009) there was in Cuba a reorganization of the agencies that are under the Cuban Central State Administration. Among these changes the Ministry of Fishery was merged with the Ministry of the Food Industry and a new minister was appointed -María del Carmen Concepción González. (http://www.granma.cu/ingles/2009/march/lun2/10cambio-i.html). Every aspect related to the Ministry of Fishery reflected on this document refers then at the period previous this modification.
possible solution to increase the fishery production of highly valued seafood for the international market as well as freshwater products for the national market.

b) Legal Framework

Considering these objectives and as a response to the crisis that Cuban marine fishery resources were facing since the end of the 1980s, a new regulatory framework for “Fisheries Regulations” (Decree Law 164) (Regulaciones Pesqueras de Cuba 164/1996d) went into effect in 1996. This new set of regulations were created in order to replace the previous set of fisheries regulations established in 1936, which had become outdated with respect to the current situation of the fishing industry. The Decree Law 164/1996, which still governs the fishing activities in the country, encloses the main management rules to achieve an economically sustainable exploitation of the marine resources. Some of the new features and resolutions incorporated in this document include:

• Creation of a broader judicial mandate for fisheries management.
• Introduction of fisheries licensing procedures for commercial, recreational, and research purposes.
• Adoption of measures to protect threatened and endangered marine species such as sea turtles, manatees, and black coral.
• Introduction and enforcement of system of fines and penalties to ensure sustainable use of fisheries resources.
• Increased monitoring and enforcement of marine resource conservation.
c) Management Structure

As mentioned before, the Ministry of Fishery is the maximum authority that controls all the aspects of the fisheries in the Cuban national jurisdictional waters, including the 12 miles of territorial sea and the 200 miles of EEZ. The MIP is in charge of harvesting, processing, marketing, and construction and repair of vessels. In addition, carrying out research and the conservation of the fishing resources are also among its functions. This poses a major concern regarding conflict of interest related to management (Adams et al., 2000). Both production by the industry as well as conservation of the resource are being controlled by the same entity, raising the specter of overemphasis of production at the expense of sustainability (Claro et al., 2001).

Before 1995, the Ministry of Fishery and its excessive number of subordinate enterprises and management entities were vertically integrated, which affected every aspect of the fisheries administrative process. Then, in 1996, as a response to the fisheries crisis, the Ministry of Fishery went through a restructure to strengthen its links with the fisheries production units, and to consequently improve the economic efficiency of the fisheries through better management and sustainable use of the fisheries resources.

In the new MIP’s structure the Fishing Regulations Division, the Fishing Inspection Office, and the provincial units (called Fishing Associations, one on each province) were introduced (Figure 8). The Fishing Associations were created for the purpose of bringing decision-making and responsibility closer to the point of production (Adams et al., 2000). This was an attempt to decentralize the day-to-day operations of the harvesting sector leaving the MIP then, in charge of the
legal and regulatory activities (e.g., government functions, enforcement, and stock assessment) (Diaz-Fernandez, 2006).

![Diagram of the Cuban Ministry of Fishery](Image)

**Figure 8. New structure of the Cuban Ministry of Fishery.** (Source: Adams et al. (2002)). Note: Marked with a dotted blue line are the newly created institutions, which have an important role in the fishery management process. (CIP: Fishing Research Center; ONIP: Fishing Inspection Office).

**d) Policy-making and implementation process**

For the process of developing detailed rules and regulations an **Advisory Commission on Fishing** (ACF) was established by the Decree Law 164. This ACF is the maximum advisory and consultation entity for the Minister of Fishery before he approves or establishes any specific fisheries regulations (Regulaciones Pesqueras de Cuba 164/1996e).
I found little literature referring to the ACF’s meeting and working process. The information presented here was mainly derived from the ministerial resolutions published on the Cuban Official Gazette, and from the description provided by Adams et al. (2000).

The permanent members and permanent guests of this Advisory Commission are appointed by the Minister of Fishery. On the Decree Law 164/1996, article 9, it is mentioned that experienced commercial and recreational fishermen, as well as different representatives from the Ministry of Fishery, Ministry of Science, Technology, and the Environment, University research centers, and other sectors involved in the management, use, and exploitation of the coastal zone (e.g., Tourism, Mining, Agriculture and Navy) will be part of the Advisory Commission. But in the most recent legal resolution (106/2007) about the reorganization of the ACF, published by the Minister of Fishery, the fishermen are not included either as permanent members or as permanent guests on this commission. This leaves out one of the most important stakeholders’ opinions that should be considered when establishing any fishing regulation, especially because the rules will have direct impact on the fishermen.

To ensure regulatory control and compliance with these measures, the MIP created the National Fishing Inspection Office (ONIP in Spanish: Oficina Nacional de Inspección Pesquera). Its mission is to enforce the conservation and rational use of aquatic resources within Cuba's commercial zone, territorial seas, and inland waters. For example, each Fishing Inspection provincial office is in charge of emitting the fishing license for commercial and sport/recreational fishery, controlling in this way the entrance to the fishery (Adams et al., 2000).
Puga & de León (2003) describes the policy-making process (Figure 9) for the establishment, implementation and control of the fisheries regulation as follows:

- The Fisheries Research Center (the scientific branch of the MIP) obtains the landing data and samples of some target species from the “Catch Bureau”—small groups of specialists that collect the biological information from the provincial Fishing Associations (the productive branch). Based on their studies, the Fisheries Research Center proposes the fisheries regulations.

- These are analyzed by the Advisory Commission on Fishing. They can make recommendations to the Fisheries Research Center so they can improve the fishing regulations. Once the ACF has analyzed and approved these regulations, submits them to the Minister of Fishery.

- Finally, the regulations are approved by the Minister of Fishery.

- The Division of Fishing Regulations implements them.

- The control and enforcement is then carried out by the Fishing Inspection Office (ONIP).
The Fishing Associations in each province are also responsible for the control and enforcement of the fishing regulations established by the MIP. They should ensure the compliance of closed season, size limits, and control the number of vessels. These provincial Fishing Associations are also responsible for producing seafood products landings in compliance with the species-specific harvest plans. According to Adams et al. (2002) these plans are developed by the associations themselves, then consulted and approved with the Executive Board of the MIP. However, from recent personal communication with a Cuban source, a different process takes place to develop the harvest plans. The MIP is the organization determining an annual total allowable catch (TAC) of the harvest plans and it is in charge of assigning specific quotas from this TAC to each provincial fishing association. These quotas are then further subdivided and assigned to the fishing vessels that operate inside the provincial association fishing zone. I also inquired to other
sources in Cuba about the existence of Fisheries Management Plans, such as the ones in the United States produced under the Magnuson-Stevens Fishery Conservation and Management Act, or similar documents reflecting the necessary information pertaining to a particular fishery (e.g. management goals and recommended management actions, status of the relevant fish stocks, fishery habitat, socio-economic impact, and user conflict), but no responses were transmitted to me.

The general public is informed of MIP’s decisions on any specific measure (e.g. resolutions indicating the restriction of fishing gear (López Valdés, 2008) and closed seasons (López Valdés, 2008a) through the publication of these fisheries regulations in the Republic of Cuba “Official Gazette” (La Gaceta Oficial). During my research I found no information regarding whether the annual harvest plans or the fishing regulations are open for public comment before they are finally approved and implemented by the MIP.
D. Status of the Caribbean Spiny Lobster Fishery in Cuba

The status of the Caribbean spiny lobster stock and the fishery exploiting this resource in Cuba are presented in the following section. This analysis considers the main biophysical and anthropogenic factors that determine the current condition of the lobster population, as well as the political, social, and economic forces that have driven the development of the lobster fishery in Cuba over the past seventy years.

- Status of the lobster fishery in Cuba

The historical as well as the present state of a fishery may be diagnosed by using long time series of data that will allow for observation any marked changes in landings with time (Grainger and Garcia 1996). The evolution of the spiny lobster fishery in Cuba over the past seven decades (1935-2007) is represented in Figure 8. This fishery experienced a rapid growth, during the mid 1950s through the 1980s, and a consistent decline since 1990 until the present. The historical development of the *P. argus* fishery in Cuba follows the expected generalized fishery development model described by Caddy (1984), with a typical “boom and bust” character.
Figure 10. Historical trend of *P. argus* annual landings in Cuba (1935-2007).

Before 1955 the spiny lobster fishery in Cuba was undeveloped, and characterized by landings of 1,000 t per year or less. A progressive change in fishing gear, from bully nets and Antillean S-traps (Appendix B) to more efficient ones (e.g. trap-like nets “jaulones”, artificial shelters “pesqueros” and gillnets “chinchorro langostero”) caused an increase in the lobster landings from 1955-1965 (Baisre, 2004). During this time there was also an increase in the fishing effort in the lobster fishery driven by higher demand and prices in the international market (Baisre & Cruz, 1994). This development phase of the fishery continued through 1977, with mean annual catches around 9,000 t.
In addition to the efficiency advances in fishing gear, two other factors influenced the rapid increase of landings during the 1960s and 1970s. The lobster fishery was open for more days, as a consequence of a reduction of the closed season to 45 days, and large quantities of undersized lobsters (<69 mm) were landed, principally in the Gulf of Batabánó. In contrast to the positive impact this may have had on the fishery production, these two factors negatively affected the lobster population causing growth overfishing (Baisre & Cruz, 1994). This effect was reflected by severe drops of the lobster landings in 1970 and 1977 following the highest catches of 1969 and 1976, respectively (Figure 10).

After 1977, there was an attempt to improve the management of the lobster fishery by lengthening the closed season to 90 days and enforcing the minimum legal size (69 mm) (Baisre, 2004). These regulatory measures caused a change in the mean size at first capture with a consequent gradual increase in the landings. Thus, during 1985-1989 the lobster fishery reached a mature phase with maximum yields of 12,210 t (five year average) (Baisre 2000).

In 1990 the lobster fishery collapsed (Figure 8) due to a very poor recruitment (Baisre & Cruz, 1994). Puga et al. (1992) explains that hurricane Gilbert (1988) most likely affected the lobster nursery grounds of the Gulf of Batabánó causing an increase in the mortality of juveniles. Besides the negative impact of this natural meteorological event on the recruits, Cruz (1999) argues that the intensive exploitation during the 1980s caused a recruitment overfishing of the lobster population. A further analysis of the minimum legal size (MLS) that was in place during that time supports the latter argument. Analyzing the curves of retention of ovigerous female
spiny lobsters presented by Cruz and Bertelsen (2008) (Appendix C) for the south of Cuba, it can be estimated that with a carapace length of 69 mm around 10% to 20% of the females carry eggs. This indicates that during all the years the Cuban lobster fishery followed this measure as the MLS limit, the spawning stock was most likely fished to a point that it did not have the reproductive capacity to replenish itself and to compensate for the loss caused by the fisheries (i.e. recruitment overfishing).

However, it is important to consider that annual landings are not only a reflection of the abundance of the resource, but also of the fishing effort. Fuel supply and other resources necessary for the operations of Cuban fishing fleets, especially by the distant water fleet, were limited after the collapse of the Soviet Union and the tightening of the United States blockade regulations against Cuba in 1990 (Adams et al., 2000, Diaz-Fernandez, 2006). Despite the fact that the lobster fishery in Cuba takes place in waters relatively close to shore and presumably requires less fuel than the distant water fleet, it is likely that this fishery could have also been affected during Cuba’s economic crisis after 1990. Although this possible cause-effect relation is not reported on the literature reviewed, the graphs presented by Puga and de León (2003) show a reduction of the fishing effort during 1990 for the Southwestern and Northern fishing zones (Appendix C).

The fisheries slightly increased in 1991 (from 7,957 t to 9,887 t) and remained relatively stable until 1999 with an average of 9,387 t. However, after the violation of the closed season during

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16 In August 1990 the Cuban government announced the implementation of the "Special Period in Peacetime" (período especial en tiempo de paz), a series of contingency plans conceived originally for use during a time of war. The período especial established a framework within which to implement a new series of austerity measures and new rationing schedules to meet the worsening economic crisis. Since Cuba lost aid and trade from the Soviet Union, it also became more vulnerable to the restrictions imposed by the U. S. embargo (Perez, 1995).
1999 and 2000, the landings declined again to approximately 7,478 t. During 1999 and 2000 Cuba was still facing an economic crisis. Because of the high market value of the lobster, an increase in its production (by fishing during the entire year) may have been considered as a quick solution to obtain revenues in order to support the ailing national economy.

Since 2000 the landings have experienced a continuous decline. Currently, the lobster fishery experiences a noticeable 61% decrease of the landings, as observed in the 4,778 t produced in 2007. A similar downward trend, from the mid-1990s to the mid-2000s, has been reported for the main spiny lobster fisheries in the Caribbean region (e.g. a 50% decline in Florida and 28% in the Bahamas) (Ehrhardt et al., unpub.). This may indicate that these fisheries along with the Cuban fishery have reached the senescent phase of fishery development.

• **Status of the resource**

Baisre (2000 and 2004) listed the spiny lobster in Cuba as a resource with a high risk to be overexploited. Puga and de León (2003) remarked the independency of the catch levels declines from the fishing effort during 1995-2001, suggesting that the lobster population is declining.

The most recent information on the status of *P. argus* across the Caribbean region is that reported by the Western Central Atlantic Fishery Commission Lobster Group in FAO (FAO-Western Central Atlantic Fishery Commission, 2007). Based on the best available information, this group estimated that the lobster population in Cuba is fully-exploited. Although within this report it is recognized that the lobster population in Cuba is showing signs of decline, the
consideration of a fully-exploited status is in discrepancy with the current senescent state of the lobster fishery in Cuba.

The term fully-exploited suggests that current catches are sustainable and close to optimum levels (the definition of which may vary between fisheries, e.g. catches are close to maximum sustainable yield -MSY) (Lawrence, 1989; Bureau of Resource Sciences, 1998; FAO 2009a). Although no MSY values or any other optimal level were found in the literature reviewed during the present research, it is evident that the lobster fishery in Cuba has been consistently producing less than their historical maximum production level since 1990 (Figure 10). This suggests that the status of the lobster stock in Cuba may be overexploited.

The assessment of fish stocks could be hindered by the difficulties of conducting direct surveys counts and estimating relative abundance indices (Walters & Pearce, 1996). However, efforts need to be increased to collect the necessary information in order to provide accurate and reliable estimates on the status of the resource.
E. Current management and implications for the sustainability of the spiny lobster fishery

The goal of fishery management is to achieve sustainable exploitation of a resource for social and economic benefits (Phillips et al., 1994). Exploitation will be sustainable only if certain biological features of the stock are maintained within limits that allow sufficient growth and reproductive capacity to provide adequate recruitment to the fishery each year (Chubb, 1994). In this section I present the current management regulations of the lobster fishery in Cuba, and analyze their effectiveness in achieving the sustainability criteria proposed by Ehrhardt et al. (2005).

Ehrhardt et al. (2005) summarizes four characteristics of the Caribbean spiny lobster fisheries for the entire region that are fundamental to consider when planning their sustainable management:

- significant environmental effects on recruitment success;
- high-valued open-access fisheries with limited enforcement capabilities that lead to gross exploitation of sublegal lobster sizes;
- interactive fishing effort units;
- regional stock mixing that does not allow definitions of units of stock.

These authors also identified some of the major problems associated with these characteristics (Table 4). In addition, they proposed several sustainability criteria (Table 5) that if followed, could lead to a more effective sustainable use of the resources both locally as well as regionally.
Table 4. Problems affecting the sustainability of the Caribbean spiny lobster fisheries including their causes and effects (Source: Ehrhardt et al., 2005).

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Significant changes observed in inter annual landings.</td>
<td>Significant changes in the abundance of the stock due to over exploitation and/or changes in recruitment success.</td>
<td>Unemployment and economic losses to the sector during periods of low abundance. Excess of fishing effort during the seasons with greatest abundance.</td>
</tr>
<tr>
<td>2. Low catch per unit of effort at higher levels of effort.</td>
<td>Excessive fishing competition (increased interaction among fishing effort units at higher levels of fishing effort).</td>
<td>Lost rent to the fishing sector and increases in the cost of the raw material to the processing and marketing sectors.</td>
</tr>
<tr>
<td>3. Interaction among fishing gear types.</td>
<td>Lack of balanced growth among competitive fishing gear types or users due to inappropriate fishery management policy development and implementation.</td>
<td>Degradation of the optimum use of the resources as a consequence of the race for fishing. Severe social conflicts created by the excess of competition.</td>
</tr>
<tr>
<td>4. Lack of balanced economic and social growth in the fishing sector.</td>
<td>High value of products in the export market encourages participation and race for fishing. Lack of political will to properly manage the situation.</td>
<td>Lack of adequate economic and social development of fishery communities.</td>
</tr>
</tbody>
</table>

As it has been described in previous sections, the spiny lobster fishery in Cuba has faced many of these problems (e.g. changes in landings due to excess of fishing effort, growth and recruitment overfishing, and illegal fishery), that caused the collapse of the fishery in 1990. In response to this crisis and with the aim to obtain the maximum economic benefits of this high-prized fishery resource, the Cuban Ministry of Fishery has modified the fisheries regulations and increased research to improve the management of this resource.
A single management regulation may have impacts in several aspects of the fishery and thus it could be used to achieve more than one sustainability criteria. To avoid repetitiveness, I fully explain the characteristics of a management regulation the first time that is mentioned.

Table 5. General sustainability criteria proposed by Ehrhardt et al. (2005) that may apply to the Caribbean spiny lobster fisheries.

**Sustainability Criteria**

1. Fishing capacity\(^{17}\) regulated to optimized raw material (catch) costs

2. Protection of sublegal lobster sizes.

3. Fishery management considers regional and national stock abundance as impacted by ecosystem regime shifts that are implicit elements in the spiny lobster population dynamics.

4. Maintain a fishery information and statistical database to support scientific and technical research to support fishery management decisions.

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1. **Fishing capacity regulated to optimized raw material (catch) costs**

Considering that the spiny lobster stock in Cuba is at least fully-exploited, special attention needs to be put towards controlling the fishing effort. An increase of fishing pressure over a limited resource that is already being fully-exploited, may lead to overfishing of the resource and consequently to a fishery that is economically no viable (Pope, 2002). The control of the fishing effort was also an urgent measure recommended by the WECAFC, especially to those countries (e.g. Nicaragua, Dominican Republic, and Turks and Caicos) where the lobster fishery is still open-access (Cochrane & Chakalall, 2001).

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\(^{17}\) Fishing capacity: the amount of fishing effort that a fishing boat, or a fleet of fishing boats, could exert if utilized to its/their full potential (http://www.afma.gov.au/information/publications/corporate/annual/ar99_00/glossary.htm).
In Cuba, access to the lobster fishery is limited. All commercial fisheries in Cuba are under a State property regime which gives the Cuban government ownership and total control over every aspect of the fishery, including who may enter. This is accomplished through a fishing authorization system (concessions, licenses, and permits) granted by the Fishing Inspection Office to Cuban citizens, according to what is stipulated in Chapter III of the Decree Law 164/1996 (Regulaciones Pesqueras de Cuba Decreto Ley 164/1996d). In the particular case of the spiny lobster fishery, the Ministry of Fishery prohibits both private and recreational fisheries (Joyce, 1997). Hence, this fishery only takes place at the commercial level, with the government controlling the number of vessels and fishermen present in each fishing associations. Every vessel requires a fishing license for lobster, which has to be renewed every year (Baisre, 2004).

A measure that has been crucial for the management of the lobster fishery is the allocation of exclusive territorial rights (previously discussed in the Human Component section). Within each subzone a specified number of vessels, organized into small fleets, fish and deliver their catch to a storage center. This prevents fishermen from running long distances and from spending more time and fuel, to go to their preferred fishing areas (Joyce, 1997; Baisre, 2004). Besides reducing cost, the allocation of exclusive fishing zones also protects lobsters stocks by avoiding an overconcentration of vessels from several ports in areas of relative abundance (Joyce, 1997).

In general, the division of the fishing territories has provided the structure for the organization of every aspect of this fishing activity. The total allowable catch is divided among the fishing associations, who then allocate the assigned quotas to their fishing fleets (see also section C). The exclusive fishing territories also facilitates the collection of statistical data of the fishery
(catch and fishing effort), sample of biological parameters of the resource (size and reproductive stage), as well as measurement of abiotic factors (e.g. water temperature, currents and water quality) (Basire, 2004).

A closed season it is also a management tool that helps control the fishing effort (Hall, 2002). With a recent increase of the closed season from three to five months (Lopez Valdes, 2008), the number of fishing days was reduced in the Cuban shelf. Nevertheless, a closed season does not diminish the race to fish\(^\text{\footnote{Fish refers to all invertebrates, shellfish and aquatic organism that can be harvested.}}\) since the fishermen will rush to catch as many lobsters as possible as soon as the season opens. This has been indicated by the strong seasonality in the catches of \(P. \textit{argus}\). Historically, the highest volumes of lobster occurred in June, right after the closed season ended (Baisre & Cruz, 1994). Additionally, this increase in the length of the closed season had negative socio-economic impacts on the fishing communities of the western coastal zone\(^\text{\footnote{The study area was a coastal zone in the south of Pinar del Rio, from Ensenada de Bacunaguas to Albufera de Cortes.}}\) of the Gulf of Batabanó (Piñeiro \textit{et al.}, 2007, see section B: Human Components).

However, after considering all these aspects related to the fishing effort, an important question still needs to be addressed: is there excess of fishing capacity in the spiny lobster fishery in Cuba? Without knowing the exact number of fishing vessels and fishermen, the number and type of fishing gears used in the commercial lobster fishery, as well as the dimensions of the illegal fishery, it is difficult to propose management regulations to protect the lobster population and reduce the cost of the fishery. These data are collected by the Ministry of Fishery in the documents “Series de Captura y Esfuerzo Anual” (Puga & de León, 2003) but its availability to those outside of this ministry is very limited. In the literature I reviewed, there was an
inconsistency with the number of vessels and fishermen currently involved in the fishery, making
difficult to ascertain the current fishing effort of the spiny lobster fishery in Cuba.

2. Protection of sublegal lobster sizes

As mentioned before, the lobster fishery in Cuba depends on the recruitment of juveniles to the
lobster fishing grounds\(^\text{20}\) (Cruz, 1999; Ehrhardt et al., unpub.). The recruitment process could be
affected by environmental (e.g. hurricanes) and anthropogenic factors (e.g. overfishing) but the
former are not controllable\(^\text{21}\). The impact caused by these natural events should be considered
when estimating the abundance of the population, but fisheries managers need to design
strategies to minimize the impact of human actions over these individuals and the recruitment
process.

Minimum legal size (MSL) is a common fisheries management tool used to protect juveniles,
and maintain spawning stock (Harley et al., 2000). In Cuba, the current minimum legal size for
lobster was recently increased to 76 mm carapace length (CL), protecting 30% to 40% of the
females bearing eggs (Cruz & Bertelsen, 2008). This increase of MLS was a great improvement
on the management of the lobster fishery in Cuba. The current MLS provides more protection to
the spawning stock than the 69 mm CL limit that was in place from 1918 until 2006 protecting
less than 20% of the ovigerous females. Ideally, the MLS should be established at 80 mm CL in
order to protect 50% of the spawning stock (Cruz & Bertelsen, 2008).

\(^{20}\) Fishing grounds: adult habitats where juveniles migrate to and are harvested after they have reached the minimum
size at which they can be legally captured.

\(^{21}\) This statement does not refer to the increase of the frequency and intensity of the hurricanes due to global
warming, which has been enhanced by the production of green gases by human activities.
In the Caribbean region, a few lobster fisheries (Florida, Bermuda) strictly monitor and control the landings of lobsters above the minimum size (Ehrhardt, 2005). The strict enforcement that Cuba has on the implementation of the minimum legal size has been highly remarked in the growing body of literature about management of the Caribbean spiny lobster (e.g. Cockrane & Chackalall, 2001; Ehrhardt, 2005; Ehrhardt et al., unpub.; FAO 2007). But the illegal fishery is not controlled, and this is the source for the take of the undersized lobsters.

Juveniles can also be protected by adjusting the selectivity of the fishing gears (Harley et al., 2000). In Cuba, there is a minimum mesh size of 3.5 cm (1.5 inches) established for the traps. This may help to reduce the number of lobster caught below the MLS. There is also a permanent ban on the use of harpoons, most likely to avoid damaging the lobster before having the chance to measure it and increasing its survival rate if needs to be returned to the water.

The highest peak of the recruitment process is protected by a closed season (Baisre, 2004). This management measure also targets the time of the year when the highest spawning activity occurs. As it was mentioned above, the current closed season in Cuba was extended until June or July, depending on the area, and covers 5 months (Resolution No 12/2008). It considers the variations of the lobster population in the different zones of the Cuban shelf, thus for the entire north coast and the Gulf of Batabanó (SW region) the lobster season is closed from 1 February- 15 June 2008, and for the southeastern zone (Santa Cruz del Sur and Niquero) extends from 1 March- 15 July 2008.
Recruitment and settlement of pueruli and small juveniles to the coastal areas greatly depends on the availability of suitable habitats (Field & Butler 1994; Herrnkind & Butler 1994). In the Cuban shelf, the main lobster nursery sites are closed to all fishing activities, providing protection to the recruitment process (Baisre, 2004). Additionally, the lobster fishermen claim that the artificial shelters (pesqueros o casitas cubanas) used in the lobster fishery does not solely concentrate the adult lobsters but also protects the juveniles from predators (Joyce, 1997; Butler, 2001). Butler & Herrnkind (1997) demonstrated through a field experiment on the Florida Keys that the numbers of small juveniles increased on the supplemented shelters. This passive fishing gear provides additional shelter and reduces predation on this vulnerable stage thus leading to their local retention. Cruz (1999) recommends increasing the numbers of artificial shelters at the nursery sites on the Cuban shelf as a measure to enhance the lobster stock.

Cuba also has regulations to protect part of the spawning stock. It is totally prohibited to land any berried female ("frezadas" in Spanish) or land any female with a black sperm mass on the sternum. Again, illegal fishery does not abide by this rule and harvests berried females.

3. **Fishery management considers regional and national stock abundance as impacted by ecosystem regime shifts that are implicit elements in the spiny lobster population dynamics**

There is no doubt that the Caribbean spiny lobster is a transboundary resource. Moved by the prevailing oceanic currents, its planktonic larvae crosses the EEZ boundary of one coastal state into the EEZ of another, thus ecologically connecting most of the nations in the Wider Caribbean region (Munro *et al*., 2004). This has implications for the management of the resource. Since
activities undertaken in the waters of one country will have an impact on the lobsters present in other countries, regional cooperation to achieve the sustainable use of the resource is needed (FAO, 2000; Cochrane & Chakalall, 2001).

Given the different political systems, socio-cultural backgrounds and economic profiles of the countries of the Wider Caribbean region, collaboration at such a large-scale may seem a daunting task (Mahon 1987; FAO 1998; Mahon, 2008). The Wider Caribbean Region also corresponds to the FAO Fishing Area 31 (Mahon, 2008). The international cooperation inside this area is assisted by the FAO’s regional fishery body: the Western Central Atlantic Fishery Commission (WECAFC)\(^\text{22}\), according to the Code of Conduct for Responsible Fisheries (FAO, 1998). In response to the rising concern of the sustainable use of the Caribbean spiny lobster at the national and regional level, the FAO under the auspices of the Western Central Atlantic Fishery Commision (WECAFC) organized several workshops to promote the collaborative research and management among the lobster-producing nations of this region (Cochrane & Chakalall, 2001). Because of the life-history characteristics of \textit{P. argus} a likely structure of the stock has not been determined. In an absence of identifiable discrete stocks within the “regional” lobster population, it was agree in the first workshop of the WECAFC in 1997 to establish hypothetical sub-stocks for practical management purposes (Medley, 2001). Thus, four possible sub-stocks were defined

\(^{22}\) The Western Central Atlantic Fishery Commission (WECAFC) was established in 1973 by Resolution 4/61 of the FAO Council under Article 4 of the FAO Constitution in the light of the challenges faced by the fishing nations operating in the area. The purpose of the Commission was to assist in international cooperation efforts for the conservation, development and utilization of living resources, especially shrimp, of the Western Central Atlantic. (ftp://ftp.fao.org/FI/DOKUMENT/wecafc/9thsess/Taske.htm)
(Table 6), based on the distribution of the species, the prevailing currents, the geographical proximity and the nature of the coastal shelves (Cochrane & Venema, 2001).

Table 6. Countries divided into 4 working groups based on the hypothetical Caribbean spiny lobster sub-stocks defined by WECAFC (Source: FAO, 2007).

<table>
<thead>
<tr>
<th>Group</th>
<th>Sub-stock</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Northern Stock</td>
<td>Bahamas, Bermuda, Cuba (Northern coast), Turks and Caicos Islands and United States of America (Florida)</td>
</tr>
<tr>
<td>II</td>
<td>North-Central Stock</td>
<td>Belize, Cuba (Southwestern coast) and Mexico</td>
</tr>
<tr>
<td>III</td>
<td>South-Central Stock</td>
<td>Colombia, Costa Rica, Dominican Republic, France (Guadeloupe and Martinique), Haiti, Honduras, Jamaica, Nicaragua, Republic Dominica, United States of America (United States Virgin Islands and Puerto Rico)</td>
</tr>
<tr>
<td>IV</td>
<td>Southern Stock</td>
<td>Antigua and Barbuda, Brazil, Netherlands Antilles, Saint Lucia and Venezuela</td>
</tr>
</tbody>
</table>

Cuba is in two different groups (Northern and North-Central). The high catches of Cuba’s southwestern fishing zone dominate the behavior of the total catches of the Western Central Atlantic’s North-Central sub-region (Group II). The lobster landings of this Cuban shelf has represented between 73%-87% of the North-Central sub-region during a 20 years period, from 1975-2005.

As it is demonstrated in Table 6, not all the countries from the Caribbean region are included here. These sub-stocks cover only countries that are major lobster producers and that are participants in the WECAFC workshops. However, other countries within the broad coastal area
of these “sub-regions” should be regarded as part of the same “sub-stock” (Cochrane & Chakalall, 2001).

The multiple workshops held by WECAFC (FAO Fisheries Reports 619, 643, 715, and 826) were aimed at assessing the status of the spiny lobster stock and fisheries at national, sub-regional and regional levels, as well as to consider the management implications of these results (Cochrane & Venema, 2001; Cochrane & Chakalall, 2001).

There has been cooperation between Cuba and other countries of these sub-regions. For example, Cuba helped the Turks and Caicos Islands with bio-economic analysis and is helping now with a fishery independent recruitment index. However, there is still considerable room to improve collaboration. In the last WECAFC workshop it was recommended that the Bahamas and Cuba could help the Turks and Caicos Islands with improving their post-harvest quality control.

Besides being an active participant of this regional effort facilitated by the WECAFC, Cuba is also involved with other cooperative agreements whose goals are the conservation and sustainable use of the regional marine resources. Cuba is a signatory of the Protocol Concerning Specially Protected Areas and Wildlife (SPAW)\textsuperscript{23} to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena

\textsuperscript{23} SPAW protocol came into force in 1986. Like CITES, it provides varying degrees of protection and regulation to wildlife species according to their conservation status. All marine turtles and all cetaceans are afforded total protection and recovery protection under SPAW through their listing in Annex II. Marine species such as queen conch (\textit{Strombus gigas}) and spiny lobster (\textit{Panulirus argus}) are listed in Annex III and as such, their use is regulated in order to ensure and maintain their populations at the highest possible levels. Another important part of the Protocol is the protection it affords to protected areas in the marine environment. (URL: http://www.nmfs.noaa.gov/ia/intlagree/spaw.htm)
Convention). The Caribbean Spiny lobster is listed under Annex III of the SPAW protocol, which enounces that the taking, possession, and sale of Annex III species, their parts and products needs to be regulated. As such, Cuba needs to adopt appropriate measures to sustainably use this resource and any other listed in this Annex in order to ensure and maintain the lobster populations at the highest possible levels. Annex III from the SPAW protocol also stipulates that the contracting Parties shall cooperate with each other to formulate, adopt and implement plans for the management of these species.

Cuba has made significant changes in the past 10 years in the management of the lobster fishery and it has also been engaged in regional collaboration with the countries that share the same sub-stock. Considering this, it can be said that Cuba has the political will to achieve a sustainable use of the resource.

4. **Maintain a fishery information and statistical database to support scientific and technical research to back fishery management decisions**

The lobster fishery in Cuba counts with a data collection system that allows obtaining a detailed inventory of the quantity, types and location of fishing gear used by all the lobster vessels (Puga & de León, 2003). The lobster vessels report their data to the lobster collection centers of their fishing association. Information is obtained from GPS (Geo-positioning System), from the log books and primarily from the inspectors of the Catch Bureau located at each of the fishing association (Joyce, 1997; Puga & de León, 2003; FAO/OSPESCA, 2006). The catch bureaus
also sample the lobster population at a network of fixed stations at each of the fishing zones and subzones (Joyce, 1997). This biological information is analyzed at the Fisheries Research Center.

The catch and effort data (e.g. number of boats, type and number of fishing gear) from the fishery are corroborated at the lobster processing plants (FAO-OSPESCA, 2006). These data are transmitted from each of the fishing associations to the Enterprise Group (Grupo Empresarial), and from here they are sent to the Ministry of Fishery. According to the report FAO-OSPESCA (2006) this transfer of information occurs almost instantly, thus allowing the MIP to control the production and close any fishery that has reached its quota. This system is called SIE-C (Sistema de Información Estadística Complementaria). A similar system called SIE-N (Sistema de Información Estadística Nacional) takes place at the level of the local offices. The fishing associations send the same fishery data to the municipal Offices of Statistics and from there, the data are sent to the National Office of Statistics (ONE) through the provincial offices. The ONE transfers this information to the Ministry of Economy. Finally, the reports produced by each system are compared monthly. What is not clear from the literature reviewed is the availability of the results produced from these reports for people outside the Ministry of Fishery.

Cuba also reports fishery data to the global database maintained by FAO. A comparison made by Baisre et al. (2003) between national source data (collected by local scientists) and FAO Fishstat data, indicated a good data transfer mechanism between Cuba and this database, something unusual in FAO Area 31.
The data used by the decision-makers in Cuba when designing fishery regulations, are mainly derived from the actual fishery. Non-fishery data about the lobster population needs to be considered as well as the scientific analyses that come from other marine research institutions besides MIP. Managers also need to be advised about the economic impacts that different management alternatives may provide. Some general bio-economic models for the lobster fishery in Cuba were developed by Seijo et al. (2001) and recently by Puga et al. (2005). Therefore, economic factors also need to be included when developing models to estimate the optimum fishing effort and maximum yield.
V. CONCLUSIONS

The most important biophysical, human and institutional components of the Caribbean spiny lobster fishery in Cuba are summarized in Figure 11. These three ecological subsystems and their interactions represent the total ecology of the most economically valuable fishery in Cuba. All these components should be considered by the Cuban decision-makers, when designing fisheries policies, in order to ensure the sustainable management of the spiny lobster.

Figure 11. Total ecology of the Caribbean spiny lobster fishery in Cuba. (CITMA: Ministry of Science, Technology and Environment; FAO-WECAFC: Food and Agriculture Organization regional fisheries body Western Central Atlantic Fisheries Commission; Ido: Institute of Oceanology; SPAW: Protocol Concerning Specially Protected Areas and Wildlife to the Cartagena Convention)
In response to the noticeable decrease in lobster landings, recruitment and stock abundance, the management of the lobster fishery in Cuba experienced some considerable changes after the collapse in 1990. More biological information has been included in the management process, resulting in an increase of the minimum legal size (CL = 76 mm), a lengthening of the closed season (up to five months) and a ban on catching berried females. These measures along with the protection of the nursery grounds provide protection to the most crucial periods of the recruitment and spawning processes. The fishing effort and cost has been controlled by limiting the access to the fishery through a fishing licensing system and by allocating exclusive fishing zones to the fishing associations. A detailed data gathering system was established at the level of the provincial fishing association in order to provide the Ministry of Fishery with up-to-date information regarding the catch and fishing effort. In addition, Cuba acknowledges the transboundary characteristics of the Caribbean spiny lobster and has joined the collaborative efforts (WECAFC and SPAW) to improve the management of the spiny lobster fisheries at the regional level.

This set of management strategies and fisheries regulations address some of the most critical problems that hindered the long term sustainability of the Caribbean spiny lobster fisheries (e.g. changes in recruitment success, excessive fishing effort and shared resource in the Caribbean region). In spite of meeting the sustainability criteria proposed by Ehrhardt et al. (2005) and the status of the stock been recently determined as fully-exploited, the spiny lobster fishery in Cuba has not recovered from the continuous landings decline.
One possible explanation is that the spiny lobster population was actually overfished. Growth and recruitment overfishing, due to the intensive exploitation from the mid 1960s to the late 1980s, caused a reduction of the population to such low levels that it has not been able to recover yet, even with the fishery management in place today. Despite the improvement on the data collection system there is inconsistency on the number of vessel, fishermen, and fishing gear reported in the published literature. Therefore, it can not be concluded if there is overcapacity or not within this fishery.

In addition, there are other human activities affecting the lobster population which are not under the control or jurisdiction of the Ministry of Fishery. Pollution, coastal development, river damming and other problems are negatively affecting the lobster essential habitats.

Finally, in order to achieve the sustainability of the Caribbean spiny lobster fishery, it is fundamentally important to integrate the human with the biophysical components in the fishery policy-making process. Fishermen are not members of the Advisory Commission. Hence, they do not have a stake in the conception of fishery management decisions that eventually affect them. There is no socio-economic analysis of the impacts that these regulations have on the fishermen or on the other human components of the Caribbean spiny lobster in Cuba.

The biophysical, human and institutional components of the lobster fishery in Cuba described here are by no means exhaustive. Additional elements could be added to each of these three subsystems of the spiny lobster fishery in Cuba, as more studies are conducted and a better understanding, especially of the human dimension, is gained. Furthermore, as in any other
ecological system, some of these components may vary in the future, depending on the influence and development of the socio-economic and political context in which the fishery is taking place.

The context in Cuba is a very dynamic one right now. New national policies and internal reorganizations, including a fusion of the Ministry of Fishery with the Ministry of the Food Industry have taken place in the last two years since Raul Castro became the new president of Cuba. Simultaneously, the new administration in the United States, with Barack Obama as president, has already started changing its policy towards Cuba. The implications of these changes for the future of the lobster fishery in Cuba are difficult to predict. But whatever the possible economic and political outcomes might be, it is important to ensure the sustainable management of this resource from which many fishing communities in Cuba and in the Wider Caribbean Region depend.
VI. RECOMMENDATIONS

There are still actions that could be taken in order to improve the management of the lobster fishery in Cuba and achieve a sustainable exploitation of this resource. I would suggest the following:

• **Protection of individuals with the highest reproductive capacity**

Since management strategies should minimize the risk of recruitment overfishing (Phillips *et al.*, 1994) I recommend that the sustainability criterion regarding the protection of the sub-legal lobster size, be expanded to include “the protection of the individuals with highest reproductive capacity”. For this, the Minimum Legal Size needs to be increased up to 81 mm CL, and a Maximum Legal Size of 142 mm CL for males and females should be implemented, as recommended by Cruz and Bertelsen (2008).

• **Spiny lobster stock assessment**

The stock needs to be assessed annually in order to accurately determine the status of the lobster population. The current fully-exploited status of the spiny lobster stock in Cuba does not correspond with the senescent state of the fishery.

• **Protection of essential habitats**

There should be a sustainability criterion to provide protection to the spiny lobster essential habitats. Since many are the factors impacting these habitats, this should be done through an ecosystem-based management approach. It could be challenging to control actions of diverse
groups of stakeholders, all the way from “the ridges to the reefs” (Chavez et al., 2007), but Cuba has some bases in Integrated Coastal Zone Management that could help to coordinate these groups.

- **A more participatory policy-making process**

All the stakeholders’ opinions, including fishermen’s opinions need to be incorporated in the process of establishing fishing regulations. Appointed fishermen — at least one from each province — should be members or guests of the fishing advisory commission. Currently, the management process is still centralized, top-down and vertical process reducing the effectiveness of the enforcement of the fishing regulations.

- **Evaluate the effectiveness of Fishing Regulations** (Decree Law No. 164/1996).

The socio-economic context that caused some of the fisheries decline has changed since this set of regulations was established 12 years ago. The efficacy of these measures needs to be evaluated in order to provide an adaptive management to the current socio-economic and political situation. This is particularly important in Cuba where the changing and unstable economic situation is influencing the way fisheries are managed.

- **Socio-Economic impact assessment**

Every fishery management decision affects people socio-economically (Orbach, 1980 and 1995; Thorpe, 2005). These effects must be defined and evaluated in order to determine the effectiveness of the decisions. A social and economic impact to the community where the fishery is taking place should be integrated with the biological analysis done by the Ministry of Fishery
to determine the lobster harvest plan and the fishing regulations. For example, it is necessary to evaluate the socio-economic impacts that the recent increase of the lobster fishery closed season has on the fishing communities. Once the management actions are enacted, it would be necessary to evaluate, over time, their actual effects on users of the exploited resource. In order to measure these effects, demographic data (e.g. employment, income, profit/loss, and changes in the coastal fisheries industry) of the different human components participating in the lobster fishery is needed. This could be obtained from government sources (e.g. the latest census of the Cuban population) or any other institution (e.g. Center for Demographic Studies at the University of Havana) that may produce this information. When relevant data do not exist different social surveys, participant observation or in-person interviews could be conducted (Bunce et al., 2000). Then the results of the socio-economic analysis should be used to inform managers and look for alternatives for the fishermen to earn an income while the lobster fishing season is closed (e.g. fishing other resources such as oysters or sponges).

**Identify the needs of fishermen**

There is no doubt that free access to public health and education provided by the Cuban government to all the Cuban people is a very favorable element for the fishing community's development. However, it is necessary to identify what needs (beyond the basic) are of the fishermen. This could help illuminate the reasons for illegal lobster fishing.

**Assess and control the illegal lobster fishery**

The volumes of illegal spiny lobster might no be as significant as those taken by the commercial lobster fleet, but their composition may encompass sub-legal size lobsters and female carrying
eggs. Accordingly, an assessment of the impact of this illegal fishery on the lobster population is needed. Fines should be higher and based on the price in Cuban Convertible Pesos (CUC) that they can receive on the black market. Supply lobster to the local markets may decrease the demand of illegal lobsters; but this requires a more in-depth economic analysis that needs to consider the socio-economic status of the Cuban population. Hence, the right disincentives or incentives need to be created in order to control the illegal lobster fishery.

- Dissemination of information

All the steps of the fishery management process should be open and transparent. The results need to be used to inform the decision-makers and the different stakeholders involve in the fishery. Also, the data and results from the analysis of the fishery or the assessment of the stock need to be published or accessible.

It is true that more monetary resources are needed to improve enforcement and monitoring in a country with such extensive coastal area. However, Cuba has the political will and the adequate human capital to improve their fisheries management through these recommendations.
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Appendix A. Systematic of the Caribbean spiny lobster

Figure A. Caribbean spiny lobster, *Panulirus argus* (Latreille, 1804). (Source: FAO²⁴)

Common names:
- Spanish: Langosta, Langosta espinosa (Cuba)
- English: Caribbean spiny lobster, Florida spiny lobster (USA)

Table A. Systematic of lobsters (source: Phillips *et al.* 1994; after Williams 1988)

<table>
<thead>
<tr>
<th>Class</th>
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<tbody>
<tr>
<td>Order</td>
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<tr>
<td>Infraorden</td>
<td>Astacoidea</td>
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<tr>
<td>Superfamily</td>
<td>Nephroidea (clawed lobsters)</td>
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<td></td>
<td>Palinuroidea (spiny lobsters)</td>
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<td>Anomura</td>
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<td>Galatheoidea</td>
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<td>(gelatheidis)</td>
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<table>
<thead>
<tr>
<th>Family</th>
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<td><em>Ibacus</em></td>
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<td><em>Pleuroncodes</em></td>
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<tr>
<td><em>Scyllarides</em></td>
<td><em>Thenus</em></td>
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²⁴ [http://nlbif.eti.uva.nl/bis/lobsters.php?selected=beschrijving&menuentry=soorten&id=149]
Appendix B. Fishing gear

(a) Artificial shelters (pesqueros o casitas cubanas)

(b) 

Figure B.1. Artificial shelters (a) and other fishing gears used to catch the lobster from them. A lobster net (b: chinchorro langostero; c: bully net) (Source: Cruz & Phillips, 1994, pages 324-327)

Figure B.2. Trap (un-baited) and a trap-like net (jaulón). (Source: Baisre & Cruz 1994, 122)
APPENDIX C. Lobster data

Figure C.1. Curves of retention of ovigerous female for the spiny lobster (*Panulirus argus*) in different areas on the south coast of Cuba. (A)- Sur Juan Garcia-Cayo Coco (21° 57’ N 82° 32’ W), (B)- Peralta-Boca Rica (20° 03’ N 77° 39’ W) and (C)- Bretón-Machos de Afuera (21° 33’ N 79° 39’ W) (Source: Cruz and Bertelsen, 2008). *Note:* $L_{50\%}$ refers to the carapace length at which 50% of the females in the population are carrying eggs; X axis is the carapace length in mm.
Figure C.2. Catch and effort for the two main fishing zones for lobster in Cuba (1962-2001) (Source: Puga & de León, 2003).