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Coastal fisheries of Latin America and the Caribbean






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Fishing boat with bottom nets for hoki in Tierra del Fuego, Argentina (courtesy of Miguel S. Isla); landing products in Holbox, Quintana Roo, Mexico (courtesy of Mizue Oe); artisanal boat operating in Santa Marta, Colombia (courtesy of Mario Rueda); artisanal fisher fishing octopus in Yucatán, Mexico (courtesy of Manuel Solis); lobster boat with traps in Cuba (Centro de Investigaciones Pesqueras de Cuba); artisanal boat operating in Santa Marta, Colombia (courtesy of Mario Rueda).

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Edited by

Silvia Salas
Centro de Investigación y de Estudios Avanzados Unidad Mérida
Mérida, Yucatán, Mexico

Ratana Chuenpagdee
Memorial University of Newfoundland
St. John's, Newfoundland, Canada

Anthony Charles
Saint Mary's University
Halifax, Nova Scotia, Canada

Juan Carlos Seijo
Universidad Marista de Mérida
Mérida, Yucatán, Mexico

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Dedication

This document is dedicated to the memory of our colleague and friend **Bisessar Chakalall**, former Fishery Officer in the Subregional Office for the Caribbean (SLC) and Secretary to the Western Central Atlantic Fishery Commission (WECAFC). Bisessar was an extraordinary human being who gave testimony to the values he believed in. He was brilliant and humble; dynamic and parsimonious; structured and spontaneous. He was an honest, generous and committed person. He had profound interest in understanding others, their culture and context, and a genuine interest in improving the well-being of fishing communities. Bisessar knew when to listen and when to speak out with his ideas and suggestions. He conducted himself with the passion and wisdom to intelligently explore life in all its dimensions. Bisessar was an excellent and unique friend. His human legacy remains in our hearts and minds.

Preparation of this document

The idea of preparing a state-of-the-art document examining the assessment and management of coastal fisheries in Latin America and the Caribbean grew naturally out of the CoastFish conference of 2004 (see www.mda.cinvestav.mx/eventos/Coastfish/english/welcome). This interdisciplinary conference, held in Mérida, Mexico, brought together individuals from many different institutions and organizations across the region, covering a wide range of perspectives, in order to contribute to a better understanding of coastal small-scale fisheries. The focus was on fishery assessment and management, taking into account biological, socio-economic and policy issues, aiming to examine the extent of information available for different countries and to identify the gaps in knowledge and management. The goal ultimately was to use this understanding to determine desirable directions for future fishery research, as well as governance and management approaches to moving towards sustainable fisheries in the region. This goal remains valid for this document as well.

This document has been prepared as an initiative of the editors – S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo – in cooperation with a strong set of authors writing about coastal fisheries in twelve countries across Latin America and the Caribbean. Writing and compilation of the document were supported by the European Union through the project Integrating Multiple Demands on Coastal Zones with Emphasis on Aquatic Ecosystems and Fisheries (INCOFISH). The Food and Agriculture Organization of the United Nations (FAO) coordinated the final proofreading, publishing and distribution. References in this document follow international bibliographic standards rather than FAO house style.

Abstract

The importance of fisheries for coastal communities and livelihoods in Latin America and the Caribbean (LAC) is well documented. This is particularly the case for 'coastal fisheries', including subsistence, traditional (artisanal) and advanced artisanal (or semi-industrial) varieties. There are, however, major gaps in knowledge about these fisheries, and major challenges in their assessment and management. Therein lies the key theme of this document, which seeks to contribute to a better understanding of coastal fisheries in the LAC region, as well as to generate discussion about ways to move towards sustainable fisheries. The document includes three main components. First, an introductory chapter provides an overview of general trends in the fisheries of the LAC countries, as well as some of the key challenges they are facing in terms of sustainability. Second, a set of twelve chapters each reporting on the coastal fisheries of one country in Latin America and the Caribbean, collectively covering fisheries of each main subregion: the Caribbean islands (Barbados, Cuba, Dominican Republic, Grenada, Puerto Rico, Trinidad and Tobago), North and Central America (Costa Rica, Mexico) and South America (Argentina, Brazil, Colombia, Uruguay). All these country-specific chapters follow an integrated approach, to the extent possible, covering aspects ranging from the biological to the socio-economic. Third, the final component of the document contains a synthesis of information from the countries examined, an analysis of the main issues and challenges faced by the various fisheries, an outline of policy directions to improve fisheries management systems in the LAC region, identification of routes toward more integrated approaches for coastal fisheries management, and recommendations for 'ways forward' in dealing with fishery assessment and governance issues in the region.

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This document is a product of collaboration among a wide range of scientists and researchers in Latin America and the Caribbean, who share common interests and concerns about coastal fisheries and the well-being of coastal communities in the region. We want to thank first the authors of the country-specific chapters in this document, who have continued to believe in the project of this document, and made strong efforts to gather the available information about coastal fisheries in their respective countries. Most of the contributors presented their initial results at the CoastFish conference. We are also grateful to conference participants who contributed to the discussion on existing assessment tools and management approaches – highlights of this discussion are included in this volume.

The document could have not been produced without funding from the European Union through the project Integrating Multiple Demands on Coastal Zones with Emphasis on Aquatic Ecosystems and Fisheries (INCOFISH) (Project No. INCO 003739). We also thank the Food and Agriculture Organization of the United Nations (FAO) for support at the publication stage. We thank Drs Rainer Froese and Silvia Opitz (INCOFISH), Dr Cornelia Naun (European Union), and Dr Kevern Cochrane (FAO) for their strong support and encouragement.

We are grateful to Kathryn Goetting, Carlos Zapata Araujo, Miguel A. Cabrera and Patricia González for their help with the translation, formatting and editing. Much appreciated as well are the patient efforts of Kevern Cochrane and Johanne Fischer at FAO in guiding the document through to publication, and of Maria Giannini and Michèle S. Kautenberger-Longo, also at FAO, for excellent proofreading and formatting. Finally, Anthony Charles acknowledges financial support from a research grant from the Natural Sciences and Engineering Research Council of Canada, and Ratana Chuenpagdee is grateful for financial support from the Social Sciences and Humanities Research Council of Canada and the Canada Research Chairs Program.

Preface

Along the coasts of Latin America and the Caribbean (LAC), fisheries are inherently complex – notably as a result of the heterogeneity of gears, boats and species, as well as the diversity of geophysical, bio-ecological and socio-economic characteristics. Coastal fishers in the region are especially vulnerable to the impacts of fisheries declines, given their livelihood and income dependence on local resources. Meanwhile, only limited technical and financial support exists for the assessment and management of coastal fisheries.

As a result, while the importance of coastal fisheries in the LAC region is clear, their assessment is highly challenging. Limitations in the knowledge base for coastal fisheries have become more and more evident. Within the environments in which coastal small-scale fisheries operate, data are typically lacking or relatively less available and, in particular, quantitative information is relatively sparse. For instance, while information about fisheries landings has regularly been gathered at a national level and aggregated to regional and global levels by international organizations like FAO, there is often no distinction made between landings from small-scale fisheries and from larger-scale commercial ventures. There are also gaps in knowledge about the various management methods used in the region. The shortfall between the information available and that needed for proper understanding of coastal fisheries makes it difficult to determine management schemes that can best fit the context of such fisheries.

We hope that this document represents a significant contribution to filling some of the many information gaps on fishery assessment and management in LAC coastal fisheries. Over the years, there have been remarkably few examinations of fisheries in the region, and certainly not many taking an integrated and broad-based perspective. This document can be seen as complementing past publications, such as those of FAO and the World Bank, among others, while also providing an integrated approach to examining fisheries of the region. We hope readers will find the volume useful, and that it might contribute both to increasing the attention paid to coastal small-scale fisheries across Latin America and the Caribbean and to identifying the ingredients for their successful management and their long-term sustainability.

The editors

1. Coastal fisheries of Latin America and the Caribbean region: issues and trends

Silvia Salas,* Ratana Chuenpagdee, Anthony Charles and Juan Carlos Seijo

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1. INTRODUCTION

The importance of fisheries for coastal communities in Latin America and the Caribbean (LAC) has been highlighted in many forums and reports, including those of the Food and Agriculture Organization of the United Nations (FAO) and other development agencies such as the World Bank and the Organisation for Economic Co-operation and Development (OECD). Coastal and small-scale fishers often have considerable livelihood and income dependency on local resources – making them highly vulnerable to negative trends in the fisheries, such as declining catches and degrading habitats, and particularly to the risk of downturns and collapse (Staples *et al*., 2004; World Bank, 2004; Bené *et al*., 2007).

* *Contact information*: Centro de Investigación y de Estudios Avanzados, Unidad Mérida. Mérida, Yucatán, Mexico. E-mail: ssalas@mda.cinvestav.mx

These realities reinforce the importance of understanding, assessing and effectively managing coastal fisheries. This is the key theme of the document – to examine the various approaches and challenges arising in the assessment and management of coastal fisheries within the LAC region. For the purpose of this document, the term ‘coastal fisheries’ refers to three main types: subsistence fisheries, traditional fisheries (artisanal), and advanced artisanal (or semi-industrial) fisheries. The adaptability of fishers, which enables them to switch gears and target species, makes it difficult in some cases to differentiate among these three types, but broadly the main distinction made here is between coastal fisheries and industrial or recreational fisheries. Coastal fisheries tend to share certain features, such as high mobility of fishers, transboundary issues related to shared resources, high competition among user groups, seasonal use of resources, and multiple livelihoods (Beltran, 2005; Agüero and Claverí, 2007; Salas *et al.,* 2007; Chakalall *et al*., 2007).

This volume strives to contribute to a better understanding of coastal fisheries in the region, in terms of their assessment and management, as well as to generate discussion about ways to move towards sustainable fisheries in the region. The heart of the document is a set of twelve chapters each reporting on the coastal fisheries of one country in the LAC region. Specifically, these ‘country chapters’ include information on the fisheries of each of the main subregions of Latin America and the Caribbean: the Caribbean islands (Barbados, Cuba, Dominican Republic, Grenada, Puerto Rico, Trinidad and Tobago), North and Central America (Costa Rica, Mexico) and South America (Argentina, Brazil, Colombia, Uruguay).

The twelve countries included in the document provide reasonable geographical coverage, but the information presented herein is certainly not exhaustive. The heterogeneity and complexity of coastal fisheries in the LAC region is clear, given its large number of countries and their diverse geophysical, bio-ecological and socio-economic characteristics. Accordingly, this document reflects only a sampling of the region’s fisheries – but it does highlight many issues and challenges shared by fisheries in the region, especially regarding assessment and management. It also provides an analytical discussion and directions for future fishery research and management.

The document is organized into three main sections. In this introductory chapter we provide an overview of the general trends in the fisheries of the LAC countries as well as some of the key challenges they are facing in terms of sustainability.

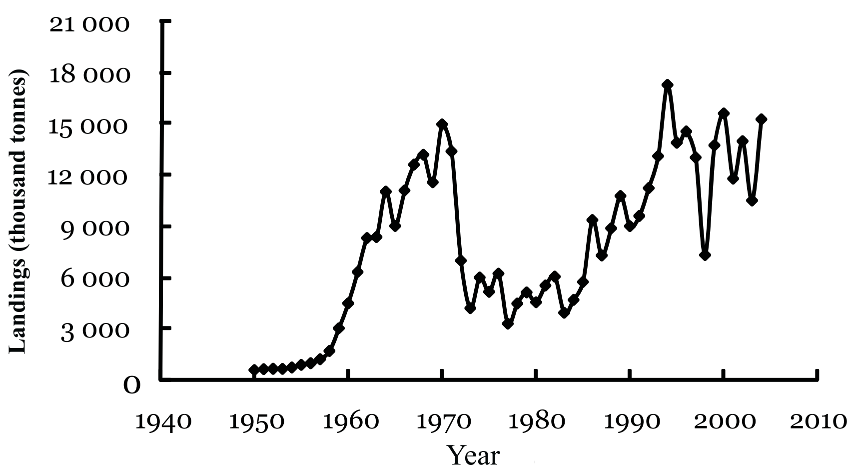
Following this is the set of 12 ‘country chapters’ described above, which present a range of contexts, and discuss common problems as well as particularities that illustrate the complexity of the fisheries in the region. All the country-specific chapters follow the same format, to the extent possible, in terms of content, ranging from biological to socio-economic information. The focus of each one varies, however, depending on key characteristics of the fisheries in the corresponding country, and the range of disciplines and specialization of the authors. Each also reflects the existing availability of information and the authors' judgements of issues that need to be discussed in order to improve assessment and management of coastal fisheries in the LAC region.

The final part of the document contains conceptual and analytical chapters, as well as concluding remarks. A synthesis of information from the twelve country chapters and an analysis of the main issues and challenges faced by each fishery are presented in Chapter 14. Then Chapter 15 outlines policy directions to improve fisheries management systems in the LAC region, and suggests how to move towards a more integrated approach to coastal fisheries management. The final chapter consolidates the lessons learned from discussions in the document, and provides recommendations for the ways forward in dealing with assessment and governance issues.

2. MAJOR TRENDS IN COASTAL FISHERIES OF LATIN AMERICA AND THE CARIBBEAN

Catch trends of the twelve countries covered in this document, as well as other key countries in the LAC region, show important fluctuations in the last five decades (Figure 1). Landings increased from 1960 to 1970 before dropping sharply; the recovery was gradual until it reached a peak in 1994. One of the main contributors of Latin America has been Peru, with close to 60% of landings. In addition to Peru, major contributors to the LAC region's fisheries are Chile, Argentina, Mexico, Brazil and the Bolivarian Republic of Venezuela. Countries from the Caribbean islands, despite small landings, receive important foreign exchange from their catches (Agüero and Claverí, 2007; Salas *et al.*, 2007).

FIGURE 1
Total landing trends of main countries that operate in the Latin America and Caribbean region



Source: Sea Around Us project database; www.seaaroundus.org.

The major contribution to the region's total landings comes from pelagic species landed by industrial fisheries. For example, the fluctuations in landings, such as the sharp rises in 1970, 1994 and 2000 and the declines in 1972, 1983 and 1994 were due largely to fluctuations on landings from purse seine fisheries in Peru and Chile. Also, high squid landings in these two countries in recent years contributed significantly to the total increase. Similar to Peru and Chile, catches from Mexico come mainly from purse seines (about 42% in 2004). On the other hand, in Argentina and Brazil, the majority of the landings come from trawling (about 72% and 50% of total country landings in 2004, respectively).

If we focus on coastal landings, by excluding from the data catches from gears operating mostly in offshore areas (i.e. bottom trawls, midwater trawls and purse seines), the contributions from Peru and Chile are reduced from 84% to about 44% of the total within our reference group of 14 countries. While this does not change the top five countries in Table 1, in terms of total landings, the importance of coastal fisheries becomes evident in countries like the Dominican Republic, Grenada, Puerto Rico, and Trinidad and Tobago, in each of which landings from gears used mostly in coastal waters exceed 50% of the total landings for that country (Table 1). Peru and Chile, on the other hand, provide far less of their catches from coastal fisheries, with landings from this sector contributing only about 2% and 9% respectively to the total for each country. Incidentally, these proportions are the lowest among the LAC countries examined here.

Mexico and most countries in Central America have fleets both on the Pacific and Caribbean coasts, and they are highly dependent on coastal fisheries, especially as a source of jobs and food. Reports by FAO (2000) for these countries indicate that catches appear to be higher on the Pacific than on the Caribbean coasts in most cases. In the latter, a lower volume seems to be compensated for by the capture of profitable species like conch, lobster and shrimp, among others, which contribute significant foreign currency to these countries. Total export of catches in the LAC region (excluding aquaculture) by the year 2001 was close to US$7 million; five countries made up 73% of this contribution (Agüero and Claverí, 2007).

Accurate figures on fishing effort in coastal fisheries of the LAC region are generally not available, and when they do exist there is typically a shortage of consistent information. Even though catch records began in the 1950s in some countries, information on fishing effort started to be collected much later. Such data are important in the evaluation of fishing capacity and labour capacity relative to catch trends. In general, the number of people involved in fishing and fish farming has more than doubled in the last three decades (FAO, 2006a; Salas *et al.*, 2007), with many of these people entering the coastal fisheries industry. In contrast to global trends (Figure 1), it is evident when evaluating landings only from coastal fisheries that between the early 1970s and the mid-1990s there was an increasing trend in catches in South America, with a declining trend after this period (Figure 2). In the Caribbean, the trend has been generally upward for three decades, afterward a sharp decline has changed the general trend.

TABLE 1

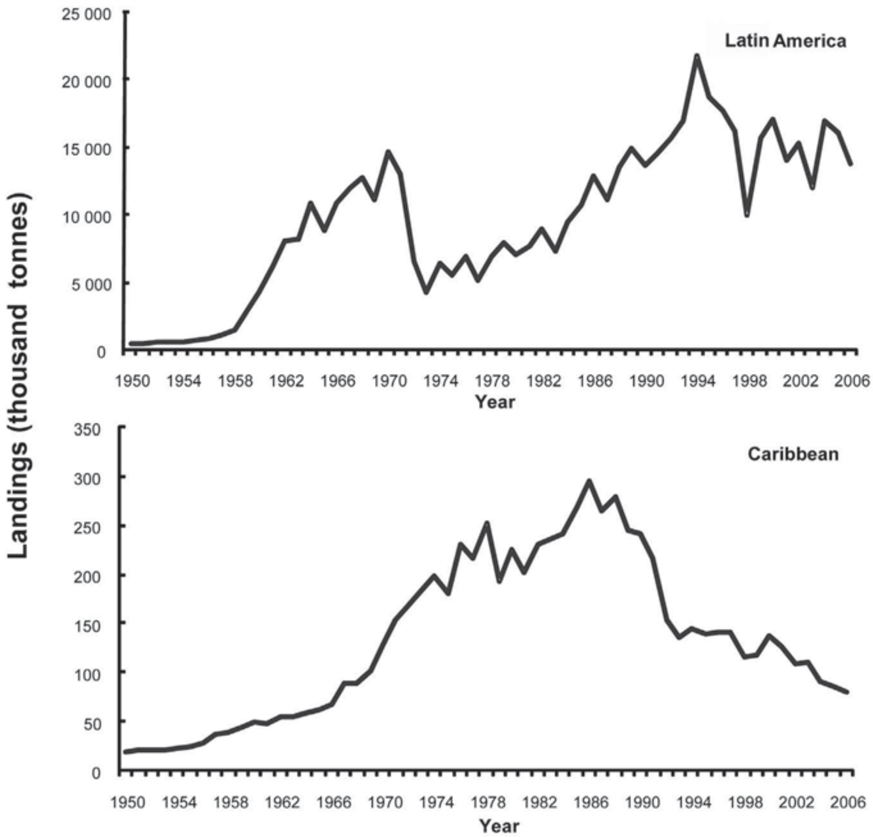
Catches for those countries included in this document plus Peru and Chile in 2004. Total landings integrate catches from all gears[1] and landings from 'coastal gears'[2] include all gears except bottom trawl, mid-water trawl and purse seines

Country	Total landings for all gears ('000 tonnes)	% of total landings of all listed countries	Landings from 'coastal gears' only (tonnes)	% of coastal landings in total for the country
Peru	9 611.94	52.68	151.27	1.57
Chile	5 317.31	29.14	492.18	9.26
Mexico	1 286.57	7.06	134.60	10.46
Argentina	945.94	5.18	187.36	19.81
Brazil	746.21	4.09	130.66	17.51
Colombia	124.95	0.68	13.82	11.06
Uruguay	122.98	0.67	15.38	12.51
Cuba	36.14	0.20	16.21	44.85
Costa Rica	20.85	0.11	3.64	17.46
Dominican Republic	14.22	0.08	7.28	51.20
Trinidad and Tobago[1]	10.03	0.06	5.10	50.84
Puerto Rico	6.12	0.03	3.50	57.18
Barbados[1]	2.14	0.01	0.92	43.00
Grenada[1]	2.03	0.01	1.80	89.00

Source: [1] FAO (2004: http://www.fao.org/fishery/geoinfo/en); [2] data from Sea Around Us, 2004 (www.Seaaroundus.org) adapting FAO data.

As in other parts of the world, the expansion in catches in the LAC region has been due to technological development and an increase in the size of the fleet, an expansion of the fishery workforce, exploration of new fishing grounds, and related impacts of government financial transfers (FAO, 2006a; OECD, 2006; Gréboval, 2007). In the last decade, in many of these countries the most important resources are considered to be at their maximum level of exploitation (World Bank, 2004; FAO, 2006b; Agüero and Claverí, 2007). Despite this situation, the status of many fisheries in the region is poorly known. Agüero (1992) states that one of the problems these countries face has been the lack of consistency in the way catches have been recorded and fisheries analysed. Fisheries institutes in many of these countries were created in the 1960s to conduct research, but they have not achieved sufficient technical capacity (human and logistic) due to limited financial support (Agüero and Claverí, 2007).

FIGURE 2
Landing trends of coastal fisheries by area from main countries that operate in Latin America and the Caribbean



Source: Sea Around Us project database (www.seaaroundus.org).

3. FACTORS AFFECTING SUSTAINABILITY OF LAC COASTAL FISHERIES

Many factors have contributed to the unsustainability of fisheries, and these in turn have led to excess capacity (Gréboval, 2002; Swan and Gréboval, 2004; Gréboval, 2007). These factors include: (i) a lack of solid governance structures; (ii) fishery complexities, incomplete knowledge and the associated uncertainties; (iii) inadequate incentives and subsidies that stimulate overcapacity; (iv) stock fluctuations due to natural causes; (v) growing demand for limited fish resources; and (vi) poverty and a lack of alternatives for coastal development. These factors are examined below as well as throughout the document.

3.1 Fisheries complexities

Scientific literature and public media have extensively reported problems that fisheries in many areas of the world are facing. While it is generally known that overexploitation, habitat degradation and unintended catches and discards are common causes of such crises, their effects on the ecosystem and the economy of the nations involved, especially in the context of coastal fisheries, are not always properly addressed. This is due mainly to the complexity of these fisheries, which makes assessment and management difficult (Cochrane, 1999; Mahon *et al.*, 2008, 2009). For instance, many coastal fishers switch among alternative fishery resources using various fishing gears throughout the year, making it difficult to determine fishing effort. Some fishers engage in other occupations such as tourism, salt mining or aquaculture to supplement their fisheries income. As coastal areas around the world continue to attract migrants, conflicts between various uses of coastal resources accelerate and consequently affect the livelihoods of the coastal communities. Balancing between uses and conservation in coastal areas has thus become more challenging, especially when information to foster comprehensive understanding of those fisheries is insufficient.

3.2 Growing demand for scarce resources

In the last few decades the increase in food consumption has been oriented to protein intake in many countries, especially in Europe and Asia. This trend has been favoured by an improvement in food technology which has provided added value to diverse products including those coming from the sea. According to FAO, the per capita consumption of fish in the world has increased from 9 kg in 1961 to 16.5 kg in 2003 (FAO, 2006b). Even though consumption in developing nations is lower than that of developed nations, the market still offers incentives to enter the fishing industry. The increase in tourism in coastal areas also keeps up the demand for marine products.

An increase in coastal population has resulted in steeper competition for a reduced level of resources. At the same time, degradation of habitats from the expansion of different activities along the coast has had an impact on the corresponding ecosystems, on their resources, and on the people depending on them.

The sharp rise in fisheries production outlined above has been caused by many factors, including uncontrolled capacity in the industry, technological improvements, an increase in demand for seafood, and a lack of governance. A general pattern of overcapacity and resource degradation has been reported in countries from the LAC region (Ehrhardt, 2007; Ormaza, 2007; Salas *et al.*, 2007; Vasconcellos *et al.*, 2007; Wosnitza *et al.*, 2007). It is important to note that while some general patterns can be observed in the whole LAC region, the situation in each country is context specific, and an understanding of the issues and challenges faced in each location, taking into account particular geopolitical conditions, could provide useful insights for the whole region (Agüero and Claverí, 2007; Chakalall *et al.*, 2007). This, we hope, will be one key outcome of this document.

3.3 Different incentives

One of the factors promoting growth of the fishing industry is the intervention of government through different types of financial transfers. Government financial transfers (GFT) are defined by the OECD (2006) as "the monetary value of government interventions associated with fisheries policies" and include market price support, untaxed resource rent, negative subsidies, as well as infrastructure expenditure. Unfortunately, limited information exists on financial transfers applied in the LAC countries and their impacts; most of the interventions reported in the country chapters of this document have to do with subsidies.

Indeed, the issue of subsidies in coastal fisheries is discussed in seven of the fisheries chapters (Argentina, Mexico, Trinidad and Tobago, Costa Rica, Grenada, Brazil and Barbados). Among the subsidies reported are: (i) grants for the construction of new vessels, traps, aggregating devices, etc.; (ii) grants for the modernization of the fleets; (iii) preferential credits; and (iv) reduced prices for purchased inputs (e.g. fuel, bait and ice). The impact of subsidies on sustainability depends on the dynamics of fleet capacity and effort of both small-scale as well as industrial vessels. To the extent that subsidies reduce operating costs in fisheries, this tends to artificially generate profits that further stimulate fishing capacity growth, lower biomass levels and raise competition.

3.4 Stock fluctuations

Clearly, independent of fishing activity, stocks will fluctuate in the short and long run due to natural causes. For pelagic resources, major stock fluctuations occurred even prior to human exploitation (Soutar and Isaacs, 1974). These fluctuations have been best documented in relation to the El Niño-Southern Oscillation (ENSO) climatic phenomenon, especially as it affects the production of small pelagic fishes in the eastern Pacific (e.g. Lluch-Belda *et al*., 1989), but also as it impacts other resources and other geographic areas. Similar climatic forcing factors have been affecting marine production systems on the global level (Kawasaki, 1992; Klyashtorin, 2001), and long-term fluctuations will be reinforced by climate change (Kelly, 1983). Thus, although 'decadal' periodicities are frequently mentioned in the fisheries literature (e.g. Zwanenberg *et al*., 2002), Klyashtorin (2001) suggests that natural cycles in productivity of around 50 to 60 years duration are likely to be dominant.

Coastal fishery resources are also vulnerable to other human activities that may affect critical habitats and/or biological and biophysical processes (e.g. Spalding and Kramer, 2004). With respect to the latter, the long-term role of environmental change in fisheries has become easier to observe in recent years now that fisheries data series more commonly exceed a half century in duration. However, our ability to discriminate between natural environmental changes, the effects of fishing, and the impact of other human activities remains poor.

3.5 Lack of governance structures

According to Kooiman *et al.* (2005), governance is beyond government and broader than management in that it involves problem solving, creation of opportunities, and interactions. Mahon *et al.* (2008) advocate an interactive fisheries governance perspective, which involves a dynamic and complex fish chain, leading from the resource and its supporting ecosystem to the global marketplace and the local consumer. The dynamics of this chain need to be balanced as the system responds to a variety of stimuli.

Interactions within complex fisheries systems in many cases have been ignored when fisheries resources are examined in an isolated manner and public participation in problem solving and creating opportunities are discouraged (Castilla and Defeo, 2005; Charles, 2001; Garcia and Charles, 2008; Mahon *et al.*, 2008). Given the current context and the high diversity that characterize coastal fisheries in LAC, alternative forms of governance are required, particularly to develop local institutions that help increase social capital and develop strategies suitable to the social, economic and political contexts faced by the corresponding fisher groups. For example, many chapters throughout the document place special emphasis on the need for collective access rights for fishing communities in order to promote co-management. This approach highlights resource use and access among the challenges fisheries face in the move towards good governance.

4. CONCLUDING REMARKS

As fishing pressure has imposed significant problems on fisheries and their managers across most LAC countries, various degrees of response, in terms of fishery management and assessment, have been developed. However, many gaps still exist in the understanding of the issues, as will be discussed in the different country chapters. These gaps arise as a result of some key limitations.

First, with regard to assessment, the limited qualitative and quantitative information on coastal and small-scale fisheries is evident. In many countries, official statistics make no distinction between landings from small-scale fisheries and from larger-scale commercial ventures. Although landings from these two sectors can be distinguished based on gear use in some cases (as attempted in Table 1), there is generally a lack of permanent programmes to monitor catches from these fisheries. Problems associated with evaluation are also common, exacerbated by limited financial support for research.

Second, the ‘management tool-kit’ appropriate for small-scale fisheries is much less developed than that for large-scale fisheries, and transferability of management approaches from the latter to the former is highly questionable given the major differences both in the characteristics of these fisheries and in their importance to fishing households. Even if these tools were transferable, an important management limitation – the lack of human and economic resources – remains a key challenge (FAO, 2000; Salas *et al.*, 2007; Mahon *et al.*, 2008).

These problems are discussed in a number of the chapters, and a summary of trends in adoption and use of the various assessment and management tools is presented in Chapter 14. This compilation of information serves three goals. First, an overview of the fisheries in terms of their biological, social and economic assessment provides insights for management purposes. Second, the document aims to identify research gaps in coastal fisheries, to provide guidance on priorities for research themes, approaches and tools. In this regard, it becomes clear that to achieve a sufficient understanding of fishery complexities, an emphasis on multidisciplinary research – incorporating the bio-ecological and socio-economic processes of fisheries – is critical. Third, we see from this analysis that from a management perspective, the complex characteristics of coastal fisheries demand a shift away from conventional approaches, towards a system that enables local organizations to adapt to both the current context inside the LAC region and to global trends.

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2. Coastal fisheries of Argentina

Inés Elías*, Claudia Carozza, Edgardo E. Di Giácomo, Miguel S. Isla, J. M. (Lobo) Orensanz, Ana María Parma, Raúl C. Pereiro, M. Raquel Perier, ✞Ricardo G. Perrotta, María E. Ré and Claudio Ruarte

Elías, I., Carozza, C., Di Giácomo, E.E., Isla, M.S., Orensanz, J.M. (Lobo), Parma, A.M., Pereiro, R.C., Perier, M.R., ✞Perrotta, R.G., Ré, M.E. and Ruarte, C. 2011. Coastal fisheries of Argentina. *In* S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo (eds). Coastal fisheries of Latin America and the Caribbean. *FAO Fisheries and Aquaculture Technical Paper*. No. 544. Rome, FAO. pp. 13–48.

* *Contact information*: Centro Nacional Patagónico (CENPAT-CONICET). Puerto Madryn, Chubut, Argentina. E-mail: elias@cenpat.edu.ar

1. INTRODUCTION

Over centuries the coasts of Argentina were inhabited by aboriginal peoples that, mostly towards the south, harvested marine resources. The archaeological record shows evidence of consumption of mammals, amphibians, molluscs and fishes along Patagonian shores. The gathering methods and knowledge of these early fishers were not, however, incorporated by the colonial society, contrary to what was the case in Peru and Chile, which became leading countries with regard to artisanal fishing activities. It is perhaps because of this, together with prevalent policies that prioritized agriculture and husbandry, that fishing and fishers are perceived as exotic (Mateo Oviedo, 2003).

Over recent decades, because of the loss of employment opportunities in traditional sectors of the economy and in industrial fisheries, as well as population growth in coastal areas, groups of artisanal fishers have sprouted in many areas where they did not operate before. Small-scale fishing is becoming a permanent way of life for many of these new fishers.

The first difficulty encountered while trying to describe and analyse the artisanal sector is its definition. A comparative look at how 'artisanal fisheries' are defined indicates that recurrent criteria are: size of the boats, gross tonnage, fishing gear and socio-economic considerations. Fishing operations that are considered 'artisanal' in some countries do not qualify as such in others. The same happens even within Argentina, a country with an extended coastline and divergent regional realities.

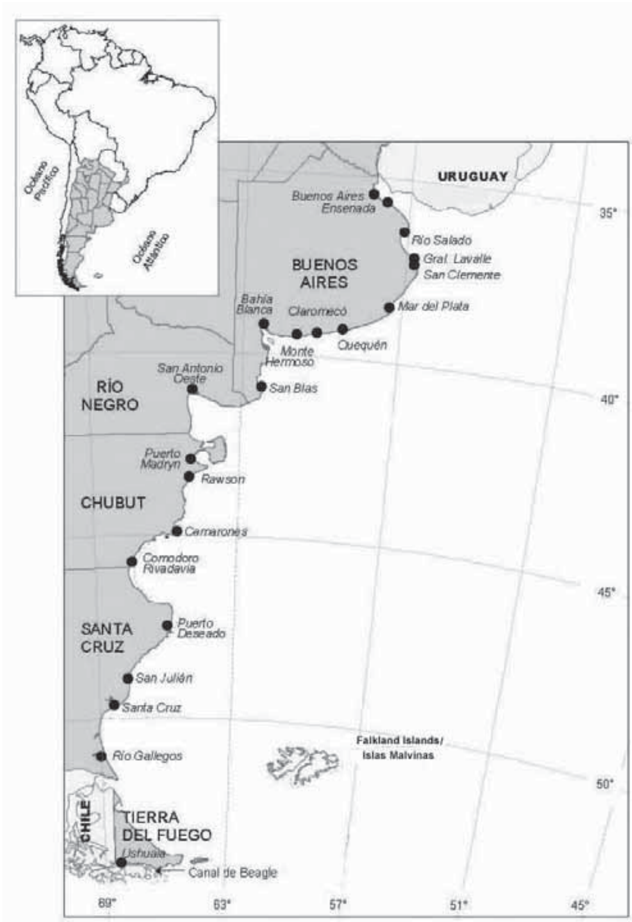
An economical anthropology perspective singles out additional factors that help the characterization: property of the means of production, production of merchandise, management of economical activities, division of labour, degree of association, etc. (García-Allut, 2002).

As used in Argentina, the term 'artisanal' encompasses a wide spectrum, from coastal gathering to inshore fleets. This chapter deals with coastal gatherers, beach seiners and boats of variable dimensions ranging, according to García-Allut (2002), from 'strictly artisanal' to 'semi-industrial'.

Argentina, located at the southern end of the Americas, has one of the largest shelf areas in the world (about 1 million km^2) and an extended coastline (4 000 km). The eastern and western boundaries of the shelf are, respectively, the continental slope and the coastline (Figure 1). The northern and southern boundaries are jurisdictional. Resources harvested by small-scale and artisanal fishers are shared with other jurisdictions: to the north with Uruguay in the Argentine-Uruguayan Common Fishing Zone between the two countries (ZCPAU), and to the south with Chile.

These settings imply that, geographically, Argentina is a maritime country yet, because of the way its population is distributed, it is effectively a continental country. Four provinces out of five with a maritime border (the exception being Buenos Aires) conform the Patagonian region, where coastal urban settlements are far apart from each other (Figure 1). This configuration highlights the significance of gulfs, bays and estuaries in the development of coastal activities.

FIGURE 1
The main fishing harbours on the continental coast of Argentina (indicated by black dots)



Water masses above the continental shelf are characterized by the mixing between water of subantarctic origin, flowing in mostly between the Falkland Islands/Islas Malvinas and Tierra del Fuego, and waters diluted by continental runoff and originating in the Magellan Strait. These water masses of mixed origin are altered by heat interchange with the atmosphere (Piola and Rivas, 1997).

Balech (1986) showed that by late September or October the water of northern origin flows south, off Buenos Aires Province and westward of the Falkland Islands/Islas Malvinas Current, reaching as far south as Valdés Peninsula (42° south latitude) by mid- or late-December. This phenomenon is very important because of its effect on coastal fisheries (Balech, 1986; Perrotta *et al*., 2001).

In the Patagonian region, between 42° and 47° south latitude, a series of frontal systems of variable intensity develop towards late spring (late November) and during the summer (December–February), favouring the establishment of spawning grounds with good conditions for the development of the eggs and larvae of several fish species (Sánchez and Ciechomski, 1995; Ehrlich *et al*., 2000).

The northern end of Patagonia (41° to 43° south latitude) has three gulfs that harbour fishing activities of regional significance: San Matías (shared by the Río Negro and Chubut Provinces) and San José and Nuevo (Chubut Province). The three are shaped as extensive basins deeper than the adjacent shelf (Rivas and Beier, 1990). Waters are more saline than in the adjacent shelf, and temperature variation is comparatively high. San José Gulf is the smallest of these three and its high productivity was highlighted by Charpy-Roubaud *et al*. (1978).

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Argentina is, by its Constitution, a representative and federal republic formed by 23 provinces and a federal district, all autonomous states endowed with political and administrative powers. The Argentina Constitution establishes executive, legislative and judiciary branches and does not contain specific language relative to fisheries or maritime jurisdictions, but assigns to the legislature and the executive authority regarding treaties, navigation, customs and ports.

Several agencies in the federal administration have a say in fishing-related subjects: the National Service of Agricultural Quality and Health (SENASA, within the Ministry of Economy and Production) certifies processing plants; the Undersecretary of Fisheries (within the Secretary of Agriculture, Husbandry and Fishing) elaborates and coordinates the execution of policies for the promotion and regulation of fishing activities; and the Prefectura Naval (the coast guard) keeps track of the vessel registry, cares for the security of navigation, grants credentials to crews (deckhands, skippers, divers, etc.) and patrols the coastal zone.

The Federal Fishing Act of 1998 (Ley Federal de Pesca, No. 24922) states that living aquatic resources from lakes and rivers, gulfs and inshore areas (from the coastline to 12 nautical miles offshore) are under provincial jurisdiction. Outside this boundary, waters within the exclusive economic zone (EEZ) and the continental shelf are in the federal domain (Article 4). The Act establishes that the application authority at the national level is the Undersecretary of Fisheries, and that a Federal Fisheries Council defines national fishing policy and research priorities. The Council is integrated by a representative from each maritime province, the Undersecretary of Fisheries, and delegates from the Undersecretary of Natural Resources and Sustainable Development, the Ministry of Foreign Affairs and the federal executive.

In addition, Act 20645 of 1974 establishes a common fishing zone with Uruguay. Regulations adopted for coastal resources and some pelagic resources within this zone must be discussed in the ambit of two bi-national commissions, the Joint Technical Commission for the Maritime Front (CTMFM) and the Managing Commission for the La Plata River (CARP).

At the regional level, coastal resources are managed by the provinces through their respective agencies (secretaries, undersecretaries, etc.), which often have overlapping mandates, both with each other within provincial administrations and with federal agencies. Governmental structures are usually organized on functional grounds with little horizontal linkage (e.g. between agencies dealing with fisheries, the environment, health, etc.).

The agency in charge of planning and execution of scientific and technical programmes at the federal level is the National Institute for Fisheries Research and Development (INIDEP), which depends on the Secretary of Agriculture, Husbandry, Fisheries and Food (Act 21673 of 1977). Its mission is to plan, execute and develop research projects, including surveys, assessments and development, aquaculture technology, fishing gear, technological processes and fisheries economics, according to guidelines and priorities defined by the application authority.

Scientific and technical support for management at the regional level is provided by other research centres, which interact to variable degrees with provincial fisheries administrations and with INIDEP. Some examples are: the National University of Mar del Plata in Buenos Aires Province; the Institute of Marine and Fisheries Biology 'Almirante Storni' in Río Negro Province; the National Patagonic Center (CENPAT), a regional branch of the National Council for Scientific and Technical Research (CONICET) and the National University of Patagonia in Chubut; a technical school for fishers (FOCAPEM) in Santa Cruz; and the Austral Center for Scientific Research (CADIC, as CENPAT, a branch of CONICET) in Tierra del Fuego.

Artisanal fishing units, as defined here, include coastal gatherers, commercial divers, beach seiners and small boats (usually less than 10 m long) deploying a variety of gear types (gill and tangle nets, longlines, hook-and-line, traps). Inshore fleets include two other size-brackets of vessels, shorter and longer than 18 m (Table 1). Small inshore vessels (10–18 m) are usually known as the *rada/ría* (roughly meaning coves and estuaries) fleet, which rarely operate beyond the 50 m isobath. Most of these boats have wooden hulls, are relatively old (50 years on average), and have minimal navigation and detection equipment. Holding capacity ranges from 4 to 14 tonnes and they have no cold-storage capacity. Crews can be up to 10 fishers. This fleet operates from most Argentine fishing harbours, with its epicentre in Mar del Plata, both in terms of landings and number of boats (Lasta *et al*., 2001). It is busy all year round and is socially dynamic. Larger vessels (longer than 18 m) operate further offshore during the autumn, targeting hake. According to the typology proposed by García-Allut (2002), the *rada/ría* fleet falls in the semi-industrial category, and is thus included in this overview. Larger vessels operating in the inshore fishery are not. In addition, Table 2 summarizes the fishing activities discussed in this section.

TABLE 1
Composition of the inshore fleet of Argentina, by harbour

Harbour (from north to south)[1]	Province	Number of registered boats in the inshore fleet		Annual catch (average) in recent years (tonnes)
		Rada/Ría (semi-industrial)	Coastal (industrial)[2]	
General Lavalle	Buenos Aires	19	3	4 147
Mar del Plata	Buenos Aires	68	48	81 852
Quequén	Buenos Aires	12	7	21 416
Bahía Blanca	Buenos Aires	10	5	19 000
San Antonio Oeste	Río Negro	4	6	10 610
Puerto Madryn	Chubut	–	1	1 805
Rawson	Chubut	26	22	10 642
Caleta Córdova	Chubut	7	1	3 781
Caleta Olivia	Santa Cruz	16	4	8 279
San Julián	Santa Cruz	–	5	28
Ushuaia	Tierra del Fuego	3	2	191

Source: from Lasta *et al*., 2001.

[1] See Figure 1.
[2] This fleet is not included in our review.

TABLE 2
Summary of information on artisanal fisheries of Argentina

Type of fisheries	Target resources	Region/ province	Gear	Boats	Number of fishing units	Crew	Annual landings[1]
Coastal shellfish gathering	Blue and ribbed mussels, snails, clams	San José Gulf	Hand	N/A	Largest concentration in the community of El Riacho, Chubut (25 permit holders)	Family groups	Not recorded
	Blue mussels, clams, limpets, snails	Beagle Channel	Hand	N/A	Few, exact number unknown		Not recorded
Coastal octopus gathering (*pulpeo*)	Tehuelche octopus	Río Negro and Chubut	Short gaffs	N/A	Unknown	Family groups	21 tonnes recorded in Río Negro in 2003. Not recorded in Chubut; in 2002 one processing plant (Harengus S.A) bought 17 tonnes
	Red octopus	Chubut, north of Santa Cruz	Long gaffs	N/A	20–30 in the main producing area (Camarones)	Individuals	Not recorded

TABLE 2 (CONTINUED)

Type of fisheries	Target resources	Region/ province	Gear	Boats	Number of fishing units	Crew	Annual landings[1]
Intertidal gill and tangle nets	Silversides, Patagonian blenny, leatherjack, Patagonian cod	Coves ('rías') and bays, of Santa Cruz and the Atlantic coast of Tierra del Fuego	Gillnets and tangle nets	N/A, occasionally assisted by rowboats	Unknown	3	Not recorded
Beach seining	Silversides, Patagonian blenny, flounders	San Matías and San José Gulfs, Atlantic coast of Tierra del Fuego	Beach seines	3–5 m rowboats (fibreglass, plastic or wood)	4–5 in San Matías. About 50 permit holders in San José/Nuevo Gulfs	2–3	San Matías: 24.6 tonnes of silversides and 14.6 tonnes of Patagonian blenny were recorded in 2003 Chubut: one processing plant (Harengus S.A.) bought ca. 180 tonnes of silversides and 1 tonne of Patagonian blenny in 2003
Demersal artisanal fishery employing powered boats	White croaker, leatherjack, stripped weakfish, Brazilian codling, smoothhound shark	Partido de La Costa (Buenos Aires Province)	Bottom gill and tangle nets	Inflatable or semi-rigid boats with outboard motors, up to 7 m long	Unknown	1–2	Not recorded
	Hoki, kinclip, Patagonian cod, southern hake	Beagle Channel (Tierra del Fuego)	Bottom tangle nets (100–120 mm stretched mesh)	Artisanal boats, less than 10 m	Number of tangle nets varies annually from 20 to 200	1–2	Not recorded
	Stiletto and Argentine shrimp, tope shark, white croaker, stripped whitefish	Bahía Blanca, Ing. White, Monte Hermoso (Buenos Aires Province)	Passive bottom nets intersecting tidal currents, with 30 mm mesh in the cod-end; tangle nets, handlines	Boats with inner engines (up to 16 m), boats with outboard motors (up to 7 m), rowboats (up to 6 m)	About 130 boats	1–3	45 tonnes of Argentine shrimp and 40 tonnes of stiletto shrimp recorded in 2002
	Stiletto and Argentine shrimp	Rawson (Chubut Province)	Beam trawl, 4 m wide beam	Boats up to 10 m, made of wood, iron or fibreglass	About 20 boats	3–4	

TABLE 2 (CONTINUED)

Type of fisheries	Target resources	Region/ province	Gear	Boats	Number of fishing units	Crew	Annual landings[1]
Commercial diving	Scallops, blue and ribbed mussels, clams, snails	San Matías and San José Gulfs	Air compressors and hookah	Boats up to 7 m (average), with outboard motors; some with echo-sounder, radio and minimal safety devices	8 boats in San Matías; 20 in San José	3–4	1 241 tonnes recorded in San Matías in 2001; 700 tonnes (600 tonnes of scallops) recorded in San José in 2003
	Blue and ribbed mussels, sea urchin, ascidians	Beagle Channel		Same as above	5 boats	3–4	85 tonnes of sea urchin reported in 1996 (usually less than 1 tonne); 7 tonnes of mussels reported in 1999
Artisanal longlining	Hake, tope shark, cock fish, seven-gilled shark, rays, rockfish, sandperch	San Matías and Nuevo Gulfs	Longlines, 2 000-3 000 hooks each	Boats with outboard motors, less than 10 m	22 boats in San Matías; 5 in Nuevo Gulf in 2002	3	1 032 tonnes recorded in 2003 in San Matías Gulf; 34 tonnes in Nuevo Gulf in 2001 and 2002 (experimental fishery)
Semi-industrial pelagic fishery	Mackerel, anchovy	Mar del Plata	'Lampara', a hand-thrown purse seine	'Rada/ría' inshore fleet; boats 10–18 Mostly wooden boats, 50 years old on average. Equipped with rafts, radio, radar and echo-sounder	The '*rada/ ría*' inshore fleet has 166 registered boats	Up to 10	900 tonnes of anchovy and 100 tonnes of mackerel landed in 2003
Trap fishery utilizing inshore powered boats	Red porgy, sandperch, rockfish, wreckfish	Mar del Plata Quequén Canal Beagle	Large basket traps	Same as above	7 boats	2–5	No data
	Kinclip, southern hake, Patagonian cod, sharks, rays	Beagle Channel	Iron-made traps				
	King crab, false king crab, octopus (occasional bycatch)	Beagle Channel	Truncated cone traps (1.2–1.5 m high, 1.6 m basal diameter)	Boats up to 15 m, with 205 hp engines	12 boats in 1994–2000, down to 6 in 2000–2004	2	32 tonnes of king crab in 1994; 392 tonnes of false king crab in 1996

[1] In most cases landings are either not recorded or grossly under-reported. Some figures (whether total or partial) are presented, however, to give the reader a rough idea of the dimension of the fishery.

2.1 Coastal shellfish gathering

Coastal gathering of shellfish along the seashores occurs at low tide, by hand or with the help of handheld devices, with regional variations that are related to the specific resources harvested. Species most commonly found in the catch of commercial fisheries are summarized in Table 3.

TABLE 3
Main species caught in the artisanal fisheries of Argentina

Scientific name	Common Spanish name	Common English name	Gear	Province[1]
Bivalve molluscs				
Aequipecten tehuelchus	Vieira tehuelche	Tehuelche scallop	Commercial diving	RN, Ch
Ameghinomya antigua	Almeja rayada	Etched clam	Coastal gathering; commercial diving	Ch
Amiantis purpurata	Almeja púrpura	Purple clam	Coastal gathering; commercial diving	RN
Aulacomya ater	Cholga	Ribbed mussel	Coastal gathering; commercial diving	RN, Ch, SC, TdF
Donax hanleyanus	Berberecho	Beach clam	Coastal gathering	BA
Eurhomalea exalbida	Almeja blanca	White clam	Coastal gathering	TdF
Mesodesma mactroides	Almeja amarilla	Yellow clam	Coastal gathering	BA
Mulinia edulis	Almeja marrón	Brown clam	Coastal gathering	TdF
Mytilus edulis chilensis	Mejillón	Blue mussel	Coastal gathering; commercial diving	TdF
Mytilus edulis platensis	Mejillón	Blue mussel	Coastal gathering; commercial diving	RN, Ch
Panopea abbreviata	Almeja panopea	Geoduck	Commercial diving	RN, Ch
Gastropod molluscs				
Adelomelon ancilla	Piquilhue	Piquilhue voluta	Coastal gathering	TdF
Buccinanops globosum	Caracolillo	Beach snail	Coastal gathering	Ch
Buccinanops gradatum	Caracol picante	Hot snail	Coastal gathering; commercial diving	Ch
Fissurella oriens, Patinigera deaurata, P. magellanica	Lapas	Limpets	Coastal gathering	TdF
Odontocymbiola magellanica	Caracol rojo	Red volute	Coastal gathering; commercial diving	Ch
Zidona dufresnei	Caracol tigre	Tiger volute	Commercial diving	RN
Cephalopod molluscs				
Enteroctopus megalocyathus	Pulpo Colorado o dormilón	Red octopus	Coastal gathering; commercial diving	RN, Ch, SC
Loligo gahi, L. sanpaulensis	Calamarete	Longfin squid	Beach seine (n.targ.)[2]	Ch
Octopus tehuelchus	Pulpito	Tehuelche octopus	Coastal gathering	RN, Ch

TABLE 3 (CONTINUED)

Scientific name	Common Spanish name	Common English name	Gear	Province[1]
Crustaceans				
Artemesia longinaris	Camarón	Stiletto shrimp	Tide-intersecting nets; beach seine	BA, Ch
Lithodes santolla	Centolla	Southern king crab	Traps	TdF
Ovalipes trimaculatus	Cangrejo nadador, pancora		Beach seine (n.targ.)	Ch
Paralomis granulosa	Centollón	False king crab	Traps	TdF
Platyxanthus patagonicus	Cangrejo buey	Rock crab	Beach seine (n.targ.)	Ch
Pleoticus muelleri	Langostino	Argentine shrimp	Tide-intersecting nets	BA
Echinoderms				
Loxechinus albus	Erizo	Chilean sea urchin	Commercial diving	TdF
Tunicates				
Pyura chilensis	Piure	Ascidian	Commercial diving	TdF
Chondrichthies[3]				
Callorhinchus callorhynchus	Gallo	Cock fish	Longline (n.targ.); beach seine (n.targ.)	RN, Ch
Dasyatis sp., *Myliobatis* sp.	Chuchos	Sting rays	Longline (n.targ.)	RN, Ch
Dipturus chilensis, *Sympterygia bonapartii*	Rayas	Rays	Longline (n.targ.); beach seine (discard)	RN, Ch
Galeorhinus galeus	Cazón, cazón vitamínico	Tope shark	Tide-intersecting nets; longline; beach seine (n.targ.)	BA; Ch
Mustelus schmitti	Gatuzo	Patagonian smoothhound	Tangle nets; tide-intersecting nets	BA, Ch
Notorhynchus cepedianus	Gatopardo	Seven-gilled shark	Longline (n.targ.)	RN, Ch
Squalus acanthias	Espineto	Spiny dogfish	Longline (n.targ.)	RN
Osteichthies				
Acanthistius brasilianus	Mero	Rockfish	Traps, longline (n.targ.)	BA, RN, Ch
Cynoscion guatacupa	Pescadilla de red	Stripped weakfish	Tangle nets	BA
Eleginops maclovinus	Róbalo	Patagonian blenny	Gill and tangle nets; beach seine	RN, Ch, SC, TdF
Engraulis anchoita	Anchoíta	Anchovy	Lampara; beach seine (n.targ.)	BA, Ch
Genypterus blacodes	Abadejo	Pink cuskeel	Longline (n.targ.), Traps	RN,Ch, TdF
Macruronus magellanicus	Merluza de cola	Hoki	Beach seine; tangle nets	TdF
Merluccius australis	Merluza austral	Southern hake	Gill and tangle nets; beach seine	SC, TdF

TABLE 3 (CONTINUED)

Scientific name	Common Spanish name	Common English name	Gear	Province[1]
Merluccius hubbsi	Merluza	Argentine hake	Longline	RN, Ch
Micropogonias furnieri	Corvina rubia	White croaker	Tangle nets	BA
Mugil platanus	Lisa	Mullet	Beach seine (n.targ.)	Ch
Notothenia (s.l.) spp.	Nototenias	Notothenias	Pre-hispanic beach seine (discard)	Ch , TdF
Odontesthes spp. (4 species)	Pejerreyes	Silversides	Beach seine	RN, Ch, SC, TdF
Odontesthes smitti	Manila, pejerrey cola amarilla	Manila silverside	Gill and tangle nets	RN, Ch, SC, TdF
Oncopterus darwini	Lenguado	Flounder	Beach seine (discard)	Ch
Oncorhynchus mykiss	Trucha arco iris	Steelhead	Sport	SC
Pagrus pagrus	Besugo	Red porgy	Traps	BA
Paralichthys spp.	Lenguados	Flounders	Tide-intersecting nets; longline (n.targ.); beach seine (discard)	BA, RN, Ch
Parona signata	Palometa	Parona leatherjack	Gill and tangle nets; beach seines	SC, TdF
Percophis brasiliensis	Pez palo	Brazilian flathead	Tide-intersecting nets; beach seine (n.targ.)	BA, Ch
Polyprion americanus	Chernia	Wreckfish	Traps	BA
Pomatomus saltatriz	Anchoa de banco	Blue fish	Beach seine (n.targ.)	Ch
Pseudopercis semifasciata	Salmón de mar	Sandperch	Traps; longline (n.targ.)	BA, RN, Ch
Salilota Australis	Bacalao criollo	Patagonian cod	Gill and tangle nets	SC, TdF
Salmo trutta	Trucha marrón	Brown trout	Sport	SC
Scomber japonicus	Caballa	Chub mackerel	Lampara; beach seine (n.targ.)	BA, Ch
Seriolella porosa	Savorín	Silver warehou	Beach seine (n.targ.)	RN, Ch
Stromateus brasiliensis	Pampanito	Butterfish	Beach seine (discard)	RN, Ch
Trachurus lathami	Jurel	Horse mackerel	Beach seine (n.targ.)	Ch
Urophycis brasiliensis	Brótola	Brazilian codling	Tangle nets	BA

1 Provinces listed are those for which a fishery (large or small) has been reported. Many species occur also in provinces for which a fishery has not been recorded. BA: Buenos Aires; RN: Río Negro; Ch: Chubut; SC: Santa Cruz; TdF: Tierra del Fuego.

2 Non-target (n.targ.) species are generally kept and marketed, and may fetch a high price (even higher than target species).

3 Names of fishes follow Cousseau and Perrotta (2000).

Bivalves and gastropods: In Buenos Aires Province, bivalves are shovelled along exposed sandy beaches. Traditionally, this fishery targeted primarily the yellow clam* (*almeja amarilla*), but because the populations collapsed, the fishery now targets beach clams (*berberechos*). However, the yellow clam sustained a significant fishery that started in the 1940s, with landings reaching a maximum of 1 073 tonnes in 1953 (Dadón, 2001, 2002). When catches declined because of a dramatic increase in effort, the fishery was closed in 1956. It reopened with a 45-tonne quota in 1957, and closed again for ten years in 1958, and it has remained closed to a commercial fishery ever since. A daily bag limit (2 kg/person) has been allowed for personal consumption, as clams are valued by tourists. Although recreational gathering is the only harvesting that has been allowed for decades, the yellow clam populations have continued to decline. This is due to a variety of reasons, including growing pressure from recreational harvesters and illegal commercial fishing. In addition, the destruction of habitat caused by the extraction of sand for construction, circulation of vehicles along the beaches, and an ever-expanding urban development has compounded the pressure on this species. After a mass mortality event decimated most populations in 1995, a complete closure was put in place in 1996, including the bag limit for personal consumption. Although illegal, harvesting continues to be a common activity during the summers and the mass mortality did not affect stocks of *berberecho* (Dadón, 1999), whose size even increased after 1998. As a result, it has been increasingly targeted recreationally but also commercially. This fishery is not regulated and catch is not monitored. Although not illegal, most of the catch is marketed through informal conduits. The daily catch is frozen and sold in bulk.

In Chubut Province, many families of coastal gatherers harvest molluscs in the intertidal zone (Figure 2), mostly in San José Gulf. They target blue mussels (*mejillón*), etched clams (*almeja rayada*), ribbed mussels (*cholga*), volute (*caracol*), and beach and hot snails (*caracoles*). In the case of clams, harvesters can recognize the holes left by the siphons at the surface, and use 2- or 3-prong forks; small snails are concentrated using bait. The shellfish catch is collected in handheld mesh bags (*chinguillos*) with an approximate capacity of 40 kg. Once a team has filled 10 to 20 *chinguillos*, these are transported ashore, 1 to 3 km across tidelands. The catch is transported by truck to processing plants, fish shops or restaurants in Puerto Madryn and Trelew. The activity is seasonal (autumn and winter), generally constrained by the onset of the red tide season (Santa Ana, 2004).

Gastropods and bivalves are also gathered in scattered locations of Santa Cruz and Tierra del Fuego Provinces. In the latter there is a small catch of blue mussels, etched clams, white clams, brown clams, limpets (*lapas*) and voluta snails. The activity is seasonally constrained by the development of red tides, usually during the summer. The product is marketed locally, fresh and unprocessed.

* Correspondence between scientific names and common Spanish and English names are summarized in Table 3. English names are used throughout text; the first time that the name is used, the Spanish name is quoted in parentheses. Fish common names follow Cousseau and Perrotta (2000) in most instances.

FIGURE 2
Artisanal gathering of intertidal mussels (*Mytilus edulis platensis*) in El Riacho, San José Gulf, Chubut Province

(Photo by Javier Rodriguez)

Small octopus: In Chubut and Río Negro Provinces, the intertidal gathering of a small-sized octopus species (Tehuelche octopus or *pulpito*) is a popular recreational activity. Octopus is also harvested commercially (*pulpeo*), being a complement to gathering of bivalves and gastropods. In San Matías Gulf, *pulpeo* has been a traditional seasonal occupation for low-income labourers who establish camps along the seashore during the summers. *Pulperos* (octopus harvesters) use a gaff built of a 6 mm iron rod, 30 to 40 cm long. The tip is sharpened and curved with a precise angle. Octopus is removed from crevices and holes and the success of the *pulperos* is strongly determined by experience. Traditional gatherers are very careful not to damage the substrate when extracting octopus, because newcomers will not establish themselves in damaged refuges. Commercial harvest is seasonal, extending from late spring (November–December) to early autumn (March–April), peaking by mid to late summer. In Río Negro Province, catch records go back to 1953 (Iribarne, 1990, 1991); the maximum recorded catch was 307 tonnes in 1967. The annual catch has been 20 to 40 tonnes in recent years. The fishery is not regulated or monitored in Chubut Province. One fisher (Cándida Vargas[*], personal communication) reported that she and her family collect up to 15 tonnes in San José Gulf during a single season. Intermediaries (*acopiadores* or *acarreadores*) have played a significant role in this fishery and processing plants also buy octopus occasionally. Ré (1998a, 1998b) observed that fishing pressure goes down when *pulpeo* ceases to be lucrative. When this occurs, immigration from the subtidal zone appears to replenish the intertidal segment of the population.

* Mrs Cándida Vargas is the daughter of *pulperos* and a *pulpera* herself. She lives with her extended family (husband, 10 children, and grandchildren) in Playa Larralde, San José Gulf.

Red octopus (dormilón): Red octopus is caught in San José Gulf, the Camarones area, Comodoro Rivadavia (all in Chubut Province), Caleta Olivia (Santa Cruz Province), and other scattered locations. As in the small octopus fishery, fishers (all male) use a gaff; however, this gaff is stronger (8 mm iron rod) and longer (1–1.2 m) (Ré, 1998b). In the Camarones area (the main producing zone), fishing takes place during winter and spring tides. Landings from this area started to be commercialized in 1995–1997 due to the abundance and increased demand of octopus (Cinti and Soria, 2003). This is the most significant artisanal fishery in the Camarones area in terms of people involved and catch landed. Although it appears to have great potential, the present catch is relatively small due to poor accessibility. Cinti and Soria (2003) estimated a total catch of 9 tonnes for the 2002 season; there are no official records and the fishery is unregulated. Red octopus is sold gutted (fresh or frozen) in fish stores of provincial coastal cities.

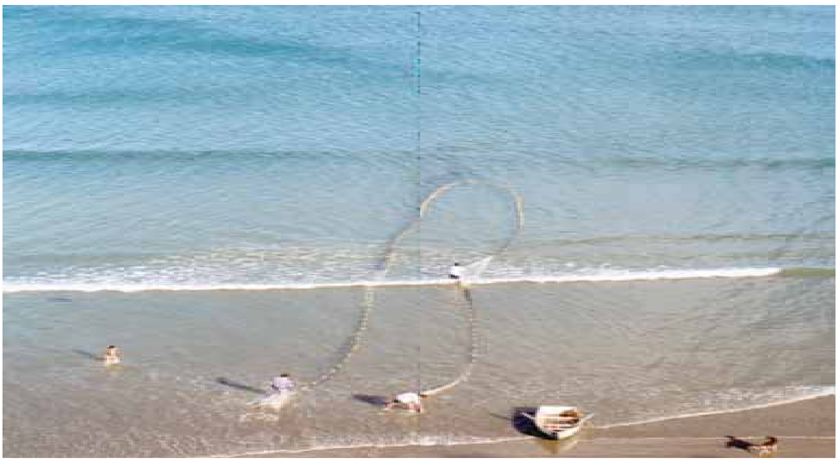
2.2 Beach seining

Beach seining is practiced in San Matías Gulf (Río Negro Province), along the coasts of Chubut Province, and on the Atlantic coast of Tierra del Fuego, always in a very narrow (30–50 m from the water edge) and shallow (up to 4–10 m depth) area (Figure 3). Teams are formed by two to four fishers that generally use a row boat and a 70 to 100 m long net that is folded on the stern and deployed forming a semi-circle, one end tied to land with a piece of rope. Seines are occasionally operated without the help of a boat, in which case the net is deployed perpendicular to the shoreline. Two fishers pull the net in parallel, one walking into the water and the other ashore. Fishing takes place all year long, although operations are constrained by meteorological conditions. Resources targeted are markedly seasonal, particularly silversides (*pejerreyes*), which are migratory. Adults are caught mostly during the autumn and spring, when they form reproductive aggregations and juveniles during spring and summer (Elías *et al.*, 1991; Ré and Berón, 1999). This is mostly a small-scale, artisanal commercial fishery, but there is also a small recreational component. Only four or five families are presently active in this traditional fishery in San Matías Gulf, where it peaked during the 1950s. Maximum recorded catch of silversides was 376 tonnes in 1956 (Perier, 1994). The catch is sold fresh in San Antonio Oeste, door-to-door or to restaurants, as is also the case in Tierra del Fuego. Fishers from Chubut Province also sell to plants that process silversides and Patagonian blennies (*róbalos*) in a variety of forms (fresh, frozen, smoked and canned). Catch records are fragmented and the fishery is not regulated.

2.3 Gill and tangle nets deployed in the intertidal zone

This fishery operates inside estuaries and bays of Santa Cruz Province and the Atlantic coast of Tierra del Fuego. Most fishers operate directly from the beach, tracking the tides: the net is deployed during a low tide and the catch is retrieved during the next low tide. The mesh used in Tierra del Fuego for large species is 100 to 120 mm (stretched) (Isla, 2001). This activity is generally seasonal, taking place between October and April. It can be categorized as a small-scale, artisanal, opportunistic, multispecies fishery. Species targeted include silversides, Patagonian blenny, parona leatherjack (*palometa*), southern hake (*merluza austral*) and Patagonian cod (*bacalao criollo*). Fish is generally sold fresh. Silversides are filleted, and large Patagonian blennies are sold whole or gutted. In Santa Cruz there are *in situ* inspections to control the gear utilized, and quality controls of processing and marketing (Pereiro, 2001). Although there are no official records, landings and the length of the fishing season have declined in Tierra del Fuego over recent years.

FIGURE 3
Beach seining used in Río Negro, Chubut and Tierra del Fuego Provinces (fishing gear in operation)



2.4 Bottom tangle nets and tide-intersecting nets deployed from boats

A fishery operating along the northern maritime coast of Buenos Aires Province (Partido de la Costa) employs inflatable or semi-rigid boats with outboard motors (Figure 4). The gear consists of tangle nets deployed up to 1 to 2 miles (1.6–3.2 km) offshore. Species caught include white croaker (*corvina*), leatherjack and, to a lesser extent, stripped weakfish (*pescadilla de red*), Brazilian codling (*brótola*) and Patagonian smoothhound shark (*gatuzo*) (Lasta *et al*., 2001; Lagos, 2001). This fishery grew rapidly towards the end of the 1990s, providing significant labour opportunities in the region. Marketing takes place mostly during the summer, coincidentally, with the peak of tourism (Lagos, 2001). There are no official catch records. Regulations include the use of two pieces of net, 50 m long each, 28 to 30 cm mesh size (stretched), and legal size limits for most species.

FIGURE 4
Boats and trailers (*catres*) in San Bernardo Beach, illustrative of the artisanal fleet from Partido de La Costa, Buenos Aires Province

(Photo from Lagos, 2001)

In the region of Bahía Blanca (Buenos Aires Province) operates a fishery with a relatively long tradition, going back to the 1940s. The main gear consists of stationary nets that intercept tidal flows. The fleet is based in Ing. White, Puerto Rosales and Monte Hermoso, all close to the city of Bahía Blanca. Hulls are made of wood, plastic or fibreglass and are up to 16 m long. Approximately 40% have inner engines; the rest are split between boats with outboard motors (up to 7.7 m long) and rowboats (up to 6 m). Fishing trips do not last longer than 3 to 12 hours. The catch includes stiletto shrimp (*camarón*), Argentine shrimp (*langostino*), flounders (*lenguados*), Patagonian smoothhound, and Brazilian flathead (*pez palo*). In addition, tope shark (*cazón*) is caught with tangle nets, and white croaker and stripped weakfish with handlines (Izzo *et al.*, 1999). Annual landings are below 300 tonnes. Starting in 1999, fishers have been required to report catches through a catch slip programme.

In the Beagle Channel (Tierra del Fuego), small boats (10 m; Figure 5) are used to catch hoki (*merluza de cola*) with stationary tide-intersecting nets. This fishery is not regulated. Iron-made traps are used to catch small amounts of kinclip (*abadejo*), Patagonian cod, sharks and rays.

2.5 Beam trawling

Initially, only one boat operated beam-trawled for stiletto shrimp in Rawson Harbor, Chubut Province. However, at the beginning of the twenty-first century, more than 25 artisanal boats (less than 10 m long as defined in provincial legislation) have requested fishing permits (Soutric and Caille, 2005). Beam trawls with a 4 m long beam (locally known as *raño*) were traditionally used in Mar del Plata, where they have been virtually abandoned (beam trawlers were 9–18 m long) (Lasta *et al.*, 2001). The main targets of the beam trawl fishery are stiletto and Argentine shrimp.

FIGURE 5
A 10-m-long boat fishing with bottom nets for hoki (*Macruronus magellanicus*) in the Beagle Channel, Tierra del Fuego Province

2.6 Commercial diving

Commercial diving takes place in the San Matías and San José Gulfs and in the Beagle Channel (Tierra del Fuego). A typical commercial diving team operates a boat approximately 7 m long with an outboard motor (40 to 120 hp), equipped with an air compressor and hookahs (Figure 6). Teams are composed of two or three divers, a deckhand and a skipper. Divers search the sea bed for shellfish, usually bivalves, which are placed in handheld mesh bags known as *salabardos*. The catch is stockpiled on the deck in bags with a capacity of 40 kg or more (Ciocco, 1995).

FIGURE 6
Boat from the commercial diving fleet that operates in San José Gulf, Chubut Province. Boats are pulled out of the water using tractors and trailers. Bags in the background are filled with scallops (*Aequipecten tehuelchus*)

San Matías and San José Gulfs: The activity is sporadic in San Matías Gulf (Río Negro Province), depending on prices and availability of resources within the range of operation of the divers (down to 30 m). Target species are blue mussels, scallops (*vieiras*), ribbed mussels, voluta snails, purple clams and geoducks (*almeja panopea*). In the adjacent San José Gulf (Chubut Province), the main targets are scallops; mussels, clams and snails are of lesser significance. These are selective fisheries, with virtually no bycatch. A total of 1 241 tonnes were recorded in San Matías Gulf in 2001 and 600 tonnes of scallop in San José Gulf in 2003. Bivalve meats are processed in plants located in San Antonio Oeste, Puerto Madryn and Trelew. In the case of scallops, only the adductor muscles are packed for export.

Beagle Channel: In the Beagle Channel small volumes of sea urchin (*erizo*) and ascidians (*piure*) are harvested in addition to blue and ribbed mussels. The annual sea urchin catch used to be less than 1 tonne, but in 1996 rose to 85.4 tonnes due to participation of Chilean divers. The shellfish catch is processed in plants certified by SENASA or sold fresh, locally. The fishery is regularly monitored for red tide toxins, and closed by the provincial health authority when a safety threshold is surpassed. In 1990, there were 36 active fishers (annual catch was 31 tonnes), which dropped to 32 in 1992 (annual catch 1.7 tonnes) (Isla, 2001).

2.7 Bottom longlining

During the period 1994–1998 a team from CENPAT conducted a research and development project to explore the prospects of bottom longlining in Chubut Province as an alternative to commercial diving for bivalves during the seasonal closures of that fishery. Artisanal fishers contributed boats and crews. In 2000, some of the latter requested experimental permits to longline for tope shark.

Nuevo Gulf tope shark fishery: This experimental fishery was monitored by CENPAT, operating only in Nuevo Gulf. Boats deployed approximately 2 000 hooks baited with anchovy at depths ranging from 40 to 120 m, and had an action radius of 24 km. A total of 34 tonnes (80% elasmobranches) were caught during the 2000–2001 and 2001–2002 seasons, with no bycatch discarded. Since then, this fishery has been very irregular (Elías, 2002).

San Matías Gulf hake fishery: In 1996 a longline fishery targeting hake boomed in San Matías Gulf (Río Negro Province), triggered by demand in the Spanish market. In its initial phase the fleet was artisanal, composed of boats less than 10 m long powered by an outboard motor, with a 15 nautical mile radius of operation. Anchovy (*anchoita*) was used as bait. The size of boats increased in 1997 (12–25 m), using 6 000 to 10 000 hooks and there were two even larger boats (25 m), operating 10 000 to 15 000 hooks. The size of the fleet peaked in 1998, when it reached 66 boats and the maximum annual catch was approximately 3 900 tonnes. The fishery collapsed in 2001 due to a drop in price. Some boats were converted for shell fishing. The fishery started to gradually recover in 2002, and in 2003 landings reached 1 032 tonnes. During the heyday of the fishery the catch was exported by plane to Spain, fresh and gutted.

Besides tope shark and hake, species caught in the two regions include seven-gilled shark (*gatopardo*), dogfish, rays (*rayas*), stingrays (*chuchos*), cockfish (gallo), rockfish (*mero*), sandperch (*salmón de mar*), kinclip and flounders.

2.8 The 'lampara' (hand-thrown seine) fishery

This net is used to fish for anchovy (September to November) and mackerel (*caballa*, October to January) in the Mar del Plata area, within the 50 m isobath. The net is thrown from the bow and maneuvered on the weather side. In the case of mackerel, the lampara is thrown on a site that is baited with anchovy heads and other fish discards (Izzo and Boccanfuso, 1993). In 2003, anchovy and mackerel landings were, respectively, 900 tonnes and 100 tonnes. Anchovy is canned or salted; mackerel is sold fresh, frozen or canned.

2.9 Trap fisheries

Rocky-reef finfish trap fishery: In the Mar del Plata area, traps (*nasas*) are used to capture finfish species from rocky reefs, like red porgy (*besugo*), sandperch, rockfish and wreckfish (*chernia*).

King crab fishery of Tierra del Fuego: A locally significant and traditional trap fishery targets southern king crab (*centolla*) in the Beagle Channel (Tierra del Fuego). Traps of conical design are deployed in lines of 10 units, using meat discards as bait. Traps are soaked for at least two to three days, then tended and deployed again (Boschi *et al*., 1984). Another lithodid crab, the false king crab (*centollón*) is also caught, but its quality is comparatively lower. In spite of this, it has become a significant alternative, considering the sharp decline of king crab stocks and subsequent restrictive regulations. Catches of false king crab have increased in recent years, reaching a historical maximum of 362 tonnes in 1996. Octopus (occasionally sold) is caught as bycatch.

The fishery is seasonal, operating between January and October. Artisanal fishers and their families process and sell the catch fresh in Ushuaia or Rio Grande, and eventually to processing plants. Presently, the plants also export king crab and false king crab. They own a fleet of larger and better equipped vessels, manned by crews of two or three people that are employees of the plant. This 'industrial' fleet soaks 800 traps, while the artisanal fleet soaks only 100 to 150 (Lovrich, 1997).

Resources are shared with Chile, but no data are available for the Chilean sector of the channel since 1983. There is no formal collaboration or exchange of information between agencies from the two countries.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

3.1 Description of fishers

Coastal gatherers and beach seiners: In Río Negro Province gatherers are mostly *pulperos* that move to the coast during the summer months. Once the harvest (*zafra*) is over, most of them return to San Antonio where they work temporary jobs (*changas*). In the past they used to build huts made out of brush branches, cardboard and other scrap materials (*enramadas*) in their temporary summer camps. *Enramadas*, used both for habitation and to hold the octopus catch, are now being replaced by small cinder block houses. Intermediaries (*acarreadores* or *acopiadores*) concentrate and market the catch in most cases, often paying the fishers in kind. As a result, *pulperos* survive the summer but end up penniless. *Pulperos* that live in urban areas (San Antonio Oeste, Puerto Madryn) sell the catch directly to consumers and fish shops, fresh or pickled (*escabeche*). In Chubut Province most families of gatherers live in El Riacho and Larralde, small rural fishing villages where wood stoves are used for cooking and heating. Water is in short supply everywhere along the coast.

In Tierra del Fuego there are only a few coastal gatherers. They depend on welfare or temporary jobs during the red tide season (Pascual *et al*., 2002). In 1994, Ré and Berón (1999) counted 69 beach seiners in Chubut Province; 61 of them were owners of their fishing gear. Considering that teams are generally composed of two persons, the number of people involved directly in this fishery was at least 120. Of these 54% were exclusively artisanal fishers and 8% alternated between beach seining and jobs as deckhands in the industrial fleet.

Gatherers and beach seiners constitute the lowest income group of fishers, often living in precarious conditions. The illiteracy rate is highest in Río Negro Province. Flamanc (1999) pointed out that in Puerto Madryn there are two subgroups: older fishers, which are more sedentary and often live near the coast, and younger, more mobile fishers that alternate with low paying jobs. There are no official figures of the number of fishers in this group, but it is estimated to be approximately 440 in the whole country (100 in Río Negro, 200 in Chubut, 100 in Santa Cruz and 40 in Tierra del Fuego).

Fishers that work from small (strictly artisanal) boats: This group is very heterogeneous. In general, their income is higher than that of workers with their qualifications in other sectors of the economy. Included here are fishers that operate in the north of Buenos Aires Province (Partido de la Costa) using inflatable or semi-rigid boats, commercial divers from San Matías and San José Gulfs, and some of the boats that operate from Rawson (Chubut Province) or in the Beagle Channel (Tierra del Fuego Province).

Fishers from Partido de la Costa are relatively young (36 years old on average) and not very experienced: only 25% come from fishing families. In general, they alternate between fishing and other jobs.

Flamanc (1999) found that in Puerto Madryn (Chubut Province) younger fishers (28 years on average) are commercial divers. This is a mostly urban group of fishers that go to the coast to fish but reside in the city (not all are homeowners), have a perception very different from that of coastal gatherers, and show concern for the sustainability of the resources that they depend on. Santa Ana (2001) conducted an interview survey in the region of Puerto Madryn, identifying 98 active fishers. This was a very dynamic group, with members alternating often between different occupations. A later interview of team leaders showed that 75% heads of household have an average time of 14 years in the fishery; fishing is the sole source of income for 63% and the main source for the remainder. Among boats in the fleet 68% showed signs of decay and 13% were definitely precarious (Elías *et al*., 2001). A few boat owners do not participate physically in the fishing operations, which is inconsistent with recent provincial legislation (Law 4725 of 2001), and are not considered here as artisanal fishers. Artisanal fishers from Puerto Madryn do not have access to welfare or retirement programmes. Most fishers have only an elementary school education level. The number of fishers in this group is around 660 for the entire country (300 in Buenos Aires Province, 200 in Río Negro, 130 in Chubut and 30 in Tierra del Fuego).

Fishers that work in the rada/ría fleet: This group has the highest income level, although it is presently affected by a generalized crisis related to the decline or collapse of many resources of the Argentine shelf. Fishers in this group can be generally defined as middle class. Children have access to all educational levels. Hierarchies in the working place are minimal (Errazti and Bertolotti, 1998). In most cases, the skipper works side by side with the deckhands. Education level is generally at the elementary level for deckhands and tertiary for skippers and engineers. There are approximately 166 registered boats in this sector, with an average crew of 4, making the total number of active fishers between 600 and 700.

3.2 Social and economical aspects

Access to credit

In contrast with the industrial sector, which has been heavily subsidized, the artisanal sector has very limited access to credit and subsidies (Godelman *et al*., 1999). The situation is better in Río Negro and Tierra del Fuego Provinces, where provincial states have granted subsidies for the construction of municipal processing plants and the purchase of boats. This assistance, however, has not been accompanied by orientation or strengthening of fishers' organizations, and so was not successful in reverting the vulnerability of this sector. It must be emphasized that artisanal fishing is not a subsistence activity in Argentina, where even the poorest fishers are commercially-oriented. However, society perceives artisanal fishery as an activity with a low status.

Women participating in artisanal fisheries

Women's presence is generally related to processing and marketing. Female participation in fishing activities is limited, being most significant among the coastal gatherers of San Matías and San José Gulfs, where only a few have worked as deckhands. In the case of the inshore fleet, virtually no women go to sea. A few women participate actively in the fishers' association of Puerto Madryn. Marta Piñeiro, wife of an artisanal fisher (personal communication), noted that women are marginalized twice: once for being women and again because of the occupation of their husbands.

Pascual *et al*. (2002) conducted a socio-economic diagnostic survey of women's participation in fisheries of the Patagonian provinces. They interviewed 251 women belonging to six groups: workers from processing plants (59%); fishers (5%, including aquaculturists); *pulperas* (8%); processers of artisanal products (preserves and souvenirs, 12%), professionals (plant managers, health-related controllers, administrators, engineers, scientists, 12%); and merchants (owners of fish stores or thematic restaurants, 4%). The average age of the women interviewed was 36 years old; age was highest among *pulperas* (47 years old) and plant workers (44 years old). Gatherers and *pulperas* stop working at age 60, because "at an advanced age it is difficult to walk over the rocky intertidal". Professionals are mostly young, as management agencies and research centres from Patagonia are generally of recent creation, at least as compared to Buenos Aires Province. The average age of recruitment for *pulperas* is 23, but some are recruited as early as 5 years old. About 68% work full-time in fisheries-related jobs, 21% are temporary, 8% seasonal and 3% occasional. With regards to education, 3% are illiterate, 21% did not complete elementary education, 12% completed high school, and 13% went through tertiary or college education. *Pulperas* are the most vulnerable sector: 20% have no education and 20% are illiterate. The survey concluded that the female segment of the fishing-related population is eager to receive some form of education or training.

Fisheries origins and traditions

Fishing peoples using canoes inhabited the Magellanic region, including Beagle Channel. As indicated earlier, the fishing traditions of prehispanic peoples were lost during the colonial period. Archaeological research conducted around Valdés Peninsula (Chubut Province) shows that 3 200 years ago hunters-gatherers already roamed the coast, occasionally moving inland in search for freshwater (Gómez-Otero, 1996). Shellfish gathering was likely conducted during the low tides, or following storm-induced strandings of subtidal bivalves. The finding of a wooden fishing hook suggests that there was some finfishing in deep tidal pools (Gómez-Otero, 1996).

Octopus gathering (*pulpeo*) had its origins on the west coast of San Matías Gulf (Río Negro Province) during the 1940s. Since then, knowledge has been transferred from parents to children. The community of El Riacho (Chubut Province) was started during the 1960s by *pulperos* from San Matías Gulf (Santa Ana, 2004), and later joined during the 1990s by some families without previous experience.

Fishing traditions were brought to the country by European immigrants around the turn of the nineteenth to the twentieth century. Many of them settled in El Tigre and La Boca, on the shores of La Plata River near Buenos Aires. Mar del Plata gained gradually in relative importance with the advent of railroads (1886), largely as it became a major destination of tourists and vacationers during the summer season. The inshore fishery developed to supply fresh fish (silversides, white croaker, flounders) to this population. A similar pattern followed later in Necochea, San Antonio Oeste and Puerto Madryn.

As late as the 1940s, fishing boats operated only within sight of the coast, never venturing beyond. The catch was sufficient to satisfy the local demand. Starting in 1943, longlining for tope shark rapidly developed in the area of Mar del Plata, paving the way for a transformation of the fishing fleet, which started targeting anchovy and mackerel. When the tope shark fishery declined in Mar de Plata, the fleet gradually moved to other ports: Monte Hermoso, Puerto Madryn, Rawson, and Comodoro Rivadavia (Mateo Oviedo, 2003). Small groups of fishers settled in these communities, but many moved to other activities after the decline of the tope shark fishery.

Commercial diving for shellfish originated in San José Gulf during the early 1970s (Ciocco, 1995). A scallop dredge fishery had boomed and collapsed in the adjacent San Matías Gulf between 1968 and 1972, and there was concern about the same happening here. Commercial diving was then envisioned as an environment-friendly alternative to dredging, and developed by a team of divers with experience in diving for mussels in Uruguay (Santiago Picallo, personal communication). Commercial diving has operated continuously ever since, incorporating new divers from other parts of the country and from Chile. Artisanal fishing was started in Tierra del Fuego by immigrant skippers, many of Chilean origin.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

4.1 Community organization

The level of organization of the fishers increases with their socio-economic status. There were attempts to create cooperatives for low-income fishers in Buenos Aires, Santa Cruz and Tierra del Fuego Provinces, but these were short lived. In San Antonio Oeste there is an association (APASAO) that groups commercial divers and longliners. Artisanal fishers are best organized in the area of Puerto Madryn (Chubut Province), where the local association (APAPM) integrates fishers from all sectors. Marta Piñeiro, an active member of this organization, believes that the scarcity of organizations like APAPM makes it difficult for fishers along the extensive Argentine coastline to unite to improve their living conditions. Increasingly, pressure from the markets fosters competition, giving significance to fishers' qualifications in catching, processing and marketing.

The first Gathering of Artisanal Fishers of Chubut took place in Puerto Madryn in 1999, bringing together 35 fishers (coastal gatherers, beach seiners and commercial divers). This was the first formal event involving fishers and scientists (Elías and Pereiro, 1999). From these beginnings there have been consistent efforts from different sectors (municipal government, scientists, universities and non-governmental organizations [NGOs]) to accompany the organization of fishers as a requisite for the sustainability of local artisanal fisheries. Interinstitutional interactions proved positive, bringing some successes. A facility close to the beach of Puerto Madryn served both as a restaurant that sold products prepared by fishers' wives and to educate the general public. The association put together its own web page (www.apamadryn.com) and an informative bulletin is published and distributed.

Organizations from Buenos Aires Province include the Chamber of Artisanal Fishers of Monte Hermoso and Pehuencó, and the Chamber of Fishers from Partido de La Costa. *Rada/ría* fishers are organized at the level of different harbours, like the Society of Skippers of Mar del Plata, the Chamber of Fishers of Bahía Blanca, and the Chamber of Fishers of the Inshore Fleet of Rawson.

The First National Gathering on Policies for Coastal Fisheries (artisanal and small scale) was held in Mar del Plata in 2000, and the second in Puerto Madryn in 2001. Both were attended by fishers from all over the country, as well as members of the coast guard, business owners and scientists. This was a forum for the discussion of many important subjects: management, conservation of coastal environments, and socio-economic aspects of fisheries development. The National Federation of Artisanal Fishers was founded during the first gathering, with a commitment to gain areas of exclusive access for artisanal fishers and small-scale fleets, consolidate the social and juridical organization in every harbour, promote the creation of cooperatives, work towards the solution of well-being and educational problems, and lobby for controls on the large industrial fleets responsible for the collapse of most major resources (Perrotta *et al*., 2000). The Federation was ratified during the second gathering, but never gained real momentum. Both gatherings made it evident that there were significant differences in the goals and priorities of artisanal and semi-industrial fishers, which made it difficult to consolidate the organization.

Participation of fishers' organizations in monitoring and management are at best incipient in most fisheries, with the artisanal fishery of Puerto Madryn (Chubut Province) leading the way. Several NGOs in the country are involved with marine conservation (e.g. Fundación Vida Silvestre, Fundación Patagonia Natural, Fauna Silvestre, etc.), but only one is exclusively related to fisheries: the Center for the Development of National Fisheries (CeDePesca). Many of these NGOs have helped with the organization of workshops and other events to discuss problems related to artisanal fisheries, but have not been involved in the discussion of management.

4.2 Interactions between fishers and other sectors

Most of the Argentina coast is sparsely populated. The long coastal zone of Patagonia (15° latitude) has only 21 human settlements and a total population of 790 000; the number of artisanal or small-scale fishers is comparatively modest. Perhaps for this reason conflicts with other uses of the coastal zone, while existent, are not generally significant.

Conflicts between industrial and small-scale fisheries: During recurrent crises in the hake fishery, the industrial fleet based in Mar del Plata has redirected effort to pelagic and demersal resources from the coastal zone, which has been a source of conflict with small-scale fleets (Lasta *et al*., 2000; Garciarena *et al*., 2002).

Conflicts between recreational and artisanal fishers: In the *rías* of Santa Cruz Province artisanal fishers occasionally compete with sport fishers targeting brown trout (*Salmo trutta*) and steelhead (*Oncorhynchus mykiss*). Conflict between artisanal and recreational gatherers of shellfish (mostly mussels) was frequent in the zone of El Riacho. Artisanal fishers pay for a permit and are regulated, while recreational fishers are not. Artisanal fishers also complain because recreational fishers use destructive practices (shovels, unselective mussel gathering, overturning of rocks, etc.). This situation led to an experiment with territorial use communal rights (Santa Ana, 2004). In the Beagle Channel (Tierra del Fuego), recreational boats occasionally accidentally cut off the buoys that mark trap lines.

Conflicts with landowners: A common conflict along the coasts of Patagonia is created by landowners cutting the access to the seashore to artisanal fisheries that pull their boats over land. The reason is recurrent complaints by landowners about fishers killing sheep for consumption.

4.3 Integrated management of the coastal zone and marine conservation

Only recently has there been a concern about integrated coastal management, mostly through Global Environment Facility (GEF) projects funded by the World Bank through the United Nations Development Programme (UNDP) (e.g. Integrated Management Plan for the Patagonian Coastal Zone, and Environmental Protection of the La Plata River and its Maritime Front). The National Under-Secretary of Natural Resources and Sustainable Development is elaborating a National Strategy for Biodiversity, according to the United Nations Convention on Biodiversity (UNCED). To date, the protection of coastal habitats has relied mostly on a number of protected areas that represent only 0.59% of the coastal zone. In most cases there is some level of economic activity, those related to tourism/recreation being the most frequent. In many cases (San Antonio Bay, Valdés Peninsula, Tierra del Fuego) those coexist with other activities. Artisanal fishers operate within the boundaries of the following protected areas.

Buenos Aires Province: Natural Integrated Reserves (RNIs; Samborombón Bay, Mar Chiquita Lagoon) are established to protect nature as a whole, allowing only scientific exploration in restricted sectors. Natural Reserves with a Specific Objective (RNODs) are conceived to protect the soil, biota and natural features; human activity is allowed but regulated. Natural Multiple Use Reserves (NMUR; Bahía Blanca, Bahía Verde, Bahía Falsa) are oriented towards research and to experiments on the rational and sustainable use of natural resources. Focus is on the ecosystem rather than on individual species.

Río Negro Province: The Natural Protected Area of San Antonio Bay includes the open coastal zone adjacent to (and under the influence of) the bay. This area has ecological, fishing, tourism and historical significance. To date there is no management plan in place. Fishing and tourism, and to a lesser extent a deep water harbour, are activities compatible with each other, sustaining the local economy. A plan for the production of sodium carbonate (Solvay method), soon to start operating, brings into question the future sustainability of this ecosystem.

Chubut Province: The Natural Protected Area of Valdés Peninsula was created with the objective of promoting sustainable activities compatible with conservation, like tourism, commercial diving, artisanal aquaculture and husbandry. Access to the area is restricted and management plans are under development for several activities.

Santa Cruz Province: The Bahía Laura Natural Reserve is a nominally intangible reserve created to protect marine birds and mammals and subtidal kelp forests. There is, however, no control. Some beach seining for silversides takes place within its boundaries. The National Park Monte León* and the Area for Scientific Use of Deseada Island are under special protection because of large bird breeding colonies. Some beach seiners and mussel gatherers operate within their boundaries.

Tierra del Fuego Province: The Reserve of the Atlantic Coast of Tierra del Fuego is part of a hemispheric network for the protection of coastal birds. It harbours many colonies of marine birds and mammals, as well as populations of introduced beavers. Economic activities within its boundaries include sheep ranching, oil/gas exploitation and sand/gravel mining. Artisanal fishers catch silversides and Patagonian blenny using beach seine. There are plans to extend the boundaries of the reserve to incorporate the adjacent sea. The National Park of Tierra del Fuego includes kelp forests and colonies of birds and mammals. Economic activities include tourism and the king crab fishery. The National Park Administration is considering the extension of the park to incorporate the adjacent sea. There are projects for other protected areas that include the adjacent sea, including the Provincial Reserve of Isla de los Estados and a protected sector in the southeast of the Isla Grande de Tierra del Fuego (Península Mitre).

5. ASSESSMENT OF FISHERIES

Quantitative assessments have been conducted only for a handful of resources:

Coastal demersal fishes, Buenos Aires Province: Biologically Acceptable Catches (BAC) of white croaker and stripped weakfish were determined by INIDEP using a Schaefer's dynamic biomass model (Ruarte and Aubone, 2003; Carozza *et al.*, 2004). Reference points considered for the management of this fishery include: maximum sustainable yield (MSY), optimum biomass (B_{opt}) and replacement catch (C_R). An indicator of the state of the resource and the fishery is the proportion of the current biomass relative to carrying capacity (K) and to B_{opt}. A risk analysis (Monte Carlo simulation) was conducted in the case of white croaker, considering the probability that next year biomass is above current biomass for different levels of catch. For other species (flathead, flounders, rockfish, red porgy, sharks and rays), the analysis suggested precautionary harvest levels are based on the average catch over the preceding decade and/or direct biomass estimates (survey data), because there is not enough biological data to be used in assessment models.

Pelagic fishes: Biomass of anchovy and mackerel has been assessed with hydro-acoustic surveys conducted by INIDEP, and BACs have been determined with production models (Perrotta *et al.*, 2003; Hansen and Garciarena, 2004a, 2004b).

Hake, San Matías Gulf: Occasional snapshot assessments have been based on survey data (area swept). Thompson-Bell's yield-per-recruit analysis was applied using bio-economic data (González and Morsán, 1998, 1999). Assessments are conducted by the provincial institute.

* Created by National Law number 25.945 in 2004.

Yellow clam, Buenos Aires Province: Stocks of yellow clam from exposed sandy beaches of Buenos Aires Province were assessed during the 1960s through extensive snapshot surveys and monthly sampling of a fix station (Olivier and Penchaszadeh, 1968a, 1968b). As described earlier, stocks are now collapsed.

Purple clam, San Matías Gulf: The purple clam stock of San Matías Gulf, which is found only in a 21-km² stretch of subtidal sandy bottom, has been composed almost exclusively by 2-year classes (1979–1980) over the last 25 years. Abundance was assessed for the first time in 1994 by means of a diving survey, following a systematic sampling design (quadrants dug on a fix grid), and using geo-statistical methods (Morsán, 2003); estimated biomass was around 53 000 tonnes. A recent survey showed no significant change, perhaps reflecting compensation between growth rate and mortality (Morsán, personal communication).

Scallops, San José Gulf: Tehuelche scallop stocks of San José Gulf were assessed in 1995–1996 and 2001–2005 by means of diving surveys (Ciocco *et al*., 1996, 2001a, 2001b, 2002, 2003), conducted by scientists from CENPAT, with participation of commercial divers through the local association of artisanal fishers (APAPM). Scallops were counted by trained divers along transects perpendicular to the shore. The basic survey design was systematic and incorporated an adaptive component. The earlier surveys provided the evidence that substantiate claims of overfishing and a 3-year closure (Ciocco and Orensanz, 1997). Since 2000, sampling surveys have provided the rationale for setting annual total allowable catches (TACs) by the provincial fisheries agency (Cinti *et al*., 2003; Orensanz *et al*., 2006).

Mussels, San José Gulf: Between 2001 and 2004, mussel beds of El Riacho were assessed twice a year (before and after the harvest season) with scientific supervision from CENPAT (Santa Ana, 2004; Santa Ana *et al*., 2003a, 2003b). The field protocol was designed to be simple, so that it can be conducted with the assistance of coastal gatherers. The design consists of a regular grid, combining quadrants and a photo survey. Results were used in a participatory context to propose management regulations.

6. FISHERY MANAGEMENT AND PLANNING

Buenos Aires Province: Fisheries are open access, and in many cases there is not even a fishing slip programme for monitoring. There is a nominal regulatory framework (e.g. restrictions on effort, gear regulations, size limits).

Río Negro Province: Fisheries are managed by the provincial fisheries agency with technical support from the Institute of Marine Biology and Fisheries ‘Almirante Storni’, located in San Antonio Oeste. Official catch statistics have been recorded since the 1960s, and were refined in 1979, when a fishing slip programme (filled by the skippers) was implemented. During the mid-1990s, when longlining was introduced, the provincial fishing authority designed a programme for reconverting trawlers to longliners. Although the initiative was partially accepted by some companies, trawling is still prevalent nowadays. Currently only the hake fishery is regulated and catch appears to be at a sustainable level. Other fisheries are not managed. However, a new provincial fishing act is being considered, which would introduce an individual transferable quota (ITQ) system.

Chubut Province: The provincial fisheries authority is based in Rawson, with delegations in Puerto Madryn and Comodoro Rivadavia. The regulatory framework is prolific, but limited in the specifics by frequent changes in political direction (Santa Ana, 2004). There are three types of individual permits: (i) coastal shellfish gathering and beach seining; (ii) motorized boats operating beam trawls and longlines; and (iii) motorized boats authorized also for commercial diving.

In 2001, a provincial artisanal fisheries act (No. 4725) defined four fishing zones: (i) Puerto Madryn, from 42° south latitude, northern provincial boundary, to Punta Ninfas (43° south latitude); (ii) Rawson, from Punta Ninfas to Punta Atlas (44° 08' south latitude); (iii) Camarones, from Punta Atlas to Punta Esquerra (45° 04' south latitude); and (iv) Comodoro Rivadavia (from Punta Esquerra to 46° south latitude, the southern provincial boundary). The law, which has not been fully implemented, also introduced a provincial registry of artisanal fishers. The provincial fisheries agency has the authority to establish temporal and spatial closures, quotas, size limits, etc. It is also in charge of enforcement. Fisheries are monitored through 'transit slips', which permit-holders must fill to report catch by species, fishing area and destination of the product. Monitoring and enforcement, however, have been and continue to be inefficient. The only artisanal fishery in the province that is regulated with a TAC is the scallop fishery of San José Gulf, for which there is a long history of research and management (Ciocco, 1995). Scientific support for management has been provided over the years by CENPAT. The provincial Ministry of Health monitors red tides produced by seasonal blooms of *Alexandrium tamarense* (Gayoso, 2001); mollusc fisheries are closed (usually during the spring) when allowable thresholds are surpassed.

Under open access the commercial diving fishery of San José Gulf grew to more than 30 teams during the early 1990s (Parma *et al.*, 2001). The scallop stock collapsed and the fishery was closed for three years (1996–1998) (Ciocco and Orensanz, 1997; Ciocco *et al.*, 2005). In 2000, the industrial hake fishery (backbone of the Argentine industrial fishery) experienced a severe crisis. Requests of artisanal fishing permits by displaced fishers increased. Faced with a complex situation, the provincial fisheries agency formed a technical committee as an ambit to discuss the management of commercial diving, and eventually of other fisheries. Parties included technical staff from the agency, scientists from CENPAT, and leaders of organized artisanal fishers. In 2004, the committee incorporated representatives of the provincial tourism agency and the autonomous regulatory board of Valdés Peninsula, which has been designated as part of Humanity's Natural Heritage by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The technical committee's mission is to elaborate management plans for the artisanal fisheries of the Puerto Madryn region. This is, effectively, the first effective co-management experiment in the context of Argentine artisanal fisheries. So far, the committee has been instrumental in implementing a limited entry programme for commercial diving and territorial use rights for the community of gatherers of El Riacho (Santa Ana, 2004). The latter became dysfunctional in 2005. The main reason is that the provincial administration cannot legally delegate management authority, as required by the effective implementation of a Territorial User Rights Fishery (TURF) system. At the same time, however, it has been incapable to exercise the authority retained because of the weakness in its enforcement capability.

Santa Cruz Province: Fisheries are regulated by a provincial agency with headquarters in Río Gallegos and delegations in coastal towns. The legal framework for management is provided by a provincial act (No. 1464 of 1982). Artisanal fisheries are open access; fishers need only to register with the provincial administration to get a permit. Regulations aim at a balance between artisanal (commercial) and incipient recreational fisheries, which are considered strategic for the development of tourism and conservation. Artisanal fisheries may pose some risks for marine wildlife, including the Magellan penguin (*Spheniscus magellanicus*) and Commerson's dolphins (*Cephalorhynchus comersoni*). Controls consist of *in situ* enforcement of fishing gear and quality controls over processing and marketing. Scientific/technical support is provided by an institute based in Río Gallegos. Stocks are not assessed. Pereiro (2001) made recommendations towards a strategic management plan, including elementary assessments and enforcement.

Tierra del Fuego Province: Artisanal fisheries are managed by a provincial agency, which grants fishing permits, under a legal framework that includes several provincial laws and written regulations. Fisheries are open access. In the case of the lithodid crab fishery, there used to be an effort quota of 1 000 traps for Beagle Channel. This regulation needs to be reconsidered. There are no forms of traditional management, nor is there a strategic plan for development. Enforcement is conducted by inspectors of the provincial agency, eventually with the collaboration of the coast guard (Prefectura Marítima) or the navy. Only lithodid crab stocks are monitored by means of periodical surveys (conducted jointly with INIDEP), which provide the scientific support for regulations. As an example, a TAC of 200 tonnes was introduced in 1999 (renewed in 2000) for false king crab in the most heavily fished sector of Beagle Channel. There is a monitoring programme for red tides, and mollusc fisheries are closed seasonally when safety threshold are surpassed.

7. RESEARCH AND EDUCATION

Most artisanal fisheries are not monitored. Catch and effort are recorded in a few cases, based on fishing slips. There are no observer programmes implemented for artisanal or small-scale fisheries of the Patagonian provinces and there are no specific training programmes oriented to small-scale or artisanal fishers.

Buenos Aires Province: INIDEP uses three sources of data: (i) fishing slips for catch and effort data; (ii) biological port sampling of most important species landed in Mar del Plata; and (iii) surveys directed to the assessment of coastal resources (demersal and pelagic) and their environment. The observer programme is limited to the industrial fleets, with the exception of anchovy and mackerel.

Specific studies have been conducted on the latter with participation of the *rada/ría* fleet since 1983. Both in INIDEP and the National University of Mar del Plata there are research teams studying a number of subjects pertaining to artisanal or coastal fisheries (see list of references). CeDePesca has organized courses oriented to fishers with the collaboration of scientists and several institutions. Subjects included biological sampling for recreational fishers, fish handling on board, and fisheries control and monitoring.

Río Negro Province: Most of the scientific and technical support is provided by the Institute of Marine Biology and Fisheries 'Almirante Storni' (San Antonio Oeste), which depends jointly from the provincial government and the National University of the Comahue. The institute offers a three-year tertiary degree programme for fishery technicians.

Chubut Province: The commercial diving fishery of San José Gulf has a long tradition of associated research. In Chubut, there is also significant documentation of coastal gathering, beach seining and longlining (see references). Most of the scientific/technical support for management has been provided by CENPAT. Since 2000, management-oriented research and training (fishers, undergraduate and graduate students, enforcement personnel of the provincial agency) have been substantially supported by the Pew Fellows in Marine Conservation Programme. The AVINA Foundation (non-profit organization focused on sustainable development in Latin America) and a GEF project play a significant role in providing support to an incipient co-management system. Many students from the National University of Patagonia (with branches in Comodoro Rivadavia, Trelew and Puerto Madryn) do internships or complete their theses on subjects related to artisanal fisheries or aquaculture. In Puerto Madryn there are two fisheries-related training programmes, one at the high school (Municipal School of Fisheries), and the other at the tertiary level (Fisheries Engineering, National Technological University). A three-month participatory training project for fishers and members of their families was conducted in Puerto Madryn in 2000. The subjects had been requested by fishers themselves during the first national gathering: biology of fishery resources, and handling of fishery products on-board.

Santa Cruz Province: The provincial fisheries agency monitors gear used by artisanal and recreational fishers. Some studies have been conducted on the biology of the most significant species, as well as cost-benefit analysis for present and projected fisheries.

Tierra del Fuego Province: CADIC has contributed significant scientific support for management, primarily in the case of lithodid crabs.

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3. Coastal fisheries of Barbados

Patrick McConney*

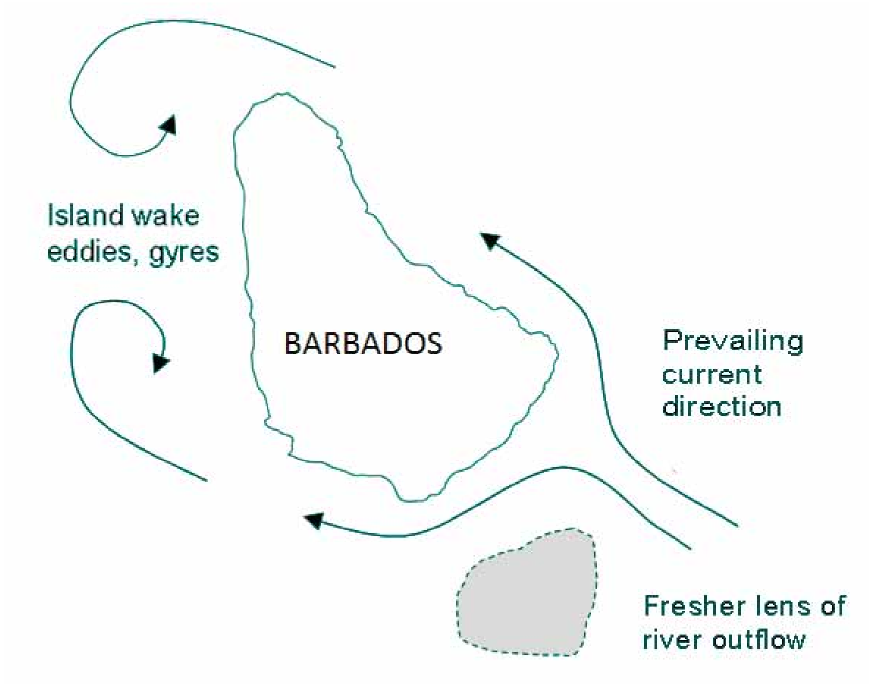
McConney, P. 2011. Coastal fisheries of Barbados. *In* S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo (eds). Coastal fisheries of Latin America and the Caribbean. *FAO Fisheries and Aquaculture Technical Paper.* No. 544. Rome, FAO. pp. 49–71.

1. INTRODUCTION

Barbados is the most eastern of the Caribbean islands, entirely surrounded by the Atlantic Ocean, and located at latitude 13°10' north by longitude 59°35' west. The mainly low relief and coralline island has a total land area of about 432 km^2 encompassed by a coastline 95 km long. The island shelf is small, only 320 km^2, and deep water is found close to shore. The oceanic surface waters are relatively low in nutrients, thermally stable and of low productivity. Surface currents off Barbados are complex but generally directed towards the northwest, sometimes bringing water lenses of lower salinity containing debris from the Amazon and Orinoco Rivers of South America. Closer to shore, systems of gyres and eddies tend to entrain and shed near-shore water for periods that vary according to a number of factors (Figure 1).

* *Contact information*: Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill Campus, Barbados. E-mail: patrick.mcconney@cavehill.uwi.edu

FIGURE 1
Location of Barbados and oceanographic features



Source: Mahon, 1996.

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

There are four major coastal fisheries in Barbados: shallow-shelf reef fishery; deep-slope and bank reef fishery; coastal pelagic fishery; and sea egg fishery. The fisheries for conch and lobster are not included since these are minor, and the sea turtle fishery is closed indefinitely. Also not included are the fisheries for flyingfish (mainly *Hirundichthys affinis*) and dolphinfish (*Coryphaena hippurus*). While these are classified as coastal in comparison to the oceanic pelagics (e.g. large tunas, swordfish and wahoo), they are mainly part of a multispecies offshore fishery. The four fisheries in this profile are coastal on the basis of their proximity to shore. They occur in a narrow band generally within 2 km from shore around the entire island except for a small area of deep reef about 7 km offshore to the south. Figure 2 shows the main fish landing areas.

FIGURE 2
Barbados fish landing sites

Source: Fisheries Division, 2001.

Tables 1–4, extracted from the 2004–2006 fisheries management plan (FMP) for Barbados (Fisheries Division, 2004), provide detailed descriptions of each fishery. Table 5 and Table 6 provide visions for the fisheries, barriers to sustainable management, and strategies for overcoming the barriers. The FMP can be described as management objective driven (MOD) rather than stock assessment driven (SAD) (Mahon, 1997; Berkes *et al*., 2001).

TABLE 1
The shallow-shelf reef fishery

Location	This fishery occurs on near shore coral reefs.
Target species	Hinds (Serranidae); Parrotfishes (Scaridae); Grunts (Haemulidae); Surgeonfishes (Acanthuridae); Triggerfishes (Balistidae).
Bycatch	Squirrelfishes (Holocentridae) and other reef fish species; Lobsters (Palinuridae); Moray eels (Muraenidae).
Ecology	***Distribution:*** seagrass beds (juveniles); coral reefs (adults). ***Growth:*** up to 50 cm (many species). ***Life span:*** 4-6 years (most species). ***Reproduction:*** varies by species, but most broadcast eggs into the plankton.
Fishing methods	***Vessel type:*** mainly small, open, outboard-powered boats (*moses*) are used. ***Fishing gear and methods:*** fishing is most intense during the period July–October when pelagics are scarce, but reef fishes are captured year-round at some sites. Mainly fished using traps of various shapes (Z , A, S, and rectangular) and of various sizes. S-traps and rectangular traps are not common. Z-traps are prevalent on the south coast, and A-traps on the west. Hexagonal wire mesh 1.25 inch (3.18 cm) is most commonly used to make traps, and the 1 inch (2.5 cm) mesh previously in limited use has been illegal since 1998. These mesh sizes retain juveniles of several species. The traps are often baited with macerated fish or black sea urchins (*Diadema antillarum)* and hauled every 2–3 days. Reef fishes are also taken by traps and handlines fished at various depths down to about 50 m.
Economics	***Economic importance:*** economic links to tourism are perhaps as important as dollar value of food fishery. ***Employment:*** important to part-time fishers year-round and full-time fishers upon conclusion of flyingfish season. ***Catch and effort trends:*** estimated annual landings of reef fish ranged from 14–60 metric tonnes for 1990–2003. Information on effort is available as numbers of vessels and numbers of trap fisheries registered with the Fisheries Division.
Resource status	Areas of reef are believed to be overfished, particularly on the south and west coasts, where fishers have reported reduced catch per unit effort and fish size. The potential yield is unknown due to lack of accurate local catch and effort data over time, or reasonable estimates of production extrapolated from similarly fished and ecologically comparable reef areas elsewhere.
Opportunities	Presence of large fish satisfies both fisheries for food, and non-food (recreation and tourism), developments. Aquarium fish export trade for particular (often non-food) species if populations are carefully managed under the existing regulations. Marine reserves and protected areas serving recreational and tourism purposes may act as population reservoirs for adjacent fished areas.
Constraints	Increased exploitation is not recommended. Low fish populations due to habitat degradation and overfishing of diminished stocks in some areas. User and use conflicts with tourism and coastal recreation. Approaches require difficult trade-offs (e.g. between food and non-food use).

TABLE 1 (CONTINUED)

Present data collection	Catch and effort statistics routinely collected at primary and secondary landing sites. Statistics only occasionally collected at tertiary landing sites. This is a major problem when assessing this fishery as a substantial portion of the catch is landed at tertiary sites.
Current legislation	***Fisheries Act:*** Use of dynamite, poisons and noxious substances is prohibited. ***Fisheries (Management) Regulations:*** Minimum mesh size 1.25 inches (3.18 cm) in traps. Trap fitted with escape panel of approved size and design to reduce ghost fishing. Trap marked for identification in an approved manner. Prohibition of trammel and any other entangling nets. Fishing is prohibited in no-take marine reserves.
Management unit(s)	Island shelf for juveniles and adults; distribution may be wider for early life stages due to egg and larval drift in ocean and coastal currents.
Possible additional management measures	Increase minimum mesh sizes in traps. Implement a permit system for the use of spear guns. Prohibit SCUBA-assisted spearfishing, to reduce effort and depth range of harvest. Co-management arrangements in the context of integrated coastal area management. This requires an integrated, participatory approach to reef fish management, involving all of the stakeholders and most of the management approaches above to deal with the complex issues surrounding this fishery. Essential for marine protected areas. For these approaches to succeed, habitat protection through the Coastal Zone Management Unit (CZMU) and associated agencies is essential.

TABLE 2
The deep-slope and bank reef fishery

Target species	Snappers (Lutjanidae), mainly queen snapper (*Etelis oculatus*), silk snapper (*Lutjanus vivanus*), and vermilion snapper (*Rhomboplites aurorubens*).
Bycatch	Unidentified groupers (Serranidae); large jacks (Carangidae) etc.
Ecology	***Distribution:*** juveniles prefer shallow waters; adults deeper waters. ***Growth:*** greater than 100 cm in length (most species); slow-growing. ***Life span:*** long-lived. ***Reproduction:*** groupers may form large spawning aggregations; several species are hermaphroditic; eggs presumed planktonic.
Fishing methods	***Vessel type:*** dayboats (fishing launches) are used. ***Fishing gear and methods:*** mainly fished by handlines which target queen snapper and vermilion snapper. Traps target silk snapper and some vermilion snapper. Most of the catch is taken from July to October when the availability of large pelagics declines. Each vessel may have crews of several fishers each tending a line.
Economics	***Economic importance:*** unknown. Preliminary assessment of fishery shows potential for increased investment in harvest. ***Employment:*** most significant during the period when pelagics are scarce (July–October). ***Catch and effort trends:*** annual estimated catches between 1990 and 1999 ranged from around 20 to 60 tonnes (Source: Fisheries Division). No clear trends. No information is available on effort.
Resource status	The resource may be fully exploited in some areas, but not in others. Potential yield estimates for the Barbados shelf range from 18 to 80 tonnes per year (Source: FAO *Fisheries and Aquaculture Technical Paper* No. 313). A precautionary approach is warranted since some species are extremely vulnerable to overexploitation due to their life history and ecology.
Opportunities	• High demand local market exists for high-priced luxury product. • Unfished and not fully exploited areas are believed to exist.
Constraints	• Resource easily overfished, so management of capacity is essential. • Present harvest methods are difficult and labour intensive. • Requires investment in fishing equipment to increase yield.
Present data collection	Catch and effort statistics routinely collected at primary and secondary landing sites. Statistics only occasionally collected at tertiary landing sites. This is a major problem when assessing this fishery as a substantial portion of the catch is landed at tertiary sites.
Current legislation	***Fisheries Act:*** Use of dynamite, poisons and noxious substances is prohibited. ***Fisheries (Management) Regulations:*** Minimum mesh size 1.25 inches (3.18 cm) in traps. Trap fitted with escape panel of approved size and design to reduce ghost fishing. Trap marked for identification in an approved manner. Prohibition of trammel and any other entangling nets. Declaring closed areas and seasons for species and fishing methods. Coastal Zone Management Act. Fishing is prohibited in no-take marine reserves.
Management unit(s)	Separate stocks may exist on the Barbados shelf given its relative isolation from other island shelves.
Possible additional management measures	Same as for shallow-shelf reef fisheries.

TABLE 3
The coastal pelagic fishery

Target species	Jacks (Carangidae); herrings (Clupeidae); silversides (Atherinidae); anchovies (Engraulidae); ballyhoo (*Hemiramphus* spp.) – 2 species; robins or scads (*Decapterus* spp.); barracuda (*Sphynaena* spp.); garfish – 3 species; small tunas and the young of large tuna such as yellowfin, may also be caught.
Bycatch	Juvenile shallow-shelf reef fish.
Ecology	***Distribution:*** mainly fished within 2 km from shore. ***Growth:*** little information available. Varies with species. ***Life span:*** little information available. Varies with species. ***Reproduction:*** jacks probably spawn offshore throughout the year; most species may have planktonic early life history stages.
Fishing methods	***Vessel type:*** both '*moses*' and dayboats are used. ***Fishing gear and methods:*** mainly caught by three different methods: boat seines, cast nets, and trolling. Fishing in the vicinity of reefs may result in undesirably high bycatches of juvenile reef fish which are discarded.
Economics	***Economic importance:*** a considerable quantity is used as bait for other fisheries although some are used as food. ***Employment:*** not yet quantified. ***Catch and effort trends:*** annual estimated catches of jacks and small tunas from 1990–1999 ranged from about 8 to 40 tonnes (Source: Fisheries Division). No information is available on effort.
Resource status	Not yet assessed. Lack of information precludes the estimation of potential yield. Qualitative reports on abundance from fishers are inconclusive.
Opportunities	Possible expansion of baitfish fishery.
Constraints	Harvest sector conflicts with other coastal users.
Present data collection	Catch and effort statistics routinely collected at primary and secondary landing sites. Statistics only occasionally collected at tertiary landing sites. This is a major problem when assessing this fishery as a substantial portion of the catch is landed at tertiary sites.
Current legislation	***Fisheries Act:*** • Use of dynamite, poisons and noxious substances is prohibited. ***Fisheries (Management) Regulations:*** • Minimum mesh size for seines 1.50 inches (3.81 cm). • Prohibition of trammel and any other entangling nets. • Declaring closed areas and seasons for species and fishing methods. • Coastal Zone Management Act. • Fishing will be prohibited in no-take marine reserves.
Management unit(s)	Island shelf for juveniles and adults, but distribution may be wider for early life stages due to egg and larval drift.
Possible additional management measures	• Permit cast netting in the marine reserve, but improve monitoring and surveillance to ensure other fishing is not also taking place. • Prohibit seining and cast netting near reefs. • Research and data collection, particularly through co-management arrangements. • Protect fish habitat through integrated coastal zone management. • Given an overlap of issues, it may be prudent to incorporate this fishery into the integrated coastal area management approach suggested for the shallow-shelf reef fishery.

TABLE 4
The sea egg fishery

Target species	White sea urchin or sea egg (*Tripneustes ventricosus*).
Bycatch	None
Ecology	***Distribution:*** adults live on sea grass beds and coral rubble. Juveniles appear to settle in same areas as adults. The sea urchin is particularly vulnerable to overfishing because it occurs close to shore, is virtually immobile, and is harvested for its gonads. Natural or man-made changes in marine habitats are concerns. ***Growth:*** varies according to environmental conditions. Gonads ripen seasonally. ***Life span:*** 2–3 years (maximum). ***Reproduction:*** sexually mature by one year; eggs and larvae are planktonic for several weeks.
Fishing methods	***Vessel type:*** when vessels are used, the launch is common, but the 'moses' is also used. The occasional ice-boat is observed. Alternatively, fishers who swim out to the sea urchin ground will often carry a floating log from which bags of harvested urchins will be suspended until returning to shore. ***Fishing gear and methods:*** sea urchins are harvested close to shore by skin divers using mask, snorkel and fins and by SCUBA divers. The sea urchins are removed from the bottom by hand or metal scraper and are collected in a net bag.
Economics	***Economic importance:*** revenue from the sea urchin fishery is an important part of some fisher's income. Significant inter-annual variation in stock size occurs such that catch size is limited mainly by stock size at low abundances but is effectively only limited by fishing effort at high stock abundances. While researchers differ on their estimates of the mean income per fisher from the sea egg harvest (largely due to differences in estimates of effort), there is little doubt that, when abundant, Barbadian sea eggs are the basis of a very valuable fishery. ***Employment:*** it is estimated that over 300 fisher-divers (part-time and full-time) are involved in this fishery. In addition, many other people crack, clean and sell sea eggs. ***Catch and effort trends:*** no regularly recorded landings statistics are available. Catch and effort fluctuate with highly variable abundance. No clear trends.
Resource status	High demand has led to overexploitation of the resource and the stock was considered to be in a collapsed state for most of the period between the mid-1980s to 2000. During this period two multiyear harvesting moratoria (1987–1989 and 1998–2001) were implemented to allow the depleted stocks to recover. Sea eggs returned in abundance in 2001 and stock levels had remained relatively high in 2002 but with some decline in 2003.
Opportunities	Market exists for high-priced luxury products, high demand. Low harvest and post-harvest investment required.
Constraints	Seasonal, unpredictable abundance. Low populations due to overfishing and possible habitat degradation. Absence of community organization to facilitate co-management by area. Failure at the attempt to sustain an island-wide fisherfolk divers association.

TABLE 4 (CONTINUED)

Present data collection	Fishers, in collaboration with the Fisheries Division and BARNUFO, conduct annual stock abundance surveys just prior to the commencement of the fishing season, and the results are used in part to determine the length and timing of the fishing season.
Current management	The designation of annual fishing seasons has been used as a management tool for the fishery since 1879. Moratorium from 1987 to 1989 when harvesting sea eggs was not allowed. Since 1989, closed season, from 1 January to 31 August. During the open season from 1 September to 31 December it was against the law to: - Leave the shell or offal of sea eggs on any bank or in shallow water. - Wilfully or wantonly destroy or injure any sea egg. (However, due to inadequate enforcement and absence of social sanctions, illegal harvesting often started as early as July.) ***Fisheries (Management) Regulations:*** Provision for closed seasons and areas. Prohibition of harvest with the assistance of SCUBA. Illegal to have, sell, expose for sale or purchase sea eggs during the closed season unless the sea eggs were obtained with the permission of the Chief Fisheries Officer. Cannot wantonly injure or destroy any sea eggs. ***Fisheries (Sea Eggs Closed Season) Notices:*** Closed season from 1 August 1998 to 31 July 2001. In 2001, the closed season was extended to 31 August and harvesting was permitted from 1 October to 30 November. In 2002, harvesting was initially permitted from 1–31 September but the open season later extended to 31 October. In 2003, harvesting was permitted from 15 September to 15 October.
Management unit(s)	A discrete stock probably exists on the Barbados shelf given its relative isolation from other island shelves.
Possible additional management measures	Co-management measures to be subsequently considered include: Licensing harvesters. Closed seasons. Setting total allowable catches. Improved monitoring and management information systems involving harvesters.

TABLE 5
Visions for coastal fisheries

Vision 1: Coastal fish resources are sustainably utilized and managed	
Barrier	**Strategies**
Degradation and destruction of coastal habitats	Work with CZMU and stakeholders to implement, enforce and monitor coastal zone management legislation.
	Work with fishers and government agencies to develop strategies to stop the use of dynamite and noxious substances in fishing.
	Monitor the use of spear guns and fishing gear and publicize their detrimental effects to the fishery.
	Discourage cast netting or seining on or near reefs.
	Research the need for seasonal closure of seine fishery.
	Strict control of fishing by permit in marine protected areas.
	Promote measures that will prevent pollution of the near shore marine environments.
	Increase public information on coastal habitat conservation.
	Encourage stakeholders and the public to get involved in marine environmental awareness and conservation activities (i.e. brochures, videos, TV programmes).
Overfishing due to high mortality of juvenile and adult reef fish occurs	Publicize the fishery regulations.
	Work with stakeholders to enforce existing gear regulations.
	Monitor compliance with regulations.
	Set up mechanisms for registering and marking fishing gear.
	Research feasibility of further gear and vessel restrictions.
	Assess the need for additional management measures.
Inadequate fishery information and statistics are available for planning and management	Review and improve sampling scheme for catches and map their locations.
	Work with fishers to develop better means of measuring fishing effort on reefs.
	Improve the collection of biological, economic and social data.
	Collaborate on data collection with fishers and students.
	Conduct stock assessments.
	Collate existing information and data, and use the results to inform further research and produce user-friendly material for stakeholders.
	Work closely with the UWI and fishers to collect necessary scientific information on all local fisheries.
The institutional arrangements for managing this fishery have not been fully developed	Explore possible institutional arrangements in collaboration with all stakeholders in data collection, implementation, management, monitoring, and decision-making.
	Implement the preferred arrangement(s) as pilot projects for trial, and evaluate to improve.
Shortage of trained staff	Provide suitable training for staff where possible and continue lobbying for additional appropriately trained staff.

TABLE 5 (CONTINUED)

Vision 2: Coastal conflicts that impair fisheries management are reduced or absent	
Barrier	**Strategies**
Conflicts among stakeholders in the coastal zone	Formally integrate fishing into coastal zone planning and management.
	Establish and maintain means for fishers and other coastal zone users to meaningfully participate in planning and management.
Not enough attention is paid to development of sustainable solutions to conflicts	Conduct more research on stakeholder analysis and solutions to conflicts.
	Use GIS and facilitation to help identify and develop solutions.
Economic linkages with tourism are not optimized for fishers	Research and develop linkages that provide more economic opportunities for fishers in tourism-related activities on the inshore reefs.

TABLE 6
Vision of the sea egg fishery

Vision 3: Optimum annual harvests that earn maximum economic benefits while conserving the resource	
Barrier	**Strategies**
Stocks usually low, highly variable, and extremely vulnerable to overfishing	Maintain stocks at a level which can sustain fishing.
	Improve co-management for monitoring and harvest.
	Eliminate illegal fishing during the closed season/moratorium.
Poor track record of compliance with and enforcement of conservation regulations	Find more innovative ways to enforce fishery regulations.
	Public education on sea egg conservation and management.
	Implement a 'coast watch' type of public surveillance system.
Inadequate fishery information and statistics for planning and management	Improve estimation of catch and effort.
	Collect more biological, economic, and social data.
	Improve collaboration on data collection and monitoring with fishers.
	Conduct more stock assessments in collaboration with university.
Possible habitat degradation and destruction and water pollution	CZMU to implement legislation for coastal zone management.
	Collaborate closely with CZMU and environmental agencies on habitat surveys, pollution, etc.
The institutional arrangements for managing this fishery have not been fully developed	Explore possible institutional arrangements in collaboration with all stakeholders. The formation of a sea egg management council comprising representatives of the sea egg fishing communities, government, and scientists is recommended.
	Implement the preferred arrangement(s) as pilot projects for trial, and evaluate to improve.

For ease of reference, each subplan follows the same format. The location, target species or species group, and bycatch are described before the ecology, fishing methods and economics of the fisheries. A general statement on resource status is given in the absence of quantitative reference points. Likewise, the opportunities and constraints appear as qualitative observations. Data collection and current legislation are described, as well as the resource management units (i.e. scale of management) and possible additional management measures. The FMPs are primarily means of communicating key concepts and information to diverse fisheries stakeholders and are, therefore, written mainly in non-technical language. A brief general description of all the fisheries is made below.

All four fisheries are small-scale commercial fisheries, but some fish are retained for home consumption and distribution to personal networks (from observation, not >10% of total catch). Some of the shallow and deep reef fishing is recreational, including a limited amount of tournament fishing. The sea egg fishery is highly seasonal by management regulations, although much illegal fishing takes place in all months once the resource is relatively abundant. The other fisheries tend to be more active from around June to October, which is the low season for the main offshore pelagic fisheries. Catches from all of the fisheries are primarily marketed fresh (the fish usually whole or only gutted; the urchins as roe), but small portions are processed mainly to be sold frozen in local supermarkets. Estimated annual fish landings from the coastal fisheries (Table 7) contain larger amounts of unknown errors and uncertainties than found in statistics for the pelagic fisheries.

TABLE 7
Provisional estimated fish landings (2001–2004)

Fish species or species group	Provisional annual total estimated landings (tonnes)			
	2001	2002	2003	2004
Flyingfish	1 673.1	1 590.4	1 912.3	1 185.6
Dolphinfish	574.4	552.8	458.1	454.7
Large tunas	150.7	114.0	162.0	191.8
Billfish	70.7	43.9	68.2	61.8
Kingfish (wahoo)	23.6	40.6	31.9	42.3
Shark	9.5	9.1	8.1	8.4
Swordfish	14.3	7.8	16.1	19.0
Snappers*	20.0	12.4	15.4	5.8
Carangids*	11.2	9.6	25.6	32.0
Small tunas*	1.2	2.4	1.6	1.3
Unspecified *	109.0	89.3	96.2	130.6
Total	2 657.7	2 472.3	2 795.5	2 133.2

*Includes catches from coastal fisheries (*Source*: Fisheries Division of the Barbados Ministry of Agriculture and Rural Development).

The fishing activity in each fishery is described in Tables 1–4, including vessels, gear and methods. In general, these fisheries tend to involve the smaller categories of vessel in the fishing fleet, particularly outboard powered 'moses' (dinghies) and dayboats (half-decked launches) (Figures 3a and 3b). A Fisheries Division publication (Willoughby and Leslie, 2000) provides detailed descriptions of fishing methods and fishing gear specifications.

FIGURE 3a
"Moses" open inshore fishing vessel

(Photo: Fisheries Division)

FIGURE 3b
Dayboat midrange vessel

(Photo: Fisheries Division)

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

The fishing industry labour force is described in the 2004–2006 fisheries management plan (Fisheries Division, 2004). There are about 2 200 people involved in fish harvest (80% full-time) and up to an additional 3 800 in fisheries-related activities. This is based on fisher registration and rough estimation, and constitutes about 2% of the total population. The primary stakeholders of the harvest sector are fishers and boat owners. Fishers comprise 63% and boat owners account for 37%. About 40% of boat owners are also active fishers. The coastal fisheries are particularly fluid in terms of labour entry and exit, with a large number of opportunistic and occasional fishers who are normally engaged in other occupations, including construction, tourism, the civil service and law enforcement. Defining the labour force in these fisheries is difficult.

As noted above, women do not participate much in harvesting; however, women are in the majority in the post-harvest sector. They account for 63% of the post-harvest primary stakeholders. The majority of fish vendors (60%), fish boners (77%) and fish scalers (70%) are female. Although males account for only 37% of the post-harvest primary stakeholders, they are in the majority among the processors (100%), exporters (100%), hawkers (62%), and skinners (51%). Of the four coastal fisheries, the work of women is most obvious in the sea egg industry of urchins, where women participate in groups by processing the product on beaches and selling it directly to consumers. In the other fisheries women are found mainly as vendors, but reef and small pelagic fishes are often sold directly by fishers to consumers.

Coastal fishers are usually Barbadians, and only Barbadian citizens or firms can legally own local commercial fishing vessels under the Fisheries Act. Fishers are mobile within the coastal waters, and fishing areas are not closely linked to particular adjacent communities except for limitations in the range of vessels or preference to have fishing gear close by, especially in the trap fisheries. There is relatively little territoriality, especially when resources such as sea urchins are abundant. The sea egg fishery has been documented and regulated for over 100 years. All of the fisheries have strong traditions and have been relatively slow to modernize. For example, traps and deep handlines are still mainly hauled without mechanical assistance.

Social and economic data disaggregated by fishery are scarce. The Fisheries Division recently undertook a drive to have all fishers registered, and this should improve the quantity and quality of information available. Some data already appear in the current fisheries management plan.

Overall, across all fisheries, males account for 99% of the fishers and 91% of the boat owners. Males in the age group 45–49 years are in the majority among both harvesters and boat owners. Stakeholders in the age group 50–59 years are in the majority among post-harvest stakeholders. Most males are 40–44 years of age while most females are between 45 and 49 years old. Men tend to enter the fishing industry between the ages of 15 and 19 years, while women enter later, between 20 and 24 years of age.

The most comprehensive socio-economic descriptions are of the sea urchin fishery, most recently summarized in Mahon *et al.* (2003) and McConney *et al.* (2003a). Historically, the annual sea egg fishing season is timely for fishers as it comes when the season for flyingfish and the other large pelagics, such as dolphin, is over. In addition, the beginning of the season also coincides with the last weeks of the school summer holidays. Hundreds of Barbadians, including women and children, become involved in some aspect of the sea egg fishery. In 1948 the industry was described as employing "almost every available fisherman and their families". Estimates of the numbers of people seasonally involved have ranged from nearly 1 000 in the mid-1950s to just over 200 at present. No other fishery in Barbados so thoroughly engages people of all ages, both sexes and of several other occupations as fully and intensely as the sea urchin fishery. The traditional roles for the women and children are the processing and sale of the sea eggs on shore. Persons are described by the tasks to which they are assigned (i.e. 'divers', 'breakers' and 'vendors'). There used to be sharper distinctions between these categories of workers in the fishery than there are today. It is said that diving for sea eggs often introduces boys to fishing, so the fishery may play an important role in the supply of new labour into the industry.

The sea urchin fishery is the most lucrative of the four in this profile, especially due to the high earning rate within the short open season. This is estimated at US$2 000 to US$5 000 per harvester, earned over approximately two months (McConney *et al*., 2003a). The trap fisheries have a longer season of about seven months that is not regulated by law, but by fishing preferences. Incomes of up to US$7 500 have been estimated as being possible from the deep reef fishery (Prescod, 1991), but will be less on average for the inshore reefs. There have been no earnings studies for the coastal pelagic fishery.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

4.1 Community organizations

Fisherfolk organizations generally include fishers and boat owners, while a few also include fish vendors in their membership, but not fish processors. About five registered groups are currently active, meaning that they have constitutionally elected executives and some regular activities for the benefit of their members (Table 8).

The secondary producer organization, the Barbados National Union of Fisherfolk Organizations (BARNUFO), was instrumental in facilitating the participation of a wide cross-section of the fishing industry in the formulation of the 2001–2003 Fisheries Management Plan, and represented the industry to a lesser extent in formulating the 2004–2006 plan. The latter was done mainly through membership on the government's Fisheries Advisory Committee (FAC) that is established under the Fisheries Act to advise the minister responsible for fisheries on a broad range of topics.

Among the primary fisherfolk groups, the Oistins Fisherfolk Organization has been attempting to introduce local area management adjacent to their landing site on the south coast (Hoggarth, 2005). The Weston Fisherfolk Organization sought to ensure that legal fish traps were not tampered with by others on the west coast. The Barbados Fisherfolk Divers Association was established to participate mainly in the management of the sea urchin fishery but was short-lived (Mahon *et al*., 2003).

TABLE 8
Fishing industry organizations in Barbados

Fishing industry organization	Registration date
Barbados Fishing Cooperative Society Limited*	18 Feb. 1986
Oistins Fisherfolk Association*	4 Nov. 1997
Weston Fisherfolk Association*	29 Jan. 1998
Sand Pit Fisherfolk Association*	6 Feb. 1998
Northern Fisherfolk Association	20 Mar. 1998
Paynes Bay Fisherfolk Association	4 May 1998
Speightstown Fisherfolk Association	20 May 1998
Tent Bay Fisherfolk Association	12 Jun. 1998
Pelican Fisherfolk Association	24 Jul. 1998
Pile Bay Fisherfolk Association	18 Nov., 1998
Conset Bay Seamoss Group	17 Dec. 1998
Barbados Fisherfolk Divers Association	5 Mar. 1999
Barbados National Union of Fisherfolk Organizations*	26 Mar. 1999
Mount Standfast Marine Preservation Association	12 May 1999

* Fisherfolk organizations currently active (adapted from Fisheries Division, 2001).

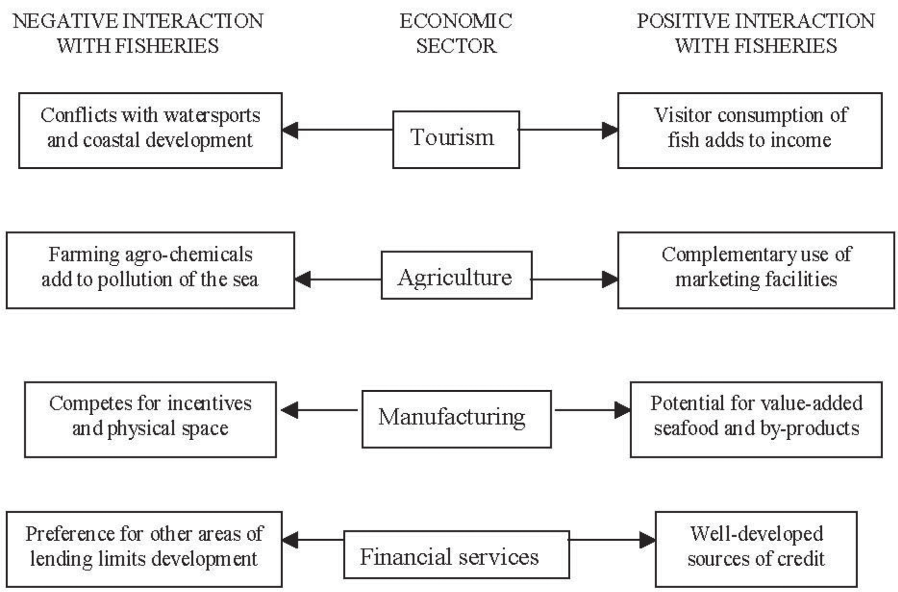
Due to the ribbon pattern of coastal settlement, and absence of deep embayments or other defining coastal features, there are few easily recognizable spatial fishing communities in Barbados. There is no system of local government (i.e. at the community level), and therefore the primary organizations described above also come closest to the means of providing community representation in management. In the context of communities of interest, the FAC has members including a fisher, boat owner, fish vendor and fish processor. However, these people are appointed for their individual expertise and do not provide representation except in cases where their views are consistent with the majority of others in the same fishery occupation.

At present, the main non-governmental organization with an interest in fisheries is the Barbados Marine Trust. Formed in May 2000, the Trust is interested in all aspects of marine management and conservation, particularly in coastal and nearshore areas. The Barbados Game Fishing Association (BGFA) is the sole body comprising recreational fishers, and tournament anglers in particular, but most of its attention is on pelagic fishing. Although perhaps not your typical non-governmental organization, the University of the West Indies (UWI) has had a long history of involvement in researching and facilitating the community aspects of participation in fisheries management. To a lesser extent, the Caribbean Conservation Association (CCA), a regional non-governmental organization (NGO), has also contributed in recent times, particularly to the sea urchin fishery.

4.2 Interactions between fishers and other sectors

The 2001–2003 Fisheries Management Plan (Fisheries Division, 2001) sets out general examples of positive and negative intersectoral interactions with fisheries (Figure 4).

FIGURE 4
Positive and negative intersectoral interactions



Adapted from Fisheries Division, 2001.

Documented conflicts in coastal fisheries have mainly been between trap fishers and other users of inshore reefs, particularly recreational divers and watersports operators. In broad context, this is over the consumptive versus non-consumptive use of reef fish. Conflicts also occur between coastal fishing vessels in the approaches to the harbour and large vessels entering or leaving port. Coastal land is highly sought after and valuable, especially for tourism. There has been shrinkage of the unused coastal areas that are suitable for boatyards, causing some conflict over boatyard space and with the occupants of adjacent properties.

Implementation plans for coastal fisheries management (Fisheries Division, 2004) point to the need to strengthen or establish institutions for conflict management since tension is expected to increase as coastal development (particularly for tourism) proceeds. It has been suggested to use a geographic information system (GIS) as a tool in conflict management, but this has not yet been implemented.

Barbados has a very progressive Coastal Zone Management Act (1998) and planning system which states that specific fisheries management plans have precedence and seeks to incorporate fisheries into coastal management as set out in the FAO Code of Conduct for Responsible Fisheries. Based on detailed diagnostic assessments, the coastal zone management plans outline desirable uses and management of defined segments of the coast. Implementation of these plans is still in the early stages and public participation is currently being sought.

5. ASSESSMENT OF FISHERIES

There have been varying levels of assessment in the four coastal fisheries. The most comprehensive are for the sea urchin fishery, followed by the reef fisheries, and with relatively little assessment of the coastal pelagic fishery. Most of the assessments have been focused on ecology and stock assessment. The sea urchin fishery has included social, economic, institutional and uncertainty aspects. All of the numerical estimates and indices produced for the fisheries are perceived as being approximate and, as shown in Tables 1–4, none of them are used explicitly for management, such as in setting target or reference points (Caddy and Mahon, 1995).

Only in the sea urchin fishery has there been much attention to traditional and local knowledge, including harvesting practices that are relevant to conservation and community-based management. A fair amount has been written on the latter, partly in the vein of how it may not be appropriate for Barbados due to settlement pattern and cultural norms about property rights (Mahon *et al*., 2003; McConney *et al*., 2003a). Figures 5 and 6 were produced by the Fisheries Division through collaborative surveys with fishers.

FIGURE 5
Distribution of sea urchin harvesters

Source: Fisheries Division.

FIGURE 6
Distribution of sea urchin resources

Source: Fisheries Division.

6. FISHERY MANAGEMENT AND PLANNING

Tables 1–4 describe the management of each coastal fishery under the jurisdiction of the Fisheries Division of the Ministry of Agriculture and Rural Development, via the Fisheries Act. The fisheries management plans use the FAO Code of Conduct for Responsible Fisheries for guiding principles. Other relevant fisheries conventions, with the dates on which Barbados became party to them, include:

- United Nations Fish Stocks Agreement (22 September 2000);
- FAO Compliance Agreement (26 October 2000);
- The Tuna Convention establishing the International Commission for the Conservation of Atlantic Tunas (ICCAT) (13 December 2000).

Barbados is also party to the following international instruments that are relevant to fisheries:

- The Programme of Action for the Sustainable Development of Small Island Developing States (the Barbados or SIDS POA);
- Convention on International Trade in Endangered Species (CITES);
- Convention on Biological Diversity (CBD);
- Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention;
- International Convention for the Prevention of Pollution from Ships (MARPOL).

None of the formal or informal management measures used in Barbados are rights-based. Formal measures are given in Tables 1–4. Informal traditional measures to reduce the harvest of sea urchins that are not in prime condition have been documented (Mahon *et al*., 2003), but the positive impacts of these practices are more than compensated for by significant illegal fishing (i.e. out of season harvest and use of prohibited gear).

Marine protected areas (MPAs) are under the jurisdiction of the Coastal Zone Management Unit through the Coastal Zone Management Act. However, the only MPA currently established, Folkestone Marine Park, was not designed primarily as a fishery management tool, but for scientific research and tourism watersports. The coastal authorities have plans for more MPAs. These are focused on conserving biodiversity.

The government, through the Fisheries Division, offers as incentives the following direct subsidies and subsidized services:

- Tax and duty subsidies on marine fuel, boats, engines and spare parts, fishing gear, fish handling equipment and other related supplies.
- Maintenance and upgrade subsidy of up to US$2 000 per boat per year.
- Administrative subsidy of free registration, licensing, inspection and other services for meeting statutory requirements.
- Utilities subsidy by payment for water and electricity at boatyards and landing sites.
- Subsidized, non-commercial fees for the tractor service used in small vessel haul-out.
- Development funds for technical assistance and loan financing.

- Grants to fishing industry organizations for approved projects.
- Free accommodation for umbrella fisherfolk organization.

These are relatively small subsidies that benefit mainly the harvest sector, and particularly the more capital intensive offshore fisheries through the duty and tax concessions. There had been a rebate on gasoline fuel used to power the outboard engines used by much of the coastal fleet. However, this subsidy was removed as a cost-saving measure, and to reduce financial abuse, rather than for fisheries conservation reasons.

Although the fisheries management plans are in place for three years before reviewing and updating, the sections on vision are expected to be enduring and strategic, with a time horizon of around 10 years. Each fishery or fishery group has a vision as shown in Tables 5 and 6. There are also vision components for the harvest and post-harvest sectors (Fisheries Division, 2004):

Vision of the harvest sector:

- Trained and well-informed fishers and fisherfolk organizations playing an active and vital role in the sustainable management of the fisheries resources and in quality assurance of seafood.
- Well-maintained and designed vessels complying with national legislation and standards for design, construction, safety at sea, and hygienic storage and handling of fish.
- Fishers using responsible fishing practices and not engaged in activities that undermine the effectiveness of any accepted national, regional or international fisheries management measures.
- Modern and appropriate infrastructure that supports the loading of supplies, sanitary offloading of catch, and construction or repair of vessels.
- Fishers supporting and benefiting from social services which contribute to their well-being in times of need.
- Local and regional fisheries stakeholders working together to manage national and shared fisheries resources.

Vision of the post-harvest sector:

- Trained fishers, informed fisherfolk organizations and other stakeholders playing an active role in fish quality assurance, food safety and small business enterprises.
- Adequate national seafood legislation and standards with systems and procedures in place to ensure compliance.
- Individuals and agencies producing and marketing quality value-added seafood products.

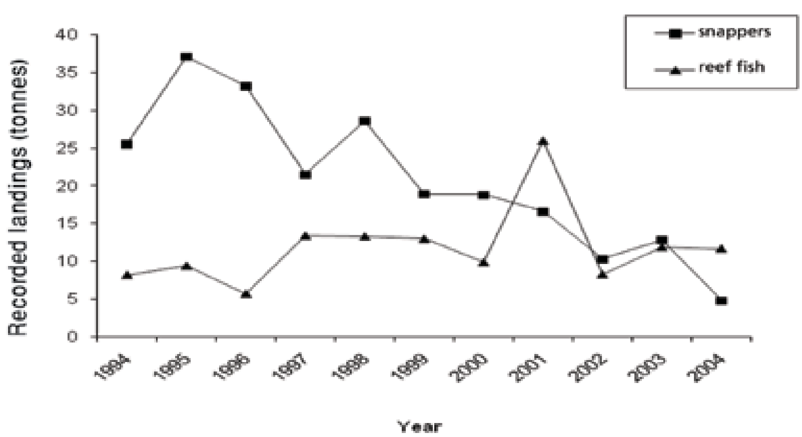
Fisheries enforcement and voluntary compliance are weak in almost all respects. The four coastal fisheries are difficult to monitor. The data collection system, and most monitoring, is concentrated at the fish markets and main landing sites that serve the offshore pelagic fisheries. While there is some monitoring at other beaches and minor landing sites, accurate information on catches and effort are scarce. The regulations on gear specifications and fishing seasons are not enforced; neither the fisheries authority nor the marine enforcement agencies have adequate capacity, and fishing violations are not priority for attention. Coast Guard operations annually yield only a handful of arrests and even fewer successful prosecutions. Most of this enforcement activity concerns harvesting sea eggs out of season (McConney and Pena, 2004).

Although there has not yet been a formal and structured or quantitative evaluation of fisheries management in Barbados, and particularly an evaluation of the performance of the plans and their implementation, there have been informal reviews. These have occurred mainly at the Fisheries Advisory Committee, which is mandated under the Fisheries Act to advise the minister responsible for fisheries on a wide range of management and development issues (McConney *et al*., 2003b). In summary, fisheries management has only been partially successful. There has been some success at creating policy and laws that reflect the intention of ensuring responsible fisheries, such as with Barbados becoming party to the international instruments identified earlier. Less progress has been made in implementing operational aspects of the management plans. This includes the poor enforcement of fisheries management regulations.

7. RESEARCH AND EDUCATION

Data and statistics on all four fisheries are collected by the Fisheries Division. At the fish markets, or primary landing sites, officers of the Markets Division are the daily data collectors. There is daily data collection by employees of the Fisheries Division stationed at the secondary landing sites and sampling by roving collectors at the tertiary sites. The data collected are catch and effort. Recent recorded landings of snappers and reef fish are provided in Figure 7.

FIGURE 7
Recorded landings of snappers and reef fish in Barbados



Most of the coastal fishery research has taken place in the sea urchin fishery, followed by the two reef fisheries, with the least on the coastal pelagics. This order reflects their social and economic importance. For all except the coastal pelagics there has been biological, ecological, social and economic research, but the volume of work on the sea urchin fishery far outweighs the others. Key references are listed at the end of this paper.

Limited quantities of conservation brochures have been produced by the Fisheries Division based on the fisheries management regulations. For the sea urchin fishery there are also television spots that urge conservation and compliance. There are no educational or vocational programmes aimed at promoting alternative occupations in the fishing industry or aimed at facilitating exit from fishing by training for occupational mobility.

8. ISSUES AND CHALLENGES

Due to the dominance of the offshore pelagic fisheries, economically, socially, politically and otherwise, the coastal fisheries of Barbados have been relatively neglected, except for sea urchins and the interest of mainly academic researchers in shallow shelf reef fish. The quantity and quality of information on these fisheries is generally poor and inadequate for management except in the most precautionary sense. However, there has been recent renewed interest in these four coastal fisheries. The fisheries management authority is aware of the need to demonstrate effective management at the national scale while tackling the regional management required for the offshore pelagic fisheries.

Taking into account its limited organizational capacity, the Fisheries Division is considering contracting studies on aspects of fisheries, many of which can be done as graduate student projects or short-term consultancies. The seine fishery is expected to be documented. There is interest in the oral histories of fishers who harvested deep snapper banks that seem to have been depleted or are perhaps not known by younger fishers. The management plans call for increasing the minimum mesh size in fish traps, especially to rehabilitate the shallow shelf reef fishery. The fisheries management regulations were recently reviewed and not found to be either enforced or complied with. The fisheries authority and fisher organizations are to collaborate in promoting the existing regulations.

Due to organizational capacity constraints and other factors, it is not expected that these fisheries will receive much attention in terms of formal stock assessment. However, the authority is aware of alternative directions for small-scale fisheries (Berkes *et al*., 2001). These fisheries have been identified as potential candidates for co-management arrangements, and it is anticipated that fisher groups will be interested in management objective driven (MOD) approaches. In this way, it is hoped that communication, compliance and capacity may improve.

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4. Coastal fisheries of Brazil

Marcelo Vasconcellos*, Antonio Carlos Diegues and Daniela Coswig Kalikoski

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* *Contact information*: Instituto de Oceanografia, Universidade Federal do Rio Grande (FURG). E-mail: marcelovasconcellos@furg.br

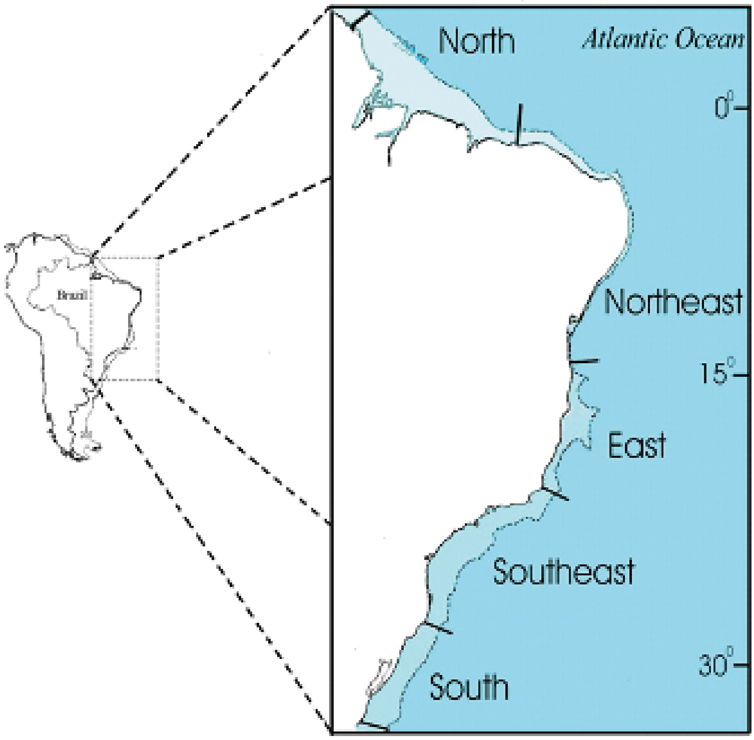
1. INTRODUCTION

Coastal fisheries have been receiving an increasing level of attention from governmental and academic institutions in Brazil in recent years. The reasons for this are many, but the most important are: the general failure of governmental policies for the development of the fisheries sector, which have been focused almost exclusively on industrial fisheries; the growing recognition of the importance of artisanal fishers who, without support from the government, continue to supply local and regional markets; the innumerable pressures that artisanal fishing communities have been suffering, owing to the expansion of the interests of the real-estate and tourism sectors and environmental degradation – factors that often force the fishers to move to cities, having lost their land; the coverage given to these conflicts by the press; the recent political liberalization in Brazil after the military regime (1964 to 1984), which allowed the marginalized and forgotten groups of society to express themselves more freely, especially in defence of their rights and aspirations in the Constituent National Assembly; the work carried out by non-governmental organizations, in particular, the Catholic Church, through the activities of the Fisheries' Pastoral mainly in the north and northeastern states; and the birth of the National Movement of Fishers (MONAPE) in 1989.

The development of artisanal fisheries faces many challenges due to the lack of policies, strategies and concrete experiences that can support sustainable fisheries production, better organization and improvement of the livelihood of fishing communities. There has been a continuous worsening of the problems affecting the production of artisanal fisheries owing to the depletion of fisheries resources, environmental degradation of coastal areas, and ultimately to the ineffectiveness of governmental strategies in overcoming the obstacles that impede the sustained development of the artisanal fishing communities along the Brazilian coast. The overall lack of information about these fisheries is a subsidiary problem that gives low political visibility to the sector and thus helps perpetuate its status. This chapter aims to provide a broad perspective of the status of artisanal coastal fisheries in Brazil, and to put forward some alternative strategies for the development of the sector. In describing these types of fisheries, we opted to concentrate as much as possible on general regional characteristics, but also highlight special features of relevance to particular fisheries when necessary.

Artisanal fishers are organized into a number of fishing communities settled along the coast and in small coastal towns in Brazil. Artisanal fishing is conducted in a variety of coastal ecosystems. The characteristics of habitats, fauna, productivity and oceanography of these ecosystems greatly influence the way fishing activities are developed. On a broad scale, the Brazilian coastline can be divided into five large ecosystems with distinct environmental characteristics of importance to capture fisheries (Matssura, 1995; Figure 1).

FIGURE 1
Major marine coastal ecosystems of Brazil



Biological production is high in the north, as a result of the continental runoff from the Amazon River (Teixeira and Tundisi, 1967). The wide continental shelf and the rich benthic community favoured the development of industrial trawling activities in this region, mostly for shrimps and large catfishes. The northeast and east regions present oligotrophic conditions due to the influence of tropical waters from the Brazil Current. Rocky bottoms and a mostly narrow continental shelf induced the development of hook-and-line and longline fisheries for rockfishes, sharks and tunas. In the southeast, primary production is mainly driven by seasonal upwelling of nutrient-rich, cold subtropical waters pumped by alongshore winds and by cyclonic vortexes originating from the Brazil Current (Bakun and Parrish, 1990; Matsuura, 1995). The southern part of the Brazilian coast is under the influence of the Subtropical Convergence between the southward and northward Brazil and Falkland Islands/Islas Malvinas currents. The confluence of water masses and the high volume of continental runoff provide physical and chemical conditions for high biological production on the shelf (Seeliger *et al.*, 1997). Trawling is the main type of fishing activity in the southeastern and southern regions, although the presence of highly abundant pelagic stocks, mainly sardine, in the southeast has also led to the development of an important purse seine fishery since 1950.

Within each of these major ecosystems, there is a variety of inshore and coastal ecosystems where diverse communities of artisanal fishers live and work. Coral reefs, mangroves, estuaries and coastal lagoons are particularly important coastal ecosystems. Coral reefs occur along 3 000 km of the northeast and east coasts and off oceanic islands. Mangroves extend almost along the entire coast of Brazil, from Oiapoque (Amapá) to Laguna (Santa Catarina), occupying an area of about 25 000 km^2. The most extensive areas of mangrove are associated with the mouth of the Amazon River in the north of Brazil. Coastal lagoons are found in the southern, southeastern and northeastern regions, and are especially important in the states of Alagoas, Rio de Janeiro, Santa Catarina and Rio Grande do Sul. The Patos lagoon, located in Rio Grande do Sul, southern Brazil, is recognized as one of the most important centres for artisanal fisheries in Brazil.

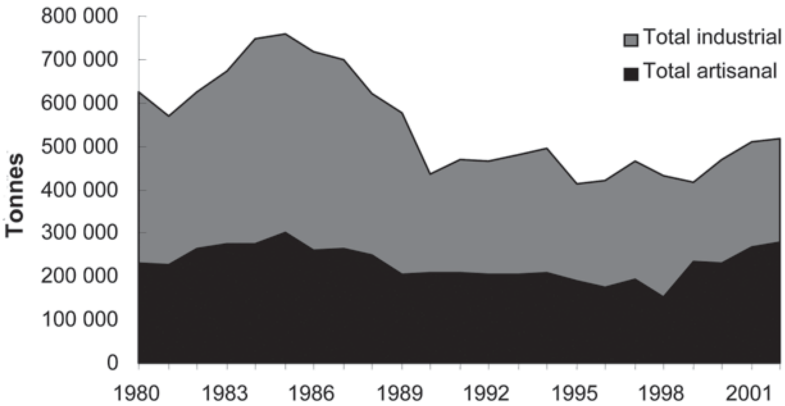
2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Two main fish production systems co-exist in Brazil: industrial and artisanal fisheries. Industrial fisheries are defined as fish harvesting undertaken by large boats that belong to a fishing company. Social and technical division of labour is high, and production is sold to processing companies and large markets. Industrial fisheries concentrate their harvesting on high market value species such as lobster, shrimp and tuna, or highly abundant stocks such as sardine.

There is a continuing debate on the definition of the term ‘artisanal fisheries’. The Superintendence for the Development of Fisheries (SUDEPE, which was the governmental agency for fisheries development from 1967 to 1988) defined the artisanal fishery as the fishery carried out by boats with less than 20 tonnes of capacity. This definition is clearly unsatisfactory considering that some industrial fishing boats also fall into this category. As a result, statistics on the production of artisanal fisheries are not accurate.

In this study coastal artisanal fishers are defined as independent fish harvesters whose livelihood is based on fishing, on a part or full-time basis, using labour and knowledge-intensive fishing techniques, and employing family or community labour, often on a sharing basis, for harvesting in coastal habitats. The fish caught are normally sold in the local market, usually through middlemen, although some is for home consumption. The artisanal fisheries sector has a longstanding tradition in Brazil. Before the governmental incentives to develop industrial fisheries in 1967, artisanal fisheries accounted for more than 80% of the fish production in the country. Today it is responsible for approximately 54% of the total marine landings of about 516 000 tonnes (Figure 2).

FIGURE 2
Landings by main types of marine fisheries



Source: IBGE, IBAMA, CEPENE, Freire, 2003.

The available information on the artisanal coastal fisheries operating in each region along the coast is summarized in Table 1. Fishing activities in the north, northeast and east coasts of Brazil are predominantly small-scale – the sector accounts for more than 90% of total landings in these regions. Industrial fisheries account for most of the fisheries production, with artisanal fisheries representing 34% and 8% of the total landings in the southeast and south, respectively, in recent years.

In the north, artisanal fisheries are concentrated in the estuary of the Amazon River, other smaller estuaries, bays and shallow coastal waters and in the extensive mangrove areas that cover the coast. Coastal fishers use small- (<8 m) to medium-sized (8–14 m) wooden boats and employ various types of gillnets, longlines and fish weirs to catch catfish, weakfish, mullets, sharks and mackerel, among other species of fish. Gillnets and hook-and-line are used for hard bottom species such as groupers and snappers as well as mackerel on offshore reefs and banks. Trawling is also used to catch shrimp in coastal areas. The capture of freshwater species is common during the rainy season when the shelf is strongly influenced by the runoff from the Amazon River. The fisheries inside the estuary use small boats and canoes, with rows, sail or small engines, and employ gillnets, hook-and-line and fish weirs to catch catfish, mullets, weakfish and freshwater species. In the mangrove areas, the main activity is the manual collection of crabs (*Ucides cordatus*).

Artisanal fisheries in the northeast are based on small- to medium-sized boats (most of them <12 m long) using sail or small engines, canoes using oars or sail, and sail rafts. There is a large diversity of species and fishing gear/methods used in coastal fisheries in the northeast. Lessa *et al.* (2004) identified, for instance, at least 16 types of gear used by small-scale fishers in Pernambuco, one of the states of the northeast region. In general, gillnets, longlines and hook-and-line are used in coastal and offshore waters to catch snappers, groupers, mackerel, sardines, pompanos, tunas and dolphinfish. Lobsters are captured mostly with gillnets (*caçoeiras*) and by diving. Shrimp trawling is conducted in certain areas close to the mouth of estuaries. Gillnets, trammel nets, cast nets, manual trawling and traps are employed closer to shore and inside estuaries and coastal lagoons to capture anchovies, mullets, needle-fish, and shrimps, among other species. The manual collection of crabs and molluscs in mangrove areas is particularly important throughout the region.

On the east coast, particularly in the state of Espirito Santo, Martins and Doxsey (2006) identified the following types of fisheries of small- and medium-size scale: an offshore hook-and-line and longline fishery, based on boats of 8 to 15 m long with engines, targeting reef associated and pelagic species; a hook-and-line fishery, based on boats of 6 to 8 m long with engines, targeting specifically the triggerfish (*Balistes capriscus*); a coastal fishery with hook-and-line and gillnets, based on small boats with oars, catching mostly Sciaenidae fish; a fishery targeting tunas and other large pelagics around oil drilling platforms based on well-equipped, medium-sized boats; shrimp fisheries based on trawling boats of 7 to 10 m long; and lobster fisheries based on small boats, using oars or small engines, and employing gillnets and diving. Mangrove areas in estuaries are also important for the manual collection of crabs.

In the state of Rio de Janeiro, on the southeast coast, the most important artisanal fisheries utilize gear such as hook-and-line, gillnet, beach seine, shrimp trawls and manual collection of shell/crab. One of the most traditional activities is the beach seine fishery based on large canoes and seine nets to encircle migrating schools of bluefish, mullets and bonitos (Silva, 2002). Shrimp are caught in the coastal lagoons using fixed nets, manual trawling and cast nets. Small purse seiners also participate in the sardine fishery in coastal waters. In the state of São Paulo, one of the most important and traditional fisheries is the engraulid *Anchoviella lepidendostole* fishery. This fishery occurs mainly in estuaries and is carried out with wooden canoes, 4 to 5 m long, using oars or small engines, and employs trawling nets and other types of gear (Gasalla and Tomas, 1998). In the state of Paraná, fishing activities are predominantly small-scale (Andriguetto-Filho *et al*., 2006). Important fishing activities in the region are the trawl fishery for marine shrimp along the coast and in estuaries, the gillnet fishery for sharks and demersal fishes (mostly Sciaenidae), and the estuarine fisheries for juvenile shrimp, engraulids and mullets. The manual collection of crabs and molluscs is also significant. Further south, in the state of Santa Catarina, beach seining for coastal fishes, estuarine fisheries for shrimps with fixed nets and trawling, gillnet fisheries for croaker, weakfish and flatfish, and jigging (*zangarilho*) for squid are important artisanal fishing activities (Sunye and Morison, 2006).

TABLE 1
Characteristics of artisanal fishing activities in Brazil

Gear type	Type and size of boats	Number of boats	Average crew size	Main targeted species
North				
Manual collection; Gillnet; Fish weirs; Hook-and-line; Longline; Trawling	Wooden canoes and boats, <8 m, using oars, sail or small engines	10 265[a]	2–3	Crab (*Ucides cordatus*); catfish (Ariidae); weakfish (*Cynoscion* spp.); shrimp (Penaeidae); sardines (Clupeidae); mackerel, (*Scomberomorus* spp.); croaker (*Micropogonias furnieri*); mullet (*Mugil* spp.).
	Wooden boats, 8–15 m, using sail and/or engine	3 358[b]	up to 10	Mackerel, (*Scomberomorus* spp.); weakfish (*Cynoscion* spp.); catfish (Ariidae); snappers (Lutjanidae); sharks; sardines, (Clupeidae); shrimp, (Penaeidae); crab (*Ucides cordatus*).
Northeast				
Gillnets; Trammel nets; Cast nets; Beach seine; Trawling; Hook-and-line; Longline; Diving; Manual collection	Wooden canoes, 3 to 9 m, using oars or sail	10 480	2–3	Needle-fish (*Hemiramphus* spp.); snappers (Lutjanidae); groupers (Serranidae); tunas (*Thunnus* spp.); dolphinfish, (*Coryphaena hippurus*); mackerel (*Scomberomorus* spp.); pompano (Carangidae); anchovies (Engraulididae); sardines, (Clupeidae); mullets (*Mugil*, spp.); lobsters (*Panulirus* spp.); shrimps (Penaeidae); crab (*Ucides cordatus*); oysters and mussels.
	Rafts and other small sail boats, <11 m	5 603	2–3	
	Medium-sized wooden boats, <5 m, using engines	6 003	3–5	
East				
Hook-and-line; Longline	Wooden boats, 8 to 15 m, with engines	372	5–6	Snappers (Lutjanidae); groupers (Serranidae); dolphinfish, (*Coryphaena hippurus*).
Hook-and-line	Wooden boats, 6 to 8 m, with engines	402	3–4	Trigger fish (*Balistes capriscus*); other demersal fish (Sparidae, Pomadasydae and Haemulidae).
Hook-and-line; Gillnet	Small (< 8 m) wooden boats, using oars	725	2–3	Coastal demersal fish, Sciaenidae.
Trolling; Hook-and-line	Medium-sized wooden boats with engines	170	6	Yellowfin tuna (*Thunnus albacares*); dolphinfish (*Coryphaena hippurus*); billfishes (*Seriola* spp.; *Acantocybium* spp.).
Otter trawling	Wooden boats, 7 to 10 m, with engines	248	2–3	Shrimps (Penaeidae).
Gillnet; Diving	Small wooden boats, using oars or engines	186	2	Lobsters (*Panulirus* spp.).

TABLE 1 (CONTINED)

Gear type	Type and size of boats	Number of boats	Average crew size	Main targeted species
Southeast				
Trawling nets	Wooden canoes, 4 to 5 m, using oars or small engines	no data	no data	Anchovy (*Anchoviella lepindostole*).
Beach seining	Large wooden canoes	65	2–3[c]	Bluefish (*Pomatomus saltatrix*); mullets (*Mugil* spp.); bonitos, (*Acantocybium* spp.).
Gillnet; Trawling; Fixed nets; Beach seining; Hook-and-line; Jigging; Manual collection	Wooden boats, 6 to 14 m, using oars or engines	no data	no data	Shrimps (Penaeidae); juvenile anchovies (Engraulididae); croaker (*Micropogonias furnieiri*); weakfish (*Cynoscion* spp.); squids (*Loligo* spp.); flatfish (*Paralichthys* spp.); mullets (*Mugil* spp.); crabs and molluscs.
South				
Gillnet; Fixed nets; Trawling; Manual trawling	Wooden boats, < 10 m, using engines	no data	2–3	Croaker (*Micropogonias furnieri*); mullets (*Mugil* spp.); sharks; flatfish (*Paralichthys* spp.); shrimps (Penaeidae).
Gillnet; Hook-and-line	Wooden boats, 12 to 15 m, using engines	no data	6–8	Demersal fishes (Sciaenidae); bluefish (*Pomatomus saltatrix*).

Sources: Reis *et al*., 1994; Gasalla & Tomás, 1998; CEPENE, 2007; BDT, 2002; Pinto da Silva, 2004; Almeida *et al*., 2006; Isaac *et al*., 2006a.

[a] Based on data for the states of Para (4 475 boats) and Maranhão (5 790 boats).

[b] Based on data for the states of Para (1 502 boats) and Maranhão (1 856 boats).

[c] According to Pinto da Silva (2004) there are 150 fishers in the beach seine fishery of Arraial do Cabo; crew size was derived from this number and number of canoes.

Finally, in southern Brazil, artisanal fisheries operate mostly in coastal lagoons, estuaries and shallow coastal waters using wooden boats, most of them less than 10 m long and under 20 gross tonnes. The main artisanal fishing activities are the gillnet fisheries for croaker, mullets and flatfish, and the fishery for shrimps with fixed nets and trawling (D'Incao, 1991; Reis *et al*., 1994; Kalikoski *et al*., 2002). A medium-scale commercial fishery operates in coastal waters (Reis *et al*., 1994). The fleet is composed of wooden boats, 12 to 15 m long, with more powerful engines, and targets demersal fishes (mostly Sciaenidae) and also pelagic species such as the bluefish (*Pomatomus saltatrix*) using gillnets and hook-and-line.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

3.1 Characteristics of fishers

Fishing and mollusc harvesting were important activities for indigenous people before the arrival of the Portuguese colonisers in the sixteenth century. In several areas of the coast there are shell middens (*sambaquis*), demonstrating that indigenous people fed on molluscs and fish for several centuries. Jean de Léry, a French Calvinist who visited Brazil in early 1500, described fishing techniques used by coastal Indians, such as bone hooks and small nets made of fibres found in the forests as well as canoes and rafts (*jangadas*) made of floating logs. Fishing was also important along the Amazonian rivers and Indians used fish as their basic source of protein.

Until the end of slavery in 1888, fishing activities in the northeast were undertaken mainly by African slaves. Small farmers also used part of their time for fishing along the coast. Coastal fish species, such as mullet, were the basis for protein consumption in coastal farms, towns and villages. The social upper classes, however, imported salted cod from Portugal (Silva, 1997a).

A variety of human cultures based on fisheries are found along the coast. In the south region, between Rio Grande do Sul and Santa Catarina, live the descendants of the Azoreans and Portuguese that settled in the region in the seventeenth century. The first European generations were both peasants and fishers, but since the late 1940s they have concentrated mainly on fishing. The *caiçaras*, who live between Paraná and the state of Rio de Janeiro, are descendants of the Indians, Portuguese colonizers and African slaves. They practice small-scale agriculture associated with artisanal fishing. The *jangadeiros* (raft-fishers) live in the northeast coast, from Bahia to Fortaleza, and they depend almost exclusively on artisanal fishing, using the *jangada* (a raft with sails) that is very suitable for the type of sea, wind and sandy coast of the area.

The cultural background and the environmental setting favoured the development of different relationships with the sea. Small farmer-fishers combined fishing with agricultural activities in the provinces of São Paulo and Rio de Janeiro. In the northeast region, coastal communities have developed a long tradition of coastal fishing, separated from agriculture. Cultural factors, as well as the shape of the continental shelf, could be responsible for the different relationships between agricultural and fishing activities. The continental shelf is narrower in the northeast than in the southeast, and thus most of the fish species in the northeast live in rocky habitats further from the coast. These factors require fishers with good navigational skills and fishing knowledge. The sandy coast in the northeast also inhibited intensive agricultural activities and therefore the artisanal fishers in this area have a strong tradition of dealing with the open sea. Most of the fishing activity in this area was carried out within a system involving a petty mode of production, where some of the harvested fish was used for subsistence and some as a commodity.

Coastal legislation has contributed to (but also interfered negatively with) the development of traditional sea tenure. Since the middle of the last century a stretch of 33 m of land measured from the 1833 highest tide belongs to the State (called *Terras de Marinha*). This area cannot be privately owned and no permanent construction can be made in this area without State permission. Small-scale fishers, although they have no legal entitlement, occupy these areas. They have customary rights of occupancy (*posse*) to live in those areas, where they build their thatched roof houses. The same right (*posse*) is transferred to the nearby coastal waters when they occupy a place in the estuaries and lagoons to build their fish weirs (*cercos*).

The State, through the Navy, also tried to control artisanal fishers through forced services. As a result, rebellions occurred in 1903 in Rio de Janeiro and Ceará. To control these rebellions, in 1921 the Brazilian Navy created the first fishers guilds (*Colônias de Pescadores*). According to the guild regulations, all fishers should be registered in order to receive permission to fish. In practice, each coastal municipality had its own guild that regulated the lives of fishers. However, with the promulgation of the new Brazilian Constitution in 1988, fishers were given rights to organize their own free associations.

Commercial fishing began to develop more intensively beginning in the twentieth century, particularly in the southern states, where the Portuguese and Spanish migrants started to use larger boats for fishing sardine, which was also used for canning. Industrial fishing further developed after the 1960s with the support of a large fisheries development programme undertaken by SUDEPE. Before then, most of the fishing was done by artisanal fishers along the coast and rivers.

It is extremely difficult to calculate the number of artisanal fishers, considering that the 'official' criteria based on boat size is not accurate. According to data from the 2000 census, there are about 248 000 fishers on the coast organized into fishers' guilds. The northeast has approximately 62% of the total number of guilds, followed by the southeast with 16%, south with 12% and the north with 10% (data provided by the Confederation of Fishers, 1986). Also, according to the Confederation there are approximately 288 500 fishers who are not affiliated with the guilds. Thus, there are approximately 536 000 artisanal coastal fishers in Brazil.

Data obtained from the Brazilian Institute of Geography and Statistics (IBGE) in the 1970s indicated that around 70% of artisanal fishers lived in coastal/rural areas and 30% resided in urban areas. In the north and in the northeast, fishers lived mainly in rural communities, while in the southeastern and southern regions they were mainly urban dwellers. Considering that since the 1970s, rural-urban emigration (which in Brazil is also synonymous with emigration from the interior to the coast) has been a widespread phenomenon, one can acknowledge that the degree of urbanization of artisanal fishers is much higher now.

In different regions of Brazil, mainly in the northeast and the north, women have traditionally participated in fishing activities by harvesting shellfish (*marisqueiras*), or fishing along the seashore (*pescadeiras*). Women also have been the main labour force in the processing of fish in artisanal and industrial fisheries. Until the 1988 Constitution, women were not legally permitted to work in fisheries, which were considered a male activity. SUDEPE only allowed women to work as harvesters of shellfish or algae. It was only in 1988 that a presidential act abolished the prohibition on female labour in fisheries. In spite of the legalization controlling their role, women rarely participate in deep-sea fishing, since fishers consider that their presence on board a boat will bring bad luck (*panema*). This situation is slowly changing and in some states of the north and the northeast regions some women work with their families in small-scale fishing. There are also cases of widows who work alone in artisanal fishing boats. Some of these women are now even presidents of fishers' guilds; however, these are still isolated cases.

The majority of women work as shellfish harvesters, selling the yield to increase the domestic income. In some states of the northeast region, such as Bahia, approximately 20 000 *marisqueiras* participate actively in earning domestic income. In states such as Maranhão, northern Brazil, women participate in fishing 'on foot' with small shrimp nets. The shrimp is brined, dried and sold by the women. This activity is also common in other states of Brazil. The activity of women is also important in some fishing communities where they weave and darn the fishing nets. In many other communities, women work in small-scale agriculture, producing yucca flour, which is the basic diet of coastal populations in many areas. Urban industrial employment is another field where women are active participants, working in the fish processing industry. In many cases the workforce is almost entirely female.

The role of women in fishing activities has decreased in some cases due to technological changes and overexploitation of coastal resources. Women who take an active part in fishing still maintain their traditional status – their activities are viewed as 'support' in running the household. The majority of the fishers' guilds maintain the traditional gender division of labour. The 'double-workday' of women continues to be thought of as 'part-time activity'. A woman involved in the administration of the *colônias* is still considered a little 'out of place'.

There are recent trends in the role of women in fisheries, which are worth mentioning. During the past five years, in the state of Pará, women have attained more than 10% of the registered members of the guilds. They are also seeking alternatives to traditional set-ups like the *colônias*. Several women's associations have flourished, providing women the possibility of holding positions of higher political/administrative importance. There have been several factors motivating women to unite and form associations, including the need to generate income and explore alternative avenues to do so. Government programmes and the initiatives of non-governmental bodies working with small producer groups have also influenced these women's organizations. Groups that already existed in the community (mostly linked to the Catholic Church, such as Mothers' Clubs, Grassroot Ecclesiastical Communities) are enthusiastically supporting these new associations.

In the *colônias* where women are admitted, integration occurred naturally. Once groups are formed, the exchange of ideas and access to new social spaces induced a reconsideration of traditional roles. These groups tend to follow examples set by other organizations that have been successful in welcoming women. During the 1990s, other various organizations supported and strengthened the role of women in fishing, such as the Fisher's Pastoral, the National Movement of Fishers (MONAPE) and several NGOs (i.e. Terramar, supported by the International Collective in Support of Fishworkers) (Maneschy, 1999).

3.2 Social and economic aspects

Socio-economic data on artisanal coastal fisheries are generally scarce. The situation deteriorated even more after the termination of SUDEPE in 1989. There are several reasons for the scarcity of socio-economic information. One cause is the dispersion of fishing communities along the coast, which makes the task of collecting information extremely difficult. Another factor that has hampered the development of programmes to evaluate the socio-economic status of artisanal fisheries is governmental priority in the industrial sector. This support to industrial fisheries has been a detriment to the artisanal sector. Among the main data deficiencies are those concerning economic aspects of the fishery, such as employment and income level, types of technologies employed, and organizational aspects of fishing communities. Some small improvements in data availability have been observed in recent years when governmental welfare programmes began to collect and disseminate information on the fishers who applied for benefits, such as the unemployment benefit received by fishers during fishing closures.

In terms of fishers' productivity, the available data from SUDEPE, Fishers Confederation and IBGE indicate that productivity increased from 1.49 tonnes per fisher in 1967 to 1.81 tonnes per fisher in 1986 and decreased to 1.12 tonnes per fisher in 2000. The decrease in the last 15 years could be caused by the depletion of coastal resources, as well as other factors, such as the increase in the number of people participating in the fishery (including, in recent years, non-fishers that fish as an alternative source of income) and the consequent reduction in the productivity per individual fisher.

The infrastructure for landing, storage and commercialization of fish is very precarious. In general, the large ports have no infrastructure to accommodate landings from artisanal fisheries. In many fishing communities, especially in the northeast, fish is landed on the beach and from there it enters a long chain of dealers until it gets to local/regional markets. The situation seems to be even worse in fishing communities close to urban centres, because they lack adequate structures to land and process fish in urban conditions. Past experiences in the northeast in the construction of fisheries production facilities for landing and cold-storage associated with cooperatives (funded during the 1980s by the Inter-American Development Bank [IDB]) did not work satisfactorily. The vast majority of these facilities ended up in the hands of middlemen. At the same time, many cooperatives failed because they were formed in a rush, without the proper evaluation of the administrative capacity of fishing communities and of market demands. More recent experiences in the northeast with the 'Pro-Renda' (a governmental programme that aims to increase the income level of poorer communities) seem to be more successful than the previous experiences with cooperatives. The programme is based on strengthening the existing fishers' guilds, improving techniques to maintain the quality of fish on board using freezers, and developing new markets for artisanal fisheries production. Fish marketing, improvement of the quality of fisheries products, and the processes of intermediation within the market chain continue to be the critical points for the development of artisanal fisheries and increasing the income levels of artisanal fishers.

Fishing livelihoods are not homogeneous along the coast. Along the northern coast, many fishers combine fishing with agriculture. In the northeast, most fishers depend exclusively on fisheries. Their livelihoods are under threat from the rapid expansion of shrimp aquaculture, tourism and urban development, as well as from overfishing of important stocks. Along the southern and southeastern coast, there are clear signs of depletion of most stocks, as well as environmental degradation which requires mechanisms of control and regulation. In the past, many fishers who lived in coastal villages also maintained other activities such as small-scale agriculture, forestry and handcrafting. With the increasing level of conflict with industrial fisheries, along with the expansion of urbanization and tourism, many artisanal fishers have turned to aquaculture or to working in general services in cities.

The urbanization of artisanal fishers (i.e. the move of fishers from rural to urban areas) is a phenomenon evident in many states, particularly in the southeastern and southern regions. Even in the 1970s, approximately 70% of fishers in these regions lived in or around urban centres. In contrast, in the northern and northeastern states, most fishers lived in coastal villages while only 44% lived in urban centres. Although there is a general lack of information, it is probably correct to assume that today most coastal artisanal fishers live in or close to urban areas, with the exception of fishing communities in northern Brazil and in the states of Maranhão and Piaui. According to data available in the IBGE database for 1991, the level of urbanization reaches 22% in certain areas of Maranhão, 48.5% in Ceará, 62.5% in Paraíba, 70% in Rio de Janeiro, 83.5% in Santa Catarina and 98% in São Paulo. The increasing level of urbanization of artisanal fishers has many drivers, including mounting economic pressure from the tourism industry that led to the appropriation of coastal areas from fishing communities; the shift from agriculture and other extractive activities; the lack of basic infrastructure to support fishing activities (e.g. supply of ice and diesel) and the lack of access to basic social services (e.g. health and education) in coastal villages compared with urban centres; the proximity to markets in the cities; and the implementation of environmental conservation units along the coast that expelled many fishers from their traditional fishing areas. Fishers that have moved to cities are often involved in urban activities (construction, general services, tourism, etc.) to complement their earnings during fishing closures.

Fishers' access to infrastructure and to social services is normally precarious in coastal communities as well as in urban zones. Table 2 compares some statistics that characterize the living conditions in certain artisanal fishing communities of selected coastal states.

TABLE 2
Percentage of households with access to basic services in fishing communities in selected areas of coastal states

Town	Access to treated water	Sewage system	Regular collection of domestic waste
Maranhão	<5. 0	7. 0	0. 5
Ceará	7. 0	7. 0	24. 0
Rio de Janeiro	62. 0	3. 0	no data
São Paulo	71. 0	<5. 0	no data
Santa Catarina	52. 0	3. 5	no data
Rio Grande do Sul	68. 0	69. 0	65. 0

Sources: Diegues, 1999; Costa, 2004.

3.3 Education level of fishers

The information provided by fishers that applied for unemployment benefits in 2003 (Ministério do Trabalho e Emprego) indicates that the illiteracy rate is 44.6% among men and 53.5% among women. Only 9% of men and women have completed elementary-level education and only approximately 1% completed high school. These figures indicate that the educational level of fishers is extremely low and well below the national average. From the same source of data it is estimated that only 13% of fishers are less than 30 years old, which reveals the difficulty of recruiting young members of the community into the fishery.

3.4 Fish marketing and processing

Most of the frozen fish traded in large cities in supermarkets is imported or is supplied by commercial fishing industries. Artisanal fisheries production is generally traded in coastal towns and regional centres. Most of the crabs, mussels, oysters and other shellfish originate from artisanal fisheries, and marketing is sometimes done through cooperatives. In Santa Catarina (in southern Brazil), many small-scale fishers are becoming oyster cultivators, partly due to the decrease in fish stocks. Mussels are also being cultivated by small-scale fishers along the northern coast of São Paulo.

The network of fish trade in artisanal fishing villages is complex, often involving middlemen on several levels, from the beach to the neighbouring cities and the central markets in state capitals. In the Amazonian region, for instance, artisanal fishers (especially those who live far from the cities) are totally dependent on the middlemen. In Pará the fish bought by the *geleiro* is resold to the 'weigher', who in turn sells it to the 'retailer' and from there it is sold in the 'retail market'. Since the 1970s, due to the roadways network development, the traders in the cities, as well as the fishing companies, send their trucks to the beaches to purchase fish from artisanal fishers. The fishing companies pay for the fuel of the motorized artisanal boats in exchange for the exclusive rights to purchase the catch.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

4.1 Community organization

Artisanal fishers are organized into fishing guilds (*colônias de pesca*), similar to the Iberian guilds, created originally by the Brazilian Navy. The objective for the creation of these guilds was to organize the fishing communities spread out along the coast into reserves for the Navy. The directors of the *colônias* are elected by fishers, who are legal members of the *colônias*, and the directors in turn elect the president of the Provincial Federation. The president of the National Confederation was personally nominated by the agriculture minister, to which the fishing sector was institutionally attached until 1989.

Before the 1988 Constitution, a majority of the directors of the *colônias* were representatives of other social and professional sectors, such as fish traders and lawyers, who utilized the fishers' organizations for political purposes. In 1973, a new statute was established for the *colônias*, but no substantial changes occurred as this new law was promulgated during the military regime and there was no consultation whatsoever with the fishers. In the beginning of the 1980s, for the first time artisanal fishers of Pernambuco (northeast) organized mass meetings against the environmental degradation of the rivers and estuaries caused by the large sugar-cane mills. The movement to redemocratize the country towards the end of the military dictatorial regime had an important influence on the democratization of the overall electoral process. This process was stronger in the northeast, where the *Pastoral dos Pescadores* (Fishers' Pastoral) created by the National Conference of Bishops of Brazil played an important role. After 1986, the artisanal fishers created the *Movimento pela Constituinte da Pesca*, which enabled artisanal fishers to express their demands in the National Congress for the first time: free and democratic association, end to fiscal incentives for industrial fishing, labour rights, recognition of women's work, development programmes, and control of environmental degradation, among other demands.

In 1989, with the declaration of the Constitution, the movement phased out, but MONAPE became operational. The main challenge for MONAPE is the stimulation of an independent and democratic organization of artisanal fishers, seeking to maintain the rights earned by the 1988 Constitution and to fight for new social and labour rights. The MONAPE has organized various national meetings of its members, also inviting representatives from organizations of fish workers from neighbouring countries like the Confederación Nacional de Pescadores Artesanales de Chile (CONAPACH). MONAPE is active only in the northern regions where it is based, as well as in some states of the northeast. Unfortunately, MONAPE has not succeeded in establishing itself as a national movement capable of offering alternatives to the existing institutional framework that is marked by protectionism and the lack of clear and effective policies favouring artisanal fishing, as mentioned before.

Before the Constitution of 1988, fishers were only allowed to organize themselves into traditional *colônias* whose role was mainly related to social services. The new Constitution allowed fishers to create their own trade unions; however, few of these unions were established effectively. In the 1980s the *Pastoral da Pesca*, which is linked to the Catholic Church, began working to secure the rights of other workers (i.e. retirement benefits) to artisanal fishers. Today, fishers have the right to inscribe themselves as autonomous workers in the National Institute of Social Security, and pay a contribution until retirement (60 years for men and 55 years for women). According to the Organic Law of Social Security, they can apply for retirement on grounds of health problems, health benefits and maternity allowances. In the regions in which fishing closures are used as management strategies, fishers that are associated to the *colônias* and have a licence from the Ministry of Agriculture receive an allowance (unemployment benefit) to compensate for the period without fishing.

4.2 Interactions between fishers and with other sectors

While the traditional use of the coastal ecosystems by artisanal fisheries has had little impact on coastal resources, the latest utilization of coastal ecosystems by urban-industrial activities has intensified the degradation of these environments considerably. The degradation and contamination of coastal areas has caused significant negative consequences to the productivity of the sector and the quality of life in fishing communities.

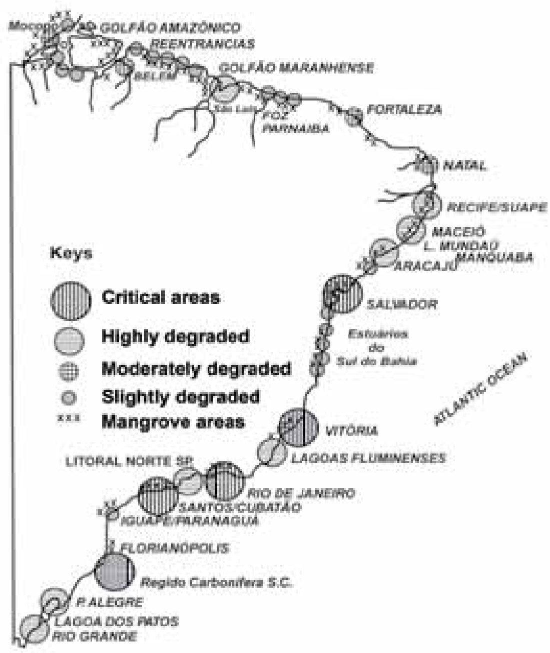
The most important ecosystem along the coast is the Atlantic Forest that covered around 1 million km^2 at the beginning of the Portuguese settlement. This forest reaches the coastline in many parts of the country; thus mangroves can be considered part of this large forest. The Atlantic Forest has a biological diversity as high as the Amazon Forest, with a large number of endemic species. The forest has been destroyed even more intensively since the increase of the urban-industrial development in the 1960s. Only around 5 to 10% of this large, forested biome still exists today, and it is mainly located along the coasts of southern Rio de Janeiro, São Paulo and Paraná States. The Atlantic Forest is also home to different human cultures, such as Indians and their descendants, the *caiçaras* and *jangadeiros*, that have developed a deep knowledge of, and traditional management system for, the forest and their adjacent coastal ecosystems.

During the colonial period, the coastal zones were used as trade centres and as the gateway to enter the hinterland, where mineral and agricultural resources were abundant. Major cities were usually located on the coast, thus ensuring communication with the colonial power overseas as well as the hinterland. Marine resources, with the exception of whale hunting, were also exploited at a subsistence level. During that period, boat construction was one of the few important industries on shore and was responsible for intensive woodcutting in some northeastern provinces. After independence, and particularly during the second half of the nineteenth century, most of the important economic activities, such as coffee, rubber and sugar-cane plantations, shifted from the coastal zone to the hinterland. At the beginning of the twentieth century, industrialization led to a shift from producing goods for the internal market to importing and exporting products. Small industrial plants for processing cotton and food products were concentrated both in the hinterland and on the coast.

After the 1950s, Brazil pursued an industrial economic model oriented towards export. Most of the large heavy industries (chemical, petrochemical, fertilizer) were and still are located in estuaries and bays, as well as next to other fragile coastal ecosystems: in São Luís Island (for aluminium processing) in the northern State of Maranhão; in the coastal lagoons of Maceió, (Alagoas), in Salvador Bay, in the Vitória Island (for iron export), Rio de Janeiro bay, Santos-Cubatão, in São Paulo, and in the Patos lagoon in Rio Grande do Sul. Huge harbours for export of mining production were established in São Luís (Maranhão) and Vitória (Espírito Santo). Examples of these large industries settled on the coast are: chemical industries in Arraial do Cabo (Rio de Janeiro) in Aratu and Camaçari in Salvador (Bahia); oil and chemical industries in Cubatão (São Paulo); Dow Chemical, Petrobrás and Petroflex in Rio de Janeiro; Salgema in Maceió (Alagoas); fertilizer production in many cities around the coast; coal mining near the coast of Santa Catarina and Rio Grande do Sul; and iron production in Cubatão (São Paulo) and in Vitória (Espírito Santo). Paper pulp production, involving large areas of eucalyptus plantations, is important along the coast of Espírito Santo and southern Bahia. Many alcohol distilleries have been established along the coast, particularly in the northeast. As a result, pollution has been heavily concentrated in this zone and coastal degradation has been extensive (Figure 3).

Increasing urbanization has a major impact on coastal areas, since five of the nine metropolitan areas in Brazil are located on the coast. In 1990, Rio de Janeiro had 9.6 million inhabitants; Recife 2.5 million; Salvador 2.4 million; Fortaleza 2.2 million; and Santos 1.3 million inhabitants. In addition, many State capitals are also on the coast: São Luís (655 000); Natal (606 000); Maceió (626 000); Vitória (523 000); João Pessoa (695 000); and Florianópolis (254 000). Many of these coastal cities have a high demographic growth, attracting migrants from the hinterland and a high percentage of these migrants live in *favelas* (slum areas in Salvador, Fortaleza and Rio de Janeiro).

FIGURE 3
Levels of degradation of estuarine ecosystems in Brazil



Source: Diegues, 1999.

Coastal cities are expanding as poor people migrate from the countryside, where the modernization of Brazilian agriculture has led to an increasing concentration of productive land in the hands of a small number of landowners and groups, both national and multinational. With the expulsion of small landowners and peasants from the countryside, slum areas have been established in large coastal cities. Most sewage systems are inadequate, resulting in increasing pollution of coastal rivers, estuaries, lagoons and bays.

As road transportation has the highest priority in Brazil's transportation system, many highways have been constructed along the coast. One clear example is the BR-101 built in the 1970s, which links many coastal capitals. During the construction process, many beaches and mangrove areas were damaged as the road was built along the coast between Santos and Rio de Janeiro. These coastal roads have also encouraged the construction of villas by tourists, and have displaced many small-scale fishing villages to inland and to the mangrove areas, resulting in the destruction of the Atlantic Forest.

Oil exploration and production is an important economic activity along the Brazilian coast, which started in 1973. The main oil drilling areas along the coast are in Campos (Rio de Janeiro), Sergipe, Piauí, Rio Grande do Norte, Amazon basin and Recôncavo Baiano. Over 56% of the oil produced in Brazil comes from marine basins. There are important harbours where oil is brought ashore, the most important of which is situated in São Sebastião (São Paulo), where tourism, fisheries, mangroves and other coastal habitats suffer from frequent oil spills in the area. Coal is also produced in the coastal area of Santa Catarina and Rio Grande do Sul. Reefs are also exploited for construction, mainly along the northeastern coast.

Tourism and recreation have become among the most important factors influencing the use of coastal areas and resources. Around 1.6 million foreign tourists visit the country annually, in particular the coastal tourist resorts, generating US$1.55 billion and roughly 1.4 million jobs. In 1992, the Brazilian Agency for Tourism (EMBRATUR) established a National Plan for Tourism that created several tourism development centres in coastal areas. In 1991, SUDENE and EMBRATUR created the Programme for the Development of Tourism (PRODETUR) and requested a US$1.6 billion loan from the Inter-American Development Bank. This large programme is directed along the northeastern coast, involving the construction of large hotels, roads, improvement of airports and urban infrastructure, such as water and sewage. This programme follows the intensive use of the coastline, which exists today in Cancún, Mexico. The ecological and social impacts of this programme have not yet been properly assessed, but social and ecological groups in the area are reacting against it, since local communities and the environment suffer the most.

In addition to the increasing degradation of inshore and coastal environments, overfishing is affecting the large stocks of shrimps, lobsters, catfish and sardines that are shared between artisanal and industrial fisheries. A recent analysis of the status of fisheries resources targeted by artisanal fisheries revealed that the percentage of collapsed stocks increases from north to south, and are in the order of 3% in the north, 12% in the northeast, 29% in the southeast and 32% in the south.

Aquaculture is a fast growing activity along the north and northeastern coast affecting several inshore ecosystems such as mangroves, sand barriers and lagoons. The highest impact comes from shrimp cultivation, which is starting to be implemented in the states of Ceará, Rio Grande do Norte, Paraíba, Maranhão and Pernambuco, resulting in massive destruction of mangroves and associated ecosystems. Large-scale shrimp cultivation is also affecting the livelihood of artisanal fishers as they are losing their traditional fishing areas.

5. ASSESSMENT OF FISHERIES

Fisheries assessment research has gone through distinct phases over the years (Castello and Haimovici, 1991). The first strategy for assessing fish stocks was implemented in the late 1950s with the establishment of a national system of fisheries statistics and assessment of industrial fishing fleets. The next stage, initiated during the 1970s, aimed at surveying and assessing the productive potential of fish stocks along the coast (Neiva and Moura, 1977). During the 1980s and 1990s, the Environmental Agency (IBAMA) established a system of technical working groups, *Grupos Permanentes de Estudo* (GPE), for each of the main fisheries resources (i.e. shrimps, demersal fishes, sardine, lobsters, snappers and tunas). The objective of the GPEs was to provide recommendations for both management and research based on the analysis of biological, technological and socio-economic information of these major resources. Thus, for most of these stocks there are estimates of biomass, optimal exploitation rates, and maximum sustainable yield obtained through the application of assessment models that range from simple production models to Virtual Population Analysis.

Not much has been done to assess in a systematic and continuous way the status of the less abundant and diverse fish stocks targeted by artisanal fisheries, in part because of the lack of data, but also because of a lack of attention from government agencies. However, some localized research initiatives have been carried out by universities and research institutes. Tables 3 to 6 and Figure 4 summarize the available information on the status of stocks targeted by artisanal fisheries in each of the coastal regions (Vasconcellos *et al*., 2007); this information is discussed in the text sections below. The results are based on published assessments of the status of marine fisheries stocks, analysis of time-series of landings of artisanal fisheries compiled by Freire (2003) and Vasconcellos *et al*. (2007) for the period 1980 to 2002, and the list of species that are threatened by extinction, overfished and threatened by overexploitation included in Annexes I and II of Norm No. 5, 21 May 2004, Ministry of Environment.

5.1 North

Information on the status of stocks of importance for small-scale (or artisanal) fisheries in north Brazil is scarce. Most of the information available refers to stocks that are also important to industrial fisheries, such as shrimp, lobster, catfish, and the southern red snapper (Table 3). The pink shrimp is under intense fishing pressure, and is probably exploited at its maximum biologically sustainable level, whereas the stocks of the seabob shrimp could possibly sustain higher catches. Recent reported landings of lobsters are very close to the predicted maximum sustainable yield, which indicates that the stock is probably fully exploited. The stock of catfish shows signs of recovery after being overfished for many years. The stock of southern red snapper has also recovered from a state of overfishing, but is now considered under high risk of becoming overfished again. The status of the stock(s) of the mangrove crab is unknown. Landing statistics indicate a decrease of about 50% in production since the early 1980s, although it is difficult to ascertain if the decrease is due to overfishing, or to the deterioration of the data collection system for fisheries statistics. All of the above species are listed in Annex II of the IN No. 5/2004, and are either overexploited or threatened by overexploitation. The total reported landings of these species for 2002 represents approximately 13% of the small-scale fisheries production in northern Brazil. The exploitation status of the remaining stocks is unknown. Through the analysis of trends in fisheries landings by species, Vasconcellos *et al.* (2007) concluded that there is a total of 74 small-scale fisheries stocks in the northern region, and that 27% of these stocks are in a developing stage, 24% are in a mature stage, 41% are in senescent stage, 4% in recovery and 3% collapsed (Figure 4). Approximately 56% of the total stocks could possibly sustain higher catches if managed sustainably in the future, while the remaining 44% (composed of stocks in a senescent or collapsed stage) are probably overfished.

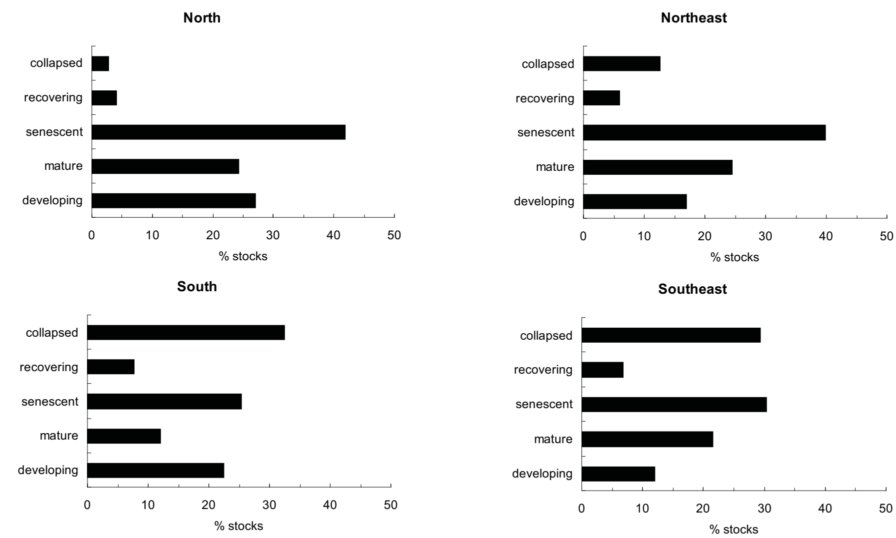
TABLE 3

Exploitation status and relative importance to small-scale fisheries of previously assessed marine stocks in north Brazil. The relative importance of a species is expressed in tonnes and as a percentage of the species catches to the total small-scale fisheries landings in the region. Species are classified according to IN No. 5/2004, 'I' being species threatened by extinction and 'II' being species that are overexploited or threatened by overexploitation

Stock	Exploitation status	Classification IN No. 5/2004	Small-scale fisheries landings (2002)	
			Tonnes	%
Pink shrimp (*Farfantepenaeus* spp.)	Intensively exploited; decreasing production	II	1 240	0.9
Seabob shrimp (*Xyphopenaeus kroyeri*)	Underexploited	II	1 235	0.9
Catfish (*Brachyplatystoma vaillantii*)	Recovering	II	1 923	1.4
Lobster (*Panulirus* spp.)	Fully exploited	II	1 460	1.1
Southern red snapper (*Lutjanus purpureus*)	Risk of overfishing	II	4 363	3.2
Mangrove crab (*Ucides cordatus*)	Unknown; decreasing production	II	7 507	5.5

Source: Vasconcellos *et al.*, 2007.

FIGURE 4
Development stage of small-scale fisheries stocks in north, northeast, southeast and south Brazil according to the analysis of trends in reported fisheries landings



Source: Vasconcellos *et al*., 2007.

5.2 Northeast

Very few stocks have been assessed in northeast Brazil (as defined in Vasconcellos *et al*., 2007). The northeast region encompasses the northeast and part of the east biophysical regions in Figure 2. The available information is summarized in Table 4. Stocks of lobsters are being overfished and show a decreasing trend in landings since the 1990s. Stocks of the two main Lutjanidae species, the yellowtail snapper and the vermilion snapper, are either intensively exploited or overfished. The other important Lutjanidae, *Lutjanus jocu* and *L. vivanus*, are considered fully exploited, whereas *L. analis* and *L. syanagris* are moderately overfished. Landings of groupers show a decreasing trend over time with long-lived species being overfished, resulting in the targeting of smaller and shorter-lived groupers. The stocks of mackerel are under moderate levels of exploitation. There are no assessments of the status of the stock(s) of mangrove crabs. The decrease in landings of mangrove crabs in most northeastern states is understood as a sign of overfishing. Likewise, there are no assessments of the status of seabob shrimp stocks in the northeast, although the trend in landings indicates that the stock(s) are still moderately exploited with potential for supporting higher yields. Among the above-mentioned resources there are species considered in threat of extinction, such as the mutton snapper (*L. analis*) and the grouper (*Mycteroperca tigris*), and species considered overexploited or threatened by overexploitation. These resources account for about 24% of the total small-scale fisheries landings in 2002.

The status of the resources accounting for the remaining 76% of the landings is unknown. An evaluation of the development stage of 253 small-scale fisheries stocks in the northeast concluded that 16% are in a development stage, 25% can be considered mature, 40% are in a senescent stage, 6% in recovery and 13% collapsed (Vasconcellos *et al*., 2007; Figure 4). Thus, about 47% of stocks could possibly sustain higher yields while 53% are probably overexploited and require more restrictive management measures if they are to be fished sustainably.

TABLE 4

Exploitation status and relative importance to small-scale fisheries of previously assessed marine stocks in northeast Brazil. The relative importance of a species is expressed in tonnes and as a percentage of the species catches to the total small-scale fisheries landings in the region. Species are classified according to IN No. 5/2004, 'I' being species threatened by extinction and 'II' being species that are overexploited or threatened by overexploitation

Stock	Exploitation status	Classification IN No. 5/2004	Small-scale fisheries landings (2002)	
			Tonnes	%
Lobsters (*Panulirus* spp.)	Overexploited; decreasing production	II	4 604	4.7
Yellowtail snapper (*Ocyurus chrysurus*) **Vermilion snapper (*Rhomboplites aurorubens*)**	Overexploited	II II	2 619 ?	2.7 ?
Dog snapper (*Lutjanus jocu*) **Silk snapper (*L. vivanus*)**	Fully exploited	–	799[a]	0.8
Mutton snapper (*Lutjanus analis*) **Lane snapper (*L. synagris*)**	Overexploited	I[e]	1 183[b]	1.2
Groupers (Serranidae)	Overexploited	I[c], II	1 686[c]	1.7
Mackerels (*Scomberomorus* spp.)	Moderately exploited	–	3 806[d]	3.9
Mangrove crab (*Ucides cordatus*)	Probably overexploited, decreasing production	II	2 987	3.1
Seabob shrimp (*Xyphopenaeus kroyeri*)	Moderately exploited	II	5 547	5.7

Source: Vasconcellos *et al*., 2007.

[a] Only *L. jocu*.
[b] Only *L. synagris*.
[c] Only *Mycteroperca* spp., *M. bonaci, Epinephelus* spp. and *E. itajara. M. tigris* is considered threatened by extinction in some states of the northeast. *E. itajara, E. marginatus, E. morio, E. niveatus* and *M. bonaci* are considered overexploited or threatened by overexploitation.
[d] Total landings of Scombridae; no specific data.
[e] *Lutjanus analis* is considered threatened by extinction in some states of northeast, southeast and south Brazil.

5.3 Southeast

Table 5 summarizes the available information about the status of small-scale fisheries resources exploited in southeast Brazil. As defined in Vasconcellos *et al.* (2007), the southeast encompasses the southeast and part of east biophysical regions defined in Figure 2. Sardine does not show signs of recovery since the collapse of the stock in the early 1990s. The stock of the broadband anchovy (*Anchoviella lepindentostole*) is under intense fishing pressure and the current level of exploitation is considered unsustainable. The stock of seabob shrimp presents clear signs of overexploitation with a continuous decrease in landings since the late 1980s. The three main demersal fish stocks, the white croaker, royal weakfish and weakfish, are either fully exploited or overexploited. The status of the grey triggerfish is unknown, but the recent increasing trend in landings and catch per unit effort (CPUE) indicates that the stock is probably not yet overfished. The anchovy (*Engraulis anchoita*) is a potential resource in the region, which is not commercially exploited yet. With the exception of the anchovies and the weakfish, all other species are listed in Annex II of IN No. 5/2004, and are considered overexploited or threatened by overexploitation. The species listed above account for 53% of the reported small-scale fisheries landings in 2002, with the grey triggerfish composing 36.1% of this total. The status of the remaining stocks responsible for 47% of small-scale fisheries production is unknown. The analysis of the development stage of 191 small-scale fisheries stocks in the southeast indicated that: 12% are in a development stage, 21% mature, 30% in a senescent stage, 7% recovering and 29% collapsed (Vasconcellos *et al.*, 2007; Figure 4). Thus, approximately 60% of the stocks are probably overfished and unable to support higher yields in the future unless measures to reduce fishing pressure are applied.

5.4 South

Table 6 synthesizes the available information about the status of small-scale fisheries resources exploited in south Brazil. Fishing intensity directed to the stock of white croaker is considered unsustainable. Stock abundance has been continually decreasing and catches are expected to decrease in the near future. The stock of the longspine drum is also intensively exploited. The royal weakfish is overexploited and the current yield is about half of the estimated maximum sustainable yield. The pink shrimp was intensively exploited for many years by industrial and artisanal fisheries and shows signs of overexploitation; despite the high variability in catches, average landings have been decreasing since the 1980s. Similarly, the stock of seabob shrimp shows a decreasing trend in landings due to overexploitation. The status of the mullet stocks is unknown, but the decreasing trend in landings also suggests the species is at biologically unsustainable levels of exploitation. Stocks of long-lived species of importance to small-scale fisheries, such as the marine catfish, the black drum and the guitarfish, have collapsed. The current yield of these species is much lower than the historical peak in landings. The guitarfish is considered threatened by extinction (IN No. 5/2004) while practically all other species are considered overexploited or threatened by overexploitation. The anchovy appears as a potential stock not presently commercially harvested in south Brazil. South Brazil provides a better situation with respect to data availability; however, approximately half of the small-scale fisheries production comes from stocks with unknown status. An assessment of the development stage of 142 small-scale fisheries stocks exploited in the region indicated that: 22% are in a developing stage, 12% mature, 25% in a senescent stage, 8% recovering and 32% collapsed (Vasconcellos *et al.*, 2007). That is, 58% of the stocks harvested by small-scale fisheries are probably being exploited at unsustainable levels, with more than half of them currently in a stage of collapse.

TABLE 5

Exploitation status and relative importance to small-scale fisheries of previously assessed marine stocks in southeast Brazil. The relative importance of a species is expressed in tonnes and as a percentage of the species catches to the total small-scale fisheries landings in the region. Species are classified according to IN No. 5/2004, 'I' being species threatened by extinction and 'II' being species that are overexploited or threatened by overexploitation

Stock	Exploitation status	Classification IN No. 5/2004	Small-scale fisheries landings (2002)	
			Tonnes	%
Sardine (*Sardinella brasiliensis*)	Collapsed	II	507[a]	1.5
Broadband anchovy (*Anchoviella lepindentostole*)	Overexploited	–	1 692[b]	5.1
White croaker (*Micropogonias furnieri*)	Fully exploited or overexploited	II	1 062	3.2
Royal weakfish (*Macrodon ancylodon*)	Fully exploited or overexploited	II	601	1.8
Weakfish (*Cynoscion jamaicensis*)	Fully exploited or overexploited	–	359	1.1
Grey triggerfish (*Balistes capriscus*)	Moderately exploited or fully exploited	II	12 046	36.1
Anchovy (*Engraulis anchoita*)	Unexploited	–	–	–
Seabob shrimp (*Xyphopenaeus kroyeri*)	Overexploited	II	1 405	4.2

Source: Vasconcellos *et al.*, 2007.

[a] Total landings of Clupeidae.

[b] Total landings of Engraulididae.

TABLE 6

Exploitation status and relative importance to small-scale fisheries of previously assessed marine stocks in south Brazil. The relative importance of a species is expressed in tonnes and as a percentage of the species catches to the total small-scale fisheries landings in the region. Species are classified according to IN No. 5/2004, 'I' being species threatened by extinction and 'II' being species that are overexploited or threatened by overexploitation

Stock	Exploitation status	Classification in No. 5/2004	Small-scale fisheries landings (2002)	
			Tonnes	%
White croaker (*Micropogonias furnieri*)	Fully exploited or overexploited	II	3 324	23.6
Longspine drum (*Umbrina canosai*)	Fully exploited or overexploited	II	472	3.4
Royal weakfish (*Macrodon ancylodon*)	Overexploited	II	437	3.1
Mullets (*Mugil* spp.)	Fully exploited	II	441	3.1
Catfish (*Genidens barbus*)	Collapsed	II	300[b]	2.1
Black drum (*Pogonias cromis*)	Collapsed	–	–	–
Guitarfish (*Rhinobatus horkelii*)	Collapsed	I[a]	9	<0.1
Anchovy (*Engraulis anchoita*)	Unexploited	–	–	–
Pink shrimp (*Farfantepenaeus paulensis*)	Overexploited	II	1 266	8.9
Seabob shrimp (*Xyphopenaeus kroyeri*)	Overexploited	II	1 589	11.3

Source: Vasconcellos *et al*., 2007.

[a] Considered threatened by extinction in states of southeast and south Brazil.

[b] Total landings of Ariidae.

According to the analysis of fisheries development stages, the percentage of collapsed stocks increases from north to south, being 3% in the north, 12% in the northeast, 29% in the southeast, and 32% in the south. The available information indicates that small-scale fisheries seem to be less limited by resource scarcity in the north and northeast, where landings have been increasing in recent years (Vasconcellos *et al*., 2007) and a larger proportion of stocks are either in a stage of development, mature, or recovering from previous overfishing. Nonetheless, the real situation of the stocks in the north and northeast is more uncertain, particularly in the northeast, because of the lower quality of fisheries statistics and the overall predominance of small-scale fisheries in these regions. On the other hand, the southeast and south regions have been experiencing a marked decline in landings and present a higher percentage of fisheries in a senescent or collapsed stage. Consequently, there are no prospects of increasing production in these regions except through the application of more restrictive fishing measures (for both artisanal and industrial fisheries that share the resources), or through the development of fisheries directed to resources not yet commercially exploited, such as the anchovy.

5.5 Other considerations: assessment of ecosystem processes, bio-economic analysis and uncertainties

Ecosystem models have been developed for the Abrolhos Bank (northeast), southeastern Brazilian Bight (southeast) and southern Brazil shelf ecosystem. These models are basically used as research tools and at this time have not been used as tools for supporting decision-making in fisheries management. Bio-economic models have been applied to industrial sardine and trawling fisheries in the southeastern Brazilian Bight and probably to other large stocks and fisheries (e.g. shrimps and lobsters). In general terms, it is not a common practice in fisheries management in Brazil to take into account uncertainties or to conduct any form of formal risk assessment when making decisions regarding fisheries regulation. Contents of regulations are the result of a number of influences, economic, political and scientific, but very often, and particularly with the phasing-out of GPEs, these influences are not transparent.

6. FISHERY MANAGEMENT AND PLANNING

6.1 Fisheries management

The management of fisheries in Brazil is mainly the responsibility of the federal government, which is responsible for assessing the status of the stocks and for setting and enforcing regulations on the use of aquatic living resources. Governmental institutional arrangements for regulating fisheries activities have been changing over the years. The role of the federal government in marine fisheries management became particularly influential in the mid-1960s with the creation of SUDEPE, an agency of the Ministry of Agriculture with sole responsibility for the development and management of fisheries. Later in 1989, fisheries became one of the agendas of IBAMA (Brazilian Institute of the Environment), a subsidiary of the Ministry of Environment. The shift of management responsibilities from SUDEPE to IBAMA was not favourable to artisanal fisheries. As IBAMA focuses its attention mostly on environmental issues, environmental legislation and law enforcement, there has been little attention given to the sustained development of artisanal fishing communities. In 1998, the government shifted a large part of the responsibilities of the fisheries sector from IBAMA to the Ministry of Agriculture, constituting the Department of Fisheries and Aquaculture (DPA). The main responsibility of DPA was to promote and execute programmes and projects to support the development of the industrial fisheries (its main objective was to promote the development of the sector and to manage unexploited fisheries resources). On the other hand, IBAMA was responsible for executing the national policies for the environment, and particularly for managing endangered and overexploited species, and encouraging the sharing and decentralization of decisions through co-management and community-based management initiatives. The development policies put forth by these two agencies were not only diverse but opposite and conflictive in their approach to resource management. According to Dias-Neto (1999) such a change represented "one of the most anarchical moments in fisheries management in Brazilian history". Dias-Neto and Marrul-Filho (2003) highlighted the three main institutional conflicts created with the division of responsibilities between IBAMA and DPA. The first one was of a legal nature, related to the division of competencies in fisheries management, and in the organization and maintenance of the national system of control and licensing of fishing activities. The second one was conceptual, since stocks are intrinsically linked in the marine environment through ecological and/or technological interactions, and in multispecific fisheries the same fishing activity often targets stocks with different exploitation levels. Besides, a stock that is considered unexploited at a given moment could eventually be overfished and, hence, the same species could be under the responsibility of two different agencies at different moments in time. As stated by the authors "IBAMA and DPA were trying to divide the indivisible". The third conflict was related to the transfer of responsibility from IBAMA to DPA for the management and control of foreign fleets fishing under joint-venture arrangement, and the consequent changes in the rules and norms.

In 2003, the fisheries agency was created at ministerial level: the National Secretariat for Aquaculture and Fisheries (SEAP). SEAP has a broader authority than the previous agencies. Its priority is the development of the aquaculture sector, particularly of shrimp cultivation for export, freshwater aquaculture and industrial fisheries. In spite of official speeches, the artisanal sector is not a top priority for this new agency.

With the enactment of the Law 11.958 of June 2009, SEAP was transformed into the Ministry of Fisheries and Aquaculture (MPA). The same law put an end to the division of responsibilities in the management of fish stocks stated above making mandatory the joint work of MPA and IBAMA/Ministry of Environment in the design of rules and the governance for sustainable use of resources. This work is to be carried out under the general coordination of MPA. However this new institutional arrangement has not yet contributed to the implementation of policies and measures to revert the critical situation of the main fish stocks.

In terms of property rights, according to the Brazilian Constitution, the fisheries resources in the coastal zone and in the exclusive economic zone (EEZ) are considered common resources under a State property regime (MMA, 2002; Dias-Neto and Marrul-Filho, 2003). The Constitution also asserts that State and society should construct the means to collaborate and participate in the process of decision-making for the sustainable use of environmental resources and in the formulation of norms and rules to that effect (Dias-Neto and Marrul-Filho, 2003), which leaves ample scope for the sharing of responsibilities between government and society in the management of fisheries.

The weakening role of the State in fostering the development of artisanal fisheries during the last two decades, mainly after the termination of SUDEPE, contributed to the general lack of organization of the sector. On the other hand, the institutional void favoured action to social movements and NGOs in developing projects and management initiatives for the sustainable management of fisheries. Many of these initiatives were born out of a crisis that required solutions and from a process of increasing participation of fishers as new protagonists in decision-making. The initiatives were developed around five main processes that are currently legitimized, some of which are promoted by the government (all of them could be placed within a spectrum of co-management):

1. Within the National System of Conservation Units (SNUC), regulated by Law 9985/2000.
   (a) Areas of Permanent Preservation (APA): defined as "large areas with a certain degree of human occupation and characterized by physical, biological, aesthetical or cultural elements of crucial importance for the quality of life and well-being of human populations, having as main goals to protect the biological diversity, to regulate the process of human occupation and to ensure the sustainable use of natural resources". APAs are managed by a council constituted by representatives of governmental bodies, NGOs, community organizations, and the local population through specific management plans. Example in fisheries: 'APA dos Corais', Pernambuco, northeastern Brazil.
   (b) Marine Extractive Reserve (MER): defined as "an area used by traditional extractive activity populations, whose livelihood is based on extractive activities but also complemented by subsistence agriculture and animal production, having as main goals to protect the livelihoods and culture of these populations and to ensure the sustainable use of natural resources". MERs are managed by a deliberative council of organizations and community representatives through a specific management plan. At the time of writing this paper there were 13 MERs implemented or in process of implementation along the Brazilian coast (see section on Coastal Marine Protected Areas).
   (c) Sustainable Development Reserves (SDR): defined as "areas used by traditional populations, whose existence is based on systems of sustainable exploitation of natural resources, developed through generations and adapted to the local ecological conditions, and that have played a key role in nature conservation and in the maintenance of biological diversity". The objectives of the SDRs are "to preserve nature and at the same time to ensure the necessary conditions and means to sustain and improve the living conditions and the use of natural resources by traditional populations, as well as to appreciate and conserve the traditional knowledge-practice systems of environmental management of these populations". SDRs are also managed by a deliberative council of organizations and communities representatives which is responsible for developing and implementing a management plan that defines, *inter alia*, no-take protected areas, buffer zones and corridors, and areas for sustainable use. The first and most well-known example is the Mamiraua SDR in the Amazon region.

2. Other processes
   (a) Fishing accords: regulated by Norm No. 29/03 of IBAMA, this instrument aims to define and legitimize access rules and norms elaborated by the fishing community to regulate the use of fisheries resources in a given region. This type of instrument does not involve the expropriation of land (like the conservation units above) but only some aspects regulating the exploitation of resources. There are examples of fishing accords in fisheries in the Amazon floodplain.
   (b) Fishing forums: this is an instrument that is not regulated by the government but created as a result of communities' initiatives to organize themselves, and to discuss their problems and seek solutions in partnership with governmental and non-governmental organizations. Since it is not regulated, this instrument can be developed in different ways, with various types of arrangements involving individual stakeholders and institutions. Some examples are the Forum of Patos Lagoon in southern Brazil, the Forum Agenda 21 in Ibiraquera, Santa Catarina, and the Forum Terramar in Ceará, among others.

Coastal marine protected areas

The establishment of protected areas – of the various forms noted above – is one of the main government policies concerning coastal ecosystem conservation. The creation of protected areas is under the responsibility of Chico Mendes Institute for Biodiversity Conservation and the State's Secretaries for the Environment. Presently, there are 28 protected areas, covering several coastal and marine ecosystems, such as coastal and oceanic islands/archipelagos, dunes, mangroves, lagoons and salt marsh habitats. The management of protected areas has been, in general, unsuccessful because of the lack of management plans, enforcement, and technical and financial means and research. The main reason, however, lies in the way these protected areas were established – without previous consultation with user groups, particularly traditional populations. According to existing legislation, these groups must be transferred from the places where protected areas are established. It is known, however, that in many areas, traditional communities have used these ecosystems with a low level of environmental impact, and they deserve to be important allies in the conservation process. Another reason for the failure of the protected areas management is that they were created mainly by federal and state agencies. Since local municipalities are excluded from the decision process, they provide very little support to these important conservation areas.

The Marine Extractive Reserve (MER), described earlier, is a relatively recent category of protected areas that reflects a new approach. Through MERs, marine areas are assigned to the exclusive use of a certain number of small-scale fishers. A management plan is agreed upon by a grassroots institution that assembles the fishers in the area of the reserve. Some six MERs have been officially established by the National Council of Traditional Populations (CNPT-IBAMA) and several others are in the process of being created, particularly in the north and northeast regions (Figure 5).

FIGURE 5
Location of marine extractive reserves in Brazil

Source: CNPT/IBAMA.

MERs offer a way to control the highly destructive, still basically unmanaged, development of the coastal zone, while at the same time reinforcing the resource-use rights and territorial claims of local communities to the micro-environments of small-scale fishing. MERs are essentially an effort to modify and extend the concept of 'extractive reserves' – a conservation and sustainable development framework successfully instituted in western Amazonian forest economies (primarily rubber-tapper) to coastal aquatic and marine domains of traditional fishing communities (CNPT[*]; Cunha, 1992; Diegues, 1999, 2001). By taking into account how both environment and society benefit from helping coastal communities secure

* Centro Nacional de Desenvolvimento Sustentado das Populações Tradicionais; http://www.ibama.gov.br/resex/cnpt.htm

continuing access to their traditional sea territories and livelihood resources, the MER is a radical departure from conventional approaches to setting up and managing marine protected areas. In the past, most marine protected areas (MPAs) were established opportunistically or, more recently, almost solely on the basis of biodiversity criteria.

The MER initiative is exceptionally promising; it has the potential to unify and reconcile elements that all too often are seen as incompatible: traditional culture heritage and cultural resource preservation needs, sustainable local fisheries, and conservation of marine biological diversity. Various provisions of national environmental legislation (namely Law No. 9.985 instituting SNUC; Decree IBAMA No. 22 / 2-10-92), civil codes, and international treaties to which Brazil is a signatory (e.g. Articles 8j, 10c, 10d of the Convention on Biological Diversity) endorse the principles on which collectively held marine extractive reserves are based. However, it remains to be seen whether protected areas can be implemented and effectively managed on a scale broad enough to have biologically significant impacts, as well as questions concerning their social feasibility and economic viability.

To successfully institute a network of MER sites, CNPT also faces a major challenge in dealing with federal, state and municipal jurisdictional conflicts, inconsistent policies and legislation across sectors, and the need for greater institutional coordination and cooperation in managing marine and aquatic resources within the environment sector as a whole (Cordell, 2002).

Local experiences in community management

In some areas, fishers and coastal communities are doing their own community-based management. In Ceará, for instance, local communities are suffering from the invasion of their beaches by land speculation, tourism and from overfishing of lobster, mainly by the industrial fleet and by divers coming from a neighbouring state. Assisted by local NGOs and research institutions, they have proposed a Coastal Forum, where the various problems are discussed by representatives of local communities, the tourism sector, the industrial fisheries sector and the federal, state and municipal governments. Within this forum they have proposed a management plan for lobster fishing, also in coordination with the industrial fisheries sector. When IBAMA announced that no funds and boats were available for surveillance of lobster fishing, the fishers equipped one of their boats in order to ensure compliance with the rules that regulate that fishery. The fishers who disobey the regulations are first reprimanded and when they violate the agreed legislation again, they are taken to a court. In some beaches, the selling of a plot of land to tourists must be approved by the community council.

In other coastal communities, such as Pirajubaé in Santa Catarina, Mandira-Cananéia in São Paulo, and Arraial do Cabo in Rio de Janeiro, MERs are being built in order to ensure access to fisheries resources for the members, and limit the access to outsiders, mainly to sport fishermen. In most of these initiatives, there is a strong resource conservation component, and as result they frequently succeed in getting the support of government and non-government environmental organizations. Further south, in the state of Rio Grande do Sul, 21 institutions have created a co-management arrangement (Forum of Patos Lagoon) to seek local solutions to the main conflicts faced by artisanal fishers, such as the impact of industrial fisheries, the control of access to outsiders, and the minimization of conflicts with industrial and port activities on the coast.

Traditional knowledge and traditional fisheries management

The different coastal cultures in Brazil each have a set of knowledge and management practices associated with the sea and fishing activities. In recent years, researchers have emphasised the importance of the knowledge produced and orally transmitted by traditional fishers and the potential role traditional fishing and related environmental knowledge can play for the development and implementation of fisheries management in the modern world (Ruddle, 2000; Cordell, 2000a, 2000b). As Ruddle (2000) points out, traditional knowledge continues to guide and sustain the management of many traditional, community-based fishing systems, as well as governing fishing decisions and fishing strategies.

Various maritime anthropology and ethno-ichthyology studies illustrate the richness and resilience of artisanal fishing knowledge in Brazil. Silva (1997b) records the analytical categories of the fishers of Piratininga (Rio de Janeiro) and Begossi (1997) documents the species nomenclature and criteria for fish classification system used by fishers on Búzios Island (São Paulo). Cunha (1992) has described how fishing knowledge operates among artisanal communities and depicted the know-how of fishers in Paraná and along the Paraíba Coast. Diegues (2000) explains how traditional knowledge functions in the rocky fishing grounds of Rio Grande do Norte and Espírito Santo states. Kalikoski and Vasconcellos (2007) highlight the importance of fishers' ecological knowledge in the definition of management rules in the co-management of artisanal fisheries in the Patos Lagoon, Rio Grande do Sul. Forman (1970), Cordell (1983), Mourão (1971) and Marques, (2001) have made important contributions to the study of traditional knowledge in Brazil.

Knowledge of the marine physical environment is extremely important for safe navigation, for the use of appropriate gear, and for the identification of certain fish species. This traditional knowledge is not evenly distributed among artisanal fishers but tends to be concentrated in the hands of boat captains and skippers and it is transmitted through different ways (Marques, 2001).

The numerous advantageous uses of artisanal sea-tenure systems do not imply that they present a panacea for overcoming all fisheries management problems. Fishing may become highly competitive and confrontational in the work setting. It seems to have an inherent tendency to generate conflict. The act of appropriating and controlling access to local sea space and resources by no means renders work environments free of conflicts.

Traditional sea tenure and fisheries management are only now receiving significant attention from scholars, scientists and fisheries managers in Brazil. One reason for this lack of interest is that vast areas of the country, such as the Amazon and the sea, were treated by powerful industrial and urban elites as 'empty spaces'. Traditional populations of the Amazon, particularly the Indians and the riverside populations, were 'invisible' until recently. This 'invisibility' served the ideological purpose of the elites wishing to exploit the Amazon, as only 'uncivilized people' were living there. The same biased view was applied to artisanal fishers and their communities. When the Indians and the artisanal fishers started to react to outsider intrusion, often by force, they became 'visible', as did their rich culture and knowledge of ecosystems and management techniques.

In many cases, traditional sea tenure and traditional management strategies have been negatively affected and even abandoned as a result of increasing disruption of fishing communities and impacts of various activities.

First, artisanal fisheries face today strong competition from industrial fisheries and from the destructive exploitation of the coast. Local fisheries are being flooded with large industrial boats using inappropriate gear. Social, spatial and technological competition is ongoing between locals and outsiders. Since 1967, industrial fishing has been established using tax incentives and suspension of import fees on fishery technology. These incentives have benefited mainly industrial groups. The result of this 'fishery modernization' has been widespread destruction of fish habitats, overfishing and marginalization of artisanal fishers. At the same time, uncontrolled use of land and sea resources reached a critical intensity. Large chemical and petrochemical plants, nuclear power stations, dredging of harbours, oil exploitation, coastal mining and tourism have threatened extensive areas along the Brazilian coast. Urban expansion and tourism have targeted biologically rich habitats such as mangroves, sand barriers and islands. One of the most affected ecosystems are the mangroves, from which an estimated two thirds of the fish caught in Brazil feed or breed during their life cycles.

In addition to these impacts on artisanal fisheries, there has been a dramatic increase in the demand for fish in the growing urban centres. Some valuable fish species, such as shrimp and lobsters, are more intensively exploited. When profitability decreased, most industrial fishing crews started exploiting fish resources with no respect for existing traditional regulations. In some cases, artisanal fishers started using the same forbidden fishing gear in order to survive.

Third, traditional sea tenure is threatened as well by erroneous environmental and aquaculture plans that should benefit artisanal fishers in principle. Government institutions are encouraging aquaculture; however, traditional extensive aquaculture systems already used by artisanal fishers are very often not considered. As a result, in some cases capital owners and outsiders are the only ones who benefit from these initiatives. The government also promoted the cultivation of species already managed by artisanal fishers. The adoption of these techniques does not necessarily lead to an improvement in the well-being of local communities. For instance, the government planned to introduce mullet cultivation through floating nets (*cercos* *flutuantes*) instead of supporting the existing technique of the traditional *cerco* made of bamboo poles. In fact, floating nets are more capital intensive, less labour intensive and would disrupt the existing social organization. In the end, the new technique was eventually rejected by artisanal fishers.

Environmentally protected areas in regions traditionally used by artisanal fishers are often perceived by them as threats. The well-conserved areas of the Atlantic Forest and associated coastal system have been used by traditional communities for centuries. Due to their isolation, as well as to the existing social structure of these communities, those areas have remained well conserved. However, due to existing legislation, traditional populations cannot live in the regions that became protected and have to be transferred to other areas. Highly conflictive situations are being created in almost all protected areas and local communities resist eviction from their traditional land. This is the case in the Ecological Station of Juréia, the Biological Reserve of Guaraqueçaba, the National Park of Lagoa do Peixe, and other areas. When eviction of traditional people occurs, environmentally protected areas are more easily invaded by commercial fishing and logging, and the overall situation becomes even worse.

Instead of using traditional knowledge, some environmental agencies are in fact destroying a suitable basis for environmental and social planning. The present situation is gradually changing in favour of traditional communities, particularly due to the fierce resistance of the traditional people of the Amazon. Rubber-tappers and Indians succeeded in convincing the federal government to create extractive reserves through which the traditional use of forest products is ensured. Other traditional populations of the coastal areas are now requesting the same treatment granted to the rubber-tappers. Now the concept of extractive reserve is by law applicable to other ecosystems where local populations live out of extractive activities, such as oyster and mussel extraction (see section on Coastal Marine Protected Areas).

6.2 Coastal management

The institution with the highest authority for coastal zone management in Brazil is the National Programme for Coastal Management (GERCO), which is administered by the Ministry of the Environment. The conditions set forth in the programme have to be implemented by each coastal state and municipality. The programme defines the legal aspects for the management of the Brazilian coastal zone, and establishes the basis for the development of regional and local policies, programmes and management plans. Although fisheries are important coastal resources, GERCO has no mandate over them.

Social movements and institutional arrangements for coastal management

Since the middle of the 1970s, public concern for coastal conservation has gathered momentum in Brazil. Some of the factors that explain this rising concern are:

(a) The growing awareness of Brazilian society about the ecological importance of the coastal area and the increasing degradation of coastal ecosystems. The earlier positions of the Brazilian Government, which led to the country's moniker: 'Brazil welcomes polluting industries', has changed since the Stockholm Conference in 1972. This is due to pressure from non-governmental organizations, international institutions and mainly because of the growing awareness of the population concerning environmental issues. In the 1970s, despite the presence of an authoritarian military regime favouring industrialization at any social or ecological cost, many environmental groups were created. In the final years of the military regime (until 1984), national campaigns were organized by environmental movements on issues such as the destruction of the Amazon and Atlantic Forests, the Pantanal wetlands, pollution in urban centres (such as São Paulo and Rio de Janeiro), and the establishment of nuclear plants along the coast. Hundreds of small groups blossomed to oppose whale hunting, tree cutting in urban areas and destruction of national parks. Although many of these groups were formed by the middle class and were urban biased, they were instrumental in raising the level of environmental awareness in the country. They succeeded in electing a few representatives in the state legislatures of the more urbanized states such as São Paulo, Rio de Janeiro and Rio Grande do Sul. In 1986, some candidates with strong environmental concern were elected to the National Congress, which developed the 1988 Constitution. For the first time specific considerations of the conservation of coastal ecosystems were included in the Constitution.

The "Cadastro Nacional de Instituições Ambientalistas – Ecolista", a roster published by the Worldwide Fund for Nature/Mater Natura, indicated that there were 1 400 Environmental NGOs registered in 2000, from which 296 were created in 1991–1992. Around 60 of them (14.7%) deal exclusively with coastal/marine ecosystems. If the 504 environmental NGOs dealing with the Atlantic Forest are added, one could say that roughly 61% of Brazilian environmental NGOs are, in one way or another, concerned with the conservation of the various coastal ecosystems. A large proportion of the environmental NGOs are located in the northeast (30%). Within the environmental NGOs dealing exclusively with coastal/marine ecosystems, there are some which address species or ecosystems conservation, such as SOS Mata Atlântica, Tamar (sea turtles), Peixe-Boi (manatee), Baleia Jubarte (humpback whales), and the Clube de Observadores de Aves (seabirds in Rio Grande do Norte). There are also socially oriented environmental NGOs, which deal specifically with traditional populations and their environments, such as Terramar, Sociedade Civil Mamirauá, Sociedade Civil São Sebastião Tem Alma, and Fundação Josué de Castro.

At the societal level, socially oriented environmentalism gained importance *vis-a-vis* the traditional environmentalism which was focused mainly on protection of species. This new environmentalism was able to establish alliances with other social movements, political parties and local movements.

(b) The increasing number of public institutions dealing with environment conservation. By the end of the military regime, there was space for public discussion and movements concerning environmental issues. Secretariats for Environment were established in many Brazilian states. At the federal level, the National Secretariat for the Environment (SEMA) created in 1973 and the Ministry of the Environment (created in 1992) have been designated as core agencies for environmental protection.

(c) The importance of the environment was also highlighted by a growing number of universities and government research centres dealing with coastal zones and marine ecosystems. Well-known oceanographic institutions, such as the Oceanographic Institute at the University of São Paulo, the Oceanography Department at the Federal University of Rio Grande in Rio Grande do Sul, Labomar in Ceará, Labohidro in Maranhão, and the Schools of Fisheries Engineering in Pernambuco and Ceará have contributed to increased knowledge of coastal/marine ecosystems in the northeast. Some other research institutions linked to universities, such as Nupaub-Research Center on Human Populations and Wetlands at the University of São Paulo, have also contributed to increasing the knowledge about the relationship between local communities and coastal ecosystems.

The role of the State, of non-governmental organizations, and local institutions in coastal management

Coastal conservation and management became an important issue in Brazil in the late 1970s and in the 1980s when the impacts of industrialization and urbanization resulted in a rapid degradation of the coastal environment.

Artisanal fishers started a movement in the northeast against the pollution of estuaries and rivers caused by the acidic waste of the alcohol-producing distilleries. It was the starting point for a stronger organization of small-scale fishers, supported by the Catholic Church and some non-governmental organizations. This social process indicated the emergence of new identities and social awareness among coastal communities and artisanal fishing communities. These identity-building processes often occurred during conflicts that saw these communities opposed to urban expansion that often resulted in the eviction of artisanal fishers from their beaches and adjacent coastal waters. In tropical countries, where warm, sandy, sunny beaches became valuable assets to national and international tourism, artisanal fishers and their activities are seen as obstacles to a free development of market forces. Artisanal fishers and local dwellers are resettled into the corner of their own beaches, which are transformed into tourist resorts. In some other cases, the establishment of large industrialization projects resulted in high levels of marine pollution, destruction of valuable habitats, such as mangroves, and ultimately led to the social disruption of artisanal fishing communities. In many cases, the social reaction against these processes led to the establishment of new and politically orientated social movements, such as the National Movement of Fishers (MONAPE).

In the late 1970s, government institutions were created at the federal, state and municipal level to deal with environmental conservation. The first federal institution was SEMA, created in 1973 and incorporated by the Ministry of the Environment, and Legal Amazon, created in 1992. In 1989, IBAMA was created and incorporated into the Ministry of Environment. In 1981, the first comprehensive national law on the environment was promulgated. The National Council on the Environment (CONAMA), which is responsible for the main policies concerning the environment, was created with the participation of governmental agencies and NGOs. In 1986, CONAMA approved the first legislation requiring environmental impact analysis for large projects. In 1988, the Brazilian Constitution declared the Atlantic Forest and its coastal zone as one of five crucial areas for management and sustainable development. Brazilian governmental and non-governmental organizations have actively participated in the United Nations Conference on Environment and Development–1992 (UNCED) during the various discussions about coastal/marine environmental issues that produced Chapter 17 of Agenda 21. Also, environmental NGOs such as the National Forum and MONAPE have participated in drawing up a Fisheries Treaty, signed by non-governmental organizations during UNCED 1992. Brazil signed the United Nations Convention on the Law of the Sea (UNCLOS) in November 1982 and ratified it in December 1988. In January 1993, the Brazilian Congress decreed Law 8.617, on which Brazil defines the 12-mile territorial sea and the 200-mile economic exclusive zone (EEZ). Among other important international guidelines, agreements and treaties ratified by Brazil that deal with coastal/marine conservation and fisheries are the Convention on Biological Diversity, the 1995 United Nations Fish Stocks Agreement and the FAO Code of Conduct for Responsible Fisheries.

7. RESEARCH AND EDUCATION

Information on artisanal fisheries is generally scarce, and the fisheries production statistics present many limitations. The institution with legal responsibility to collect and disseminate fisheries statistics is IBGE (Brazilian Institute of Geography and Statistics), but in 1990 IBGE's system of collection was interrupted. Since 1995, IBAMA started compiling and disseminating the data collected by different institutions in different states. Some projects include: ESTATPESCA developed by IBAMA's Center of Fisheries Research and Management for the Northeast Coast (CEPENE) for the northeastern states and by IBAMA's Center of Fisheries Research and Management for the North Coast (CEPENOR) for Pará; the system of control of landings developed by São Paulo's Instituto de Pesca, Univali, IBAMA's Center of Fisheries Research and Management for the South Coast (CEPSUL); and IBAMA's Center of Fisheries Research and Management of Estuarine and Lagoon Fisheries (CEPERG) in southeastern and southern Brazil. However, the lack of a standardization of methodologies used in the collection of statistics is a factor that precludes the comparative assessment of fisheries production among states. One particular problem with the landings statistics in some states is the lack of a more precise classification of fisheries production by artisanal fishery types, with a tendency to aggregate all artisanal fisheries production in a single category of boats with less than 20 tonnes of gross tonnage. One exception is the system of data collection of the project ESTATPESCA, which provides more detailed information about artisanal fishery production in the northeastern states. Another important limitation of landings statistics is the large volume of catches that are not precisely identified. Landed fish is often classified according to the commercial or common names, which do not allow the precise identification of the species. This problem occurs due to a combination of factors: the difficulty in monitoring of fishing in areas of high biodiversity and the preferential allocation of human and financial resources to the monitoring of large stocks targeted by industrial fisheries, among other causes. Illegal, unregulated and unreported fishing is also recognized as a problem that erodes the quality of fisheries catch statistics and leads to an underestimation of fisheries production (Isaac *et al*., 2006b; Peres *et al*., in press; Vasconcellos *et al*., in press).

Information on biological and ecological aspects of coastal fisheries resources is not routinely collected by official agencies. Instead, it is produced by research projects conducted by universities and research institutes. The same also applies to socio-economic data. Among the research institutions that routinely carry out studies about fisheries in coastal areas are: the Oceanographic Institute of the University of São Paulo, Oceanography Department of the Federal University of Rio Grande, Univali in Santa Catarina, the Federal Universities of Paraná, Espírito Santo, Bahia, Pernambuco, Rio Grande do Norte and Pará, the Fisheries Institute of São Paulo, Labomar in Ceará, Labohidro in Maranhão, and the Schools of Fisheries Engineering in Pernambuco and Ceará. Some other research institutions linked to universities, such as NUPAUB-Research Center on Human Populations and Wetlands of the University of São Paulo, and Nepan-Research Center on Environmental Research of the University of Campinas, have also cooperated in increasing the knowledge about the relationships between local communities and coastal ecosystems. There are also some research network initiatives in the country that aim to improve the knowledge of coastal processes, fisheries and management through collaboration among research institutes. It is worth mentioning the programme Renewable Resources of the EEZ (REVIZEE) conducted by a consortium of universities and research agencies to improve knowledge about the oceanography and ecology of fisheries resources in the Brazilian EEZ. The Coastal Resources of the Millennium Institute (a consortium of universities funded by the Ministry of Science and Technology) is collecting ecological and socio-economic data on coastal fisheries of seven states.

In order to coordinate the various governmental research projects on marine resources, the Interministerial Commission for Marine Resources (CIRM) was created in 1974. CIRM's main responsibilities are the promotion of research and the rational management of marine resources. The Commission was formed by representatives of eight ministries (Navy, Foreign Relations, Agriculture, Transport, Education, Industry and Commerce, Mines and Energy, and Interior) and the Planning Office and the National Council for Scientific and Technological Development. In 1979, a Secretariat was established (SECIRM) and was chaired by the Navy. Since 1988, CIRM has implemented various research projects concerning the marine environment, including the Project Leplac, which aimed to collect geophysical data to define the limits of the Brazilian EEZ and the REVIZEE programme, an effort to assess the potential of marine resources according to the framework established by the United Nations Convention on the Law of the Sea (UNCLOS). In this process, CIRM has established research agreements with the main oceanographic institutes to collect and evaluate the information.

During most of the 1990s, IBAMA maintained technical working groups on the main industrial fishery resources (lobsters, shrimps, demersal fish, sardine, snappers, tunas and catfish). In general, there is more information for these resources and fisheries than for any other coastal fishery in the country.

8. ISSUES AND CHALLENGES

Historically, artisanal fishers in Brazil have been labelled as inefficient and unproductive and, consequently, considered as objects of social welfare programmes. The available information about the sector demystifies this approach by showing, for instance, that the artisanal fishery is as productive as the industrial fishery in terms of total landings' volume. Therefore, the artisanal fishery deserves at least the same level of attention for development policies as received by the industrial fishery sector. In fact, it has been argued that the artisanal fishery is more economically viable and more socially desirable, especially for the exploitation of coastal ecosystems. This is justified by a number of factors, such as the nature of the fishery resources available in coastal tropical areas (multispecies and small-stock sizes), the spatial dispersion of fishing communities, the ample utilization of materials locally available, the direct supply of fish to local/regional markets, and the reduced use of fossil fuels.

With a few exceptions, the development of fisheries in Brazil has followed an unsustainable path for resource exploitation in the different coastal regions. The causes behind the failures in maintaining resources at biologically sustainable levels must be properly identified to support the development of policies for the sector. In this sense, particular attention must be given to the analysis of the interactions and interferences among the artisanal and industrial sectors. It is not by coincidence that the situation of stocks is more critical in the areas where resources are shared between industrial and artisanal fisheries. For instance, in the south and southeast, the industrial trawling fishery has been pointed out as one of the main culprits of the overfishing of traditional demersal stocks, because of intense direct harvest of the stocks, and also due to the bycatch and discards of juveniles. Similarly, the rapid development of the industrial purse seine fishery for sardine in the southeast was one of the main reasons behind the collapse of the stock. Nonetheless, there should also be analysis of the artisanal fishery factors that contributed to each of the fishery collapses.

As artisanal fisheries have been decreasing in importance in the south and southeast and maintaining their predominance in the north and northeast, it is clear that the strategies for development, management and assessment of fisheries must be different among these regions. Although conservation policies are important for all regions, they are particularly required in the south-southeast, due to the depletion of traditional resources and the decrease in resource availability to artisanal fishers. Strategies of resource conservation and rebuilding (decrease in effort, protected areas, etc.) must be balanced by incentives and strategies to increase fishery profits through the exploitation of alternative resources, the development of alternative economic livelihoods and other strategies. In fact, the participation of fishers in small-scale, family-based aquaculture has been increasing in recent years in these regions. The feasibility and potential of aquaculture as an alternative to a fishing livelihood is case-specific and needs to be further explored.

In the north and northeast, where the abundance of resources is not yet a limiting factor for the maintenance of the artisanal fishery, management actions must also deal with the recovery of stocks that are in trouble, but should aim particularly to: establish institutional arrangements and strategies to prevent the increase in fishing capacity to a level beyond the productive capacity of the coastal resources and ecosystems; minimize and mitigate impacts of other coastal activities on fisheries; and provide secure access rights to small-scale fishers that have been threatened or displaced by unplanned coastal development.

There is not only a great diversity of habitats and species used by artisanal coastal fisheries, but also a variety of cultures of which fishers are part, with distinct livelihoods and knowledge of resources, the environment, and traditional forms of resource use accumulated through generations along the Brazilian coast. This paper is an attempt to illustrate this diversity and hence to serve as a reference on the bio-physical, socio-economic and cultural context in which fishers are placed in each region.

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5. Coastal fisheries of Colombia

Mario Rueda[*], Jacobo Blanco, Juan Carlos Narváez, Efraín Viloria and Claudia Stella Beltrán

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1. INTRODUCTION

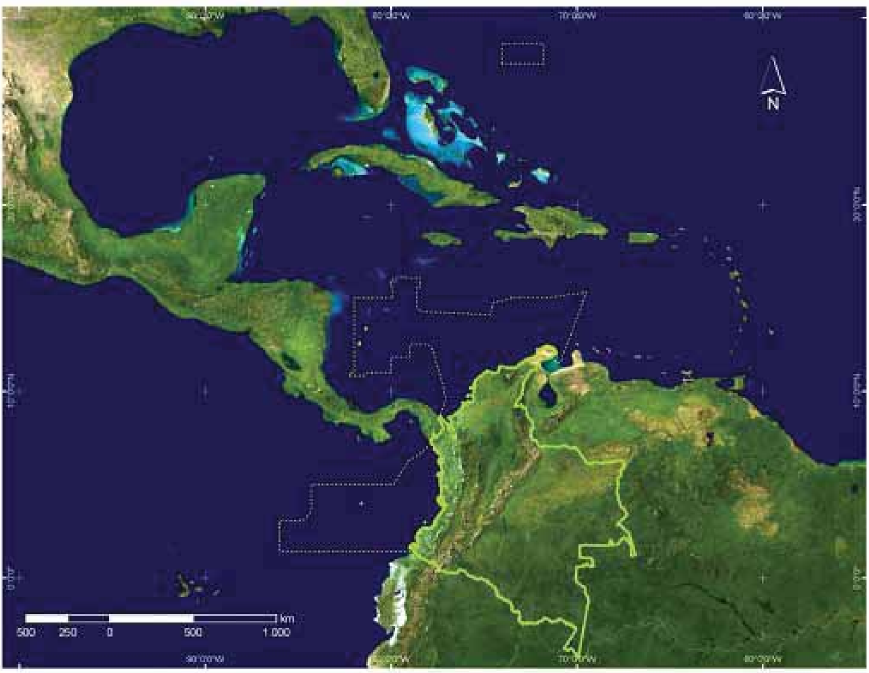
Fisheries in Colombia are mainly marine based (80%) including different species of fishes, molluscs and crustaceans. In 2005, the fisheries and aquaculture sectors contributed 0.54% to the national gross domestic product (GDP) and 3.86% to the agricultural sector (FAO, 2005). The value of fishing production during the last seven years has been around US$143 million per year. Most fishing production is for human consumption (85%), with 14.5% allocated to process concentrated foods and 0.5% based on ornamental fish and seed for aquaculture. Direct employment in the industrial fisheries, artisanal fisheries and aquaculture provided 88 000 jobs (FAO, 2003).

Colombia borders Panama and the Caribbean Sea to the north, the Pacific Ocean to the west, Venezuela (Bolivarian Republic of) and Brazil to the east, and Ecuador and Peru to the south (Figure 1). The country has various

* *Contact information*: Instituto de Investigaciones Marinas y Costeras, INVEMAR, Colombia. E-mail: mrueda@invemar.org.co

micro-climates according to altitude, and it is divided into 32 departments. It has 1 141 748 km² of surface area, of which 880 376 km² are exclusive economic zone with 2 308 km of coastline (1 760 km in the Caribbean and 1 480 in the Pacific). Colombia is the only country in South America that has access to the Pacific and Atlantic oceans, with a marine area of 988 000 km². In addition, the country accounts for 238 000 hectares of permanent waterbodies, such as lagoons (FAO, 2005).

FIGURE 1
Colombia's geographical limits and the exclusive economic zone

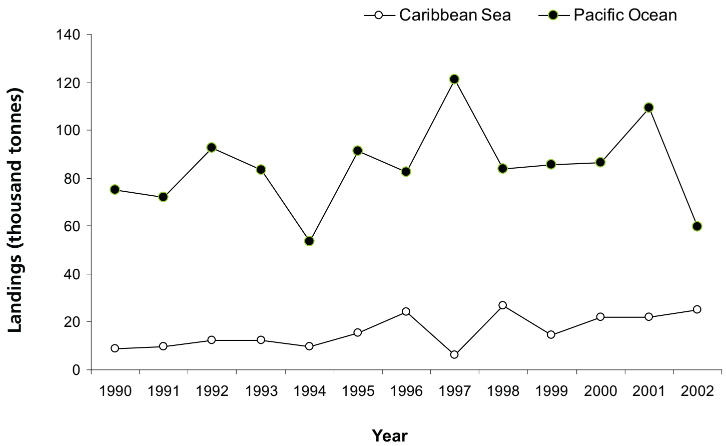


2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Marine fisheries in the Pacific and Caribbean are industrial and artisanal (or small scale). By 2005, marine fisheries production was reported at 160 000 tonnes, with industrial fisheries contributing the most (55%), and the rest coming from artisanal fisheries (25%) and aquaculture (20%) (FAO, 2005). Fisheries in the Pacific Ocean make the main contribution to fisheries production (Figure 2), while in the Caribbean region production is characterized by a high number of species but small quantities of each. However, the main resources are of high commercial value (tuna, shrimp, lobster, snail, snappers, groupers and small pelagics).

FIGURE 2

Colombian industrial and artisanal marine landings for the period 1990–2002



Source: INCODER, 2003.

Marine fisheries are mainly conducted by industrial fleets which represent 89% of the total fleet, while artisanal fleets represent 11%. The artisanal fleets are comprised of small boats with limited range (3–5 miles from shore), employed by groups of fishers of low socio-economic status distributed along the coast, targeting mainly shrimp in shallow waters, finfish and small pelagics (FAO, 2005).

Shrimp targeted in shallow waters support an important fishery, although overexploitation has been reported since the 1980s. In the Pacific, the shrimp fishery in deep waters is still considered sustainable. The small-scale fishing of shrimp represents 70% of captures in the Pacific and 5% in the Caribbean (INCODER, 2003).

Small pelagics like herrings (*Ophistonema* sp.) are used to produce flour and fish oil and are also considered sustainable. Finfish fisheries (named locally as *Pesca blanca*) include demersal species (snappers and groupers), crevalle jacks and sharks. The latter already show signs of overexploitation.

The marine small-scale fisheries are operated by fishers from small coastal communities of the Pacific and Caribbean. These fleets are composed of fibreglass and wooden boats with outboard engines (15, 40 and 75 hp) or manual propulsion, depending on the economic capacity and target species of the fishers. The most important small-scale marine fisheries are: shrimp of shallow waters (*Penaeus* sp.), black skipjack (*Euthynnus lineatus*), snappers (*Lutjanus* sp.), weakfish (*Cynoscion* sp.), dolphinfish (*Coryphaena* sp.), Pacific sierra (*Scomberomorus* sp.), barracuda (*Sphyraena* sp.), shark (*Carcharinus* sp.), shells (*Anadara* sp.), clam (*Chione* sp.), lobster (*Panulirus* sp.) and snail (*Strombus* sp.).

The majority of small-scale marine fishing units are composed of two or three fishers who undertake daily trips from the shore up to five nautical miles.

However, those who own boats with a greater range and who have incorporated navigation systems like GPS and sonar are able to go fishing for one or two weeks with a crew of 10 or 15 people. This advanced fishing provides high landings of high value that are frequently sold to the processing plants.

Nets are the most frequent gears used for shrimp and finfish. They include *chinchorros* (beachnets), *trasmallos* (gillnets) and *atarrayas* (cast nets), as well as longlines and shortlines (these last two exclusively used for finfish). Traps and some nets are used to catch lobster (free skin diving is practiced as well), snail, and some other fishes and crustaceans.

The inland artisanal fishing is developed in the rivers of the Magdalena, Orinoco and Amazon basins. Fishers alternate their activity with agriculture, small trade and construction. Household economies are typically diversified because formal possibilities of employment are scarce.

Until the mid-1980s inland fisheries were important sources of revenues, food security and local development for rural communities. Since then, the collapse of the main fisheries due to water contamination and deforestation became evident, mainly throughout the Magdalena River, located in the Andean region of the country. Freshwater fisheries continue to fall in spite of the management measures implemented 20 years ago. This is due to weaknesses in the fisheries institutional framework that prevent the advancement of inspections and surveillance duties.

As with marine small-scale fisheries, the system of prices between fishers and consumers is affected by the intermediary chain. This is primarily due to the fact that marketing and service centres are away from fisheries locations and communities, particularly in the Orinoquía and Amazonia regions.

Sport fishing is still not a primary contributor to the economy and fisheries systems. Thereby, there are no statistical records or management plans for sport fishing. In Colombia, the annual tournaments of international marine sport fishing take place in the ports of Bahía Solano (in the Pacific coast) and Cartagena (in the Caribbean). Regarding inland waters, two competitions in the Meta River (basin of the Orinoco) and five in the Magdalena and Cauca rivers (basins of the Magdalena) are organized annually.

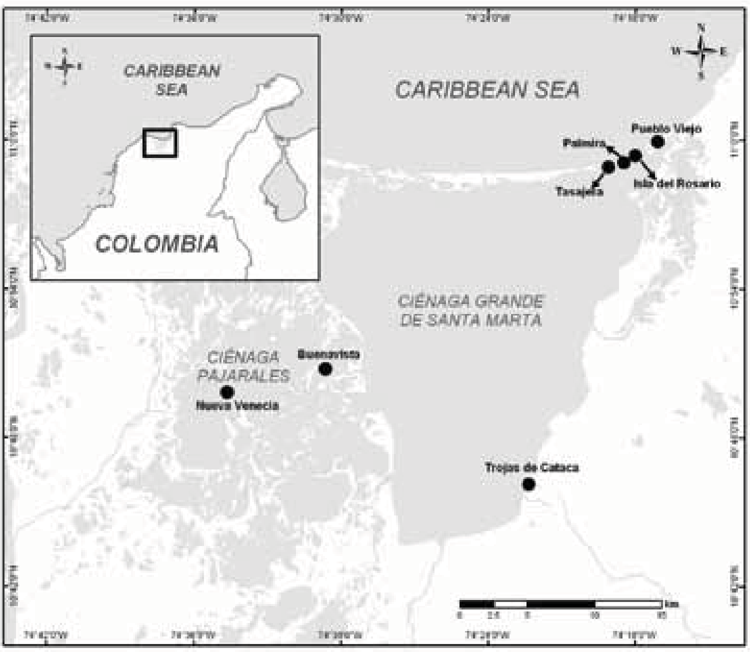
During the last 40 years Colombia has had four fishing authorities, all of them with national jurisdiction, as follows: Instituto Nacional de los Recursos Naturales Renovables (INDERENA) from 1968 to 1990, National Institute of Fishing and Aquaculture (INPA) from 1992 to 2003, Colombian Institute of Rural Development (INCODER) from 2003 to 2007 and Colombian Institute of Agriculture (ICA) since 2008 until present. All of these have carried out detailed and general analyses of diverse locations and communities of marine and inland small-scale fishing, as well as several international cooperation programmes executed during more than 30 years by organizations such as the Food and Agriculture Organization of the United Nations (FAO), European Union (EU), Japan International Cooperation Agency (JICA), World Wildlife Fund (WWF) and International Development Research Centre (IDRC), among others. The last changes in the fishing authority (from INPA and INCODER to ICA) emphasize one of the biggest problems in the Colombian fishing industry: the changing institutional framework. As a result of these changes, there has been a 70% decline in technical positions over time, which has constrained the fishery and aquaculture research necessary to support valid management strategies. Currently, the functions of research and management of fisheries are carried out by the Submanager of Fishing and Aquaculture under ICA.

Biological, technical, socio-economic and political aspects are common across the various marine and inland small-scale fisheries of Colombia. In this document, such aspects are illustrated through a particular case study of a fishing community from Ciénaga Grande de Santa Marta (CGSM), a brackish waterbody of high importance in northern Colombia.

2.1 Ciénaga Grande de Santa Marta (CGSM)

The CGSM is an estuarine lagoon located on the Caribbean coast of Colombia. The 'Pajarales complex' (mangrove swamps) forms one of the largest coastal lagoon systems of the country (Figure 3). This ecosystem constitutes an important habitat for a wide diversity of fish fauna relevant to small-scale fishing, where there were around 3 500 artisanal fishers, 2 300 canoes and a catch of 7 700 tonnes of fish resources in 2000, contributing 35% to the small-scale catches of the Caribbean for that year (INVEMAR, 2003a).

FIGURE 3
Ciénaga Grande de Santa Marta and surrounding area



The small-scale fleets of the CGSM's communities consist of boats with outboard engines, and sail and row canoes ranging from 3 to 9 m in length, using six types of fishing gears. In the past, the aborigines used spears and bows and arrows to fish. In modern times, cast nets and handlines were the first gears used. Other more advanced methods have been used since the 1960s with a clear increase in their fishing power (Restrepo, 1968).

The catch is characterized by a high number of species, particularly gerreids, ariids and mugilids, but also including clupeoids, sciaenids, carangids, centropomids, oysters, crabs and snails (Santos-Martínez *et al.*, 1998). Because of its ecological and social value (as a source of both food and income for rural communities in this area), the area was declared a Natural Park and Fauna and Flora Sanctuary in 1969, a Ramsar Wetland in 1998, and a World Biosphere Reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2000.

During the last five decades, the ecosystem has been progressively deteriorated due to anthropogenic activities (e.g. road and channel constructions, pollution and increased fishing pressure). This situation, combined with the poor implementation of management and conservation schemes, led to a marked decrease in availability of fishing resources. During the 1990s, the project Proyecto de Rehabilitación de la Ciénaga Grande de Santa Marta (PRO-CIÉNAGA) aimed at rehabilitating the system, giving special emphasis to water quality, mangroves and fishery resources monitoring (Botero and Salzwedel, 1999). However, recent research results show the high dependence of the system's hydrology on global climate variations (INVEMAR, 2002, 2003a), with an ultimate influence on fisheries composition, distribution and abundance.

2.2 Technical aspects of the fishing activity in CGSM

The CGSM region is a multispecies and multigear fishery, where gear dimensions depend on the targeted resources, as indicated in Table 1.

The resources targeted in CGSM include: parassi mullet (*Mugil incilis*); nile tilapia (*Oreochromis niloticus*); striped mojarra (*Eugerres plumieri*); chivo mapalé (*Cathorops* sp.); tarpon (*Tarpon atlanticus*); sea catfish (*Ariopsis* sp.); ladyfish (*Elops saurus*); striped mullet (*M. liza*); whitemouth croaker (*Micropogonias furnieri*); yellowfin mojarra (*Caquetaia kraussi*); moncholo (*Hoplias malabaricus*); ground croaker (*Bairdiella rhonchus*); bocachico (*Prochilodus magdalenae*); snook (*Centropomus undecimalis, C. ensiferus*); blue and red crab (*Callinectes sapidus; C. bocourti*); shrimp (*Lithopenaeus schmitti, Farfantepenaeus notialis, F. subtilis, Xiphopenaeus kroyeri*); oyster (*Crassostrea rhizophorae*); and snail (*Melongena melongena*). These two last shellfish species, which were representative until 1996, are now nearly extinct and are absent from current commercial catches.

TABLE 1
Fleet characteristics and fishing gears employed by fisheries in CGSM

Species	Gear		Size of canoes (m)	Number of canoes	Average crew size
	Type	Mode size; range (m)			
Mullet	Cast nets	2.5; 2–3[a]	3–7	287	2
	Gillnets	283; 40–1 600[b]	4–9	148	2
	Encircling gillnets	270; 250–320[b]	4–9	65	3
Snook	Cast nets	2.5; 2–3[a]	3–7	287	2
	Gillnets	283; 40–1 600[b]	4–9	148	2
Tarpon	Cast nets	2.5; 2–3[a]	3–7	287	2
	Gillnets	283; 40–1 600[b]	4–9	148	2
Sea catfish	Longline	12; 8–12[c]	3–7	51	2
	Cast nets	2.5; 2–3[a]	3–7	287	2
Ladyfish	Encircling gillnets	270; 250–320[b]	4–9	65	3
	Gillnets	283; 40–1 600[b]	4–9	148	2
	Cast nets	2.5; 2–3[a]	3–7	287	2
Tilapia	Trawlnet	180; 135–220[b]	4–9	11	4
	Cast nets	2.5; 2–3[a]	3–7	287	2
	Gillnets	283; 40–1 600[b]	4–9	148	2
Mojarra spp.	Encircling gillnets	270; 250–320[b]	4–9	65	3
	Gillnets	283; 40–1 600[b]	4–9	148	2
	Cast nets	2.5; 2–3[a]	3–7	287	2
Bocachico	Gillnets	283; 40–1 600[b]	4–9	148	2
	Cast nets	2.5; 2–3[a]	3–7	251	2
Striped catfish	Gillnets	283; 40–1 600[b]	4–9	148	2
	Cast nets	2. ; 2–3[a]	3–7	287	2
Crabs	Pots	0.1 x 0.08 x 0.03[d]	3–7	109	2
Shrimps	Fyke net	1.5; 1–2[b]	3–7	515	1

[a]Size in depth; [b] size in length; [c] hook number; [d] size in length x width x depth.
Source: Santos-Martínez *et al.*, 1998; INVEMAR, 2003a.

Traditional fisheries in CGSM include around 70 species, although all of them are not target resources (Table 1). The most important are: Mojarra blanca (*Diapterus rhombeus*, *Gerres cynereus, Eucinostomus* sp.); striped catfish (*Pseudoplatystoma fasciatum*); arenca (*Triportheus magdalenae*); whisker catfish (*Pimelodus clarias, Rhamdia sebae*); boconas (*Anchovia clupeoides, Cetengraulis edentulus*); and freshwater prawn (*Macrobrachium* sp.). These non-target species contribute 2 to 8% to the total catch and they are not discarded, but sold or kept for fishers' consumption. Nevertheless, those proportions vary as the fishing resource' assemblages change. In addition, environmental perturbations linked to global climate variability have also affected resource abundance in recent years (INVEMAR, 2002, 2004). According to information from 2003

(INVEMAR, 2004), the quantity of active fishers in the area is: 502 fishers with cast nets; 270 fishers using gillnets; 144 fishers with encircling gillnets; 33 fishers with trawlnets; 6 fishers with handlines; 90 fishers with longlines; 428 fishers with pots; and 372 fishers with fyke nets. Figure 4 depicts some examples.

FIGURE 4
Gears for small-scale fisheries in CGSM

Fishing is carried out the whole year. However, certain species like mullets are caught in higher abundance at the end of the year when they start their spawning migrations due to the dynamics of the fishery and the high demands of the market. Besides, freshwater fishes like bocachico, striped catfish and Nile tilapia among others, are caught during the rainy months when movements from the river to the lagoon system take place near the end of the year. Most of the fish products are sold fresh (80%), with the remaining being processed (10%) or consumed by rural communities (10%), usually as minced, dried and salted fishing products.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

3.1 Social and economic aspects of the fishing activity in CGSM

Fishing is carried out by men from the local communities of the CGSM system, with approximately 70% of the total male population involved in the activity; however, when there is abundance in catches some fishers come temporarily from other areas, mainly from towns located about 50 km away from the CGSM.

Men are in charge of fishing, sales of fishing products, maintenance to outboard motors, and manufacture and repair of fishing gears and wooden boats. Women are not directly involved in fisheries, but around 183 of them participate in processing and marketing of dry and salted fish as well as the meat of crab. Basically, women are in charge of the household, taking care of the children and carrying out some activities that contribute to the family's economy. The number of family members, for an average fishing household, ranges from 4 to 7. Sometimes the house has only two rooms and one of them is the living room.

Fishers attempt to diversify their economy in a variety of ways. Nearly 600 people work in other occupations, such as the processing and marketing of fishing products, sales in small stores, agriculture, transportation, livestock farms, aquaculture and salt extraction. Although artisanal fishers of other marine and inland areas of Colombia have diversified their activities, the communities of CGSM have more alternatives than others.

Contrary to most Colombian fishing communities where a high proportion of the population is illiterate, 82% of the CGSM's population has some level of education. However, in most poor rural communities throughout the country, education levels are lower than in the CGSM, with 16% completing basic education, 5% finishing high school, and a much lower percentage continuing on to higher levels of education. Likewise, more children and teenagers go to school than did their parents 15 or 20 years ago.

Although younger men learn how to fish from their fathers, now most of them prefer to develop more profitable and less demanding activities that generate a more permanent income. It is important to highlight that the average income for small-scale fisheries in CGSM is around US$1 600 family/year, which is below the poverty line.

Quality of life in fishing communities depends largely on the location. Thus, towns located nearest to tourist and/or industrial cities have better services and facilities coverage than the distant palafitte (stilt) villages (Figure 5). This is the case in CGSM, where rural communities near and over the road between the cities of Barranquilla and Ciénaga have better conditions than those located within the lagoon.

Infrastructure conditions in CGSM vary according to the town and service. Aqueduct facilities are found in 37% of the villages, but only Ciénaga city has sewer facilities for a portion of the population. Electricity is present in 83% of the towns, including in the stilt villages through submerged cables. In 33% of the villages traditional means of communications and/or cellular phones exist. Access to road transportation occurs in 50% of the cases and the whole population has aquatic transport. While houses in villages near the road could eventually be threatened by flooding, those in palafitte towns are built on poles and stay above the water level most of the year. People in these communities use canoes as transportation throughout waterways.

Regarding social services, rural schools depend on the government but they are insufficient and badly maintained. There are some high schools in Ciénaga city, 10 km from the nearest fishing town. Only a few students can go to university and when they conclude their education they prefer to stay in the cities than return to their towns. Health facilities are scarce and people depend on the care services they can get from hospitals in locations like Ciénaga and Barranquilla cities. Family planning advice, usually from NGOs, was more frequent a decade ago than now due to diminishing assistance.

FIGURE 5
Palafitte (stilt) town in the CGSM

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

As outcomes of the PRO-CIÉNAGA project, two large associations were created: Association of the Community Organizations of the CGSM (ASOCOCIÉNAGA) and the Association of Artisanal Fishers Pro-defense of the CGSM (GRANPES). These organizations have about 1 500 members, with the mission of contributing to the conservation and environmental restoration of the CGSM in order to improve the life quality of its inhabitants.

Although these associations have presented their initiatives at the Fishing Community Assembly for the Fishing Ordinance in the CGSM, their proposals have not yet been implemented, a primary source of discouragement for members. In general, although the participation of communities is important during the analysis of management measures for fisheries or particular areas, this is not a requirement for the governmental agencies to advance in the management process.

Private organizations, such as 'Social Foundation' and 'Restrepo Barco Foundation', have participated in the consolidation of communities in CGSM, the granting of small credits and project formulation in order to diversify the economy with other productive activities. Nevertheless, the results obtained are not good enough to improve family economies.

Because most fishing areas lie within the reach of any fisher with a boat, one of the conflicts among fishers is between the cast-net fishers and those using more effective gears, such as gillnets and surrounding nets with small mesh sizes called *boliche* (Rueda and Mancera, 1995). Conflicts also arise regarding fishing practices that may be considered harmful due to sediment disturbance or the burning of mangroves (the *zangarreo* fishing gear). In addition, unsafe operations in distant waters cause disputes between fishers and authorities.

More often, conflicts between fishers and other coastal activities are linked to the use of waterbodies. In most cases they are related to small-, medium-, and large-scale livestock farmers and agricultural producers. Agrochemical pollution from plantations near CGSM often leads to confrontation between farmers and fishers. Road construction poses another conflict as it disturbs the natural water exchange with the adjacent sea and the communication within the lagoon system and also adversely affects the movements, distribution and abundance of the water supply.

No integrated coastal management effort has ever succeeded, even though the Environmental Management Plan produced by PRO-CIÉNAGA in 1994 constitutes a solid basis to design and implement an integrated management approach for the CGSM, considering the numerous economic activities sharing the resources in the region. However, such a management plan requires the agreement of the participating actors, and because of political, as well as complex socio-economic reasons, this has never been accomplished.

5. ASSESSMENT OF FISHERIES

Taking into account the lack of long time series on catch and effort data, much of the population assessments of the main commercial organisms have been based on direct methods (i.e. population size estimation) and the only attempt took place in the middle of the 1990s. However, severe perturbations suffered by the ecosystem and its resources in the late 1990s rendered those results out-of-date and seldom useful for future stock or biomass projections. The utilization of indirect methods, starting with size frequency, has focused on the estimation of exploitation rates based on growth and mortality parameters. Beverton and Holt yield models and biomass per recruit have been applied, aiming to bring fishing mortality and mean catch size to optimal levels (Mancera and Mendo, 1995; Rueda and Urban, 1998; Sánchez *et al*., 1998; Tíjaro *et al*., 1998; Rueda and Santos-Martínez, 1999). In addition, gillnet selectivity experiments were implemented to regulate mesh size for 10 fish species (Rueda and Santos-Martínez, 1999; Rueda *et al*., 1997; Rueda and Defeo, 2003c). Recent selectivity assessments were performed for cast nets and small trawlnets as a means to detect impacts of fishing on fish stocks during the monitoring (INVEMAR, 2001; Rueda, 2007).

Yield estimations in the last 10 years have been obtained for about 50 species of fishes, crustaceans and molluscs, along with related fishery information derived from monitoring (INVEMAR, 2003a). Both recruitment patterns and values were estimated for at least five species supporting this fishery (Mancera and Mendo, 1995; Rueda and Urban, 1998; Sánchez *et al*., 1998; Tíjaro *et al*., 1998; Rueda and Santos-Martínez, 1999). Key species biomass and distribution were estimated in seasonal fishing surveys performed once in the mid-1990s (Rueda, 2001; Rueda and Defeo, 2001) during high-salinity perturbations in the CGSM and then just before restoration processes started. However, there have been no updates of those biomass estimates, which are urgent since the conditions are now quite different regarding resource populations and the CGSM environment.

Since it has been determined that there is a need for an ecosystem model in order to have a conceptual picture of the processes taking place in the CGSM and their effects on resource populations and the fishery, some isolated attempts have been made to assess fishing impact using an ecosystem approach (Rueda and Defeo, 2003c) and to model climatic and hydrologic effects on resources (Blanco *et al*., 2006; Blanco *et al*., 2008). However, the complexity of the relations occurring in a variable environment such as this one have precluded so far the design of an actual integrated model useful to give management recommendations, either for environmental or for fishery purposes.

The fishery has been evaluated using bio-economic indicators (i.e. threshold profits for the *boliche*, including variable costs and size-at-price data), analyzing theoretical management scenarios based on direct biomass estimation and fish-length compositions (Rueda and Defeo, 2003b). More recent estimates, derived from monitoring data, include variations in fish prices, investment, variable costs per fishing gear type, income per day, monthly income of fishers, number of jobs and marketing of fish products (INVEMAR, 2003b). The Fishing Information System (SIPEIN) software has been re-engineered to allow updated simple bio-economical analyses in agreement with the present context of the fishery on a monthly basis (Narváez *et al*., 2005).

Some works have been conducted on fishery financial analysis and marketing channels (INVEMAR, 2001). As noted before, the required input exists to analyse periodically how the cost-benefit balance changes in the fishery. In addition, the spatial and temporal distribution of some stocks in the CGSM and its influence on the fishers' behaviour has been determined (INVEMAR, 2003b; Rueda and Defeo, 2003b). Since certain species depend highly on the hydrological conditions in the system (i.e. tilapia), forecasting their spatial abundance and distribution demands a closer analysis.

Risk and uncertainty analysis of several fishing indicators (i.e. harvestable and spawning biomass, mean catch size, threshold profit) has been performed, applying the precautionary approach in order to determine the status of the fishery and to formulate risk-averse management strategies (Rueda and Defeo, 2001, 2003b; INVEMAR, 2003b).

An example of a fisheries assessment was as a result of the reopening of the channels connecting the Magdalena River with the CGSM in 1996–1998. To evaluate the impact of this, abundance data (catch-per-unit effort), species richness, and economic revenues were compared for the years before and after the channels were implemented (INVEMAR, 2003b). The high environmental perturbation caused by El Niño conditions in 1992–1995 and 1997, and later by La Niña (lowering salinity) in 1999–2000, produced not just a variation in the overall community but also a change in the fish assemblage, where freshwater species, once assumed as a sign of ecosystem recovery, were really another element of perturbation caused by prolonged flooding conditions in those years (INVEMAR, 2002; Leal-Flórez *et al.*, 2008). After 2001, CGSM environmental and fishery conditions returned to those that they experienced before the opening of the channels. Successive changes are indicative of the climatic and environmental variability experienced in CGSM and ultimately its fisheries.

There was also an examination of the reopening of the channels, since this work generated high expectations. The resulting impact on the fishery has been assessed in terms of income per fisher and number of jobs generated by fishing (INVEMAR, 2003b). Reference information to characterize the fishery and the resident fishers community demographics in the CGSM was acquired by means of a census carried out by PRO-CIÉNAGA in the early 1990s (Campo and Barroso, 1993).

It is not as simple as just comparing the scenarios before and after the channels were built, because four scenarios can be discerned, complicating the assessment. Unfortunately, there are also unavoidable uncertainties caused by political and social unrest, due to actions of illegal armed groups in the area, disturbing the extractive activity and the free access to certain fishing zones and leading to forced displacement and migration of fishers, mostly in 2000–2001 (INVEMAR, 2001). In recent years, law enforcement conditions have improved, but have not yet normalized.

6. FISHERY MANAGEMENT AND PLANNING

At the national level, the fisheries management system is regulated by Law 13, 1990. The measures are supported by scientific and technological research, as well as the precautionary principle. However, there are weaknesses inside the institutional framework to execute surveillance and control in many regions. Particularly in CGSM, some management actions based on enforcement of fish catch sizes and banning of particular fishing gears have been implemented, although these regulations have not been consistent through time.

Although fisheries legislation does not establish mechanisms to implement global mandates and initiatives, those accepted by Colombia are adopted by administrative acts of ICA, the Ministry of Agriculture and Rural Development, or of the Ministry of Environment, Housing and Territorial Development, as appropriate.

In the particular case of CGSM, the environmental authorities presented in the area (National Parks Office [UAESPNN]; Magdalena Regional Corporation [CORPAMAG]) have taken control and surveillance of the water conditions and biological resources within the framework of international agreements as the Biodiversity Convention. These efforts are clearly not enough, in spite of the international recognition of the CGSM as a World Biosphere Reserve (UNESCO, 2000) and Ramsar wetland. Although it is important to implement environmental mandates, those agreements aimed at fisheries need to be implemented in CGSM, especially the FAO Code of Conduct for Responsible Fisheries.

At the national level, regulatory and non-regulatory measures are established for management. The former are associated with the norms (laws, agreements and resolutions) established to control access to fisheries resources; the latter aim to train and raise awareness among the users about the need for responsible fishing and compliance with fisheries regulations (FAO, 2003).

Regulatory measures issued by ICA pertain to fishing fleet control (vessel number, size and type, and duration of affiliation or lease contracts of foreign flagged vessels to national companies with fishing permits); allocation of fishing quotas to permit holders, and a resource fee for artisanal fishers; closures over the resources and fishing grounds; reserve areas and areas exclusively for artisanal fisheries; minimum catch sizes; regulation of artisanal fishing gear and methods; authorization to fish (authorizations, permits, patents, licences, safe-conducts and concessions); inspection visits to capture, marketing and mobilization sites; and establishing sanctions and fines for infractions to fisheries regulations. It is important to highlight that Law 13, 1990 allows open access to subsistence fishers, although there is not a real differentiation between subsistence and small-scale fishers.

Frequently-used non-regulatory measures include: awareness-raising campaigns and distribution of information materials about the legislation and regulatory measures issued periodically; formation of strategic alliances and discussion meetings with the users, civil and military authorities to design and implement management activities as well as to issue the respective norms; training courses on sustainable use and responsible fishing; technical assistance and technology transfer; and evaluation of national and international conventions, agreements and norms related to the activity (FAO, 2003).

Because the CGSM is an area for subsistence and small-scale fisheries, its fishers operate under the regime of open access and the management measures have serious gaps that allow environmental degradation and resource overexploitation. Formal management systems have not been implemented even though the ideas, requirements and traditional knowledge of fishers, as well as scientific and management knowledge, were combined for several years within an agreement called '*Asamblea de Comunidades pesqueras para el Ordenamiento Pesquero de la CGSM*' (Fishing Communities Assembly for Fishing Management in the CGSM). However, these have not yet been supported by ICA.

Even though one of the outcomes of the PRO-CIÉNAGA project was an Environmental Management Plan for the CGSM (PRO-CIÉNAGA, 1994) aimed toward management and conservation strategies for fish resources in the medium term, which could be implemented by ICA, this initiative has been fruitless so far. There is still no current control or surveillance system for fishing in the CGSM. There is only monitoring of the fishing activities carried out during the last 12 years by Instituto de Investigaciones Marinas y Costeras (INVEMAR). This monitoring becomes a tool for the periodic assessment of the fishery and to give management guidelines. Nevertheless, in the absence of fishing management, there is no related performance evaluation whatsoever.

7. RESEARCH AND EDUCATION

Daily catch, effort and size data – by species, fishing gear and zone – have been recorded for 12 years already in every landing site in the CGSM. In addition, information about fishing power, prices and variable costs of fishing effort were collected. This information is based on a random sampling design, with sample sizes higher than 30% of all active fishing units per gear. Field data are recorded by native fishers, trained and supervised by INVEMAR, which is currently the institution gathering, storing and analyzing fishing information at CGSM using the database SIPEIN (Narváez *et al*., 2005). Field information about water conditions and hydrological variations is recorded simultaneously in the lagoon system, as a means to analyse and interpret resource-environment relationships (INVEMAR, 2003a).

Research dealing with biology and ecology of the main commercial species of fish, crustaceans and molluscs has been conducted in the CGSM. From the biological point of view, reproductive cycles, spawning periods, condition factors, and mean sizes of sexual maturity have been studied in no less than 20 fish, crustacean and mollusc species, characterizing this multispecies fishery (Santos-Martínez and Acero, 1991; Mancera and Mendo, 1995; Bateman, 1998; Rueda and Santos-Martínez, 1999; Sánchez and Rueda, 1999; Rueda and Defeo, 2003a). Many cases have shown that environmental variables (e.g. salinity, currents and tides) affect the reproductive strategy of the species.

Concerning ecological aspects, research has been focused on trophic chains (Santos-Martínez and Acero, 1991; INVEMAR, 2001), showing that the most abundant species are those feeding on lower trophic levels, but the fish predator species are the largest biomass portion (54%).

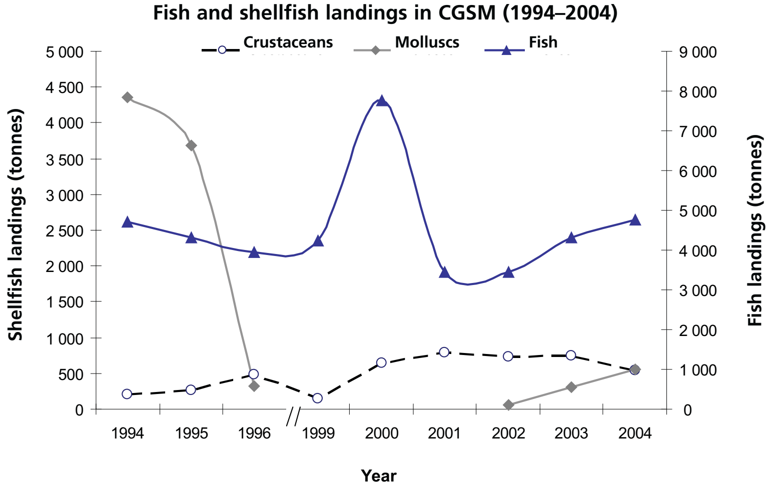
There are also several papers about community structure (Álvarez and Blanco, 1985; Santos-Martínez and Acero, 1991; Sánchez, 1996; Bateman, 1998; Sánchez and Rueda, 1999; Rueda and Defeo, 2003a), allowing spatial and temporal comparisons that show how the structure of fish assemblages shifts seasonally. Other work addresses the population dynamics of several species (Mancera and Mendo, 1995; Rueda and Urban, 1998; Sánchez *et al*., 1998; Tíjaro *et al*., 1998; Rueda and Santos-Martínez, 1999; Rueda, 2001). The majority of this research corresponds to estimation of growth parameters, mortality rates and recruitment patterns of the resources.

More scarce are studies of the effects of environmental change on fishery resources and their habitat preferences (INVEMAR, 2001, 2002; Rueda, 2001). Nevertheless, recent studies point out the links between those aspects, neglected in the past, when analysis relied just on fish catch data.

Studies have been carried out on demography and community needs, culture, lifestyle and organization of fishers in the CGSM (Abello, 1978; Campo and Barroso, 1993; Moscarella and Barragán, 1994; Pinilla, 1999). These communities lack public facilities such as sewer systems and garbage disposal services. There is research dealing with the inventories and ownership of boats and fishing gears, as well as studies of the economically active population (Jiménez, 1983; Santos-Martínez *et al.*, 1998; INVEMAR, 2001). Others studies have evaluated fishery production in different times (Restrepo, 1968; Santos-Martínez *et al.*, 1998; INVEMAR, 2000, 2001, 2002, 2003b). This information has been periodically reviewed and updated by INVEMAR.

Fish catches and incomes have varied markedly during the last decade in the CGSM. Both variables diminished before 1996, as a result of environmental changes in the lagoon system and strong increases in both salinity values and fishing effort. Resources like oysters and snails disappeared in 1996. From 1999 to 2000, the CGSM underwent another fluctuation, and freshwater fish species catches rose up to levels like those in 1994. However, they dropped again after 2001, when salinity rose once more, and catch levels remained at nearly one half of those in 1999–2000 (Figure 6). Nevertheless, even though catches rose between 1999 and 2000, the fishers' incomes did not, due to the lower price of freshwater species compared with marine or estuarine species, and to the fact that large amounts of freshwater fish in the market kept prices down in those years. There is an apparent recovery of shellfish catches after 2002, but this corresponds to clam harvests in neighbouring Isla de Salamanca, and not to the recuperation of the oyster and snail resources.

FIGURE 6
Fish and shellfish landings in CGSM (1994–2004)



Other surveys describe the structure of the commercial channels, study the fish market prices to evaluate the participation of fishers, and examine the revenues of the fishing activity for the community (Restrepo, 1968; Charris *et al*., 1994; INVEMAR, 2001, 2002). Bio-economic aspects of the fishery have recently been examined using risk and uncertainty analyses of fishing indicators to assess the status of the fishery (Rueda and Defeo, 2003b).

Currently, there are no educational programmes for fishers in the CGSM. Nevertheless, it is important to mention the efforts conducted in the 1990s for the 'Rehabilitation Project for CGSM-PRO-CIÉNAGA' (PRO-CIÉNAGA, 1994). Those educational endeavors were not directly aimed to local fishers, but to build up public awareness of the environmental issues in the CGSM, and how the local communities could contribute to alleviate these issues through supportive actions and attitudes. As in other fishing communities of the country, there are no local vocational schools. However, some NGOs include in their projects training activities to diversify the occupations and economy of fishing communities, such as honey production in CGSM. Some initiatives have been focused on providing practical education to women in order to foster their productive role within the communities.

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6. Coastal fisheries of Costa Rica

Ángel Herrera-Ulloa[*], Luis Villalobos-Chacón, José Palacios-Villegas, Rigoberto Viquez-Portuguéz and Guillermo Oro-Marcos

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1. INTRODUCTION

Costa Rica is a small country, with a territory of 51 000 km^2 (Figure 1). Due to the small and open economy, export of products is a major component in many industries, including fisheries. Joaquín and Windevoxhel (1998) indicate that by the 1990s, most marine landings of the Central America region were contributed by Costa Rica (179 000 tonnes), accounting for US$616 million, close to those reported by Panama. The Central Valley, in the central region of the country, comprises 60% of Costa Rica's population. It is in this area where major cities are located and thus where most of the jobs are generated.

Table 1 shows Costa Rica's sea limits; the coastal zone holds only 7% of the population. It represents one of the less developed areas, encompassing many socio-economic problems, and includes four cities with fewer than 100 000 inhabitants. On the Pacific coast, the three main areas are: Puntarenas (95 000 inhabitants), Golfito (30 000 inhabitants) and Quepos (20 000 inhabitants). Limón (70 000 inhabitants) is located on the Caribbean coast.

* *Contact information*: Universidad Nacional de Costa Rica, Costa Rica. E-mail: fherrera@una.ac.cr

FIGURE 1
Map of Costa Rica showing the Pacific and Caribbean regions

TABLE 1
Main characteristics of the Caribbean and Pacific coasts in Costa Rica

	Caribbean	Pacific
Coastline (Villalobos, 1982)	212 km, rectilinear coastline	1 016 km, three gulfs and several bays
Percentage of areas protected (PRADEPESCA, 1995)	Slightly higher than 40% of the coastline	Less than 30% of the coastline
Exclusive economic zone (Palacios, 2007)	24 000 km^2	589 682.9 km^2
Continental platform (MINAE and PNUD, 2002)	2 400 km^2	15 600 km^2
Wind patterns	Strong influence of northeast winds, hurricane season influence	Scattered storms, wind direction changes according to the season
Climate	Humid tropical, high rain influence	Dry tropical in the north, humid tropical in the south
Small islands	Two islands	Many islands close to the coast and Coco Island about 644 km southeast
Fisheries stocks	Mainly migratory lobster, mackerel, sharks	Pelagic fishes, sharks, demersal fishes, crustaceans

Protection of wild areas comprises 12.5% of the national territory. These protected areas include: 9 national parks, 3 biological reserves, 2 no-take natural reserves, and 16 wildlife refuges and wetlands. They cover a higher percentage in the Caribbean (50%) than in the Pacific area (21%). Protection is one of the main strategies within the country, since it has been estimated that the world has between 13 and 14 million species, from which Costa Rica accounts for about 4% of them (500 000 species). However, only 17% (almost 90 000 species) of these species have been identified (i.e. it represents about 5% of the currently known species in the world, which is about 1 700 000 species) (Ministerio de Ambiente y Energía y PNUD, 2002).

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

2.1 Description of fisheries

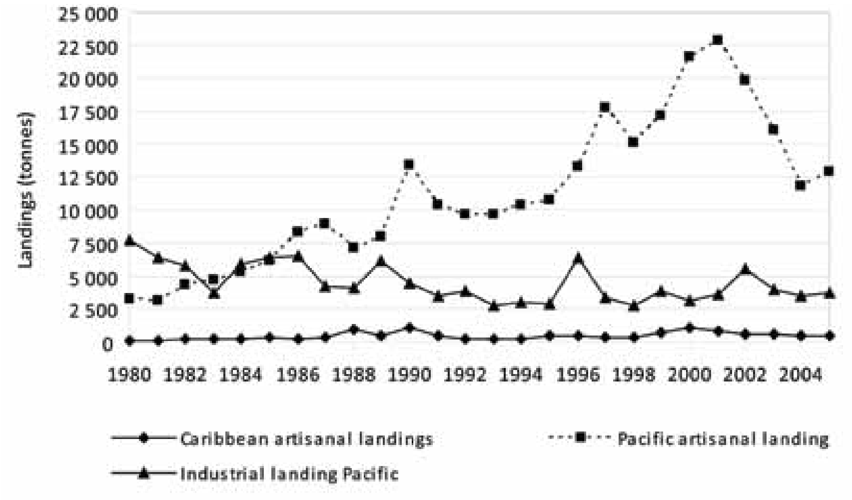
In Costa Rica, between 75% and 80% of the landings come from the artisanal fleet. From those, about 95% of the fleet operates in the Pacific Ocean, which has a larger exclusive economic zone (EEZ) (Table 1). This area can be divided into four zones: north or Guanacaste region (divided into three zones, neighbouring with Nicaragua); Gulf of Nicoya region; Central Pacific region (divided into three zones); and south Pacific region (neighbouring with Panama, divided into two zones) (Palacios, 2007).

From the Pacific area, the Gulf of Nicoya concentrates the principal fleet and the highest landings; this is one of the largest and most exploited estuaries in Central America (Palacios, 2007; Palacios and Villalobos, 2007). This area has important mangrove coverage which, in spite of comprising only 1% of the area and accounting for 1% of the primary productivity, represents 76% of the system biomass (Wolf *et al*., 1998).

One of the characteristics of the Caribbean coast is the presence of coastal lagoons, where important recreational fisheries occur. In this region, several important protected areas have been established limiting commercial fisheries mainly to small-scale fleets. In contrast to the Pacific region, where several zones are used for landing, in the Caribbean region only one area (Limón) concentrates the fishing activity, which includes several landing sites: Barra del Colorado, Puerto Limón and small landing sites on the southern coasts, including Cahuita and Puerto Viejo. Catches in this region are much lower than on the Pacific coast, despite the reduction in catches in the latter (Figure 2).

The volume of species caught by the small-scale fishing fleet on the Pacific coast began to decrease by the beginning of the 1980s, affecting exports. The market was supported by species such as snapper and groupers and new technologies allowed an increase in shrimp landings. Since 1986, a decrease in fish catches was observed and it was attributed to overexploitation of benthic resources on the marine platform in Costa Rica, although there is not scientific support on this matter. Given this situation, boat owners, aided by government export incentives, started to built bigger boats and began to sail longer distances.

FIGURE 2
Catch landed trends in the Pacific and Caribbean coasts by artisanal fleets operating in Costa Rica



Source: Incopesca, 2006.

Fishing fleets in Costa Rica have been classified into five categories which target demersal and pelagic species (Table 2). Most boats are small-scale artisanal and they concentrate on high-value species such as lobster, shrimp and molluscs. Industrial fleets concentrate on sardine and there is a shrimp fishery that has been classified independently (Palacios, 2007). Over time, recreational fisheries have become more important for the economy of the country.

The diversity in the characteristics of the artisanal fleet is wide in Costa Rica. It includes artisanal fleets which operate small boats without motors mainly in the mangrove area where people collect molluscs; boats that use outboard engines operate about 3 miles from the coast on day trips. Other boats have navigation systems and can sail about 40 miles from the coast (Chacon *et al.*, 2007). A higher proportion of an artisanal fleet operates in the Pacific and land in Puntarenas (Sancho, 2000) with about 200 boats (Table 2). However, there are significant fleets in Quepos, Playa del Coco and Golfito (Li, 2002). In these fleets, 55% of the boats are wooden, 30% are fibreglass and 15% are steel. Interviews indicated that most of the boats' lengths vary between 9 and 12 m. However, in the advanced scale artisanal fishery, boats can reach up to 30 m. They all have internal engines with an average power of 450 hp, although it is possible to find boats with only 70 hp, or more than 600 hp. Average product storage capacity is 3 000 kg; however, there are boats with up to 1 tonne storage capacity, or even 60 tonnes in the case of advanced artisanal fishery boats.

TABLE 2
Characteristics and targeted species for various Costa Rican fishing fleet categories

Category	Subcategory	Main coverage	Coast	Number of boats in 2000	Main target species
Artisanal	Small scale	Coast	Pacific and Caribbean	3 110	Croaker (*Cynocsion* sp.) Swordspine snook (*Centropomus* sp.) Snapper (*Lutjanus* sp.) Shrimp (*Lytopenaeus* sp.) Molluscs (several genera) Lobster (*Panulirus* sp.)
Artisanal	Mid-scale	Demersal	Pacific 30–50 miles	519	Snapper (*Lutjanus* sp.) Grouper (*Epinephelus* sp.) Mahi-mahi (*Coryphaena hippurus*) Sharks (several genera)
Artisanal	Advanced	Pelagic	Pacific, EEZ and international waters	143	Mahi-mahi (*Coryphaena hippurus*) Swordfish (several genera) Tuna (several genera) Sharks (several genera)
Industrial		Coast	Pacific	73	Shrimp (*Lytopenaeus* sp.)
Industrial		Semi-pelagic	Pacific	2	Sardine (*Opisthonema* sp.)

The advanced artisanal fleet has a wide range of operation. According to fishers, fishing days per boat are between 10 and 20 days, depending on the fishing productivity of the zone. Boats fishing independently, such as the advanced liners, have fishing trips that last approximately one and a half months. The normal area of fishing extends from Central America to Colombia. In the case of the advanced artisanal fishery, the area of fishing extends from southern Peru (10°S) to Mexico (30°N).

The product cooling methods have evolved along with the fishery, boats and techniques. Ice blocks were used years ago, changing in the mid-1980s to ice flakes. In the last couple of years, new boats with cooling systems on board were incorporated for the pelagic fishery, allowing greater independence. In the beginning, the cooling system presented problems for both national and international markets. Exports were rejected, or accepted at low price, since the quality was not the same as the product preserved in ice, due to flesh characteristics. The producers were changing and adapting techniques in order to achieve the standards demanded by the market. Currently, the product is stored and packed in better conditions, improving the dock price.

There is an international artisanal fleet, which is mainly operated by Taiwan Province of China, with flags of convenience from countries such as Panama and Belize. This is not a regular year-round fleet and is estimated at 50 boats. The main reason for allowing these boats into Costa Rica is economics. There is no regulation on the landings of these boats. There are some enterprises that unite the business people from Taiwan Province of China who live in the country and the Costa Rican people.

In the case of trawlers, there are licences for 69 boats; however, only between 40 and 50 are in operation, due to the economic fisheries crisis caused by overexploitation. The industrial fleet is mainly composed of small sardine boats, with limited contribution, since it has traditionally been developed in the external areas of the Gulf of Nicoya. Nevertheless, for about 10 years, some companies have tried to obtain more licences. However this has not been possible given the status of the sardine populations in the Gulf of Nicoya, which feeds humpback whales. This factor, in addition to fishing pressure, has not allowed the recovery of the stock. Nonetheless, there is still pressure to open the fishery, especially in the south (Golfo Dulce).

One problem reported in Costa Rica is associated with the shark fin fishery, which is mainly carried out by the pelagic fishery. A few years ago, due to lobbying, a control process was developed to prevent the disposal of shark carcasses offshore. However, statistics are not accurate and it is hard to follow trends and regulate this activity because this measure does not prevent the fishing pressure and the risk of overfishing as the boat owners find multiple ways to avoid restrictions.

2.2 Fishing activity

Multiple species are targeted by fishers in the area. The small-scale fishery is based on coastal species, where white shrimp (*Litopenaeus stylirostris* or *L. occidentalis*) are the most sought. This activity is generally carried out with drift nets or gillnets in shallow waters, and in boats with outboard engines of 25 hp. The most valued species by fishers are presented in Table 3. Local and scientific names of commercial species are provided.

In this document, we will refer primarily to the fishing activity in the small-scale artisanal fishing coastal area located in the Gulf of Nicoya.

2.3 Target species and fishing gears

As outlined above, different fleets operate in Costa Rican waters. Table 4 compares the production in percentage of the fleets, showing an increase of landings for the medium-scale fleet and a reduction for the small-scale fleet in the analysed period. From 2000 on, international advanced fleets started moving out of Costa Rica, mainly because of legal restrictions against shark finning, giving more potential to the medium-scale fleet.

Depending on the time of the year, the moon phase, currents or area, the same fishers may seek different fish species. Sciaenidae are the most valued; however, Lutjanidae, Serranidae and Scombridae are also fished. Generally, fishing is carried out in boats with 25 hp outboard engines. Wooden boats, generally with on-board engines and four crew members, fish mahi-mahi in waters less than 80 km from the coast. Along the coast, fishing occurs in shallow waters for species like snappers which reside in rocky areas.

TABLE 3
Main species targeted by fishing gear, boats and number of boats and crew that fish in the Costa Rica EEZ

Species	Type and size of fishing gear	Type and size of boat	Number of boats in the fishery	Average number of crew members
Shrimps (*Litopenaeus stylirostris* or *L. occidentalis*)	Gillnet, larger than 0.7 m, from 300 to 400 m	Small scale, less than 6 m	Approx. 850	2
Croacker (*Cynocsion* sp.) **Snook (*Centropomus* sp.)** **Snapper (*Lutjanus* sp.)**	Midwater longline/200 hooks Gillnet of 0.7 to 0.9 m	Small scale, 7 to 9 m	Approx. 100	2
Black tuna (*Euthynnus lineatus*), mackerel (Scombridae)	Drift gillnet of 0.1 m of 600 m	Mid-scale, 7.5 m to 9 m	Approx. 200	3
Mahi-mahi (*Coryphaena hippurus*), sharks (Carcharhinidae, Sphyrnidae, Lamnidae) and swordfish (*Istiophorus platypterus*, *Makaira mazara*, *Makaira indica* and *Tetrapturus audax*)	30 km maximum Surface longline/ 36-40 hooks/mile American type	Mid-scale Maximum 14 m	Approx. 530	5
Snapper (*Lutjanus* sp.) and grouper (Serranidae)	6.5 km maximum Bottom longline	Mid-scale Maximum 10 m	Approx. 600	4
Tunas (*Thunnus albacares* and *Thunnus obesus*), swordfish (*Xiphias gladius*), sharks (Carcharhinidae, Sphyrnidae)	97 km maximum longline, 36 to 40 hooks/mile	Mid-scale, pelagic. Maximum 17 to 18 m (fleet from Costa Rica) Between 800 to 1 000 miles	Approx. 100	7–8
Tunas (*Thunnus albacares* and *Thunnus obesus*), swordfish (*Xiphias gladius*), sharks (Carcharhinidae, Sphyrnidae)	235 km maximum longline, 36 to 40 hooks/mile	Mid-scale, pelagic. Maximum 30 to 37 m. International fleet, mainly Taiwanese	Approx. 50, mainly Chinese	13–15

TABLE 4
Percentage comparison of artisanal fish fleet landings from 1996 to 2002

Fishing fleet	1996	1997	1998	1999	2000	2001	2002
Handline	0	1	0	0	0	0	0
Small scale	19	17	22	19	1	10	12
Medium scale	35	33	25	29	43	51	49
Advanced scale	43	46	47	49	43	38	39
Not available	3	4	5	3	1	1	1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: INCOPESCA, 2006.

The pelagic mid-scale fleet focuses on export species such as mahi-mahi, swordfish and sharks. The foreign fleet, as well as the local fleet, fish on the same species; however, the foreign fleet has a larger autonomous capacity, and in the case of sharks this fleet has shown clear interest in the fins rather than the flesh.

In terms of pelagic species, most of the information is provided by the International Commission for the Conservation of Atlantic Tunas (ICCAT), and studies focus primarily on tuna (Hinton and Bayliff, 2002).

The shrimp fishery is carried out by 55 trawlers (INCOPESCA, 2006); these boats operate along the Pacific coast where several species are targeted. Wild shrimp populations are the most studied species, specifically Gulf of Nicoya shrimp which is monitored to assess the implementation of annual closures.

Shrimp fishery

The artisanal shrimp fishery in the Gulf of Nicoya started around 1924 (Campos, 1984). Between 1950 and 1960, the number of boats fluctuated between three and six, but by 1970 there were 60 artisanal boats catching shrimp in the area. According to González *et al.* (1993), the use of trawlnets in the shrimp fishery by the semi-industrial fleet from 1945 to 1975 caused severe damage to the internal area of the gulf. Even in the 1960s, the artisanal fishery was very small and small boats were launched from the beach. The main development of this fishery occurred around 1986, when the use of monofilament net increased (Araya, 1995).

The target species of this fishery are white shrimp (*Litopenaeus occidentalis, Litopenaeus stylirostris, Litopenaeus vannamei),* and Titi shrimp (*Xiphopenaeus riverti* and *Trachipenaeus byrdi*), both caught between 5 and 50 m depth. Ping shrimp (*Farfantepenaeus brevirostris*) and Kolibri shrimp (*Solenocera agassizii, S. foca*) are caught between 40 and 100 m, and Camello shrimp (*Heterocarpus vicarius, H. affinis*) are caught between 180 and 500 m. Table 5 shows the periods with the highest landings for a variety of shrimp species. The 1960s were the most important decade for white shrimp and the 1970s saw the highest Titi shrimp landings. Kolibri shrimp maximum landings occurred in the 1980s, whereas the early 1990s saw highest landings for Pink and Camello shrimp.

The shrimp fishery is a good example of the typical evolution process of fisheries from the development to the declining phase. The shrimp fisheries started in the 1950s, and the four different stages are shown in Figure 3. A steady phase was observed between 1952 and 1957, an increase of catches marks the development stage from 1958 to 1978, a peak phase from 1979 to 1986, and declines began in 1985.

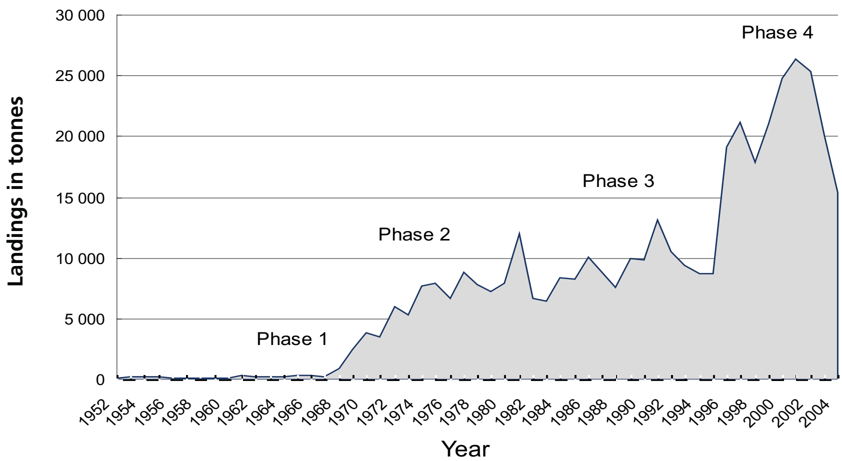
Finfish fisheries

Several studies have been undertaken to evaluate the conditions of fisheries in the area (Palacios, 2007; Palacios and Villalobos, 2007), but an integrated analysis is still lacking. A summary of catch trend analysis is presented here.

TABLE 5
Shrimp fishery by group of species between 1952 and 2004

Shrimp group	Scientific name	Landing 2004 (tonnes)	Maximum average landing in last five years (tonnes)	Maximum landing (year)
White shrimp	*Litopenaeus occidentalis, L. stylirostris, L. vannamei*	196	368	1963–1967
Titi shrimp	*Xiphopenaeus riverti, Trachypenaeus bydi*	54	934	1971–1975
Pink shrimp	*Farfantepenaeus brevirostris*	29	545	1988–1992
Kolibri shrimp	*Selenocera agassizii, S. foca*	399	1 366	1984–1988
Camello shrimp	*Heterocarpus vicarius, H. affinis*	70	619	1987–1991
Total		**748**	**3 832**	

FIGURE 3
Shrimp fishery evolution in Costa Rica from 1952 to 2002



Catch trend analysis of finfish (including all species) was undertaken to identify trends and maximum catches (using a five-year average to smooth the data). When the average value of the catch series is compared with catches in 2004, a 41% decrease in landings is evident (Table 6). Given the limitation of information by species, comparisons were based on groups of species (Palacios, 2007). Except in the case of sardine, most fisheries resources reached the highest catches between the 1980s and 1990s. Sharks and swordfish reached the highest values by 2004, and sardine and the mix of low-quality species showed the lower values regarding long-term average catches.

TABLE 6
Evaluation of catch trends of finfish species landed in Costa Rican fisheries in the Pacific area

Common name	Scientific name	Catch in 2004 (tonnes)	Maximum average catch in 5-year period (tonnes)	Period of maximum catches	2004 proportion of maximum catch
First quality (corvina and snook) > 2.5 kg	*Cynoscion albus* *Centropomus viridis* *Centropomus nigrescens*	135.6	382	1980–1984	0.35
First quality (corvina and croaker) < 2.5 kg	*Cynoscion squamipinnis* *Cynoscion stolzmanni* *Cynoscion phoxocephalus* *Cynoscion reticulatus* *Nebris occidentalis*	992.9	1 634	1995–1999	0.61
Spotted rose snapper	*Lutjanus guttatus*	158.3	330	1993–1997	0.48
Pacific red snapper	*Lutjanus peru*	219	605	1984–1988	0.36
Lower quality **(44 species of 17 families)**	*Caranx hippos* *Oligoplites mundos* *Paralunchurus dumerilli* *Mugil curema* *Anisotremus dovii* *Other species*	943	2 085	1986–1990	0.14
Sardine (jack, grunt and mullet)	*Opisthonema libertate* (65%) *Opisthonema bulleri* (35%) *Opisthonema medirastre* (5%)	975	6 554	1970–1974	0.15
Barracuda	*Sphyraena ensis*	7.14	14.3	1991–1995	0.50
Corvina	*Micropogonias altipinnis*	271	695	1979–1983	0.39
Conger	*Ophisoma prorigerum* *Ophisoma macrurum* *Rhynchoconger nitens* *Ariosoma gilberto* *Chiloconger labiatus* *Paraconger similis*	78.5	165	1993–1997	0.47
Grouper and bass	*Epinephelus* spp. *Paralabrax humeralis* *Paralabrax loro* *Paralabrax nebulifer* *Alphestes multigutats*	144.3	871	1984–1988	0.16
Dolphinfish	*Coryphaena hippurus*	2321	7 059	1997–2001	0.33
Sharks	*Mustelus lunatus* *Carcharhinus leucas* *Sphyrna lewini*	2025	3 979	1996–2000	0.51
White marlin	*Tetrapterus angustirostris*	416.5	690	1997–2001	0.60
Striped marlin	*Tetrapterus audax*	234	316	1994–1998	0.74
Sailfish	*Isitophorus platypterus*	1 244	1 235	1996–2000	1
Swordfish	*Xiphias gladius*	178	1 798	1995–1999	0.09
Total		11 534	28 412.3		0.41

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

Tourism is the main economic activity in the country. Since the late 1980s, the export trend has caused a change in the Costa Rican production structure, from mainly agriculture to electronic and tourism-based by the end of the 1990s. Since 1995, tourism activity reached an annual growth of 11%, accounting for 28.2% in the total dollar export (Joaquín and Windevoxhel, 1998; Instituto Costarricense de Turismo, 2002).

In 1999, the coastal zone comprised 58% of the country's hotel accommodations with 26 500 hotel rooms; these facilities are projected to reach 31 200 rooms by 2010 (Agencia de Cooperación del Japón e Instituto Costarricense de Turismo, 2001). On the other hand, according to Li (2002), the percentage of international tourists interested in aquatic activities that visited Costa Rica is above 25%, which represented by that time 33% of the total income coming from tourism.

Agriculture is the second most important economic activity in the country. It provided about 14.9% of the gross domestic product (GDP) in 2004 (MAG, 2005). About 20% of the land is suitable for agriculture (Joaquín and Windevoxhel, 1998). In both coastal areas, even though the land is not well suited for agriculture, it is still the main source of jobs, especially in plantations of banana, coconut, cocoa, rice and sugar. Another relevant component is extensive livestock farming.

The fishing industry had no significant relevance before the 1970s. The catalyst for economic development in fisheries is the industry sector, such as the development of a fleet directed to catch shrimp, sardine and tuna (Blondin, 1992). According to Breton *et al.* (1991), by the 1990s export from fishing represented 0.4% of the GDP, giving the artisanal fisheries little relevance in the occupational structure of Costa Rica. This condition has not changed much into the twenty-first century.

Demographic statistics on the population employed in fisheries are limited. Surveys carried out by Programa para el Desarrollo Pesquero en Centroamérica (PRADEPESCA, 1995) showed that the Pacific coast had 8 395 fishers, and the Caribbean coast had 800 fishers (9 195 fishers in total).

Although the above data, both in economic and demographic terms, seem to indicate that fisheries have little relevance, the truth is that the Costa Rican fisheries play particularly important roles in the generation of labour in coastal areas, not only as alternative primary work for marginal sectors, but also because small-scale artisanal fisheries are the main source of marine products for domestic consumption. Other fleets, particularly artisanal medium scale, advanced scale and industrial, focus their production on the export market, with species such as mahi-mahi, marlin and sharks, while the coastal fishery provides species such as croaker, catfish, small sharks and low-value fish. The latter offer a relatively low price and are the only option for the consumer population in Costa Rica. The strategic importance of fisheries resources should be viewed in terms of social value, since under economic criteria it holds little relevance.

Most people who are employed in fisheries have an elementary education with a low level of illiterate persons, and only a small proportion of people have a high level of education (Table 7).

TABLE 7
Fishers´ educational levels to 1995

Educational level	Percentage (%)
No studies	4
Primary educational level incomplete	30
Primary educational level complete	40
Secondary educational level incomplete	21
Secondary educational level complete	3
University educational level incomplete	1
University educational level complete	1

Fishing tradition is stronger in the small fishing communities located along both coastlines; however, it is more significant on the Pacific coast than on the Caribbean coast. Most fishers are men; however, there are also women, especially in activities related to mollusc extraction. The canning industry hires many women (about 1 200), mainly for cleaning tuna. There are urban fishers, located principally in Puntarenas city (Pacific coast) and Limón (Caribbean coast); the rest can be considered rural fishers. Puntarenas city is where most of the medium- and advanced-scale fleets land.

Moreover, although there are no up-to-date precise figures or studies on the matter, it is important to mention the contribution fishing has on the household economy through child labour. This is mostly from the extraction of species and by-products of mangroves, as well as children's participation in the cleaning of the products landed by small-scale fishers. In most cases, children do not receive salaries, but they occasionally receive some lower-value fish which they can sell or use for direct consumption.

The Gulf of Nicoya is the area where most of the small-scale fishers are located. This is also where most scientific and social studies have taken place. Since 1829, Puntarenas has been the first port and commercial centre in the country on the Pacific coast (Blondin, 1992). Most fishers live in the area of the Gran Chacarita, with very limited local power at the political and economic levels, which diminishes the possibilities of local development. There is also a high rate of unemployment; it is difficult to estimate, though it is presumed to be about 35%.

Studies on the Pacific coast include those of Charles and Herrera (1992) who gathered information from the Cooperativa de Pescadores de Puerto Thiel/Port Thiel Fishers Cooperative (COOPETHIEL) to evaluate the monthly income of fishers. They found a range between US$88 and US$176 for the period from 1988 to 1991, showing that although this income is not high, it does not fall within the category of extreme poverty. More recent studies conducted by the Instituto Mixto de Ayuda Social (Social Aid Institute), a governmental institution responsible for working with poverty groups, obtained similar results, leading to the conclusion that most fishers fall at the poverty level and not into the extreme poverty level.

Herrera and Charles (1994) compared the situation of COOPETHIEL (as an example of an artisanal fishery) on the Costa Rica Pacific coast with artisanal fisheries on the Caribbean coast. They found similar levels of income earned by fishers but with different cultural patterns. For instance, the population along the Caribbean coast experiences a strong influence from international tourism, speaks Caribbean English and is predominantly black.

Villalobos and Hernández (1998) undertook a study on the social conditions of the Gulf of Nicoya using an ecosystem-based approach. They established a process of differentiation of the artisanal fishing fleet by specific socio-economic, technological, environmental and production factors. They argue that these differences should be considered in the implementation of fisheries management protocols in the area, based on technical criteria and results derived from social studies.

The tourism industry is changing the process of artisanal fisheries in many regions of the country. The increase of tourism development on a large scale has sometimes led to an increase in demand for fish products to supply local tourism demand. In this sense, Gónzalez and Villalobos (1999) and Villalobos and Gónzalez (2000) analysed the processes of interaction between traditional fishing and tourism in the northern Caribbean. They also looked at the effects of technological development on the fishing environment in the Caribbean. Their results showed that tourist activity was becoming increasingly relevant as a strategy for coastal development. In addition, tourism is changing the coastal marine environment, as well as the social and cultural patterns of the artisanal fishing communities.

In other cases artisanal fishing communities have substantially transformed their traditional ways of operation and have opted for new forms of employment related to recreational fishing, tourism and ecotourism. Examples are found along the Pacific coast in Tambor, Puerto Níspero, Puerto Moreno and Moreno, and along the Caribbean coast, such as Manzanillo. All of these towns were dedicated to traditional commercial fishing by the mid-1990s, but currently remnants of fisher activities are virtually imperceptible. There is a tendency that seems to be increasing in some parts of the country, such as Quepos, Osa Peninsula and the Golfo Dulce, where more and more fishers are incorporated into activities directly linked to tourism.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

The history of the Costa Rican fishing industry shows various organizational experiences different in nature from the late 1970s and early 1980s. The fishing cooperative organizational model was the most practiced until the end of the 1980s. The model incorporated nearly 18% of the fishing population (about 20 fishing cooperatives). However, by 2000, almost 50% of cooperatives had disappeared. Although no comprehensive studies have been conducted to analyse fully this decrease in organizations, one clear factor has been a perceived inconsistency between the cooperative model used and the nature of traditional fishing activity.

Other organizational forms have been used at different times and from different institutional perspectives for the local fishers' committees (COLOPES) from 1987 to 1995. These had considerable success and acceptance among fishers, although they disappeared due to political decisions.

It is estimated that there are 50 organizations actually linked directly or indirectly to the fishing industry in Costa Rica for the Central Pacific area, although only 37 of these were formally incorporated and duly registered. Included in this category are two cooperatives, fishing associations, chambers, trade unions and some COLOPES (Araya, 2006). Table 8 shows main activities or duties undertaken by fishing organizations along the Central Pacific coast.

TABLE 8
Fishing organization activities in the Central Pacific region in 2006

	Fishing associations	Fishers' committees (COLOPES)	Fish cooperatives	Labour unions	Fishers' chambers	Total
Fuel subsidy	3	–	1	–	1	4
Marketing	2	–	1	1	–	3
Legal services	12	7	–	1	–	20
Productive projects	1	–	–	–	–	1
Other activities	5	2	–	1	–	8
Total	23	9	1	3	1	37

Source: Departamento de Extensión y Capacitación, INCOPESCA.

Other organizational efforts have developed in some fishing communities, especially in the Gulf of Nicoya region. These efforts have been promoted by the Universidad Nacional (National University) and other support institutions, which seek to incorporate productive alternatives in these communities, articulating the main activity with ecotourism and mariculture to benefit marginal sectors, mainly small-scale fishers, women and youth.

5. FISHERY MANAGEMENT AND PLANNING

By law, fishery planning and management is the responsibility of the Instituto Costarricense de Pesca y Acuicultura (INCOPESCA, Costa Rica Fishery and Aquaculture Institute). The Universidad Nacional (National University), the Universidad de Costa Rica (Costa Rica University), the Ministerio de Ambiente y Energía (Ministry of Environment and Energy), as well as various other foundations and non-governmental organizations, participate in marine activities, such as the World Wildlife Fund, Instituto Nacional de Biodiversidad (Biodiversity National Institute) and Fundación Costa Rica – USA (CRUSA).

In Costa Rica there is abundant legislation on environmental matters in the form of specific laws, regulations and decrees, but legislation is fragmented and non-cohesive. INCOPESCA coordinates the fishery and aquaculture sectors, promotes and organizes fishery development, marine hunting, aquaculture and research, and encourages conservation and sustainable use of aquaculture and marine biological resources based on technical and scientific criteria. INCOPESCA is responsible for issuing hunting, marine fishery and boat-building permits, as well as the licences and concessions for aquaculture production (Cajiao-Jiménez, 2003).

The Ministerio de Ambiente y Energía (MINAE – Ministry of Environment and Energy) is the institution responsible for marine protected areas, which include mangroves. Sea turtle capture is prohibited (Red Regional para la Conservación de las Tortugas Marinas en Centroamérica, 2001) and INCOPESCA is responsible for protecting and conserving sea turtles in the jurisdictional waters of Costa Rica.

Fishery laws date back to 1948, but were challenged in the mid-1990s through unconstitutional measures. Because of this, the laws remained for more than five years in the National Congress, causing serious problems for resource management. The most recent revisions were done before 2005, but there are still shortcomings that limit the application of laws by INCOPESCA, which leads to high rates of non-compliance in the fishery sector.

6. ISSUES AND CHALLENGES

Current fishery policies are not applied with an integral vision of resource management or integrated resource management. There are no clear policies regarding the use of international tendencies, such as the FAO Code of Conduct for Responsible Fisheries or the Precautionary Approach. Moreover, there are no clear policies in terms of resource allocation; basically, licences provide the right to fish any resource fishers want to exploit. Efforts to avoid overfishing are limited to closed areas, but are difficult to enforce due to the lack of resources.

Despite being the most developed country in Central America, Costa Rica still needs to improve its conditions to compete with other countries in Latin America. Given the reduction in catches of important resources, attention is needed to control the fishing effort and, in some cases, to reduce the size of the fleet as well as upgrade it. However, subsidies on fuel increase the existing pressure on marine resources and, in the case of closures, the government provides little monetary support. INCOPESCA has been inefficient during its 14 years of existence due to the problems noted above in regard to the application of law, low budget, and the shortage of qualified professional personnel. On the other hand, an increase in added value has been considered, but this will require improvement in fisheries infrastructure and sanitary control.

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7. Coastal fisheries of Cuba

Servando V. Valle*, Mireya Sosa, Rafael Puga, Luis Font and Regla Duthit

Valle, S.V., Sosa, M., Puga, R., Font, L. and Duthit, R. 2011. Coastal fisheries of Cuba. *In* S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo (eds). Coastal fisheries of Latin America and the Caribbean. *FAO Fisheries and Aquaculture Technical Paper*. No. 544. Rome, FAO. pp. 155–174.

1. INTRODUCTION

Within Cuba's exclusive economic zone (EEZ), the fisheries went through a growth phase from 1955 up to the end of the 1970s (Baisre, 1985a, 1993). From 1962 to 1965, motorboats replaced sailboats, fisheries cooperatives were created, prices of the species harvested increased, and more efficient fishing gears were introduced. Landings coming from the EEZ expanded considerably, reaching up to 79 000 tonnes by the mid-1980s; afterwards, a 20-year period of annual catches show values lower than 10 000 tonnes (Baisre, 2000).

The high economic value of many fisheries resources off the Cuban shelf and the fishing capacity created after 1959 (i.e. increase on fishing effort) have contributed

* *Contact information*: Centro de Investigaciones Pesqueras, La Habana, Cuba. E-mail: servando@cip.telemar.cu.

to high fishing pressure on many fishery resources, so that many of them are fully exploited and, in some cases, overexploited. Various studies concluded that many of the fisheries resources were exploited at their maximum sustainable yield (MSY) (Baisre, 1981, 1985a, 1985b, 1993; Baisre and Páez, 1981). In 1981, regulatory efforts aimed to protect overfished species and fishing effort was redirected to underutilized species such as rays, blue crabs and clams.

According to Baisre (2000), by 1995 approximately 39% of the resources were showing a negative trend in catches, 49% were in a mature phase with a high level of exploitation, and only 12% were in the development phase with some possibility for future increases. This means that 88% of the fishery resources were in a critical situation from a fisheries management perspective by the end of the 1990s, and consequently required urgent measures to reduce fishing pressure. The case of Nassau grouper and mullets, with a decrease of 95% and 88%, respectively, are among the most dramatic. Baisre (2000) has completed the most recent evaluation of catch trends, so the current situation for Cuban fisheries is difficult to assess. In addition, despite the management strategies implemented to reduce pressure on fisheries resources, changes in the ecosystems in the region are irreversible, making it difficult for catches to recover to previous levels (Baisre, 2000). Furthermore, there are no perspectives on the economics of fishing in distant waters given the fuel costs, and aquaculture appears as the most viable way to obtain fish products (FAO, 2008).

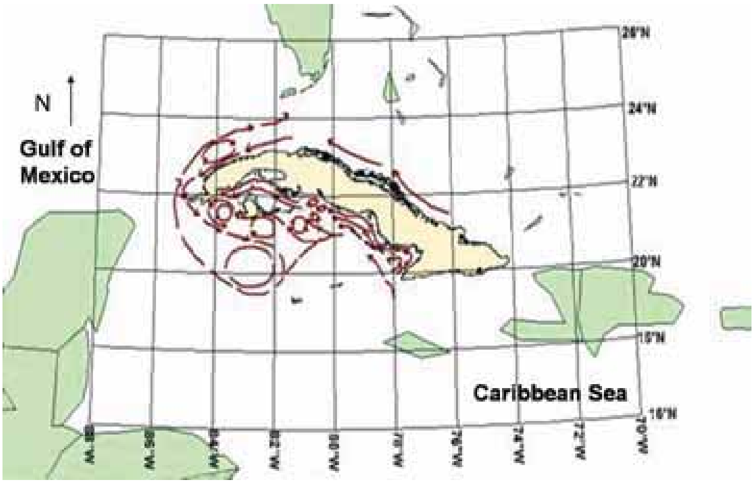
2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

Marine fisheries are an important source of foreign currency, animal protein and generation of jobs for about 17 000 people in Cuba, including fishers, workers, administrative personnel and other people involved in economic entities directly related to fisheries (FAO, 2008). A number of species are exploited in Cuba, using diverse fishing gears that are mainly artisanal, with boats less than 23 m in length. These smaller vessels limit the distance the fishers can go in search of fish (Baisre, 1985a).

The Cuban Archipelago has an extension of 110 922 km^2 and is located in the tropical western region of the Atlantic Ocean, including the Caribbean Sea, as well as the waters of the Gulf of Mexico and adjacent waters of the Atlantic Ocean in the Bahamas and the Great Antillean Archipelago. The more detailed oceanographic characteristic of the region is a continuous current of water (Antillean Current) that, due to the action of trade winds, moves along Florida and the east coast of the United States to form the Gulf Stream (Figure 1).

According to Claro and Parenti (2001), around 140 fish species have some commercial value and many of them are exploited by a multispecies fleet. Fishers use diverse types of fishing gears and methods to target a mix of the resources, although specialization by area or species in some cases occurs.

FIGURE 1
Cuba and oceanographic features observed in the region



Source: Adapted from Siem (1988) and Garcia *et al*. (1991).

The Cuban fleet comprises three types of boats according to the area where they operate: the coastal fleet, the Gulf fleet and the continental waters fleet. The second one operates on the Yucatán Peninsula within the EEZ of Mexico under agreement. This fleet targets mainly groupers and snappers using 16 boats of 23 m length that operate like a mothership of smaller boats (6 m length). The coastal fleet includes 990 boats (10–23 m length) made of fibreglass, iron and ferrocement; all of them are equipped with motors and a GPS system. This fleet belongs to 14 State enterprises that land their catches in the main ports of the country (FAO, 2008).

The distinction between artisanal fisheries and small-scale fisheries varies between countries. For example, a one-person canoe may be considered artisanal in a developing country, while 20 m trawlers, seiners or longliners are categorized as artisanal in developed countries. Hence, according to the concepts defined by Copemed (2004) and Johnson (2000), which take into account boat length, gross tonnage of the boat, fishing gears, target species and technology efficiency, most fisheries operating on the Cuban shelf, with the exception of shrimp fisheries, could be considered as artisanal/small-scale fisheries. Despite the diversity of species available, the topographic characteristics of the bottoms and the presence of many rocky zones and reef areas prevent the use of trawl fisheries and determine the artisanal nature of most of these fisheries.

Although commercial, sport and recreational fisheries harvest several species of crustaceans, molluscs, sponges and fishes, many of these species are not recorded separately in the statistical system. The same applies for some minor fisheries such as blue crab, sea cucumber and conch. On the other side, some resources, such as lobster, tunas, oysters, crabs, sponges and turtles, have developed specialized fisheries. All these facts contribute to the complexity of the Cuban fisheries, making it difficult to assess them in one dimension or to define viable management programmes for sustainable fisheries.

Catches are used for human consumption, with 29% of the local market products allocated to institutional consumption, such as schools, daycares and hospitals. The rest is sold to the local populations in State stores. Lobster and shrimp provide 23% of the seafood export and the main fisheries concentrate on lobster, finfishes and shrimp. This chapter concentrates only on the first two fisheries, as the shrimp fishery is the more industrialized of these fisheries; shrimps are frozen on-board and taken in a transportation vessel to the processing plant. Catches from the lobster are kept fresh and processed by the industry and they are all exported, while finfish catches generally are marketed fresh and are sold locally; small portions of the catches are processed to be sold in supermarkets or to export.

2.1 The lobster fishery

Spiny lobster of the Caribbean (*Panulirus argus*) is the most important commercial fishery in Cuba given its high economic value. This species inhabits all waters of the marine shelf and depends primarily on availability of shelters and the rate of production and renovation of food resources. The geology of the area, meteorological conditions and marine climate (tides, wave action, currents and turbidity) have favoured the presence of lobster habitats (mangroves, seaweeds, coral reefs). The fleet that targets lobster operates in practically all shallow waters of the Cuban shelf, characterized by the presence of sandy bottoms with dispersed rocks and corals which provide shelter for the lobsters.

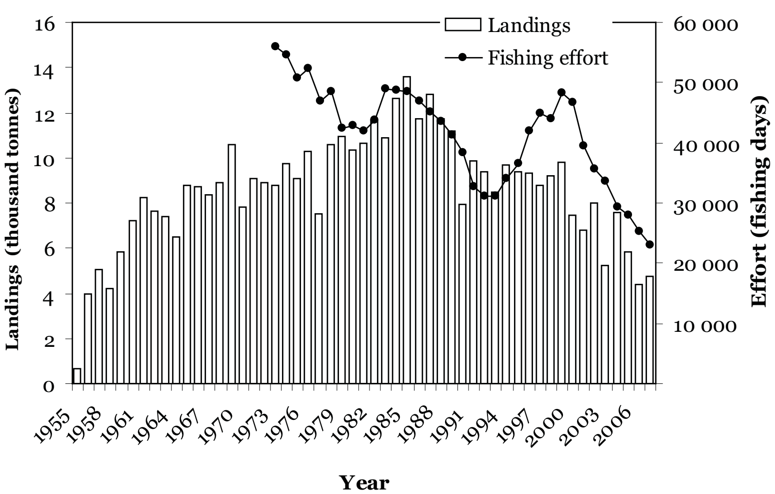
The fishery is performed by 9 companies with boats coming from 15 ports. They land their catches in 12 ports, 5 by the north coast and 7 at the south coast (Figure 2). In the last five years, the fishery has generated a net income of around US$70 million per year, and has provided direct employment to 1 110 fishers and indirect employment to approximately 7 800 people (Puga *et al.*, 2006).

The principal fishing grounds for the lobster fishery are located by the Gulf of Batabanó, at the southwestern region of Cuba. This area is also known as 'Lobster Triangle' and, at some point, sustained catches of around 7 000 tonnes annually. At present, this zone produces 66% of national lobster landings, with the rest distributed among the southeast (17%), northeast (14%) and northwest (3%) (Puga *et al.*, 2006). There are nine processing plants that produce precooked entire lobster and packs of lobster tails, which are the principal products exported to Europe, Japan and Canada (Puga and de León, 2003).

FIGURE 2
Location of landing ports and plants that process lobster along the coast of Cuba

During the last ten years, catches have decreased from between 9 000 and 10 000 tonnes to an average value of 6 600 tonnes (Figure 3). Despite a reduction on fishing effort since 1999 and an increase in the length of the closed season (from 90 to 120 days), no signs of recovery have been observed. Puga *et al.* (2005, 2006) state that one of the main reasons for the reduction of catches is the decrease on recruits and population abundance since 1989, caused by the combined effect of fishing pressure and habitat damage. The latter has been due to hurricanes and anthropogenic activities in coastal areas, such as river damming and reductions in nutrient input (Baisre, 2006; Baisre and Arboleya, 2006; Piñeiro *et al.*, 2006).

FIGURE 3
Lobster annual landings and fishing effort trends between 1955 and 2007



There are 200 fishing boats, 250 000 fishing gears and about 1 110 fishers directly involved in the Cuban lobster fishery. The crew of the lobster boat is composed of four to six people (e.g. skipper, cook, engine operator and sailors). The boats operate in four large management zones or subareas (Figure 2), which are also partitioned into ten smaller divisions within each enterprise. The fishing boats are linked to 28 holding centres, located at sea, where lobsters are kept alive until they are shipped to the eight processing plants.

The lobster fleet includes boats made of different materials and sizes, ranging from 10 to 18 m in length. Although there are still some boats made of ferrocement, most of the lobster boats are fibreglass boats (Figure 4). One special feature of the lobster boats is a fish-well constructed in the hull of the boat which allows water circulation through holes and keeps lobsters alive for transportation to the gathering centre where it is landed daily. At the gathering centre the lobsters are kept in cages in the water before being transported to the processing plant.

FIGURE 4
Fibreglass boats used in the lobster fishery

The fishing gears include the artificial habitat *pesquero* (also called *casita cubana* in other parts of the Caribbean), *jaulon* and traps. *Pesquero* is an artificial habitat for lobster and it is used by fishers mainly between May and September (e.g. during the open season). To remove the lobsters a net is placed around the artificial reef. Then the lobsters are scared out by shaking the *pesquero*, trapping the lobsters in the net. This operation is carried out by two men on a small boat. Other techniques used include the bully net or free diving for lobsters. More recently, a new type of *pesquero* has been built, which can be lifted from the vessel with a winch and then the lobsters can be extracted. In the southeast region, old car tyres are also used as artificial reefs.

Jaulon is a 5-cm chicken-wire mesh or large plastic trap used during the lobster winter migration, between October and February. The mesh has two 40-m long wings beside the entrance, which can be adjusted to increase or decrease the effective fishing area.

The traps used are 5-cm chicken-wire mesh traps set during the whole fishing season. These are common in the northeast region.

2.2 Finfish fisheries

In Cuba, approximately 150 different species of finfish are harvested. Following Baisre (1985a), the principal species can be grouped as follows:

Demersal
- Estuarine:
  - Mugilidae (mullets)
  - Gerridae (mojarras)
  - Other species (snooks, croakers)
- Grass meadows and reef zones:
  - Lutjanidae (snappers)
  - Serranidae (groupers)
  - Haemulidae (grunts)
  - Other species (numerous)

Pelagic
- Littoral:
  - Clupeidae (sardines and Atlantic thread herring)
  - Engraulidae (anchovies)

Coastal
  - Carangidae (jacks)
  - Scomberomorus (mackerels)
  - Inshore sharks (numerous species)

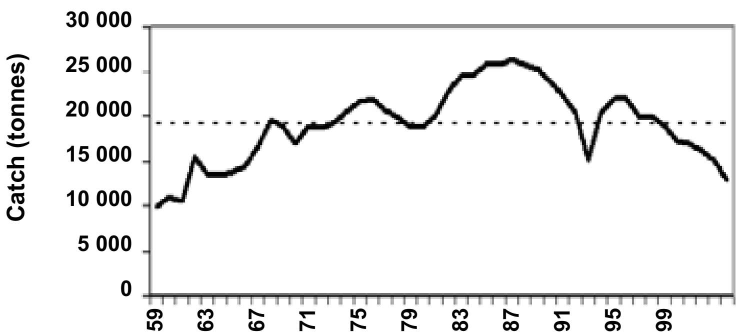
Oceanic
  - Oceanic sharks (various species)
  - Tunas (skipjack, blackfin and yellowfin)
  - Billfishes (marlins and swordfish)

Pelagic species represent 37.6% of the fish captured. Between the inshore groups there are some representatives of clupeids (sardines, Atlantic thread herring). Jacks (horse-eye jack, blue runner, bar jack, etc.) constitute a large group, mostly inhabiting offshore waters, but sometimes penetrating estuarine areas. The same occurs with other pelagic species such as sharks and different species of *Scomberomorus*.

The finfish fishery occurs from all fishing ports (Figure 2), along the whole continental platform of the country. Catches of fishes started to rise in 1959 and reached maximum value around 1986 and 1987. Since then, the catches decreased continuously and currently the stocks of the principal commercial species are considered fully exploited and in some cases overexploited (Figure 5).

Demersal fishes represent 62.4% of finfish captures in the Cuban shelf. In this fishery, mullets and mojarra are found in estuarine and littoral zones, while grunts, snappers and some groupers inhabit reef and rocky bottoms, near grass meadows (*Thalassia*). In deeper waters by the edge of the shelf, there are bigger and more specialized species of snappers (silk snapper) and groupers.

FIGURE 5
Historical catches of finfish in Cuban waters



Lutjanidae is the fish family of higher economical importance for the Cuban fishery. This group comprises 7.5% of the national capture and 21% of fish catches, especially the lane snapper (*Lutjanus synagris*), mutton snapper (*L. analis*), grey snapper (*L. griseus*) and the yellowtail snapper (*Ocyurus chrysurus*).

Seasonal landings are the result of fishing a variety of species. For instance, many species are fished during their reproductive season. The most significant spawning aggregations under fishing exploitation are lane snapper, mutton snapper, grey snapper, mullets, Nassau grouper, blue runner and billfishes.

The absence of territorial rights between different enterprises complicates the current statistical system and makes it difficult to assess the potential of different regions because various enterprises operate in the same fishing zone, competing for the resources without a clear benefit for the domestic fishery economy.

Most of the boats utilized for the finfish fishery in Cuba are made of ferrocement and wood, with only few made of fibreglass. The length ranges from 15 to 20 m (Figure 6). In 1988, the fleet was composed of around 840 vessels, but in 1998 this number decreased to 400 vessels.

The most common fishing gears used in this fishery are pots, nets, fixed nets (*tranques*), gillnets, longline (bottom and surface) and trawlnets. Castile pots, bottom longlines and vertical longlines are used in the fishery for deep snappers. In oceanic waters, the Japanese pelagic longline is used to fish tuna and pelagic sharks, but is limited to 300 hooks. For fishing small tunas there is a fleet of 18 baitboats.

Nets are used mainly in shallow waters and in coastal lagoons. The most common nets are the trawling nets, fixed nets and gillnets. The common trawlnet (*chinchorro*) is between 800 and 1 000 m long (8–10 m high). These trawlnets are used in broad flat areas (seagrass meadows and sandy areas), where they are pulled by two 15 to 20-m boats for two to three hours. This fishing gear is used mainly in the northeastern region of the country.

FIGURE 6
Ferrocement vessel used in the finfish fishery

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

The Ministry of Fishing Industry of Cuba registered a total of 42 012 workers (25 457 are males and 9 076 are females). Women do not participate in harvesting, but they can be found in all the other stages of the process. The labour distribution by categories is presented in Table 1.

TABLE 1
Labour distribution in the fishing activity in Cuba

Affiliation	Number of people
Fishers	7 479
Directives	3 727
Technicians	6 149
Administrative	1 134
Services	4 378
Workers	19 145

To learn about fishers' experiences in the fishery, 105 lobster fishers from two companies were interviewed through surveys. The results show that 53.3% of them have more than 20 years dedicated to fishing lobsters, confirming the labour stability of the fishers.

Education in Cuba is free and mandatory up to grade nine, unlike other developing countries in Latin America, which makes the level of education of fishers above basic compared with countries in the same region. For instance, the captain and the engine operator of the boats must have qualifications at the technical level. Cultural and sport activities are frequently organized in the fishery communities.

Fishery communities have a variety of services including running water, sewage systems, free medical services, primary and secondary schools, shopping centres, community social centres and postal offices. In these communities, fishers are considered well paid and, in general, they have comfortable houses. A retirement fee is paid to fishers when they attain 60 years of age for men and 55 years for women. The amount of this fee is estimated from the number of years worked and the income from the last ten years. In order to benefit the worker even more, the best five years are taken into account.

Currently, a share system is in place among fishers. Fishers receive an amount of money according to their catch (by kilogram of lobster or shrimp landed). They receive payment according to the quality of the product. From the amount earned in each trip, fishers subtract operating costs (ice, fuel, food), and 5% which is used for social security. They receive the remainder in two instalments, 80% in Cuban pesos and 20% in United States dollars. The amount of money they earn improves their personal incomes significantly.

Fishers are affiliated with a union which advocates for the protection and fulfilment of their rights and defends their interests before the managers of the enterprise. In addition, if fishers need financial assistance to cover various expenses (e.g. boat or engine repairs) during the closed season, they have open access to credit, which can be paid back when they earn more money (e.g. during the periods of higher abundance).

Generally, fishers are invited to participate in the meetings of the Fishery Advisory Committee, which is the main board of the Ministry of the Fishing Industry, to present, discuss and approve the principal guidelines of fishery regulations and management before they are adopted. Participants include the principal officers of the Ministry of the Fishing Industry, fisheries scientists and representatives of the Ministry of Science, Technology and Environment, Havana University, tourism, and from other related organizations within the fishing industry. Aside from the regulations revised in this committee, allocations of territorial rights are granted to the lobster and shrimp fisheries. Each enterprise has its own territory previously defined and they define access to newcomers; generally, the presence of other vessels is not allowed.

In the last few years, there has been an increasing effort to promote conservation of fish stocks and their habitats, as well as the implementation of marine protected areas (MPAs). There is a plan to include 20–25% of the Cuban shelf in marine protected areas in the near future.

4. ASSESSMENT OF FISHERIES

4.1 Lobster fishery

Historically, assessments of the spiny lobster resource in Cuba have been based on several types of analysis, including prediction of future catch based on patterns of juvenile settlement (Cruz *et al*., 1995b); yield-per-recruit analysis (Puga *et al*., 1995); virtual population analysis (VPA) (Puga *et al*., 1996, 2005, 2006); surplus production models (de León *et al*., 1991; Puga *et al*., 2003); and Delury depletion model (González-Yáñez *et al*., 2006).

In Cuban waters, reproduction occurs all year with the largest number of breeding females between March and May and a secondary peak in September. The smallest length of a captured breeding female was 67 mm CL (carapace length) (Cruz and de León, 1991), and the estimated lengths at maturation at 50% and 100% were 81 mm and 97 mm CL, respectively.

Puga *et al*. (1999) used a Thompson and Bell analysis based on information from the fishery between 1992 and 1998 in the south zone of Cuba. To introduce risk analysis while testing alternative management options, a stochastic variant of the model was used taking into account the uncertainty of some of the biological parameters. In addition to this analysis, Puga *et al*. (2003) adjusted the biomass dynamic model to the catch per unit effort series from 1991 to 2001 with a catch series from 1928 to 2001, taking into consideration observation errors in catch and fishing effort, and the structural error in the method of calculation of the catchability coefficient. The goal of this is to assess the status of the resource in relation to some bio-economic reference points.

By comparing lobster catches from the 1980s to current trends, a reduction of 42% of landings has been observed at the national level (Puga *et al*., 2006). The results of all assessments undertaken in Cuban waters suggest that the lobster fishery is fully exploited. The last stock assessment indicates a potential catch around 8 000 tonnes (Puga, 2005). Recruitment patterns show a declining trend since the 1980s and currently reductions of 37% in the south and 49% in the north have been reported (Puga *et al*., 2006). Taking into account this situation and the accumulative effect in habitat damage, the current potential catch is likely to be around 6 000 tonnes.

4.2 Finfish fishery

From all species captured by the finfish fishery in Cuban waters, one of the most important is the lane snapper, especially in the Gulf of Batabanó. Cruz (1978), using a surplus production model, estimated the MSY for 1978 at 3 300 tonnes. The author has raised concern about certain levels of overexploitation since 1975 and suggested an increase in the minimum legal size to 17 cm. Carrillo (1979) reported lower levels of biomass for the MSY (2 310 tonnes for the entire Gulf of Batabanó, and a MSY of 1 920 for the eastern part). Obregón *et al*. (1990), using a production model with mortalities, estimated the MSY for lane snapper between 220 and 251 tonnes for the northeastern platform. Valle (2003), using a dynamic production model (Praguer, 1994, 2000), incorporated uncertainty and estimated the MSY at 128 tonnes, concluding that this stock is overexploited and suggesting some alternative strategies for biomass recuperation. Baisre (1985b) suggested growth overfishing combined with recruitment overfishing for this fishery, due to the use of very productive and no non-selective fishing methods (*tranque*). After this period, some management measures were put in place: reproductive closure from April to June, minimum legal size of 18 cm and catch quotas. After 15 years, some signs of recovery were assumed; however, new assessments performed by Valle (1997, 2001, 2003), using different approaches (Csirke and Caddy, 1983; Caddy and Defeo, 1996) and considering uncertainty in the parameters, concluded that the stock was overexploited (MSY = 1 009 tonnes ±183 tonnes).

Pedroso *et al*. (1986) assessed the lane snapper in the northwest platform of Cuba using Beverton and Holt models. They determined a recruitment of 2.7 million individuals and a potential annual catch of 268 tonnes; similar results were obtained ten years later through VPA by Valle (1996). By using a VPA analysis and Dynamic Production Model (Hilborn and Walters, 1992; Darby and Flatman, 1994), Valle estimated a potential catch of 268 tonnes. Some other assessments have been performed in other species such as yellowtail snapper and grey snapper using mainly surplus production models and VPA. For these assessments, uncertainty was not considered.

5. FISHERY MANAGEMENT AND PLANNING

The commercial fishing industry of Cuba is an important source of fishery products originating from the Gulf of Mexico and Caribbean region. The Ministry of the Fishing Industry (MIP) is the agency in charge of directing and implementing the policies of the State and Government concerning research and the conservation, extraction, processing and marketing of fish resources.

Aiming to improve economic efficiency and sustainable use of fishery resources, a change in management focus has been in place. Probably the most significant change in the MIP includes the decentralization of the day-to-day operations of the harvesting sector. The MIP was in charge of the legal and regulatory activities (i.e. administrative functions, enforcement, stock assessment, etc.), while the production enterprises were delegated to control most day-to-day productive activities and services. To facilitate the introduction of policy changes aimed at decentralization, a new overall organization structure was created within the MIP. The central idea of the new MIP structure is to incorporate modern entrepreneurial and management techniques via more horizontal and flexible structures called ‘associations’ (at present, these associations receive the name of Industrial Fisheries Enterprises). These associations were created to bring decision-making and responsibility closer to the point of production thereby increasing the efficiency of the economic activities (i.e. fleet operations) related to fisheries harvests (Adams *et al*., 2000).

The new MIP structure consists of numerous divisions, fisheries-related associations, the National Fishery Inspection Office (ONIP), and the Fisheries Research Centre (CIP). All of these units are subordinated to the minister. The associations consist of 15 provincial fishing associations (PFAs) and six other associations which have specific logistical responsibilities.

A PFA is located within each province, including the Isla de la Juventud. These PFAs are responsible for producing shellfish and finfish landings in compliance with the species-specific harvest plans. These plans are developed by the associations themselves, then consulted with and approved by the Executive

Board of the MIP. The PFAs have independent control over productive resources (i.e. vessels, fuel, supplies, ice, labour, etc.). The PFAs also have control over the number of vessels in operation, as well as ensuring the enforcement of a variety of regulations, including animal size restrictions, gear restrictions and closed seasons. The other six associations provide the necessary resources and logistical support for the PFAs. They also assist in feasibility studies of proposed projects with the overall purpose of broadening fisheries market potential, finding new business opportunities, and further development of other activities of common interest (Adams *et al*., 2000).

The principal rules for fishery management are included in the Decree-Law No. 164 'Fishery Rules', approved by the Government of the Republic of Cuba on 26 May 1996.

Some of the more important aspects of this law are:

- The establishment of a System of Fishery Authorizations, through which each vessel must hold a licence, which is granted by year.
- The control and supervision of all fishery regulations is performed by a National Office of Fishery Inspection, which has 200 inspectors in charge of enforcement of the regulations. Also, a system of penalty and sanctions exists for those who do not comply with the law.
- The Commission of Fishery Consultation is the council for advice and consultation that establishes regulations. In this council, commercial and recreational fishers, state enterprises, universities, the Ministry of Science, Technology and the Environment, and other interested organizations (tourism, mining, transport, etc.) are represented.
- The Centre for Fisheries Research proposes measures of fishery regulations; these measures are analysed in the Commission of Fishery Consultation and finally approved by the Minister of Fishing Industry. The Director of Fisheries Regulations is in charge of the implementation of the resolutions and the management measures, and the Office of Fishery Inspection is responsible for control and enforcement of the regulations. Regulations regarding each particular fishery are summarized in Table 2.

5.1 Lobster fishery management

One of the most important characteristics in fishery management of lobster is the allocation of territorial rights for fishing to the different fishery enterprises. Such grants at enterprise level are shared between the boats operating on each enterprise. Due to the fact that the artificial shelter (*pesquero*) is a fixed gear, which can remain at the bottom for long periods, they are exposed to being fished by other people and not necessarily by who did the investment, construction, movement and placing of the shelters in the most convenient places. With this system, fishers have their own territory and, in some ways, they 'cultivate it'; the sense of property helps them to invest on their grounds, repair their gears, take care of the bottom, and obtain benefits which tie them to their territory. Special management regulations for these species are in place and reported in Table 2.

5.2 Finfish fishery management

It is obvious that the only way to avoid the collapse of a fishery or economical losses is through the regulation of fishing effort. In the finfish fishery in Cuba, the principal fishing regulations are based on the establishment of legal size limits for different species of fish, and regulations of the size of the meshes in gillnets, traps and in the cod-end in trawling nets (Table 2).

TABLE 2
Summarized information regarding regulations applied to the main fisheries in Cuba

Regulation	Lobster	Finfish
Closures	Reproductive closure of 120 days between February and June	Seasonal closure during reproductive season
Legal size limits	Minimum legal size of 76 cm cephalothorax length	Legal size limits for different species; maximum sizes in length or weight for species suspected of having 'ciguatera' poisoning
Territorial rights	Territorial division by enterprises	-
Landing regulations	Prohibition of land reproductive females	-
Others	Prohibition to fish in nursery areas	The use of fixed nets known as *tranques* is banned in the Cuban platform; eventual elimination of all the trawlers in Cuban waters; regulations of the size of the meshes in gillnets, traps and in the cod-end in trawling nets

At present, the status of the principal commercial species of fish in the Cuban platform is critical, showing symptoms of overexploitation. This is primarily due to massive fishing gears, such as fixed nets (*tranques*), being deployed across the path of spawning fish. The other fishing gear that has contributed to the overexploitation of different commercial species is the trawling net, which is a non-selective gear capturing a great number of juveniles.

Recently, the direction of the Ministry of the Fishing Industry, in order to protect finfish species and achieve the recovery of the stocks, signed two new regulations. The first one is to ban the use of the system of fixed nets known as *tranques* in the Cuban platform to protect the migration of the spawning aggregations. The second regulation is the gradual elimination, in a period of four years, of all the trawlers in Cuban waters. It is expected that these astringent measures can contribute to the recovery of the depleted fish populations in the Cuban shelf.

6. RESEARCH AND EDUCATION

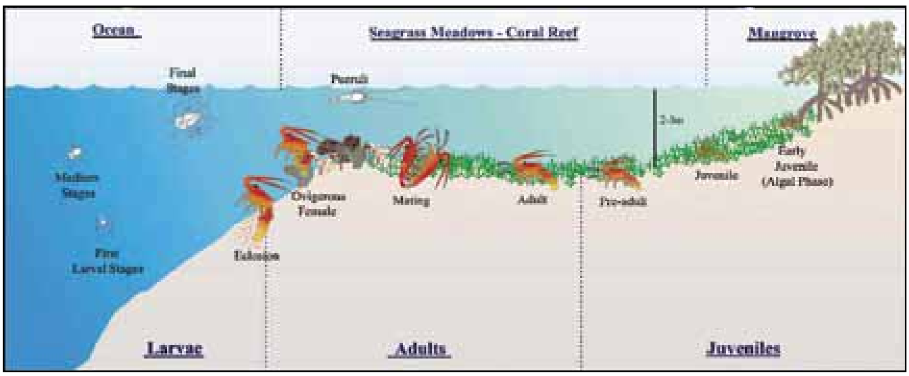
Commercial statistics collection has always been an important task undertaken in order to be able to provide information to make management decisions. For the collection of primary information, there is a group of professionals and specialists in each fishery enterprise comprising a 'Capture Board' who, methodologically assessed by the Centre of Fishery Research, are in charge of the survey trips and collaborate in the collection of commercial fishery data. This information is periodically sent to the Centre of Fishery Research for their analysis and is introduced in the database of the fisheries to perform assessments.

6.1 Lobster fishery research

Research regarding this fishery covers a wide variety of disciplines given the fact that the economy of the country relies a great deal on the income derived from it. Research includes studies from the biological point of view (i.e. larvae, juvenile recruitment and population dynamics) to the socio-economic and technological analyses. Recently, studies regarding oceanographic factors that can impact biomass and catch trends of lobster populations have begun to take place (Puga, personal communication, September 2006).

The life history of lobster in Cuban waters has been described by different authors (Baisre, 1964, 1978; Buesa, 1965; Cruz *et al*., 1986, 1995a; Lalana, 1989; Alfonso *et al*., 1991; Brito and Suárez, 1994). Research in Cuba has covered almost all stages of the life cycle of the spiny lobster (Figure 7).

FIGURE 7
Life history of the spiny lobster



6.2 Finfish fishery research

Claro (1981, 1982, 1983a,b,c) and García-Cagide (1985, 1986a,b, 1987, 1988) found that size-dependent pattern of sex ratios in snappers, jacks and grunts suggest that females are more abundant in almost all length classes and reach a larger size than males. Female dominance in the population might be explained by a greater survivorship, but also by differences in habitat preferences of both sexes, such as in the grey snapper.

Patterns of sexual cell development (gametogenesis), particularly oogenesis, have been detailed in many Cuban marine species. Numerous papers contain information on this important aspect of tropical marine fish reproduction (Álvarez-Lajonchere, 1979, 1980; García, 1979; García and Bustamante, 1981;

Claro, 1982; García-Cagide and Claro, 1983; García-Cagide, 1985, 1986a,b, 1987, 1988; García-Cagide and Espinosa, 1991; Ros and Pérez, 1998).

Sierra *et al*. (2001) summarized the existing information on feeding habits of fishes in the Upper Caribbean and particularly in Cuba. The existing information on feeding should not be considered definitive. Some data from Cuba show great intraspecific differences among different regions. Large changes might also occur through time relative to environmental conditions.

Most of the available data on age and growth to adult stages of Caribbean fish are based on predictable annual marks. Research in Cuba on adult life stages has emphasized the use of rings deposited on bones (particularly the urohyal), scales and otoliths (Olaechea and Quintana, 1970; Pozo, 1979; Claro, 1983a; Claro *et al.*, 1989; García-Arteaga and Reshetnikov, 1992). Claro and García-Arteaga (2001) did a revision of the growth patterns of fish of the Cuban shelf.

7. ISSUES AND CHALLENGES

Fish resources of the continental shelf of Cuba are limited; the potential biomass available is around 60 000 tonnes. Analysis of catch trends of several resources show a historical loss of 20 000 tonnes caused by a combined effect of overfishing and changes in the marine ecosystem (Baisre, 2000). Even if some improvements in fisheries policies could help to improve the current conditions, changes in the ecosystem appear to be irreversible; hence, the fisheries in Cuban waters cannot support an increase in fishing pressure.

In Cuba, it is expected that one way to improve conditions in aquatic production to increase economic development is through: (a) improvement of infrastructure and technology for sustainable use of the resources; (b) aquaculture development; and (c) improve training programmes to increase the skills of those participating in the activity at different levels (extraction, processing, etc.). All of this should go coupled with strategies to protect the environment from which the resources depend.

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8. Coastal fisheries of the Dominican Republic

Alejandro Herrera*, Liliana Betancourt, Miguel Silva, Patricia Lamelas and Alba Melo

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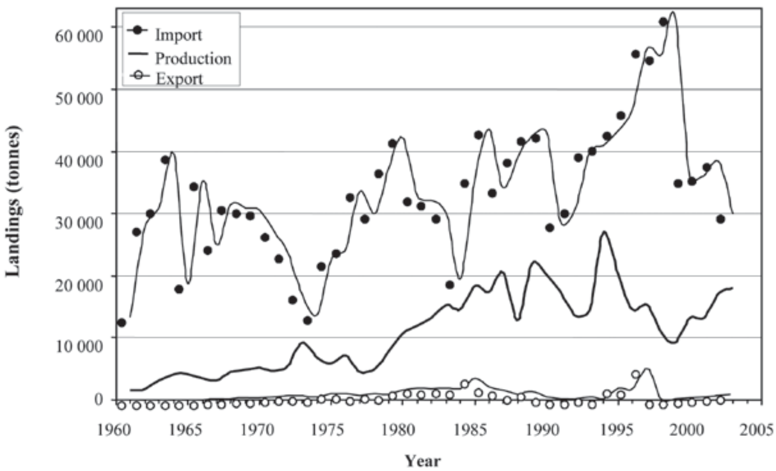
* *Contact information*: Programa EcoMar, Inc. Santo Domingo, Dominican Republic. E-mail: ongprogramaecomar@yahoo.com

1. INTRODUCTION

In the Dominican Republic, fishing has traditionally been considered a marginal activity that complements other sources of income. This, and the low impact that fishing has on the gross domestic product (GDP) (approximately 0.5%), are likely causes for the limited economical and institutional support that the fishing sector has received compared with other sectors, such as agriculture or hydro resources. Despite this, Dominican Republic fishing activity has a long history, and has developed rapidly during the last two decades. The number of fishing boats, fishers and catches has grown since the beginning of the 1980s (FAO, 2001). The fleet, which is comprised of more than 3 361 boats (98% of them artisanal), 8 399 fishers and an average annual production of 11 000 tonnes, generates significant pressure on the traditional coastal and marine fishing resources (SERCM, 2004). Nevertheless, the national demand is still not fulfilled, leaving little opportunity for export (which is estimated at 900 tonnes), which results in an annual import of seafood products averaging 34 000 tonnes (Figure 1).

FIGURE 1
Fishing production, and import and export of seafood products, of the Dominican Republic from 1960 to 2005



Source: Subministry of Marine and Coastal Resources.

Fishing activities in the Dominican Republic include more than 300 species of fishes, crustaceans, molluscs and echinoderms. These species are captured along 1 575 km of coastline, 8 000 km^2 of platform (between 0 and 200 m of depth), and 4 500 km^2 of oceanic banks and the adjacent oceanic environment, though the exclusive economic zone (EEZ) encompasses 238 000 km^2 (Figure 2).

Fishing is carried out with more than 20 different fishing gear types and methods (Colom *et al.*, 1994), and catches are landed at more than 200 sites distributed among the 16 coastal provinces (SERCM, 2004; Table 1). Specialists are amazed by the growing dynamic nature of the fishing sector in the Dominican Republic, which has been developed solely through artisanal fishers' technologies and knowledge, with informal finances and resources and little external intervention (FAO, 2001).

FIGURE 2

The Hispaniola map shows the jurisdiction of the Dominican Republic, the 16 coastal provinces, the 200 m iso-bathymetric line, the oceanic banks and the EEZ

Note: The letters indicate: MO (Montecristi), PP (Puerto Plata), E (Espaillat), MT (María Trinidad Sánchez), S (Samaná), ES (El Seibo), HM (Hato Mayor), LA (La Altagracia), LR (La Romana), SP (San Pedro de Macorís), SD (Santo Domingo), SC (San Cristóbal), PV (Peravia), AZ (Azua), BH (Barahona), and PD (Pedernales).

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Although it is not yet acknowledged, it is difficult to provide an exact definition of the fishing types in the Dominican Republic due to two key aspects of the fishing activity. First, the partially controlled fishery and open access to the fishing grounds allows for any available resource to be caught at any moment and in any accessible area of the coast, insular platform or surrounding oceanic region. Second, the Dominican Republic artisanal fishery does not target exclusively one resource. Whatever is caught is considered potentially useful for consumption or commercialization.

For the purpose of this report we based the definition of fishing types on Colom *et al*. (1994) and CFRM (2004), and have included some types which have not been previously reported. We took a general approach, based on: (a) type of resources and their fishing productivity; (b) fishing areas; (c) fishing gear exclusivity; (d) depth intervals; and (e) relevance of the resource to the national fishing regulations (Table 1).

2.1 Description of fisheries

Spiny lobster fishery

The spiny lobster fishery is the most valued in the Dominican Republic (SERCM, 2004). The key species is the Caribbean spiny lobster (*Panulirus argus*). However, this fishery includes other species such as: the spotted spiny lobster (*Panulirus guttatus*; langosta pinta), the green lobster (*Panulirus laevicauda*; langosta verde), the copper lobster (*Palinurellus gundlachi*; langostín), the slipper lobster (*Parribacus antarticus*), and the Spanish lobster (*Scyllarides aequinoctialis*) (Silva, 1994).

Colom *et al*. (1994) indicates that spiny lobster is caught with traps in the Jaragua National Park, in the Pedernales Province. Historically, the spiny lobster coastal fishery has been associated with the Sud-Occidental platform (marine protected area of the Jaragua National Park), where lobsters are especially abundant. The frequent reports of puerulus stage larvae on the trap ropes and in the shallow larvae grounds in coastal protected areas could indicate important local post-larvae recruitment. In fact, we have observed juvenile lobsters in all the stages (algal, transitional and post-algal) in the area. A shallow marine grass and algae platform of 90 km^2 offers ideal conditions for a nursery area, while 25 km^2 of rocky bottom and coral reefs provide the appropriate environment for migrating juveniles and resident adults which require sites for reproduction (Herrera and Colom, 1995).

Despite Pedernales' importance as a lobster fishing area, it is questionable to place such a high value on an extractive practice where sublegal juveniles compose 90% of the catches from this area (Herrera and Betancourt, 2003b). Pedernales is not the only fishing site; spiny lobster is subject to strong fishing pressure along the whole Dominican Republic platform up to a depth of 30 m. This is documented with ecological and fishing data in Barahona (Schirm, 1995, 1995a), Azua (Melo and Herrera, 2002), La Altagracia (Chiappone, 2001) and Samaná (Herrera and Betancourt, 2003a). Lobster is also captured on the oceanic banks, where the fishery is associated with the reef environment; however, there are no studies on this matter.

TABLE 1

Main fishing types in the Dominican Republic. Fishing gears: At (Atarraya; casting net); Ba (Raft); Bu (Diving); Chah (Chinchorro de ahorque; gillnet); Char (Chinchorro de arrastre; trawl); Cd (Line); LC (Squid line); Ml (Manual); Nb (Nasa del bajo; shallow trap); Nc (Nasa chillera; depth trap); PA (Longline); Ja Jamos; bully nets); Main fishing zones Provinces of the Coasts (PC): AZ (Azua); BH (Barahona); BN (Banco de la Navidad – Christmas Bank); BP (Banco de la Plata – Silver Bank); LA (La Altagracia); MC (Montecristi); PE (Pedernales); PP (Puerto Plata); SA (Samaná); TP (Coastal provinces platform).

Name	Key species (local name/scientific/common)	Associated habitat	Depth (m)	Distance (nm)	Gear	Type of fishery	Main fishing zones	Key references
Lobster fishery	Caribbean spiny lobster *Panulirus argus* (langosta)	Coastal/coral reef/ocean banks	0–30	≤5.3	Nb, Bu	Small-scale artisanal/ Subsistence	PE, LA, MC, AZ, TP	Herrera and Betancourt, 2003b, 2003c
Shrimp fishery	White shrimp *Litopenaeus schmitti* (camarón blanco), pink shrimp *F. duorarum* (camarón rosado), Atlantic seabob *Xiphopenaeus kroyeri* (camarón siete barbas)	Demersal/bay	-	4-15	Char, At	Small-scale artisanal/ Subsistence	SA, MC	Núñez and García, 1983; Sang *et al.*, 1997
Queen conch fishery	Queen conch *Strombus gigas* (lambí)	Coastal/ocean banks	0–30	≤5.3	Bu	Small-scale artisanal/ Subsistence	PE, LA, MC, TP	Tejeda, 1995
Reef fishery	Many fish species (Lutjanidae, Haemulidae, Acanthuridae, Balistidae, Holocentridae, Serranidae, Pomacanthidae, Pomacentridae, Scaridae, Sparidae, Labridae), crustacean (Majidae y Xanthidae) and molluscs (Cassidae, Trochidae, Ranellidae, Fasciolaridae, Strombidae and Octopodidae)	Coastal/ocean banks	0–30	≤5.3	Nb, Bu Chah, Cd	Smal- scale artisanal	PE, MC, LA, SA, PP, AZ, TP	Schirm, 1995, 1995a; Sang *et al.*, 1997; Chiappone, 2001
Deep-sea fishery in the platform border	Silk snapper *Lutjanus vivanus* (chillo), blackfin snapper *L. bucanella* (chillo oreja negra), queen snapper *Etelis oculatus* (boral), cardinal snapper *Pristipomoides macrophtamus*, (roamo), vermilion snapper *Rhomboplites aurorubens* (besugo), misty yellowedge grouper *Epinephelus mystacinus*, misty grouper *E. flavolimbatus* (meros)	Coastal	100–500	≥5.3	Pa, Nc, Cd	Smal- scale artisanal	BH, SA, PE, TP	Sang *et al.*, 1997; Arima, 1997, 1998-1998b, 1999-1999b.
Ocean banks fishery*	Silk snapper *Lutjanus vivanus* (chillo), blackfin snapper *L. bucanella* (chillo oreja negra), queen snapper *Etelis oculatus* (boral), cardinal snapper *Pristipomoides macrophtalmus* (roamo), misty yellowedge grouper *Epinephelus mystacinus* (mero)	Ocean banks	300–600	90	Pa	Semi-industrial	BN, BP	Kawaguchi, 1974; Arima, 1997, 1998-1998b, 1999-1999b.

TABLE 1 (CONTINUED)

Name	Key species (local name/scientific/common)	Associated habitat	Depth (m)	Distance (nm)	Gear	Type of fishery	Main fishing zones	Key references
Pelagic fishery or FAD fishery**	Tunas, bonitos and albacores: *Thunnus albacares* (yellowfin tuna), *Euthynnus alleteratus* (little tunny), *Auxis thazard* (frigate tuna), *Katsuwomis pelamis* (skipjack tuna), mackerels *Scomberomorus* sp. (macarelas), wahoo *Acanthocybium solandri* (guatapaná), dolphinfish *Coryphaena hippurus* (dorado) and Atlantic sailfish *Istiphorus albicans* (aguja)	Pelagic	–	≥5.3	Co, Ba, Cu	Small scale artisanal	S and NE coasts	Schirm, 1995b
Marlin fishery	Blue marlin *Makaira nigricans* (marlin azul), white marlin *Tetrapturus albidus* (marlin blanco)	Pelagic	40–100	8–32	Co	Sport	LA	Just Us, 2006
Squid fishery	Diamond squid *Thysanoteuthis rhombus* (calamar diamante)	Pelagic	300–750	3–4	LC	Small scale commercial	SA	SERCM, 2000
Pelagic coastal fishery	Carangidae (jacks), Clupeidae (herrings), Atherinidae (silversides), Hemiramphidae (ballyhoo), Gerridae, Sciaenidae (drums), Centropomidae (snooks), Engraulidae (anchovies), Sphyraenidae (juvenile barracuda), some juvenile sharks (bull, blackfin, hammerhead, nurse, reef and lemon sharks)	Pelagic/coastal	–	–	At, Co	Small scale commercial	Whole coastline	SERCM, 2004
Crab fishery	Blue land crab *Cardisoma guanhumi* (paloma de cueva), swamp ghost crab *Ucides cordatus* (zumbá), black crab mountain *Gecarcinus ruricola* (cangejo moro)	Mangrove, coastal	0	–	Ml	Small scale commercial	SA, PE, LA, MC	Ramírez and Silva, 1994
Ornamental species fishery	Many fish species: (Apogonidae, Balistidae, Chaetodontidae, Diodontidae, Grammidae, Haemulidae, Labridae, Ostracidae, Pomacanthidae, Pomacentridae, Sciaenidae, Syngnatidae, Tetrodontidae) and invertebrates	Coastal, coral reef	0–30	≤5.3	Ja	Medium scale commercial	MC	CIBIMA, 1994; SERCM, 2004

* Does not include the lobster, queen conch and reef fish fishery in the shallow ocean banks region.
** FAD: fish aggregating device.

The traps used for the lobster fishery in Pedernales catch many bycatch fish species, particularly white grunt (*Haemulon plumieri*; bocayate blanco) and spotted goatfish (*Pseudopeneus maculates*; salmonete). There are also invertebrate bycatch species caught in this fishery. These species are also considered part of the catches (Schirm, 1995, 1995a); however, the small ones and those with no commercial value are discharged. Some invertebrates, such as the starfish (*Oreaster reticulates*), are used as bait. There is no estimation of the proportion of discarded species. This fishery can be considered as a small-scale artisanal fishery and as a subsistence fishery. The fishery takes place year-round, except during the closure from April to July (Decree 316-86).

According to the Subsecretaría de Estado de Recursos Costeros y Marinos (SERCM – Environment and Natural Resources State Subsecretariat, 2004), lobster markets can be classified into three types: (a) internal consumption in restaurants, supermarkets, fish shops; (b) tourism; and (c) export. The highest consumption occurs in the tourism market, in which all the capture is commercialized and consumed fresh in the domestic market. The lobster production of the last 12 years (1992–2003) has fluctuated from minimum values of 500 tonnes in 1996 up to a maximum of 2 651 tonnes in 2002, with a drastic drop in 2003. This drop is attributed to loss of information in the fishing areas, or to a decrease in the capture due to extreme meteorological events that occurred along the Dominican coastline in 2003.

Shrimp fishery

Colom *et al.* (1994) recognize the shrimp fishery carried out with gillnets and casting nets in Sánchez, Samaná Province, as a national fishing unit, which was described by Núñez and García (1983) and complemented by Silva and Aquino (1993) and Zorrilla *et al.* (1995). This fishery started in the early 1960s, when the closure of train operations forced the local people to seek out other income sources. Three shrimp species are landed in Sánchez town (Núñez and García, 1983): the Atlantic seabob (*Xiphopenaeus kroyeri*), the pink shrimp (*Farfantepenaeus duorarum*) and the white shrimp (*Litopenaeus schmitti*). The white shrimp can be considered the key species, since it comprises between 86% (Sang *et al.*, 1997) and 95% (Then *et al.*, 1995) of the total shrimp catch.

The west region of Samaná Bay is the most important due to the fishing area extension, the resource abundance and the number of fishers involved in the fishery. The flow of the Yuna and Barracote Rivers define an estuary region of 400 km^2 in the west of Samaná Bay. Due to its high productivity, Samaná is considered the most important fishing area of the country, though SERCM (2004) indicates Manzanillo, Montecristi as another important fishing area.

The fishing gear used in the shrimp fishery catches great quantities of non-target (or incidental) species, both invertebrate and fish species, which can comprise 54% of the total catch. Sang *et al.* (1997) showed that this bycatch could include up to 24 fish families and two crustacean families. Atlantic anchoveta (*Cetengraulis edentulous*), Jamaica weakfish (*Cynoscion jamaicensis*; gogó), stardrum (*Stellifer colonensis*; mandarín chino), whitemouth croaker (*Micropogonias furnier*; corvina), hospe mullet (*Mugil hospes*; lisa), swordspine snook (*Centropomus ensiferus*; robalo) and the blue crabs (*Callinectes sapidus* and *C. danae*; portúnidos) were among the main species of bycatch. This is a small-scale fishery, which is carried out year-round except during closure, in February and March (Decree 3546-73).

The landings ranged between 125 and 200 tonnes between 1963 and 1980 (Fisheries Development Limited, 1980), and according to recent data the average catch between 1992 and 2003 has been 184 tonnes with important fluctuations (SERCM, 2004). This amount is smaller than the production figures (400 tonnes) resulting from aquaculture in other regions of the country (FAO, 2001).

Queen conch fishery

The queen conch (*Strombus gigas*) fishery occurs all along the Dominican Republic platform. This is a highly valued resource that represents between 6% and 16% of the national fisheries value. The queen conch fishery is linked to the platform areas with sea grass and algae, where juveniles and adults are especially abundant. These areas are located in the southeast of La Altagracia (Delgado *et al*., 1998; Chiappone, 2001), Montecristi (Geraldes *et al*., 1998) and particularly Pedernales, where most of the landings of the Dominican Republic take place (Appeldoorn, 1993; Tejeda, 1995, 1995b; Posada *et al*., 1999, 2000). Nevertheless, the queen conch is under strong fishing pressure along the whole Dominican Republic platform up to a depth of 30 m, as well as on the oceanic banks.

This is a small-scale fishery that takes place year-round. The fishery's main commercial target is the domestic market (fresh or frozen), with a high tourism demand. Queen conch production in the last 12 years (1992–2003) has fluctuated between a minimum of 1 200 tonnes in 1999 and a maximum of 3 000 tonnes in 1992, with an average of approximately 2 000 tonnes. The export figures in 2000 were around 300 tonnes (SERCM, 2004). Because diving is the method of harvesting, there is no bycatch in this fishery.

Coral reef fishery

The coastal reef fishery takes place on the coral reefs along the entire Dominican Republic platform, up to 30 m of depth. The main fishing locations are the wide platform areas with relevant coastal reef ecosystems, including barrier reefs (with the typical ecological zoning from the reef lagoons to the deepest frontal reef), fringe and patch reefs. Reef fishery studies have been conducted on the platforms of Montecristi (Luczkovich, 1991; Geraldes *et al*., 1998), Puerto Plata (Betancourt and Herrera, 2004), María Trinidad Sánchez (Decena and Díaz, 1982), Samaná (Sang *et al*., 1997), La Altagracia (León *et al*., 1995; Schmitt, 1998; Chiappone *et al*., 2000; Chiappone, 2001), Santo Domingo (Geraldes *et al*., 1997), Azua (Bouchon *et al*., 1995), Barahona (Aquino and Infante, 1994; Beck and Colom, 1994; Beck *et al*., 1994; Schirm, 1995, 1995a; Tejeda *et al*., 1995) and Pedernales (Schirm, 1995, 1995a; Reveles *et al*., 1997). Reef fish and invertebrates are under strong fishing pressure on the whole Dominican Republic platform, as well as in the shallow areas of the oceanic banks.

More than 100 species are caught, and they belong to typical reef species, mainly Lutjanidae and Serranidae; however, the list also includes Haemulidae, Acanthuridae, Balistidae, Holocentridae, Pomacanthidae, Pomacentridae, Sparidae, Scaridae and Labridae. These species are distributed in mangroves and sea grass (juvenile stages), as well as on coral reefs (adult stages).

An exploratory trap fishery on the Barahona reef (Aquino and Infante, 1994) indicates that there are more than 30 families of fish, with half of the catch composed by Haemulidae (27%), Scaridae (16%) and Acanthuridae (12%). In Samaná, Sang *et al.* (1997) report 29 families in the reef fishery caught with various gear in Sabana de la Mar. The study indicates that half of the catch is composed of Lutjanidae (33%), Haemulidae (15%) and Scaridae (8%). Among the most frequently reported species caught in the reef fishery are: mutton snapper (*Lutjanus analis*; sama), grey snapper (*L. griseus*; pargo prieto), lane snapper (*L. ynagris*; bermejuelo), yellowtail snapper (*Ocyurus chrysurus*; colirrubia), graysby (*Cephalopholis cruentata*; arigua), Nassau grouper (*Epinephelus striatus*), many species of parrotfish (*Sparisoma aurofrenatum* and *Scarus taeniopterus*), *Haemulon aerolineatum, H. flavolineatum* and *H. plumieri* (grunts) and *Acanthurus bahianus*.

This fishery also catches crabs (Majidae and Xanthidae), such as the coral crab (*Carpilius corallinus*; dormilona), *Mitrax spinosissimus* (centolla) and the spider crab (*Stenocionops* furcata; cangrejo araña), as well as molluscs (Cassidae, Trochidae, Ranellidae, Fasciolaridae, Strombidae and Octopodidade), cameo helmet (*Cassis madagascariensis*; lambí), West Indian Top Shell (*Cittarium pica*; burgao), Atlantic trumpet triton (*Charonia variegate*; tritón), common tulip snail (*Fasciolaria tulipa*; tulipán), *Strombus costatus* and *Stromus pugilis* (lambíes), and the Caribbean reef octopus (*Octopus briareus*; pulpos) and common octopus (*Octopus vulgaris*; pulpos).

This is a coastal artisanal, small-scale fishery mainly directed to the local market, with a high tourism demand. The fishery is characterized by the various fishing gear utilized, which relates to the species diversity: traps, gillnet, diving (including diving with compressor), and a variety of fishing lines. Traps can catch non-targeted species, and only the small species or those invertebrates which have no commercial or fishing value are discarded. There are no reports on the amount of discarded fish. The gillnet causes accidental death of many non-targeted species, including some pelagic species, which do not belong to the reef fishery. There is no estimation of bycatch numbers. This fishery takes place year-round.

Reef resources are under high fishing pressure; however, there are no production estimations of the reef fishery as a whole. For example, as we indicate later in this chapter, SERCM (2004) reports all Lutjanidae species together, without specifying whether the species had been caught in the reef fishery with trap or in the deep sea fishery at 500 m with longline. Linton *et al.* (2002) recognize that the artisanal fishery represents one of the most important challenges for the recovery of the Dominican Republic reefs, which are now lacking most of the relevant commercial species. Our numerous diving experiences in the reefs indicate almost complete absence of the fish in the Puerto Plata, Santo Domingo and Punta Cana reefs. This impact is increased by the overexploitation of fish and invertebrate species for the artisanal market that is induced by tourism.

Deep-sea fishery in the platform border

In some areas of the Dominican Republic platform, a deep-sea fishery is undertaken beneath the slope, at 100 to 500 m of depth. The most important areas are documented by exploratory fisheries, and they coincide with the areas where the platform narrows and 100-m depth can be reached a short distance from the coast by an artisanal boat. Examples of these areas are the Bahía de Neiba in Barahona (Aquino, 1994; Colom, 1994; Colom and Aquino, 1994; Colom and Infante, 1995; Tejeda and Feliz, 1995), around Isla Beata and Alto Velo, in Pedernales (Schirm, 1995b), and the north and east coast of the Península de Samaná (Sang *et al*., 1997; Arima, 1997, 1998a, 1998b, 1998c, 1999a, 1999b, 1999c).

The fishery is directed for Lutjanidae and Serranidae, in particular to seven species that could account for 80% of the catch. Such species are (listed according to their importance): cardinal snapper (*Pristipomoides macrophtalmus*; roamo), silk snapper (*Lutjanus vivanus*; chillo), blackfin snapper (*L. bucanella*; chillo oreja negra), vermillion snapper (*Rhomboplites aurorubens*; besugo), queen snapper (*Etelis oculatus*; boral), and the misty yellowedge grouper (*Epinephelus mystacinus*; meros) and yellowedge grouper (*E. flavolimbatus*; meros). Every exploratory deep-sea fishery and catch analysis shows that these are the dominant species by weight in the catch; however, the percentages of the species may vary according to the location, depth and fishing gear.

CFRM (2004) indicates another set of species as representative to the deep-sea fishery. They are: snappers (*Apsilus dentatus, Lutjanus apodus, L. mahagoni,* and *L. analis*); and groupers (*Epinephelus adscensionis, E. guttatus, E. striatus* and *E. morio*). These species are typical of more shallow waters; however, their distribution pattern does allow for them to be caught in the deep-sea fishery, though they are not dominant. Similarly, *L. synagris, L. campechanus, Verilus sordidus, Mycteroperca venenosa* and *Cephalopholis cruentata* have been reported in exploratory deep-sea fisheries. Traps, handlines and bottom longlines are the fishing gear used in this fishery.

There are more than 20 species reported as bycatch in the deep-sea fishery. The species belong to the families: Branchiostegidae, Brotulidae, Carangidae, Congridae, Holocentridae, Labridae, Mullidae, Muraenidae, Ophycthidae, Polimyxidae, Sciaenidae, Sparidae and Synodontidae. The deep-sea fishery also reports catches of shark: *Carcharinus limbatus* and *Mustelus canis* (Colom, 1994). Traps capture most of the accidental fish species (belonging to 12 families), as well as crabs (*Carpilius coralinus*) and lobsters. In deep waters, most of the catch is composed by large species. This is a small-scale fishery that applies fishing effort year-round, and it seems to be spatially allocated in seasonal spawning areas that are well known by fishers.

Deep-sea fishery on the ocean banks

There are two ocean banks in the Dominican Republic marine territory: La Navidad and La Plata, as well as other small banks in the north. The ocean bank fishery shares many species with the deep-sea fishery on the inshore platform. Nevertheless, this work separates the ocean bank fishery from the deep-sea fishery since it is undertaken more than 90 miles from land, which makes it inaccessible to most artisanal fishers. In fact, FAO (2001) considers the ocean bank fishery as a semi-industrial fishery, in which boats with decks, diesel engines, freezing equipment and ice storage, and 5 to 25 crew members, make 7- to 10-day trips to the ocean banks. Kawaguchi (1974) carried out the first exploratory fishery in the La Navidad Bank, and indicated the relevance of species such as Etelis oculatus and Pristipomoides macrophtalmus. Later papers by Arima (1997, 1998–1998b, 1999–1999b) reported 16 species and defined Lutjanus vivanus, Lutjanus bucanella, and Epinephelus mystacinus as key species other than those reported by Kawaguchi (1974). Puerto Plata and Samaná are departure ports, and bottom longline and handline are the fishing gear used in this year-round fishery, which can be limited by the hurricane season.

Pelagic fishery or fish aggregating device (FAD) fishery

The pelagic fishery occurs along the south coast, particularly in the provinces of Barahona (Lee and Aquino, 1994; Colom and Tejeda, 1995; Reyes and Melo, 2004), San Pedro de Macorís (Schirm, 1995b), Samaná (León, 1996; Sang *et al*., 1997) and the north region. The main species are yellowfin tuna (*Thunnus albacares*), little tunny (*Euthynnus alleteratus*), frigate tuna (*Auxis thazard*), skipjack tuna (*Katsuwomis pelamis*), mackerels (*Scomberomorus* sp.), wahoo (*Acanthocybium solandri*), dolphinfish (*Coryphaena hippurus*) and Atlantic sailfish (*Istiphorus albicans*). Sharks are also accidentally caught in this fishery.

This is a seasonal small-scale artisanal fishery. Nevertheless, since it targets many species (most of them are migratory species), the fishery occurs year-round, depending on resource availability. SERCM (2004) considered the pelagic fishery as a developing fishery that produced 227 tonnes in 2003. Rainbow runner (*Elegatis bipinnulatus*; macarela), jack (*Seriola* sp.; blanquilla) and barracuda (*Sphyraena barracuda*; picúa) are non-target species; nonetheless, they are caught and consumed.

Sport fishery

Since 1998, the sport fishery is undertaken in the coastal regions of Bávaro, Cabeza de Toro, Punta Cana, Boca de Yuma, Santo Domingo, La Romana and Montecristi. This activity is run by nautical clubs and it can be part of the tourist activities offered by hotels and resorts. Among the main nautical clubs which organize annual fishing contests in the Dominican Republic are the Club Náutico de Santo Domingo, located in Boca Chica, which has branches in Cabeza de Toro and Boca de Yuma, the Club Náutico de Haina, Club Caza y Pesca de La Romana and Club Náutico de Montecristi, as well as Marina de Chavón (SERCM, 2004).

This is a seasonal sport activity. The main species are the blue marlin (*Makaira nigricans*; marlin azul) and the white marlin (*Tetrapturus albidus*; marlin blanco), though other species can be included in this fishery. The white marlin is usually caught about 8 to 10 nautical miles from the coast, at 40 to 100 m depth. The fishing season for this species runs from the end of April until the end of July. The best fishing area for blue marlin is located 32 nautical miles from Punta Cana, on the Pichincho Bank, Canal de la Mona. This species is generally distributed in deeper waters, generally at 70 m of depth. The fishing season starts in June and continues until the end of August. There are no official catch statistics for these species. Tourism promotional Web sites offer some sporadic data. For example, in 2003 during 28 fishing days, 46 white marlins and 10 blue marlins were reported to be caught and released (Just Us, 2006).

Pelagic coastal fishery

CFRM (2004) refers to the pelagic coastal fishery that occurs particularly on the sea grass bottom in reef lagoons. Target species are numerous, and they belong to a wide range of families: Carangidae (jacks), Atherinidae (silversides), Hemiramphidae (balyhoo), Sciaenidae (drums), Sphyraenidae (juvenile barracuda), Gerridae (mojarra), Clupeidae (herrings), Centropomidae (snooks) and Engraulidae (anchovies). The last four families are related to outflows of fresh water to the coast, where Mugilidae (mullet) is also caught. The pelagic coastal fishery catches some juvenile sharks as well, such as bull, blackfin, hammerhead, nurse, reef and lemon sharks.

The fishery occurs year-round, catching both target and incidental species with gillnets, casting nets, hook-and-line, and occasionally traps. CFRM (2004) indicates that the most abundant species in terms of volume of catch are *Caranx bartholomaei*, with a mean annual catch of 176.20 tonnes, and *Caranx hippox* with a mean annual catch of 143.68 tonnes. However, in the case of the species used for baits, such as sardines and machuelos (*Opisthonema oglinum*), the exact volume of catch is unknown, though they can reach high values. The pelagic coastal fishery is considered a moderately exploited fishery; nonetheless, there are no data to conduct a complete assessment. The fish stocks could also be affected by coastal pollution. The fishery is unregulated.

Diamond squid fishery

The diamond squid fishery started in 2001 in the Dominican Republic under the direction of the Japanese expert Tsinchichi Arima. The fishery was undertaken on-board of the Guarionex ship, donated by the Japanese government to the Centro de Desarrollo Pesquero (CEDEP/Fishing Development Center), in Samaná (SERCM, 2004). The target species is the diamond squid (*Thysanoteuthis rhombus*), which is an oceanic epipelagic species whose mantle can reach a length of 1 m and weight of 20 kg. The species distribution area covers the tropical and subtropical waters in the world. Fishing depth ranges between 300 and 750 m, and the main fishing site is three miles off the coast, to the east of El Francés, on the east coast of the Samaná Peninsula. The diamond squid is fished with a special line for squids (squid dropline fishing). This is an artisanal seasonal small-scale fishery in the early stages of development. The fishing seasons are not clearly defined since the diamond squid's oceanic migration patterns are practically unknown. The Subsecretaría de Estado de Recursos Costeros y Marinos (State Subsecretariat of Coastal and Marine Resources) indicates that the diamond squid fishery could develop into the most important fishery in the near future (SERCM, 2004).

Mangrove crab fishery

Many species of crab are caught in the mangrove areas of the Dominican Republic, which occupy 260 km^2. The mangrove crab fishery is more relevant in the provinces that have the largest mangrove ecosystems, particularly in Samaná, Montecristi, Pedernales and La Altagracia, which total almost 70% of the mangroves in the Dominican Republic. The target species are blue land crab (*Cardisoma guanhumi*; paloma de cueva), swamp ghost crab (*Ucides cordatus*; zumbá) and black mountain crab (*Gecarcinus ruricola*; cangrejo moro), with 2003 catches of 77.83, 28.49, and 33.01 tonnes, respectively.

Though these crab species are highly commercialized and consumed throughout the country, the mangrove crab fishery has never been reported among the Dominican Republic fisheries. Nevertheless, its relevance is acknowledged since this is the most regulated fishery in the country, with seven Presidential Decrees in 37 years (Ramírez and Silva, 1994). The regulations address key fishing-biological issues, such as the prohibition to catch females (Decrees 1345-67 and 2515-72); restriction to the legal minimum length; closures (Decrees 2945-72, 976-79 and 317-86); fishing prohibitions (Decree 1867-76); and the national closure of five years from 1996 to 2000 (Decree 68-96).

Ornamental fish and invertebrate fishery

SERCM (2004) groups this fishery together with the coral reef fishery because the fishing occurs basically in the same environment. However, we considered addressing the ornamental fishery independently since: (a) the objective of the fishery is not consumption, but commercialization in aquariums; (b) the target species are small and colourful fish and invertebrate species, which do not have commercial value for consumption; (c) fishing is undertaken manually, with small bully nets and traps; and (d) currently the fishery is located only in the country's northwestern region, in the Montecristi Province. The ornamental fishery is a commercial medium-scale fishery undertaken by a small number of fishers and for which there is no precise statistical control in place.

The export of ornamental fish started in the 1980s, and currently is distributed exclusively among three companies (Tropical Seas, Petrosa S.A., Montecristi Export y Puerto Libertador S.A.), which direct the fishery to 30 species of ornamental fish and a similar number of marine invertebrates. The companies export to international markets, mainly the United States. The amount of reef species caught is not accurately known, though it has been estimated at 205 901 animals between 1996 and 2001, averaging 34 316 animals per year and 56 317 animals in 2003 (SERCM, 2004), indicating a substantial increasing trend.

The families represented in the catch are predominantly Apogonidae, Balistidae, Chaetodontidae, Diodontidae, Grammidae, Haemulidae, Labridae, Ostracidae, Pomacanthidae, Pomacentridae, Sciaenidae, Syngnatidae and Tetrodontidae. SECRM (2004) indicates that the species with highest catch volume are: blue chromis (*Chromis cyanea*; cromis azul) and Royal gramma (*Gramma loreto*; gramma real), but the Centro de Investigaciones de Biología Marina (CIBIMA) had reported other species that even today are still caught, such as Sergeant Major (*Abudefduf saxatilis*; sargento mayor), cardinal fish (*Apogon binotatus*; cardenal), banded butterflyfish (*Chaetodon striatus*; banderita), porcupine fish (*Diodon hystrix*; guanábana), spotted drum (*Equetus punctatus*; obispos) and jacknife fish (*E. lanceolatus*; obispos), small mouth grunt (*Haemulon chrysargyreum*; bocayate), slippery dick (*Halichoeres bivitattus*; doncella), rock beauty (*Holacanthus tricolor*; guinea), spotted boxfish (*Lactophrys bicaudalis*; pez cofre), blue head wrasse (*Thalassoma bifasciatum*; cabeza azul) and slender seahorse (*Hyppocampus reidi*; caballito de mar) (CIBIMA, 1994). All these species are protected by the Ley Sectorial de Biodiversidad (Biodiversity Sectorial Law) (USAID, 2002), in particular the slender seahorse which is on the Lista Roja (Red List) of the International Union for Conservation of Nature (IUCN).

CFRM (2004) indicates that statistical data also report the export of black coral, anemones, crabs, bivalves, gastropods, polychaetes, starfish, sea cucumbers and other invertebrates. The extraction of these resources can affect the equilibrium of coral reefs; however, there are no studies on this subject. Moreover, the country is losing a valuable source of organisms with bioactive substances, which are highly valued in the international market. The extraction and commercialization of these resources is regulated by Decree 318-86.

2.2. Fishing activity

Spiny lobster (Panulirus argus)

Lobster is caught along the Dominican Republic platform by artisanal fishery methods. The main fishing gear is trap. The trap could be made of chicken wire or plant fiber (Haitian traps). Most of the lobster fishing traps have a mesh size of 24 mm (if they are made of wire), and 41 mm (if they are Haitian traps). None of these traps have escape vents or biodegradable panels. The mesh used in the current traps catch lobsters of 35 to 45 mm carapace length, although 80 mm carapace length is the minimum legal size. This explains the high percentage of sublegal lobsters in shallow fishing areas on sea grass (in or close to nursery areas), which can reach 90% in Pedernales and Samaná.

Average crew size is two men fishing in small wooden boats called *cayucos* (2.9 to 6.4 m in length), wooden or fibreglass boats called *yolas* (3 to 7 m in length), or small boats called *botes* (5.5 to 8.4 m in length). Fishers set 10 to 100 traps, mainly on the sea grass bottom, between 1 and 30 m of depth, for 3 to 13 days. Some lobsters are caught by free diving (between 1 and 10 m), or with a compressor (up to 30 m) using hooks or harpoons. Occasionally, lobsters are caught with gillnets.

About 40% of the fishers at national level target lobster exclusively (SERCM, 2004). Therefore, it is estimated that 3 360 fishers and more than 1 500 boats are concentrated in this fishery. Thus, the remaining 60% of fishers may catch lobster incidentally; however, they still land and consume or commercialize their catch. It is a fact that the growing and uncontrolled fishing effort on the lobster resource and unsustainable fishing practices have caused a significant decrease in the catch, a disappearance of commercial-sized lobster, and an extinction of lobster in some regions (Herrera and Betancourt, 2003, 2003e).

White shrimp (Litopenaeus schmitti)

The white shrimp is caught in the Samaná Bay using 250 casting nets and 350 trawls, which operate from 387 *cayucos* (small boats) and an average crew of two men. About 933 fishers participate in this fishery (SERCM, 2004). Even though the resource is overexploited, the high prices and the tourism demand have resulted in increased fishing effort despite decreasing catches.

There are no biological fishery studies on the white shrimp, and the stock (already overexploited) has never been assessed. Sang *et al.* (1997) measured 492 shrimps and indicated an average of 35 mm for the cephalotorax length of white shrimp (113 mm of total length). There is a clear lack of biological information on this resource, whose life cycle in the bay has never been studied, as well as a lack of information on gear selectivity and exploitation levels.

Queen conch (Strombus gigas)

Queen conch is the most important resource in the Dominican Republic. The queen conch fishery is completely artisanal; catches are obtained manually, by free diving or diving with an air compressor on the sea grass marine bottom. It occurs in up to 33 m of depth. Crew members are two free divers, or three divers, if the diving is done with compressor. The fishery is undertaken with *cayucos*, or boats (*yolas*), whose exact number is unknown. The number of divers is also unknown. The fishery is regulated by Decree 312-86, which establishes the minimum legal fishing size at 25 cm of siphon length; and Decree 833-03, which establishes the annual closure of the fishery from 1 July to 31 October. However, there is no effective control of the fishery. In fact, the resource is overexploited in the whole country, and the reports of sublegal juveniles in catches can reach 90% (Tejeda, 1995). The species is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (UNEP-WCMC, 2006), and export permits have been temporarily suspended to protect the species.

Grouper (Serranidae)

There are about 30 species of the Serranidae family in the Dominican Republic reef and deep-sea fishery (Silva, 1994; Sang *et al.*, 1997). *Cepalopholis fulva, C. ruentatus* (graysby), *Epinephelus guttatus* and *E. striatus* (Nassau grouper) are reported in practically all reef fishery areas, while *Epinephelus mystacinus* and

E. flavolimbatus (yellowedge grouper) are reported in the deep-sea fishery on the platform border and the oceanic banks. In the case of the reef fishery, Serranidae are caught by handline, traps (made of wire of fibre, similar to the lobster fishery), or diving. In the deep-sea fishery, the fishing gear are longlines, handlines and type-Z traps that are 2.30 m long, 1.80 m wide and 0.55 m high, made with chicken wire with a maximum mesh size of 0.37 cm, and using sardines as bait.

The Serranidae catch reached 6 605 tonnes between 1992 and 2001, with an annual average of 657 tonnes. In terms of catch volume, the main species was *E. adcensionis* with an annual average of 521 tonnes, equivalent to 79% of the total catch of Serranidae (SERCM, 2004). Non-discriminatory fishing, paired with the lack of effective regulations, has caused many Serranidae species to be in a critical state in some regions of the country. Studies in Samaná (Sang *et al*., 1997) reveal that all reef species are being caught before reaching maturity. Data from La Altagracia indicate that the intensive exploitation on the reef manifests itself through population decreases, as well as decreases in species composition and size. Currently, the dominant species in terms of number and biomass are small-sized species such as *C. cruentatus* (graysby) and *C. fulva* (coney) (Chiappone *et al*., 2000), which are no larger than 35 cm (Schmitt, 1998).

There are no studies addressing the state of the Serranidae family species that are targeted in the deep-sea fishery. Thus, high exploitation on the reproductive stocks could be occurring, especially in the spawning areas where they aggregate. The Serranidae family is protected only by Decree 2099-84, which prohibits fishing during the spawning season, but the Decree does not clarify dates or species that are to be protected.

Snapper (Lutjanidae)

There are about 16 Lutjanidae species caught in the reef and deep-sea fishery (Silva, 1994; Sang *et al*., 1997). *Lutjanus analis*, *L. griseus*, *L. synagris* and *Ocyurus chrysurus* are reported in practically every reef fishery, while *L. vivanus*, *L. bucanella, Etelis oculatus*, *Pristipomoides macrophtalmus* and *Rhomboplites aurorubens* are reported in the deep-sea fishery on the platform border and the oceanic banks. The Lutjanidae family is caught with the same fishing gear as the Serranidae family: handlines, traps or diving in the reef fishery, and longline, handline and traps in the deep-sea fishery.

Lutjanidae catches from 1992 to 2003 fluctuated from a minimum of 800 tonnes in 1997 to a maximum of 3 000 tonnes in 2003 (SERCM, 2004), with an annual average of 1 600 tonnes. Like Serranidae, biological fishery studies reveal that most of the Lutjanidae species caught in the reef fishery are smaller than their size at maturity. This group is not protected by any specific regulation.

Other demersal fish

The reef fishery catches over 70 species of fish that belong to the families Acanthuridae, Balistidae, Haemulidae, Holocentridae, Labridae, Pomacanthidae, Pomacentridae, Scaridae and Sparidae, from which there is almost no information on the catches. However, Chiappone *et al.* (2000) data from ecological studies on La Altagracia reef indicate that the intensive fishery has changed the abundance ranges, density and size of the parrotfish in the region, as the most abundant species (*Scarus taeniopterus, Sparisoma aurofrenatum* and *Scarus croicensis*) have sizes that do not exceed 30 cm in length. Schmitt (1998) shows the same low density and small-size situation in the Haemulidae commercial species. Sang *et al.* (1997) data in Samaná are consistent with these examples.

Pelagic resources

Pelagic resources are comprised of a large group of tuna, bonito and albacore, mackerel (*Scomberomorus* sp.), wahoo, dolphinfish and sailfish. These species are caught in the sport fishery and in the pelagic fishery or by using FADs. The fishery can be undertaken with longline, gillnet, trolling and live baiting fishing (viveo), with or without rafts. There are no regulations to control the pelagic fishery. Pelagic fish catches increased from 2001 to 2003, reaching 217 tonnes (SERCM, 2004). This is attributed to the improvement of fishing technology and the use of rafts, as well as the fishers' sailing capacities, which allow them to work in areas further from the coast.

In terms of the exploitation of the pelagic species by the sport fishery, and by national or international tourist fishers, there are no official statistics. However, it is estimated that there are between 1 000 and 1 500 sport fishers, and about 250 boats of every size, and that more than 3 000 tourists request sport fishery services in Bávaro, El Cortecito, Macao, Punta Cana and Cabeza de Toro (SERCM, 2004).

Diamond squid (Thysanoteuthis rhombus)

Diamond squid is caught from boats with a three-man crew by dropline fishing. Currently, only 20 fishers, 6 boats and 12 types of fishing gear are involved in the diamond squid fishery. Catches per boat can reach up to four or five squids a day (E. Fermín, personal communication). SERCM (2004) indicates that in 2003 the diamond squid experimental catch was estimated at 2 tonnes. The average weight per squid was about 13 kg. There have not been any biological fishery studies for this species, whose reproduction, feeding and migratory patterns are unknown (Kazunari *et al.*, 2001).

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

3.1 Fishers' characteristics

The last SERCM (2004) census showed that the total number of fishers in the Dominican Republic was 8 399 (Table 2). Also, there are about 46 500 people indirectly employed in activities related to the fishery (SERCM, 2004).

TABLE 2
Number of fishers, landing sites and boats per coastal province

Coastal province	Landing sites	Number of fishers	Number of boats
Montecristi	8	612	225
Puerto Plata	19	1 232	342
Espaillat	4	105	48
María Trinidad Sánchez	13	435	170
Samaná	37	2 514	1 082
Hato Mayor	6	402	259
El Seibo	5	309	138
La Altagracia	10	185	143
La Romana	7	255	148
San Pedro de Macorís	8	318	185
Santo Domingo	4	228	128
San Cristóbal	4	160	57
Peravia	8	376	135
Azua	7	387	180
Barahona	13	432	192
Pedernales	12	449	229
Total	165	8 399	3 661

Source: Based on SERCM fishing census data (2004).

Most of the fishers are not dedicated full time to fishing. The Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno, Inc. (CEBSE, 1994) reports that in Samaná only 27% of fishers are exclusively dedicated to fishing. Other income activities are carpentry (6%), street/beach vending (2%), and agriculture (46%). Agriculture can be undertaken simultaneously with fishing activities. In Montecristi, 80% of coastal fishers are full-time fishers (Luperón, 1998). The percentage of fishers who are dedicated full time to fishing is related to the economic benefits of the activity. Overexploitation of resources has resulted in more and more fishers looking into alternative economical activities, making tourism (direct or indirect) related activities one of the most relevant options.

Fishing in the Dominican Republic is primarily artisanal, and it is undertaken almost exclusively by men. Very few women participate directly in this activity on-board, since working conditions are very hard and work can last the whole day. Women participate in cleaning of fish and its commercialization, either fresh or processed (fried). Also, many women's associations are oriented to the aquaculture of fish in tanks (Nolasco, 2000).

At the national level, artisanal fishers show loyalty to their fishing grounds, and are generally very territorial. For example, the CEBSE (1994) reports that 93% of Samaná fishers were born in the province. Historically, fishing has been recognized as an important traditional family economic activity. Moreover, there are family names that have been linked to the exploitation of certain fishery resources for many years.

In Montecristi, 22% of fishers have been fishing in the area for more than 25 years. However, there is also a migratory population that lives between different communities, fishing during specific times of the year and linking their fishing activity to seasonal species such as wahoo (*Acanthocybium solandri*) (Luperón, 1998). In Samaná, 40% of fishers have been fishing for more than 20 years (Silva and Aquino, 1993). This indicates the existence of a permanent fishing population that carries out a significative historical traditional fishery.

3.2 Social and economic aspects

The socio-economic studies of the fishery sector are fragmented, rare, and more descriptive than quantitative. The most recent national artisanal fishery censuses (Colom *et al*., 1994; SERCM, 2004) include only the number of fishers, fishing sites, fishing gear and boats, but do not address education or any other social and economic aspects of the sector. In general, it is understood that fishers have a low education level; however, the actual data are provided by local studies. Luperón (1998) indicates that 72% of the Montecristi fishers have completed primary studies, 18% secondary studies and 7.2% are illiterate. The workforce in the fishery has a very low educational level and a high illiteracy rate, and no fishers with any university level of education. CEBSE (1994) reports that 64% of fishers have primary educational level, 11.2% secondary level and 0.2% has reached some kind of technical or university level; 24.4% of fishers are illiterate. Only approximately 50% of fishers have some elementary educational level (SERCM, 2004).

In terms of the fishers' family structure, CEBSE (1994) is the only source of information available in Samaná, which reports between 3 and 6 people in the household, with an average of 5 people. There are households with a significantly higher number of members, reaching 12 or 13; however, these cases represent less than 1% of the total households. We have not been able to find information on family planning or family members' roles. It is known, however, that fishing activity has a family tradition in the Dominican Republic.

Unfortunately, national artisanal fisher censuses (Colom *et al*., 1994; SERCM, 2004) do not include economic income data. Therefore, the available information is scattered, dated and narrowly focused. In Montecristi, in the northwest area of the country, 58% of coastal fishers received a monthly income that fluctuated between RD$500 and RD$1 000, which was below the national minimum salary established by the government; 22% received income between RD$1 000 and RD$1 500; and 20% between RD$1 500 and RD$4 000 (Luperón, 1998). In Barahona, González *et al*. (1995) estimated fishers' average monthly income as less than RD$500. SERCM (2002) recently indicated that the average monthly income in this area was RD$3 000, and RD$4 000 in Azua. One United States dollar is equivalent to 37 RD pesos.

CEBSE (1994) shows age structural data of the Samaná fishers grouped by less than 20 years (8%), from 20 to 30 years (32%), from 30 to 40 years (28%), from 40 to 50 years (16%), from 50 to 60 years (11%), and more than 60 years (5%). These numbers are similar to the Montecristi data, where 71.2% of the workforce in the fishery is between 20 and 50 years old, with values of 29.6% and 23.2% for the age groups of 20 to 30 years and 40 to 50 years, respectively (Luperón, 1998).

With regard to the quality of life of fishers, the information available for the south region (González *et al*., 1994, 1995a, 1995b) and north region (CEBSE, 1994; Luperón, 1998), as well as the authors' experiences with fishing communities in the whole country, show that the majority of the fishing sector lacks the appropriate basic living infrastructure, medical care and education. The low educational level, low income (that must be distributed among large families), and the total dependence on fish buyers and processors are the main causes of poverty in the fishery, which has never been eradicated by any official programme.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

4.1 Community organization

Nationally, it is recognized that fishers' organizational levels are low, and generally occur circumstantially under the influence of a local leader who typically then becomes an entrepreneur. In Samaná, CEBSE (1994) reports that 81% of fishers are not organized, 16% participate in some kind of association, 2% in cooperatives, and 1% are unionized. In Montecristi, Luperón (1998) comments on the current absence of organizations, and explains that the heterogeneity of occupations and interests make it difficult to create an organizational structure that responds to the collective interests of the sector. There have been many attempts to create cooperatives, which have received fishing gear, boats, refrigerating systems, vehicles and technical assistance; however, the absence of fiscal policies and resource mismanagement have damaged the institutionalization and sustainability of these endeavors, whose goods ended up in private entrepreneurs' hands.

Nevertheless, in other regions of the country there are fishing organizations that are strong locally. They define themselves as associations or cooperative groups, though they do not differ much from each other in their organizational structure and functioning. Some organizations are simply collaborative groups with a few members united by working relationships and common problems. On the other hand, there are some organized associations with Memorandums of Understanding, administrative and accounting registry, and associated economic and social achievements. We have not found a national registry of these organizations; thus, Table 3 has been constructed on the basis of our field experience.

The engagement of fishers and community in co-management at the national level seems limited. Mateo *et al*. (2000) offers an example of a co-management experience by Jaragua Group, an NGO that works in Pedernales region, with the design of a joint programme for fishing in Oviedo Lagoon. However, the pioneer for fishing resources co-management strategies with fishers is Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno (CEBSE), an

NGO that works in Samaná region (Lamelas, 1997). NGOs have been the only successful initiators for co-management of fishing resources with fishers in the Dominican Republic. This has not been the case with governmental institutions, even though they are responsible for promoting co-management work.

TABLE 3
Some of the fishing organizations in the Dominican Republic

Coastal province	Site	Fishing organization
Azua	Puerto Viejo	Asociaciones El Progreso y Centolla (association)
	Puerto Viejo	Grupo Cooperativo Pedro Tejeda (group)
	Puerto Viejo	Asociación San Rafael (association)
Barahona	Barahona	Grupo Manatí (group)
La Altagracia	Boca del Yuna	Cooperativa de Pescadores de Boca de Yuma (coop.)
Puerto Plata	Luperón	Asociación de Pescadores de Luperón (association)
Samaná	Sánchez	Asociación de Pescadores de la Fe (association)
	Samaná	Cooperativa del Golfo de la Flecha (coop.)
	Las Terrenas	Asociación de Pescadores Unidos de Las Terrenas (association)
	Las Pascualas	Asociación de Pescadores de Las Pascualas, El Valle y La Majagua (association)
San Cristóbal	Nigua	Asociación de Pescadores de Nigua (association)
San Pedro de Macorís	San Pedro	Asociación de Pescadores del Parque (association)

As part of the strategy to integrate all social sectors in the co-management process, CEBSE created programmes for organizing the fishing sector that includes a diagnostic study for the sector. By a participative process that included hundreds of persons, CEBSE managed to identify the main problems, recommend policies, and suggest the people or groups of people who should be involved in the problem-solving process. CEBSE (1996) offers an integrated management plan for Samaná region that includes concrete actions to address the fishing sector problems with the participation of state stakeholders (Samaná Municipality), control stakeholders (Navy), financial stakeholders (Fishing Commerce and Agricultural Bank), educational stakeholders (CEDEP) and fishing stakeholders (independent fishers and associations).

4.2 Fishers' interactions with other sectors

The Dominican Republic coastal zone has tourism, ports and industry as priority uses, with tourism being the most influential activity on the fishing sector. From a socio-economic and cultural point of view, this new industry has established itself in the middle of villages that have traditionally lived on coastal resources, resulting in use conflicts, changing demographic patterns, and increasing the impact of human activities on coastal ecosystems. Tourism increased the range of impacts in coastal areas by developing new uses (to satisfy tourism demand) or by introducing non-sustainable practices.

The fishing sector's interaction with other sectors that use the coastal zone is not documented in any published work. The information provided in this work derives from the authors' experiences, as well as some isolated data from environmental impact studies and public consultation, which analyse the fishing sector as part of the socio-economic realm. For example, interaction with the tourism sector has been negative in the east and northeast, where tourism development has impacted the fishing sector. The negative impact of tourism manifests itself through the physical exclusion of the coastal zone (fishing villages and landing sites) and the marine zone (traditional fishing areas). Also, in many cases, tourism development is responsible for the relocation of fishers to sites far away from the fishing areas, causing fishers to look for other economic alternatives that are foreign to their traditions. In other cases, fishers have incorporated the possibilities that tourism offers, increasing the exploitation of highly demanded species such as lobster and queen conch. One of the worst consequences of these new practices is the extraction of reef species for handicrafts, which are sold to tourists in hotels or at shops on the beach. More than 50 invertebrate and fish species are involved in these practices, most of them protected by national and international laws. Many of these species are key species of the ecosystem and, furthermore, relevant for the maintenance of its biological equilibrium. It is also clear that overfishing of marine organisms results from the high demand of these species in tourist centres.

Another antagonistic factor between the fishing and tourism sectors is the destruction and contamination of fishing sites due to nautical and subaquatic activities, which are carried out without any educational environmental approach. This is common in diving enterprises, which are concessionaries of tourist hotels in Puerto Plata, Bávaro or San Pedro de Macorís. Most of these problems have arisen due to the lack of national policies in territorial planning and integrated coastal management, even though there are many proposals with regard to the latter that have not been pursued, such as the most recent CFRM (2004) proposal. Impacts from diving also occur during non-regulated excursions, which are undertaken with no environmental educational purposes.

Resorts established mainly in coastal areas have now been globalized, with change as well in the fishing village culture that was so attractive to tourists when tourism began its development in the Dominican Republic. Currently, we find a mix of behaviours and lifestyles that have forgotten, and in many cases neglect, the cultural values that have taken hundreds of years to develop (ABT, 2002).

There are some examples where the fishing and tourism sectors have been able to share the use of the coastal zone. In Bayahibe, La Romana, some fishers managed to integrate into the local tourism sector via an economically beneficial maritime transportation system for tourists. In the Bahía de Luperón (Luperón Bay) in Puerto Plata, the Marina Tropical Luperón (Luperón Tropical Marine) prioritized jobs for local fishers (Betancourt and Herrera, 2004).

5. ASSESSMENT OF FISHERIES

As a starting point, we should make clear that biological fisheries studies have basically taken a descriptive approach in the Dominican Republic; and traditional stock assessment methods that are based on size frequency analysis, estimation of mortality and growing parameters, cohort analysis, fishing gear selectivity, predictive modelling and others have been absent. In fact, most of the references in this report relate to works that have addressed population dynamics in a general manner, or simply have addressed general biological or ecological aspects of valued fishing species.

This is understandable when considering that most of the development of this activity has occurred outside the academic realm, without official support, and with a major autodidactic component. In fact, 75% of the national researchers' works that are cited in the Reference section belong to biologists working independently in NGOs. State subsidized academic institutions have had a smaller influence in the development of fishery biology, due mainly to the fact that their work has been directed to basic research; while independent organizations, which require financial support from international organizations for their projects, need to present applied research proposals with participation and benefits to the communities.

Only a few works have attempted to obtain production estimates in Barahona and Pedernales (Infante and Silva, 1994; Schirm, 1995; Silva, 1995) and Bahía de Samaná (Samaná Bay) (Silva and Aquino, 1994; Herrera, 2000), but they are isolated efforts. One of the main problems for fishery research in the Dominican Republic is the lack of stock assessments. As part of the Proyecto Propescar Sur (Propescar Sur Project), Schirm (1995) estimated some population parameters for four relevant fishing resources in Pedernales (Table 4), though we have not found more information on this matter.

TABLE 4
Basic population parameters for some resources in the Dominican Republic

Species	Males		Females		Combined		Measure
	$L\infty$	k	$L\infty$	k	$L\infty$	k	
Panulirus argus	21	0.24	19.5	0.28	–	–	CL (cm)
Haemulon plumieri	–	–	–	–	42	0.34	FL (cm)
Pseudopeneus maculatus	27	0.70	25	0.35	–	–	FL (cm)
Lutjanus synagris	–	–	–	–	45	0.23	FL (cm)

Source: Estimated by Schirm (1995) using FISAT Programme.
Note: $L\infty$ = maximum length; k + parameter of curvature (from von Bertalanffy growth model).

Fisheries Development Limited (1980) was responsible for one of the most comprehensive fishery plans in the Dominican Republic. Based on acoustic and exploratory research on the platform over one year, Fisheries Development Limited estimated the annual maximum fishing production. According to its results, the fishing resources on the platform (up to 200 m) and on the oceanic banks Navidad and La Plata had the annual sustainable production capacity shown in Table 5, with 1.8 tonnes/km² of yield per year.

TABLE 5
Annual sustainable production capacity tonnes of the fishing resources on the platform and oceanic banks

	Extension (km²)	Demersal	Pelagic	Total
Platform (200 to 500 m)	3 400	1 500	–	1 500
Platform (up to 200 m)	8 000	10 738	3 439	14 177
Oceanic banks	4 500	6 325	1 810	8 135
Total	12 500	18 563	5 249	238 012

Source: Based on Fisheries Development Limited (1980) and Giudicelli (1996).

These figures, which seem to be the only realistic estimation available, are also supported by later assessments, which offer similar numbers for the annual productivity of pelagic and demersal resources on the southwestern platform (1.7 tonnes/km²) (Infante and Silva, 1994) and demersal resources (0.9 tonnes/km²) (Schirm, 1995). For Bahía de Samaná (Samaná Bay), Silva and Aquino (1994) estimated a total annual production of 163.3 tonnes for demersal and pelagics which, considering catch data from Sang *et al.* (1997), they were theoretically divided in 17.6 tonnes for the estuarine littoral complex and 143.8 tonnes for the coral reef-sea grass complex, with 1.2 tonnes/km² and 0.3 tonnes/km² of yield per year, respectively (Herrera, 2000).

Giudicelli (1996) calls attention to the fact that former assessments have only taken into account coastal pelagic and demersal resources up to 180 to 200 m of depth, without considering the demersal resources of the slope at 200 to 500 m of depth and the oceanic pelagic resources. Therefore, he adds to the assessment an estimated figure for the slope demersal resources, concluding that the sustainable annual production potential for the platform, slope and oceanic banks could be around 18 500 tonnes for demersal and 5 000 tonnes for pelagic, with a total of 23 500 tonnes. This limit has already been reached; thus, we can think that all potential demersal (and some pelagic) species of the country are exploited to the limit of their maximum level. Therefore, increasing production in a rational manner would require directing the effort to oceanic pelagic resources.

As far as we know, ecosystem modelling, cost-benefit analysis, financial analysis, or risk analysis applied to fisheries have not been undertaken. The only economic fisheries assessment was done by Walter (1994), which has not been updated. León (1997) analysed the distribution, commercialization and end-point of fishing products in Samaná.

Artisanal fishery endeavors are not large enough to require undergoing an environmental impact assessment process. Artisanal fishery proposals are managed by the State. Social impact assessments directed to artisanal fisheries have not been done. However, many environmental impact studies consider this sector as a socio-economic component of the projects, and thus they are treated as secondary. Even though some works have analysed social and economic aspects of the artisanal fishery sector as we mentioned before, we cannot state that actual demographic studies of the sector have been systematically undertaken.

6. FISHERY MANAGEMENT AND PLANNING

Currently, the Dirección de Recursos Pesqueros (DRP) is responsible for fisheries management in the Dominican Republic. DRP responds to the Environment and Natural Resources Subministry, which in turn responds to the Environment and Natural Resources State Secretariat (SEMARN). The Environment and Natural Resources State Subsecratariat (SERCM) replaced the former Ministry of Agriculture (SEA), and at the moment is the only national authority for the fishing sector.

Theoretically, there is a traditional management system in place that covers the basic control, enforcement and monitoring aspects of the national fishing activities. Part of this system involves developing and maintaining a Registro Nacional de Pescadores (Fishers National Record), which considers licence applications to ensure that whoever undertakes any fishing activity is properly registered. To control the authorized fishing activity, fulfillment of the licence system and regulations are enforced, particularly fisheries closures, minimum catch size and gear. This is carried out by inspectors trained by SERCM. On the other hand, SERCM periodically collects statistics data from the freshwater and marine fisheries to assess catch trends and the degree of exploitation for the fishing resources. This provides key information for new temporary or permanent regulations at the national or local level. SERCM indicates that data are collected in eleven Fishing and Coastal and Marine Administrative Service Stations that are distributed state-wide and which receive instructions to collect field data.

Other institutions related to the fishing sector are the Banco Agrícola de la República Dominicana (BAGRICOLA), which offers loans for acquiring equipment and gear to fishing groups, or associations, and the Development and Cooperative Credit Institute (IDECOOP), which advises and certifies fishing cooperatives according to the legislation on national cooperatives. IDECOOP has implemented financing projects for equipment to cooperatives on a few occasions.

Fisheries management in the Dominican Republic has been the objective for several national plans, which coincided with the beginning of the 1980s (Fisheries Development Limited, 1980; ONAPLAN, 1983), 1990s (JICA/SEA, 1992) and

2000s (ICRAFD, 2001). The first of these plans was developed by Fisheries Development Limited (1980), in coordination with the Instituto Dominicano de Tecnología Industrial (INDOTEC), which presented a report for fishing development in the Dominican Republic that included a comprehensive compilation of former studies. This first plan also provided the first census for the fishing sector, with socio-economic, technological, commercial and biological fishing data, as well as results from exploratory fisheries and the first estimates of fishing productivity. The Planning National Office (ONAPLAN) adds some recommendations for scientific and technological policies for the fishing sector (ONAPLAN, 1983). The second plan was developed by the Japan International Cooperative Agency (JICA) that, together with SEA, elaborated the basic design of the Dominican Republic coastal fishery development project (JICA/SEA, 1992). This work analyses in detail the fishing antecedents in many regions of the Dominican Republic and provides criteria for implementing fishing projects. More recently, ICRAFD (2001) and CFRM (2004) offer a third plan that analyses the current situation, which provides practical guidance for future actions to improve the organization of fisheries in the Dominican Republic. Besides some isolated achievements, none of these plans have actually contributed to improving the socio-economic situation of the fishing sector at the national scale. Moreover, none of them have developed into a long-term plan to address and solve the multiple problems of the system.

Even though there is an institutional framework, and despite the above-mentioned plans indicating the major problems and needs, fisheries management in the Dominican Republic has not been fully successful. One of the first challenges is open access. While there is a legal requirement for fishers to obtain a fishing licence issued by SERCM, in practice, there is no adequate control; thus any resource is fished at any time of the year, on any coastal area, platform or oceanic region. Even then, the official licence does not indicate precise catch quotas, fishing areas, species to be caught or fishing gear. Therefore, fishing is an uncontrolled activity directed by economic interests. Moreover, none of the Dominican Republic's artisanal fisheries target exclusively one species. Regardless of gear type, catches are utilized for consumption or commercialization, regardless of size or quality.

This situation also reaches protected areas, such as the National Park Jaragua in Pedernales or the National Park Montecristi, where fisheries resources are under the same fishing pressure as in non-protected areas. The management plans of these protected areas include measures to protect fisheries resources, but they are simply not followed. There are several basic regulations for the protection of fishing resources at the national level; however, they cannot be enforced since there are no personnel or resources for this purpose.

The major problem relates to the institutional instability because SERCM employees are removed every four years in accordance to the electoral term. This causes loss of time, knowledge and valued personnel. Since there are no biological research institutions (either private or governmental), there is no periodical scientific assessment independent from the fishery management sector, and official reports generally focus more on achievements than on difficulties.

7. RESEARCH AND EDUCATION

7.1 Fishing statistics

One of the main challenges to organizing the Dominican Republic fisheries is the lack of standardized and continued series of timely data, which would allow for a regional and national analysis of the catch trends. At the national level, the Subministry of National Resources, under the SEA and currently SERCM, has been reporting official global data of the catch (SERCM, 2004). It is stated that the information comes from statistics obtained in various landing sites in the country. These are the only available statistics, and their reliability is questioned (Giudicelli, 1996).

Nevertheless, there have been some relevant local attempts to address this matter. CEBSE maintained the fishing statistics in Samaná for some years (Silva and Aquino, 1994; Silva *et al*., 1995; Aquino and Silva, 1995). Silva and Colom (1996) elaborated guidelines for collecting fishing statistics in the Dominican Republic. In Pedernales, Schirm (1995) offered the only known work for the estimation of fisheries productivity on the south platform, and showed the increasing trend in catches. However, these efforts were discontinued when the projects that supported them finished and are no longer up-to-date.

The catch classification system applied in the Dominican Republic is one of the problems that make statistics difficult to be obtained (Silva and Colom, 1996). Independent from where it is caught, catches are divided into special categories that follow a commercial criterion, rather than an ecological or biological criterion, and fish are grouped according to the quality and acceptability by consumers (Table 6). This also applies to many of the research catches.

TABLE 6
Dominican Republic catch classification

Categories	Groups of species
Class 1	Lutjanidae, Serranidae and Scomberidae
Class 2	Lutjanidae, Carangidae, Mugilidae, Serranidae and small Scomberidae
Class 3	Pomadasidae, Pomacantidae and Scaridae
Class 4	Acanturidae, Balistidae and others
Lobster	Lobsters from the Family Palinuridae and Scyllaridae
Shrimp	Family Penaeidae
Crab	Genus *Cardisoma, Callinectes, Mithrax*
Queen conch	Genus *Strombus*
Octopus	Genus *Octopus*
Others	Rays and sharks

Source: Silva and Colom, 1996.

This system can be useful commercially; however, it is not useful for fishing statistics. For example, Class 1 is a heterogeneous mix of snappers, yellowtail snappers, silk snappers, mutton snappers, groupers, jewfish, graysbies, and king and Spanish mackerels. This includes demersal fish such as Lutjanidae (about 20 species) and Serranidae (about 50 species), which are distributed in the mangroves and at 600 m, as well as pelagic species such as Scomberidae (about 14 species). Some of these species have clear seasonality, some represent a reef fishery, while other species represent the deep-sea fishery on the border of the platform or pelagic fishery, and they are caught with different fishing gears, making difficult any attempt of fishing effort standardization.

To analyse the catch, it is necessary to identify individual species or groups of species; thus, the current commercial classification must be complemented with biological criteria. On this subject, it has been demonstrated that the concept of ‘complex ecological fishing’ (Baisre, 1985) could be an approximation of high methodological and practical value (Silva and Colom, 1996; Herrera, 2000). One of the key concepts to achieving clear statistics is categorizing resources harvested, so that catch, effort, and size and sex composition registries can be carried out in a relatively easy manner to obtain reliable statistics.

7.2 Biological and ecological fishing research

The Dominican Republic does not have a fishing research centre, nor does it have a national research plan to respond to scientific needs for fisheries management. Some governmental institutions, such as the Centro de Investigaciones de Biología Marina (the Center for Marine Biology Research) and the Acuario Nacional (National Aquarium), have temporarily adopted these functions through specific projects. Even more relevant than these endeavors are the results obtained by non-governmental organizations, such as the CEBSE, Grupo Jaragua, Centro para el Desarrollo del Noroeste, and Programa EcoMar (CEBSE, Jaragua Group, Center for the Development of the northeast and EcoMar Programme). Despite their limitations in time and geography, these efforts have created the basis for the Dominican Republic fish biology studies over the long term (e.g. Table 4). Coastal provinces have been the pilot areas for these endeavors, and thus the available information is concentrated in those areas (Montecristi, Samaná, La Altagracia and Pedernales). There is practically no information in the remaining provinces. There is some isolated information on pelagic resources from regional institutions that have included Dominican waters in their study areas. All these results, which are presented in Table 7, belong to isolated efforts.

Shrimp fishery data: There are only general descriptive works on the shrimp fishery: key species, fishing gear and number of fishers (Núñez and García, 1983; Silva and Aquino, 1993; Then *et al*., 1995). Sang *et al*. (1997) offer some data on size and catches of accidental species.

TABLE 7
Projects that have contributed to the Dominican Republic fishing research. Coastal provinces: Barahona (BH), Pedernales (PD), Samaná (SA) and La Altagracia (LA)

Year	Name of the project	Area	Sponsors/ participants
1980	Fishing development in the Dominican Republic	General	FDL/INDOTEC
1987–1995	Promotion of artisanal coastal fishery at the south littoral	BH, PD, AZ	GTZ/SEA
1992–1996	Fishing communities involvement in the co-management of fishing resources in Samaná Bay	SA	FF/CEBSE
1993	Parks in peril: National park of the east	LA	TNC/MAMMA/ PRONATURA
1993–1996	Biodiversity inventory and characterization of the communities around Samaná Bay and Peninsula	SA	HELVETAS/CEBSE
1995–1998	Conservation and management of the marine coastal biodiversity in the Dominican Republic	MC, SA, PD	PNUD/ONAPLAN/ CEBSE/GJI/CIBIMA/ CIDEN
2002–2003	Fishing and ecological research of the lobster *Panulirus argus*	PD, SA, AZ	Programa EcoMar, Inc.

Acronyms: CIDEN: Centro para el Desarrollo del Noroeste; CEBSE: Centro para la Conservación y Ecodesarrollo de la Bahía de Samaná y su Entorno; CIBIMA: Centro de Investigaciones de Biología Marina; FDL: Fisheries Development Limited; FF: Ford Foundation; GJI: Grupo Jaragua, Inc.; GTZ: German International Cooperation Agency; HELVETAS: Switzerland Association for Development and Cooperation; INDOTEC: Instituto Dominicano de Tecnología Industrial; JICA: Japan International Cooperation Agency; MAMMA: Fundación Dominicana Pro-Investigación y Conservación de los Recursos Marinos; ONAPLAN: Oficina Nacional de Planificación; SEA: Ministry of Agriculture; TNC: The Nature Conservancy; UNDP: United Nations Development Programme.

Lobster fishery data: All the information on the lobster fishery has been recently summarized by Herrera and Betancourt (2003b–2003d), who offer the first diagnosis of the resource. Information comes from catches on 60 landing sites in the coastal provinces of Pedernales, Samaná, El Seibo, Hato Mayor and Azua, where 3 594 lobsters were measured, sexed, and had their reproductive condition assessed. Lobsters were caught between 2 and 37 m of depth, in 3 325 traps (as well as by diving or using gillnet). Sites, gear and fishing methods are described for this fishery; selectivity of wire traps and Haitian traps are compared; structure of size (by sex, fishing areas and depth) are analysed; and catch and effort data are assessed. This analysis enabled the identification of the primary problems in the management of this fishery, as well as offered specific recommendations for organization of the fishery and the implementation of future regulations. The lobster (*Panulirus argus*) also underwent a Postlarvae Recruitment Monitoring Programme, which was developed but not completed (Herrera, 1996).

Queen conch data: There are some general fishing evaluations on queen conch (Appeldoorn, 1993, 1997), but the most complete fishing-biological works are by Tejeda (1995a–1995c), which offer a complete description of the fishery in Pedernales, including size structure, habitat, distribution, morphometry of the shell, areas and fishing gear, catch data by effort unit by area and depth, and production estimations. More recent ecological work has been focused on larvae studies (Vargas and Billini, 2000) and abundance estimation, distribution, and juveniles and adults size structure in the marine protected areas in Parque Nacional Jaragua (Jaragua National Park) in Pedernales (Delgado *et al*., 1998; Posada *et al*., 1999, 2000) and Parque Nacional del Este (east National Park) (Torres *et al*., 2000; Torres and Sealey, 2002a, 2002b).

Oceanic banks fishing data: Arima's studies (1997, 1998a–1998c, 1999a–1999c) are the only data on fishing operations with bottom longline on the oceanic banks Navidad and Plata between 90 and 600 m of depth. The information relates to seasons, depth, species, catch weight and fishing effort for about 16 species, among which there are key species (*Lutjanus vivanus, Lutjanus bucanella, Etelis oculatus* and *Pristipomoides macrophtalmus*). These biological data can be the basis for future assessments of fishing stocks on the oceanic banks, and have special relevance when comparing key species on the coastal platform and the oceanic banks fisheries (Table 8).

TABLE 8
Comparison of weight data (in grams) of the species and frequency (in percentage) in the catch of four key species caught on the oceanic banks and Samaná Bay

Local name	Scientific name	Weight range (g)		Catch frequency (%)	
		Samaná platform	Oceanic banks	Samaná platform	Oceanic banks
Ruama	*Pristipomoides macrophthalmus*	92–432	227–953	0.3	93.0
Queen snapper	*Etelis oculatus*	386–964	227–2 903	0.1	90.6
Ojo amarillo	*Lutjanus vivanus*	92–1 132	454–3 629	0.3	11.6
Ala negra	*Luthanus bucanella*	154–1 364	544–1 724	0.2	10.5

Source: Based on Arima, 1999c and Sang *et al*., 1997.

Pelagic fishery: Lee and Aquino (1994) and Colom and Tejeda (1995a) offer the first data on catch-per-unit effort for the pelagic fishery with rafts in Barahona. Schirm (1995c) offers a more complete analysis in this type of fishery, including sites, fishing methods, species composition, abundance, resource seasonality, catch-per-unit effort, fishing yield, and management measures. Valdivia (2003) provides data on an experimental tuna fishery with longline. There is relevant research on pelagic species undertaken by Virginia University in oceanic waters, around Punta Cana, which includes marking and recapture of species and their habitat preferences (Graves, 2002; Graves *et al*., 2003; NOAA Fisheries, 2004). In particular, sport fishery data on marlin belong to Web pages that promote this type of fishery as a tourism option. Data include species, catch weight and seasonality (Just Us, 2006).

Fishing gear assessment in exploratory fisheries: Fishing gears have been assessed in certain fisheries, including: variation in species composition and catch for three types of traps (Aquino and Infante, 1994), the effect of trap mesh size on the size structure (Herrera and Betancourt, 2003a), and the comparison between bottom longline types in the catch of deep-sea fisheries (Arima, 1999c). Many fishing gears and methods have been tested, such as the trawl (Beck and Colom, 1994; Beck *et al*., 1994), bottom longline (Colom, 1994; Valdivia, 2003), depth line fishing (Aquino, 1994; Colom and Aquino, 1994; Colom and Infante, 1995), FADs (Lee and Aquino, 1994; Colom and Tejeda, 1995; León, 1996), handline (Tejeda *et al*., 1995) and traps (Lee, 1995; Tejeda and Feliz, 1995). All these studies provide specific data on species caught, catch volume and catch-per-unit effort.

There are inventories of fishing biodiversity in the provinces of Montecristi (Luczkovich, 1991; Geraldes *et al*., 1998), Samaná (Sang *et al*., 1997), María Trinidad Sánchez (Decena and Díaz, 1982), La Altagracia Sur (León *et al*., 1995; Schmitt, 1998), Santo Domingo (Geraldes *et al*., 1997), San Cristóbal (Terrero, 1989), Azua (Bouchon *et al*., 1995) and Pedernales (Silva, 1994; Reveles *et al*., 1997).

In general, fisheries biology studies have had a descriptive approach, whether economical, commercial, technological, social, taxonomical, or focused on gear assessment. Research on fishery biology with a long-term approach and with stock assessment of key species is practically non-existent. Despite the relevance in fishery biology of studying the size and sex composition of exploited populations with a spatial-temporal approach, there are no studies on this matter and much of the population data is inconsistent.

Due to the limited research efforts as mentioned above, according to Giudicelli (1996) it is difficult to undertake reliable assessments for maximum sustainable catch in Dominican waters. The only fisheries where population structure has been studied are queen conch (Posada *et al*., 1999, 2000) and lobster (Herrera and Betancourt, 2003b–2003d) in Samaná, Pedernales and Azua, where spatial distribution criteria has been derived for many life stages (nursery and reproductive areas), as well as direct proof of overexploitation in growing and recruitment stages. However, these fisheries have not been studied over a long enough duration to assess population parameters and thus there have been no attempts at some kind of fisheries modelling.

7.3 Fishery socio-economic research

Social and economic research on the fishery sector has not been a priority in the scarce studies undertaken, which have basically followed a descriptive approach. There are general data on the socio-economic characteristics of the fishing communities in Samaná (CEBSE, 1994), Barahona, Pedernales (Beck *et al*., 1994a; González *et al*., 1994, 1995a, 1995b) and Montecristi (Stoffle *et al*., 1994; Luperón, 1998). It should also be mentioned that Nolasco (2000) addresses gender issues.

7.4 Fishery environmental education

There are no national plans or programmes for fishers' environmental education. The NGOs have taken the responsibility of developing informative materials, as well as carrying out workshops and educational activities with fishers and coastal communities. There are important examples of environmental educational activities undertaken by PRONATURA in the Parque Nacional Submarino La Caleta (Submarine National Park La Caleta) in Santo Domingo (Vega, 1998), the Grupo Jaragua, Inc. (Jaragua Group, Inc.) in Pedernales (Reveles *et al*., 1997; Mateo *et al*., 2000), the didactic manual from Fundación Dominicana ProInvestigación y Conservación de los Recursos Marinos (MAMMA – Dominican Foundation for Research and Conservation of Marine Resources) (Geraldes *et al*., 2001), and the workshops in ecology and conservation of the lobster, carried out at the national level by Programa EcoMar, Inc. (EcoMar Programme, Inc.).

The only centre devoted to fishers capacity building is the Centro para el Desarrollo y Entrenamiento Pesquero (CEDEP – Center for Fishery Development and Training) in Samaná (SEA, 2000). This centre was donated by the Japanese government through the Japan International Cooperation Agency (JICA) and it is managed by SERCM. According to SERCM (2004), 150 professional fishers have been trained in the country, especially in Samaná and surrounding areas. This is a very low number considering that the centre has sufficient resources to train at least 50 fishers per month in its facilities.

JICA has provided important support to the development of artisanal fishers in Samaná. Japanese specialists have developed educational materials on every issue that could be relevant for artisanal fishers, such as freezing equipment, fish preparation and conservation, gear, fishing methods, use of GPS and ultrasound, repairing and maintenance of boats and engines, and basic knowledge on fishing cooperatives (Saito, 1999). All of these materials are in Hara's (1999) Manual of Fishery Techniques and Knowledge introduced in the Dominican Republic.

According to SERCM (2004), approximately 1 660 fishers in the south region received assistance from PROPESCAR-Sur, either in administration matters or in social organization and business management.

8. ISSUES AND CHALLENGES

Currently, there is much strength that we can rely on to improve the fishery system in the Dominican Republic. First, despite the above-mentioned deficiencies, there is a history and institutional organizational basis for the management and ordering of fisheries. Second, key issues are clearly identified for the main resources, as well as the necessary measures to start solving the problems. Third, there is a group of technicians who can face the challenge of taking fishery biology to a new level of development. Fourth, the development of the Environmental Management System (Sistema de Gestión Ambiental), promulgated by the Natural Resources and Environment General Law (Ley General de Medio Ambiente y los Recursos Naturales), provides the setting for addressing fisheries resources and coastal community impacts.

However, there are many gaps that have to be addressed in order to take advantage of the above-mentioned strengths, such as the lack of institutional assessment, management and fisheries control, as well as the absence of national plans for short-, mid- and long-term development, existing fragmented fishery legislation without efficient enforcement mechanisms, lack of reliable and precise fishery statistics, and the absence of fishery research institutions with scientific sustainability criteria to undertake socio-economic studies directed to the fishery sector.

The establishment of management institutions that are independent from the dynamics of the national political sector is one of the major challenges that the fishing sector faces. There is need for stable, experienced, responsible and knowledgeable institutions to develop and implement a long-term National Plan for Fishery Development in the Dominican Republic (Plan Nacional para el Desarrollo Pesquero de la República Dominicana). This plan must have an open scientific vision, promote modern and efficient legislation, include reliable statistical fishery systems, represent the reality of the national fishery in every aspect, position the country as a leader in fishery resource management, and firmly support international fishing commitments. One of the national challenges would be to create a scientific institution responsible for undertaking fishery biological studies of the national resources. This would concentrate the national experience and would assure (through research and projects) a move from the current descriptive research to the assessment and modelling of fisheries.

8.1 Institutionalism

If we really want to start assessing and managing our fisheries resources in a rational manner, the Dirección de Recursos Pesqueros (DRP – Fishing Resources Directorate) of SERCM must become a scientific institution for national fisheries management (stable and long-lasting), independent from political changes, rather than the current situation where office personnel are removed every four years. It would be necessary to implement policies for hiring technical personnel, as well as developing specific programmes to educate the authorities in the sustainability of coastal zone management concepts. The fishing sector requires clear administrative direction by implementing strategies based on technical, ecological, economic and social criteria to achieve rational management.

8.2 Fishery sector plans and policies

It is necessary to review the fishery plans developed since 1980 to the present, to identify the positive aspects related to fisheries development and elaborate a unified and definitive National Plan for Fishery Development in the Dominican Republic, which would identify solutions for all the sector's issues and gaps. Based on the changes in the world economy, this plan should consider a subject that has never been addressed before: the relationships between the fishing sector stages (commercialization, distribution, export and import) to establish the sector trends in relation to current global economy processes. It is necessary to develop clear policies for each of the sector components, especially for the most vulnerable element: the fishers.

8.3 Diffusion and fishery legislation

It is necessary to develop pieces of legislation unified in a General Law of Coastal and Marine Fishery Resources in the Dominican Republic to incorporate the country's international commitments. Legislation should be explicit in terms of the resources being regulated and the specifications of the minimum legal size, closure periods and protected areas; and the legislation must be based on the ecological and biological scientific knowledge of fishing resources. Regulations for those resources that are not yet regulated should be developed, and stricter legislation should be assessed for protected resources. Regulation should clarify that fisheries' resources cannot be exploited prior to the undertaking of experimental fishing and population assessments. The updating and complementation of fisheries legislation should be accompanied by efficient administrative and enforcement mechanisms, as well as by effective diffusion mechanisms that reach every level of the fishery sector. Environmental education programmes should be developed by governmental and non-governmental institutions to teach the biological, ecological and conservational aspects supporting the regulations. This would allow for understanding the regulations as a means of preserving the resources that support the fishery, and not just as restrictive rules. In this sense, diffusion of the FAO Code of Conduct for Responsible Fisheries is essential.

8.4 Fishery statistics

It is necessary to implement a national fishery resources organizational system that includes economic (commercial categories) and ecological (resources, fishing type, fishery ecological complex) criteria to define general categories, which would provide the basis for the systematic compilation of the fishery biological information. It is necessary to develop and maintain a fisheries statistics system for the Dominican Republic, which would include a permanent inventory of species composition, length, weight, catch, effort, as well as other fishery biology data to assess the evolution of the fisheries and develop predictive models. To contribute to controlling fishing activities it is necessary to start planning the establishment of catch assessment and monitoring centres in at least some key areas in every coastal province, in particular those with major potential such as Montecristi, Puerto Plata, Samaná and Pedernales.

8.5 Establishment of INDOPESCA

An important aspect for the assessment and management of the Dominican Republic fishery would be the creation of the Instituto Dominicano de Investigaciones Pesqueras (INDOPESCA – Dominican Fishery Research Institute). INDOPESCA would be responsible for designing and implementing the fishery biology research plan, which should include comprehensive studies of distribution processes and life cycles of the fishery resources, as well as address, for the first time, relevant aspects such as stock assessment and population dynamic studies of our main resources. It should also include fishery productivity estimates, with an emphasis on important areas such as the slope edge and La Navidad and La Plata oceanic banks which encompass highly valued reproductive stocks. INDOPESCA would also be responsible for baseline social and economic studies of the fishery sector, as well as advising official institutions for the protection of fishery resources through cutting-edge assessment and management criteria. Moreover, INDOPESCA would play the main role in fisheries environmental education and technical assistance to the national fishery sector.

8.6 Conventions/agreements and organizations/institutions

It is essential to review and update the national and international agreements on fishing and fisheries resources, which have been subscribed to by the Dominican Republic. Therefore, it is crucial to create an office to address these issues while working closely with the Ministry of International Affairs. It is crucial to analyse our participation in and commitment to current agreements, and identify inaction on agreements that could be relevant for national development. The same applies to our involvement in regional organizations or institutions related to fishery cooperation. This would allow for improving the fishery sector with international financial and technical support.

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9. Coastal fisheries of Grenada

Roland Baldeo*

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1. INTRODUCTION

Grenada is one of the small island developing states in the eastern Caribbean. It comprises the main island by that name, the inhabited islands of Carriacou and Petit Martinique, and several uninhabited smaller islands mainly off the northeast and southeast coasts (Figure 1). It is located in the Caribbean Sea between latitudes 11.5° and 12.5° north and longitudes 60° and 61° west. The main island of Grenada has a width of 18 km, a length of 34 km, a coastline of about 121 km, an area of 340 km^2, and its highest point reaches nearly 900 m. Carriacou, located 24 km to the northeast of the mainland, is less mountainous and has an area of 34 km^2. Petit Martinique is 2.3 km^2 and lies east of the northern part of Carriacou (FAO, 2006).

* *Contact information*: Fisheries Officer. Fisheries Division. Ministry of Agriculture and Fisheries. St. George's, Grenada. E-mail: rolandbaldeo@hotmail.com

Grenada has a relatively large insular shelf area of 3 100 km². The shelf is narrow on the western coast, extending from shore less than 1 km to 200 m depth. From the southeast to the northeast, the shelf varies in width between 4 and 12 km, and extends to the west-southwest in a 19-km-wide tongue for about 32 km. Depths on the shelf vary from 40 to 80 m with average depths of 30 to 40 m. In the Grenadines, the shelf is from 20 to 60 m deep over the greater part of the area. Ocean currents generally flow from the east-southeast towards the northwest. Sauteurs and Isle de Ronde are at the north of the island, and Gouyave is on the west (FAO, 2006).

FIGURE 1
Geographic location of the island of Grenada

Source: FAO, 2006.

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

Grenada's most important fishery targets coastal pelagics within the country's exclusive economic zone (EEZ). The main species targeted are:

Yellowfin tuna	(*Thunnus albacares*)
Blackfin tuna	(*Thunnus atlanticus*)
Albacore	(*Thunnus alalunga*)
Blue marlin	(*Makaira nigricans*)
Swordfish	(*Xiphias gladius*)
Atlantic sailfish	(*Istiophorus albicans*)
Dolphinfish	(*Coryphaena hippurus*)
Wahoo	(*Acanthocybium solandri*)
King mackerel	(*Scomberomorus cavalla*)
Bigeye scad	(*Selar crumenophthalmus*)
Round scad	(*Decapterus* sp.)

The fishery is essentially medium-scale commercial in which the entire catch is sold. Grenada's fishery does not record bycatch since there is a market for all species captured. Because the main species targeted are migratory pelagics, there is an element of seasonality both in effort and catches. Catches of pelagic species are most prevalent between October and July; however, this does not imply a totally inactive period in between where catches approach zero. In this context, one may argue that the fishery is essentially year-round.

2.1 Beach seine fishery

The beach seine fishery in Grenada has been researched and described by Finlay (1996). It targets coastal pelagic species in bays around the islands of Grenada, including jacks, round robins, rainbow runners, sprats and anchovies.

In 1994, there were 41 large beach seines operating in Grenada, operated by 289 fishers, most of whom are not the owners of the gear (Finlay, 1996). About 25% of the seines in Grenada were based in Gouyave, and only one or two out of the more than a dozen have been owner-operated. Net units are operated by groups of six to eight fishers who position themselves at a fishing location and take turns fishing. Fishing practices are governed by a well-defined set of 15 traditional rules enforced at the haul by the seine net community. The rules institutionalize how fishers stake a claim to a haul by anchoring and tying the sternline to shore; how they determine the sequence of turns if more than one boat is preparing to seine; how to share the catch or revenue from it when helpers and volunteers take part; and other practices designed to make fishing operations work smoothly and predictably. In recent years, increasing competition and conflict among seine nets and also between seine nets and non-fishing coastal sea users have tended to disrupt the traditional practices necessitating consultations to decide on agreed upon management measures.

The process of formalizing the system of rules for seine fishing in Grenada has been ongoing since 1982, when the Chief Fisheries Officer became aware that there was an informal system. In the following years he interviewed many seine fishers and interpreted, compiled and documented the rules. These were then reconfirmed with groups of fishers in meetings at all major fishing areas and formulated into a set of rules that they could endorse for adoption by the government as regulations. A survey to determine fishers' views concerning beach seine fishing practices showed that 97% of captains strongly supported legalizing the traditional rules.

The seine net fishery in Grenada is a case of an attempt by the government to systematically document traditional fishing rules and customs in order to consider incorporating them into formal fisheries legislation. A basic assumption and prerequisite is that the communities in which the fishing takes place should be willing and able to perpetuate the traditional rules.

Information regarding fishing activities for pelagic fisheries in Grenada is shown in Table 1, updated up to 2004. It is important to note that the information provided is also historically accurate (early 1980s). The most flexible variable is the number of boats in the fishery.

In Grenada, other fishery species are targeted, as in the case of the Caribbean spiny lobster. This species is of high importance in the wider Caribbean given its high economic value. In Grenada, this crustacean is captured using of trammel nets.

TABLE 1
Summary of fishing activity for pelagics in Grenada

Species	Type and size of gear	Type and size of boat	Number of boats in fishery	Average crew
Yellowfin tuna Sailfish Swordfish Blue marlin	Surface longline 500 hooks	Launch 10–15 m	75	4
Yellowfin tuna Sailfish Swordfish Blue marlin	Surface longline 200 hooks	Pirogue 7–9 m	120	3
Yellowfin tuna Sailfish Blue marlin	Surface longline 150 hooks	Open 5–7 m	210	2
Blackfin tuna Dolphinfish Barracuda	Trolling lines – 3	Open pirogue	130	2–3
Jacks Round robin Scads	Beach seine	Double ender 5–7 m	25	8

Source: Statistical Unit, Fisheries Division, Grenada.

2.2 Lobster fishery

Around Sauteurs and Isle de Ronde in the north of Grenada, fishers have used trammel nets as the main method for harvesting Caribbean spiny lobster since the 1980s. Nowhere else in Grenada is this gear used primarily for lobsters, and many of these enterprises are owner-operated. These nets are non-selective, and hauling them physically damages productive bottom habitats. Use of trammel nets was recently prohibited in Grenada. The nets were prohibited in neighbouring countries several years earlier.

A boat will typically catch 30 to 60 kg of lobster per week in a season of 16 to 24 weeks. Between 6 and 10 boats are usually operating, so landings of about 10 tonnes per season of whole lobster from Sauteurs and Isle de Ronde are possible. Lobsters may be landed in Sauteurs or taken to holding pens in shallow water for accumulation. Landings are usually taken by road to the Grenville fish market for sale, and some also find their way to the capital, St. George's. The market accepts lobster caught by the illegal fishing gear, as well as lobster caught by Self-contained Underwater Breathing Apparatus (SCUBA) divers by hand or using loops. Although Sauteurs fishers exploit several fisheries, lobsters are the mainstay that provides them with their fishing identity and main livelihood. Estimates of personal and fishery-wide income vary considerably. However, fishers are said to expect about US$2 000 per eight-month season. The seasonal value of the lobster fishery at these locations may be around US$100 000, not counting indirect employment and value added in final marketing through hotels.

While recognizing the illegality of their actions and agreeing to stop using the nets, trammel net fishers at Sauteurs and Isle de Ronde have argued that they need first to be provided with alternative and legally acceptable fishing gear that yields adequate returns. Dialogue between the fishers and Fisheries Division on this issue has been ongoing for several years. Fishers argued successfully, at policy level, for relaxing enforcement of the legislation until the Fisheries Division introduced suitable alternative gear. Phillip (2002) provides details of fishing methods. The Fisheries Division's work with the fishers on alternative gear and persuading them to comply with the fisheries regulations is an attempt at co-management in a fairly narrow sense. Due to the relatively remote location of the fishing areas away from the capital and regular enforcement efforts, obtaining the fishers voluntary compliance with the legislation is critical for management of the fishery.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

As of 2004, 1 931 fishers were registered with the Fisheries Division. Records also reveal that there are 35 weekend fishers and 365 part-time fishers, while the remainder is classified as full-time fishers (1 834). A part-time fisher is usually engaged in farming part of the time. Occupations engaged in by part-time fishers include construction and boat building. Some may travel abroad for part of the year.

Few women in Grenada are involved in active fishing. However, their participation in the industry is fairly high profile in the following areas: fish vending, fish processing (salting, smoking), export sector (as exporters), clerical work (for major exporters), quality control (for exporters), and financial controllers for their male fishing partners.

The last role is of critical importance in maintaining the viability of the fisher family (Johnson St. Louis, personal communication, 2004). A fact that is not commonly noted is that some women invest substantially in the industry as boat owners. Every parish in Grenada along the coast has communities with a long fishing tradition. However, with regards to the movements of fisheries from one locality to another, the situation is fairly fluid. Fishers based in a particular location may originate elsewhere.

In Grenada, 84.3% of all fishers possess a minimum elementary education (i.e. pre-secondary); 7.1% have reached secondary level; and 8.7% have completed tertiary level education (ranging from junior college to university). The average fishing family size is five. The wife and sons usually play a supporting role to the father (usually the fisher). The wife may help to process surplus catch (salting). The sons, if old enough, may accompany the father on fishing trips during school vacations. Fishers of small boats may earn between US$9 300 and US$10 000 per year. (Johnson St. Louis, personal communications, 2004). For the larger boats (i.e. longliners) annual income ranges between US$15 300 and US$33 700.

Grenada does not possess 'fishing communities' in the sense understood in some countries. Fishing is just another occupation in a normal community. There is no discernable difference in a community with a sizeable number of fishers from any other community, except perhaps the presence of boats, fishing gear and fishing infrastructure (jetty, fish markets). Grenadian fishers have the same access to housing (with electricity, running potable water), transportation, medical care, school and entertainment facilities as the rest of the population.

4. COMMUNITY ORGANIZATION AND INTERACTIONS WITH OTHER SECTORS

Not all fishers belong to a fisheries organization, but a significant number of them do belong to some organized group. There are six fisher organizations nationwide. These organizations take the form of registered fishermen cooperatives and/or associations. Additionally, investors such as bankers and administrators may actively participate in meetings in an advisory capacity.

To the extent that fishers belong to registered organizations, they may participate in fishery management. It must be noted, however, that fishers' contributions to management at this level are mainly related to advocacy. Fishers may sometimes share information on an ad hoc basis of a nature that can be directly utilized in fishery management. Such information is usually of the sort that has implications for monitoring, control and surveillance (MCS). Another way in which fisheries participate in fishery management is by sharing traditional ecological knowledge (TEK) with fishery managers.

Community-wide involvement in fishery management is restricted to advocacy by individuals on specific issues and reporting of illegal activities (MCS). However, the community is not sufficiently informed about fishery issues in order to be effective as it could be.

Non-governmental organizations' (NGOs) involvement in fishery management is very limited. Mainly, they have served to facilitate training programmes and community discussions. From time-to-time, an NGO will focus attention on some aspect of the marine environment (e.g. habitat degradation, coastal erosion). Grenada currently has a number of NGOs (conservation groups and three universities) involved in marine turtle research that is aimed at protecting populations.

In terms of interactions with other sectors, fishers targeting large pelagics using the surface (drifting) longlines sometimes do get into conflict over sea space. A drifting longline occupies a substantial portion of available sea space thus increasing the likelihood of gear overlapping and entanglement. Within the inshore coastal area, the beach seine targets mainly scads (bigeye and roundeye scads). These fishes are an important source of low-cost, high-quality protein for the Grenadian community. In recent times, however, the demand for these fishes as bait for the large pelagic fishery has increased markedly.

Other coastal activities include fishing for demersals, tourism-related activities, recreational diving, yachting and shipping. Very often, direct conflicts develop between yachts and inshore pelagic fishers when the former get in the way of beach seines.

Grenada does not possess anything resembling an integrated coastal management policy.

5. ASSESSMENT OF FISHERIES

Stock assessment of large pelagics is normally conducted by the International Commission for the Conservation of Atlantic Tunas (ICCAT), which uses a variety of models and tests. Neither Grenada nor other Caribbean countries have been conducting any assessments on the smaller pelagics (with the possible exception of wahoo and dolphinfish). Population parameters include length and age at maturity. ICCAT also provides estimates of recruitments, yields and biomass.

Under the ecosystem approach to the Lesser Antilles Project (FAO, 2006), some attempt is being made to develop workable ecosystem modelling. One of the models being looked at is ECOPATH. There are large knowledge gaps as it relates to Grenada's pelagic fishery. Knowledge deficiency covers such areas as: no bio-economic assessment of the fishery; no cost-benefit or financial analysis; no risk/uncertainty analysis; no environmental impact assessment; and no social impact assessment.

There may be some information on demographics of the fishing community. But issues as they relate to gender, movement of labour, traditional knowledge and community-based management have never been subjects of targeted research.

6. FISHERY MANAGEMENT AND PLANNING

Grenada's fishery is centrally managed through a Fishery Management Unit (referred to as the Fisheries Division) within the Ministry of Agriculture. The Fisheries Division was established by an Act of Parliament in 1986. This piece of legislation, administered by the Fisheries Division, provides for the appointment of a chief fisheries officer and other fisheries officers responsible for the formulation and review of fisheries management and development Plans, and a fisheries advisory committee made up of fishers, investors and other stakeholders in the industry. The Fisheries Act also makes provisions for the establishment of access agreements, local and foreign fishing licences, fish processing operations, local management areas, fisheries conservation, fisheries research, and control of gear and effort. In addition, the Fisheries Act provides for enforcement, and grants rule-making powers to the Minister responsible for fisheries.

Subsidiary legislation includes the following:

- Fisheries Regulations SRO #9 of 1987;
- Fisheries (Fishing Vessel Safety) Regulations SRO #3, 1990;
- Fisheries (Amendment) Regulations SRO #24, 1996;
- Fisheries (Amendment) Regulations SRO #2, 2001;
- Fisheries (Amendment) Act #1, 1999;
- Fisheries (Marine Protected Regulations), 2001.

Legislation directly related to fishers includes:

- Grenada Territorial Seas and Marine Boundaries Act #25, 1989 (defining EEZ a consolidation of SRO #17 and #20 of 1978);
- CARICOM Common External Tariff Order #18, 1995 (Archipelagic baseline Ordinance);
- Grenada Ports Authority Act (Cap. 247);
- Fish and Fishery Products Regulations SRO #17, 1999;
- Merchant Shipping Act (1994);
- Waste Management Act #16, 2001.

The Fisheries Division is under the Ministry of Agriculture and hence policies guiding fisheries management and development are formulated and implemented within a framework that was developed and agreed upon for the agricultural sector as a whole. Within this context, the issues of target stock conservation and management, infrastructure enhancement and socio-economic development are the main areas of focus.

Grenada is signatory to the FAO Code of Conduct for Responsible Fisheries (which incorporates the Precautionary Principle) as well as the Convention on Biological Diversity. The offshore pelagic fishery operates under the principle of the 'commons', whereas fishing opportunity is governed by a 'first-come basis'. On the other hand, fishing opportunity in the inshore pelagic fisheries (scads) is subject to traditional conventions in territorial use rights in fisheries (TURF). Fishing opportunity is allocated to specific seines at specific times by common agreement. This TURF system has evolved over many decades and is not written. It has proved to be effective in preventing conflicts among seine owners and for this reason is adhered to by all. The 'right' to fish in this sense simply refers to having a designated 'turn' to encircle a school of fish within a particular bay.

Conservation measures as they relate to the pelagic fishery are twofold. In the case of large pelagics falling under the mandate of ICCAT, the conservation/ management measures proposed by that organization are followed. With regard to the inshore pelagics, the law provides for the regulation of mesh sizes in beach seines. The Fishery (Amendment) Regulations of 1996 and 2001, and the Fisheries (Marine Protected Areas) of 2001, provide for habitat protection and enhancement. These pieces of legislation envisage the protection of both spawning and foraging habitats.

All fishery officers are empowered by the Fishery Act as enforcement officers. Enforcement is normally conducted jointly with police/coast guard. Enforcement covers such areas as illegal fishing (including fishing during the closed season and foreign fishing). Compliance within the pelagic fishery is fairly high.

Grenada's commercial fishery is subsidized. Subsidies include a rebate on fuel purchased (82 cents on the gallon), all fishing gear and all safety-at-sea items (100% duty and 100% general consumption tax off). The law stipulates that only 'bona fide' fishers are eligible for concessions.

6.1 Long-term plan

Generally the objective of fisheries management is to sustain and increase yields from fisheries resources for the purpose of satisfying and enhancing human food consumption and contributing to the socio-economic options available to the Grenadian community. In this regard, long-term planning incorporates the following aspects:

- Apply the concept of maximum sustainable yield (MSY) in the management of specific stocks and habitats and use as reference points in conservation and management programmes.
- Apply technology that is efficient and selective.
- Continue the control of fishing effort in order to protect stocks from both local and foreign fishers.
- Ensure that various fisheries sector providers are controlled and facilitated for the socio-economic development of the Grenadian community as a whole.
- Implement FAO Code of Conduct for Responsible Fisheries, Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) and ICCAT's management measures.
- Continue to promote co-management in all fisheries. In addition, initiatives to implement an ecosystem approach to fisheries management will continue.
- Strengthen the Fisheries Division's capacity in data collection, processing and analysis.
- Improve fishery infrastructure.
- Continue the drive to ensure the security of the fishing fleet by vigorously enforcing safety at sea regulation.

- Pursue institutional strengthening at the level of the Fisheries Division with emphasis on human resource development.
- Maintain regional and international collaboration in the interest of fishery management and conservation.

6.2 Monitoring, control and surveillance

All fishery officers are empowered by the Fishery Act as enforcement officers. Enforcement is normally conducted jointly with police/coast guard. Enforcement covers such areas as illegal fishing (including fishing during the closed season and foreign fishing). Compliance within the pelagic fishery is fairly high.

Unfortunately, there is no formal mechanism to evaluate fisheries management in Grenada.

7. RESEARCH AND EDUCATION

The following data are routinely collected at primary landing sites: catch and effort, landings by species and weight, and fishing area/ground.

Table 2 summarizes the type of data normally collected.

TABLE 2
Summary of fisheries data collected

Type of data	Fishery type	Data collected/method	Location	Agency/organization/ institution
Catch and effort	1 and 2	From production and landings	All primary and tertiary landing sites	FD/MALFF
Biological[1]	1 and 2	Measurements done by data collectors at market whenever available	Primary landing sites	FD/MALFF
Biological[2]		Used to be collected during the national billfish tournament but discontinued as the tournament is basically of catch and release type	GYS	FD/MALFF for ICCAT through CRFM
Biological	1 and 2	Planned for as part of the ecosystem based system of management	All markets	FD/MALFF, CRFM, FAO

Note: type 1 refers to the large offshore pelagic fishery (yellowfin tunas, billfishes), while type 2 are small pelagics (blackfin, wahoo, dolphinfish, etc.).

Note: GYS = Grenada Yacht Services; FD = Fisheries Division; MALFF = Ministry of Agriculture, Lands, Forestry and Fisheries; ICCAT = International Commission for the Conservation of Atlantic Tunas; FAO = Food and Agriculture Organization of the United Nations; CRFM = Caribbean Regional Fisheries Mechanism.

[1] Length frequency.

[2] Length frequency, weight, sex.

With regard to large tuna and tuna-like species (especially billfishes), both stock assessment and fishery management is relegated to ICCAT. As a consequence, all countries targeting species under ICCAT's mandate, whether contracting parties or not, are obligated to provide ICCAT with catch and effort and other relevant data. ICCAT then determines available biomass and decides on appropriate management measures. All countries must comply with management measures proposed by ICCAT.

A limited amount of work has been done through the Organization of Eastern Caribbean States (OECS) Fisheries Unit on the economic and social aspects of the fishery. While the study was a country-specific survey of fishing vessels, it did incorporate information on fishers. Data included information on crew, social status, dependencies, costs and expenditure, among others.

There is no formal structured educational programme (environmental or conservation) on fishing or fisheries. From time-to-time, fisheries officers will make ad hoc presentations in schools, community centres, cooperatives, and at the university on issues concerning sustainable utilization of marine resources and conservation. During such presentations, the concept of sustainable utilization is normally explained. Much focus is also placed on sensitizing people on fishery conservation laws.

Only one vocational institution (except for the Grenada Fishing School, 1980–1982) has ever sought to promote fishing as an occupation, but this programme has since been stopped. As a rule, vocational institutions offer alternative occupations to fishing.

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10. Coastal fisheries of Mexico

José Ignacio Fernández*, Porfirio Álvarez-Torres, Francisco Arreguín-Sánchez, Luís G. López-Lemus, Germán Ponce, Antonio Díaz-de-León, Enrique Arcos-Huitrón and Pablo del Monte-Luna

Fernández, J.I., Álvarez-Torres, P., Arreguín-Sánchez, F., López-Lemus, L.G., Ponce, G., Díaz-de-León, A., Arcos-Huitrón, E. and del Monte-Luna, P. 2011. Coastal fisheries of Mexico. *In* S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo (eds). Coastal fisheries of Latin America and the Caribbean. *FAO Fisheries and Aquaculture Technical Paper*. No. 544. Rome. pp. 231–284.

* *Contact information*: Instituto Nacional de la Pesca-SAGARPA. Mexico. E-mail: WECSG20@yahoo.com.mx

1. INTRODUCTION

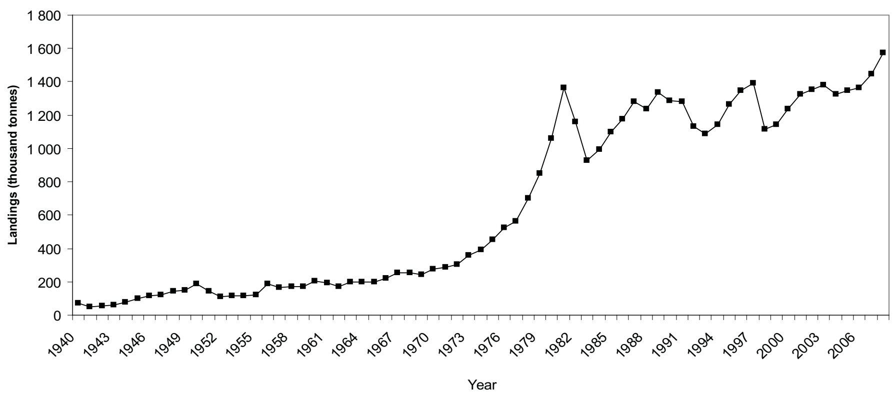
Small-scale fisheries in Mexico account for about 97% of the marine fleet. These fisheries cover about 70% of the continental shelf, which accounts for 10% of the exclusive economic zone (EEZ), and occur scattered along both coastal regions: the Pacific Ocean, and the Gulf of Mexico and the Caribbean (Figure 1). In this chapter, we first present an overview of the Mexican marine fisheries, emphasizing the most important small-scale fisheries in each region, and providing more detailed information when available. We refer to coastal, small-scale or artisanal fisheries as those that generate products for local consumption and marketing, use small-scale boats that operate with low capital investment, are labour intensive with limited autonomy and capacity, and usually undertake daily fishing trips. Other fisheries (midscale and industrial) are referred to when applicable.

FIGURE 1
Map of the coastal area in Mexico surrounded by waters from the Pacific Ocean, Gulf of Mexico and the Caribbean Sea

Source: Beltrán-Turriago, 2007.

Total annual catch in Mexico has fluctuated in the last three decades around 1.3 million tonnes (Figure 2). Different governmental programmes provided the incentive for the development of the fisheries between the 1970s and the 1980s, especially by improving technology and increasing fishing effort (Salas *et al.*, 2007); more recently, catches range around 1 million tonnes (Figure 2).

FIGURE 2
Landing trends from 1950 to 2003 in Mexico



Source: CONAPESCA, 2002.

The development of Mexican fisheries has been different between regions, as landings from the Pacific contribute the most to the total national catch (77%), compared with those from the Gulf of Mexico (21%) and the Caribbean region (2%) (CONAPESCA, 2002). However, the Gulf of Mexico and the Caribbean region play an important role in terms of catch value and job generation. In these areas, a high proportion of total catch comes from the artisanal (small-scale) fleet that targets highly profitable species; other proportions of the landings come from multispecies fisheries that are mainly seasonal.

Landings from the Pacific have fluctuated more over the last two decades than those from the Gulf of Mexico/Caribbean region (Figure 3). This occurred mostly during the early 1990s when El Niño-southern Oscillation (ENSO) events caused declines in abundant sardine stocks. Catches in the Gulf of Mexico and the Caribbean Sea peaked by 1993–1994, the shrimp and the octopus fisheries contributing the most to the overall catch.

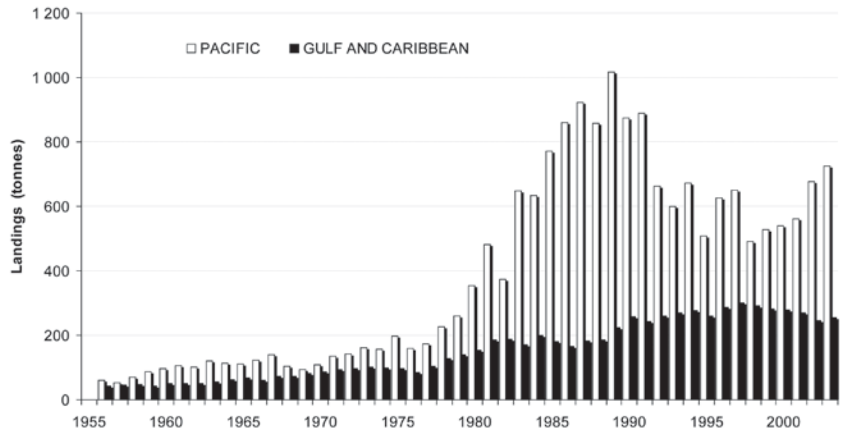
2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

Small-scale coastal fisheries can be described in terms of the catch of a variety of target species, plus several incidental species. Target species comprise 28% of the catches in the Gulf of Mexico and the Caribbean, as registered in statistical yeardocuments. Although subsistence fisheries are widespread, most artisanal fisheries can be characterized as small- to medium-scale commercial, since a significant fraction of the catch is sold to local markets or to middlemen for both domestic and overseas markets.

According to statistical yeardocuments (CONAPESCA, 2001), there are 56 412 small artisanal vessels in the Pacific shores: 1 609 in Baja California;

3 633 in Baja California Sur; 7 234 in Sonora; 11 828 in Sinaloa; 4 442 in Nayarit; 2 938 in Jalisco; 791 in Colima; 5 171 in Michoacán; 4 744 in Guerrero; 5 090 in Oaxaca; and 8 932 in Chiapas.

FIGURE 3
Landing trends from the Pacific Ocean and Gulf of Mexico and Caribbean Sea of main species targeted by coastal fleet in Mexico



Source: SEMARNAP, 2004.

On the other hand, there are 43 392 small artisanal vessels in the Gulf of Mexico and Caribbean shores: 6 662 in Tamaulipas; 15 898 in Veracruz; 9 601 in Tabasco; 5 362 in Campeche; 4 981 in Yucatán; and 888 in Quintana Roo (CONAPESCA, 2001).

Despite the differences in small-scale fisheries on both coasts, the per capita investment in fishing gear and boat equipment is generally low in both cases, compared with semi-industrial fleets. However, fishing technology has been improved during the past two or three decades as increases in both boat motorization and the use of more efficient fishing gears have occurred. These changes are the result of investments applied in these fisheries in Mexico, similar to investments in technology that have occurred in many other countries in Latin America and the Caribbean during the same period (Salas *et al*., 2007). Regardless of these improvements, productivity has not increased accordingly, since near-shore fishery resources are fully exploited, overexploited (Díaz de León *et al*., 2004) or fished down (Salas *et al*., 2004). Increasing fish demand and marketing of fish products has led to an excess of fishing capacity, resource depletion, waste of economic and human resources, and poor returns on investments. In addition, fishers have been faced with increases in frequency and intensity of natural phenomena in coastal areas such as hurricanes, tropical storms and red tides, which have impacted the resources and limited their fishing operations, thus affecting fishers' profits (Díaz de León *et al*., 2004; Salas *et al*., 2006).

2.1 Fisheries technology

Mexican artisanal fisheries vary in their degree of technology. The simpler side has fishers operating from the shore or from propelled wooden canoes using cast nets or beach seines. However, most fishing vessels are made of fibreglass and are 6 to 10 m long. In some regions, the outboard-powered small vessels are called *panga*.

Some fisheries, like the shrimp fishery that operates in coastal waters, use fixed gears which block migrations to the sea (*tapos*) and use small vessels to load the catches and take them to shore. In Tamaulipas and Veracruz, fishers use small vessels and 'V' shaped fixed nets (*charangas*) and they store the catch until it is taken to shore.

In some cases, such as the octopus-grouper fishery in Yucatán and the lobster fishery, several fleets of varying size and capacity target the same species. The larger vessels generally use fishing methods and gears which incorporate the same level of mechanical support for extraction, such as winches for grouper or traps for lobster. These vessels have the ability to expand their operations to deeper areas, usually targeting species of larger size, or other species like octopus. These fisheries can be sequential, as different types of vessels operated by different stakeholders target various life stages of the exploited populations, resulting in social interactions that are not always explicitly considered in management. Even though it is generally forbidden by regulations, diving is also a common fishing method in the Gulf of Mexico and the Caribbean, targeting species like lobster, conch and octopus.

2.2 Gulf of Mexico and Caribbean fisheries

A variety of species are targeted in the Gulf of Mexico and the Caribbean. However, only a dozen of them represent the highest contribution in volume and profit; other species are caught incidentally or in a complementary manner. A summary of the characteristics of the vessels used, as well as the usual crew employed by the fleet that undertake fishing operations in the Gulf of Mexico and the Caribbean region, are presented in Table 1. Appendix I presents a complete list of species targeted in the area.

One of the most important fisheries in the Gulf of Mexico targets grouper and related species. The demersal species associated with reef areas (Veracruz) and rocky areas (Yucatán) are usually reported in a group called *escama*. This situation can obscure the organization of catch records and the assessment of stocks, further complicating the implementation of management strategies that properly regulate the effort allocated to different stocks. The demersal fishes included in the '*escama*' group include the following: groupers (*Epinephelus flavolimbatus, E. morio, E. itajara, E. adscencionis, E. drummondhayi, E. nigritus, Mycteroperca bonaci, M. microlepis, M. venenosa, M. interstitialis*); snappers (*Lutjanus bucanella, L. vivanus, L. synagris, L. analis, L. griseus, L. jocu, Ocyurus chrysurus, Rhomboplites aurorubens*), porgies (*Calamus bajonado*); grunts (*Haemulon plumieri*); banded rudderfish (*Seriola zonata*); hogfish (*Lachnolaimus maximus*); and tilefish (*Lopholatilus chamaeleonticeps*) (Monroy *et al.*, 2000a). At certain locations in the Gulf of Mexico, between 35% and 70% of the total catch of *escama* is made up of the red grouper (*E. morio*).

TABLE 1
Summary of characteristics of boats and gears employed in the fisheries that operate in the Gulf of Mexico and the Caribbean region

Species	Type and size of gear	Type and size of boat	Number of boats	Average crew size
Octopus	*Alijos* (small boats) carrying *jimbas* (wooden stick with several lines and baits)	3–4 m long, fibreglass boat, carried by a 7–9 m long boat with outboard engine (15–75 hp) or by a 12–22 m long vessel acting as mother ship for the *alijos*. Around 10 *alijos* for mid-size vessels and 2 *alijos* for small vessels	Around 3 500 small vessels, and 500 mid-size vessels	1–4 for small boats, 10–12 for mid-size vessels
Shrimp	V-shaped nets 15 to 50 m wide (*charangas*), cast nets, gillnets	4–6 m long, fibreglass boat with outboard engine (15–100 hp)	Around 4 000 small boats in Tamaulipas-Veracruz At least 200–400 vessels in seabob fishery	1–4
Mullets	450–1 500 m long gillnets, 2–3.75 in mesh size	4–6 m long fibreglass boat, with outboard engine (15–75 hp)	No records	1–4
Grouper	Longline with 1 500–2 000 handlines or short longlines	3–4 m long, fibreglass boat, carried by a 7–9 m long boat with outboard engine (15–75 hp) or by a 12–22 m long vessel acting as mother ship for the *alijos*	Around 4 000 small vessels, 500–600 mid-size vessels	1–4 for small boats, 4–12 for mid-size vessels
Spanish and king mackerels	Gillnets (300 m long, 3.5–4 in mesh size), beach seines (400–800 m), handlines	4–6 m long fibreglass boat with outboard engine (15–100 hp)	No records	1–4 in boats, up to 20 when using beach seines
Sharks and rays	Longlines, gillnets	4–6 m long fibreglass boat with outboard engine (up to 100 hp)	Around 3 665 small vessels	1–4
Lobster	Hooka system, artificial habitats (*casitas*) and traps in Yucatán; nets, diving and same as above in Quintana Roo	7–9 m long, fibreglass boat with outboard engine (between 50–75 hp) and mid-size vessels (10–22 m long)	998 small vessels and 16 mid-size vessels	1–3 for small vessels, 6–12 for mid-size vessels
Finfish	Gillnets, longlines, cast nets, handlines, beach seine nets	7–9 m long, fibreglass boat with outboard engine (15 up to 100 hp)	Up to 43 392 small vessels	1–4 for small vessels

In Tamiahua, Veracruz, the following species account for more than 50% of the total catches: spotted and silver weakfish (*Cynoscion nebulosus* and *C. nothus*); mojarras (*Eugerres* spp.); sheepshead (*Archosargus probatocephalus*); croaker (*Micropogon undulatus*); drum (*Pogonias cromis*); and red drum (*Sciaenops* *ocellatus*). White mullet and mullet catches account for another 9%. In Laguna Madre, Tamaulipas (north of the Gulf of Mexico), spotted weakfish, croaker, sheepshead and drum (together, 28% of catches) are caught with gillnets (Gómez and Monroy, 2000).

Some fish species can also be caught in lobster traps (González-Cano *et al*., 2000), namely grouper (*Epinephelus morio*), hogfish (*Lachnolaimus maximus*), cabrilla (*Serranus cabrilla*), and snappers (*Lutjanus* spp.). Other crustaceans, such as crabs and lobster (*Scyllarides nodifer*), are also caught incidentally and are consumed locally. On the other hand, white shrimp are caught in nets used to catch seabobs in shallow waters of the Campeche Bank. In this zone no artisanal fishery for white or pink shrimp in shallow marine waters is allowed, although it occurs frequently enough to be considered a serious problem. In Tamaulipas and Veracruz, small fishes and crabs of several species are caught in the *charangas*, although a list of such species has not been published (Fernández *et al*., 2000). In Yucatán, shrimp are caught in the estuaries using nets called *triangulos*, which are operated manually (Salas *et al*., 2006).

2.3 Pacific coast fisheries

Several fisheries based in the Pacific region could be considered as a single group (or species) since they are very specialized (e.g. seaweeds, kelp, octopus, lobster and crabs). Other species, such as the abalone, conch, clams, mussels and sea urchins, are hand-picked by divers using boat-based air compressors (called 'Hooka'). In these fisheries it is not very common to report incidental catch, although some complementary species are captured by the divers. Table 2 depicts a summary of the characteristics of some of the fisheries in the Pacific region and Appendix II includes a complete list of species targeted in the region.

The Pacific littoral fisheries are similar to the fisheries for shrimp in coastal waters, with fishers using fixed gears blocking migrations to the sea (locally called *tapos*) and small vessels to collect catches and take them to shore. There are also active fishing gears to catch shrimp in shallow water, such as cast nets and *suripera* (a quasi-trawlnet).

One of the most specialized fisheries in the area is the one for sharks, as it requires different fishing strategies and gears than those used for finfish. However, some fleets that target finfish using gillnets and longlines also catch sharks. There is high species richness for sharks in the Mexican Pacific and almost all are sold commercially when caught.

In the squid fishery, which primarily targets the giant squid (*Dosidicus gigas*), some species appear as bycatch, for example, the common Pacific squid (calamar común del Pacífico, *Loligo opalescens*), the dart squid (calamar dardo, *Loliolopsis diomedeae*), *Lolliguncula* spp., *Illex* spp., *Ommastrephes* spp., and *Symplectoteuthis* spp. These are also caught as bycatch by industrial shrimp trawlers.

TABLE 2
Summary of vessels and gear characteristics of the fisheries in the Pacific littoral

Fishery	Type and size of gear	Type and size of boat	Number of vessels
Seaweed	SCUBA diving, Hooka	5–7 m fibreglass vessels, outboard engine	59
Kelp	Hand-picked	Small fibreglass vessels, outboard engine	613
Abalone	SCUBA diving, Hooka	Small fibreglass vessels, outboard engine	878
Conch	SCUBA diving	Small fibreglass vessels, outboard engine	
Clams	SCUBA diving, Hooka, hand-picked on low tide	Small fibreglass vessels, outboard engine	200
Mussels	SCUBA diving, Hooka, hand-picked on low tide	Fibreglass vessels, outboard engine	55
Giant squid	Poteras	Small fibreglass vessels, outboard engine	2 000
Octopus	SCUBA diving, Hooka	Small fibreglass vessels, outboard engine	1 188
Shrimp	Castnets, *suripera* or *dragona*, seine	Small fibreglass vessels, outboard engine (55 hp)	12 339
Lobster	Metal, wood and plastic traps (Californian type)	5-7 m fibreglass boats, outboard engine (40–75 hp)	1 110
Crabs	'Chesapeake trap', maximum dimensions 60 x 60 x 40 cm	Small vessels, fibreglass, outboard engine	2 700
Stone crabs	Traps	Small vessels, fibreglass, outboard engine	760
Sea urchin	SCUBA diving, Hooka	Up to 7 m fibreglass, outboard engine	615
Sea cucumber	SCUBA diving, Hooka	Small fibreglass vessels, outboard engine	7
Groupers	Gillnets, line	7 m fibreglass boat, outboard engine (45–60 hp)	
Croakers and drums	Gillnets 100–500 m long, 3–6 in. mesh size	Small fibreglass vessels, outboard engine	
Snappers	Bottom gillnets 200–300 m long, 82.55 mm mesh size, line, handline	Small fibreglass vessels, outboard engine	
Jacks	*Almadraba*, beach net, lines (*currican*)	Small fibreglass vessels, outboard engine	
Flounders	Bottom gillnets, trawling, lines	Small fibreglass vessels, outboard engine (115 hp)	
Mullets	Gillnets 2.5–3.5 in. mesh size	Small fibreglass vessels, outboard engine	848
Tilefishes	Handlines, gillnets	Small fibreglass vessels, outboard engine	500 in BCS, 33–380 in the west coast BC
Snooks	Gillnets; handline, SCUBA diving, harpoon	Small fibreglass vessels, outboard engine	
Mackerels	gillnets 500 m long, 2.5-3.5 in mesh size	Small fibreglass vessels, outboard engine	
Coastal sharks	Longline 1 500–3 000 m long, 500–1000 hooks; up to 750 m long and 350 hooks	Small fibreglass vessels, outboard engine	4 973
Rays	Bottom gillnets 4–10 in. mesh size	7-8 m overall length, fibreglass outboard engine (75 hp or more)	
Sailfish	Fishing rod	Sport fishing fibreglass vessels, outboard engine	966
Dolphinfish	Fishing rod	Sport fishing fibreglass vessels, outboard engine	966
Marlin	Fishing rod	Sport fishing fibreglass vessels, outboard engine	966

BCS = Baja California Sur; BC = Baja California.

2.4 Seasonality

Multispecies catches occur due to the seasonality of stock abundances; fishers target species that are most abundant at any given time. In addition, multigear fleets often switch target species with changes in resource abundance or regulations (Salas *et al*., 2004). One example of this involves the giant squid fishery. This fishery is a single-species fishery in the central region of the Gulf of California during the periods of high abundance of squid. But when the abundance of this resource decreases, the fleet switches primarily to finfish. The same applies with lobster and octopus fisheries along the Yucatán coast.

Seasonal effort shifting from one target species to another is common in many small-scale fisheries of Mexico. Seasonal effort and changes in catch patterns are due to three main factors: (i) closed seasons; (ii) changes in stock abundance (or resource availability in coastal areas); and (iii) changes in relative prices of harvested species. A summary of the main seasonal allocation of effort of Mexican small-scale fisheries is presented below.

Octopus: Caught in the Yucatán shelf during last five months of the year as a result of a closed season, mostly determined by the seasonal recruitment of *Octopus maya*, the Mexican four-eyed octopus (Solís-Ramírez *et al*., 1998).

Shrimp: In Tamaulipas and Veracruz, brown shrimp (*Farfantepenaeus aztecus*) are more abundant from April to July for the artisanal fishery operating in the lagoons. Seabob (*Xiphopenaeus kroyeri*) is more abundant at the beginning of the second part of the year. Seasonality of the fishery is affected by the closed season (late May to mid-July in Tamaulipas and Veracruz and May to October in Campeche). Juvenile pink shrimp are found in greater numbers in shallow waters off the western seashore of the Yucatán Peninsula from June to September and white shrimp are abundant from May to early September in lagoons of the southern Gulf; both species are caught illegally in those areas (Fernández *et al*., 2000). In Yucatán, shrimp are caught by men and women in estuarine areas. Shrimp are caught between October and February in Chabihau (Cabrera, 2003); in Celestun, the abundance of the four species (*Farfantepenaeus aztecus, F. brasiliensis, F. duorarum* and *F. notialis*) in the estuarine area varies throughout the year, so the area provides alternatives to fishers all year round (Defeo *et al*., 2005).

Grouper: Due to reproduction-linked aggregations, groupers are more vulnerable to fishing from January to March. A closed season has been established between mid-February and mid-March. By the end of July fishing effort allocated initially to grouper and related species shifts mostly to the octopus and lobster fisheries, and catches diminish to a third of the maximum (Monroy *et al*., 2000a; Salas *et al*., 2006).

Spanish and king mackerel: These species migrate regularly along the Gulf´s shores, from south to north in spring–summer and from north to south in autumn–winter (Mendoza, 1968; Doi and Mendizabal, 1978; Schultz *et al*., 2000). As a result, two seasonal abundance peaks can be found, occurring at different times according to location along the migration's path. Spanish mackerel is more abundant in Tamaulipas in April and September to October, in March and October in Veracruz, in March and October–November in Tabasco, and in January and November in Campeche, Yucatán and Quintana Roo. For the king mackerel these peaks occur in June and August in Tamaulipas, May and August in Veracruz, May and October for Tabasco, in December to February in Campeche, in December and January in Yucatán, and in December and February in Quintana Roo (Schultz *et al*., 2000).

Sharks and rays: In many species caught by this fishery, abundance varies according to migratory movements occurring mostly during winter, when several species are caught (Cid *et al*., 2000; Fuentes-Mata *et al*., 2002).

Spiny lobster: Although migratory movements dependent on age and size have been described (González-Cano, 1991), their effect on availability has not been clearly defined. Seasonality of the fishery is determined mainly by management, with a closed season from 1 March to 31 June (González-Cano *et al*., 2000). Catches are usually higher from July to September.

2.5 Non-target species and bycatch

Because of the low selectivity and diversity of fishing gears and methods in the small-scale fisheries, the catches contain a considerable number of different species. It is important to notice here, however, that most of the products harvested by the small-scale fleet are sold and rarely discarded. In multispecific fisheries, as many stocks are diminishing and catch-per-unit effort continues to decline, fishers tend to keep those resources that can be traded in such a way that the travel costs can be compensated and a profit generated from every fishing trip. This condition, however, does not apply in the case of the shrimp fishery. A list of non-target species harvested incidentally is presented in Appendix III for artisanal fisheries and in Appendix IV for shrimp trawl bycatch.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

The statistical yeardocument report indicated that 268 727 persons were employed in fisheries in Mexico in 2001 (CONAPESCA, 2001). In 1999, the National Institute of Statistics, Geography and Information (INEGI) reported 154 379 persons employed directly in fisheries and aquaculture and 83 058 employed in jobs directly related to them.

According to the statistical yeardocument of 2000 (CONAPESCA, 2001), there were 104 028 persons involved full time in fisheries in the Gulf of Mexico and Caribbean seashores: 15 153 in Tamaulipas; 32 277 in Veracruz; 21 499 in Tabasco; 12 307 in Campeche; 19 711 in Yucatán; and 3 081 in Quintana Roo. These numbers include artisanal and industrial fishers as well as 1 203 involved in aquaculture and other jobs directly related to the sector. In most cases, those registered by INEGI as employed in fisheries satisfy the criterion of obtaining most of their income from fisheries or related activities. Despite these records, there is no accurate information published that estimates the number of people involved in each of the most important fisheries in the country, nor does discrimination by type of fleet exist.

Gómez and Monroy (2000) report that in the Laguna Madre there were 1 233 small vessels operating in the finfish fishery. According to the same authors, there were 3 111 fishers operating in the northern Veracruz finfish fishery with 2 408 small vessels.

The number of fishers per vessel varies according to the type of fishery and the region. For instance, in Tamaulipas, Veracruz, Tabasco and Campeche the average number of fishers by registered small vessel is 2.2, while in Yucatán and Quintana Roo the average is 3.7 fishers per vessel.

The Pacific littoral presents a north-to-south decreasing gradient in the number of fishers per vessel. This is due mainly in part to the fact that the Gulf of California (north) is a highly productive area, reflected in the economy through the presence of industrial fleets targeting mainly tuna, sardine and shrimp. In comparison, the rest of the Pacific shores are dominated by artisanal fisheries. The southern Pacific shores also experience higher indices of poverty.

According to statistical yeardocuments (CONAPESCA, 2001), there are 149 522 persons involved full time in fisheries in the Pacific seashores: 6 444 in Baja California; 11 027 in Baja California Sur; 22 638 in Sonora; 39 681 in Sinaloa; 10 627 in Nayarit; 5 001 in Jalisco; 2 281 in Colima; 8 527 in Michoacán; 11 071 in Guerrero; 13 755 in Oaxaca; and 18 470 in Chiapas. These numbers include artisanal and industrial fishers as well as 15 969 persons involved in aquaculture and other related activities.

The proportion of people working in fishing by state in the Pacific is as follows: Baja California (4.67%); Baja California Sur (5.21%); Sonora (13.53%); Sinaloa (24.36%); Nayarit (7.94%); Jalisco (3.70%); Colima (1.50%); Michoacán (7.22%); Guerrero (11.37%); Oaxaca (9.07%); and Chiapas (11.42%).

In the Gulf of Mexico and Caribbean, distribution of people employed in fisheries is as follows: Tamaulipas (0.55%); Veracruz (0.47%); Tabasco (1.14%); Campeche (1.8%); Yucatán (1.2%); and Quintana Roo (0.34%) (data comes from INEGI, 1999 and CONAPESCA, 2001). Dependence on fishing is more evident in small fishing communities. For example, Méndez (2004) reports 67% of households are dependent on fisheries in Celestún, Yucatán.

No official statistics give a clear idea of part-time employment in fisheries in the Gulf of Mexico. Chenaut (1985) reports that many fishers along the Yucatán coast were originally peasants; they engaged in fisheries when they were displaced from agriculture. Many of these retained some of their agricultural activities. However, this situation should be considered a special case. The same author reports that in the neighbouring Quintana Roo, the dependence of communities on fisheries is higher because the land in the north of that state is unfit for agriculture. Fishing traditions date back many years in many locations along the Mexican coast; Alcalá (1986) reports a figure of 500 years for some communities.

3.1 Average annual income level

There are big differences between the incomes derived from fisheries among regions and types of fisheries. The average monthly income derived from fisheries in municipalities of the five states around the Gulf of California for the period 2000–2001 was 2 714 Mexican pesos (MXN) (1 US$ = 11.50 MXN), while in the Gulf of Mexico states the average was 624 MXN. In Tamaulipas, the average monthly income was 702 MXN, 471 MXN in Veracruz, 579 MXN in Tabasco, 475 MXN in Campeche, 526 MXN in Yucatán, and 989 MXN in Quintana Roo. It is worth noting that the states with the highest average income have the most valuable fisheries: shrimp (Tamaulipas) and lobster (Quintana Roo) (data processed from INEGI, 1999). Nadal (1996) reported that 14% of fishing units (employed in industrial fisheries) received 43% of the total income while 67% of them (those employing 1–15 fishers per unit) received only 2.8%.

In many small fishing communities the lack of basic services such as running water, education and electricity has been reported (e.g. Melville, 1984; Rodríguez, 1984; Cheanaut, 1985; Alcalá, 1986; Cesar and Arnaiz, 1998; Méndez, 2004). Even in communities with basic services, the low income and the low average wages create low living standards for many artisanal fishers.

Those states with large littorals and low populations, such as the whole Baja California Peninsula and Sonora in the Mexican northern Pacific, are characterized by the lack of basic services and the dispersion of fish landing locations. In some states such as Oaxaca and Chiapas in the southern Mexican Pacific, as well as northern Tamaulipas and Campeche, fishing communities are characterized by low standards of living.

Most fishers are native to the regions where they operate. However, there is a considerable seasonal migration in certain areas associated with local variations of resource abundance. Fernández *et al*. (2000) and Gómez and Monroy (2000) reported on the seasonal migration of fishers to Tamaulipas from other states (mostly Veracruz) when the shrimp and mullet fisheries are in periods of high abundance. Alcalá (1986) reports the presence of transient fishers from Veracruz to Tabasco. Cesar and Arnaiz (1998) report migrant fishers from Veracruz establishing fishing communities in northern Quintana Roo. In the Mexican Pacific, some groups move seasonally between Chiapas and the Gulf of California for the shark fishery.

3.2 Fishers' levels of education and roles of family members in coastal fisheries

Generally speaking, the educational level among artisanal fishers is low. Méndez (2004) reported that less than 25% of boys in a fishing community in Yucatán reached secondary school. A similar figure was reported in Michoacán, on the Pacific shore, where 28% of fishers studied some years of elementary school and only 31% finished this educational level; 21% reached secondary school and only 1% enrolled in college (Toledo and Bozada, 2002).

Concerning family participation in the fishery, most times women have marginal roles in the harvesting process but play significant roles in processing. Younger members of the family play auxiliary roles and act many times as apprentices (Chenaut, 1985; Alcalá, 1986; Méndez, 2004). This level of participation is reflected in the annual income of families in fishing communities.

INEGI (1999) reports that only 3.7% of the people registered as directly involved in fisheries and aquaculture are women, and 21% of them are working in administrative and control areas. Women, along with the elderly and children, are more involved with subsistence fisheries (Chenaut, 1985; Méndez, 2004).

3.3 Processing and marketing

Fishery products coming from artisanal small-scale fisheries are mainly fresh, iced, frozen and, in very limited cases, processed. National, local and international markets receive the products from these fisheries. Finfish and shark (up to a certain size) are usually sold whole. Most of the shrimp artisanal catches in the Gulf fisheries are of small sizes and are not suitable for international markets.

Octopus is processed (frozen) for the export market. Around 20 to 25% of catches were exported in 2001, but in 1997 nearly 14 000 of the almost 18 000 tonnes caught were sent to international (mostly Asian) markets (CONAPESCA, 2001). After 1996, when the north African octopus fishery collapsed, international demand rose, doubling the price of octopus paid to fishers in the Yucatán and Campeche fishery (Solís-Ramírez *et al*., 1998; Hernández *et al.*, 2000). However, prices were lower in consecutive years, and demand decreased (Salas *et al*., 2006).

Around 40 to 50% of lobster catches are exported (González-Cano *et al.*, 2000). Frozen lobster tails comprise around 30% of the exported volume, the rest being fresh and iced (CONAPESCA, 2001).

Close to 4 000 tonnes from approximately 8 000 tonnes of grouper catches are exported to the United States of America, frozen whole or in fillets. The rest is distributed in national markets and little is consumed locally (Monroy *et al*., 2000a).

Nearly 70% of shark is sold fresh, 22% frozen, and the rest dried-salted. Shark leather has been exported to the United States and Europe (294 tonnes in 1990, worth US$10 million). Although it does not appear in statistical yeardocuments since 1996, shark fins are exported to Asian markets (190 tonnes and US$2.5 million in 1987) (Cid *et al*., 2000).

The female gonads of mullets earn a price four to five times that of the rest of the fish (120 Mexican pesos per kg, around US$30 in 1994). Fresh mullets are consumed locally and only 4% are exported. Around 48% of female gonads are consumed locally, 24% are for the national market, and 28% are exported. Dried-salted mullets comprise 97% of the mullet products for the national market (Gómez and Monroy, 2000).

On the Pacific littoral, seaweed is dehydrated and sold mostly in national markets. Kelp is dehydrated and sold in national markets and exported. Both are used to extract alginates.

Abalone is sold fresh and iced in national (local) markets. It is also frozen or canned for national markets and exportation. Most species of conch are sold fresh and iced locally and are rarely canned. Conch is also used for handicrafts. Clams and mussels are mostly sold fresh and iced; they are rarely frozen or in brine.

Squid is mostly sold fresh and iced. Sometimes it is processed (canned), while octopus is sold mostly fresh and iced for the national market.

Most of the shrimp coming from artisanal catches are of small sizes, making them unsuitable for international markets. These shrimp are consumed at local and national levels. Large white shrimps caught in coastal waters are usually exported and a small amount is allocated to national markets.

More than 70% of lobster catches are exported, mostly frozen. At the national level, lobster is sold iced and fresh. Crab is mainly sold fresh and iced for the national market. Some large boats targeting crab and operating under a special licence process the meat into crabs sticks, which are cooked and exported.

Practically all production of sea urchin is frozen and mostly exported; sea cucumber is dried and mostly exported. Most marine fishes are sold whole or in fillets and are fresh, iced and frozen for national markets. A small amount of groupers and snappers are exported frozen, whole or in fillets. In several cases, gonads earn the highest prices and some species, such as mullets, are targeted mostly for the gonads. Some species (i.e. mullets) are dried-salted or smoked and sold in national markets.

3.4 Conflicts between fishers and other coastal activities

Allocation of marine resources has always been a complex issue to address in fisheries. This issue is further complicated when deciding who will be granted access to the most profitable resources, such as shrimp, lobster, abalone and conch, in Mexico. By decree these resources were allocated to members of fishing cooperatives in the 1970s and 1980s, restricting access by the members of the organizations once they got the concession of the resources. By the 1990s this decree was changed and the access was opened to other participants. However, preference was given to those who have historical rights over the resources as long as they were able to demonstrate they were efficient in the production system.

Another potential source of conflict in fisheries is the interaction of small-scale fisheries with industrial fisheries, especially in the cases where the same resources are targeted by both fleets. This is the case for the shrimp fisheries in Mexico, as juvenile shrimp are caught by artisanal fishers in the estuaries, while the adults are caught in marine areas. Juvenile shrimp can be overfished, reducing the stock available for population reproduction and as a fishing stock for the industrial fleet. The shrimp fishery is one of the most important fisheries in economic terms in Mexico and the conflict between artisanal and industrial fishers is a growing concern for fisheries managers (Fernández *et al*., 2000). Similar types of interactions occur within the octopus and grouper fisheries, although the conflicts have not been as drastic as those reported in the shrimp fishery. However, octopus artisanal fishers along the interstate border of Campeche and Yucatán have been clashing periodically over access to fishing grounds.

Other conflicts arise between fisheries and conservation. One case in particular involves interactions between harvesters and marine mammals in the Gulf of California. In the upper Gulf of California there is a marine reserve aimed to primarily protect the *vaquita* (*Phocoena sinus*) and the *totoaba* (*Totoaba macdonaldii*), which are threatened by shrimp trawl fishing activity and the use of gillnets by the artisanal fishery. Moreover, there is restricted access to the core area of the reserve for all fleets which is not respected by the artisanal fishers (Morales-Zárate *et al*., 2004; Lercari, 2006).

Conflicts between commercial and recreational fisheries are also present. For instance, commercial fishers claim access to the dolphinfish stock normally reserved for sportfishers. Commercial fishers claim that there is enough biomass of the stock to allow their participation, but sportfishers argue that reduction in individual sizes could cause a negative impact on the tourist sector.

Prohibiting fishing around oil platforms is a growing problem for fishers in the Campeche Bank as the area has been banned to fishing operations. Pollution from oil extraction activities is also a growing concern. Social disruption in fishing communities as a result of oil worker immigration has been noticeable in the Ciudad del Carmen, Campeche (Rodríguez, 1984).

Resort developments and tourism-related activities have been interfering with fishing activities in a high degree in the northern coast of Quintana Roo (Cesar and Arnaiz, 1998) and several places along the Pacific coasts, such as Huatulco, Acapulco, Manzanillo, Puerto Vallarta, Mazatlàn and Los Cabos, among others.

4. ASSESSMENT OF FISHERIES

The National Institute of Fisheries has developed assessment of the stocks of the most important fisheries in Mexico; this assessment is periodically updated (INP, 1998, 2000). As a means to unify methods that facilitate comparisons and understanding of the results by the fishing community and all fishing sectors, these assessments have been based on biomass models and in several cases uncertainty and risk analysis have been included. This data includes information from the most important artisanal fisheries considered in those analyses. An important contribution for knowledge of the status of small-scale fisheries from the Gulf of Mexico is reported in Flores *et al.* (1997). A summary of some of the methods employed for stock assessment of several fisheries are listed below and the status of the main fisheries by region is integrated afterwards.

Arreguín-Sánchez and Pitcher (1999) analysed changes in catchability by size of the grouper fishery, comparing fleet trends through time. Several studies on reproduction have been conducted for grouper, including Brulé *et al.* (2003). Monroy *et al.* (2000a) and Giménez-Hurtado *et al.* (2005) applied an age structured model to assess the grouper fishery. Age-structured models have also been employed to assess the octopus fishery (Solís-Ramirez *et al*., 1998; Arreguín-Sánchez *et al*., 2000; Hernández *et al*., 2000), the shrimp fishery (Castro and Arreguín-Sánchez, 1991; Fernández *et al.*, 2000), and sardine in the Gulf of California (Morales-Bojórquez *et al*., 2003). Cohort analysis has been used to assess the lobster fishery.

Age-structured models have been used in many fisheries because of the importance of considering age-related events (migrations, individual growth, reproduction and sex shifts in protogynous hermaphrodite species like red grouper), which facilitate the development of strategies for fisheries management.

Yield-per-recruit analysis has been applied to shrimp fisheries (Arreguín-Sánchez and Chávez, 1985) and the Spanish and king mackerel (Schultz *et al.*, 2000). Shark fisheries assessments are still in early stages, possibly due to lack of data. Yield-per-recruit analyses have been applied to the shark fishery by Cid *et al.* (2000).

Biomass dynamics models, fitted assuming equilibrium, have been applied to several fisheries, including grouper (Arreguín-Sánchez, 1985) and octopus (Arreguín-Sánchez *et al.*, 1999). These are also used to evaluate recovery time of some stocks after high levels of exploitation, as in the case of abalone and red grouper (Arreguín-Sánchez, 1992). Non-equilibrium conditions have been assumed in more recent applications for the mullet and snapper fisheries (Gómez and Monroy, 2000; Monroy *et al.*, 2000b).

Dynamic bio-economic analyses have been applied to several fisheries: shrimp (Arreguín-Sánchez and Chávez, 1985), octopus, lobster and grouper (Seijo, 1986; Seijo *et al.*, 1987; Seijo *et al.*, 1991; Díaz de León and Seijo, 1992; Hernández, 1995; Seijo *et al.*, 2001; Monroy, 1998). The inclusion of estimation of dynamic costs and revenues helps in decision making and to understand the effect on fishers' short-term and long-term dynamics.

Due to the economic importance of crustacean fisheries, including shrimp which produces half of the export revenues from fisheries and currently receives subsidies and tax returns, financial analyses have been required (Goudet and Goudet, 1987; FAO/World Bank, 1988; FIRA, 2003). However, these studies concentrate primarily on the industrial shrimp fishery.

Although some analyses, including uncertainty and risk analysis, in the assessment of some fishery resources have been undertaken by the National Fisheries Institute, the results have not yet been published. Few case studies have been reported. Solís-Ramirez *et al.* (1998) evaluated the octopus fishery integrating uncertainty on the estimation of some parameters on the predictions made based on an age-structured model.

Some ecosystem trophic models based on the Ecopath-Ecosim software have been applied to different ecosystems on both coasts of the country: Campeche Bank, the coasts of Veracruz and Yucatán, the northern and central Gulf of California, La Paz Bay, Huizache-Caimanero system of lagoons, and the coasts of Jalisco and Michoacan, among others (Arreguín-Sánchez, 2002; Arreguín-Sánchez and Calderón-Aguilera, 2002; Arreguín-Sánchez *et al.*, 2004; Zetina-Rejón *et al.*, 2004; Arreguín-Sánchez and Martínez-Aguilar, 2004; Lercari, 2006; Cruz-Escalona, 2005; Zetina-Rejón, 2004; Galván-Piña, 2005; Díaz-Uribe *et al.*, 2007).

4.1 Status of the fisheries

A summary of the status of the main small-scale fisheries of both the Gulf of Mexico-Caribbean and the Pacific regions is presented in Tables 3 and 4.

TABLE 3
Status of the main Mexican small-scale fisheries of the Caribbean and Gulf of Mexico region

Small-scale fishery	Status	Catch 2003 (tonnes)
Shrimp		26 798
Brown (*Farfantepenaeus aztecus*)	Fully exploited	
Seven Bearded (*Xiphopenaeus kroyeri*)	Development potential	
White (*Litopenaeus setiferus*)	Overexploited	
Pink (*Farfantepenaeus duorarum*)	Exhausted	
Red (*Farfantepenaeus brasiliensis*)	Development potential	
Finfish		9 081
Red grouper (*Epinephelus morio*)	Overexploited	
Octopus		15 713
Octopus maya	Fully exploited	
Octopus vulgaris	Development potential	
Spiny lobster		828
Panulirus argus	Fully exploited	
Panulirus guttatus	Development potential	
Shark (27 species)	Fully exploited	5 651
Conch/snails		50
Queen conch (*Strombus gigas*)	Exhausted	
White conch (*Strombus costatus*)		

Development potential — Fully exploited — Overexploited — Exhausted

Source: Adapted from Seijo and Martínez, 2006.

The status of the main fishing stocks in the Gulf of Mexico, except those of *Octopus vulgaris*, is critical since most of them are fully exploited or exhausted. Effort expansion in the octopus fishery of the Yucatán Shelf is directed toward *O. vulgaris*. The National Institute of Fisheries (NIF) assumed that this increase would not impact the fully exploited *O. maya* stock since *O. vulgaris* occurs at greater depths (>10 fathoms [>18 m]) than *O. maya*. The highest concentrations of *O. maya* occur around 3 to 7 fathoms in near shore limestone crevices. However, there is no control over the operation areas of the fleet.

Most fisheries require precautionary measures to avoid their depletion. In fact, four of the main stocks in the Gulf of Mexico/Caribbean region are fully exploited, two overexploited and two show signs of exhaustion. In contrast with the Pacific region, most of the fisheries are artisanal.

Most artisanal fisheries in Mexico present a high degree of overlap. It is not uncommon to find fishing cooperatives in the same locality that have permits to catch shrimp, shark and finfish throughout the year. This condition complicates the assessment of the stocks involved in different fisheries; usually assessment has been based on single-species analysis. In some regions fishers shift seasonally from one species to another according to patterns of seasonal abundance, as already noted. A list of the main target species (English common name, Spanish local name and scientific name) involved in the above-mentioned fisheries is provided in Appendix I.

TABLE 4

Status of the main Mexican small-scale fisheries of the Pacific region

Small-scale fishery	Status of the stock	Catch 2003 (tonnes)
Shrimp		
Blue shrimp (*Litopenaeus stylirostris*)	■ (Fully exploited)	97 107
Pacific white shrimp (*L. vannamei*)		
White shrimp (*L. occidentalis*)		
Brown shrimp (*Farfantepenaeus californiensis*)		
Cristal shrimp (*F. brevirostris*)		
Seabob (*Xiphopenaeus riveti*)		
Lobster		
Red (*Panulirus interruptus*)	■ (Fully exploited)	2 140
Central Baja California Peninsula	■ (Exhausted)	
Northern and southern Baja California populations	■ (Exhausted)	
Clams		
Baja California Sur and Sinaloa	■ (Fully exploited)	11 290
Baja California and Sonora		
Octopus	■ (Fully exploited)	1 044
Sharks (30 species)		
Oceanic		
Alopis pelagicus	■ (Exhausted)	20 960
A. vulpinus	■ (Fully exploited)	
Coastal		
Carcharinus falciformis	■ (Fully exploited)	
Snappers		4 314
Lujanidae spp.	■ (Fully exploited)	

■ Development potential ■ Fully exploited ■ Overexploited ■ Exhausted

Source: Modified from Seijo and Martínez (2006); Seijo *et al.* (2006).

None of the major fisheries along the shores of the Pacific Ocean have possibilities of effort expansion. Six of them are categorized as fully exploited and three as exhausted. For instance, Sala *et al*. (2004) report that, although some catches are stagnant or still increasing for some species groups, catch-per-unit effort shows a declining trend after 1980 in the Gulf of California. The authors state that coastal food webs in the area have been 'fished down' during the last 30 years. A shift in the target species from high to low trophic levels has resulted in a dramatic increase in fishing effort in the region. Fishing not only impacted targeted species, but also caused community-wide changes. In fact, large predatory fishes such as sharks, gulf groupers, gulf coneys, goliath groupers and broomtail groupers were among the most important catches in the 1970s, but became rare by 2000. The results also show that species that were not targeted in the 1970s, such as parrotfish, whitefish, spotted snapper, tilefish and creolefish, have now become common catches. The authors argue that their results exhibit a clear trend that Gulf of California fisheries have fished down the food web, leading to effects on the entire coastal ecosystem well beyond the direct impacts on targeted species. These fisheries are unsustainable in their current state and management needs to be re-evaluated with sound regulatory measures to prevent further degradation.

5. FISHERY MANAGEMENT AND PLANNING

5.1 Historical trends

Since 2000, most small-scale fisheries shifted from an open access regime to a licence limitation management strategy. Effort regulations have historically been enforced by government and, in a limited and successful number of cases, through community management and co-management schemes such as in the case of the spiny lobster fisheries of Punta Allen (Seijo, 1993; Sosa-Cordero *et al*., 2008) and Baja California.

Fisheries management in Mexico has undergone changes of emphasis and approaches several times in the last decades. In the 1970s, a promotion policy reasserted exploitation of shrimp, lobster, abalone (the most valuable species), oyster, *totoaba*, pismo clam, *cabrilla* and sea turtles to cooperatives.

During the 1970s and 1980s, emphasis was put on production increases. The Ministry of Fisheries was established by 1982. At the end of the 1970s, catches reached nearly 1.4 million tonnes, a fivefold increase in ten years as a result of a fisheries sector development policy that greatly increased fishing effort. However, national catches oscillate around 1.2 million tonnes since the early 1980s.

In the early 1990s, a change in policies occurred that aimed to promote private investment, favour industrial fishers and abrogate the 'reserved species' regime. This policy matured in 1992, when the current Federal Fisheries Law was enacted. Thorpe *et al*. (2000) documented the effect of the introduction of the 'New Economic Model' in fisheries management in several Latin American countries, including Mexico. These authors present the change in emphasis from privileging the social (cooperatives) sector to favouring private investment.

As a result, the fisheries industry was incorporated in 1994 in the newly formed Ministry of Environment, Natural Resources and Fisheries (Secretaría de Medio Ambiente, Recursos Naturales y Pesca [SEMARNAP]) as an underministry, and as part of a global policy aimed at attaining sustainable development. Hernández and Kempton (2003) discussed the effect of attempts to introduce a greater degree of scientific input in the management and public participation processes in Mexico in the mid- to late-1990s. This intended to include fisheries in a broader framework of natural resources management. The new fisheries plan stated sustainability as a goal and the Precautionary Principle as a guideline. Three elements were introduced: (a) an attempt to make the decision-making process more scientific-based; (b) a new legal instrument, the National Fisheries Chart (Álvarez-Torres *et al*., 2002); and (c) a more active participation of stakeholders in decision-making.

Since the end of 2000, at the beginning of the new administration, fisheries were transferred to the Ministry of Agriculture: Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación: SAGARPA), shifting again to 'incentives' of development (SAGARPA Plan Sectorial, 2001). At present, the agency responsible for fisheries management, monitoring and enforcement is the National Commission of Aquaculture and Fisheries (Comisión Nacional de Acuacultura y Pesca [CONAPESCA]). As a result of its transfer, the underministry of fisheries was downsized, and its state delegations (formerly one in every one of the 32 states) were reduced in number and incorporated into SAGARPA delegations, losing their hierarchical link to CONAPESCA.

5.2 Legal instruments, strategies and management tools

The fisheries included in this analysis are regulated in several ways. The octopus fishery is managed through a closed season (from January to August) that protects individual growth to marketable sizes and an annual catch quota. The shrimp fishery is regulated by closed seasons, mesh size and gear type restrictions and zonal restrictions for different users (prohibitions of trawling for industrial ships below five fathoms, a 15 nautical miles from shore no-fish zone in the Yucatán Peninsula). The lobster fishery has effort restrictions (by limiting the number of concessions), legal size limits, a prohibition of catching ovigerous females and a closed season. The grouper fishery has legal size limits and effort restrictions (number of permits), and a quota awarded to the Cuban vessels operating in the fishery is an allocation instrument. In the mullet fishery, a closed season, legal size limit and mesh size regulations are applied. In the shark fishery, an issuing of new permits moratorium has been in place for some years (Cid *et al.*, 2000), but proposed regulations on closed seasons and protection of breeding areas have still to be applied. Regulations on the finfish fishery have yet to be applied widely.

A relatively new legal instrument, the Official Mexican Standards (Normas Oficiales Mexicanas [NOM]), was developed which included the usual regulations such as permits, gear type restrictions, season and area closures, legal size limits, quotas and bycatch excluding devices. Until 2000, only 14 fisheries were regulated by NOMs, including shrimp, lobster and octopus.

Fisheries on the Pacific littoral are regulated with different instruments as described below.

Seaweed: Fishing area, gears and landing places are controlled.

Kelp: Exploitation of fishing areas are allocated to groups while areas, fishing gears, seasons and amount of fishing are defined by permits.

Abalone: Closures by area and time. Four administrative areas were established and a quota is defined separately. There is a minimum legal size, fishing gear is regulated and fishing at low tides is prohibited. A stocks-recovery plan has been implemented with measurable success in some areas. The goal is to maintain biomass at 50% of the pristine biomass.

Clam: Pacific calico scallop includes a minimum legal size, catch quota and effort by area in the Baja California Peninsula. A closed season is defined. Pismo clam and the purplelip rock oyster are currently species under special protection and officially they are not commercially exploited. Their use is now regulated by the General Law of Ecological Equilibrium and Environmental Protection (Ley General de Equilibrio Ecológico y la Protección al Ambiente).

Molluscs: Catch quotas by bank are defined for conch; fishing permits allowed for mussel and octopus in the Pacific. Giant squid has a fishing effort control based on an annual catch quota.

Shrimp: Seasonal and spatial closures by region, controls on fishing gears and amount of effort. Fixed gears are used as defined by the fishing law.

Lobster: Minimum legal size by species and area, seasonal and spatial closures. In the central Baja California, fishing cooperatives agreed voluntarily to the use of windows for escapement in traps to reduce pre-recruits (sizes below L_{50}).

Crab: In Sonora, the fishing sector has agreed on a seasonal closure to control fishing effort of several species such as 'stone crabs', where the number of permits is controlled. Fishing areas and minimum legal size are defined by target species. It is prohibited to capture gravid females.

Sea urchin: Characteristics of the gears and landing places are controlled and seasonal and spatial closures, minimum legal size and catch quotas have been introduced.

Sea cucumber: From 2000 to the present, this fishery is regulated under the 'promotion' (*fomento*) scheme because limited information of the resource does not allow access to a high number of users. Promotion permits involve the commitment of the users to generate information for the better understanding of the resource for management purposes.

Marine fishes: All marine fishes are globally managed by controlling access through fishing permits. Some details are added for groupers where areas and fishing gears are defined and for mullets where minimum legal size, mesh size and seasonal closures are established by species and region.

Sharks: Limited number of permits; new participants only by substitution of vessels.

Rays: Just fishing permits.

Sport fishing: Dolphinfish, marlin and swordfish appear as associated species in some commercial fisheries. However, there is no commercial fishing for dolphinfish or swordfish. Marlin is regulated under a commercial fishery, where permits specify fishing gears and areas.

5.3 Management and enforcement

Before the mid-1990s, the Secretariat of Fisheries had an inspection and enforcement body. After being incorporated into SEMARNAP, fisheries inspection and regulation enforcement was incorporated in the PROFEPA (an environmental attorney's office within the Ministry of Environment). When the fisheries regulation was transferred to SAGARPA, most former fisheries inspectors remained in PROFEPA or were transferred to SAGARPA's delegations with no formal links to CONAPESCA, which formally did not have a fisheries inspection role. Since illegal fishing is a serious problem in many parts of the country, the effectiveness of enforcement has been limited at best, even if institutional redesign had not played a role.

The navy, in collaboration with fisheries management institutions, has played an important auxiliary role in enforcement over the years. Several research centres across the country have developed scientific research efforts on fisheries issues. However, although scientists from those institutions have been participating with fisheries (federal and states) authorities and advising enterprises or fishers about management in the last decade, there are no institutional schemes to completely formalize the use of this scientific infrastructure.

5.4 Fishers' participation in fisheries management

Industrial fishers are associated with the National Fishing and Aquaculture Chamber. Artisanal fishers have the National Fishing Cooperatives Confederation. There are 2 976 registered fishing cooperatives in Mexico, along with 2 954 organizations of other types, such as Fishing Production Societies, Fishing Production Unions, Social Solidarity Societies and others. In total, there are 185 756 people associated within these organizations, 118 328 in cooperatives and 67 428 in other kinds of organizations (CONAPESCA, 2001).

In a process regulated by the Federal Metrology and Standardization Law (Ley Federal de Metrología y Normalización), committees should be formed to allow stakeholders to participate in decision-making processes, such as issuing Mexican Official Norms or assisting with certain management decisions (i.e. setting closed seasons). Although the fisheries regulatory agency (at present CONAPESCA) is the one that makes the final decision (and bears full responsibility for it), this process is intended to be enhanced by stakeholder participation. At present, this process is far from perfect. Only some committees have been formed so far. The functioning of those already established still has to be improved. Most artisanal fishers' organizations have yet to have consultants who can assist them on technical issues. Full representation of those invited to attend the meetings has yet to be achieved. Hernández and Kempton (2003) discuss difficulties found in implementing this system in the shrimp fishery, in particular the interactions of artisanal and industrial fishers.

Recently an advisory body, the National Fisheries Council (Consejo Nacional de Pesca), was formed that included representatives from industrial and artisanal fishers. However, it is still too early to discuss the results of the implementation of such a body in designing and implementing fisheries policies.

5.5 Community and NGO involvement in fishery management

Beyond state committees, there is little involvement of the local community in fisheries management. However, some communities in the Pacific and in Punta Allen, Quintana Roo, in the Caribbean have experienced successful community-based management programmes applied to the spiny lobster fishery (Seijo, 1993; Bourillon and Ramade, 2004).

Pérez-Sánchez and Muir (2003) quote fishers as saying that distrust over the honesty of cooperative leaders and authorities as an obstacle to an effective community organization. Ostrom (2000) points to these factors as a prerequisite for community management of resources.

The NGOs have had an increasing indirect role in the shape of proposals and studies performed on local fisheries. One example is NGO involvement in processes like ecolabelling (Bourillon and Ramade, 2004). However, this participation is not yet widespread.

Chenaut (1985) reported a traditional, self-imposed, territorial partitioning system for lobster fishers in eastern Yucatán and northern Quintana Roo, where territorial units were assigned to communities, independent of their affiliation to fishing cooperatives. This author comments on the fact that fishing authorities did not recognize the territorial divisions. However, such systems are not widely used in the Gulf of Mexico and the Caribbean. In the Pacific littoral there are several examples of management where communities are participating, such as the cases of abalone, sea urchin and lobsters. Some attempts to involve stakeholders in management have been made in finfish fisheries but without clear results yet.

5.6 Management in accordance to international guidelines

In 1982, Mexico signed the United Nations Convention on the Law of the Sea (UNCLOS) and the Agreement regarding the implementation of Part XI of the Convention. Previously in 1976, the National Constitution was modified to include the 200-nautical-mile EEZ. In 1999, Mexico signed the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. In 1995, Mexico signed the FAO Code of Conduct for Responsible Fisheries. Mexico has been an active promoter of this Code.

Although in the period 1994–2000 the Precautionary Principle was included explicitly in the Fisheries Sector Plan, it is not mentioned in the new sector Fisheries Plan that defines ‘sustainability’ as an aim.

The main instrument of allocation of fishing rights is the fishing permit. Although in some cases, issuing of short-term permits has been recommended in fisheries of uncertain status, as in the shark fishery (Cid *et al.*, 2000), there is a trend to issue longer term permits or concessions as a way of “giving legal certainty” to fishing activities and as a “tool for countering deterioration of the resources” (SAGARPA, 2001). At first, concessions had been issued to exploit demersal resources, mostly invertebrates that lend themselves to territorial divisions (such as lobster or abalone).

Quotas have been sparingly used in Mexico’s fisheries management. The grouper fishery has a quota awarded to Cuban vessels fishing in the Yucatán. The octopus fishery has a TAC-type (total allowable catch) overall quota that has been used as a substitute for effort regulations. This quota has not been very effective and researchers recommended against it early on (Solís-Ramírez *et al.*, 1998). The closest to an individual quota system is the one applied to abalone cooperatives in Baja California.

6. RESEARCH AND EDUCATION

Statistics are gathered periodically by local fishery offices, subordinated to SAGARPA’s delegations. This information is processed by CONAPESCA to produce, among other things, statistical yeardocuments. The National Fisheries Institute (Instituto Nacional de la Pesca [INP]) gathers data from samples on some fisheries included in research projects.

Concerning fisheries research, a number of scientific research projects have been conducted to assess stocks harvested by small-scale fisheries in Mexico, including:

(i) Studies on the octopus fisheries dating back to the early 1960s, which include the description of the main exploited species (*Octopus maya*) (Voss and Solís-Ramírez, 1966), growth and recruitment (Arreguín-Sánchez, 1992), and the development of the fisheries (Arreguín-Sánchez *et al*., 1987; Solís-Ramírez, 1975, 1988, 1991, 1994, 1997; Solís-Ramírez and Chávez, 1986; Solís-Ramírez *et al*., 1998; Arreguín-Sánchez *et al.*, 2000).

(ii) Studies on the shrimp fishery, including some relevant to the management of the artisanal fishery (Castro and Santiago, 1976; Schultz and Chávez, 1976), population dynamics, mortality and growth assessments (Smith, 1984, 1988; Re-Regis, 1989, 1994; Castro and Arreguín-Sánchez, 1991, 1997), and overviews of the fishery (Fernández *et al.*, 2000; Ramírez-Rodríguez *et al*., 2001).

(iii) Several studies on migration, growth, mortality, reproduction and general population dynamics on the Spanish and king mackerels (Mendoza, 1968; Doi and Mendizabal, 1978; Chávez, 1981; Mendizabal, 1987; Vasconcelos, 1988; Aguilar *et al*., 1990; Olvera *et al*., 1991; Sánchez *et al*., 1991; Arreguín-Sánchez *et al*., 1995). Schultz *et al.* (2000) present a general overview of the fishery.

(iv) Studies on mullets, including growth, mortality and general ecological observations from the mid- to late-1970s (Márquez, 1974; Castro, 1978). Gómez and Monroy (2000) summarized results from several unpublished research reports and made a detailed description of the fishery.

(v) The grouper fishery has been studied in depth. Early studies date back to the 1960s (Solís, 1969). Later studies include growth (Rodríguez, 1986), catchability (Arreguín-Sánchez, 1999), the state of the fishery (Doi *et al.*, 1981; Arreguín-Sánchez, 1985; Contreras *et al.*, 1995; Burgos and Defeo, 2000; Burgos and Defeo, 2004: Giménez-Hurtado *et al.*, 2005), and interaction of fleets (Zetina *et al.*, 1996a). Monroy *et al.* (2000a) summarize many important aspects of the fishery. Mexicano-Cintora *et al.* (2007) also integrate a list of references of studies related to grouper and other demersal fishes from the Yucatán shelf.

(vi) The lobster fishery studies include works on feeding (Colinas and Briones, 1990), reproduction (Ramírez, 1996), morphometrics (Zetina *et al.*, 1996b), density and distribution (Bello *et al.*, 2000), and descriptions of the fishery (Arceo and Seijo, 1991; Briones and Lozano, 1994; Ríos *et al.*, 1995, 1997, 2000; Cervera *et al.*, 1996; González-Cano *et al.*, 2000). An overview of the fishery can be found in González-Cano *et al.* (2000) and Salas *et al.* (2005).

Although earlier work on shark fisheries can be found (e.g. Hernández, 1971), the first systematic studies in the 1980s and 1990s were performed by the INP (e.g. Uribe, 1990; Castillo-Géniz, 1992; Castillo-Géniz *et al.*, 1998). Studies performed include species proportion in catches, morphometrics, types of fishing gears used, and times and places of occurrence of juveniles (Bonfil, 1997; Cid *et al.*, 2000; Márquez, 2000; Soriano *et al.*, 2000).

Many studies of several finfish species from different areas have been presented in different catalogues (e.g. Vega-Cendejas, 1998; Espino *et al.*, 2003, 2004). Other aspects such as growth and reproduction studies of some demersal fishes can be found in different theses (e.g. Rodríguez, 1992; Leonce-Valencia, 1995). Mexicano-Címtora *et al.* (2007) present about 500 references on studies undertaken on fishery resources from the Yucatán shelf.

6.1 Ecosystem-based management approach

A number of ecosystem models based on trophic webs have been developed with emphasis on fishing activity using an 'Ecopath with Ecosim' platform (i.e. Arreguín-Sánchez, 2002). Several of them have been used for modelling fisheries dynamics in the context of the ecosystem approach management strategies or assessing fisheries impact on the ecosystems.

A number of trophic ecosystem models have been constructed along both littorals, putting emphasis on the role of fish resources. Generally most of these models consider functional groups at the level of families with the exception of target or overfished species which are considered individually. The research has been focused to investigate the role of some stocks within the ecosystem, concentrating on fisheries management and conservation, and to evaluate the impact of fishing of some resources on the ecosystem. In Table 5, existing trophic ecosystem models are listed indicating the type of ecosystem considered for the analysis and the main research purpose.

TABLE 5
Ecosystem trophic models constructed in Mexico indicating the type of ecosystem and the main purpose for their construction

Ecosystem	Trophic web/role	Fisheries conservation management	Impact of fishery	Reference
Coral reefs Caribbean Sea	X	X		Älvarez-Hernández (2003), Arias-González *et al*. (2004).
North Continental Shelf of Yucatán	X	X	X	Arreguín-Sánchez *et al*. (1993a, b), Vega-Cendejas *et al*. (1993a, b), Arreguín-Sánchez (2000). Arreguín-Sánchez & Manikchand-Heileman (1998), Arreguín-Sánchez & Valero (1996).
Campeche Bank	X	X	X	Arreguín-Sánchez *et al*. (2004), Arreguín-Sánchez & Manikchand-Heileman (1998), Vega-Cendejas (1993a, b), Zetina-Rejón (2004), García-Cuellar (2006), Zetina-Rejón & Arreguín-Sánchez (2002), Arreguín-Sánchez (2002), Arreguín-Sánchez *et al*. (1993a), Arreguín-Sánchez *et al* (2008a, b).
Tabasco	X			Cabrera-Neri (2006)
Southwest Gulf of Mexico (Veracruz)	X	X		Arreguín-Sánchez *et al*. (1993b), Arreguín-Sánchez & Chávez (1995), Cruz-Escalona (2005).
Gulf of Mexico synthetic model	X			Vidal & Pauly (2004)
Jalisco and Colima	X	X	X	Galván-Piña (2005), Galván-Piña & Arreguín-Sánchez (2008)
Southern Sinaloa	X			Salcido-Guevara (2006), Salcido & Arreguín-Sánchez (2007), Lozano (2006)
Central Gulf of California	X	X	X	Arreguín-Sánchez *et al*. (2002), Arreguín-Sánchez & Martínez-Aguilar (2004), Arreguín-Sánchez & Calderón-Aguilera (2002).
Northern Gulf of California	X	X	X	Morales-Zárate *et al*. (2004), Lercari (2006), Lercari & Arreguín-Sánchez (2008), Lercari *et al*. (2007).
Gulf of Ulloa	X			Del Monte-Luna (2004), Del Monte *et al*. (2007).
Models from bays and coastal lagoons				
La Paz Bay	X	X	X	Arreguín-Sánchez *et al*. (2004), Díaz-Uribe *et al*. (2007), Arreguín-Sánchez *et al*. (2007).
Concepción Bay	X			Gorostieta-Monjaraz (2001)
Huizache and Caimanero	X	X	X	Zetina-Rejón *et al*. (2001, 2003, 2004)
Celestun Lagoon	X			Chávez *et al*. (1993). Vega-Cendejas (1998), Vega-Cendejas & Arreguín-Sánchez (2001)
Terminos Lagoon	X	X		Manikchand-Heileman and Arreguín-Sánchez (1998), Rivera-Arriaga *et al.* (2003), Zetina-Rejón (2004), Zetina-Rejón *et al*. (2004).
Alvarado Lagoon	X			Cruz-Escalona (2005), Cruz-Escalona *et al*. (2006).
Tampamachoco Lagoon	X			Rosado-Solórzano & Guzmán del Proó (1993)

TABLE 5 (CONTINUED)

Ecosystem	Trophic web/role	Fisheries conservation management	Impact of fishery	Reference
Madinga Lagoon	X			De La Cruz-Aguero (1993)
Tamiahua Lagoon	X			Abarca-Arenas & Valero (1993)
Ascención Bay	X			Vidal & Basurto (2003)
Mangrove system	X			Vega-Cendejas & Arreguín-Sánchez (2001), Vega-Cendejas (2003), Rivera-Arriaga *et al* (2003).
Interdependent ecosystems				
Alvarado Lagoon and adjacent continental shelf	X	X	X	Cruz-Escalona (2005)
Terminos Lagoon and Campeche Bank	X	X	X	Zetina-Rejón (2004)

7. ISSUES AND CHALLENGES

7.1 Fisheries assessment and approaches needed for integration

There is a reasonable scientific effort on stock assessment when it comes to evaluating fisheries in Mexico. Originally there was a single species focus and, more recently, the ecosystem models have been introduced in some evaluations. However, social science studies related to the fishing sector (including social and economic analysis of fisheries) are poorly developed in Mexico (or at least carried out by only a few researchers and ignored by managers). In recent years, the international community (Jentoft and MacCay, 1995; Berkes *et al.*, 2001; Euan *et al.*, 2004; Salas and Gaertner, 2004; Salas *et al.*, 2007) has recommended the need to integrate natural and social sciences to find management strategies that focus on sustainability. Fisheries need to be examined within a broader natural resource research and management framework.

7.2 Lack of long-term vision on fisheries management

Fisheries management in Mexico has undergone changes in emphasis and approach several times in the last decades, but still lacks a long-term plan. Accordingly, related institutions have undergone several modifications. Fisheries plans are updated every six years and usually change in approaches and emphasis. The Federal Fisheries Law and related regulations are general in scope and mainly give broad structure for management. Hernández and Kempton (2003) and Beltran-Turriago (2007) have discussed the problems resulting from the complete redesign of Mexican institutions every six years, most especially the introduction of new administrations; those shifts have prevented the development of a coherent fisheries policy. Some efforts have been made to generate management instruments that transcend the institutional administrative changes and shifts in approaches, such as the case of the National Fisheries Chart, which includes a diagnosis of the state of the resources, characteristics of the fisheries, and setting legal limits to fishing effort on a per fishery basis (Álvarez-Torres *et al*., 2002). This chart is updated regularly based on scientific information, but could benefit from widening its scope. There is also a need to develop the mechanisms for social participation in the decision-making and possibly the implementation of management and research programmes.

7.3 Flaws in fishery policies and lack of transparency

Hernández and Kempton (2003) stated that conditions such as low stock levels, too many fishers, trends of rent reduction, and no incentives to conserve the resource generate a race to fish and overcapitalization of the resource. In our view, institutional fragility should be added as a cause of these problems. The reduction of institutions devoted to fisheries research and management that have resulted from administrative changes generates deficits in terms of attention to problems in the sector and effectiveness in management (Beltran-Turriago, 2007). Ostrom (2000) points out that effective social organization and institutional structure are the only ways to combat problems related to poorly defined property rights. Allocation of property right has been defined as one of the effective management tools dealing especially with artisanal fisheries. Thorpe *et al.* (2000) also state that greater management resources and expertise are required under such conditions.

Other weaknesses in the management system concern equality among different users of resources and development alternatives during policy changes. It is important not to remain stagnant while searching for solutions to overexploitation and overcapacity. For example, reductions between 50 and 60% of fleet size have been suggested recently for the Mexican Gulf of Mexico shrimp fleet (Goudet y Goudet, 1987; FAO/World Bank, 1988) and financial support from the government has shifted to shrimp culture (36% of credits awarded), compared with 22% of credits devoted to industrial fisheries and 16% to artisanal fisheries. Geographically, there are also differences, with 83% of the credits awarded to five states in the north Pacific Region (CONAPESCA, 2001).

On the other hand, there is a widespread perception of fisheries as a 'production activity' that does not consider the need for environmental protection. This, along with the dire economic situation of many fishers and the ever-growing dependence of the fisheries sector on subsidies, drives upper level officials to design policies that in many occasions are not compatible with other branches of government.

7.4 Need for a definition of use rights

The increasing degree of conflict in Mexico's fisheries stems in part from a free-access regime that persisted for decades. The environment of poorly defined property rights can only lead to a 'tragedy-of-the-commons' and a 'prisoner dilemma' type of outcome (Ostrom, 2000). Hence, cooperation among stakeholders to conserve and obtain maximum benefits from an exploited resource is an important prerequisite for successful management schemes. There is a broad consensus among social scientists on the pivotal role of institutional arrangements in shaping peoples' interactions with their natural environments and negotiation processes in natural resource management. Incentives for sustainable exploitation of fishing resources come in the shape of long-term assurance of being able to reap benefits from them in a fair and equitable fashion. But this assurance can only occur in a setting of well-defined use or property rights. The co-management of common-pool resources in different parts of the world has been shown. However, territorial concessions are not widespread in Mexico. An exception would be the area concessions awarded to cooperatives exploiting benthic resources such as abalone or lobster in the Baja California peninsula. However, even though allocation of inshore areas to artisanal fisheries has been proposed, it still remains unclear how these reserved areas would be established, especially with pressure from the industrial sector on government agencies and the lack of flexibility of the centralized management system.

7.5 Interactions between industrial and artisanal fleets and with other sectors

Thorpe *et al.* (2000) discuss that conflicts between fishers, particularly between the artisanal and industrial sectors, have generated serious problems in Mexican fisheries. In this sense, it is common to find that industrial fishers and artisanal fishers blame each other for decreases in catches of several resources in different areas. Illegal actions from artisanal fishers are reported by industrial fishers. In contrast, artisanal fishers are concerned with the effects the excessive fishing power from industrial fishers might have on several resources, especially spawners of some species (i.e. grouper or shrimp). Either way, it is a fact that effort and fishing power have increased greatly in Mexican fisheries. For example, the number of artisanal vessels rose more than fivefold since 1970 from 15 000 vessels to 102 000 in 2000. Before 1982, about 1 600 new artisanal vessels were incorporated each year. On the other hand, even though the industrial fleet has decreased approximately 5% from its maximum in 1983, the fishing power has increased due to the adoption of new fishing techniques and gears.

Other productive activities compete for resources use, areas, or can limit the expansion of fishing activities or serve as a complementary source of income for fishers in Mexico. Different regions present different conditions and the interaction of fisheries with other sectors varies among areas. For example, oil exploitation has been an increasingly important activity in the Campeche Bank since the mid-1970s (Melville, 1984). Exclusion of some areas to fishing still remains a problem for some people. Tourism is an important activity in the Yucatán (Méndez, 2004) and Quintana Roo (Cesar and Arnaiz, 1998) coasts and the expansion of this sector increases demand for seafood and labour. On the Pacific coast, there are well developed tourism locations such as Los Cabos, Acapulco, Huatulco, Mazatlan, Manzanillo, Puerto Vallarta, Bahia de Banderas, and a number of smaller tourist centres. Cargo activities in some areas have been expanding, such as Lázaro

Cárdenas, Manzanillo and Salina Cruz. Multiple uses of the coastal areas require efforts to identify possible human and ecological interdependencies. In addition, definition on users' rights of natural resources is required.

7.6 Impact of subsidies on fishing activities

Subsidies to fisheries (in the form of reduction in diesel fuel prices) went from 468 million Mexican pesos in 2001 to 887 million in 2002. Initially, subsidies were directed towards supporting the operations of the industrial fleet (as it only uses diesel). However, they began to be earmarked also to gasoline, used by the artisanal fleet at the end of 2003 (Cámara de Senadores, 2003). Subsidies were seen as an important issue in the Chamber of Deputies consultation's results to 'increase competitiveness' (Comisión de Pesca de la Camara de Diputados, 2001). Although it has been acknowledged that subsidies should not be directed to increasing fishing effort (Cámara de Senadores, 2003), it seems that little attention has been paid to the economic effects, and those over the exploited stocks, of subsidies in maintaining present levels of fishing effort (National Research Council, 1999; World Wildlife Foundation, 2001).

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APPENDIX I

Target species in the Gulf of Mexico and Caribbean region by type of organism, common and scientific names

Groups	Common name	Spanish name	Scientific name
Molluscs Cephalopods	Mayan (red) octopus	Pulpo maya, pulpo rojo	*Octopus maya*
	Common octopus	Pulpo común, pulpo patón	*O. vulgaris*
Crustaceans	Brown shrimp	Camarón café	*Farfantepenaeus. aztecus*
	White shrimp	Camarón blanco	*Litopenaeus setiferus*
	Pink shrimp	Camarón rosado	*F. duorarum*
	Seabob	Camarón siete barbas	*Xiphopenaeus kroyeri*
	Spiny lobster	Langosta espinosa	*Panulirus argus*
	Spotted lobster	Langosta pinta	*P gutatus*
	Green lobster	Langosta verde	*P. laevicauda*
Fish	Lisa	Lisa	*Mugil cephalus*
	White mullet	Lebrancha	*M. curema*
	Grouper	Mero	*Epinephelus morio*
	Spanish mackerel	Sierra	*Scomberomorus maculatus*
	King mackerel	Peto, carito	*S. cavalla*
	Mojarra	Mojarra	*Gerres* sp., *Eugerres* sp., *Eucinostomus* sp.
	Gafftopsail catfish	Bandera	*Bagre* spp.
	Jack	Jurel	*Caranx* spp.
	Snook	Robalo	*Centropomus* spp.
	Weakfish	Trucha	*Cynoscion* spp.
	Snapper	Guachinango, pargo	*Lutjanus* spp.
	Seabass	Corvine	*Cynoscion* spp.
	Rudderfish, amberjack	Esmedregal	*Seriola* spp.
	Yellowtail snapper	Rubia	*Ocyurus* spp.
	Vermilion snapper	Besugo	*Rhomboplites* spp.
	Grunt	Ronco	*Pomadasys, Anisotremus*
	Sea catfish	Bagre	*Arius* spp.
	Croaker	Berrugata	*Menticirrhus* spp.
	Pompano	Pompano	*Trachinotus* spp.
	Cabrilla	Cabrilla	*Paralabrax, Epinephelus*
	Flounder	Lenguado	*Paralichtys, Syacium*

APPENDIX I (CONTINUED)

Groups	Common name	Spanish name	Scientific name
Sharks and rays	Atlantic sharpnose shark	Cazón de ley, caña hueca	*Rhizoprionodon terraenovae*
	Blacktip shark	Tiburón puntas negras, volador	*Carcharhinus limbatus*
	Bonnethead	Cazón cabeza de pala, pech	*Sphyrna tiburo*
	Scalloped hammerhead	cornuda	*S. lewini*
	Bullshark	Tiburón chato	*C. leucas*
	Blacknose shark	Cazón canguay, pico negro	*C. acronotus*
	Smalltail shark	Tiburón poroso,cuero duro	*C. porosus*
	Spinner shark	Tiburón curro, puntas negras, picudo	*C. brevipinna*
	Hammerhead	Cornuda grande, cornuda gigante	*S. mokarran*
	Night shark	Tiburón nocturno, ojo verde	*C. signatus*
	Sandbar shark	Tiburón aleta de cartón, aletón	*C. plumbeus*
	Angel shark	Tiburón ángel, angelote	*Squatina dumerili*
	Dusky shark	Tiburón prieto, negro, tabasqueño	*C. obscurus*
	Spotted eagle ray	Chucho, chucho obispo, chucho pintado	*Aetobatus narinari*
	Skate	Raya	*Raja texana*
	Southern stingray	Raya látigo	*Dasyatis americana*
	Longnose stingray	Raya látigo hocicona	*D. guttata*
	Cownose ray	Raya gavilán	*Rhinoptera bonasus*

APPENDIX II

Target species in the Pacific region by type of organism, common and scientific names

Groups	Common name	Spanish name	Scientific name
Molluscs (Gastropods)	Blue abalone	Abulón azul	*Haliotis fulgens*
	Yellow abalone	Abulón amarillo	*H. corrugada*
	Black abalone	Abulón negro	*H. cracherodii*
	Chinese abalone	Abulón chino	*H. sorenseni*
	Red abalone	Abulón rojo	*H. rubescens*
	Crown conch	Caracol burro	*Melongena patula*
	Pink murex	Caracol chino rosa	*Hexaplex erythrostomus*
	Northern radix murex	Caracol chino negro	*Muricanthus nigritus*
	Purpura conch	Caracol de tinta	*Purpura pansa*
	Cortez conch	Caracol burro	*Strombus galeatus*
	Wavy turban	Caracol panocha	*Astrea undosa, A. turbanica*
Bivalves	Pismo clam	Almeja pismo	*Tivela stultorum*
	Squalid callista	Almeja chocolata	*Megapitaria squalida*
	Golden callista	Almeja chocolata roja	*M. aurantica*
	Disk dosinia	Almeja blanca	*Dosinia ponderosa*
	Many-ridged venus	Almeja roñosa de risco	*Peryglipta multicostata*
	Frilled californian venus		*Chione undatela*
	Ornate venus		*C. gnidia*
	Californian venus clam	Almeja roñosa	*C. californiensis*
	Pacific lion´s paw	Almeja mano de león o almeja voladora	*Lyropecten subnodosus*
	Pacific calico scallop	Almeja catarina	*Argopecten circularis*
	Scallop	Almeja voladora	*Pecten vogdesi*
	Ark	Pata de mula	*Anadara tuberculosa*
	Purplelip rock oyster	Almeja burra	*Spondylus calcifer*
	Rugose pen shell	Callo de hacha	*Pinna rugosa*
	Maura pen shell	Callo de hacha china	*Atrina maura*
	Mussels	Mejillón	*Mytilus californianus, M. edulis, Modiolus capax*
Cephalopods	Octopus	Pulpo	*Octopus hubbsorum, O. vulgaris*
	White spotted octopus	Pulpo manchado	*O. macropus*
	Two spotted octopus	Pulpo manchado	*O. bimaculatus*
		Pulpo rojo	*O. rubescens*
	Giant squid	Calamar gigante	*Dosidiscus gigas*
Echinoderms	Red sea urchin	Erizo rojo	*Strogylocentrotus franciscanus*
	Sea urchin	Erizo púrpura	*S. purpuratus*
	Sea cucumber	Pepino de mar	*Isostichopus fuscus, Parastichopus parvimensis*

APPENDIX II (CONTINUED)

Groups	Common name	Spanish name	Scientific name
Crustaceans	Brown shrimp	Camarón café	*Farfantepenaeus californiensis*
	Blue shrimp	Camarón azul	*Litopenaeus stylirostris*
	White shrimp	Camarón blanco	*L. vannamei, L. occidentalis*
	Cristal shrimp		*F. brevirostris*
	Rock-shrimp	Camarón roca, japonés	*Sicyonia dorsalis, S. penicillata*
	Seabob	Camarón siete barbas	*Xiphopenaeus riveti*
		Camarón zebra	*Trachypenaeus faoe*
		Camarón botalón	*T. pacificus*
	Green crab	Jaiba verde	*Callinectes bellicosus*
	Blue crab	Jaiba azul	*C. arcuatus*
	Black crab	Jaiba negra	*C. toxotes*
	Red lobster	Langosta roja	*Panulirus interruptus*
	Green lobster	Langosta verde	*P. gracillis*
	Blue lobster	Langosta azul	*P. inflatus*
	Lobster	Langosta insular	*P. penicillatus*
	Stone crabs	Cangrejo amarillo	*Cancer anthonyi*
		Cangrejo rojo de roca	*C. productus*
		Cangrejo púrpura	*C. gracilis*
		Cangrejo de roca moteado	*C. antennarius*
		Cangrejo	*C. magister*
		Cangrejo mexicano	*C. jhongarti*
Fishes	Jewfish	Cherna o mero	*Epinephelus itajara*
		Verdillo	*Paralabrax nebulifer*
		Sandía	*Paranthias colonus*
		Cabrilla piedrera	*Epinephelus labriformis*
		Baqueta	*Epinephelus acanthistius*
		Cabrilla sardinera	*Myoteroperca rosacea*
	Spotted sandbass	Cabrilla de roca	*Paralabrax maculatofasciatus*
	Spotted cabrilla	Cabrilla pinta	*Epinephelus analogus*
	Flag cabrilla	Cabrilla piedrera	*Epinephelus labriformis*
		Cabrilla cueruda	*Dermatolepis dermatolepis*
		Baya	*Mycteroperca jordani*
		Cabrilla plomada	*Mycteroperca xenarcha*
		Pescada	*Stersolepis gigas*
	Shortfin *corvina*	Corvina azul, corvina de aleta corta	*Cynoscion parvipinnis*
	Orange mouth *corvina*	Corvina boca anaranjada	*C. xanthulus*
	Gulf curvina	Corvina del golfo	*C. othonopterus*
	Stripped *corvina*	Corvina rayada	*C. reticulatus*

APPENDIX II (CONTINUED)

Groups	Common name	Spanish name	Scientific name
Fish (continued)		Corvina chiapaneca	*C. albus*
	White seabass	Corvina blanca	*Atractoscion nobilis*
	Drum	Corvina chata o boquinete	*Larimus argenteus*
		Chano sureño	*Micropogonias altipinnis*
	Gulf croacker	Chano norteño o berrugata	*Micropogon megalops*
		Corvineta armada	*Bairdiella armata*
		Corvineta ronco	*B. icistia*
	King croacker	Berrugata, gurrubato	*Menticirrhus panamensis*
		Berrugata californiana	*M. undutatus*
	Highfin *corvina*	Berrugata real	*M. nasus*
		Berrugata roncadora	*Umbrina xanti*
		Berrugata aleta amarilla	*U. roncador*
	Grunter	Ronco	*Pomadasys macracanthus, P. panamensis*
	Burrito grunt	Burrito	*Anysotremus interruptus*
	Cortez grunt	Mojarrón	*Lythrulof flaviguttatum*
	Bronzestriped grunt	Roncacho	*Orthopristis reddingi*
	Pacific red snapper	Huachinago del Pacifico	*Lutjanus peru*
	Spotted rose snapper	Pargo lunarejo, flamenco	*L. guttatus*
	Yellow snapper	Pargo amarillo, coyotillo, alazan, clavelino	*L. argentiventris*
		Pargo rojo, pargo colmillón	*L. jordani*
	Colorado snapper	Pargo colorado, pargo listoncillo	*L. colorado*
	Dog snapper	Pargo mulato, pargo prieto	*L. novemfasciatus*
		Pargo rabirrubia	*Lutjanus inermis*
	Blue and gold snapper	Pargo azul-dorado,rayado	*Lutjanus viridis*
	Mangrove snapper	Pargo raicero, pargo de manglar	*Lutjanus aratus*
	Mexican barred snapper	Pargo coconaco, tecomate	*Hoplopagrus guentheri*
	Common jack	Jurel	*Canarx hippos*
	Jack	Ojón	*C. marginatus*
		Jurel toro	*Caranx caninus*
		Jurel voraz, ojo de perra	*C. sexfasciatus*
	Green jack	Cocinero, jurel bonito	*C. caballus*
		Chicharro ojoton	*Selar crumenophtalmus*
	Yellow tail	Esmedregal, jurel de castilla	*Seriola dorsalis*
	Amberjack	Esmedregal limón	*Seriola rivoliana*
		Esmedregal cola amarilla	*Seriola lalandi*
		Esmedregal fortuno	*S. peruana*

APPENDIX II (CONTINUED)

Groups	Common name	Spanish name	Scientific name
Fish (continued)	California halibut	Lenguado californiano	*Paralichthys califomicus*
		Lenguado huarache	*Paralichthys woolmani*
	Cortez halibut	Lenguado de Cortes	*Paralichthys aestuarius*
		Lenguado cola de abanico	*Xystreurys liolepis*
		Lenguado bocón	*Hippoglossina stomata*
		Lenguado diamante	*Hypsopsetta guttulata*
	Fourspot sole	Lenguado cuatrojos	*Hippoglossina tetrophthalmus*
		Lenguado resbaloso	*Microstomus pacificus*
	Three-eye flounder	Lenguado	*Ancylopsetta dendritica*
	Striped mullet	Lisa rayada, cabezona	*Mugil cephalus*
	White mullet	Lisa blanca, liseta, lebrancha	*Mugil curema*
		Lisa hospe	*Mugil hospes*
		Pierna o blanco	*Caulolatilus princeps*
		Conejo, salmón	*Caulolatilus affinis*
		Robalo plateado o garabato	*Centropomus viridis*
	Black snook	Robalo prieto o piedra	*Centropomus nigrescens*
		Robalo aleta prieta o paleta	*Centropomus medius*
		Robalo espina larga	*Centropomus armatus*
	Black snook	Robalo aleta amarilla, constantino, robalito	*Centropomus robalito*
	Tarpon snook	Constantino	*Centropomus pectinatus*
	Chub mackerel	Macarela	*Scomber japonicus*
	Pacific mackerel	Sierra	*Scomberomorus sierra*
	Spanish mackerel	Sierra	*Scomberomorus concolor*
	Yellowfin mojarra	Mojarra de aletas amarillas	*Diapterus peruvianus*
	Silver mojarra	Mojarra plateada	*Eucinostomus argenteus*
		Mojarra blanca	*Gerres cinereus*
	Pacific flagfin mojarra	Mojarra	*E. gracilis*
	Dolphinfish	Dorado	*Coryphaena hipurus*
Sharks and Rays		Cazón mamón	*Mustelus henlei, M. lunulatus*
	Sharpnose shark	Cazón bironche	*Rhizoprionodon longurio*
	Scalloped hammerhead	Cornuda o martillo	*Sphyrna lewini*
	Pacific angel shark	Angelote	*Squatina californica*
		Tiburón cornudo	*Heterodontus mexicanus*
		Cornuda prieta	*S. zygaena*
	Blacktip shark	Tiburón volador, puntas negras	*Carcharinus limbatus*
		Tiburón aleta de cartón	*Carcharhinus falciformis*
		Tiburón coyotito	*Nasolamia velox*

APPENDIX II (CONTINUED)

Groups	Common name	Spanish name	Scientific name
Sharks and rays (continued)		Tiburón perro	*Alopias superciliosus*
		Tiburón chato	*Carcharhinus leucas*
		Tiburón perro	*Alopias pelagicus*
	Tiger shark	Tintorera	*Galeocerdo cuvier*
		Cornuda gigante	*Sphyrna mokarran*
		Gata	*Ginglymostoma cirratum*
		Tiburón azul	*Prionace glauca*
		Cornuda	*Sphyrna media*
		Mako	*Isurus oxyrinchus*
	Thresher shark	Tiburón zorro	*Alopias vulpinus*
		Tiburón puntas blancas	*Carcharhinus longimanus*
		Tiburón martillo	*Sphyrna corona*
	Small tail shark	Tiburón cuero duro	*Carcharinus porosus*
	Lemon shark	Tiburón limón	*Negaprion brevirostris*
			Mustelus californicus
			Cephaloscyllium ventriosum
			Heterodontus francisci
			Carcharhinus obscurus
			Triakis semifasciata
			Hexanchus griseus
			Notorynchus cepedianus
	Stingray	Raya	*Dasyatis longus*
	Pacific manta	Manta o mantarraya	*Manta hamiltoni*
	Longtail diamond stingray	Raya con espinas	*D. brevis*
	Bat ray	Raya gavilán o tejolote	*Myliobatis californicus*
Seaweeds	Sargazo	Sargazo gigante	*Macrocystis pyrifera*

APPENDIX III
Non-target species and/or bycatch

English name	Spanish name	Scientific name
Finescale triggerfish	Cochi	*Batistes polylepis*
Ocean whitefish	Pierna, blanco	*Caulolatilus princeps*
Bighead tilefish	Conejo, salmón	*Caulolatilus affinis*
Cortez flounder	Lenguado de Cortés	*Paralichthys aestuarius*
Pacific bearded brotula	Lengua	*Brotula ctarki*
California scorpionfish	Lapón californiano	*Scorpaena guttata*
Spotted scorpionfish	Lapón, escorpión, rascado	*Scorpaena plumieri*
Mexican hogfish	Vieja mexicana	*Bodianus diplotaenia*
California sheephead	Vieja californiana	*Semicossyphus pulcher*
Bocaccio	Rocote	*Sebastes paucispinís*
Kelp rockfish	Rocote sargacero	*Sebastes atrovirens*
North Pacific hake	Merluza norteña	*Merluccius productus*
Speckled guitarfish	Guitarra punteada	*Rhinobatos glaucosiigma,*
Whitesnout guitarfish	Guitarra trompa blanca	*Rhinobatos leucorhyncfius*
Shovelnose guitarfish	Guitarra viola	*Rhinobatos productus*
Banded guitarfish	Guitarra rayada	*Zapteryx exasperala*
California butterfly ray	Raya mariposa californiana	*Gymnura marmorata*
Pacific chupare	Raya coluda del Pacífico	*Himantura pacifica*
Whiptail stingray	Raya látigo común	*Dasyatis brevis*
Pacific angelshark	Angelote	*Squatina califomica*
Grey smooth-hound	Cazón, tiburón mamón	*Mustelus califomicus*
Siklefin smooth-hound	Cazón segador	*Mustelus lunulatus*
Brown smooth-hound	Cazón hilacho	*Mustelus henlei*
Pacific sharp-nose shark	Tiburón bironche	*Rhizoprionodon longurio*
Inshore sand perch	Serrano cabicucho	*Diplectrum pacificum*
Spotted sand bass	Cabrilla de roca	*Paralabrax maculatofasciatus*
Flag Serrano	Serrano bandera	*Serranus huascarii*
Flathead mullet	Lisa rayada, lisa cabezona	*Mugil cephalus*
Pacific porgy	Mojarron, pluma marotilla	*Calamus brachysomus*
Paloma pompano	Pampano paloma	*Trachinotus paitensis*
Yellowfin surgeonfish	Cirujano aleta amarilla, barbero	*Acanthurus xanthopterus*
Pacific mutton hamlet	Guaseta del Pacifico	*Alphestes immaculatus*
Scrawled filefish	Lija garrapatera, bota trompa	*Aluterus scriptus*
Burrito grunt	Burro bacoco	*Anisotremus interruptus*

APPENDIX III (CONTINUED)

English name	Spanish name	Scientific name
Threadfin jack	Jurel de hebra, cocinero, chicuaca	*Carangoides otrynter*
Pacific crevalle jack	Jurel toro	*Caranx caninus*
Bigeye trevally	Jurel voraz	*Caranx sexfasciatus*
Pacific graysby	Enjambre	*Cephalopholis panamensis*
Shortfin weakfish	Corvina azul, corvina aleta corta	*Cynoscion parvipinnis*
Pacific spadefish	Zopilote, peluquero, chavelito, chambo, ojo de perra	*Chaetodipterus zonatus*
Rooster hind	Baqueta	*Epinephelus acanthisbus*
Spotted grouper	Cabrilla pinta	*Epinephelus analogus*
Itajara	Mero guasa, cherna	*Epinephelus itajara*
Starry grouper	Cabrilla piedrera	*Epinephelus labriformis*
Star-studded grouper	Baqueta ploma	*Epinephelus niphobles*
Yellow spotted grunt	Ronco, chano, burro manchas amarillas, jiniguaro	*Haemulon flaviguttatum*
Spottail grunt	Burro rasposo	*Haemulon maculicauda*
Greybar grunt	Burro almejero, guzga	*Haemulon sexfasciatum*
Blue-bronze sea chub	Chopa rayada	*Kyphosus analogus*
Cortez sea chub	Chopa de Cortes, chopa gris	*Kyphosus elegans*
Giant manta	Mantarraya, manta gigante	*Manta birostris*
Wavyline grunt	Ronco rayadillo	*Microlepidotus inornatus*
Gulf grouper	Baya	*Mycteroperca jordani*
Leopard grouper	Cabrilla sardinera, mitan	*Mycteroperca rosacea*
Bronze-striped grunt	Burrito, ronco rayado	*Orthopristis reddingi*
Goldspotted sand bass	Cabrilla extranjera, lucero	*Paralabrax auroguttatus*
Parrot sand bass	Cabrilla cachete amarillo, lucero	*Paralabrax loro*
Pacific cownose ray	Manta gavilán	*Rhinoptera steindachneri*
Pacific spotted scorpionfish	Lapón, escorpión	*Scorpaena mystes*
Almaco jack	Esmedregal limón, esmedregal almaco	*Seriola rivoliana*
Bullseye puffer	Botete diana	*Sphoeroides annulatus*
Orangeside triggerfish	Cochi naranja, bota, pejepuerco	*Suflamen verres*
Gafftopsail pompano	Pampano fino, pampano rayado	*Trachinotus rhodopus*
Polla drum	Berrugata roncadora	*Umbrina xanti*
Longfin salema	Chula, jiguagua, salmonete	*Xenichthys xanti*
Pacific ladyfish	Macabi	*Elops affinis*
Yellowfin mojarra	Mojarra bandera, mojarra rayada	*Gerres cinereus*
Pacific sierra	Sierra del pacifico	*Scomberomorus sierra*
Bluespotted cornetfish	Trompeta, corneta pintada	*Fistularia commersonii*

APPENDIX III (CONTINUED)

English name	Spanish name	Scientific name
Californian needlefish	Agujón californiano	*Strongylura exilis*
Roosterfish	Papagayo	*Nematishus pectoralis*
Threadfin jack	Jurel de hebra, chicuaca	*Carangoides otrynter*
Rainbow runner	Macarela salmón	*Elagatis bipinnulata*
Snouted eagle ray	Raya águila picuda	*Myliobatis longirostris*
Bat eagle ray	Tecolote, raya murciélago	*Myliobatis californica*
Longfin sanddab	Lenguado alón	*Citharichthys xanthostigma*
Spotted eagle ray	Chucho pintado	*Aetobatus narinari*
Threadfin bonefish	Quijo, macabi, chile, banana	*Albula nemoptera*
Anchovy	Anchoveta, anchoa chicotera	*Anchoa sp*
Black snook	Róbalo prieto	*Centropomus nigrescens*
Yellowfin snook	Róbalo aleta amarilla, constantino, robalito	*Centropomus robalito*
Pacific anchoveta	Sardina bocona, boquerón	*Cetengraulis mysticetus*
Milkfish	Sabalote	*Chanos chanos*
Pacific bumper	Jurel de castilla, casabe	*Chloroscombrus orqueta*
Golden mojarra	Mojarra palometa	*Diapterus aureolus*
Peruvian mojarra	Mojarra aletas amarilla, mojarra china, malacapa	*Diapterus peruvianus*
Pacific ladyfish	Machete del pacifico	*Elops affinis*
Pacific flagfin mojarra	Mojarra tricolor	*Eucinostomus curan ischana*
Graceful mojarra	Mojarra charrita	*Eucinostomus gracilis*
Blackfin jack	Chocho, jurel chumbo	*Hemicaranx zelotes*
California kingcroaker	Berrugata	*Menticirrhus undulatus*
Longjaw leatherjack	Piña bocona	*Oligoplites altus*
Squint-eyed croaker	Corvineta bizca	*Ophioscion strabo*
Pacific thread herring	Sardina crinuda	*Opisthonema libentate*
Brassy grunt	Burrito corcovado	*Orthopristis chalceus*
Blue bobo	Barbudo seis barbas	*Polydactylus approximans*
Panama grunt	Ronco mapache	*Pomadasys panamensis*
Bigscale goatfish	Chivo, chivato, salmonete	*Pseudupeneus grandisquamis*
Mexican lookdown	Jorobado escamoso, tostón	*Selene brevoortli*
Barred sand bass	Verdillo, cabrilla de arena	*Paralabrax nebulifer*
Mexican barracuda	Barracuda mexicana	*Sphyraena ensis*
Bigeye croaker	Chano norteño	*Micropogonias megalops*
Gulf weakfish	Corvina golfina	*Cynoscion othonopterus*
Dow's mojarra	Mojarra cantileha o blanca	*Eucinostomus dowii*

APPENDIX IV

List of fish species composing shrimp-trawl bycatch of the southern Gulf of California

Family	Species	Percent (weight)	Cumulative %
Diodontidae	*Diodon holocanthus*	14.08	14.08
Serranidae	*Diplectrum pacificum*	8.64	22.72
Synodontidae	*Synodus scituliceps*	7.72	30.44
Serranidae	*Paralabrax maculatofasciatus*	6.27	36.71
Gerreidae	*Eucinostomus dowii*	6.26	42.97
Hamulidae	*Haemulon steindachneri*	5.64	48.61
Balistidae	*Balistes polylepsis*	4.04	52.65
Haemulidae	*Orthopristis reddingi*	3.50	56.15
Rhinobatidae	*Rhinobatos glaucostigma*	3.09	59.24
Achiridae	*Achirus mazatlanus*	2.70	61.94
Paralichthyidae	*Etropus crossotus*	2.28	64.22
Sparidae	*Calamus brachysomus*	2.25	66.47
Haemulidae	*Haemulidae*	2.14	68.61
Batrachoididae	*Porichthys analis*	2.13	70.74
Triglidae	*Prionotus stephanophrys*	1.87	72.61
Ariidae	*Arius platystomus*	1.60	74.21
Haemulidae	*Haemulopsis elongatus*	1.58	75.79
Sciaenidae	*Micropogonias ectenes*	1.56	77.35
Lutjanidae	*Lutjanus peru*	1.27	78.62
Paralichthyidae	*Hippoglossima tetrophthalma*	1.25	79.86
Urolophidae	*Urobatis halleri*	1.17	81.03
Serranidae	*Diplectrum* spp.	1.06	82.09
Narcinidae	*Diplobatis ommata*	1.05	83.14
Scorpàenidae	*Scorpaena russula*	1.03	84.17
Lutjanidae	*Lutjanus guttatus*	0.79	84.96
Haemulidae	*Haemulon maculacaudi*	0.74	85.71
Tetraodontidae	*Sphoeroides lobatus*	0.74	86.45
Paralichthyidae	*Cyclopsetta panamensis*	0.73	87.18
Mullidae	*Pseudupeneus grandisquamis*	0.63	87.81
Triglidae	*Prionotus ruscarius*	0.60	88.41
Gerreidae	*Diapterus peruvianus*	0.59	89.00
Tetraodontidae	*Sphoeroides* spp.	0.52	89.52
Haemulidae	*Haemulon elongatus*	0.44	89.96
Ophidiidae	*Lepophidium prorates*	0.39	90.35
Paralichthyidae	*Citharichthys* spp.	0.39	90.75
Triglidae	*Prionotus birostratus*	0.39	91.14
Urolophidae	*Urobatis maculatus*	0.38	91.52
Sciaenidae	*Umbrina xanti*	0.36	91.88
Haemulidae	*Pomadasys panamensis*	0.31	92.19
Gerreidae	*Eucinostomus gracilis*	0.29	92.48
Narcinidae	*Narcine entemedor*	0.29	92.76
Rhinobatidae	*Rhinobatos productus*	0.29	93.05
Ariidae	*Arius* spp.	0.28	93.33
Paralichthyidae	*Syacium latifrons*	0.28	93.61
Synodontidae	*Synodus evermanni*	0.26	93.87

11. Coastal fisheries of Puerto Rico

MÓNICA VALLE-ESQUIVEL*, MANOJ SHIVLANI, DANIEL MATOS-CARABALLO AND DAVID J. DIE

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* *Contact information*: MRAG Americas, Inc., St. Petersburg. Florida, USA. E-mail: monica.valle@mragamericas.com

1. INTRODUCTION

Puerto Rico is composed of an archipelago that includes the main island of Puerto Rico and a number of smaller islands and keys, the largest of which are Vieques, Culebra and Mona (Figure 1). The main island of Puerto Rico is the smallest by land area but third largest by population among the four Greater Antilles (Cuba, Hispaniola, Jamaica and Puerto Rico). The length of its coastline is approximately 1 094 km and the continental shelf area extends to 4 073 km² (FAO, 2003).

Until 2003 there were 44 marine protected areas (MPAs) in Puerto Rico making a total of 3.4% of land area (FAO, 2003).

FIGURE 1
Map of Puerto Rico

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITIES

The fisheries of Puerto Rico can be classified as small scale and mostly artisanal in nature. Multiple gears are used to harvest a wide variety of fish and shellfish for commercial, recreational or subsistence use. A high level of mixing is observed in the landings, so a species-wide segregation of fisheries is not possible, except for some snapper and grouper species within the reef fish complex, the queen conch and the spiny lobster. These species have been targeted commercially and have been better documented in the historical records. On the other hand, there is limited information on bait, ornamental, or recreational and subsistence fisheries.

In the sections that follow, an overall description of the entire fishery of Puerto Rico will be presented. However, focus will be placed on the commercial fishery and on those species that, due to larger abundance or to traditional value or economic importance, have been better documented and for which management regulations exist. Other components of the overall fishery will be merely outlined, but should deserve further consideration as more data become available.

2.1 Commercial fishery

The commercial fisheries of Puerto Rico can be classified as small scale, multispecific, multigear and mostly artisanal in nature. While the fisheries are largely demersal, some fishers also target pelagic species. The demersal fishery includes harvest for reef, bait, ornamental and deep-water species.

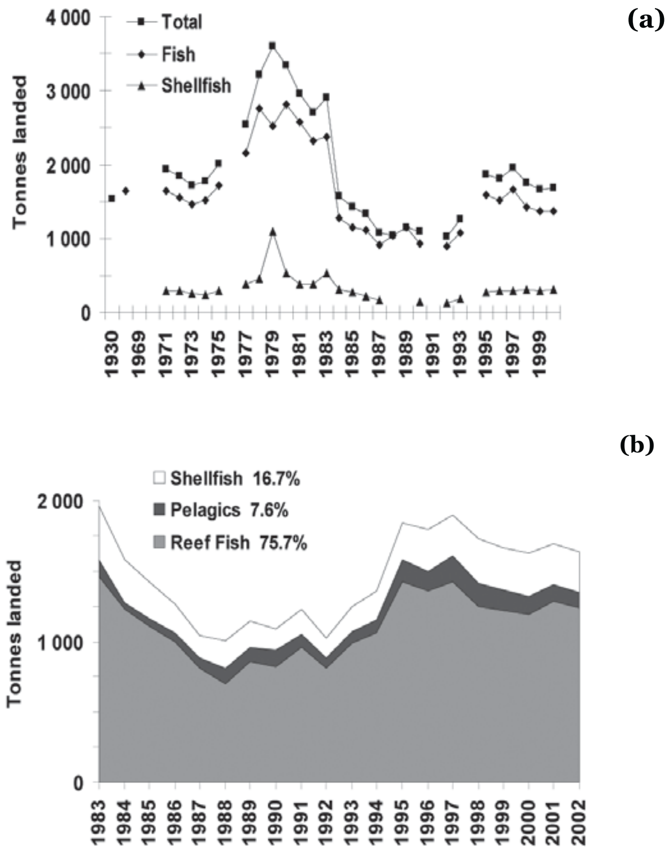
The reef fishery harvests over 155 finfish groups or species and approximately ten species of shellfish. The most prevalent groups in the reef fisheries include snappers, groupers, grunts, mackerels, parrotfish, trunkfish, spiny lobster and queen conch. The deep-water fishery targets snappers, groupers and tilefish. A variety of (ornamental) fish are sought after by the aquarium trade industry, including angelfishes, damselfishes, surgeonfishes, blennies, wrasses, basslets, jawfishes and others. The pelagic fishery is quite small and targets mostly tunas, dorado, wahoo, marlin, sailfish and swordfish.

The Fisheries Research Laboratory (FRL) of the Puerto Rico Department of Natural and Environmental Resources (DNER) monitors the commercial landings of fish and shellfish in Puerto Rico since the implementation of the Fisheries Statistics Programme (FSP) in 1967. Currently, this project is supported by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA/NMFS) through the State/Federal Cooperative Fisheries Statistics Programme. The main goals of this programme are to: (i) collect landings data from the island of Puerto Rico ensuring coverage of all coastal municipalities and their major fishing centres; (ii) determine the total weight and ex-vessel value of the principal finfish and shellfish landed in Puerto Rico each month; (iii) manage, correct, evaluate, and summarize data and prepare reports; (iv) collect biostatistical data; and (v) collect data to estimate catch-per-unit effort (CPUE) from landings and from biostatistical data (Matos-Caraballo, 2001).

Over the period 1971 to 2000, the total reported commercial landings of all fish and shellfish ranged from 907 tonnes (1992) to 3 266 tonnes (1979) and averaged 1 724 tonnes from 1969 through 2000 (Figure 2a). Between 1995 and 2002, total landings declined slightly, from 1 814 tonnes to 1 361 tonnes (Figure 2b) (NOAA, 2003).

FIGURE 2

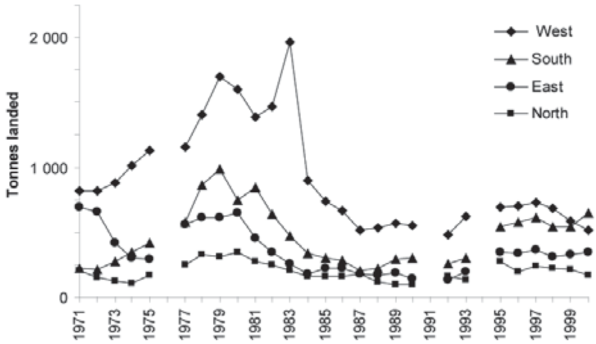
Historical reported commercial landings of fish and shellfish in Puerto Rico, (a) 1930-2000, and (b) 1983-2002, with an approximate proportion of fish and shellfish (invertebrate) species. Pelagics include tunas, dorado, wahoo, marlin, sailfish and swordfish; shellfish include crabs, molluscs (clams, octopus, snails and other) and lobsters



Sources: Puerto Rico DNER/FRL and NOAA Fisheries Cooperative Statistics Reports and Landings Files, NOAA, 2003.

By 2003, reported landings dropped to 1 089 tonnes (not shown), perhaps as a result of under-reporting (Matos-Caraballo, 2004a). Over these 30 years, the total combined fish and shellfish landings show declines beginning around 1979 and continuing through 1993. The proportion of fish and shellfish of the total combined landings remained relatively constant, at about 83% and 17%, respectively. The reported commercial landings of combined fish and shellfish by region indicate a consistent trend over the period 1971 to 2000. Historically, 48% of the total catch has been landed in the west coast, followed by the south (24%), east (18%) and north coasts (10%) (Figure 3).

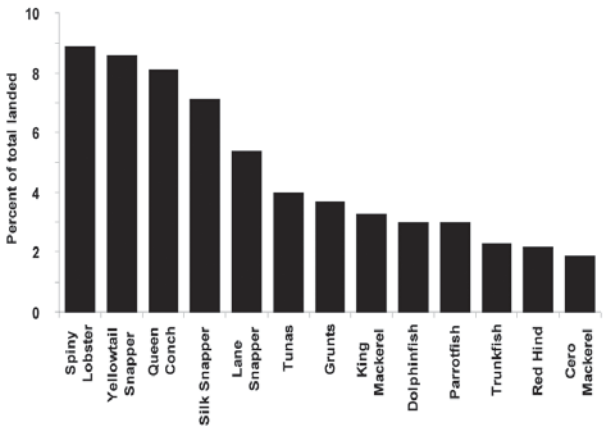
FIGURE 3
Historical reported commercial landings of fish and shellfish in Puerto Rico, 1971–2000, by region



Sources: Puerto Rico DNER/FRL Cooperative Statistics Reports and NOAA, 2003.

Recent data (2001–2003) showed that the most important fish categories, in terms of percentage of total landings, were the spiny lobster (*Panulirus argus*) with 8.9%; yellowtail snapper (*Ocyurus chrysurus*) 8.6%; queen conch (*Strombus gigas*) 8.1%; deep water snappers (mainly silk snapper, *Lutjanus vivanus*) 7.1%; lane snapper (*Lutjanus synagris*) 5.4%; various species of tuna (mainly yellowfin, *Thunnus albacares* and skipjack, *Katsuwonus pelamis*) 4%; grunts (mainly white grunt, *Haemulon plumieri*) 3.7%; king mackerel (*Scomberomerus cavalla*) 3.3%; dolphinfish (*Coryphaena hippurus*) 3%; parrotfishes 3%; trunkfish 2.3%; groupers (mainly red hind, *Epinephelus guttatus*) 2.2%; and cero mackerel (*Scomberomerus regalis*) 1.90% (Figure 4) (Matos-Caraballo, 2004a).

FIGURE 4
Most represented species categories in the Puerto Rican commercial landings between 2001 and 2003



Source: Puerto Rico DNER/FRL and NOAA Fisheries Cooperative Statistics Reports and Landings Files.

The gears most commonly employed during the period (2001–2003) were lines (handlines, troll lines, longlines and rod and reel), accounting for 40% of the total reported landings. Lines were followed by traps (fish trap and lobster trap) with 22%; divers (skin and SCUBA) caught 19.6%; and nets (beach seine, gillnet, cast net and trammel net) accounted for 18% of the total (Matos-Caraballo, 2004a).

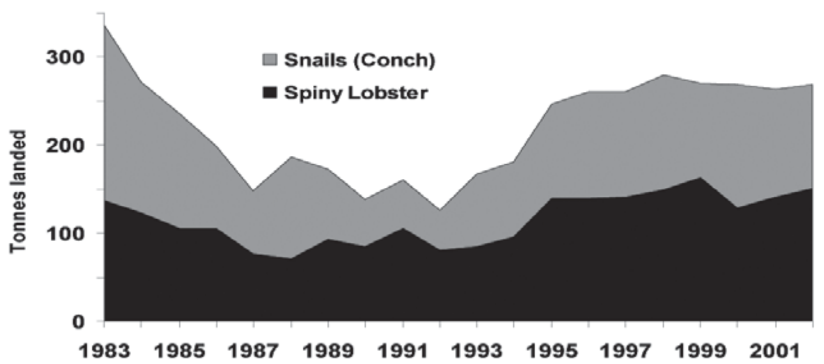
The commercial fishery in Puerto Rico is a year-round activity, but decreases during the hurricane season, particularly in the months of August and September. Certain species are harvested seasonally, such as dolphinfish (October through March in the north Coast, May to August in the south Coast), and yellowfin tuna (between May and September). Some other species (i.e. red hind, mutton snapper) are captured at greater rates during the reproductive season, when they form spawning aggregations (Matos-Caraballo, personal communication). The DNER has implemented seasonal/area closures to deal with this problem, for example, a prohibition on fishing in an area off the west coast of Puerto Rico (Tourmaline Bank) from 1 December through 28 February, a period that coincides with the spawning season for red hind (CFMC, 1994).

Approximately 99% of the fishery products are marketed as fresh food. The remaining 1% is processed to make fish empanadas (*empanadillas*) or fried fish patties (*bolitas de pescado*).

Historical time series are available from the Puerto Rico Department of Natural and Environmental Resources, Fisheries Research Laboratory (DNER/ FRL) for a broad range of species and species groups from 1983–2003 (Matos-Caraballo, 2004a). Raw data for the main fish and invertebrate categories have been summarized to illustrate general trends over time (Figure 2a, Figure 5). Landings for all categories have fluctuated between 1983 and 2002, with an initial decline until 1992 and a general increase thereafter, peaking in years 1995–1997 at approximately 262 tonnes of shellfish, 176 tonnes of pelagic species, and 1 270 tonnes of reef fishes.

FIGURE 5

Reported commercial conch and spiny lobster landings in Puerto Rico for 1983–2002



Sources: Puerto Rico DNER/FRL and NOAA Fisheries Cooperative Statistics Landings Files.

Between 1983 and 2002, the approximate proportion of each group from the total landings was: reef fishes (including ornamental and bait fish) near 75.7%; pelagics (tuna, dorado, wahoo, marlin, sailfish and swordfish) 7.6%; and invertebrates (crabs, clams, other molluscs, snails, octopus and lobster) 16.7%. If we disaggregate conch and spiny lobster from the invertebrate landings, they correspond to 7.3% and 7.9% of the total, respectively. These relative proportions have remained fairly stable over time, with a few fluctuations. Since 1995, larger amounts of shellfish and pelagics are observed, compared with the previous values (1983–1994).

2.2 Recreational fishery

Until recently, the recreational fisheries of Puerto Rico were not well documented. In 1979, NOAA Fisheries implemented a national programme, the Marine Recreational Fisheries Sampling Survey (MRFSS), to provide a reliable database for estimating the impact of recreational fishing on marine resources. The MRFSS has only been conducted consistently in Puerto Rico since 2000. This survey provides estimates of total fish landed, the variance of the total, auxiliary information on the estimated number of fish released and the size composition of the fish harvested and released (NOAA Fisheries, 2003).

The species groups targeted in the recreational fishery are snappers, groupers, grunts, jacks, dolphin, wahoo and blue marlin. There are a series of recreational tournaments for marlin, dolphin and wahoo. Although not necessarily targeted, the spiny lobster and queen conch are also harvested by recreational fishers (Matos-Caraballo, personal communication).

Recreational fishing in the United States Caribbean can be a significant source of fishing mortality, and consists of activities by both locals and tourists. Current fishing regulations for territorial waters require recreational fishers to have a licence or permit, and both federal and local regulations require the registration of recreational vessels. However, information on recreational fishing activities is generally missing (NOAA Fisheries, 2003), so the level and trends in this fishery remain largely unknown.

2.3 Commercial fishing activity

For descriptive purposes, the commercial fisheries of Puerto Rico can be divided into four categories: reef, bait, deep water and pelagic fisheries. The reef fishery can be further subdivided into reef fish, queen conch, spiny lobster and ornamental fisheries. While fishing for different groups can occur on the same fishing trip given the multispecies and multigear nature of the overall fishery, each of these categories can be characterized by the group(s) of species targeted, the type of gear used, the type and size of the boats, the approximate crew size, and the number of participants in the fishery (Table 1).

A census conducted in 2002 (Matos-Caraballo, 2004b) calculated that a total of 956 active commercial fishing vessels and 1 163 fishers were operating in Puerto Rico. Data from this census also indicated that the multigear and multispecies nature of the Puerto Rican fishery led most of the commercial fishers to exploit two or more species categories (Table 1). Reef fish (including conch and lobster) were exploited by 87% of the total number of fishers interviewed (1 163), 36% exploited the pelagic species, 37% the deep-water species (particularly snapper), and 56% targeted bait fish; overlapping of target species exists. The gear types that accounted for the highest percentage of landings by weight between 2001 and 2003 were lines (handline, troll line and rod-and-line), taking 40% of the total catch; traps (fish trap and lobster trap) with 22.1%; divers (skin and SCUBA) with 19.6%; and nets (beach seine, gillnet, cast net and trammel net) with 18.3% (Figure 6) (Matos-Caraballo, 2004b).

TABLE 1
Subdivision of the commercial fisheries of Puerto Rico into four categories, with their corresponding characteristics. The total number of fishers in the 2002 census was 1 163

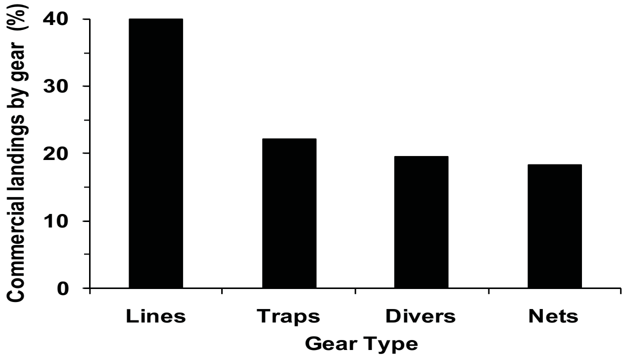
Category	Species	Type and size of gear	Type and size of boat (length in metres)	Average crew size	Number of fishers (2002) (% of total)
1. Reef	1a. Reef fishes	Fish traps, lobster traps, bottom lines, beach seines, gillnets, trammel nets, skin diving and SCUBA diving.	4.6–12	2	87
	1b. Spiny lobster	Skin diving and SCUBA diving.	4.9–6.7	2	
	1c. Queen conch	Skin diving and SCUBA diving.	4.9–6.7	2	
	1d. Ornamental	SCUBA and skin divers	5.5–7.3	2	
2. Pelagic	Tuna, dorado, wahoo	Bottom lines and troll lines	4.6–9	2	36
3. Bait		Cast nets, beach seines, gillnets, troll lines and bottom lines	4.6–7.3	2	56
4. Deep water	Deep water snappers, groupers, tilefishes	Bottom lines and fish traps	4.6–12	2	37

Source: Matos-Caraballo, 2004b.

Note: Due to the multispecies and multigear nature of the fishery, the sum of the reported percentage of fishers by category does not add up to 100%.

FIGURE 6

Percentage of total commercial landings by gear type reported in years 2001–2003



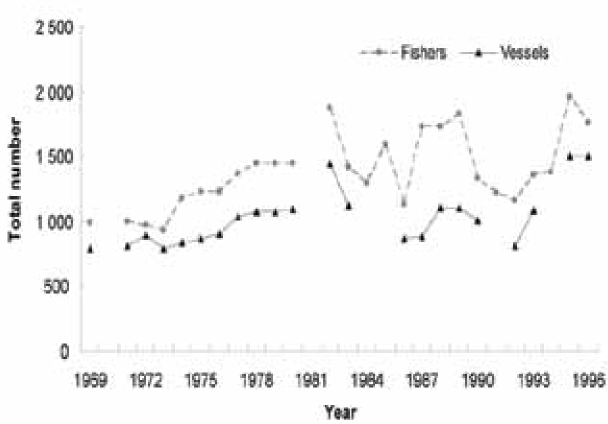
Source: Commercial Landings Statistics Report (April 2001–March 2004); Matos-Caraballo, 2004b.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

According to Matos-Caraballo (2004b), the number of commercial fishers has been declining steadily in Puerto Rico over the past decade. In 1996, a census determined that there were 1 758 active fishers on the island, but that total had declined to 1 163 active fishers by 2002. Overall, the industry lost almost 34% of its participants in that six-year period, after enjoying several decades of stability (Figure 7). Much of this decline has been attributed to a decreasing resource base, as evidenced by lower catch in recent decades. Importantly, remaining fishers have also shifted effort from traditional gears, such as traps and nets, to SCUBA diving, free-diving and hooks (Matos-Caraballo, 2004b). The results thus suggest a consolidation brought upon mainly by resource constraints and associated economic effects.

FIGURE 7

Total number of fishers and vessels in the Puerto Rico fisheries from 1969 to 1996



Source: Puerto Rico DNER Cooperative State Federal; NOAA Fisheries, 2003.

Matos-Caraballo (2004b) reported that 36% of the 1 163 fishers interviewed in a 2002 census are full-time, and the remaining 64% are part-time. The level of professionalization varies with the type of fishery. For example, a NOAA Fisheries study conducted with members of the fish trap industry in the United States Caribbean found that Puerto Rican fishers obtained an average of 60% of their household income from commercial fishing (Shivlani *et al*., 2005). Similarly, western Puerto Rico's pelagic fishery is largely full-time and industrial in composition, due mainly to the higher catch rates in the region. However, the majority of the fishery's participants are artisanal (Griffith and Valdés-Pizzini, 2002; Matos-Caraballo, 2004b), and distinctions such as full- and part-time are fluid for these participants, based on factors such as resource abundance, access to fishing capital, and other employment opportunities, among others. Other occupations in which fishers participate include jobs in the construction (especially in the past decade) and agricultural sectors. Others migrate, either temporarily or on a permanent basis, to the mainland United States to seek employment in a variety of mostly labour-intensive sectors (Griffith and Valdés-Pizzini, 2002).

Female participation is very limited in Puerto Rican fisheries or within the processing sector, as women only rarely participate directly (i.e. as fishers). In the fish trap industry, for example, women made up less than 1% of the 2003 trap fisher population. Instead, women generally engage in ancillary activities such as gear maintenance and repair, fishery product sales and marketing (e.g. running restaurants, selling fish, etc.), and accounting and other paperwork, among other activities; however, there is no cultural or otherwise defined division of female labour as exists in other fishing communities.

Most fishers are local, in that they fish in adjacent waters and live within local communities. This is due partly to the artisanal nature of the fishery and its capacity, as well as the *de facto* (if not *de jure*) existence of territories, especially in the trap fishery (Posada *et al*., 1997). Most fishers use small, open vessels less than seven metres in length and with small, outboard motors. The pelagic fleet in Puerto Real, in western Puerto Rico, was an exception, as these fishers used to fish the deeper, offshore waters of Puerto Rico's exclusive economic zone (EEZ). This pelagic fleet, however, disappeared seven years ago (Griffith and Valdés-Pizzini, 2002). Also, certain trap (and other gear) fishers may target deeper fishing grounds, but such individuals also represent exceptions to the mainly local nature of Puerto Rican fisheries. In total, the 1 163 fishers represent only a small fraction of Puerto Rico's 3.81 million residents (United States Census, 2004), making up 0.03% of the island's overall population. However, partly because much of Puerto Rico's population is located in urban centres, certain smaller coastal communities exhibit considerable fishing characteristics, including ports such as Guayama, Puerto Real and Las Croabas, among others.

Apart from the local, mainly artisanal fleets in Puerto Rico, there has been the seasonal influence of United States mainland longliners, especially in the 1980s and 1990s (NOAA Fisheries, unpublished data). At their peak in 1987–88, over 70 vessels operated seasonally from the United States Caribbean, longlining swordfish and tuna in both Atlantic and Caribbean waters.

Fishing represents a long tradition in Puerto Rico, spanning well into the pre-Columbian period. Hook-and-line and traps are among the oldest gear types in the Caribbean and have been used for centuries on the island. Similarly, net fishing has also been a traditional activity in Puerto Rico and can be traced back to the time of Spanish colonialism (Griffith and Valdés-Pizzini, 2002). More recently, fishers have begun to supplement free diving – another traditional fishing technique – with SCUBA diving. Importantly, gear types have been and continue to be used in combination, rather than separately; that is, Puerto Rican fishers have adopted a pliable approach, utilizing gears as conditions and resource abundances dictate. As Griffith and Valdés-Pizzini report, gears such as nets are traditional and have existed in Puerto Rican fisheries for several decades, but their use has increased considerably since the 1970s with the advent of technology and decline of trap catch rates.

Little is known about the socio-demographic aspects of the Puerto Rican fishery (NOAA Fisheries, 2004b). Gear-specific research, such as that conducted with trap fishers (Shivlani *et al*., 2005), found that respondents completed an average of 9.4 years of schooling, and that only a small percentage (5.7%) continued past high school. The same study found that family size averaged just over three individuals (3.19) per family unit, which is slightly smaller than the 3.41 persons per family unit reported for Puerto Rico in the 2000 United States Census (United States Census, 2004).

As noted previously, there are no culturally defined roles for family members in the fishery. Many fishing operations involve more than one family member, and there is evidence (see Griffith and Valdés-Pizzini, 2002) of in- and out-migrations from the family fishing operations, where offspring may leave to pursue other opportunities before returning to continue or re-establish fishing operations. Similarly, women in the family assist in marketing and sell fishery products, maintaining and repairing gear, and updating accounts; however, many women also pursue other, often professional careers, thereby supplementing household incomes from non-fishery sources.

Other aspects concerning the quality of life in the fishing community are best understood via the prism of the economic welfare provided by fishing activities. Because most of the fisheries are artisanal in nature, most members of fishing communities are not affluent. Many supplement their incomes by undertaking other activities either on a part-time basis or as opportunities arises. Due to the availability of public schooling, socialized medical care and institutionalized welfare, the economic malaise that otherwise is prevalent in other Caribbean small-scale fisheries is not observed in artisanal Puerto Rican fishing communities. However, quality of life remains an important issue that requires immediate attention within the island's fishing sector.

4. COMMUNITY ORGANIZATION AND INTERACTION WITH OTHER SECTORS

4.1 Community organization

There are two main fishery organizations in Puerto Rico: *Villas Pesqueras* and cooperatives. The *Villas Pesqueras* (or fishery organizations) play several roles in many fishing communities, including locations to land and sell products (i.e. processing sites), places to store gear, and meeting locations. Each association is comprised of a governing body, organized as a board of directors. The most experienced (and politically deft) fishers are those who make up the board, with one fisher serving as association president. The *Villas Pesqueras* also are polarized organizations, in that they often provoke as much disdain as they attract affiliation (Griffith and Valdés-Pizzini, 2002). Nevertheless, the *Villas Pesqueras* remain the most prominent fishery organizations within most of the communities in which they are located.

The other form of organization in Puerto Rico, encouraged primarily by the government agency CODREMAR (Corporacion para el Desarrollo y Administracion de los Recursos Marinos, Lacustres y Fluviales de Puerto Rico) in the 1980s, is that of fishery cooperatives. Cooperatives have not fared as successfully as first planned, and their overall success varies considerably by location and depends on a variety of fishery-related (marine resource abundance and quality, fishery technology and capacity) and non-fishery-related circumstances. Anecdotal information indicates that out of Puerto Rico's 42 coastal municipalities and 90 fishing centres (ports where commercial fishing activity occurs), only the following fishing centres actually work as real associations or cooperatives:

Fisher Cooperative of Culebra, Isla de Culebra
Fisher Association of Villa del Ojo, Playuela, Aguadilla
Fisher Association of Playa de Ponce, Ponce
Fisher Association of Boquete, Peñuelas
Fisher Association of Hoar, San Juan
Fisher Association of Villa Pesquera de Puerto Real, Cabo Rojo

Fishers exert influence in the fishery management process in the United States of America mainly via membership in organizations (such as the aforementioned *Villas Pesqueras* and cooperatives) which lobby for fishery interests and by representation in the regional fishery management councils (Ross, 1997; Hanna *et al*., 2000). In the case of Puerto Rico, the regional council responsible for fishery management is the Caribbean Fishery Management Council (CFMC). The CFMC is comprised of seven voting members and three non-voting members. These members are drawn from various federal and state (in this case territorial) agencies and from interest groups. Interest group representatives, which include commercial fishery interests, are selected by the governors of Puerto Rico and the United States Virgin Islands (United States Census, 1852). The CFMC has at least two fishers as voting members. Other fishers belong to CFMC's advisory panel.

Many fishers participate in the public hearings. The DNER has approximately ten fishers to work in the review process for Puerto Rico's Fishing Regulations.

Involvement at the community level is exerted mainly through fishery organizations, which may represent community interests; presidents of fisher associations often participate in public hearings. However, there is no formal community-based representation in the management framework.

There exist a number of local and extra-local non-governmental organizations in Puerto Rico, and all of these exert some influence on fishery management on the island, either formally through lobbying effort or informally by shaping public opinion. Groups such as the Committee for the Rescue and Development of Vieques (CRDV), which are interested in local issues that may include fishery interests, often work with fishers to address environmental and cultural impacts CRDV, 2004). Larger, United States-based and international non-governmental organizations, including The Nature Conservancy and The Ocean Conservancy, maintain a strong presence in the United States Caribbean, influencing fishery and marine protected area (MPA) agendas, among others (TNC, 2004; TOC, 2004).

4.2 Interactions between fishers and with other sectors

Fishers using different gear types may compete for the same resource, especially in a mixed fishery as exists in Puerto Rico (Scharer *et al.*, 2002). That is, because fishers often use different gear types (i.e. nets, traps, SCUBA diving and hook-and-line) to target the same species, there is direct competition between gear types. Conflicts arise when fishers using one gear are affected by or are perceived to be affected by fishers using another gear. Trap fishers, for instance, often argue that their catch is poached by divers (Scharer *et al.*, 2002; Shivlani *et al.*, 2005).

Coastal activities in Puerto Rico are dominated by development and tourism, and both sectors compete and thereby conflict directly with commercial fishing (Griffith and Valdés-Pizzini, 2002). As gentrification proceeds along the island's coastal zone, fishers are often outcompeted by more lucrative uses, including coastal development (resorts, hotels and housing) and recreational facilities (such as harbours and marinas); the end result is a decline in commercial fishing influence and presence within the coastal zone, similar to what has occurred in other areas (for example, see Schittone, 2001, for a review of gentrification in Key West, Florida). In some parts of Puerto Rico, modest *Villa Pesqueras* cohabit the coastal zone with modern developments and sprawling marinas (Shivlani *et al.*, 2005). Inevitably, as competing uses vie for presence in the coastal zone, conflicts arise over use and eventually existence rights. Recreational interests, for the most part, are winning the competition in Puerto Rico and much of the United States, as commercial fisheries decline due to a combination of lower resource abundance, greater access to fishery products from foreign markets, and higher profits to be realized from recreational and non-fishery sectors, among others.

5. ASSESSMENT OF FISHERIES

NOAA Fisheries is in charge of conducting periodic assessments and evaluating fishery management. Selected species for assessment are analysed via the Southeast Data, Assessment, and Review (SEDAR) process, which is a region-wide initiative involving the Gulf of Mexico, south Atlantic and Caribbean states. Scientists and stakeholders from local and federal agencies, as well as an external review panel, participate in this stock assessment process.

Stock assessment efforts in Puerto Rico have concentrated on reef species, particularly those of greater economic importance, such as queen conch, spiny lobster, shallow-water snappers and groupers, and more recently, deep-water species. Assessments for ornamental, bait or pelagic species have not been conducted. The main stock assessment studies conducted in Puerto Rico are described in the sections that follow.

5.1 Reef fisheries

Research efforts in the United States Caribbean have provided some insight into the life history, growth and biology of fish and shellfish species, and into the effects of fishing pressure on some exploited stocks. Fishery independent surveys have provided information on size structure, density, abundance and community structure of coral reef fishes and invertebrates of commercial importance. Many studies have concentrated on spiny lobster and queen conch.

In the early 1990s, stock assessments of spiny lobster, the shallow water reef-fish complex and queen conch were conducted by Bohnsack *et al*. (1991), Appeldoorn *et al*. (1992), and Appeldoorn (1991, 1992), respectively. Cummings *et al*. (1997) performed catch rate, size composition and stock assessment analyses of red hind and coney from St. Croix, United States Virgin Islands. In recent years, Valle-Esquivel (2002a) conducted a review of the United States Caribbean fisheries information with emphasis on queen conch, followed by assessments of the Puerto Rico and St. Croix, United States Virgin Islands stocks (Valle-Esquivel, 2002b). In 2003, a group of scientists from NOAA Fisheries and the University of Miami conducted a comprehensive review of data and information for the deep-water snapper-grouper complex (NOAA Fisheries, 2003). Mateo (2004) calculated relative indices abundance and performed yield-per-recruit analyses of the Puerto Rico spiny lobster. These efforts resumed in 2004 with comprehensive assessments of the Caribbean spiny lobster and the yellowtail snapper (NOAA Fisheries, 2005a, 2005b).

The Fishery Management Plans (FMPs) and amendments for reef fish, lobster, queen conch and coral fisheries in the United States Caribbean have been supported by Environmental Impact Statements (EIS), Regulatory Impact Reviews (RIR), Regulatory Flexibility Analyses (RFA), and socio-economic assessments (CFMC, 1981, 1985, 1994, 1996, 2002, 2004).

The objective of the Environmental Impact Statements is to assess the environmental consequences of management alternatives and to propose action for those impacts. On the other hand, the prominent concerns in the regulatory policy considerations are the costs and benefits of regulatory actions. Costs and benefits are evaluated on socio-economic grounds, and include thorough financial analyses.

Most recently, the final Environmental Impact Statement (EIS) for the Generic Essential Fish Habitat (EFH) Amendment to the four United States Caribbean FMPs (CFMC, 2004) describes the EFH for each fishery, identifies the Habitat Areas of Particular Concern (HAPC), addresses adverse effects of fishing, and evaluates the consequences of alternatives. The EIS describes the physical, biological, human and administrative environments of each fishery, and highlights the fishing and non-fishing threats to EFH. A Social Impact Statement is implicit within the EIS, as the consequences to the fishing communities of each of the proposed alternatives are carefully outlined and evaluated.

Other surveys have been conducted independently from the FMPs and RIRs that include socio-economic information: comprehensive censuses of the fishers of Puerto Rico (Matos-Caraballo, 1996, 2004b), an economic report of the fishers of Puerto Rico (Matos-Caraballo, 2002), a queen conch stratification survey for the United States Caribbean (Rosario, 1995), and a conch CPUE assessment (Rivera, 1999). These have been used to evaluate the number of full-time and part-time fishers, the alternative economic activities, the number of boats operating in different areas for each fishery, the gears commonly used, the species targeted, and the proportion of fishers. A more recent study (Murray and Associates, 2003) characterized the economic and social conditions of the fish trap fleet that operates in Puerto Rico and the United States Virgin Islands. Their survey collected data on demography (age, education, number of dependents), fishing practices (usage, soak time, catch composition), revenue and cost (variable and fixed), capital investment (vessel, traps), capacity utilization, regulatory contingent behaviour (trap limitation) and spatial deployment of effort.

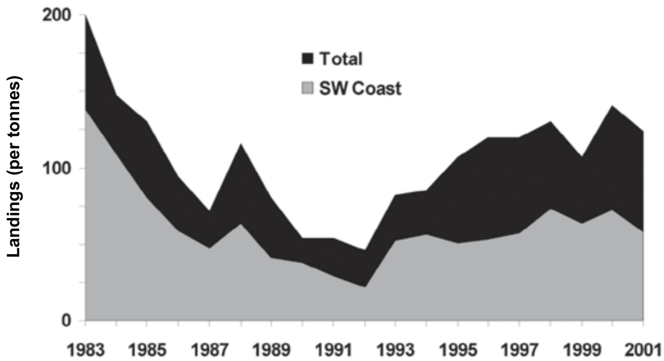
5.2 Queen conch assessments

Two stock assessments have been made of the queen conch stocks of Puerto Rico. Appeldoorn (1991, 1992) performed yield-per-recruit and production model analyses using biological data and catch and effort information from 1970 to 1986, and estimated maximum sustainable yield (MSY) values of 227 tonnes for the whole coast of Puerto Rico, and 86 tonnes for the west coast, where fishing effort is concentrated due to higher conch productivity.

More recently, Valle-Esquivel (2002b) performed catch rate analysis and stock assessments for the queen conch fisheries of Puerto Rico, the southwest coast of Puerto Rico, and St. Croix, United States Virgin Islands. The author estimated relative indices of abundance for the commercial sector using generalized linear mixed models (GLMM). For the stock assessment, the author adjusted a non-equilibrium surplus production model (ASPIC) (Prager, 1994) to a time series of commercial landings (1983–2001) (Figure 8) and standardized CPUE indices (Figure 9). Median MSY values were calculated at 63.5 tonnes for the whole fishery and at 32 tonnes for the southwest coast.

FIGURE 8

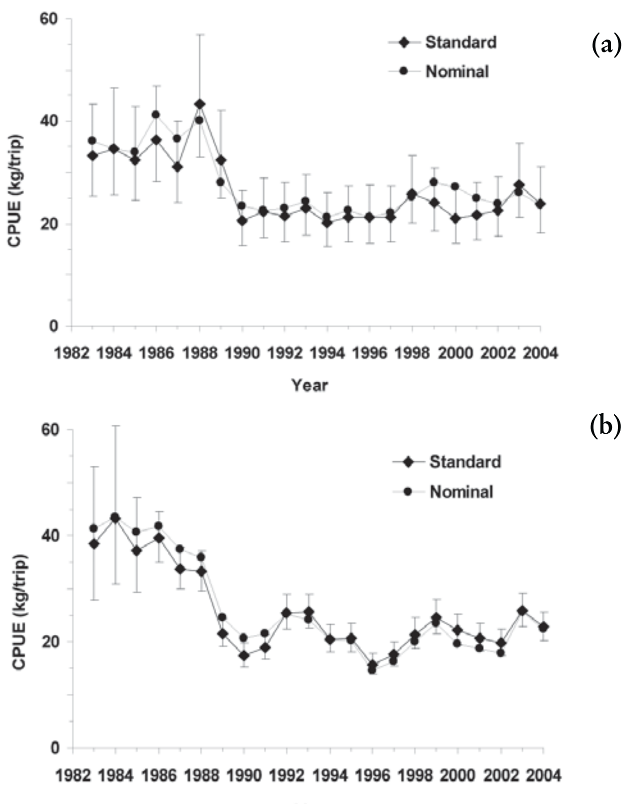
Estimated commercial queen conch landings for Puerto Rico during 1983–2001. Landings from the southwest coast (light grey) represented 58% of the total conch landings (dark grey) during those years



Source: Valle-Esquivel, 2002b.

FIGURE 9

Nominal and standardized CPUE indices for the whole coast (a) and the southwest coast (b) of Puerto Rico. Bars represent 95% confidence intervals

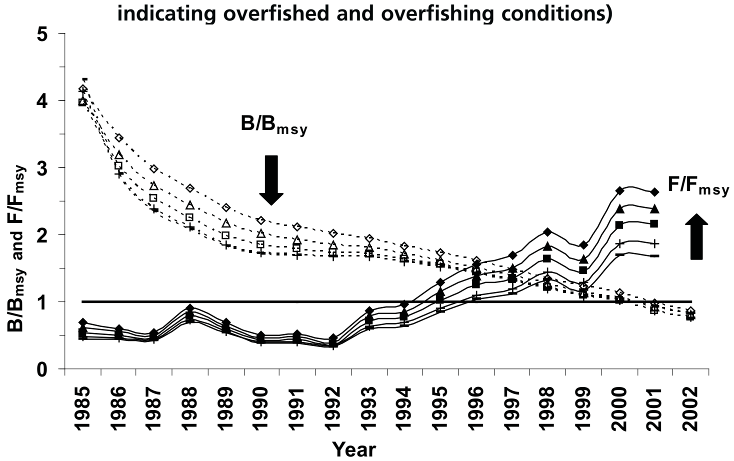


Source: Valle-Esquivel (2002b), updated in 2005.

From a range of assessment scenarios, this author concluded that the queen conch fishery was undergoing overfishing and approaching an overfished state (Figure 10). Model projections under different management alternatives showed that current fishing practices are not sustainable, and that fishing mortality should be reduced immediately through the implementation of catch quotas, effort reduction, temporal/area closures, and/or size-limit regulations. Given the high uncertainty in the data and in the ASPIC results, Valle-Esquivel recommended the continuation of survey programmes to estimate fishery-independent indices of abundance and the collection of recreational fisheries information and biological data to improve assessments (Valle-Esquivel, 2002b).

FIGURE 10

ASPIC biomass (B/B_{MSY}) and fishing mortality ratio (F/F_{MSY}) trajectories for different stock assessment scenarios, with MSY ranging between $0.5e^5$–$0.8e^5$ kg (Biomass ratios are below the MSY threshold, fishing mortality ratios are above, indicating overfished and overfishing conditions)



Source: Valle-Esquivel, 2002b.

5.3 Spiny lobster assessments

Periodic assessments have been conducted in the United States Caribbean to determine the status of the resource and to guide fisheries management. In 1990, Bohnsak *et al.* (1991) conducted the first formal stock assessment using an equilibrium production model. Their analysis showed that between 1970 and 1990 Puerto Rico's lobster landings had fluctuated significantly around an average of 144 tonnes, and that undersized lobsters accounted for 40% of the total catch. The authors recommended that more effort should be used to enforce and increase compliance with the minimum size regulations and suggested that the lobster stock would continue to be defined as overfished until the spawning potential ratio levels rose above 20% spawning potential ratios (SPR).

Matos-Caraballo (1999) analysed the status of Puerto Rico's spiny lobster fishery from 1992 to 1998 and found significant signs of overfishing. In 1951, a total of 202 tonnes of spiny lobster were harvested by 466 fishers. By 1991, only 96 tonnes were harvested by 576 fishers, thus showing an overall decrease in abundance. Results also suggested a decrease in the mean carapace length of harvested lobster over a forty-year period (1951–1991). In addition, approximately 59% of the spiny lobster caught between 1989 and 1991 were below legal size, perhaps due to poor enforcement. By 1998, an increase in enforcement efforts by the Department of Natural and Environmental Resources (DNER) did lead to a reduction in the catch of undersized lobsters to only 24% of the lobster landed. With this study, the author concluded that increased enforcement would help to decrease overfishing.

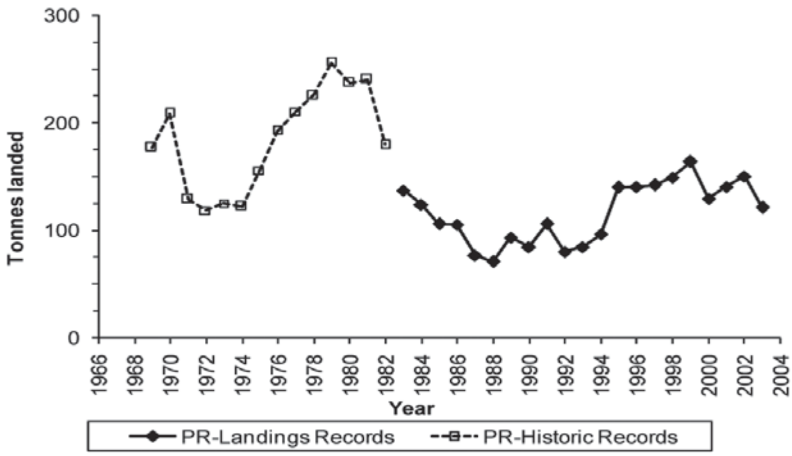
Bolden (2001) assessed the status of spiny lobster in the United States Caribbean from 1980 to 1999. The author's analyses were based upon data gathered from commercial landings reports and biostatistical data from the NOAA Fisheries commercial trip-interview programme. Bolden's results indicated that the annual spiny lobster landings in Puerto Rico decreased steadily from 1984 to 1988 and fluctuated since then. Despite this decline in the fishery, the commercial value for the species increased substantially, by nearly 60% from 1994 to 1995 (from US$802 959 to US$1 373 497). Biostatistical data revealed that 20% of the spiny lobsters landed were below legal size. Bolden concluded that consistent declines in carapace length and CPUE and changes in sex ratios were signs of a declining fishery and recommended that authorities monitor landings more carefully, particularly the compliance with minimum size regulations.

In 2003, Mateo and Die (2004) re-examined the fishery and found that lobster landings in Puerto Rico had increased throughout the 1990s and had remained stable since 1995, averaging roughly 129 tonnes. They estimated a combined-gear index of relative abundance, with values fluctuating around 7 kg/trip between 1983 and 2001. The authors recommended a continued improvement in data collection, particularly of CPUE, and the use of size and relative abundance indices for future assessments.

In 2004, Mateo estimated the exploitation rates of spiny lobster by analysing trip-interview data for the period 1999–2000 and using a yield-per-recruit analysis. Exploitation rates were estimated at 0.66 for males and between 0.68 and 0.71 for females. The author concluded that the resource was fully exploited and that overfishing might be due to three main factors: management failure to enforce size regulations, a lack of basic biological and ecological knowledge of the species, and a lack of management oriented research. The author recommended the need for fully coordinated spiny lobster research involving government, fishers and industry (Mateo, 2004).

The most recent evaluation of the spiny lobster fisheries of the United States Caribbean was conducted in 2004–2005 at the Southeast Data, Assessment and Review workshops (NOAA Fisheries, 2005b). Analyses included a review of all previous assessments, historical data, commercial landings, biological information and abundance survey data. Results indicated that the main methods used to harvest lobster in Puerto Rico are SCUBA diving (43%), fish traps (38%) and lobster traps (9%). Trends in the landings showed several fluctuations, with an average of 105 tonnes harvested from 1983 to 2003, representing almost 50% of the average landings from the peak years (1977–1982) (Figure 11).

FIGURE 11
Estimated commercial spiny lobster landings for Puerto Rico, from 1969 to 2003. The dotted line represents the best estimate of historical landings and the solid line represents data from landing records



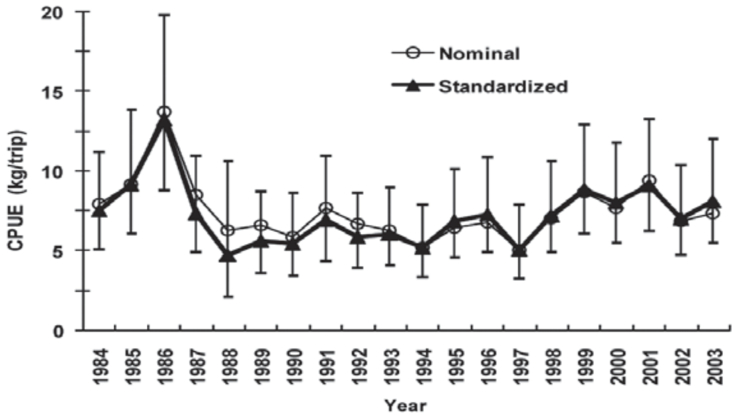
Source: NOAA Fisheries, 2004b.

Length frequency analysis of the commercial landings showed significant differences in size composition over time and space and among gears. The proportion of undersized lobsters declined significantly, from a level of 40–50% in the 1980s to approximately 15% between 2000 and 2003. This information, coupled with past yield-per-recruit studies (Mateo and Tobias, 2002; Mateo, 2004), suggested that the current minimum size was appropriate to maximize yield-per-recruit.

To identify temporal trends in relative abundance, new standardized catch rates by gear and for the combined fishery were estimated for years 1984 to 2003 (Figure 12). Fairly steady abundances were observed over this period, averaging roughly 7 kg per trip. These trends and the length distributions indicated some stability over the past 20 years. However, the application of standard and age-structured production models failed to provide reasonable results regarding stock status, due to the uninformative nature of the available data. It was also suggested that spiny lobster assessments based on local dynamics would continue to fail unless it is considered that recruitment, movement and connectivity may occur at a larger scale within the Caribbean basin. A number of recommendations were discussed to improve future data collection and research programmes, to modify the modelling approaches for stock assessment, and to develop and strengthen partnerships with the fishing community (NOAA Fisheries, 2005b).

FIGURE 12

Puerto Rico combined-gears relative abundance index for spiny lobster from trip interview data. Nominal CPUE, standardized index of abundance and 95% confidence limits for period 1984–2003 are shown



Source: NOAA Fisheries, 2005b.

In general, each assessment conducted since 1980 has yielded results indicating that the spiny lobster fishery in the United States Caribbean has shown signs of overfishing, and that landings, catch rates and relative abundance have declined significantly since the beginning of the fishery. The general consensus is that increased enforcement of the current spiny lobster Fishery Management Plan should lead to a healthier fishery, while the standardization of available fishery data and the collection of data more applicable to the assessment process should allow for a more accurate determination of its status. Further, management of spiny lobster by means other than by relying on minimum carapace length regulations may prove more effective at maintaining a sustainable and profitable fishery (NOAA Fisheries, 2005b).

5.4 Reef fish assessments

A stock assessment workshop conducted in 1991 examined fishery trends for shallow and deep-water reef fishes in the United States Caribbean based on fishery landings and biostatistical data (Appeldoorn, 1992). Results showed that the reef fishery from Puerto Rico had declined from previous levels: in 1931, 1 403 fishers using 711 vessels (only 9 with motors) landed 1 397 tonnes, and by 1989, 1 822 fishers with 1 107 vessels landed 1 046 tonnes. Between 1974 and 1990, landings averaged 1 429 tonnes, reaching a peak of 2 431 tonnes in 1979 (see Figure 2b). Composition of snapper landings shifted from mostly shallow water to deeper water species. Catch-per-unit effort based on fish traps declined, and landings of larger individuals of groupers such as coney and hind decreased over that period; Nassau grouper in particular continued to be very scarce. Biostatistical data showed that growth overfishing was a prevalent problem.

The most noteworthy management recommendations from this workshop were to improve compliance and secure compatible regulations between the Caribbean Fishery Management Council and the Commonwealth and Territorial Governments; to reduce fishing effort, particularly on small fishes; to establish no harvest zones to protect spawning aggregations; and to include deep-water species in the Fishery Management Plan.

Stock assessments have also been performed for individual species in Puerto Rico and the United States Virgin Islands using mainly yield-per-recruit, production models and biostatistical data analyses. The main reef-fish species that have been studied are red hind (*Epinephelus guttatus*) and coney (*Cephalopholis fulva*) (Beets and Friedlander, 1992; Sadovy and Figuerola, 1992; Sadovy, 1993; Bolden, 1994, 2001; Cummings *et al.*, 1997), lane snapper (*Lutjanus synagris*) (Acosta and Appeldorn, 1992), and yellowtail snapper (*Ocyurus chrysurus*) (NOAA Fisheries, 2005a).

In 2003, a comprehensive review of Caribbean deep-water reef fish information was conducted at the Southeast Data, Assessment and Review workshop (SEDAR No. 4, NOAA Fisheries, 2003). The workshop focused on the deep-water species that are most common in the commercial landings: silk snapper (*Lutjanus vivanus*), queen snapper (*Etelis oculatus*), blackfin snapper (*Lutjanus buccanella*) and sand tilefish (*Malacanthus plumieri*). Analyses included examination of the commercial and recreational landings, and of biological and abundance survey data to investigate the possibilities for stock assessment. While in some cases the data was considered insufficient, trends in the landings, species and size composition, and catch rates were estimated for silk and queen snapper for Puerto Rico and the United States Virgin Islands for years 1983–2002.

A similar effort took place in 2004–2005 with the Southeast Data, Assessment, and Review workshops (SEDAR No. 8) for the Caribbean yellowtail snapper (*Ocyurus chrysurus*) and the Caribbean spiny lobster (NOAA Fisheries, 2005a, 2005b). Analysis of the yellowtail snapper fishery of Puerto Rico included the development of standardized indices of abundance from fishery independent sampling and the examination of the size composition from commercial catches. Due to data limitations, only simple assessment methods were pursued, including an innovative catch-free model and a non-equilibrium production model (ASPIC). Results from these models showed that the data were insufficient and inadequate to provide information on current stock status. Recommendations for effective management of the yellowtail snapper (and of reef-fish species in general) in the United States Caribbean emphasized a commitment for long-term research, data collection and monitoring (NOAA Fisheries, 2005a, 2005b).

6. FISHERY MANAGEMENT AND PLANNING

Fisheries in Puerto Rico are a shared responsibility between the Commonwealth and the United States federal government. Federal waters extend from nine nautical miles (nm) to the lesser of 200 nm or an international border off Puerto Rico. These are administered through FMPs developed by the Caribbean Fishery

Management Council (CFMC) and approved by the Secretary of Commerce, with guidance from the National Marine Fisheries Service (NMFS, NOAA Fisheries). Each FMP defines the management unit (i.e. the species or groups of species that are relevant to the management objectives). Currently, the CFMC manages 179 fish stocks under four FMPs: (i) spiny lobster; (ii) queen conch; (iii) reef fish; and (iv) corals and reef associated invertebrates. They are described in detail in the following sections. Federal regulations apply to commercial and recreational fisheries.

The fishing activity inshore, in territorial waters, is managed by the Commonwealth of Puerto Rico through the Department of Natural and Environmental Resources (DNER). The Puerto Rican Department of Agriculture (PRDA) also has some interest in fisheries, primarily administering landing facilities and markets.

6.1 Federal fisheries management

Fishery Management Plan for the Spiny Lobster Fishery of Puerto Rico and the United States Virgin Islands (CFMC, 1981)

This FMP was implemented in January 1985, and was supported by an Environmental Impact Statement (EIS) and a Regulatory Impact Review (RIR). The management unit was defined to include *Panulirus argus* (Caribbean spiny lobster), described objectives for the fishery, and established management measures to achieve these objectives.

The primary management measures for spiny lobster established by the FMP are: definitions of MSY (376 tonnes per year) and optimal yield (OY) (from 264 to 376 tonnes per year); prohibition on the retention of egg-bearing (berried) females; a minimum carapace length of 8.9 cm; requirements to land lobster whole, to include a self-destruct panel on traps and pots, and to identify and mark traps, pots, buoys and boats; and a prohibition on the use of poisons, drugs or other chemicals, and on the use of spears, hooks, explosives or similar devices to take spiny lobsters. Amendment 1 (May 1991) to the FMP added definitions of overfished and overfishing based on 20% spawning per recruit (SPR).

Fishery Management Plan for the Queen Conch Resources of Puerto Rico and the United States Virgin Islands (CFMC, 1996)

This FMP was implemented in January 1997, and was supported by an EIS and an RIR. Primary management measures include: definitions of MSY (335 tonnes per year) and OY (allow 20% SPR to remain intact); size limits including minimum length (23 cm) and lip thickness (1 cm); a requirement that conch be landed in the shell; a prohibition on the sale of undersized shells; a recreational bag limit of three queen conch per day, not to exceed 12 per boat; a commercial catch limit of 150 queen conch per day; an annual spawning season closure that extends from 1 July through 30 September; and a prohibition on the use of hookah gear.

Fishery Management Plan for the Reef Fish Fishery of Puerto Rico and the United States Virgin Islands (CFMC, 1985)

This FMP was implemented in September 1985 and was supported by an EIS, an RIR, and modified by three subsequent amendments. The reef fish fishery management unit includes shallow and deep-water species, comprising virtually all finfish that are known or believed to be captured by commercial, recreational, and/or subsistence fishers in the United States Caribbean.

Primary management measures include: definitions of MSY and OY (3 493 tonnes, excluding marine aquarium finfish); specifications for the construction of fish traps; minimum mesh sizes for traps (3.8–5.1 cm); a requirement to identify and mark gear and boats; a prohibition on the use of poisons, drugs and other chemicals and explosives to take reef fish; size limit with 2.5 cm increase by year for yellowtail snapper (20.3–30.5 cm); a prohibition on the take or possession of Nassau and Goliath groupers; definitions of overfished and overfishing with respect to 20% SPR levels; a prohibition on the harvest, possession, and/or sale of certain species used in the aquarium trade (seahorses and foureye, banded and longsnout butterflyfish); and area closures for red hind and mutton snapper in the United States Virgin Islands and in the Tourmaline, Sierra and Bajo de Cico Banks off Puerto Rico.

Fishery Management Plan for the Corals and Reef Associated Invertebrates of Puerto Rico and the United States Virgin Islands (CFMC, 1994)

The CFMC's Coral FMP was supported by an EIS and an RIR, was implemented in December 1995, and amended in 1999. Primary management measures include prohibitions on the take or possession of gorgonians, stony corals, and any species in the fishery management unit if attached or existing upon live rock; on the sale or possession of any prohibited coral; on the use of chemicals, plants or plant-derived toxins, and explosives to take species in the coral fishery management unit; a requirement that dip nets, slurp guns, hands and other non-habitat destructive gear types be used to harvest allowable corals; and a requirement of a permit to harvest allowable coral species.

Generic Fishery Management Plans' Amendments (CFMC, 2002, 2004)

The CFMC submitted a *Comprehensive Sustainable Fisheries Act Amendment to the Spiny Lobster, Queen Conch, Reef Fish, and Coral Fishery Management Plans* to NOAA Fisheries in May 2005. The three-part purpose of this action is to analyse within each fishery a range of potential alternatives to: (i) describe and identify essential fish habitat (EFH) for the fishery; (ii) identify other actions to encourage the conservation and enhancement of such EFH; and (iii) identify measures to prevent, mitigate or minimize the adverse effects of fishing on such EFHs.

6.2 Local fisheries management

On 11 February 2004, a new Fishery Regulation Act for the Conservation and Management of the Territorial Fishery Resources of Puerto Rico was issued by the Department of Natural and Environmental Resources (DNER) (DRNA, 2004). These regulations are applicable to territorial waters and complement the Federal Fishery Management Plans. Puerto Rico follows the National Atmospheric Administration/National Marine Fisheries Service (NOAA/NMFS) international guidelines and therefore not a 'rights based' system.

Commercial fishers in Puerto Rico enjoy several forms of subsidies: (i) registration of each fishing vessel only costs US$5.00; (ii) 9% of the income from fishing activities is exempt from taxes; and (iii) subsidies from the Department of Agriculture to acquire fishing equipment and gear, up to a maximum of US$2 000. The implementation of Fishery Management Regulations in Puerto Rico is fairly recent, so the effects of management have not accrued or been fully evaluated. The new Fishery Regulations include closed seasons, marine reserves and minimum sizes and there are MPAs on the islands of Culebra, Mona, Monito and Desecheo. Because management regulations in territorial waters were implemented very recently, their effectiveness is yet to be seen.

7. RESEARCH AND EDUCATION

The Commercial Fishery Statistics Programme (CFSP) of the DNER Fisheries Research Laboratory (FRL) has collected landings information since 1971. Landings data of the multispecies and multigear fisheries of Puerto Rico are collected using a landing trip ticket system, which has been consistent since the programme's inception. Trip tickets contain the following information: fishing date, name of fish buyer, fisher and/or helper, fishing licence number, municipality, fishing centre (landing area), number of trips reported, gear type, fishing effort (hours fishing), weight in pounds by species or taxonomic family, market value, depth, and fishing area. Tickets use common names and species identification is possible using Erdman's (1985) numeric codes. Fishers usually land fishes, lobster, oyster and octopus in the round (not eviscerated); conch weights include (dressed) meat only (Matos-Caraballo, 2001).

The CFSP also collects biostatistical data through the cooperative NOAA-DNER/FRL Trip Interview Programme (TIP), which consists of the identification of the individuals caught by species, individual measurement in millimetres, and weight in grams. This programme also provides an estimation of the catch-per-unit effort and the catch composition. Landings and biostatistical data are mandatory by Law 278 issued on 30 November 1998. Finally the CFSP conducts fishery censuses every five to six years when funds are available (Matos-Caraballo, personal communication).

In addition to the CFSP, the DNER/FRL Fishery Monitoring Programme collects fishery-independent data. Catch from these scientific campaigns provides detailed information on species composition and biostatistics, such as the size, age and weight structure of the species harvested. The DNER/FRL Research programme is also conducting a study on the reproductive cycles and size of maturation of many reef fish species that are important in the commercial and recreational fisheries (see DNER/FRL Commercial Fishery Statistics Reports between 1989 and 2004).

The CFMC and NOAA Fisheries are currently conducting socio-economic studies of the commercial fisheries of Puerto Rico. One such example is an economic study of the trap fishery in the United States Caribbean conducted in 2003 (Murray and Associates, 2003). The objective of this survey was to collect realistic economic and demographic data to describe the socio-economic characteristics of trap fishers and trap fishing in Puerto Rico and the United States Virgin Islands. The data was collected via interviews with a group of randomly selected licence holders who fish with traps. The questionnaire provided information on operational, fixed, licence and management costs; the use of fish and or lobster traps; specialization in other fisheries; fishing effort (number of traps deployed, soak times); cost and lifetime of traps; use and cost of other gear; vessel information (maintenance costs, lifespan, power, associated gear); catch information by area (species, trips, costs); crew share; and household income.

Education on environmental issues and the conservation of Puerto Rico's fishery resources are provided by the University of Puerto Rico Sea Grant College Programme and the DNER. Conferences are regularly held in schools around the island, targeting not only children, but other diverse members of the fishing community. Unfortunately, there are no vocational schools or training to promote alternative occupations (Matos-Caraballo, personal communication).

8. ISSUES AND CHALLENGES

The fisheries of Puerto Rico are generally well documented, and a relatively long time series of catch and biological data have accrued over the past three decades. A variety of fishery-dependent, fishery-independent and socio-economic surveys have been conducted in the area to support fisheries assessments and develop solid management strategies. Strengths therefore include a good working knowledge of the basic fishery sector, in terms of participants, gear and catch trends. Additional strengths include the capacity among the research community to obtain data, provide support and to realize analyses conducive to improved knowledge of the status of the fishery resources. Finally, Puerto Rico has a robust set of management regulations in place to preserve and rebuild fish and shellfish stocks, to protect the essential habitat needed for their subsistence, and to preserve the livelihood of people dependent upon these fishery resources.

Gaps include a poor understanding of socio-economic dynamics and relationships, and how these affect fishing (e.g. bartering seems to be an alternative to cash economies in some areas); characterization of fishing communities; socio-historical and cultural dimensions of fishing on the island; spatial capture and effort profiles; misreporting or under-reporting by fishers; inconsistent or irregular sampling programmes; incomplete fishery databases; scarce or inadequate stock assessments; uncertainty on stock status for key species; and deficient enforcement of management regulations, among others.

Major challenges remain on how to improve data collection to the point where consistency is achieved, how to best characterize and report on the multispecies component of the fishery, how to determine ways to retain fishing as a traditional activity in a region subject to gentrification and development, and how to best incorporate fisher participation in the management process.

To meet the challenges presented requires further and more expansive data collection (including the characterization and monitoring of key fisheries and fishing communities); improving and enforcing zoning strategies that maintain a diverse coastal community and one which includes a working fishing sector; developing participatory research programmes that assist in data collection and minimize costs, while affording buy-in from the fishers; and improving the attractiveness of local markets for sustained or higher ex-vessel values (in the wake of imported marine products).

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12. Coastal fisheries of Trinidad and Tobago

Elizabeth Mohammed*, Lara Ferreira, Suzuette Soomai, Louanna Martin and Christine Chan A. Shing

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* *Contact information*: Fisheries Division, Ministry of Food Production, Land and Marine Affairs. St. Clair Circle, Port of Spain, Trinidad, West Indies. E-mail: eliza_moham@yahoo.com

1. INTRODUCTION

The fisheries of Trinidad and Tobago are multispecies, multigear and multifleet. Fisheries resources off the two main islands of the archipelagic state differ because of significant ecological differences. Due to its location on the South American shelf, the resources off Trinidad are diverse, including soft-substrate demersal species as well as small coastal pelagic species and large migratory pelagic species. Off Tobago, the prevailing oceanic conditions are favourable to small coastal pelagics and highly migratory pelagic species, and to a lesser extent, reef species. The differences in bathymetry and oceanographic conditions have resulted in greater similarities between the fisheries of Tobago and other northern islands with small shelf areas in the eastern Caribbean, while the fisheries of Trinidad are similar to those off the Bolivarian Republic of Venezuela. In Trinidad, the main fisheries are the soft-substrate demersal fishery (shrimp and groundfish), the hard-substrate demersal fishery, the coastal pelagic fishery, and the oceanic (highly migratory) pelagic fishery. The coastal pelagic and hard-substrate demersal fisheries are dominant in Tobago. Except for the oceanic (highly migratory) pelagic fishery, all fisheries are coastal. However, some gears capture juveniles of highly migratory species in inshore coastal waters. This chapter focuses on the three main coastal fisheries of Trinidad and Tobago.

Trinidad and Tobago, the southernmost islands of the Caribbean region, occupy a total area of 5 128 km^2, of which 4 828 km^2 corresponds to Trinidad and only 300 km^2 corresponds to Tobago. Tobago is located approximately 32 km to the northeast off Trinidad (Figure 1). The coastline measures 470 km and the shelf area extends to about 204 000 km^2 (FAO, 2006).

FIGURE 1
Geographic location of the islands of Trinidad and Tobago

Source: Fisheries Division.

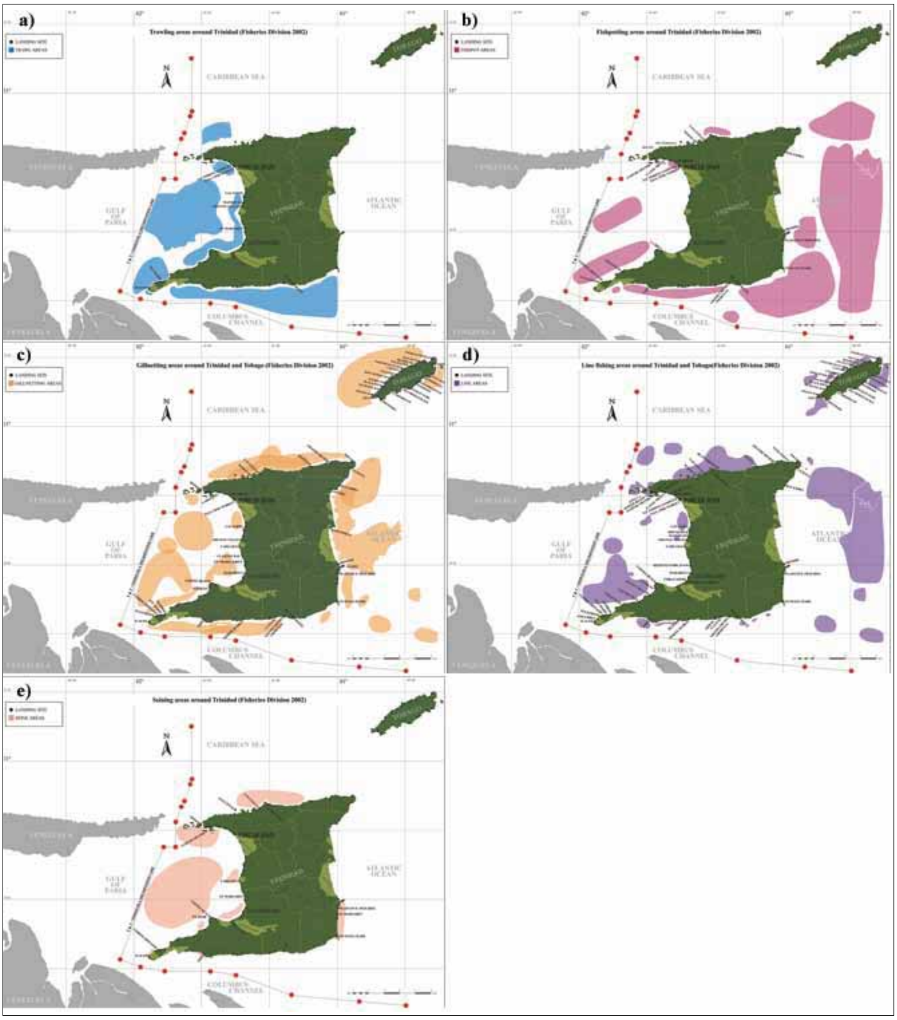
2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

2.1 The soft-substrate demersal fishery (shrimp and groundfish)

The soft-substrate demersal fishery targets mainly shrimps and groundfish. Several species of shrimps (mainly Paenidae) are caught including *Farfantepenaeus subtilis* (brown shrimp), *F. notialis* (pink shrimp), *F. brasiliensis* (pink-spotted shrimp, hoppers), *Litopenaeus schmitti* (white/cork shrimp), and *Xiphopenaeus kroyeri* (honey/jinga shrimp, seabob). Key groundfish species in this fishery are Sciaenidae (e.g. *Cynoscion jamaicensis*, *C. acoupa*, *Macrodon ancylodon*, *Micropogonias furnieri*), Clupeidae, Engraulidae, Gerreidae (e.g. *Diapterus* sp.), Lutjanidae (e.g. *Lutjanus* sp., *Rhomboplites aurorubens*), Haemulidae (e.g. *Haemulon* sp., *Genyatremus luteus*, *Orthopristis* spp.) and Ariidae (*Bagre* sp., *Arius* sp.). Shrimps are caught mainly by trawlnets, while groundfish are either targeted by the artisanal multigear fleet, using gears such as gillnets, fish pots, demersal handlines and demersal longlines, or caught as bycatch in the trawlnets. To a lesser extent, shrimp are also caught by beach/land seines, as part of the artisanal multigear fishery. Trawlnets operate mainly in the Gulf of Paria (west coast of Trinidad) (Figure 2a), although larger trawlers also operate off the north and the south coasts. The artisanal multigear fleet, which targets soft-substrate demersal fish, operates mainly off the west and south coasts of Trinidad. The fishery is seasonal, with shrimp catches being greatest from June to December and groundfish catches greatest from January to July.

FIGURE 2

Fishing areas off Trinidad and Tobago: (a) soft-bottom demersal fishery (trawl); (b) hard-bottom demersal fishery (fish pots); (c) coastal pelagic fishery (gillnets); (d) coastal pelagic fishery (pelagic lines); and (e) coastal pelagic fishery (beach seine).



Source: Fisheries Division.

Trawlers operate only in Trinidad and are grouped into four categories (types). Type I is the smallest vessel with an average size of 6.7 to 9.8 m, and a 56 hp outboard engine. Type II is larger in size (7.9 to 10.4 m) and is generally equipped with inboard engines ranging from 48 to 100 hp. Both Types I and II use trawlnets of average head rope length between 10.4 and 10.7 m, with 3 cm mesh size at the cod end. Each vessel carries one stern trawl which is manually retrieved. Trawler Type III is larger (between 9.3 to 12.1 m, with 165 to 250 hp inboard engines) and deploys nets of 12.9 m average head rope length with mesh size at the cod end averaging 3.5 cm. Each vessel carries one stern trawl which is operated using a hydraulic winch. The largest trawler, Type IV, range between 10.9 and 23.6 m, with powerful inboard engines of 365 to 425 hp. The average head rope length of the trawlnet is 15 m, with the same mesh size as Type III, but each vessel carries two nets which are fastened to outriggers and retrieved with a hydraulic winch (Maharaj *et al*., 1993; Kuruvilla *et al*., 2000). According to the 2003 Vessel Census conducted in Trinidad (Fisheries Division, unpublished data), there are 47, 55, 10 and between 20 and 25 trawlers of each type (I to IV respectively), on which are employed, on average, 92, 110, 30 and 80 persons, respectively.

Bycatch of the trawl fleets is comprised mainly by several species of demersal finfish and crabs. The ratio of bycatch to shrimp, estimated for the artisanal trawl fleet in the late 1980s, was 15:1 (Maharaj, 1989). About 80% of the finfish component of the bycatch comprised subadults and juveniles of the Ariid, Carangid, Clupeid, Engraulid, Gerreid and Sciaenid families. Kuruvilla *et al*. (2000) estimated a bycatch to shrimp ratio of 12:1 for the same fleet in 1999. The ratio of bycatch to shrimp in catches of the semi-industrial fleet was estimated at 12:1 in the early 1990s (Amos, 1990) and 9:1 in the late 1990s (Kuruvilla *et al*., 2000). Few data are available for the industrial fleet; however, based on logdocument data collected over a seven-month period, Kuruvilla *et al*. (2000) estimated a bycatch to shrimp ratio of 0.6:1 in the early 1990s. In general, some commercially important fish species such as snappers and croakers are targeted when there is a high market demand or a decline in abundance of shrimp catches. Most of the bycatch in the shrimp trawl fishery is discarded. Discards were estimated at 94% overall catch for Types I and II trawlers, 60% for the Type III fleet (Amos, 1990) and 66% for the Type IV fleet (Maharaj, 1989; Kuruvilla *et al*., 2000).

Generally, boats in the artisanal multigear fleet of Trinidad are between 7 and 10 m, with outboard engines ranging from 40 to 75 hp (Chan A. Shing, 1999a), while those in Tobago are between 6.7 and 12.1 m with outboard engines of 15 to 100 hp (Potts *et al*., 2002). There are 947 vessels in Trinidad (Fisheries Division, unpublished data on 1998 vessel census) and 126 vessels in Tobago (Potts *et al*., 2002). Based on an estimate of two fishers per boat, approximately 1 894 and 252 persons are employed in the artisanal multigear fleet in Trinidad and Tobago, respectively. Although similar gears are used on the two islands there are variations in the gear characteristics. Gillnets used in Trinidad are larger in mesh size (9.5 cm monofilament and 10.2 cm multifilament) with net lengths of 450 to 1 098 m (monofilament) and 732 to 1 190 m (multifilament) (Hodgkinson-Clarke, 1994; Chan A. Shing, 1999a, 2002). Nets used in Tobago are of smaller mesh size (about 4.4 cm) and overall dimensions (4 to 7 m long and 2 to 2.5 m deep) (Samlalsingh and Pandohee, 1992). Fish pots are constructed with steel or wooden frames and wire mesh. Fish pots in Trinidad are either square or arrowhead shaped, with diagonal mesh size of 3.8 to 5.0 cm, while those in Tobago are Z-shaped with mesh size of about 3.0 cm (Manickchand-Heileman and Phillip, 1992a). In addition to gillnets and fish pots, demersal handlines and longlines are also used. The latter consists of a nylon rope line of ¼-inch thickness and a leader line of nylon twine with about 200 hooks of Number 1, 2 and 3 sizes each placed at about 4 m apart.

As shown in Figure 3a, shrimp has dominated catches from this fishery in Trinidad since 1995 (26 to 56% of annual landings), with croaker being the second most abundant species (6 to 24% of annual landings). Annual landings have varied between 2 000 and 3 600 tonnes, peaking at over 3 000 tonnes between 2000 and 2002. Locally, shrimp is marketed as fresh-chilled, peeled and breaded, or frozen with heads and carapace removed. Shrimp is also processed into patties or 'fingers' (Jobity *et al.*, 1997). Catches from Types III and IV trawlers are mainly exported. Shrimp exports increased from 288 tonnes valued at US$ 1.1 million in 1992 to 500 tonnes valued at US$3.1 million in 1995, with the United States of America being the main export market (67% of exports in 1995). Other traditional markets included the United Kingdom of Great Britain and Northern Ireland, Canada and the Caribbean Community countries. Since 1995, shrimp exports have declined considerably to less than 100 tonnes by 2004, valued at just over US$0.58 million (Kuruvilla and Chan A. Shing, 2002; Fisheries Division, 2007a). The decline was due mainly to price competition in the United States, exclusion from the European Union (EU) market, and an increase in local sales due to growth in the national economy.

2.2 The hard-substrate demersal fishery

The hard-substrate demersal fishery targets mainly snappers year-round. The main species of snappers caught are *Lutjanus synagris* (lane snapper), *L. purpureus* (southern red snapper) and *Rhomboplites aurorubens* (vermilion snapper). Other snappers of lesser importance in the catch are *L. griseus* (grey snapper), *L. jocu* (dog snapper) and *L. vivanus* (silk snapper/vivanot). *Epinehelus* sp. and *Mycterperca* spp. are the main species of groupers caught. *Haemulon* sp. is also caught and *Panuliris* sp. is present in the bycatch. The Trinidad fishery operates mainly on the continental shelf off the east and southeast coasts of the island (Figure 2b), while boats from Tobago operate on the continental shelf and shelf edge northwest of Tobago, as well as the north and northeastern coast of Trinidad (Manickchand-Heileman and Phillip, 1999a). The fishery is exploited by both artisanal and semi-industrial multigear fleets, using mainly fish pots and demersal handlines, with demersal longlines to a lesser extent. The same vessels of the artisanal, multigear fleet operating in the soft-substrate demersal fishery also operate in the hard-substrate demersal fishery. There are 15 semi-industrial multigear vessels in Trinidad and 10 in Tobago. Some of these vessels once formed part of the trawl fleet but were subsequently outfitted for pot fishing and target deep-water demersal snappers off the east coast of Trinidad and southeast coast of Tobago. The vessels in Trinidad are larger (average length of 14.28 m) with engines of 234 hp, compared to an average length of 6 to 12 m, with engines of 75 to 335 hp in Tobago (Fisheries Division, unpublished data; Potts *et al.*, 2002). On average, there are five crew members per vessel on board the Trinidad fleet, and three on board the Tobago fleet.

The snapper resource is the most commercially valuable component of the hard-substrate groundfish fishery. Over the period from 1995 to 2006, estimated annual landings of snapper by the artisanal, multigear fleet in Trinidad varied between 200 and 550 tonnes and accounted for between 30 and 74% of annual landings in the hard-substrate demersal fishery (Figure 3b). Annual landings from this fishery have varied between 310 and 1 250 tonnes, with a substantial decline from 1 251 tonnes in 1995 to 392 tonnes in 2006. Exports of snappers are grouped with shark, croaker, grouper, seatrout and dolphinfish in the records of the Central Statistical Office. Between 1997 and 2003 average annual exports for the group declined from 1 329 tonnes to 500 tonnes, with a US$0.98 million reduction in value. In the 1980s, the fishery expanded to the offshore continental shelf on the east coast of Trinidad due to the increasing importance of the export market. The fishery almost exclusively supports the export market for red snapper.

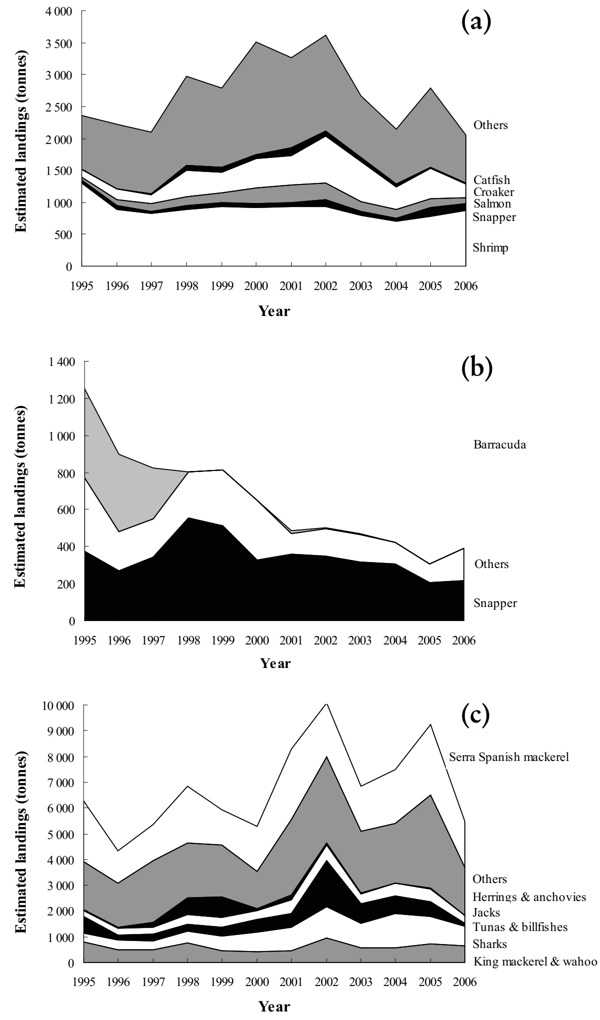
Snappers are also landed as trawler bycatch from the soft-substrate demersal fishery operating on the west and south coasts of Trinidad or as gillnet bycatch from the coastal pelagic fishery operating in shallow waters off the south coast of Trinidad. During periods of consistently low shrimp catches snappers may also be targeted by industrial trawlers. Snapper resources on the east and north coasts of Trinidad are, however, illegally caught by vessels from neighbouring countries which use both handlines and longlines. In the case of Venezuela (Bolivarian Republic of), a 1997 bilateral agreement between the governments of Trinidad and Tobago and this country designated the area outside of two miles from the southern coastline of Trinidad and northeastern Venezuela (Bolivarian Republic of) as a Joint Fisheries Management Regime Area (Maharaj and Rivas, 1997). This arrangement is still in place.

2.3 The coastal pelagic fishery

The coastal pelagic fishery targets Scombridae species, Serra Spanish mackerel (*Scomberomorus brasiliensis*) and king mackerel (*Scomberomorus cavalla*), in Trinidad, and Exocoetidae (mainly Hirundichthys affinis), Coryphaenidae (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), bigeye scad (*Selar crumenophthalmus*) and round scad (*Decapterus* sp.) in Tobago. The bycatch in Trinidad is comprised of Clupeidae, Engraulidae, Belonidae, Carangidae, Pomatomidae, Elasmobranchii (e.g. *Sphyrna tudes*, *Rhizoprionodon lalandii*, *Carcharhinus porosus* and *C. limbatus*), *Selene vomer*, *Oligoplites saurus*, *Diapterus rhombeus*, *Selene spixii*, *Caranx hippos* and *Caranx crysos* (Henry and Martin, 1992). As shown in Figure 3c, Serra Spanish mackerel dominates catches from the fishery in Trinidad, accounting for between 21 and 37% of estimated annual landings from 1995 to 2006. Overall annual landings in the coastal pelagic fishery have varied between 4 300 and 10 000 tonnes, but only exceeded 9 000 tonnes in 2002 and 2005.

FIGURE 3

Time series landings data for (a) the soft-substrate demersal fishery; (b) the hard-substrate demersal fishery; and (c) the coastal pelagic fishery in Trinidad



Source: Fisheries Division databases; groundfish landings from Type IV trawlers prior to 2000 and landings of the semi-industrial, multigear fleet are not available.

The coastal pelagic fishery is the most widespread in Trinidad, operating off all coasts (Figures 2c, d and e). In Tobago, this fishery operates mainly off the north coast from Pigeon Point to Charlotteville (Figures 1 and 2c). These fisheries are targeted by the artisanal, multigear fleets in both islands using gillnets, beach or land seines (340 to 660 m long with mesh size of 13 mm at the cod end and 152 mm at the wings) and pelagic handlines (lines of either steel, bronze, nylon or nylon chord 20 to 90 m length, each line with one hook). As well, the semi-industrial, multigear fleet (iceboats) in Tobago targets the fishery with pelagic handlines and gillnets. Coastal pelagic fishes are present in the bycatch of the Trinidad semi-industrial, longline fleet which targets highly migratory pelagic species and the Types I and II trawl fleets which target shrimp and groundfish.

Most landings from gillnets in Trinidad are sold fresh or chilled. Flyingfish, caught mainly off Tobago, is also processed and sold as frozen fillets. Large pelagic species such as dolphinfish, wahoo and tunas may be sold fresh at beaches or markets; however, large quantities are also processed and sold as frozen steaks or fillets. Catches from beach seines and bait seines are either utilized locally as food or as bait. Some clupeids and possibly engraulids are exported. Between 1995 and 2004, average annual export of herrings, sardines, anchovies and flyingfish declined from 605 tonnes (US$1 191 754) to 216 tonnes (US$806 437) (Fisheries Division, 2007a). Exports of dolphinfish are grouped with snapper, grouper and seatrout in the records of the Central Statistical Office. Trends are as previously described under the section describing the hard-substrate demersal fishery.

3. FISHERS AND SOCIO-ECONOMIC ASPECTS

In Trinidad, about 6 500 people are employed in the marine fishing sector, 61% of whom are fishers, about 19% are involved in the processing industry, another 19% in fish marketing and distribution, and the other 1% in vessel and gear construction and maintenance (Kuruvilla *et al*., 2002). The participation of women in the industry is not well documented; however, women are more likely involved in the processing and marketing activities. Some fishers, employed with the artisanal fleet in Trinidad, migrate along the coasts, fishing in different areas depending on the seasonality of the Serra Spanish mackerel. In Tobago, approximately 228 fishers are employed in the coastal pelagic fishery that utilizes gillnets and troll lines (Potts *et al*., 2002).

Social and economic assessments have been conducted on selected fleets and fisheries in Trinidad and Tobago: the trawl fleet operating from Orange Valley and Otaheite on the west coast of Trinidad which target the soft-substrate demersal fishery; the recreational fleet from the northwest peninsula of Trinidad which target coastal and offshore pelagics; the artisanal, small-scale, multigear fleet from Tobago which target flyingfish and large pelagic species; and the artisanal multigear fleet from Ortoire to Guayaguayare on the east coast of Trinidad which target a variety of fisheries.

The 1993 project on Integrated Coastal Fisheries Management, partly funded by the Food and Agriculture Organization of the United Nations (FAO), focused on two fishing communities (Orange Valley and Otaheite) on the west coast of Trinidad, where activities are strongly dominated by trawl fleets in the soft-substrate demersal fishery (shrimp and groundfish). Under this project, a review of the 1990 National Population and Housing Census showed that fewer people within the fishing community achieved senior secondary education (up to age sixteen) or training in a trade or skill, and none received tertiary education compared with the non-fishing community (Mohammed, 1995). The fishing community also had a greater mean household size (average of five persons compared with four persons for non-fishing community), with women bearing children at an earlier age and having more children throughout their life than those in non-fishing communities. The 1994 household survey, conducted under the project, showed that the average fisher household size of the two communities had increased to six persons, with individual households ranging between three and thirteen people, with a slightly higher ratio of males to females (Camps-Campins, 1995).

Fishing community surveys confirmed that activities at Otaheite were essentially artisanal and small scale (Boodoosingh, 1995). There was greater diversity in the occupational structure of the non-fishing population, with employment in the public service, oil industry, agriculture and the construction sectors. A local bottling plant also hired both skilled and unskilled labour. At Orange Valley, however, fishing activities ranged from artisanal, small scale to industrial and medium scale. The non-fishing community relied considerably on employment by a state-owned agricultural enterprise which also provided part-time employment for some fishers. Fishing was restricted to the male members of the household. Higher priority on formal employment than education at Orange Valley resulted in young males terminating education at an earlier age than young females (Camps-Campins, 1995). In many instances, male household members were the sole bread winners while other family members engaged in subsistence activities such as home-based food production, agriculture and small-scale animal husbandry. Apart from fishing, the male household members were generally responsible for hiring of labour if they were boat owners, supervision of market activities for the sale of catch, and management of household accounts. In some instances the female head of the household assisted with supervision at the markets and management of household accounts.

The average monthly income of the fishing household was generally lower than the non-fishing household. Average monthly income was less than US$228 in 82% and 84% of fisher households in Orange Valley and Otaheite, respectively (Mohammed, 1995). However, the distribution of monthly income levels in the fishing households differed at the two sites, with some households at Orange Valley receiving more than US$1 404 per month (owners of semi-industrial, medium-scale trawlers) while no fishing household at Otaheite (artisanal, small scale) earned more than US$702. Although the fishing community recognized a potential entrepreneurial activity for the household within the service industry (e.g. food shops, beauty salon, taxi service, dress-making, handicrafts, etc.), inadequate or incomplete training, child-rearing responsibilities, lack of cash flow or limited access to credit, fear of theft and vandalism, as well as lack of demand for certain services, were major impediments (Camps-Campins, 1995).

The fishing communities at both locations experienced a lower standard of living than the non-fishing community (Mohammed, 1995). A smaller percentage of fisher households were supplied with electricity, water and proper sewage disposal facilities compared with the national average (Mohammed, 1995). In the case of land tenancy, fewer persons within the fishing community owned land (20% in Orange Valley, 13% in Otaheite) compared with the non-fishing community (45% in Orange Valley, 38% in Otaheite).

Over 75% of the households acknowledged changes in the fishing industry between 1984 and 1994, notably the reduction in catch and of the average fish size, high operational costs, increasing number of new entrants to the fishing industry and difficulties in securing employment outside the fishing sector. These changes have negative economic impacts on the fishers. At Otaheite, over 50% of the households indicated little future for the fishing industry and therefore youths were discouraged from fishing. Fishers at Orange Valley, on the other hand, were still positive about their future, but recognized the need for cooperation within the community.

A study to describe and assess the social and economic importance of the landed bycatch of the shrimp trawl fishery in communities at Orange Valley and Otaheite was implemented in 2005 under the project – "Reduction of Environmental Impact from Tropical shrimp Trawling through the Implementation of Bycatch Reduction Technologies and Change of Management" (Hutchinson *et al.*, 2007). This project is funded by FAO, the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF). A Rapid Appraisal Household Survey (RAHS) of the entire community showed that 17% of households at Orange Valley caught their own seafood, while 68% purchased seafood and 28% received seafood as gifts from family and friends who fish. In addition, 85% of households bought fish (assumed bycatch in the trawl fishery) at the fish market compared with other sources such as supermarkets. The mean weekly expenditure on food for each household during the three weeks preceding the survey was US$85.86, of which 12% was expended on seafood, 20% on meat, 21% on vegetables and legumes, 10% on fruit and 37% on other foods. The Serra Spanish mackerel and Whitemouth croaker were the most popular fish species consumed (24% and 16% of the households, respectively). The study estimated that 21 292 kg of fresh fish, valued at US$43 345, was consumed annually by the 248 households at Orange Valley. Generally, the majority of families believed that the local fishery was important to the community as a source of food, a contributor to health, nutrition, well-being and employment, as well as an income generator. The fishery had a positive impact on community lifestyle and recreation. Although 14% of the households felt that the fishery had no negative impacts on the community, some believed that it contributed to problems of drug and alcohol abuse (18%) and school absenteeism (14%).

The RAHS conducted at Otaheite showed that 66% of households purchased fresh seafood from markets compared with other sources (supermarkets and roadside vendors). Of these households, 96% purchased fish from the Otaheite Fish Market. The mean weekly expenditure on food for each household was US$105.31, of which 12% was expended on seafood, 21% on meat, 11% on vegetables and legumes, 13% on fruit and 43% on other foods. A variety of fish species were consumed at Otaheite, however, bechine (*Sphyraena* sp.), salmon (*Cynoscion* sp.), Serra Spanish mackerel and king mackerel were the most popular. The study estimated that 25 921 kg of fresh fish, valued at US$67 788, was consumed annually by the 250 households at Otaheite. Overall, the majority of families felt that the local fishery was important to the community, citing the same reasons as families at Orange Valley. Although 37% of the households felt that fishing had no negative impacts on the community, some believed that fishing contributed to pollution as well as drug and alcohol abuse (8% and 5% of households, respectively). Most households suggested that contribution of the local fish market to the community could be increased by improvement of the infrastructural and cold-storage facilities.

Fisher surveys conducted under the project received few responses. At Orange Valley, where only four fishers were interviewed, 80% sold all of their landed bycatch, while 20% sold 95% and gave the other 5% as gifts to family and friends. The average weekly value of total landings, from each two-day fishing trip, ranged between US$758.83 and US$319.51 at peak and low seasons, respectively. The corresponding estimated bycatch was 21.25% and 90.88% of total landings in the peak and low seasons. Fishers estimated that 5% to 10% of bycatch, comprising mainly eels and rays, was discarded at sea. All landed bycatch was sold to vendors at Orange Valley, and there was no preference for any particular species of fish. Bycatch was perceived as an important contributor to income generation (80% of fishers interviewed), employment (60%), and nutrition and food security (40%). A survey of seven Type III trawlers estimated an average replacement value of US$55 435, with vessel painting and net replacement being the main contributors to annual maintenance expenses (US$1 278 and US$2 019, respectively). Fishers perceived the unmonitored at-sea purchases of shrimp from foreign vessels with consequent negative impacts on market prices for catches from local vessels and acquisition of labour on fishing vessels as the main challenges faced by the fishery.

The fisher survey at Otaheite identified 50 fishers operating and landing their catch at the Otaheite Fish Market. Trawlers were all of either Type I or II (*pirogues*) and privately owned. These vessels mainly targeted shrimp, but caught fish such as bechine, sardines and herrings during the low shrimp season. About 250 persons were directly employed in fishing and 50 persons were employed in support activities for the sector. Almost all the catch was sold to eight wholesale vendors who supplied the San Fernando and Orange Valley markets. The estimated average replacement values of a *pirogue*, associated engines and nets were US$19 171, US$6 390 and US$575 respectively. A new *pirogue* with an inboard engine of 100 hp was estimated to cost between US$15 336 and US$19 171. The cost of used *pirogues* (10 years old) varied between US$5 112 and US$6 390 depending on whether or not an engine and additional furnishings were installed. About two or three nets were used per year, each at a cost of US$192 and US$80 for repairs. Boats were repainted every four months with material costs of US$128 per boat. Fishers perceived pollution (due to industrial, agricultural and domestic activity), piracy at sea, as well as inadequate infrastructure and business opportunities in the sector, as the main challenges faced by the fishery.

A study on the recreational fishery in the northwest peninsula of Trinidad was conducted in 1993. Forty-seven fishers were interviewed and the results showed that they lived mainly in Diego Martin and surrounding areas such as Carenage and West Moorings. The Port of Spain and the townships along the main east-west thoroughfare of northern Trinidad were also popular places of residence. Most of the fishers (32%) were over 50 years of age and none were below 20 years. Retired persons accounted for 9% and senior executives accounted for 41% of the persons interviewed, while 23% were professionals and 13% middle managers. Most fishers owned their own boats. Although some recreational fishers sell a portion of the catch, there is no information on the income generated.

In Tobago, a socio-economic study was conducted on the artisanal, small-scale, multigear fleet targeting flyingfish and large pelagics. Based on an interview of 50 fishers operating at four main landing areas in Tobago, approximately 68% attained education up to the primary level (age 11 to 12 years) and 30% up to secondary level (age 16 to17 years) (Potts *et al.*, 2002). The remaining 2% pursued post-secondary education. Approximately 77% of the interviewees were 49 years and under, with more young men entering fishery since the late 1990s (Ferreira, 2002). The livelihood of household members in the fishing communities depended largely on the flyingfish trade. Unemployed persons also assisted with offloading the catch, deboning and other similar activities. During the late 1980s, eight processing plants were in operation in Tobago; collectively, these employed about 200 people.

Coastal communities between Ortoire and Guayaguayare, on the east coast of Trinidad, were surveyed in 2004 to characterize the biological, technical and socio-economic attributes of the associated fisheries (Kishore and Clarke-Marshall, 2005; Kishore *et al.*, 2005). Gillnets were the main gear utilized (45.1% of vessels), except for fish pots and demersal handlines at Ortoire. Pelagic lines, beach seines, lobster and shark nets were of lesser importance. The area experiences considerable influx of fishing vessels from other areas, especially the south coast of Trinidad between December and May. This influx occurs as fishers track the movement of Serra Spanish mackerel which arrive along the east coast of Trinidad from the South American mainland. It allows an increase in economic activity as well as expansion of social networks during the first half of the year.

Eighty-six fisher households were surveyed, of which 87% were headed by men. Several fishers lived with extended families and as single persons, with the overall mean household size of 4.4 persons. Many of the fishers had been fishing since their early teens and about 23% had been fishing for more than 25 years. Few members of fisher households had achieved tertiary level education (< 4%), while 51% and 25% had achieved up to primary level and secondary level, respectively, and 14% had acquired technical and vocational skills. Although fishing was the main source of income for these households (60%), other substantial contributors, particularly for women, were employment in the government services and private companies as well as non-governmental organizations. Women were involved in the industry as boat owners, net menders, purchasers of fishing equipment, accounting and financial managers, assisting with deployment of beach seines and as vendors. Women also performed leadership roles in community groups and managed the households. About 37% of fishers had no alternative source of income while boat owners had a wider range of employment opportunities compared with crew members. Fishing contributed more than 60% of household income for 80% of the full-time fishers.

Home ownership among fishers (74.7%) compared favourably with the wider Mayaro/Guayaguayare community (80.6%). A variety of household amenities were also available to fishers: refrigerators (62–89% of interviewees); freezers (25–64%); motor vehicles (8–21%); stoves (92–96%); telephones (50–75%); water tanks (71–86%); televisions (73–89%); washing machines (63–75%); and computers (4–14%), among other articles. About 50% of 112 persons interviewed were boat owners and 50% of these boat owners owned more than one boat.

The major concerns of the fishing industry pertained to the lack of fishing facilities; the declining fish stocks due to overfishing, pollution, damage to fishing grounds and nursery areas, as well as the harvesting of juvenile fish and berried lobsters; lack of organization in the fishing industry as there are few formal organizations; limited involvement of regulatory agencies; and lack of cooperation among fishers. Despite these concerns, 88% of the interviewees indicated that they enjoyed fishing because of the excitement of bringing in a catch, self-satisfaction, and the challenge and serenity of being at sea rather than for the economic reasons (15%). However, many of these persons indicated that they would discourage participation of their children in the industry due to declining catches and failure of the industry to provide a steady income.

4. COMMUNITY ORGANIZATIONS AND INTERACTIONS WITH OTHER SECTORS

In general, the organization of fishers in Trinidad and Tobago is volatile, with groups set up on an ad hoc basis to address a specific, short-term goal. Once the goal is achieved the organization attains a state of dormancy until another threat is identified. Organizations are of two types, fishing associations or fishing co-operatives. Of the two, the co-operatives are more organized, with formal registration at the Ministry of Labour and Co-Operatives and managed by a Board of Directors. Fishing associations are informal groups with no legally binding commitments. Although it is recognized that issues impacting the livelihood of fishers can best be resolved by lobbying as a group, lack of trust with regard to financial matters is usually the main factor negatively impacting the continued operations of the organizations. In 2003, there were 34 fishing organizations (9 co-operatives and 25 associations) in Trinidad and Tobago. Of these, 24 were in Trinidad and the remaining 10 in Tobago. These organizations are generally not well managed (Picou-Gill, 2003).

Currently the more vibrant fishers' organizations in Trinidad are the Trinidad and Tobago Game Fishing Association, Almoorings Fishing Cooperative, Cocorite

Fishing Association, Moruga Fishing Association, north Coast Multi-Purpose Society Limited, Cedros Fishing Cooperative, Women in Fishing Association, and the South East Fishing Association. The latter two associations were established as a result of initiatives under the 2004 study to develop a co-management framework (Kishore *et al*., 2005). The eight organizations are financially viable with effective organizational structures, goals and planned activities that serve the interests of their members (Fisheries Division, 2007b). In Tobago, developments in the fishing sector during the 1980s spurred the Tobago House of Assembly to encourage the formation of fishers' organizations. However, the lack of the government's financial support has been a major constraint. Investment is almost totally from the private sector. In 1999, the All Tobago Fisherfolk Association (ATFA) was formed as a legal entity. In 2007, an 'umbrella' fisher organization – Trinidad and Tobago Unified Fisherfolk – was established to coordinate activities among fisher organizations and bring issues impacting the industry to the attention of decision-makers.

The interactions between fishers and other sectors are not well documented. Within the fishing sector, however, there are conflicts among fishers. During the mid-1990s conflicts among fishers utilizing gillnets, fish pots and trawls off the north and south coasts of Trinidad escalated. Fish pot fishermen accused those utilizing gillnets of entanglement of their pots while gillnet fishers in turn accused those utilizing fish pots of destruction of their gear. In general, gillnet and fish pot fishermen accused those utilizing trawls of destruction of the fishing ground and depletion of fisheries resources. A ministerial committee was established to address the conflict and to propose recommendations for sustainable utilization of the fisheries resources (Fisheries Division, 1997). Recommendations included stricter zoning of trawl activity. Fishers also experience vandalism of boats and gear as well as piracy at sea. Since there is some association between fishing and drug activity, it is difficult to ascertain the true reasons for the conflicts. Currently, the Fisheries Division is without the resources to exercise a greater role in conflict resolution. As a result, the Division's intervention is constrained to crisis situations.

5. ASSESSMENT OF FISHERIES

5.1 Stock assessments, bio-economic analyses and abundance surveys

Stock assessments have been conducted for each of the coastal fisheries of Trinidad and Tobago since the late 1980s (Table 1). The soft-substrate demersal fishery has been extensively studied under a Working Group of the Western Central Atlantic Fishery Commission (WECAFC). This Working Group conducts both stock assessments and bio-economic analyses. The hard-substrate demersal and small coastal pelagic fisheries were assessed under an FAO project to improve data collection systems and to assess marine fisheries resources in Trinidad and Tobago. Future stock assessments for the soft-bottom demersal and small coastal pelagic fisheries are facilitated under the respective working groups of the Caribbean Regional Fisheries Mechanism. As well, an ad hoc Working Group under the

WECAFC is responsible for assessment of the flyingfish resources in the eastern Caribbean. Abundance estimates for certain species groups were available from a 1988 research cruise conducted by the Fridtjof Nansen, a Norwegian vessel.

As shown in Table 1, several methods have been used to assess the various fisheries, including surplus production models, catch-at-age models, length-based models, virtual population analyses, yield-per-recruit models and abundance surveys. Some assessments were conducted jointly with Venezuela (Bolivarian Republic of), using methods such as biodynamic production models and bio-economic analyses. Recent assessments indicate that the majority of the fisheries are either fully or overexploited. Earlier assessments showed that some resources were either underexploited or inconclusive, such as the lane snapper and sharks, respectively. However, declining catch quantities and sizes of fish in the catch suggest that these resources may currently be overexploited.

5.2 Ecosystem analyses

In addition to stock assessments, preliminary ecosystem analyses have been conducted on the soft-substrate demersal fishery. Ecosystem statistics and network flow indices were derived, and the possible impacts of trawling on the biomass of model components were explored using a trophic model for the Gulf of Paria (Manickchand-Heileman *et al*., 2004). Almost 80% of the catch trawl fleet consisted of fish from trophic levels 2 and 3, with an average trophic level of 2.97. The associated primary production required for the 1997 total catch was 28.3 tonnes per km^2 (about 2% of net primary production). For the major component of the catch, comprising several shrimp species, the associated primary production required for the 1997 catch was 8 tonnes per km^2 (0.56% of net primary production). The total system flow of biomass was 2 285 tonnes per km^2, of which 25% was attributed to all consumption, 16% to respiration and the remaining 59% to input of detritus. Estimated high ecotrophic efficiencies for many system components suggest efficient utilization of secondary production by predators. Mean transfer efficiency was 12.2%. The food web was dominated by the detrital pathway (bottom-up control) and the ecosystem was relatively mature (Finn cycling index of 7.2%). Simulations showed marked decreases in fish biomass and conversely increases in invertebrate biomass (notably shrimp and crab) when fishing mortality rate was increased by 50% over five years. On relaxation of fishing effort, the fish biomass recovered but that of crabs declined even further. Except for a decline in the biomass of crabs, a reduction in fishing mortality rate elicited the opposite response in system components. A comparison of the 1997 biomass of system components with those obtained from a 1945 trawl survey showed significantly higher biomass in 1945, with the exception of carangids, penaeids and possibly clupeids, suggesting a possible shift towards a system dominated by lower trophic levels.

TABLE 1
Stock assessment, bio-economic analyses and abundance surveys conducted on fisheries of Trinidad and Tobago

Species (assessment year)	Method	Stock status and reference points	Management recommendations	Source
***Farfantepenaeus subtilis* (brown shrimp) 1973–1996**	Biodynamic production model (joint assessment with Venezuela)	Overfished: MSY = 1 200–1 300 tonnes	No further increase in fishing effort beyond the 1996 level for a few years	Alió *et al.* (1999)
***F. subtilis* (brown shrimp) 1973–2001**	Surplus production models: BIODYN and ASPIC (joint assessment with Venezuela)	Severely overfished: overfishing since 1970; $F_{current}$ = >3 F_{msy} $B_{current}$ = 0.23 B_{msy} MSY = 1 000 – 2 000 tonnes	Reduction of fishing mortality and adoption of common strategy for effort control by both countries	Dié *et al.* (2004)
***F. notialis* (pink shrimp) 1992–2001**	Catch-at-age and Virtual Population Analysis models	Fully exploited $F_{current}$ = 0.71F_{msy} $BPR_{current}$ = 0.40 BPR_0 Mainly young shrimp caught	Immediate restriction on increased fleet size; future reduction in effort and increased size at capture	Medley and Ferreira (2004)
***Xiphopenaeus kroyeri* (seabob) 1992–2001**	Catch-at-age and Virtual Population Analysis models	Overexploited $F_{current}$ = 0.71F_{msy} $BPR_{current}$ = 0.20 BPR_0	Immediate restriction on fleet size; future reduction in effort and increased size at capture	Medley and Ferreira (2004)
***F. subtilis*, *F. notialis*, *Litopenaeus schmitti* (white shrimp), and *X. kroyeri* 1995–1998**	Bio-economic analysis (joint assessment with Venezuela)	Fully to overexploited Overcapitalized Effort $_{current}$ = 17 523 days at sea (Trinidad: 8 175 days; Venezuela: 9 348 days) B_o of *F. subtilis* = 481 tonnes At current effort 39% chance that B of *F. subtilis* will be <0.25 B_o	Reduction in current fishing effort by 20% would reduce probability of B < 0.25B_o by 15% for *F. subtilis* and increase profits by 12%. Profits of this shared fishery could be maximized by reducing current effort by 61% (Trinidad fleet) and 82% (Venezuela fleet)	Seijo *et al.* (2000); Ferreira and Soomai (2001)
Sciaenidae (croakers) 1988	Abundance survey using demersal trawl	Biomass = 5 500 tonnes (south Trinidad) and 35 500 tonnes (north Trinidad)		Institute of Marine Research (1989)
***F. subtilis*, *F. notialis*, *F. brasiliensis*, *L. schmitti* (white shrimp), and *X. kroyeri* (1975;, 1988–2004)**	Biomass dynamic (production) model for the shrimp resources shared between Trinidad and Tobago and Venezuela	Overfished relative to MSY. MSY = 1 765 tonnes B_{1988} = 10 536 tonnes B_{inf} = 16 706 tonnes $B_{current}$ = 5 250 tonnes R = 0.47 F_{msy} = 0.235 $F_{current}$ = 0.300	A closed season for trawling (1–4 months) at the time when the smallest sizes of shrimp are caught. Involve stakeholders in the process and investigate the social and economic implications of this measure. Limit the number of trawlers in the fishery. Strictly enforce current regulations on cod-end mesh size and permitted fishing areas. Set appropriate and specific reference points for the fishery.	Ferreira and Medley (2007)
***Micropogonias furnieri* (Whitemouth croaker) 1977–1982**	Yield-per-recruit analysis	Fully exploited Tc = 3 years $F_{current}$ = F_{msy} $F_{current}$ = 0.8 $YPR_{current}$ = MSYPR $YPR_{current}$ = 175g	No further increase in fishing mortality	Manickchand-Heileman and Kenny (1990a)

TABLE 1 (CONTINUED)

Species (assessment year)	Method	Stock status and reference points	Management recommendations	Source
M. furnieri **(Whitemouth croaker) 1989–1997**	Depletion and yield-per-recruit modelling	Overexploited	Limit fishing effort for all fleets (trawl and multigear)	Soomai *et al.* (1999)
M. furnieri **(Whitemouth croaker) 1989–1997**	Surplus production biodynamic modelling and yield-per-recruit analyses (joint assessment with Venezuela)	Overexploited MSY = 1 500 tonnes F_{msy} achieved between 1987–1993 F_{1998} = 0.4–3.2 Y_{1998} = 1 800 tonnes	No further increase in fishing effort; limited entry in future; reduce fishing mortality to 0.4 to achieve 0.4 SSB_0	Alió *et al.* (1999)
Cynoscion jamaicensis **(Jamaican weakfish) 1989–1997**	Depletion and yield-per-recruit modelling	Overexploited	Limit fishing effort for all fleets (trawl and multigear)	Soomai *et al.* (1999)
M. furnieri C. jamaicensis **1989–1997**	Multispecies, multigear dynamic bio-economic analysis	Fully to overexploited $B,_{1989}$ = 6 322 tonnes (*M. furnieri*) and 602 tonnes = (*C. jamaicensis*) $B,_{1997}$ = 3 754 tonnes (*M. furnieri*) $B,_{1997}$ = 273 tonnes (*C. jamaicensis*) $Effort,_{1997}$ = 11 635 days at sea Maximum rent generated in 1997 (US$101 per day per vessel)	Limit fishing effort to 1997 level for all fleets since this option maximizes the minimum final biomass attainable and minimizes loss of opportunity	Soomai and Seijo (2000)
Pomadasyidae Grunts 1988	Abundance survey using demersal trawl	B = 100 tonnes (Trinidad south coast)		Institute of Marine Research (1989)
Lutjanidae Snappers 1988	Abundance survey using demersal trawl	Biomass = 400 tonnes (Trinidad north coast) and 450 tonnes (Trinidad south coast, 5% biomass of all demersal fish)		Institute of Marine Research (1989)
Lutjanus synagri **(Lane snapper) 1988**	Abundance survey using demersal trawl	Mean catch rate of 10 kg/hr (south Trinidad) and 25 kg/hr (east Trinidad) 86% sampled individuals on south coast were 1–30 kg and 14% between 30–100 kg		Institute of Marine Research (1989)
L. synagris **(Lane snapper) 1980–1981**	Yield-per-recruit analysis of multigear fleet which uses fish pots off north and east Trinidad	Underutilized (however currently species may be approaching high level of exploitation or overexploited) TC = 1.38 years $F_{current}$ = 0.17 YPR = 70g	Increase TC to 2 years (corresponds to 30 cm TL; average Lm is 28 cm TL) by increasing mesh size of pots, mesh size of trawlers and hook size on lines. Increase F to 0.8. These will increase year-per-recruit to 122 g. However, need to consider effects on other species in fishery	Maingot and Manickchand-Heileman (1987)

TABLE 1 (CONTINUED)

Species (assessment year)	Method	Stock status and reference points	Management recommendations	Source
L. synagris **(Lane snapper) (1908–2004)**	Mean size model and Catch-free model for the fleets using gillnets, handlines and trawl gear in Trinidad	Uncertain. Possibly growth-overfished due to high proportion of immature fish in the catch. Emigration of large fish may account for the high F estimated. $F_{(1980,\ 1997)}$ = 0.94 – 3.69 Constant CPUE trends despite high F suggest constant recruitment	Preliminary assessment. Fishing effort should be monitored and not increase until further research on migration patterns, stock structure and status indicate otherwise	Soomai and Porch (2007)
L. purpureus **(Caribbean red snapper) 1990–1991**	Yield-per-recruit analysis of multigear fleet which uses fish pots off north and east Trinidad and east Tobago	Fully to overexploited $TC_{current}$ =1.4 yrs (28 cm TL) $TC_{current}$ < Tm (Lm = 33 cm TL) $F_{current}$ = 0.29 F_{max} = 0.26 $F_{0.1}$ = 0.15 at $Tc_{current}$ $YPR_{current}$ = 489g	Restrict fishing effort and increase age at first capture to 3 years by increasing mesh size in pots. This will increase yield-per-recruit to 569 g at $F_{current}$	Manickchand-Heileman and Phillip (1992b; 1996)
Rhomboplites aurorubens **(Vermillion snapper) 1990–1991**	Yield-per-recruit analysis of multigear fleet which uses fish pots off north and east Trinidad and east Tobago	Overexploited $Tc_{current}$ = 2.1 years $Tc_{current}$ > Tm (0.6 years) $F_{current}$ = 0.79 – 1.54 $YPR_{current}$ = 350g	Restrict fishing effort and increase TC to 3 years by increasing mesh size in pots. This will increase yield-per-recruit to 401 g at $F_{current}$	Manickchand-Heileman and Phillip (1992b)
Serranidae Groupers 1988	Abundance survey using demersal trawl	Biomass = 200 tonnes (Trinidad south coast)		Institute of Marine Research (1989)
Epinephelus flavolimbatus **(Yellowedge grouper) 1990–1991**	Yield-per-recruit analysis of multigear fleet which uses fish pots off north and east Trinidad and east Tobago	Fully or overexploited Lm = 52.8 cm TL $TC_{current}$ = 3.3 years $TC_{current}$ < Tm $F_{current}$ = 0.1 – 0.12 $YPR_{current}$ = ≈ 235 g	Restrict fishing effort, increase mesh size of traps since other species in fishery are overexploited, estimate impacts of illegal foreign fishing	Manickchand-Heileman and Phillip (1992a)
Mycteroperca interstitialis **(Yellowmouth grouper) 1990–1991**	Yield-per-recruit analysis of multigear fleet which uses fish pots off north and east Trinidad and east Tobago	Fully or overexploited Lm = 38 cm FL $TC_{current}$ = 3.3 years $F_{current}$ = 0.17 $YPR_{current}$ = ≈ 240 g	Restrict fishing effort, increase mesh size of traps, estimate impacts of illegal foreign fishing	Manickchand-Heileman and Phillip (1992a)
Scomberomorus brasiliensis **(Serra Spanish mackerel) Late 1980s**	Yield-per-recruit analysis for fishery off Trinidad	Underexploited (however currently overexploited) F = 0.27 TC = 3 years YPR < 50 g	No increase in the existing mesh size of gillnets (11.4 cm)	Sturm *et al.* (1987)
S. brasiliensis **(Serra Spanish mackerel) 1991–1992**	Length-based model for fishery off Trinidad	Fully exploited $F_{current}$ = 0.6 $Y_{current}$ = 2 815 tonnes $SSB_{current}$ = 0.22 SSB_0 $SSB_{current}$ = 6 258 tonnes	No increase in fishing effort, gillnet mesh size should not be < 4.75 inch stretched mesh, encourage line fishing over gillnets	Henry and Martin (1992)

TABLE 1 (CONTINUED)

Species (assessment year)	Method	Stock status and reference points	Management recommendations	Source
S. brasiliensis **(Serra Spanish mackerel) 1972–2002**	Surplus production model (ASPIC) using data for entire distribution range of species including Trinidad	B_{msy} = 8 000 tonnes F_{msy} = 0.2 B_{2003} = 0.84 B_{msy} F_{2001} = 1.17 F_{msy} Status quo performed badly and 0.75 $F_{current}$ performed best in the long run (25 years)	Study preliminary, improve time series of input data as well as age and size data, obtain specific management objectives from decision makers	Martin and Nowlis (2004)
S. cavalla **(King mackerel) Late 1980s**	Yield-per-recruit analysis for fishery off Trinidad	Underexploited (possibly overexploited currently) F = 0.34 TC = 4 years YPR > 300g	No increase in the existing mesh size of gillnets (11.4 cm)	Sturm *et al.* (1987)
S. cavalla **(King mackerel) (1996–1998; 2004)**	Biomass dynamic Schaefer production model and yield-per-recruit model for the fishery in the southern Caribbean (including Trinidad)	Inconclusive - Possibly overexploited $F_{0.1}$ = 0.26–0.66 $F_{20\%SPR}$ = 0.62–1.11 $F_{96\text{-}98}$ = 16% below or 80% above $F_{20\%SPR}$ F_{04} = 85–202% above $F_{20\%SPR}$ At $F_{0.1}$ Rel. YPR = 0.13–0.24 Rel. SSBPR = 0.26–.4 At $F_{20\%SPR}$ Rel YPR = 0.14–0.25	Study preliminary, improve input data to generate growth parameters. Reduce current fishing mortality by 66% or alternatively impose a 6-month closed season to increase relative spawning stock biomass per recruit from 10 to 22%. Enforce fish or mesh size regulations to increase TC. Impose limited entry to replace current free access. No increase in fishing effort until assessment is updated.	Martin and Hoggarth (2007)
S. cavalla **(King mackerel) (1996–1998; 2006–2007)**	Biomass dynamic Schaefer production model and yield-per-recruit model for the fishery in the southern Caribbean (including Trinidad)	Inconclusive $F_{0.1}$ = 0.34 – 0.45 $F_{20\%SPR}$ = 0.66 - 0.80 $F_{96\text{-}98}$ = 149 to 350% of $F_{0.1}$ 84 to 180% of $F_{20\%SPR}$ $F_{06\text{-}07}$ = 182 to 332% of $F_{0.1}$ 103 to 171% of $F_{20\%SPR}$	Research to ascertain stock range and migration patterns, growth and mortality rate parameters. Inclusion of catch, effort and biological data from all countries targeting the stock into assessment analysis. Inclusion of historical time series data on catch and effort into assessment analysis.	Martin and Dié (2008)
Hirundichthys affinis **(Four-winged flyingfish) (1990–1992)**	Length-based model for fishery off Tobago	Fully exploited TC = 0.6 years $F_{current}$ = 3.3 $Y_{current}$ = 433 tonnes $B_{current}$ = 906 tonnes	Conservative approach to increasing local effort, restrict foreign effort, consider ecological role of species in management	Samlalsingh and Pandohee (1992)
Clupeidae and Engraulidae (Herrings, anchovies and sardines) 1988	Abundance (hydroacoustic) survey	B = 6 000 tonnes (Trinidad north coast); 16 000 tonnes (Trinidad east coast) and 24 000 tonnes (Trinidad south coast). Potential yield = 20 000 tonnes		Institute of Marine Research (1989)

TABLE 1 (CONTINUED)

Species (assessment year)	Method	Stock status and reference points	Management recommendations	Source
Carangidae, Sphyraenidae, Scombridae 1988	Abundance (hydroacoustic)	B = 12 000 tonnes (Trinidad north coast); 14 000 tonnes (Trinidad east coast) and 12 000 tonnes (Trinidad south coast)		Institute of Marine Research (1989)
Sharks 1988	Abundance survey using demersal trawl and acoustic techniques	Biomass = 1 100 tonnes in waters off Trinidad		Institute of Marine Research (1989)
***Carcharhinus porosus* (Small tail shark) 1992**	Analysis of catch and effort, length frequency and age-length data	Inconclusive M = 0.245 q = 0.22 (however, currently, species may be overexploited)	Preliminary assessment. Improved data collection necessary. Need to incorporate catches of other countries exploiting the resource in analyses	Walker (1992)
***C. limbatus* (Blacktip shark) 1992**	Analysis of catch and effort, length frequency and age-length data	Inconclusive M = 0.303 q = 0.44 Underexploited (however, currently, species may be overexploited)	Preliminary assessment. Improved data collection necessary. Need to incorporate catches of other countries exploiting the resource in analyses	Walker (1992)

5.3 Economic analyses: costs and earnings studies

Soft-substrate demersal fishery: Three costs and earnings studies have been conducted for the soft-substrate demersal fishery. The first focused on Types I and II trawlers legally operating off Venezuela (Bolivarian Republic of) during the 1991/1992 fishing season (Ferreira and Maharaj, 1993). The fleet appeared marginally profitable. In fact, vessels operated at a little better than break-even point and at a loss in years when recruitment was particularly low. The average annual return to owners' management and capital was estimated at US$723, or 10% average rate of return on capital. Profit was maximized at 58% of the contemporary effort. The second study examined operations of all trawl fleets (Ferreira, 1998). Thirty-three percent of Type II trawlers, 50% of Type III trawlers and 60% of Type IV trawlers appeared to be operating at a loss. Without accounting for depreciation, Type II trawlers operated between a loss of US$5 900 and a profit of US$15 300. Similarly, Type III trawlers operated between a loss of US$4 300 and a profit of US$17 800. Type IV trawlers had much higher losses, with US$25 500 for losses and US$17 000 for profit. Type II trawlers appeared more efficient than Types III and IV as the revenue-per-cost ratio, benefits to crew and owner per unit of revenue and returns on investment were higher. Small trawlers were also more labour intensive than capital intensive. Mean labour costs to current vessel value were 0.7, 0.2 and 0.1 for Types II, III and IV trawlers, respectively. The net profit of a Type II trawler was US$1 800, while Types III and IV trawlers suffered net losses of US$2 400 and US$19 700, respectively, and returns on investment were estimated at 21%, -5% and -20% for Types II, III and IV trawlers (Kuruvilla *et al.*, 2000). The third study was similar to the second but conducted more recently (Kuruvilla *et al.*, 2002). In this instance, only the Type III trawlers, on average, realized a profit (US$8 900), which corresponded to 15% return on investment. Types II and IV trawlers suffered losses of US$389 (-4% return on investment) and US$996 (-1% return on investment), respectively. Despite negative cash flows, vessels continued to operate because owners had ceased repayments on their loans. Given the expected high maintenance costs (many vessels were between 10 and 20 years old), many owners also opted to reduce costs by working their own vessel, doing repairs on vessel and gear themselves, and purchasing used engines and parts (Kuruvilla *et al.*, 2002).

Hard-substrate demersal fishery: A simple cost analysis was conducted on the artisanal, multigear fleet operating between Ortoire and Guayaguayare on the east coast of Trinidad (Kishore *et al.*, 2005). The average trip preparation cost was highest for vessels utilizing demersal longlines (US$170), compared with fish pots (US$107), and banklines or demersal handlines (US$131). Fuel was the greatest contributor to overall trip cost (average US$131 for vessels utilizing each of three gear types), followed by bait (average US$33) and food for crew members (average US$10). The average cost of ice, ground transport for landed catch and post-landing cleaning operations per fishing trip was US$8.00, US$3.57 and US$9.25, respectively. The cost of entry to the fishery for a vessel utilizing fish pots (primary gear) and pelagic lines (secondary gear) was estimated at US$11 623, while a vessel utilizing banklines (primary gear) and demersal longlines (secondary gear) would cost US$7 098.

Small coastal pelagic fishery: Costs and earnings studies were conducted on the artisanal, multigear fleet (component using gillnets) in Trinidad and the artisanal and semi-industrial multigear fleets targeting flyingfish in Tobago. Simple cost analyses were also conducted on the artisanal, multigear fleet operating between Ortoire and Guayaguayare on the east coast of Trinidad and the recreational fleet operating off north Trinidad. In the artisanal, multigear fleet (component using gillnets) of Trinidad, costs and revenues were found to vary significantly between landing beaches due to differences in the production activities (Parkinson, 1992). Gross seasonal revenue was US$4 500 per fisher from the sale of an average catch of 4 200 kg. Average monthly fishing operation costs was US$1 100 per fisher, with variable costs (boat and engine repair, net repair, fuel, oil and other trip related expenses) accounting for 93% of total costs. The average monthly net revenue above the variable and total costs was US$132 and US$68, respectively. Preliminary studies for the Tobago fleets (Ferreira, 2002; Potts *et al.*, 2002) showed profits which far exceeded those of other, similar fleets in the region and, therefore, the results require verification.

The average trip preparation cost was highest for artisanal vessels fishing off the east coast of Trinidad and utilizing multifilament gillnets (US$107.60) compared with pelagic lines (US$101.79), monofilament gillnets (US$81.10) and beach seines (US$23.65) (Kishore *et al.*, 2005). Fuel was the greatest contributor to the overall trip cost (average US$50.97 for vessels utilizing each of four gear types). The average cost of ice, post-landing cleaning, ground transport for landed catch, and food for crew members was US$6.17, US$6.00, US$4.06 and US$11.69, respectively. Bait was utilized only by vessels deploying pelagic lines (average cost of US$10.28 per trip). The cost of entry to the fishery was greater for a vessel utilizing gillnets (US$13 222) compared to beach seines (US$11 575). Fuel cost per fishing trip in the Trinidad recreational fleet was greatest for vessels using troll lines (US$44) and least for those using gillnets and demersal longlines (US$8) (Mike, 1993). Initial gear costs were high for boats involved in line (US$200 to US$300) and spear (US$210) fishing, while gear replacement costs were greatest for vessels using troll lines (US$12). Spears and fish pots were replaced infrequently and the cost of gillnet replacement was negligible.

6. FISHERY MANAGEMENT AND PLANNING

Marine fisheries activities in Trinidad and Tobago are evolving in the context of a dynamic international environment of governmental and non-governmental organizations towards the sustainable natural resource management objective. Trinidad and Tobago is signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Convention on Biological Diversity, the Cartagena Convention, the Ramsar Convention, the Convention on Fishing and Conservation of Living Resources of the High Seas, the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and a contracting party to the International Commission for the Conservation of Atlantic Tunas (ICCAT). Trinidad and Tobago adopted the FAO Code of Conduct for Responsible Fisheries in 1995. Adoption of these conventions and other ‘soft-laws’ (i.e. non-binding) place specific responsibilities on the country for management of marine resources, including fisheries. The implementation and evaluation of fisheries management measures is the responsibility of the Fisheries Division of the Ministry of Food Production, Land and Marine Affairs in Trinidad and the Department of Marine Resources and Fisheries, Tobago House of Assembly, in Tobago.

Support for administration of the fisheries sector, including resource and coastal zone management, is provided by a number of governmental agencies, including the following Ministries: Works and Transport; Health; Trade and Industry; Finance; National Security; Foreign Affairs; the Office of the Prime Minister; and the Tobago House of Assembly. Regional organizations such as the Caribbean Community, the Caribbean Regional Fisheries Mechanism (CRFM), and the University of the West Indies (UWI), as well as international organizations such as FAO and other United Nations agencies, the Global Environment Facility and foreign donor governments (e.g. European Union and Japan) also play a key role in the research and administrative activities of the Fisheries Division.

6.1 Fisheries management policy

Trinidad and Tobago has recently reviewed its marine fisheries policy and associated legislation (Moore-Miggins and Company and Scales Consulting Limited, 2006; University of the West Indies, 2006; Fisheries Division, 2007b). The draft policy for the fishing sector addresses recommendations from a 2005 review of the fish and fish processing industry (Fish and Fish Processing Industry Team, 2005) and supports the Government's Vision 2020 Plan for Trinidad and Tobago's achievement of developed country status by 2020. This plan emphasizes the need to enable competitive business in the agricultural sector while recognizing the need for sustainable fisheries. The major fisheries-related objectives of the plan are to improve the management and regulation of fisheries, to improve product safety for fish and fish products so as to meet international standards, to safeguard fisheries resources and augment stocks to optimal levels, and to develop aquaculture as a major enterprise as a basis for diversification, income growth and enhanced food security (Fisheries Division, 2007b).

The overarching policy objectives support the Precautionary Approach to sustainable fisheries management and conservation (Fisheries Division, 2007b). These objectives aim to introduce a management structure with the capacity and resources to address current national, regional and international issues in fisheries, including obligations under associated treaties and conventions. To effect management, attention is given to modernizing the legal and regulatory framework with introduction of appropriate mechanisms to strengthen the fisheries surveillance and enforcement capability. In addition, the policy promotes transparency in decision-making, with participation of stakeholders in the management process and consideration of the socio-economic implications of management measures in decision-making. To address the impacts of multisectoral and competing use of the coastal zone on fisheries, the policy supports an integrated approach to coastal zone development with mechanisms to reduce associated conflicts and compensate impacted fishers. The policy objectives also seek to address environmental issues in fisheries and to promote the protection of critical fish habitats. Modernization of fisheries infrastructure, with emphasis on local and international food quality assurance and efficient use of resources, as well the creation of a safe working environment for fishers, are also promoted.

6.2 Fisheries legislation

The principal legislation governing domestic fishing in Trinidad and Tobago is the Fisheries Act of 1916 and the subsequent amendments to the Act, the Fisheries (Amendment) Act 1966, and the Fisheries (Amendment) Act 1975. The Act applies to all rivers and tidal waters in Trinidad and Tobago and to the 12-mile territorial sea. It empowers the minister responsible for fisheries to make regulations to prescribe mesh size of nets, to restrict the size of fish, shrimp, crabs and turtles caught, to prohibit their sale, and to prevent the catching of these species either absolutely or to limit it by season or area. A Fisheries Management Bill, prepared in 2006, will repeal the Fisheries Act of 1916 and the relevant sections of the

Archipelagic Waters and Exclusive Economic Zone Act of 1986. The Bill embraces the principles outlined in the United Nations Law of the Sea Convention and the FAO Code of Conduct for Responsible Fisheries. The Bill facilitates the preparation of fisheries management plans and the establishment of management systems and will, in accordance with the management plans, facilitate the control of access to fisheries resources through the establishment of a licensing system for both local and foreign fishing vessels.

The Fishing Industry (Assistance) Act of 1955 makes provisions for the granting of financial assistance to the fishing industry. The Marine Areas (Preservation and Enhancement) Act (1970), through regulations implemented in 1973, provides for designation of restricted areas and the requirement of the minister's approval to enter and remove marine fauna from such areas (limited to coral reef management). A National Parks and Other Protected Areas Bill has been drafted, which will have an effect on the Marine Areas (Preservation and Enhancement) Act when enacted. The Archipelagic Waters and Exclusive Economic Zone Act (1986) provides for the declaration of archipelagic waters, the establishment of a 200-mile exclusive economic zone (EEZ), the determination of total allowable catch by nationals, and makes provisions for foreign fishing and associated surveillance and enforcement. The Fish and Fishery Products Regulations (1998) under Section 25 of the Food and Drugs Act Chapter 30:01 authorizes the minister with responsibility for health to grant licences for the import and export of fish which have been handled and packed under conditions conforming to health and safety standards prescribed under the Act. The regulations specify the requirements for handling fish, the general and specific operating requirements for establishments handling or processing fish, the requirements for vessels used for fishing or transporting fish, and for vehicles and equipment used for unloading, handling, holding and transporting fresh fish for processing. As a consequence of non-compliance with the regulations, fish and fishery products originating in Trinidad and Tobago were banned from export to the European Union in 1999. Currently, the Fish and Fishery Products Regulations are under review.

The soft-substrate demersal fishery: Legislation regulating operations of the trawl fleet targeting the soft-substrate demersal fishery specifies fishing areas and gear dimensions (the Fisheries Control of Demersal Bottom Trawling Activities Regulations of 1996 and the associated Amendment Regulations of 1998 and 2004). Within the Gulf of Paria, Types I and II trawlers are permitted to operate outside of one nautical mile from the coast, Type III trawlers, with engines less than or equal to 180 hp, are permitted in areas of six fathoms or more in depth, and Type IV trawlers, with engines greater than or equal to 180 hp, are permitted in depths of ten fathoms and more. On the north and south coasts of Trinidad trawling is permitted outside of two nautical miles. However, off the north coast, the fishing area is further restricted to the region west of Saut d'Eau. Trawling off the north coast of Trinidad is restricted to the period from 15 November to 15 January, while night fishing is prohibited. Trawling is also prohibited off the east coast of Trinidad and within 12 nautical miles off the coast of Tobago. The minimum diagonal, stretched mesh size on the cod end of the trawlnet is restricted to 7.6 cm when trawling for fish, and 3.8 cm when trawling for shrimp. The entry of new trawlers to the fishery is restricted under a 1988 Cabinet decision.

To reduce turtle bycatch in the trawl fishery, the Fisheries (Conservation of Marine Turtles) Regulations were implemented in 1994. These regulations stipulate the use of Turtle Excluder Devices (TED) on nets deployed by Types III and IV trawlers and provide the type and design specifications. This conservation measure facilitates trade between Trinidad and Tobago and the United States. Conservation of marine turtles is also supported by the Protection of Turtle and Turtle Eggs Regulations of 1975. Trawlnets are subject to inspection by United States trade officials, who also grant certification that permits export from Trinidad and Tobago to the United States. Trinidad and Tobago is also currently participating in a project funded by FAO, UNEP and GEF aimed at reducing the environmental impacts of tropical shrimp trawling through the introduction of bycatch reduction devices.

The hard-substrate demersal fishery: Legislation aimed at the demersal hard-substrate fishery prohibits the capture or sale of snapper less than 20.3 cm. Assessment studies on major snapper species confirmed the capture of snappers prior to maturity. It was recommended that mesh sizes be increased to maximize yield and to prevent overfishing, and biodegradable panels be utilized in the construction of fish pots. A study was also commissioned to ascertain the appropriate mesh sizes for fish pots (Mohammed, 2000).

The coastal pelagic fishery: Prior to 2000, regulations limited gillnet lengths (up to 272.73 m), minimum mesh size (4.4 cm) and minimum length of several species marketed, including the Serra Spanish mackerel and king mackerel (30.5 cm). Due to conflicts among various fishing groups (Fisheries Division, 1997) and the near full exploitation of the Serra Spanish mackerel (Henry and Martin, 1992), regulations were amended in 1998 to increase the minimum diagonal stretched mesh size to 10.8 cm, with exceptions for those nets used to catch mullet and flyingfish (Ministry of Food Production and Marine Resources, Fisheries Division and the Monitoring and Advisory Committee on the Fisheries of Trinidad and Tobago, 2001). In addition, a 0.64 cm incremental increase in the current mesh size (10.2 cm) was proposed over a three-year period to arrive at the recommended 12.1 cm mesh size for the fishery (Fisheries Division, 2003).

Due to the greater efficiency of monofilament nets compared with multifilament nets, and continuing conflicts between fishers utilizing gillnets, fish pots and trawls on the south coast of Trinidad, a ban on the use of monofilament gillnets was imposed in March 2000. Continuing dissatisfaction by the fishing community regarding this ban resulted in an amendment of the regulations in 2002. These regulations again specified a minimum diagonal stretched mesh size of 10.2 cm for gillnets, but 8.9 cm for nets used to catch mullets and 4.5 cm for nets used to catch flyingfish. The quantity of any species other than mullet landed by the 9 cm mesh size should not exceed 15% of the total catch, and vessels are prohibited from carrying nets of less than 11 cm mesh size together with nets of other mesh sizes on the same fishing trip. The main objective of management is to increase the size at capture, through increased mesh size, in order to avoid recruitment overfishing.

6.3 Fisheries monitoring and surveillance

A Fisheries Monitoring, Surveillance and Enforcement Unit (FMSEU) was established within the Fisheries Division in 2004, thereby strengthening the capability for enforcement of national fisheries regulations as well as for international fisheries management recommendations for large migratory pelagic species. The FMSEU has initially played a greater role in management of the offshore fisheries through implementation of trade-related monitoring and inspections programmes to ensure compliance with ICCAT regulations, issuance of the required certificates of eligibility (COE) or statistical documents for export of swordfish to the United States, compliance with regulations governing the use of TEDs, monitoring of processing plants and export shipments to deter mislabelling of goods, and monitoring and data collection from foreign vessels utilizing the transshipment port at the National Fisheries Company to deter illegal, unreported and unregulated fishing (Fisheries Division, 2004). Additionally, the FMSEU acts as liaison between fish processing plants and the Chemistry, Food and Drug Department of the Ministry of Health, to facilitate inspections for compliance with sanitary and phytosanitary regulations. Coastal fisheries are monitored at landing sites and at sea operations investigated to ensure compliance with mesh size and other fisheries management regulations. The FMSEU is assisted by the Trinidad and Tobago Coast Guard (at sea) and Protective Services (on land), particularly in areas of high security risk. An assessment of the impact of the FMSEU on industry compliance with current regulations is to be undertaken. However, until the unit is adequately staff with trained and experienced personnel and legislation is updated to address current issues in fisheries management, the unit's effectiveness remains constrained.

6.4 Fisheries subsidies

The Fishing Industry (Assistance) Act of 1955, amended in 1975, provides for government's financial assistance to the fishing industry. Subsidies are provided on fuel and oil used by vessels, cost of vessel replacement, cost of semi-industrial, multigear vessels and cost of vehicles used in commercial fishing. Duty and taxes are also exempted on imported engines, vessels, engine parts and marine accessories. The criteria for the award of subsidies are that applicants must be fishers, fishing vessel owners or fishing proprietors who are citizens of Trinidad and Tobago and are registered with the Fisheries Division. The fisher registration system, though voluntary and not used for management, is linked to administration of the incentive programme. As a result, most fishers, including recreational fishers, are registered. The government's additional support to the fisheries sector is largely through the provision of services at no cost to the sector. These services include administration of the incentive programme, implementation of fisheries recurrent and development projects, infrastructural development, issuance of import and export licences for fish and fishery products, assessment of fisheries resources, provision of fisheries-related information, registration of fishers and fishing vessels, and monitoring, surveillance and enforcement.

6.5 Marine protected areas

The Buccoo Reef area in Tobago is the only area that has been designated a restricted area under the Marine Areas (Preservation and Enhancement) Act of 1970. Traditionally a major tourist attraction in Tobago, this reef is impacted by a number of socio-economic and environmental factors. In 1990, under a cooperative project between the Institute of Marine Affairs (IMA) and the Tobago House of Assembly (THA), ecological surveys of the reefs around Tobago were conducted and a management plan was proposed for the Buccoo Reef Marine Park. The project had several components which studied the environmental conditions of the reef, and included public education and awareness as well as socio-economic aspects (Institute of Marine Affairs, 1994a, 1994b).

7. RESEARCH AND EDUCATION

7.1 Research and projects

A research project developed in 1999, which was a collaborative effort between the University of East Anglia, the University of the West Indies and the THA (Brown *et al.*, 1998, 1999), attempted to develop and promote sustainable resource-use strategies through an analysis of the conflicts and trade-offs between different uses and users of the marine protected area. The project was viewed by stakeholders and the THA as an important contribution to implementing sustainable coastal resource use, as outlined in the management plan for the Buccoo Reef Marine Park, especially since the existing situation was one of conflicting management, ineffective enforcement and suspicion and non-communication between stakeholders, including resource managers. The study used multi-criteria analysis (MCA) as a framework for assessing the resource use strategies and for quantifying the impacts of coastal zone management options on the urban and rural communities in the coastal zone. Research included the collection of economic, social and ecological data to perform an environmental economic valuation of the Buccoo Reef Marine Park. Social and economic data collection was based on a survey to estimate consumer surplus from recreational use of the marine park, a census of informal business vendors, and a series of semi-structured interviews. Ecological data, including fish counts by species, mangrove leaf fall, water quality and plankton tows, were used to estimate productivity. The Tobago tourism sector was modeled to determine the economic costs and benefits of various tourism development options. Results of the surveys showed a high degree of consensus among stakeholders which provided the potential action for co-management. Future work will seek to address how the participatory processes can be institutionalized.

Fisheries research is the responsibility of mainly two governmental agencies, the Fisheries Division in Trinidad and the Department of Marine Affairs and Fisheries in Tobago. The Institute of Marine Affairs (IMA) and the University of the West Indies (UWI) also conduct fisheries research. However, these two institutions share a much broader mandate. IMA operates a regional Fish Age and Growth Laboratory established under the Caribbean Regional Fisheries Mechanism (CRFM). Although there is collaboration among the government agencies, UWI and IMA, there is room for improvement in the coordination of research which would significantly improve the efficiency, relevancy and technical output for fisheries management in Trinidad and Tobago. Additionally, the Fisheries Division collaborates with other departments within the Ministry of Agriculture, as well as other governmental bodies with responsibility for trade, the environment, health and research. The Division also collaborates with FAO, ICCAT, CRFM and other regional bodies with common fisheries-related interests.

This report focuses only on data collection programmes implemented by the Fisheries Division and Fisheries and Marine Affairs Section. These programmes are designed to collect data on fisheries landings and effort, biology of selected, commercially important species, and details on fishing boats and gear.

Biological studies have been conducted on several major commercial species. These include several species of shrimp (Henry, 1987; Lum Young *et al*., 1992), groundfish (Dass, 1983; Manickchand-Dass and Julien, 1983; Manickchand-Dass, 1987; Manickchand-Heileman and Phillip, 1992a, 1992b, 1996, 1999, 2000; Manickchand-Heileman and Kenny, 1990a, 1990b), flyingfish (Samlalsingh and Pandohee, 1992), sharks (Chan A. Shing, 1993, 1999b) and mackerels (Sturm, 1974, 1978; Sturm and Julien, 1983; Julien *et al*., 1984; Sturm *et al*., 1987; Sturm and Salter, 1990; Henry and Martin, 1992). Among the biological characteristics studied are morphometrics, reproduction, age and growth and length-weight relationships.

The Fisheries Division does not routinely conduct ecological studies. These studies are usually conducted in association with the IMA and UWI. Further, there are no routine social and economic data collection programmes. As a result, studies conducted thus far have been either ad hoc or the subject of short-term projects funded externally.

7.2 Data and statistics

Fisheries landings and fishing effort: Collection of fisheries landing and fishing effort data in Trinidad was instituted in the mid-1950s (Kenny, 1955; Kenny and LaGois, 1961). The early system focused on two major fish markets: one in the north of the island at Port of Spain, the other in the south at San Fernando (Figure 1); but this system has since been expanded to include 23 of the 65 existing landing sites around Trinidad (Ferreira, 2003). The current system records data on all trawl fleets (soft-substrate demersal fishery) and the artisanal multigear fleet (all three fisheries), but no data are recorded for the semi-industrial multigear fleet which targets the hard-substrate demersal fishery. The interview method is used to acquire information on the quantity of fish landed by species, ex-vessel price by species, fishing duration, gears used, areas fished, crew number and ex-vessel price per species. The system incorporates a formal process for data verification and editing, as well as regular training of data collectors in species identification and data collection techniques. Data from 1995 are computerized in an Oracle-based system which generates estimates of total landings, ex-vessel value and fishing effort from recorded data. Various institutional capacity impediments constrain the Fisheries Division's ability to computerize and analyse historical data collected between 1960 and 1994. Ad hoc collection of landings data began in the early 1970s in Tobago. In 1988 the system was regularized but focused only on the artisanal multigear fleets which targeted flyingfish from about three landings sites on the island. A 1995 system modification sought to include all three coastal fisheries through monthly random sampling at 8 of 45 landing sites. However, institutional capacity difficulties have hindered use of the data for stock assessment and management.

Biological data collection: Prior to 1991, biological data were collected on an ad hoc basis to address short-term projects and data needs. Routine collection of biological data began in 1991 under an FAO/UNDP project to establish data collection systems and assess marine fisheries resources. The project focused on five major shrimp species, Serra Spanish mackerel, king mackerel and sharks (Carcharhinidae) in Trinidad, as well as the four-winged flyingfish (*Hirundichthys affinis*) in Tobago. Length frequency data were collected for both shrimp and fish species. In addition, maturity (including gonad weight) data were recorded and otolith samples extracted for ageing of fish species. The collection of biological data was also assisted by the regional Caribbean Community Fisheries Resource Assessment and Management Programme (CFRAMP). In Tobago, monthly collection of biological data (length frequency and maturity) for flyingfish began in 1988 under a regional Eastern Caribbean Flyingfish Project. The FAO/UNDP project continued and strengthened the data collection between 1991 and 1992. Biological data collection was reintroduced in 1996 for a year's duration under the CFRAMP, and expanded to include dolphinfish (*Coryphaena hippurus*), yellowfin tuna (*Thunnus albacares*), wahoo (*Acanthocybium solandri*), albacore (*Thunnus alalunga*), king mackerels (*Scomberomorus cavalla*) and vermillion snapper (*Rhomboplites aurorubens*). Institutional capacity difficulties have hampered the collection of biological data at varying times on both islands.

Fishing vessel and fisher details: The earliest census of fishing vessels was undertaken in Trinidad and Tobago in 1942 (Brown, 1942; Mohammed and Chan A. Shing, 2003). A recent study identified several other similar surveys: 1946 (Anonymous, 1948); 1957 (Anonymous, 1958; 1959 (Kenny, 1960); 1968 (Vidaeus, 1970); and 1980 (Fisheries Division Vessel Census, unpublished data). The level of detail has varied from a simple list of fishing vessels to a list of vessels by landing site, fishery and gear type. Since then, national vessel censuses have been conducted in 1991 (under the FAO/UNDP project referred to previously), 1998 and 2003 (Chan A. Shing, 1999a; Fisheries Division, unpublished data).

These censuses have further expanded the scope of the data collected to include information on vessel and engine characteristics, associated seasonality of operations, fishery targeted and species caught. The data are currently used with catch statistics to generate estimates of total landings. A vessel registration system captures details on vessel characteristics (e.g. length, width, depth, colour, method of propulsion, engine horsepower and brand, year of construction, costs of vessel and engines, dates of purchase). A fisher registration system captures economic as well as demographic information on fishers (e.g. date of birth, address, physical characteristics, family size, level of education, fisheries-related training, gear used and an inventory on the number of boats, engines and vehicles owned). Both the fisher and vessel registration systems are, however, voluntary and are used mainly for the management of subsidy claims.

7.3 Information management system

An information management system was established at the Fisheries Division in 1989, with funding from the International Development Research Centre (IDRC). Although there are three modules, socio-economic, harvest and stock assessment, only the latter two have been developed. The harvest module contains landings and fishing effort statistics described previously. The stock assessment module comprises an electronic bibliographic database on regional marine fisheries resources and management (in published reports, theses and grey literature) and data processing methodologies. Approximately 60% of holdings are available in hard copy form at the Division's Library/Information Centre. Specific research projects also contributed to the inclusion of research survey cruise information and social, economic, ecological and environmental information for the Gulf of Paria in this bibliographic database. The information is available to the local public and the Division also responds to requests from regional and international institutions.

7.4 Education, training and capacity building

Currently, the Fisheries Division presents general information describing fisheries, stock status, management and conservation through seminars, posters and exhibitions to the public and at the request of institutions. Conservation-related programmes, specifically for marine turtles, are implemented by the Forestry Division of the Ministry of Food Production, Land and Marine Affairs. Conservation is generally promoted by a number of non-governmental organizations in Trinidad and Tobago. However, there is no national database identifying all such establishments and their focus of interest.

The Caribbean Fisheries Training and Development Institute, based in Trinidad, provides training in seamanship, navigation, engine repair and fish processing techniques to members of the fishing community in Trinidad and Tobago and the rest of the Eastern Caribbean. Fishers can also access a variety of education and training programmes, implemented by the Ministry of Social Development, which promote employment in other non-fishing sectors.

8. ISSUES AND CHALLENGES

Currently, fisheries management in Trinidad and Tobago is driven by regional and international initiatives for sustainable utilization of living marine resources, amidst threats of possible trade embargoes in response to non-compliance. Although elements of a management system exist, outdated legislation, weak linkages among key government and non-governmental agencies, limited stakeholder involvement, inadequate monitoring and enforcement, absence of a mechanism linking science with policy, exclusion of fisheries consideration in coastal zone management, and inadequate socio-economic data have contributed to the weak performance of the current management system. Current management suffers from a lack of planning and non-implementation of measures already recommended. Some critical management issues, with emphasis on Trinidad, are discussed below.

8.1 Legislation

The overall fisheries policy embodies international conservation and management initiatives. However, the legal basis for implementing management recommendations is limited for the majority of fisheries in Trinidad and Tobago. The new Draft Fisheries Management Act, when passed by Parliament, will address many of the country's fisheries management issues. The proposed new legislation incorporates all management requirements under international conventions and regional initiatives to which Trinidad and Tobago is signatory, as well as measures to ensure sustainable use of fisheries resources, involvement of stakeholders in the management process, and acquisition of fisheries data and information to guide future management measures. Between the Fisheries Act (1916) and the Archipelagic Waters and Exclusive Economic Zone Act (1986), there still remains no control over local fishing in the EEZ area outside the 12 nautical mile territorial sea, no regulations for the management of freshwater fisheries and no legal basis for the licensing of vessels as a management measure (Fish and Fish Processing Industry Team, 2005). As a result, the majority of fisheries in Trinidad and Tobago have remained open access.

8.2 Institutional structure

The institutional structure of the Fisheries Division in Trinidad has remained essentially unchanged since the 1980s. The Division, within the last ten years, has experienced a loss of 'institutional memory' and a severely reduced capacity to address current national, regional and international fisheries management issues. The Division is comprised of a Marine Fishery Analysis Unit, an Extension Unit, a Fisheries Monitoring, Surveillance and Enforcement Unit (described previously), an Aquaculture Unit and an Administrative Unit. The Marine Fishery Analysis Unit collects fisheries catch and effort and biological data, conducts stock assessments and other fisheries related assessments, and provides associated management advice. The Extension Unit conducts vessel inspections, issues fisher and vessel registrations, implements the subsidies programme, processes fish import and export licences, and attends to fishers claims for loss of earnings. The Aquaculture

Unit encourages the establishment of small-scale aquaculture business enterprises through training of aquaculturists. The Administrative Unit is responsible for the general day-to-day functions of the Division and matters relating to fisheries policy and management in consultation with decision-makers at higher levels within the Ministry of Food Production, Land and Marine Affairs. Development of the Division's technical capability to assess the social and economic impacts of fisheries management as well as the impacts of coastal development on fisheries, and to undertake long-term policy review and planning, is critical to addressing current national, regional and international fisheries management issues.

The Fisheries Division receives administrative, financial and technical support from a number of national, regional and international agencies. However, current linkages between the Fisheries Division and other government agencies, as well as non-governmental organizations, are weak. These linkages provide little support for directed social assistance programmes to the industry, training and alternative employment opportunities, apart from those already administered by the Division. The role of fisheries in rural development and poverty alleviation is also not well articulated.

8.3 Linkage between scientists and decision-makers

Research findings suggest that much of the marine coastal resources are either heavily or overexploited, yet several management recommendations have not been implemented. The limited implementation of management recommendations thus far has been motivated either by regional or international pressure or extreme dissatisfaction of the fishing community. Current research initiatives and management could benefit considerably from a formal communication mechanism among the decision-makers, fisheries scientists and the fishing industry that would be expected to facilitate policy driven research and industry support for resulting management measures. The draft fisheries policy and draft Fisheries Management Act provide for such a mechanism (Fisheries Division, 2007b).

8.4 Monitoring and enforcement

Effective fisheries management, as might be achieved through the monitoring and surveillance of the industry's operations, is hampered by the existing legislative framework, as well as the low priority assigned to fisheries by the standard regulatory agencies (i.e. Coast Guard and Police Services). The geographical area covered by current surveillance activities of the Trinidad and Tobago Coast Guard is therefore inadequate. Illegal fishing by vessels from other countries continues (e.g. longline and handline vessels fish off the north and east coasts of Trinidad and iceboats fish off the north coast of Tobago). The limited national monitoring and enforcement capability has put local fishers at the risk of piracy, resulting in the loss of boats, engines and fishing gear, and occasionally the loss of life (Fish and Fish Processing Industry Team, 2005). The situation is exacerbated by the non-adherence of fishers to basic safety requirements while at sea.

8.5 Traditional resource management and stakeholder participation

Rights-based resource allocation or conservation-based traditional management systems are not implemented for any of the fisheries in Trinidad and Tobago. However, a ‘turn’ system, based on informal rules which confer the right of a net owner to operate his beach seine at a specified time and in a specified area, is in effect. This system reduces the incidence of conflict when several beach seine owners operate their gear at a beach of limited space.

A forum for stakeholder involvement in policy formulation and decision-making on matters impacting their livelihoods and the sustainability of fisheries is provided under the Monitoring and Advisory Committee (MAC), established in 1997. Representatives from the Ministry of Food Production, Land and Marine Affairs, the Institute of Marine Affairs, the University of the West Indies, the Trinidad and Tobago Coast Guard, the Environmental Management Authority, the fishing industry, and a non-governmental community-based organization comprise the MAC. Despite this diverse membership, however, there still remains limited stakeholder participation in the management process since the Committee is largely public sector driven.

8.6 Integrated coastal zone management

In Trinidad and Tobago, the responsibility for environmental and coastal zone management rests with the Institute of Marine Affairs, the Environmental Management Authority (arising from the Environmental Management Act No. 3 of 1997) and the Ministry of Planning, Housing and the Environment. Multisectoral use of the coastal zone has developed in an uncoordinated manner, resulting in conflict among users. On the west coast of Trinidad, for example, industrial activity associated with the oil and gas sector as well as chemical, aluminium and steel plants, agriculture and human settlement all occur simultaneously with fishing. In Tobago, fisheries-related conflict occurs mainly with tourism sector activities. Due to the country’s developmental thrust, access to the coastal zone is restricted. Future development is expected to further restrict access.

A mechanism for consideration of the impacts of coastal zone development on fisheries was proposed by a 1993 FAO/UNDP Project on Integrated Coastal Fisheries Management. Some of these impacts include displacement of fishers from traditional fishing areas and associated loss of income, pollution of the marine environment, destruction of critical habitats such as nursery areas and breeding grounds of marine fish and invertebrate species of commercial importance, and changes in the distribution of fisheries resources due to seismic activity associated with the petrochemical industry. The Fisheries Division, along with several other state agencies, currently reviews environmental impact assessments provided by developers prior to the issuance of Certificates of Environmental Clearance (CEC) by the Environmental Management Authority. Developers are required to modify their plans and include mitigation measures should their activity have potential to negatively impact the fishing industry. However, appropriate legislation, monitoring and enforcement mechanisms are required to ensure industry accountability and effectiveness of the process. The fishing sector remains marginalized as the petrochemical and natural gas sectors and related industries take precedent in the development agenda in Trinidad and the tourism industry takes precedent in Tobago. These sectors are the main sources of foreign exchange for the country. Zoning use of the coastal area is required to ensure non-disruption of fishing and related activities by other users of the coastal zone (Fish and Fish Processing Industry Team, 2005).

8.7 Data availability

Consideration of the social and economic impacts of coastal development and fisheries management decisions on the livelihood of fishers has been limited. In addition, there is need for systems which make available information easily accessible for management decision-making. Currently, there are few established reporting systems through which the economic performance of fishing fleets, wholesale and retail sales and regional and international trade can be monitored.

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13. Coastal fisheries of Uruguay

Omar Defeo*, Pablo Puig, Sebastián Horta and Anita de Álava

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1. INTRODUCTION

Uruguay is a country approximately 176 000 km², with a population of over 3.2 million. It is the second smallest country in South America, and is located between Argentina and Brazil and borders the Río de la Plata estuary and the South Atlantic Ocean. The terrain is mostly plains and low hills, with 718 kilometres of coastline. The capital, Montevideo, is located on the coast and utilizes its natural harbour to act as an important commercial centre. The country is highly urbanized, with more than 92% of Uruguayans living in urban areas.

Uruguay is divided up into 19 departments, which are political divisions with their own administrator elected by popular vote. The Uruguayan fisheries sector contributes significantly to the country's gross national product (GNP), representing more than US$160 million per year in export earnings derived from catches reaching up to 140 000 tonnes. There are six departments which

* *Contact information*: UNDECIMAR, Facultad de Ciencias and DINARA. Montevideo, Uruguay. E-mail: odefeo@dinara.gub.uy

participate in coastal fisheries: Colonia, San José, Montevideo, Canelones, Rocha and Maldonado. Uruguayan ecosystems where fisheries are developed are mainly included within the Uruguay-Buenos Aires shelf ecoregion, which has been assigned with the highest rank of conservation importance in Latin America and the Caribbean (Sullivan and Bustamante, 1999).

In this chapter, we provide an overview of coastal fisheries in Uruguay. First, we describe the temporal extractive phases experienced by Uruguayan fisheries, and the corresponding socio-economic and managerial scenarios. Second, we define artisanal and coastal fisheries and the methodological implications when addressing them for Uruguay. Third, we assess the role of coastal artisanal fisheries within the global activity of the fishing sector, in terms of temporal variations in global catch, fleet composition and number of fishers. These fishery descriptors are compared with those obtained for the industrial subsector. We also address several bio-socio-economic indicators to characterize the status of the most important coastal fisheries in the country. Last, we discuss management and policy alternatives directed to improve the situation of artisanal fisheries.

2. DESCRIPTION OF FISHERIES AND FISHING ACTIVITY

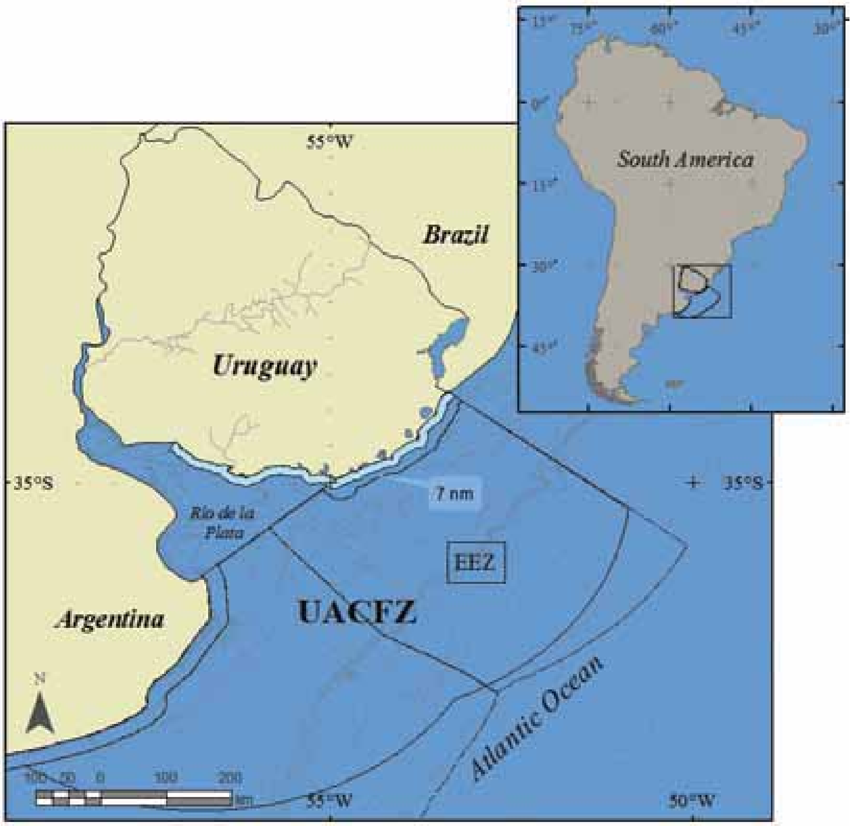
2.1 Introduction

The Uruguayan Plan for Fisheries Development began in the early 1970s. In 1973, the signature of the 'Tratado del Río de la Plata y su Frente Marítimo' with Argentina allowed the industrial fishing fleet of Uruguay to have access to shared resources in the Uruguayan-Argentinian Common Fishing Zone (UACFZ) extended between 34° south latitude and 39°30' south latitude (Figure 1). In 1975, a legal and institutional framework was established, which facilitated the development of the sector through a policy that privileges the promotion of exportations through incentives and credits. An assessment of the sector (INFOPESCA, 2001) revealed that the three most important fish resources targeted by the industrial fleet (hake, white croaker and stripped weakfish) showed signs of overexploitation. In a later study (Milessi *et al*., 2005), the application of a multispecies approach (60 stocks considered) showed declines in: (i) total landings; (ii) the Mean Trophic Level in major trophic webs; and (iii) the Fishing-in-Balance index (FishBase, 2008) of Uruguayan landings between 1990 and 2001. These results can be considered as surrogate indicators of impact and quality of marine ecosystems.

The above concerns have been widely documented in Uruguayan industrial fisheries, as in many parts of the world (Botsford *et al*., 1997; Pauly *et al*., 2002; Myers and Worm, 2003). However, small-scale artisanal fisheries constitute a second component for this world fishery crisis, normally ignored or erroneously lumped into the industrial component (Castilla and Defeo, 2005). In the past, proximate causes of fishery overexploitation and potential (but ineffective) solutions, already documented for industrial fisheries, have ignored this artisanal subsector. This overemphasis on industrial fisheries also occurred in Uruguay, from the very beginning of the Fishing Plan developed in the 1970s.

FIGURE 1

Study area comprising the 7 nm from the coast along the Río de la Plata and Atlantic Ocean waters. The Uruguayan-Argentinian Common Fishing Zone (UACFZ) and the Uruguayan exclusive economic zone (EEZ) are also shown



Coastal fisheries in Uruguay are mostly artisanal in scale and provide a broad range of services important to human socio-economic development in the country's coastal areas (INFOPESCA, 2001; Puig, 2006; Pin *et al*., 2006). Pressure on the country's artisanal fisheries appear to be continuously growing due to new entries into the sector; a trend that can be attributable to relatively high unemployment rates, coupled with low investment and operating costs, and easy access to stocks even under diminishing catch rates and economic returns. The above concepts take utmost importance when considering that some coastal ecosystems of Uruguay constitute essential habitats that include spawning and nursery grounds for the most important exploited species in Uruguay (Norbis *et al*., 2006; Retta *et al*., 2006), notably the white croaker (*Micropogonias furnieri*) and the stripped weakfish (*Cynoscion guatucupa*), which together represented almost 40% of total Uruguayan catches for the period 2001–2003. These coastal ecosystems are especially labile because they support important artisanal fisheries of these species in the country. Moreover, coastal lagoons and river mouths along the coastline constitute nursery grounds for several species artisanally targeted by fisher communities. Additionally, Atlantic rocky (e.g. Isla de Lobos and Isla Gorriti) and subtidal soft bottoms support coastal invertebrate fisheries (artisanal or 'medium-scale' industrial) of increasing economic value that are fully exploited (blue mussel) or under high risks of overexploitation (clams, gastropods: see Rey, 2000), some of them with important discarding rates (Rey *et al.*, 2000) and under an open access system.

2.2 Historical fishery phases in Uruguay

The historical analysis of the Uruguayan fishing sector revealed three exploitation phases to describe long-term landing patterns: development, expansive and overexploitation-diversification.

(1) The development phase extended approximately between the late 1960s and the second half of the 1970s. It was characterized by relatively low and constant landings. The fisheries operated primarily under open access regimes and the products were mostly channelled to domestic markets. There were no major foreign market openings. Incipient, although not reliable, statistical coverage of fishery activity was set (Defeo, 1989). Absence of information was not only restricted to this phase: it actually prevails in some non-traditionally Uruguayan fisheries subject to increasing effort levels.

(2) The expansive extraction phase occurred during the second half of the 1970s and early 1980s as a result of the Fishery Development Plan carried out by Uruguay with the support of FAO. This period included the development of the industrial fishing fleet, port infrastructure and the concomitant increase of the processing sector. Uruguayan landings increased sixfold between 1975 and 1981 (Figure 2a), as a result of increasing demand from foreign markets (e.g. Asia, United States of America) and the steady increase in the unit prices of fishery products. Landings were mainly based on three demersal fishes exploited by the industrial fleet: hake (*Merluccius hubbsi*), croaker (*Micropogonias furnieri*) and the stripped weakfish (*Cynoscion guatucupa*). Improvements in fishery technology and government credits stimulated fishery activities (INFOPESCA, 2001). During this phase, employment rates, income and welfare for the sector exponentially increased. The representation of the fishery sector in the national economy increased from 0.13% of the gross national product in 1975 to 0.61% in 1985, constituting the highest increment of a given sector in the national economy during the 1980s. The Uruguayan fishing industry was mainly directed to export markets. This phenomenon persists today: the domestic market constitutes only approximately 5% as a result of the relatively high prices of fish products when compared with traditional products for domestic consumption such as meat. Even though not

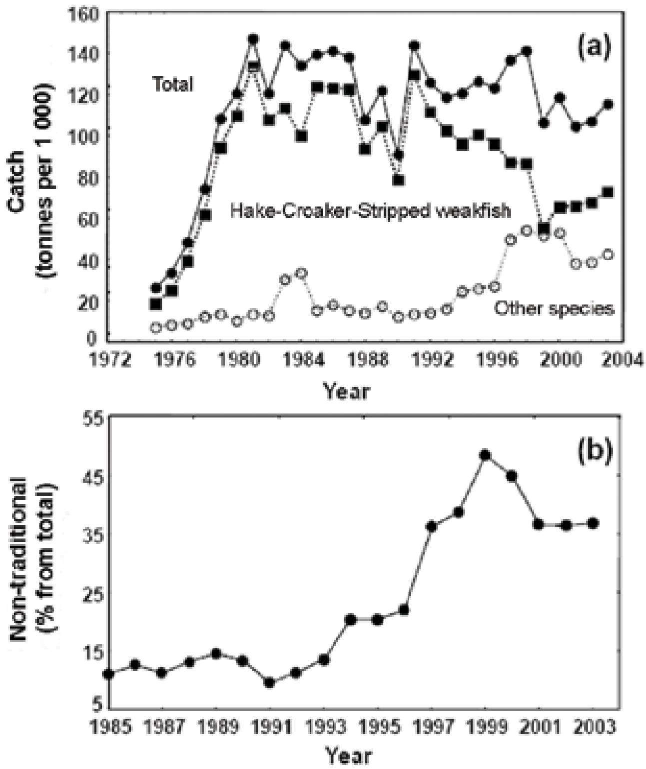
all the stocks are subject to external market forces (export), the foreign market constitutes an important driving force in fishery operations in Uruguay. This expansive phase was somewhat stabilized in the mid-1980s (Figure 2a) when management measures were implemented in the three stocks mentioned above, which reached their respective maximum sustainable yield (MSY) levels.

(3) The overexploitation-diversification phase began in the second half of the 1980s, but gained intensity during the 1990s. Two concurrent phenomena occurred during this phase (Figure 2): (i) the most traditionally exploited fish stocks displayed a decreasing trend in catches and fishing yield and also showed signs of overexploitation, which were evident from the early 1990s onwards and which persist today (Figure 2a); and (ii) new fisheries based on virgin or underexploited stocks and also on incidental or bycatch species (Figure 2b) were developed. This did not imply a significant shift of the fishing effort exerted on traditional demersal stocks; rather, a development of new fisheries based on virgin resources of high unit value and international demand occurred (Milessi *et al.*, 2005, and references therein).

Not only traditional demersal resources were fully exploited or even overexploited. In several coastal artisanal fisheries the increase in unit prices, the lack of employment and the open access regime stimulated short-term entry in these fisheries (Defeo, 1989). The easy access to resources at open coasts makes regulatory efforts expensive and ineffective, and signs of overexploitation were detected in species like the yellow clam (*Mesodesma mactroides*) (Castilla and Defeo, 2001) and in the blue mussel (*Mytilus edulis platensis*) (Defeo and Riestra, 2000).

The diversification trend in fisheries, stimulated by government incentives directed to promote exportation of products from non-traditional species (Nion, 1985), resulted in a marked increase in their relative representation in the total catch, especially between 1993 and 1999 (Figure 2b). Indeed, at the beginning of this time series, total landings were dominated by traditional demersal fishes (i.e. hake, white croaker), but this trend was reversed during the 1990s, with landings of non-traditional fisheries representing more than 45% of total landings (Figure 2b) (see also Milessi *et al.*, 2005). Consequently, total catches fluctuated around 130 000 tonnes, similar to amounts seen in the early 1980s. However, the more recent trend was the result of a combination of factors, including the overexploitation of traditional stocks and a steady rise in exploitation of non-traditional species. Furthermore, the increased pressure of non-traditional resources compensated for the depletion of traditional species, hiding the issue of overexploitation and depletion of once abundant stocks.

FIGURE 2
(a) Historical fishery landings of Uruguay, total and discriminated by traditional (hake, croaker and stripped weakfish) and non-traditional stocks. (b) Percentage of non-traditional catches for the period 1985–2003



The diversification of fisheries was, in some cases, accompanied by multidisciplinary scientific research, ranging from the basic biology of the species to economic analyses directed to assess the potential socio-economic benefits of the activity (Defeo *et al*., 1994; Gutiérrez and Defeo, 2003). However, in most cases, the absence of studies about life history traits, demography, and the dynamics of stocks and the fishery leads to weak management schemes. The impressive increase in fishing power of industrial vessels that occurred over the last two decades determined progressive and yet unmeasured changes in catchability, which is also subject to variations in fishing intensity and stock biomass. These interactions have resulted in a poor ability to calibrate fishing effort, and hence have added to the difficulty and uncertainty associated with estimating this variable in the long term (Milessi and Defeo, 2002).

In Uruguay, the overexploitation trend in non-traditional resources occurred during the diversification phase, a pattern that was supported by stock assessments and percentage of total catch (Figure 2b). In this sense, a sequential depletion pattern, already observed for Alaskan crustaceans throughout this century (Orensanz *et al.*, 1998), was also detected in the lapse of only two decades. The depletion of formerly targeted species determined a shift onto formerly low-value species or newly developed fisheries, thus shortening the temporal distance between fishery phases. This phenomenon is actually occurring in the coastal multispecific fishery of the gastropods (*Pachycymbiola brasiliana*, *Adelomelon beckii* and *Zidona dufresnei*) (Riestra and Fabiano, 2000).

2.3 Definition of a coastal fishery

It is difficult to generalize on definitions embracing artisanal (often also called small-scale) fisheries (Berkes *et al.*, 2001; Castilla and Defeo, 2001). Artisanal fisheries are difficult to define unambiguously and the term tends to cover different realities in different countries. For instance, in some developing countries artisanal fisheries include hand-gathering in the intertidal or a one-man canoe, while 20-m trawlers, seiners or longliners are used in developed regions (Defeo and Castilla, 2005). Further, the subdivision between artisanal and industrial fisheries is not an internationally agreed concept. Definitions and associated data are eventually found in selected national statistics using different criteria. This is one of the main reasons why FAO, through the Fishery Information, Data and Statistics Unit (FIDI), has never attempted to allocate systematically world catches to one or other of the two categories. Here we define a Uruguayan artisanal fishery as an activity mainly operating in inshore coastal waters, aimed for sale and/or subsistence, by a single or small group of fishers that may or may not use boats. If boats are used, they are generally small (wooden or fibreglass boats) and equipped with oars, or outboard or inboard engines of less than 10 gross register tonnage (GRT). Fishing trips are normally run during the day, and activities are usually conducted at short distances from the base port, in the marine coastal zone or in coastal lagoons. Intertidal hand-gathering fisheries in sandy beaches (surf clams) or rocky shores (blue mussel) are also included. It should be noted that in 2003, the National Direction of Aquatic Resources (DINARA) did not allow the incorporation of artisanal vessels with a GRT greater than 3 (Decree-Law No. 149/997) to the artisanal category; however, the figure of 10 GRT is kept here in order to assess historical variations of the artisanal fishery.

In order to circumscribe the term ‘coastal fishery’, the area analysed here extended from the intertidal to seven miles offshore. In this setting, it is possible to assign an artisanal character to most coastal fishing activities developed within the seven-mile jurisdiction zone. This definition is also supported by administrative reasons, because the adjacent seven miles to the coast constitutes a fringe of exclusive jurisdiction for the country included within the Territorial Sea defined under the United Nations Convention on the Law of the Sea (UNCLOS) as the 12 nautical mile zone from the baseline or low-water line along the coast. In this coastal area, Uruguay establishes spatial and temporal closures directed to protect aquatic resources, as well as the proper fishing gears to be used (Art. 37, Decree-Law No. 149/997). The analyses of coastal fisheries provided in this document give special emphasis to artisanal activities. However, in the case of sequential fisheries, where two fleets are spatially segregated (e.g. coastal artisanal and industrial in open seas), different components of the life cycle of one or more species are affecting the extent of these technological interdependencies (Seijo *et al.*, 1998).

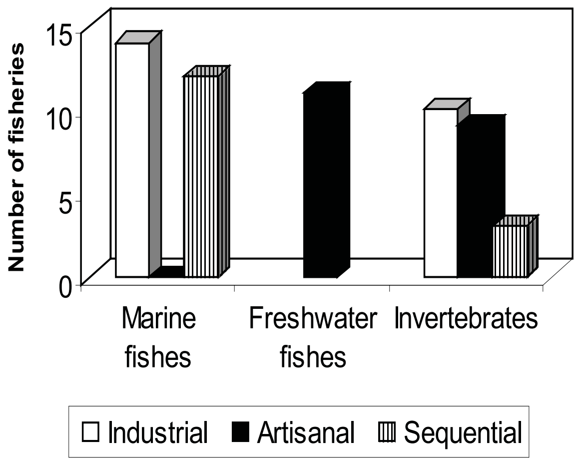
2.4 Description of artisanal fisheries

Artisanal coastal fisheries in Uruguay are developed in continental waters (rivers), coastal lagoons, rocky and sandy shores, and in inshore coastal waters extending from the intertidal to some seven miles offshore. Fishes from continental and marine-estuarine waters dominate artisanal catches, even though invertebrates are increasingly exploited. Coastal fishes are exploited by a fishing fleet with a GRT of less than 10 tonnes and 25 horsepower (hp) outboard engines, operating from 48 small ports along the coast and using a wide variety of fishing gears that include gillnets, lines, hooks and traps. These fishing gears, as well as the main characteristics of the fleet, have not been drastically altered during the last decades, with the exception of a very low number of vessels (approximately 15), with a GRT between 3 and 10. Nowadays, artisanal vessels are less than 3 GRT (Puig, 2006).

Extraction of intertidal or shallow subtidal invertebrates is done by fishers, who tend to operate individually under benign sea conditions at the intertidal and/or the near surf zone in these microtidal coasts using shovels or even by hand-picking. Divers operating from small artisanal boats, usually equipped with outboard or inboard engines and 'hookah' air compressors, harvest subtidal beds of blue mussels (Defeo and Riestra, 2000). They dive to maximum depths of 12 m and the extracted shellfish are sold to a middleman. A very small percentage of the catch is for self-subsistence. In the case of gastropods, the main activities are performed by coastal bottom trawlers with a higher GRT than artisanal ones. The fishery could be seen as sequential, even though artisanal fleet activities over these stocks have been sporadic.

Physiographic characteristics of the coast determine that the most important coastal fisheries are in fact sequential fisheries where adult stages are exploited by the industrial fleet in open seas. Figure 3 categorizes all Uruguayan fisheries according to their mechanization degree: (i) in case of marine fishes, artisanal fleets mostly operate on resources shared with industrial ones, defining sequential fisheries; (ii) freshwater fishes from continental waters (not included in this document) are exploited exclusively by artisanal fleets; and (iii) invertebrates are exploited by industrial (e.g. deep sea red crab) or artisanal (e.g. blue mussel and yellow clam fleets) and, in some cases, in a sequential form (e.g. gastropods). In case (i), the management framework is even more complex because most of these fisheries are shared with Argentina, as is the case in the most important coastal fisheries (i.e. white croaker and stripped weakfish).

FIGURE 3
Uruguayan fisheries by the mechanization degree of the fleets and by resource type



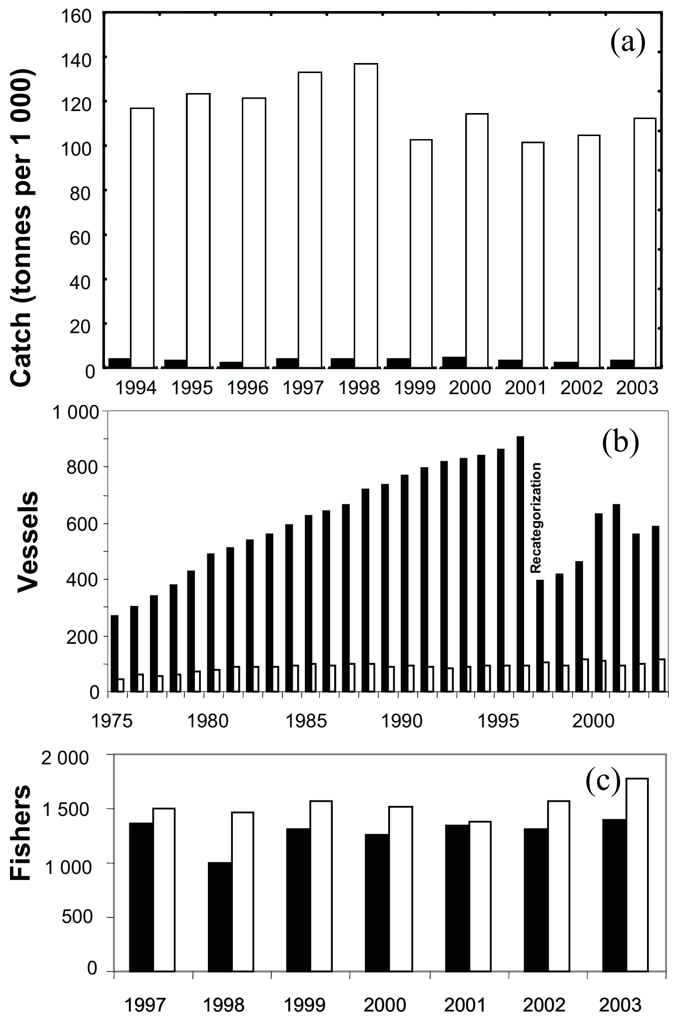
The artisanal fishery exhibits comparatively reduced extractive catches and sometimes competes with the industrial fishery. Catches from traditional industrial fisheries decreased from 1992 onwards because the three most important industrial fisheries achieved an upper ceiling close to their MSY (Figure 2a). The fairly constant catch levels for the period 1994–2003 have been achieved because of the exploitation of other stocks during the diversification phase. However, a decreasing trend is also noticed from the historical maximum close to 140 000 tonnes in 1998. In contrast, the artisanal fishery remained fairly constant (3 000– 4 000 tonnes) during the same period (Figure 4a).

The number of artisanal vessels has been, on average, more than six times higher than in the industrial subsector (Figure 4b). The number of industrial vessels registered between 1975 and 2003 has been close to 90, showing a slight increase from 1997 to present, with a maximum of 116 in 2003 (last year analysed). On the other side, the number of artisanal vessels increased linearly from 1975 (269) to 1996 (905). In the latter, DINARA updated the information of the fleet to those with a GRT of less than 3, cancelling permits of those vessels which did not perform fishing activities during the last years or for a variety of other reasons. However, the number of artisanal vessels increased again from 1996 to 2003, reaching almost 600 vessels at the end of the analysed period (Figure 4b). It must be highlighted that fishers who carry out hand-gathering activities in the intertidal (e.g. *almejeros*) are not included here.

Artisanal and industrial fisheries directly engage the same number of fishers: the industrial fleet registered an average of 1 538 fishers for the period 1997–2003, whereas the average of artisanal fishers has been close to 1 283 (Figure 4c). Both subsectors have shown an increase in the number of fishers through time, with a historical maximum of 1 782 (artisanal) and 1 400 (industrial) fishers for the last year of analysis (2003). Taking into account the catch volumes obtained by both fleets, the mean catch per unit of employment generated has been almost 30 times higher in the artisanal subsector, highlighting its critical socio-economic importance in Uruguay.

FIGURE 4

Temporal variations in: (a) catch; (b) number of vessels; and (c) fishers in the artisanal (■) and industrial (□) fleets of Uruguay.



Note: The number of stakeholders in related activities (e.g. processing plants) is not considered here.

3. ASSESSMENT OF FISHERIES

3.1 Methodological framework

Most information was collected from the DINARA in Uruguay. The methodological approach was based on the analysis of the following information (see also INFOPESCA, 2001): (i) surveys directed to assess the abundance and population dynamics features of the stocks; (ii) commercial samplings; and (iii) fishery statistics obtained from logdocuments. In order to assess the status of each fishery, the following criteria were considered: (i) distributional patterns of stocks; (ii) mechanization degree of fleets; (iii) exploitation levels and stock status; (iv) definition of main taxonomic groups; and (v) assessment of scientific knowledge coming from primary (databases) and secondary (scientific papers and information from the private sector) sources. The main characteristics of these criteria could be summarized as follows:

(i) *Distributional patterns of stocks*. In this document we considered the distributional patterns of coastal resources within the exclusive economic zone (EEZ), as well as those shared with Argentina in the Río de la Plata or in adjacent waters of the UACFZ. Thus, species inhabiting international waters or those in continental inner waters were left aside from this review unless explicitly stated otherwise.

(ii) *Mechanization degree of fishing fleets*. We discriminated between artisanal and industrial (mechanized) fisheries. In the case of sequential fisheries, we described potential technological interdependencies between them, including a spatial analysis of overlap areas between artisanal and industrial fisheries in the study area.

(iii) *Exploitation levels and stock status.* We defined the status of the stocks in Uruguayan waters as follows: (a) virgin or non-exploited; (b) underexploited; (c) underexploitation; (d) fully exploited; and (e) overexploited. Fishery performance indicators (e.g. bio-economic reference points: BRPs) contained in primary papers or reports were used to define the status of the stocks. In this context, precautionary approaches were operationalized by limit reference points (LRPs), such as the MSY, which represents conditions of immediate concern to management; when MSY is achieved, complete cessation of fishing, or curtailment of fishing effort to much lower levels, should occur (Caddy and Mahon, 1995). Thus, fully exploited stocks are defined as those exploited at levels close to some LRP. The term ‘underexploitation’ makes special allowance to exploited resources for which the lack of scientific information precludes the definition of a specific exploitation level. When quantitative information was lacking, the definition of stock status was based on judgements derived from technical assistance from scientists and managers. Decisions as to which indicator to choose, and what value of the indicator should correspond to an LRP, were chosen by analysis and/or by sessions between experts and stakeholders, reviewing past annual indicator values from historical performance (Caddy and Defeo, 2003). Moreover, under a precautionary management scheme (Caddy and Mahon, 1995; FAO, 1995; Caddy and Defeo, 2003), in data-poor situations we categorized the corresponding fishery as it was in the immediate stage (in terms of increasing exploitation) to those judged by scientific experts.

(iv) *Main taxonomic groups*. We provide a broad categorization of stocks, as follows: (a) fishes; and (b) benthic invertebrates (molluscs and crustaceans). The main reason underlying this classification is that differences in life histories generate different harvesting strategies (Orensanz and Jamieson, 1998; Castilla and Defeo, 2001).

(v) *Scientific knowledge and information sources*. Information for each species and fishery was classified as follows: (a) good quality; (b) out of date; (c) insufficient; (d) inadequate; (e) absent; and (f) variable according to site. In the latter, explicit allowance was made to the dissimilar amount of information collected according to the location/area/habitat considered, particularly in species distributed over a wide area, which precludes obtaining feasible information all along the distributional range. Evaluation of the quality of the scientific information available for each stock was done for the following issues: biomass, growth, reproduction, natural mortality, fishing mortality, fishing effort (nominal and effective), catchability coefficient, economic information, and existence of BRPs.

3.2 Fishes

The coastal artisanal fishing fleet targets species distributed in the Río de la Plata and Atlantic Ocean. The Río de la Plata can be divided into three zones (inner, middle and outer) with different hydrological characteristics. The main species exploited in the inner and middle zones are streaked prochilod (*Prochilodus lineatus*), characin (*Leporinus obtusidens*), and catfishes (notably *Pimelodus clarias*). The two former ones comprise almost 50% of the total catches in the coasts of Uruguay. In the outer Río de la Plata and Atlantic coasts, the white croaker is the dominant species in the catches (Figure 5) and, together with stripped weakfish, represents almost 40% of the total catch. Other exploited species are the Brazilian codling (*Urophycis brasiliensis*) and various shark species (*Mustelus schmitti, Galeorhinus galeus, Isurus oxyrhinchus* and *Lamna nasus*).

Table 1 summarizes the information about distribution, mechanization degree and stock status of the main fishes exploited in the coastal zone of Uruguay. The historical analysis provided by more than 30 years of information show that several stocks that were non-exploited or underexploited during the 1970s are now overexploited. This occurred during the last phase of fishery development depicted above (Figure 2a). Some 90% of the stocks can be considered fully exploited or overexploited and the remaining 10% virgin or underexploited. The fact that there is no accurate scientific information about the status of important stocks exploited in the inner and middle Río de la Plata (e.g. streaked prochilid, characin) is a major cause of concern. Moreover, the most important marine stocks (white croaker and stripped weakfish), which are subject to a sequential exploitation by artisanal and industrial fleets, are overexploited, especially the white croaker. Several stocks are defined as ‘underexploitation’, suggesting a dangerous lack of scientific information needed to properly assess the status of the stocks. In the case of non-exploited stocks, the absence of stock estimates opens a wide margin of uncertainty about the possibility of sustainable development of these fisheries.

FIGURE 5

Main species captured by the artisanal fleet of Uruguay (%), also categorized by ecosystem inhabit

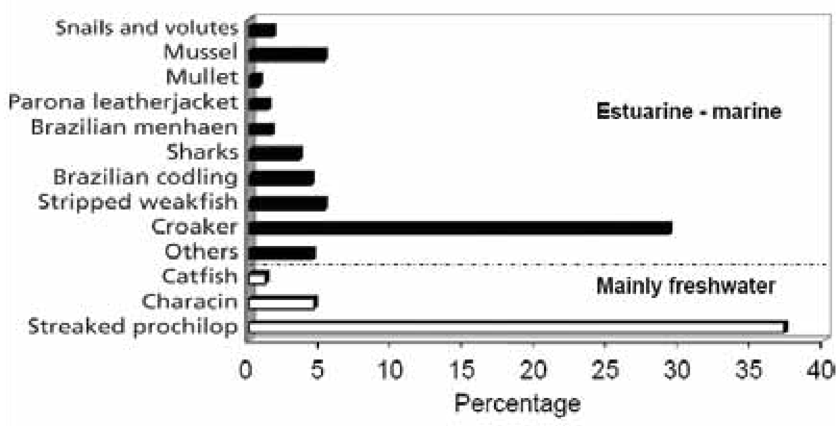


TABLE 1

Assessment of several coastal stocks exploited by the artisanal and industrial fleets of Uruguay, based on indicators defined by the distributional extent, degree of mechanization and phase of fishery development. RdlP: Río de la Plata; MF:Maritime Front; IW: international waters; CW: continental waters; Ind-Art: sequential fishery (industrial + artisanal)

Common name	Scientific name	Distribution	Fleet	Development phase
White croaker	*Micropogonias furnieri*	MF–RdlP–IW	Ind-Art	Overexploited
Stripped weakfish	*Cynoscion guatucupa*	MF–RdlP–IW	Ind-Art	Overexploited
Flounder	*Paralichthys* spp.	MF	Ind-Art	Overexploited
Sharks	*Mustelus schmitti* *Galeorhinus galeus* *Isurus oxyrhinchus* *Lamna nasus*	MF–IW	Ind-Art	Overexploited
Brazilian menhaden	*Brevoortia* spp.	MF–RdlP	Ind-Art	Underexploited
Wreckfish	*Polyprion americanus*	MF	Ind-Art	Underexploited
Southern eagle ray	*Myliobatis* spp.	MF–RdlP	Ind-Art	Underexploited
Mullet	*Mugil platalus*	MF–RdlP	Ind-Art	Underexploited
Largehead hairtail	*Trichiurus lepturus*	MF	Ind-Art	Non-exploited
King weakfish	*Macrodon ancylodon*	MF–RdlP	Ind-Art	Underexploited
Brazilian codling	*Urophycis brasiliensis*	MF	Ind-Art	Underexploited
Streaked prochlod	*Prochilodus lineatus*	RdlP–CW	Artisanal	Underexploited
Characin	*Leporinus obtusidens*	RdlP–CW	Artisanal	Underexploited
Catfish	*Luciopimelodus pati* *Pimelodus clarias*	RdlP–CW	Artisanal	Underexploited

Adapted and updated from INFOPESCA (2001).

Table 2 summarizes bio-economic information of fish stocks, provided by primary and secondary sources gathered for the last 30 years. The following conclusions arise: (i) a relatively good scientific knowledge is found for the white croaker and stripped weakfish, but this knowledge is mainly based on information provided by stock assessment and statistical fishery information gathered for the area of operation of the industrial fishery; (ii) estimates of biomass and BRPs are circumscribed to these two stocks, and a notorious lack of information (quality and quantity) is depicted for the remaining ones; (iii) the lack of scientific information precluded the implementation of solid management schemes; and (iv) no economic information (i.e. unit costs of effort, unit prices and returns) has been included in the analysis of fisheries.

TABLE 2

Assessment of information available for the main coastal stocks exploited in Uruguay: fishes. Information quality: G: good; D: out of date; I: inadequate; R: insufficient; A: absent; VSS: variable according to the system analysed; M: natural mortality; F: fishing mortality; Nom: nominal effort; Ef: effective effort; q: catchability coefficient; BRPs: bio-economic reference points. See scientific names in Table 1

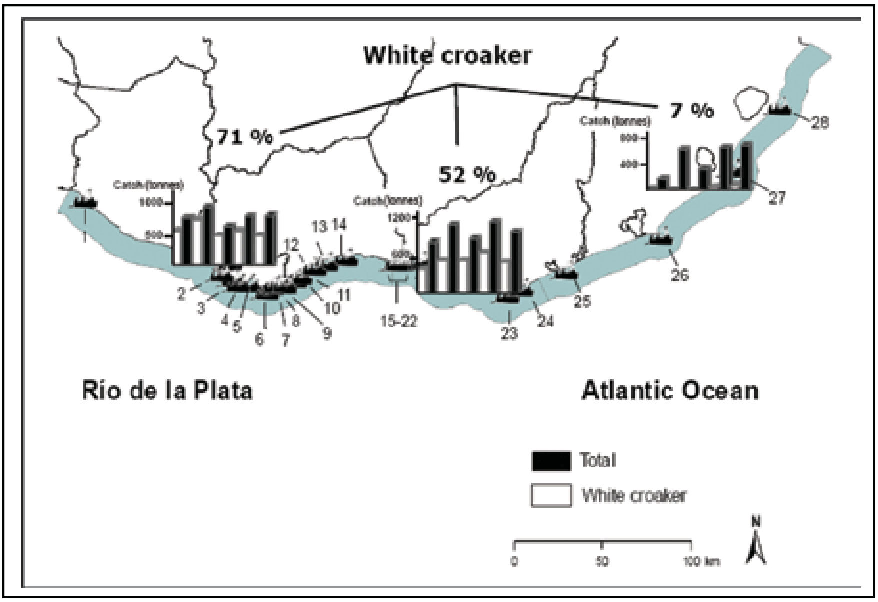
Resource	Biomass	Growth	Reproduction	Mortality		Fishing effort			Economics	BRPs
				M	F	Nom	Ef	q		
White croaker	VSS	G	G	I	G	G	G	I	I	G
Stripped weakfish	VSS	G	G	I	G	G	G	I	I	G
Flounder	G	G	G	I	I	I	I	I	I	I
Sharks	G	G	G	I	I	I	I	I	I	I
Brazilian menhaden	D – I	R-I	I	I	I	I	I	I	I	I
Wreckfish	D – I	R-I	I	I	I	I	I	I	I	I
Southern eagle ray	D – I	R-I	I	I	I	I	I	I	I	I
Mullet	D – I	R-I	I	I	I	I	I	I	I	I
Largehead hairtail	I	R-I	I	I	I	I	I	I	I	I
King weakfish	D – I	R-I	I	G	I	I	I	I	I	I
Brazilian codling	D – I	R-I	I	I	I	I	I	I	I	I
Streaked prochilod	D	G	G	G	G	G	G	G	A	G
Characin	D	G	G	G	G	G	D	I	A	I
Catfish	I	G	G	G	G	G	D	I	A	I

Adapted and updated from INFOPESCA (2001).

White croaker and stripped weakfish: The above conclusions are of particular concern for the most important marine stocks exploited in a sequential manner (white croaker and stripped weakfish). Information gathered for the white croaker shows that this stock is overexploited; judging from several assessments based on different population dynamic models (Arena and Rey, 2000; Pin and Defeo, 2000; Rey and Arena, 2000). The stock is exploited by the Uruguayan and Argentinian industrial fleets in open seas, whereas the artisanal fleet of Uruguay exploits the stock at coastal zones, mainly in the middle and outer Río de la Plata and in Atlantic waters. Pre-adult stages are found in coastal waters (Puig and Fontenla, 1993; Retta *et al*., 2006), even though the high selectivity of the fishing gears employed by the artisanal fleet minimizes the impact of the fishery on this population component (Norbis and Verocai, 2001; Pin *et al*., 2006). In contrast, the trawling activities made by the industrial fleet not only affect the adult stages, but also the juvenile ones. Increments in fishing power of the trawling vessels of Uruguay and Argentina have affected the stock, increasing the probability of overexploitation.

The spatial dynamics of the fleet showed that the main fishing grounds for artisanal activities that target white croaker are mainly circumscribed to the middle and outer zones of Río de la Plata, representing, respectively, 71% and 52% of the artisanal catches (Figure 6). A daily analysis of the artisanal fleet carried out between 2000 and 2004 showed a decreasing relative representation of this important species from Río de la Plata to coastal waters in the Atlantic Ocean, where it represents only 7% of the catch. These results are important in evaluating potential conflicts between fleets. Indeed, to assess potential interactions between industrial and artisanal fisheries in Uruguay, we evaluate bottom trawling fishing effort at the adjacent zone of artisanal activities (Figure 7), expressed as the number of trawls per vessel in a year (vessel/nm^2/year). Daily fishing vessel activities for 2004 were obtained from the official National Vessel Monitoring System programme developed by DINARA, with data filtered by trawl velocity (assumed between 3 to 4 knots). The colours denoting increasing indicator values of fishing intensity (from green to red), separated by cut-off values as in a Traffic Light Precautionary Management Framework (Caddy, 2002), show that main potential conflicts between fleets occurred in areas where the main catches of white croaker are obtained by the artisanal fishery (orange and red in Figure 7). The heavily exploited fishing grounds where the industrial fleet operates could impact benthic habitats and communities, thus affecting the ecosystem as a whole and generating a negative externality to the artisanal fleet.

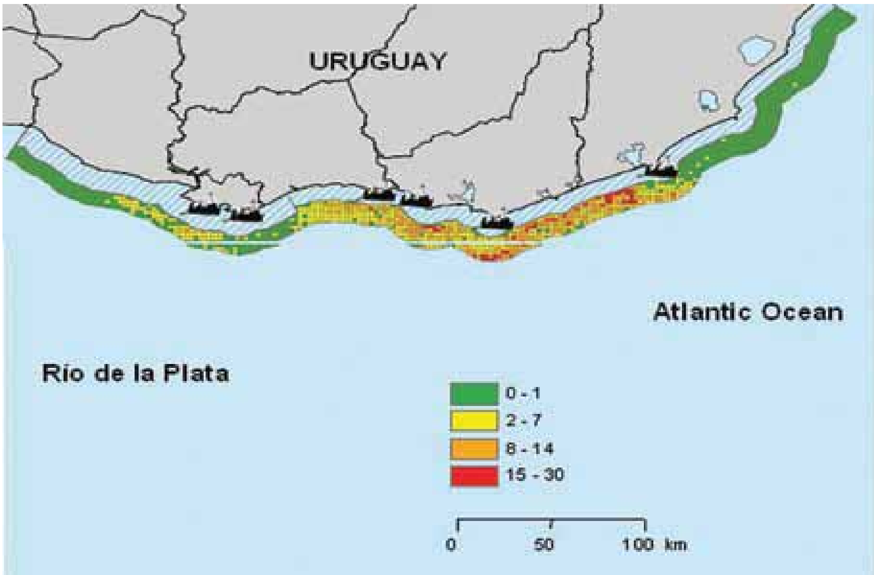
FIGURE 6
Spatial variation in annual mean catch (kg) and relative representation of white croaker catches obtained by the Uruguayan artisanal coastal fleet from 2000 to 2004. 28 of the 48 artisanal fishery ports ( ) are shown as reference: 1- Arazatí; 2- La Colorada; 3- Pajas Blancas; 4- Santa Catalina; 5- Cerro; 6- Punta Carretas; 7- Buceo; 8- Malvín; 9- La Mulata; 10- Arroyo Carrasco; 11- Shangrilá; 12-Solymar; 13- Arroyo Pando; 14- Atlántida; 15- Parque del Plata; 16- La Floresta; 17- Costa Azul; 18- San Luis; 19- La Tuna; 20- Araminda; 21- Santa Lucía del Este; 22- Cuchilla Alta; 23- Punta del Este; 24- Arroyo Maldonado; 25- Laguna de José Ignacio; 26- La Paloma; 27- Barra de Valizas; 28-Punta del Diablo.



The stripped weakfish occupies third place in Uruguayan landings, after the hake and the white croaker. Argentinian and Uruguayan catches have fluctuated between 9 122 tonnes (1985) and 34 414 tonnes (1997), which makes it the second most important resource in the coastal trawling fishery. The resource is overexploited (Arena and Gamarra, 2000; Table 1). A minimum landing and commercialization size (27 cm total length), a prohibition of trawling nets in coastal waters for vessels higher than 10 GRT, and defined minimum net sizes for vessels of different categories were implemented. Studies show that it is neither possible nor recommendable to increase the fishing effort exerted intentionally or incidentally over this resource. Even though the industrial bottom trawling fishery is the most important one, the fact that the stripped weakfish is not the target species of any fleet and that it is captured by fleets of different characteristics and fishing power generates uncertainty in fisheries management. Also in this case, it is necessary to integrate information coming from the artisanal and coastal trawling fleets in order to develop solid management schemes.

FIGURE 7

Main 2004 bottom trawl zones quantified by number of vessels trawling/nm²/year, from trawl exclusion zone (lined area) to 12 nm. Data obtained from the National Vessel Monitoring System (VMS) programme. The main artisanal fishery ports ( ) are shown: 1- Pajas Blancas; 2- Buceo; 3- San Luis; 4- Piriápolis; 5- Punta del Este; 6- La Paloma. Colours denote increasing indicator values, separated by cut-off values, of fishing intensity (from green to red), as in a Traffic Light Precautionary Management Framework (Caddy, 2002)



Other fishes: Many species that started being exploited during the last decade (i.e. the diversification fishery phase) have been subject to increasingly intense fishing effort (e.g. sole, *Paralichthys* spp.). These circumstances have caused overexploitation in the medium term (Tables 1 and 2). Recent research conducted on non-traditional species show a decrease in the catch per unit effort (CPUE) and in the average size and age of exploitation, as well as a turnover effect of sequential target species as a result of a decrease in fishery yields (Fabiano *et al*., 2000; Spinetti, 2000). In all these cases, population dynamics of the stocks, as well as spatial dynamics of the fishing fleet, are unknown. This is especially important in other species, such as the narrownose smooth-hound shark (*Mustelus schmitti*), which is endemic to the southwest Atlantic and which has been registered on the red list of threatened species as 'Endangered' (Massa *et al*., 2005). Indeed, the scarce scientific knowledge acquired has not been translated in effective management schemes to prevent the negative effects of fishing (see below). The lack of statistical information derived from logdocuments is another negative factor common to many coastal fisheries, which underestimates catch volumes. This is especially noticeable for the artisanal fleet.

3.3 Invertebrates: crustaceans and molluscs

The development of invertebrate fisheries was encouraged during the diversification phase. Table 3 gives information about the invertebrates currently or potentially exploited in the coastal waters of Uruguay. Several benthic resources that remained virgin in the 1980s and 1990s are currently fully exploited or suffer an imminent risk of overexploitation. This trend has also expanded to other non-coastal species, such as the deep-sea red crab (*Chaceon notialis*) (Defeo and Masello, 2000), evidence that the issue goes beyond coastal fisheries. The situation is particularly worrying for the yellow clam fishery on sandy beaches, which has been permanently closed to fishery activities during the last decade because of the occurrence of massive mortalities of unknown origin throughout the Atlantic coast of South America (Fiori *et al*., 2004). The blue mussel is fully exploited and managed with spatio-temporal restrictions of fishing effort and a minimum harvestable size limit (Defeo and Riestra, 2000).

TABLE 3

Assessment of several coastal stocks exploited by the artisanal and industrial fleets of Uruguay, based on indicators defined by the distributional extent, degree of mechanization and phase of fishery development: benthic invertebrates (crustaceans and molluscs). UW: Uruguayan waters; IW: international waters; Ind-Art: sequential fishery (industrial + artisanal); UE: underexploitation

Common name	Scientific name	Distribution	Fleet	Development phase
Crustaceans				
Pink shrimp	*Farfantepenaeus paulensis*	UW and IW	Artisanal	UE
Blue crab	*Callinectes sapidus*	UW	Artisanal	UE
Mole crab	*Emerita brasiliensis*	UW	Artisanal	Non-exploited
Molluscs				
Yellow clam	*Mesodesma mactroides*	UW	Artisanal	Overexploited
Erodona clam	*Erodona mactroides*	UW	Artisanal	UE
Hard shell clam	*Pitar rostratus*	UW	Industrial	UE
Purple clam	*Amiantis purpurata*	UW	Artisanal	Non-exploited
Blue mussel	*Mytilus edulis platensis*	UW	Artisanal	UE
Wedge clam	*Donax hanleyanus*	UW	Artisanal	Non-exploited
Black snail	*Pachycymbiola brasiliana*	UW	Ind-Art	UE
Angulate volute	*Zidona dufresnei*	UW	Ind	UE
Giant tun	*Tonna galea*	UW	Ind	UE
Pod mollusc	*Buccinanops cochlidium*	UW	Artisanal	Non-exploited
Whelk	*Stramonita haemastoma*	UW	Ind-Art	Non-exploited

Adapted and updated from INFOPESCA (2001).

The gastropods (*Pachycymbiola brasiliana* and *Zidona dufresnei*) have been the target of fishery development during the diversification phase, as the result of the opening of new markets due to the depletion of similar stocks in other parts of the word (Masello, 2000; Riestra and Fabiano, 2000). This is a typical case where fishing methods developed faster than the understanding of scientific knowledge, leading to a lack of strong management schemes. The resource became fully exploited even before scientific knowledge was achieved, and scientific information is still insufficient to provide robust management guidelines (Riestra *et al*., 2000). It must be highlighted that the fishery is almost circumscribed to trawling vessels, and the impact of the artisanal fishery is very low.

The scientific information on coastal invertebrate fisheries is qualitatively and quantitatively variable (Table 4). With the exception of the yellow clam and the blue mussel, no spatial management measures have been implemented, and biomass estimates are out of date or non-existent. The analysis of the spatial dynamics of the fishing fleet and the resource, a critical issue in coastal fisheries (Castilla and Defeo, 2001; Salas and Gaertner, 2004), has not been undertaken. This in turn has precluded the implementation of management areas.

TABLE 4

Assessment of information available for the main coastal stocks exploited in Uruguay: benthic invertebrates (crustaceans and molluscs). Information quality: G: good; D: out of date; I: inadequate; A: absent; VSS: variable according to the system analysed; M: natural mortality; F: fishing mortality; Nom: nominal effort; Ef: effective effort; q: catchability coefficient; BRPs: bio-economic reference points. See scientific names in Table 3

Common name	Biomass	Growth	Reproduction	Mortality		Fishing effort			Economics	BRPs
				M	F	Nom	Ef	q		
Crustaceans										
Pink shrimp	D	I	I	A	A	A	A	A	A	A
Blue crab	A	A	A	A	A	A	A	A	A	A
Mole crab	G	G	G	G					A	A
Molluscs										
Yellow clam	G	G	G	G	G	G	G	G	G	G
Erodona clam	A	A	A	A	A	A	A	A	A	A
Hard shell clam	A	A	A	A	A	A	A	A	A	A
Purple clam	A	A	A	A	A	A	A	A	A	A
Blue mussel	G	G	G	G	D	G	D	A	D	D
Wedge clam	G	G	I	G					A	A
Black snail	A	A	I	A	A	I	A	A	A	I
Angulate volute	A	A	I	A	A	I	A	A	A	I
Giant tun	A	A	A	A	A	A	A	A	A	A
Pod mollusc	A	A	A	A	A	A	A	A	A	A
Whelk	A	A	I	A	A	A	A	A	A	A

Adapted and updated from INFOPESCA (2001).

Nowadays there is scarce baseline information on few virgin resources that could withstand the development of small coastal artisanal fisheries, such as the wedge clam (*Donax hanleyanus*) and the sand crab (*Emerita brasiliensis*) in sandy beaches, and the pink clam (*Amiantis purpurata*) in the shallow sandy subtidal. For transient stocks artisanally exploited in coastal lagoons, as the penaeid shrimps (*Farfantepenaeus* spp.) and the blue crab (*Callinectes sapidus*), the erratic occurrence and high abundance fluctuations make them unpredictable to propose management schemes for solid fishery development.

4. FISHERY MANAGEMENT AND PLANNING

Artisanal fisheries in Latin America are mostly open access regimes, and thus the risks of overexploitation and dissipation of the economic rent are very high (Castilla and Defeo, 2001, 2005; Defeo and Castilla, 2005). They are also greatly unregulated because of the underestimation of the societal role played by this subsector, directly and indirectly engaging many more people per unit of fish landed (fishers, co-workers, processing and commercialization sectors) than the industrial fishery (Berkes *et al*., 2001; Defeo *et al*., 2007). Following the same pattern, many artisanal fisheries in Uruguay could be considered open access, with eventual operational management measures based on individual sizes and closed seasons. Fishing intensity increased even under diminishing catch rates because of low operating and opportunity costs of fishers. This could be the response of a weak or non-existent dialogue (last 20 years), including transfer of knowledge between the national government and artisanal fishers, as well as a lack of commitment among policy and decision-makers towards conservation and sustainable use issues.

Artisanal coastal fisheries of Uruguay are continuously expanding, despite longstanding policy support for industrialization of fisheries. This is most likely due to its critical role as an economic buffer and safety valve for people moving in and out of the fisheries according to the opportunities in the national economy. These fisheries exhibit comparatively reduced catches and sometimes compete with the industrial fishery (sequential fisheries). Several socio-economic factors, both local and international, have aggravated the artisanal fishery situation in Uruguay, as in the rest of Latin America (Cabrera and Defeo, 2001; Castilla and Defeo, 2001; DINARA, 2005). These are: (i) high unemployment rates, which favour the migration of people to coastal zones to work in artisanal fishery activities; (ii) low operative costs and easy access to coastal resources that justify an increase in fishing effort even under low stock abundance levels; (iii) an increasing international market demand in unit prices, partly as a response to the depletion of similar stocks in Europe, the United States and Asia, which promoted an increase in fishing effort that was not supported by sound science and management; (iv) weak management schemes and inefficient enforcement of management measures, especially in the coasts with easy access to stocks; (v) weak legislation schemes built on a top-down approach that neglects the active participation of fishers under co-management schemes; (vi) lack of knowledge, as most fishery systems still remain poorly understood regarding the linkages between the structure of the stock, its dynamics and bio-economic features of the fishing process; and (vii) changes in local political conditions and a lack of a long-term policy for the subsector, which has generated uncertainty about future modifications of the management process, and in the response of fishers to regulations.

In addition to the weaknesses mentioned above, the critical situation of the Uruguayan artisanal subsector is also due to the lack of capacity and organization (Defeo, 1989, 1996; Amestoy, 1999; INFOPESCA, 2001; Puig, 2006, and references therein). Artisanal fisheries development programmes that served as a basis to the creation of Uruguayan cooperatives in the 1980s were initially well-structured, involving the construction of cold-storage rooms. These rooms were an attempt to encourage independence of fishers from middlemen and offered them a higher negotiation power, as well as a place to store their products for three or four months (INFOPESCA, 2001). However, these programmes failed, mainly because of the lack of specialization and qualification of fishers, as well as their highly individualistic personalities that make it difficult to work together in cooperative systems. The lack of organization determined that low prices are paid from middlemen systems. This is particularly important when the products are not intended to satisfy the local markets, but are resold to middlemen or industrial processing plants that eventually export the products. These factors together undermine most fishermen cooperatives in Uruguay.

Major conflicts between small-scale artisanal and large-scale industrial fisheries have been occurring in different parts of the world, with resulting threats to food security and local economies and, in some cases, ecosystem health (Berkes *et al*., 2001). This also happens in the study area, and these conflicts often result in disadvantageous competition for the artisanal fleet for fishing grounds and resources. Industrial and artisanal Uruguayan fisheries usually compete for resources, notably the white croaker. Thus, management systems must be strengthened in regards to species target of sequential fisheries. The industrial fleet that operates outside seven nautical miles catches approximately 80% of the resources shared with the artisanal fleet. It is essential to evaluate the evolution of the fishing power of all the fleets that take part in the fishery in order to develop robust management schemes. The huge improvements of fishing power in industrial vessels has compensated for nominal reductions in fishing effort, affecting the target species and any incidentally caught species, as well as the habitat. In addition, this can generate a *de facto* ‘legalized’ overexploitation scheme with ineffective operational management measures based on restrictions of catch, effort (i.e. global quotas, temporal closed seasons), and individual sizes (Milessi and Defeo, 2002).

5. ISSUES AND CHALLENGES

The implementation of management schemes that explicitly take into account the different fleets acting in coastal stocks is a major challenge to be tackled in the short term in Uruguay, because overexploitation risks are high and exclusion of one fleet could occur as a function of the magnitude of effort exerted by the competing fleet. However, as industrial and artisanal fisheries operate on different spatial and temporal scales and with diverse *modus operandi*, this implies the need to use different drivers/priorities/governance and institutional arrangements according to the characteristics of each fishery in order to solve overexploitation concerns (Castilla and Defeo, 2005; Defeo and Castilla, 2005).

Artisanal fishery information is inconsistent, weak, fragmented, inaccurate and unreliable. The easy access and dispersed nature of near-shore resources and landings makes regulatory efforts expensive and ineffective and these areas are often lacking in site-specific scientific information (Castilla and Defeo, 2001). The increase in catch volumes has historically contrasted with the rate of acquisition of scientific information, which has generated weak management schemes. Most of the world's fishery science is devoted and applied to large stocks, and is seldom feasible for small, artisanally exploited resources (Mahon, 1997; Castilla and Defeo, 2005). If sophisticated stock assessment models are to be applied and management strategies, such as closures, are to be used, then the existence of significant gaps in scientific knowledge must be filled. In addition, determining the management systems that are most acceptable for resource users and most successful for managers is essential (Defeo *et al.*, 2007). These facts preclude the application of sophisticated assessment models in these fisheries and call for a more simplistic, short-term approach, based on easy-to-use fishery indicators in a precautionary management context, which would require strong collaboration among the scientific, management and fishing communities (Mahon, 1997; Johannes, 1998). Successful management of artisanal fisheries in Uruguay is a major challenge, but one of upmost importance.

Operational management measures have not been useful in Uruguay (INFOPESCA, 2001), a phenomenon that has been verified worldwide (Caddy and Cochrane, 2001). In this context, marine protected areas (MPAs) have been suggested as spatially explicit tools that could reduce deleterious effects of the fishery on coastal habitat and biodiversity (Caddy, 1999; Castilla and Defeo, 2001, 2005; Manson and Die, 2001; Roberts *et al.*, 2001; Pauly *et al.*, 2002; Stergiou, 2002; Caddy and Defeo, 2003). The MPAs could operate in a wide spectrum of spatio-temporal scales under different judgements and uses that range from 'no-take' areas to management areas in which the sustainable use of the resources is planned (UICN, 1994; SANCOR, 1997). Given that many management strategies have failed in Uruguay, the MPAs arise as one of the few tools directed to protect species biomass, maintain biodiversity (including genetic biodiversity) and diminish the trend on the organisms' size reduction and on their reproductive capacity and success (Defeo *et al.*, 2004). Another threat to the artisanal fishery is the increasing environmental damage in Uruguayan coastal and continental waters as a result of different sources of anthropogenic activities. Cascade ecosystem effects have been observed in Uruguayan coastal systems that include the exploited species, the sympatric fauna and the habitat (Defeo and de Álava, 1995; Defeo, 1998). The existence of several anthropogenic impacts, together with the absence of integrated management schemes, have affected the whole coast, including its biodiversity (Lercari and Defeo, 1999, 2003; Lercari *et al*., 2002; Muniz *et al*., 2002). This highlights the short-term need to implement integrated management and conservation plans. Consequently, MPAs, if seen and used as managed areas, should enhance habitat restoration and biodiversity conservation, and will concurrently have a direct and positive socio-economic impact in the artisanal fishing communities (Castilla and Defeo, 2001).

One of the main critical aspects that deserves utmost attention in the near future in Uruguay is the implementation of strategic institutional structures (Charles, 2001), defined as co-management, that include fishers in the decision-making and in the control and vigilance of the resources (Castilla and Defeo, 2001; Wilson *et al*., 2003). Thus, the classic 'top-down' management scheme could be changed to one in which fishers, together with the management agency (DINARA), are co-responsible in the resource management, and that responsibility would be institutionalized in the appropriate legal framework (Defeo and Pérez-Castañeda, 2003; Castilla and Defeo, 2005). This could be in conjunction with the implementation of MPAs and the concession of territorial rights for fishing to organized fishing communities. The effective inclusion of the fishers in institutional management schemes will constitute a positive element that will tend to avoid the fishery collapse in coastal resources of Uruguay. The successful example of Chile on the development of institutionalized co-management schemes with active state participation of the artisanal fishing community in monitoring, enforcement and evaluation of management plans (Castilla, 1994; Castilla *et al*., 1998) could set the basis for developing similar schemes in Uruguay.

The above reflections could only be effectively set if implemented under a long-term sectorial policy that links biological, social and economic aspects. These long-lasting actions are directed to rebuild populations to increase chances for success and to minimize future ecological, social and economic costs. This should rely on the introduction of efficient multiscale management regimes, effective social policies and a close follow up of catch and stock status through sound science. In this setting, the Uruguayan government has begun to recognize the importance of the artisanal fishery subsector and it is currently developing the National Plan for the Development and Management of Artisanal Fisheries (DINARA, 2005). This plan includes the development of a legal framework that will provide recognition and support to the artisanal fisheries subsector, including fishers' empowerment through the implementation of long-term co-management schemes.

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14. Assessing and managing coastal fisheries of Latin America and the Caribbean: underlying patterns and trends

Ratana Chuenpagdee[*], Silvia Salas, Anthony Charles and Juan Carlos Seijo

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A synthesis of the characteristics of fisheries in Latin America and the Caribbean (LAC), and of the methods and tools used for the assessment and management of these fisheries can provide some insights and enable comparisons that may be useful for improving the situation of coastal fisheries in the region. The synthesis presented in this chapter is drawn largely from the information provided by the twelve country chapters, supplemented by previously published literature. In the first section, we present the key characteristics of these fisheries. The second and third sections provide a comparative description of the various fishery assessment and management tools employed and discussion on the challenges faced. In the final section, we summarize needs and prospects for improving assessment and management of the fisheries in the region.

* *Contact information*: Memorial University of Newfoundland, St John's, Newfoundland, Canada. E-mail: ratanac@mun.ca

1. CHARACTERISTICS OF COASTAL FISHERIES

While acknowledging the uniqueness of each coastal fishery, several attempts to define and characterize coastal fisheries show emerging commonalities (e.g. Panayotou, 1982; Russel and Poopetch, 1990; Charles, 1991; Agüero, 1992; FAO, 2000; Staples *et al*., 2004; Chuenpagdee *et al*., 2006). Generally, coastal and small-scale fisheries share the following characteristics (Salas *et al*., 2007a):

(a) Multispecies, multiple gears, with changing and flexible target species and gears employed.
(b) Labour intensive, low-capital investment.
(c) Many small landing sites dispersed along coasts, including remote areas.
(d) Livelihood diversification (including non-fishing) is common among coastal fishing households.
(e) Significant provision of food, income and jobs for coastal communities.
(f) Migration of people from upland areas to coasts in search of jobs and income from fisheries is common.
(g) Intricate relationship between fishers and fish traders who often serve as money lenders.
(h) Health provision and education facilities are generally poor due to remoteness of the areas.

The complexity of these fisheries is increased by the heterogeneous characteristics of the fleet among countries and even within countries. This makes it difficult to evaluate the dynamics of the fleet and its fishery. The fleet has increased significantly in the last decade; an example of this trend as it applies to the countries considered in this publication is depicted in Table 1.

Coastal fisheries of LAC are also characterized by a number of challenges and problems which, while not necessarily universal, are certainly widespread. These range from the high levels of labour involved and social implications and the lack of policy support for such fisheries to the marginalization of some fishing communities due to physical remoteness and economic disempowerment (Agüero, 1992; Pauly, 1997; Thorpe *et al*., 2000; FAO, 2006). Also commonly found in many coastal fisheries are open access conditions, which have contributed to the overexploitation of fishery resources. For instance, in the 1980s, most countries encouraged increases in fleets as a way of generating jobs and food for coastal communities (Thorpe *et al*., 2000; Agüero and Claverí, 2007). At times, governments have also supported the migration of people to coastal areas, to participate in fisheries as a 'last resort' source of employment (Salas and Torres, 1996). These programmes may have assumed that it was unnecessary to control fishing intensity, as coastal populations grew, on the basis that this was not seen as threatening the resources – yet the increased targeting of such resources has created severe problems with fish stock declines (Agüero, 1992; Salas and Torres, 1996; Pauly, 1997).

TABLE 1
Number of fishers and fleet size of coastal fisheries in the twelve countries of LAC included in this publication for the period between 1980 and 2004

Country	Boat size and other characteristics of the fleet	1980s–1990s		2000–2004	
		Fishers	Boats	Fishers	Boats
Argentina	Small boats (<10 m) and small vessels (10–18 m)			2 185	144
Barbados	Small boats (< 12 m)			2 200	613
Brazil	Small boats (< 10 m)	554 000	49 100		
Colombia	Boats with outboard motors of 15, 40, 75 hp	50 000	11 000		9 000
Costa Rica	Boats fishing in areas up to 100 m from shore	6 000	2 344	8 000	3 040
Cuba	Boat size 10–23 m				999
Dominican Republic	Fishing in areas up to 100 m from shore			9 500	3 675
Grenada	Small boats (5–15 m)			1 931	560
Mexico	Small boats (8–13.5 m)	186 000	40 250	138 941	102 807
Puerto Rico	Small boats (4.5–12 m)				
Trinidad and Tobago	Small boats (7–10 m) of 40–75 hp (Trinidad); small boats (6.7–12 m), of 15–100 hp (Tobago)			2 146	1 471
Uruguay	Boats < 10 GRT; fishing within 13 km from shore	790	250	1 400	571

Sources: Agüero, 1992; Beltran, 2005; Chuenpagdee *et al.,* 2006; FAO, 2004, 2006, years vary by country (see Fisheries Profile at www.fao.org./fi/fcn/profile); Quesada Alpízar, 2006; and country chapters in this volume.

Despite their contribution to national economies, the approximately two million people linked to coastal fisheries in LAC do not appear to have significantly improved their livelihoods in the last couple of decades (FAO, 2000). This situation has encouraged people to seek diversification of their activities by becoming involved in non-fishery coastal activities like tourism (Quesada Alpízar, 2006). In many cases there has been a decline of economically important species in fisheries, and while economic theory may predict that this would lead to an exiting of fishers from the fisheries and thus a decline in fishing effort (Smith, 1969), in fact, resource declines have often been accompanied by a long-term trend of increasing fishing effort. This has occurred either because fishers have spent more time and money to catch the same or a reduced amount of fish, or because they have taken fishing activity farther offshore. Either of these results in the fishery being less efficient in economic and social terms, and has a consequent impact on biological systems.

2. FISHERIES ASSESSMENT TOOLS

Pauly and Agüero (1992) stated that by the 1990s the focus of fishery science in LAC had traditionally concentrated on the collection of data of total catches of main fishery resources, and on fish stock evaluations based mainly on fish growth and mortality estimates. Salas *et al.* (2007a) observed that currently some countries in the region still present limited human and logistic capacity to evaluate their resources, although some changes in these trends are evident in Mexico and certain South American countries. Another issue regarding stock assessment that needs attention has to do with the use of old paradigms when evaluating resources, some of which have already been shown to be inadequate (Caddy, 1996; Caddy and Seijo, 2005). Several authors emphasize the need to go beyond analysis of information based on the landings and to begin, for example, to explore the spatial distributions of resources, catch and effort spatial trends, as well as to assess fishing strategies and fleet dynamics (Seijo *et al.*, 1994; Cabrera and Defeo, 2001; Salas and Gaertner, 2004; Caddy and Defeo, 2003; Caddy and Seijo, 2005). A more recent trend calls for incorporation of an ecosystem approach in the analyses (Pauly *et al.*, 1998; Plagányi, 2007; De Young *et al.*, 2008).

Table 2 provides information on fishery data and assessment methods, drawn from country-specific chapters in this volume, as well as from workshop discussions held during the CoastFish conference. It is evident that collection of catch statistics and data on size frequency of fishing resources obtained from the landings seems a common practice; fishing effort information in most countries is presented mainly in nominal figures when available. Of the twelve fisheries reported in this publication, data collection relating to Mexico, Cuba and Argentina are the most comprehensive.

Bio-ecological studies in the countries are diverse, ranging from basic biology to stock assessment through modelling. Environmental factors *per se* are seldom included. Observer programmes existing in Mexico and Argentina have generated detailed spatial data on resource distribution. With this seemingly strong data collection programme, these two countries are able to perform several types of bio-ecological assessment using different types of models. Ecosystem-modelling approaches on the other hand have been employed in Brazil, Mexico, and Trinidad and Tobago.

On socio-cultural aspects, although many countries report a census on the number of fishers or boats or some general information, four countries of the twelve – Argentina, Barbados, Brazil and Mexico – have assessed issues such as social and cultural dimensions, institutional arrangements and fisher perceptions on resource use, as well as management and compliance for some of their fisheries. These countries, as well as Cuba, also have performed economic assessment using methods such as benefit-cost analysis and, in some instances, bio-economic modelling.

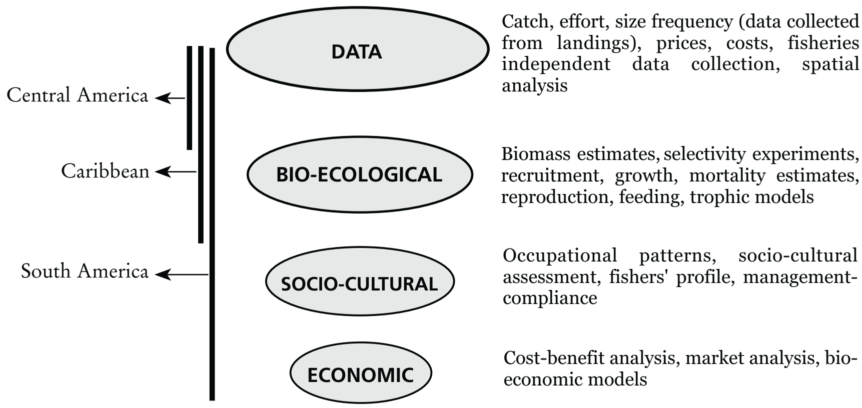
TABLE 2
Data and assessment methods employed in the twelve LAC countries

Issues/Tools	Argentina	Barbados	Mexico	Cuba	Colombia	Costa Rica	Brazil	Uruguay	Dominican Republic	Puerto Rico	Grenada	Trinidad and Tobago
DATA												
Catch statistics	X	X	X	X	X	X	X	X	X	X	X	X
Size frequency	X		X	X	X	X	X	X	X	X		X
Spatial data	X	X	X					X		X		
Types of gears	X		X	X	X				X	X		X
Biological surveys	X		X	X	X	X		X		X		
Observer programme	X		X									
Number of fishers	X		X	X	X	X			X		X	X
Oceanography information	X		X	X						X		
BIO-ECOLOGICAL												
Growth	X	X	X	X	X	X	X	X	X	X	X	X
Mortality	X	X	X	X	X	X	X	X		X		X
Recruitment		X	X	X	X	X	X	X	X	X		X
Larval studies	X		X	X					X	X		
Feeding	X		X	X								
Reproduction	X		X	X	X	X	X	X	X			
Trophic models			X		X							X
Selectivity			X	X	X	X		X				
Surplus production models	X		X	X	X	X	X	X	X	X		X
VPA	X	X	X	X	X		X			X		X
Yield per recruit	X		X	X	X		X			X		X
Biomass dynamic models			X	X	X					X	X	X
Environmental issues	X		X	X								
Ecology	X		X	X					X			
Fishing effort analysis			X	X	X			X				
CPUE trend analysis	X	X	X	X	X	X	X	X		X		X
SOCIO-CULTURAL												
Fishers' perception	X	X	X				X	X				
Inst. arrangements		X	X				X		X			
Fishers' social profile	X		X				X					X
Migration		X	X						X			
Traditional knowledge		X					X					
ECONOMIC												
Cost–benefit analysis		X		X					X			X
Occupational structure	X	X	X	X						X		
Economic assessment	X	X	X	X	X		X	X		X		X
Bio-economic models			X	X	X		X	X				
Market				X			X					X

Figure 1 summarizes the use of assessment tools within the LAC region. Data collection is common in all countries; Caribbean countries also have elements of bio-ecological assessment and some socio-cultural studies; South American countries generally cover all aspects of assessment, including those areas covered by Caribbean countries plus economic assessments as well. Central America seems to be the area where less comprehensive assessment is undertaken.

The complexity of coastal fisheries systems, given their heterogeneity and high uncertainty, together with limited capacity for data collection and data analysis, has generated challenges to the assessment of such fisheries in the region. The discussion at the CoastFish conference (Salas *et al*., 2007b), in addition to literature reviews, reveal limited capabilities within fishery research institutes in the region. This is due largely to a lack of trained personnel, insufficient financial support for data collection, and an absence of well-defined programmes for routine assessment and monitoring of resources.

FIGURE 1
The range of assessment tools employed in the LAC region



The reliability of catch statistics may be questionable in some cases due to inconsistent format and non-standardized methods of data collection. Usually only the most important species (by volume or value) are separately recorded, and separating data on individual species from the mix of species traditionally landed in coastal fisheries has been problematic. The difficulty in obtaining information about fishing effort is attributable to the diversity of gears and vessel types, and fishing seasonality. Thus, using the number of boats and number of fishers to assess fishing effort may not reflect the actual fishing pressure. The application of an ecosystem-based approach to fisheries management and other integrated models is still at an early stage in the region. There is also a general lack of trained personnel to undertake interdisciplinary research.

Despite the above challenges, some progress in fisheries assessment in the region has been observed. It has been recognized in recent years that improving scientific knowledge on coastal fisheries requires a shift in approaches; some examples are reported in the country chapters included in this volume (Puerto Rico, Cuba, Mexico). Among the positive efforts to date are the introduction of the spatial analysis and the conceptual development of meta-populations and connectivity to address coastal fisheries problems (Caddy and Defeo, 2003; Ehrhardt, 2005; Rios-Lara *et al*., 2007; Seijo, 2007). There has also been an increasing recognition of the need to incorporate social and economic issues, and to engage in multidisciplinary work on integrated fishery analyses, including stakeholder analysis (Quesada Alpízar, 2006; McConney and Baldeo, 2007).

Another group of positive experiences in fishery assessment deals with the progress in: (i) monitoring programmes that include collection of data independent from the landings; (ii) the involvement of fishers in data collection;

(iii) improvements in the capacity of research institutes; and (iv) widening the geographic and spatial coverage of data collection. In several countries, some international agencies have promoted such initiatives (e.g. FAO, International Development Research Centre [IDRC], Caribbean Community [CARICOM], World Wildlife Fund [WWF], World Bank, European Union [EU], etc.).

3. FISHERIES MANAGEMENT TOOLS

Data availability limits the range of applicable assessment methods. The choice of management measures is in turn affected, since this choice depends largely on both the type of data collected and this assessment. The types and range of management tools employed in the twelve case studies for different types of fisheries resources, i.e. demersal (D), benthic (B) and pelagic (P) are shown in Table 3.

TABLE 3
Common measures and approaches used for the management of coastal fisheries in the LAC region

	Argentina	Barbados	Brazil	Colombia	Costa Rica	Cuba	Grenada	Mexico	Puerto Rico	Dominican Republic	Uruguay	Trinidad and Tobago
MANAGEMENT SYSTEM												
Institutional management bodies	D	P				D		P,D				D,P
State management	D,B,P	D,B,P	D,B,P	D,B,P	D,B,P,	D,P	D	D,B,P	D,B,P	D,B,P	B,P	D,P
Co-management	B,D	B,D	B				D	D,B				
Sea tenure								D				
ACCESS RIGHTS AND REGULATIONS (who, when and where have access to the resources)												
Open access	D(*)			X(*)						D(*),P		
Restricted access	D,B	B,P		D	D	D	P	D,B,P	P	D		D
Exclusive fishing area (TURFs)	D	B	B	X	D			D	B		B	
Fishing permits	B	B	B	D	D,B,P	D		D,B,P				D,P
Closed areas	D,B,P	B,P	B		D	D		D	D	D	B	
Seasonal closure	D	B		X	D	D		D,B,P	D	D	B	D
Marine protected areas		X	X	X								
FISHERY POLICY INSTRUMENTS												
Restrictions on gear and fishing effort	D	D,P						D,P	D,B			D,P
Minimum legal size	D,B	B,D,P	D	D	D	D	P	D,B,P	D,B,P	D	B	D,P
Total allowable catch (total quota)	D,B,P			D,P		D		D			B	
Community quotas				D,P	D			D	D			
Protection of berried females						D		D	D			
Fishing restricted during spawning season								D		D		
Individual quotas (fisher or boat)	B	B	B	D	D			B,P			B	
Species excluding devices	D			D	D			D				D
Use of explosives or pollutants forbidden		B,P	B	D	D				D,B			

Notes: D = Demersal; P = Pelagic; B = Benthic; X = Not specified by resource; *applicable to some species or for subsistence fisheries.

When it comes to the range of policy instruments employed to manage all three types of fisheries, Mexico uses the widest range, followed by Argentina and Colombia. Barbados employs a wide range of tools as well, but mainly to manage the dominant benthic resources, as is also the case in Brazil and Uruguay. The Dominican Republic, Uruguay and Grenada use comparatively fewer tools than other countries in LAC. The top-down system dominates in the region, although fisheries co-management has been reported in Argentina, Barbados, Grenada, Brazil, Mexico and Costa Rica. Such institutional arrangements have proved to be easier to implement for the management of species with limited mobility. They are becoming more widespread in the region, along with related schemes such as marine tenure arrangements and territorial use rights, all of which can provide more practical mechanisms of enforcement and monitoring (Castilla and Defeo, 2001; Hernández and Kempton, 2003; Quesada Alpízar, 2006; country chapters in this volume).

Minimal legal size, seasonal closures and fishing permits are the main instruments applied for most resources in all twelve countries. Mexico is the only country reporting the use of sea tenure, and together with the Dominican Republic, it imposes fishing restriction during spawning seasons. Countries reporting use of marine protected areas (MPAs) are Barbados, Brazil, Colombia and Mexico. Quesada Alpízar (2006) also reports the existence of MPAs in Costa Rica.

Banning of chemical use, poison and explosives are also common for demersal species, particularly in reef areas. Compared to that for demersal and benthic resources, management of pelagic species is sparse, with monitoring and enforcement generally more difficult, especially in cases of strong migratory behaviour. Management of pelagic fisheries can include restrictions on gears and fishing effort.

It has been noted that given the uncertainty in fisheries, and the need to apply a Precautionary Approach, fishery managers need a set of multiple, mutually reinforcing management tools, to increase the robustness of the system and the resilience of the fishery overall (Cochrane, 1999; Charles, 2001). At the same time, not all management tools are appropriate in every situation. For instance, while the setting of total allowable catches (TACs) as global quotas – i.e. catch (output) controls – is used in a number of fisheries, concerns over the efficiency of such an approach arise due to: (i) unreliable biomass estimates; (ii) limitations on the reliability of catch and fishing effort statistics; (iii) unreported catches; (iv) illegal fishing; (v) inadequate resources for monitoring and enforcement; and (vi) a more general lack of institutional capacity. Problems of allocation can also arise. Thus, a broad set of management tools can be helpful, but careful selection would be required to fit the situation at hand. Proper enforcement programmes are of course mandatory in order to be able to implement management plans.

Challenges in the management of coastal fisheries in the region relate largely to the characteristics of the fisheries and the implementation methods. Generally, the existence of open access fisheries and a lack of control over fishing effort, combined with high levels of illegal fishing, make the management tasks difficult. Participation of fishers is high in some cases but is generally lacking in most. Conflicts between coastal and industrial fisheries are still prominent. Weak institutions and lack of appropriate frameworks to implement management regulations are also limiting factors as reported in many cases in the country chapters.

Despite the challenges in the management of coastal fisheries in LAC, some success stories can be noted. Increasingly, involvement of fishers in the management process has reduced some of the conflicts, and led to successful allocation of local fishing rights. This is a notable trend in Barbados, Mexico and Cuba. These advances do not apply, however, to whole countries, but only to a certain fishery or fisheries in a particular location within those countries (see Seijo, 1993; FAO, 2000; Castilla and Defeo, 2001; McConney and Baldeo, 2007; Sosa *et al.*, 2008).

Fisheries management often requires a combination of measures, approaches, and institutional arrangements compatible with the particular situation. Measures such as marine protected areas may be used in conjunction with stock enhancement and habitat restoration, as well as restriction of fishing effort in the areas, as is done in Barbados and Mexico, to increase management effectiveness. For demersal and benthic species, fishing permits and quotas may be implemented together, provided that the latter are not excessive and can be accompanied by adequate monitoring and enforcement. Good examples of this arrangement are found in Argentina, Colombia and Mexico. In the case of pelagic species, given the high vulnerability to climate-related environmental change, both risk and uncertainty analyses are valuable tools when assessing and managing these fisheries, as is the use of adaptive approaches through which management (and fishing intensity) responds to changing conditions.

4. PROSPECTS IN FISHERY ASSESSMENT AND MANAGEMENT

Coastal fisheries are facing many problems, and while certainly some of these are specific to certain subregions within the overall LAC region, several issues and challenges reported by authors of the country chapters seem common; some of these have also been reported by other authors working with coastal (small-scale) fisheries (Staples *et al.*, 2004; Agüero and Claverí, 2007; Béné *et al.*, 2007; García *et al.*, 2008). The challenges are wide-ranging in LAC fisheries, from those relating to fishery management (e.g. illegal fishing and a lack of institutional capabilities – technical, logistical and economic – for enforcing regulations) to those relating to fishery assessment (e.g. a poor understanding of the dynamics of the socio-economic relationships in coastal fisheries that arise through interactions among diverse, complex ecosystems and communities). The challenges also go beyond the strict boundaries of fisheries themselves, to include concerns over environmental disturbance and habitat destruction, as well as the need for attention to factors that contribute to the vulnerability of coastal communities and small-scale fisheries.

Addressing the problems associated with coastal fisheries in LAC will require a set of key responses, to be discussed sequentially in this section: (i) comprehensive fisheries assessment, which requires improved technical and financial support for research, on a permanent basis, and suitable support for developing and implementing appropriate assessment methods; (ii) building capacity for fishery data collection, assessment and management; (iii) incorporation of social, economic and livelihood considerations in the broader ecosystem-based and livelihood-based approaches, (iv) exploration of alternative management schemes, moving from traditional systems to new governance; and (v) promotion of equitable access and clear fishery use rights among fishers, fishing communities and other relevant stakeholders, as well as organization and self-regulation of fishers, to enable full participation in fisheries management.

4.1 Comprehensive fisheries assessment

Implementation of fishery management plans relies heavily on fisheries assessments, which are undertaken in most countries of LAC by national institutes of fisheries or the like. However, in many cases these institutes lack the financial and technical support to keep up to date with changes arising in the fisheries. Most efforts have concentrated on gathering basic catch data, size frequency of individual organisms and, in only a few cases, fishing effort information. Given such data limitations, scientists are unable to undertake a full and integrated assessment of a given fishery (including biological, social and economic aspects). Further, single species approaches are the most common for this region, which may not necessarily be appropriate given the complexity of coastal fisheries (with their multispecies and multigear context). In addition to some comments here, this latter point is examined in more detail later, in Chapter 15, within the context of the ecosystem approach to fisheries.

While fishing pressure has imposed significant problems on coastal fisheries and their managers across most of the LAC region, the analysis undertaken here indicates varying degrees of response in terms of fishery assessment. For example, major assessment efforts are apparent in parts of South America and some Caribbean islands like Puerto Rico, while the capacity to implement such measures is less in Central America – where continuing use of conventional assessment tools limits the capability to benefit from a broad package of management tools. This can be a reflection of differences in the economic and human capacity to address ongoing needs as well as specific problems.

A focus on biological approaches has dominated across much of the LAC region, but this focus has proven insufficient. Integrated assessment produces multidimensional advice with a broader perspective (Charles, 2001; García *et al*., 2008). García *et al*. (2008) also emphasize the fact that assessment must be cost effective, rigorous, timely, integrative of approaches from different disciplines, and incorporating local knowledge in order to be effective. Of course, the presence and extent of these attributes will depend on the conditions prevalent in the particular region where the evaluation takes place (scientific capacity, financial support, etc.) and the nature of the institutional framework for management.

Finally, the information exchanges that led to, and that are reflected within this volume, indicate that an open and positive attitude by fisheries scientists to seek out and implement new approaches for assessment, and a general willingness to interact with others across the region in order to generate a suitable knowledge base, are crucial ingredients in the quest for sustainable fisheries resources.

4.2 Building capacity

A move toward sustainable fisheries management, aiming to maintain healthy ecosystems and improve fisheries in the Latin America and Caribbean region, requires the building of appropriate capacity. This in turn necessitates suitable project development and training for (i) the selection and/or design of appropriate assessment approaches to match the diverse manpower and financial possibilities in the region (including, at least initially, designing approaches for data-limited situations); (ii) design of data collection systems for answering relevant fishery management questions, notably within the context of ecosystem considerations; (iii) aiding decision-making in fisheries management in a context of uncertainty and incomplete knowledge of the fishery and the ecosystem in which it operates; and (iv) fostering, among fishers and fishing communities, an understanding of ecosystem dynamics, interdependencies and the effects that various options for human interventions may have on these over time.

The aid provided by some international agencies has partially helped LAC countries (e.g. through working groups organized by FAO, like that on spiny lobster, or training courses or workshops such as those organized by the Danish International Development Agency (DANIDA) and the International Development Research Centre (IDRC). However, it is a common concern that, when international agencies leave, government agencies do not (or cannot) take responsibility to maintain the programmes initiated or promoted by the international agencies, and the results of those efforts fade. Thus, more attention is required, on an ongoing basis, to build capacity and maintain it within the region to improve the assessment of fisheries and to promote sustainable fisheries management.

4.3 Incorporating social, economic and livelihood considerations

A major gap in the information reported in most country chapters within this volume relates to a poor understanding of how socio-economic, cultural and legal considerations affect fishing and fisheries. Many fisheries problems are socio-economic in nature, and many involve aspects of the coastal economy that extend beyond the fishery (Fraga, 2004; Staples *et al*., 2004; Agüero and Claverí, 2007; Salas *et al*., 2007a; García *et al*., 2008). For instance, while it has been stated in many cases that coastal fisheries can contribute to food security and poverty alleviation of local communities (Staples *et al*., 2004; Béné *et al*., 2007), a better understanding of the socio-political circumstances, the legal frameworks and local conditions of communities is necessary in order to evaluate how government interventions may succeed or fail with alternative management programmes or future development assistance in the search for sustainable fisheries and sustainable coastal communities (Jentoft, 2000; Garcia *et al*., 2008; Hauck, 2008).

It is necessary to understand the characteristics and functioning of fishing communities, the perceptions of people regarding the use and management of natural resources, the dynamics of fishing operations, the behaviour of resource users regarding compliance, as well as the way people cope with vulnerability given an increase in threatening conditions for coastal fisheries and those who depend on them (Allison and Ellis, 2001; Chuenpagdee *et al*., 2004; Salas and Gaertner., 2004; De Young *et al*., 2007; Hilborn, 2007).

4.4 Alternative management schemes

In complex fisheries systems, where data is scarce, knowledge incomplete, uncertainty high, and fishers compete heavily for limited resources, conventional management systems – relying on top-down control by state agencies and based on narrow approaches – have proved ineffective. Degnbol *et al.* (2006) call for a change in the way fisheries managers have been approaching the problems of complex fisheries. They contend that the main trend in fisheries management has been to look for solutions in the form of 'discipline-specific approaches'. These might involve economic tools (e.g. individual transferable quotas – ITQs) focused on economic efficiency, bio-ecological tools (e.g. MPAs) promoted by biologists and focused on resource conservation, or community-based management (CBM), promoted by anthropologists and emphasizing empowerment. The authors argue that any one discipline alone cannot fully address the complex and diverse problems of fisheries management and an integrated vision (transdisciplinary) and changes in paradigms are necessary to challenge current fisheries problems.

According to Degnbol *et al*. (2006), when only one criterion (e.g. biological, economic or social) is used to evaluate or implement management tools, there is a risk of 'tunnel vision'. Application of a single management tool may be appropriate for a particular context, but when promoted as 'universal remedies', it ceases to be useful in tackling fisheries problems (a point highlighted by Charles, 2001). On the other hand, if several 'discipline-specific approaches' can be combined (subject to concerns over conflicting objectives), the selection of one approach over others, or a combination of several, will depend on managers' preferences, political will and implementation costs, among other factors (Seijo *et al.,* 1998). While the use of multiple management tools is important for a resilient system, it may be both possible and more practical for managers to follow a well-known path using a set of simple tools (ones that are easy to explain to user groups, easy to implement and less costly to enforce). In some cases, this may limit the use of more complex approaches such as an ecosystem approach for management (Plagányi, 2007), but may lead to an adaptive management process (Walters and Martell, 2004), or to move beyond the traditional biological approach, which has dominated fisheries management of small-scale fisheries in many countries (Staples *et al.,* 2004).

Employing a mixture of policy instruments and involving fishers in the decision-making process and policy formulation are necessary steps towards improved management schemes in the LAC region. There are some positive trends in developing effective alternative management systems for LAC coastal fisheries, as shown in some of the country chapters; these could signal progress for the region in moving towards resource sustainability and social well-being. There is a need, however, to expand and, where possible, replicate some positive examples of self-governance to improve on conventional management systems. Responsibility for a change of vision and approaches must come from scientists, fishers and managers. To reach this goal, a broader and more participatory approach to governance of fisheries is required. This policy direction will be explored in more detail in Chapter 15.

4.5 Promoting equity, use rights and participation in management

An issue faced across the coastal fisheries of the LAC region is that of providing equitable access to and distribution of the resource among competing groups, and keeping fishery access from being concentrated in too few hands. One avenue for achieving this is the allocation of fishery use rights – i.e. the right to go fishing, rather than ownership over the resources *per se* (Charles, 2002). Such schemes are said to create incentives for those holding rights to safeguard the well-being of fishery resources (Berkes *et al*., 2001; Castilla and Defeo, 2001; Castilla and Gelcich, 2008). However, allocation of fishing rights by themselves will not ensure good fishery practices, to conserve resources, if the rights holders are not involved in the management of the fishery. Furthermore, institutional adjustments are also necessary in order to achieve cooperation from different users' groups to maintain healthy resources (Chuenpagdee and Jentoft, 2007).

It is useful to highlight some successful examples in the LAC region, which may encourage further exploration of options for allocation of fishing rights, whether by area or by resource, or a combination of both. For example, in Chile and Peru, marine areas are allocated for fishing to specific groups, who also enforce their own rules (FAO, 2000; Mendo *et al*., 2002; CeDePesca, 2005; FAO, 2000; Castilla and Gelcich., 2008). In Mexico, concessions by species and area are allocated for lobster fishing to some groups of fishers – these groups have regulated access to the use of this profitable resource. The security of access through use rights has encouraged self-enforcement actions in communities in Mexico and Grenada (Chuenpagdee *et al*., 2004; Seijo, 1993, McConney and Baldeo, 2007; Sosa *et al*., 2008).

5. CONCLUDING REMARKS

This chapter has provided an analysis of the state of fisheries assessment and management along the coasts of LAC, as synthesized from the country chapters in this volume, as well as from additional insights arising in the CoastFish conference. We have seen that there has been progress in various areas, but also significant gaps remaining. The final section of this chapter focuses on the future, on the prospects for LAC coastal fisheries, and some directions forward, with an emphasis on (i) developing comprehensive fisheries assessment; (ii) building capacity for fishery data collection, assessment and management; (iii) incorporating social, economic and livelihood considerations; (iv) implementing alternative management schemes;

and (v) promoting equity, appropriate use rights and participation in fishery management. While these directions appear crucial for the future, choosing the most appropriate approaches for their realization will undoubtedly be crucial in increasing the likelihood of improving the state of coastal fisheries in LAC.

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15. Toward sustainability for coastal fisheries of Latin America and the Caribbean: effective governance and healthy ecosystems

Juan Carlos Seijo*, Anthony Charles, Ratana Chuenpagdee and Silvia Salas

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Small-scale fisheries of Latin America and the Caribbean (LAC) have tended to suffer from the same overexploitation syndrome that characterizes many fisheries of the world today, one that has led to a global pattern of exploitation, in which there is little room for expansion of the world's fish catches and, indeed, many resources are overexploited or even exhausted (FAO, 2008). With the fish resources and fisheries of LAC so often in a poor state, what can be done about it? How can fishery sustainability be achieved in a coastal context – whereby the needs of the present local coastal populations of fishers can be met without

* *Contact information*: Universidad Marista de Mérida, Mérida, Yucatán, Mexico. E-mail: jseijo@marista.edu.mx.

compromising the ability of future generations to meet their needs – in the same location and other interdependent locations (Caddy and Seijo, 2005).

Chapter 14 drew on a synthesis of results from the country-specific chapters in this volume in order to review the overall state of fishery assessment and management along the coasts of the LAC region. This led to five specific directions proposed to improve the state of these fisheries, namely (i) comprehensive fisheries assessment; (ii) building capacity for fishery data collection, assessment and management; (iii) incorporating social, economic and livelihood considerations; (iv) adopting alternative management schemes; and (v) promoting equity, use rights and participation in fishery management. These themes all fit into the two major policy frameworks being advocated globally as essential to the future of fisheries – the development of new innovations in fishery governance and institutional design, and the adoption of an ecosystem approach to fisheries.

In this chapter, we examine in some depth the nature of these two major frameworks and explore how they can be effectively applied in the context of small-scale fisheries management, particularly in the LAC region. The chapter then closes with a synthesis of the key messages of this volume, highlighting in particular the directions forward in improving the state of coastal fisheries across Latin America and the Caribbean.

1. FISHERY GOVERNANCE AND INSTITUTIONAL DESIGN

A focus on 'governance' of fisheries implies a broad perspective that encompasses activities well beyond the day-to-day routines of management, and that also extends beyond the responsibility of governments alone. In other words, governance involves various social actors, including private enterprises, civic organizations, communities, political parties, universities, the media and the general public (Costanza *et al*., 1998; Chakalall *et al*., 2007). Governance is about the collective, aggregated and integrative process that these actors explore together in solving problems and creating opportunities for society (Kooiman *et al*., 2005).

These interactions can be fostered through communication, learning and negotiation. Such initiatives will help to rebuild catch levels and ensure sustainable livelihoods by providing the mechanisms for decision-making needed to initiate a control on fishing intensity. The resulting improvements will reduce the overall pressure on the resources and counteract the declines in catches and the consequent increases in travel and transaction costs that fishers incur when competing for the most valuable resources. Recognition of the dynamics of the fisheries calls for adaptive strategies. Institutional arrangements, bio-ecological processes, market conditions and environmental impacts must be reviewed and revised and then management strategies adapted accordingly.

Three major themes relating to these challenges of fisheries governance are explored in this section: (i) the need for, and the evolution toward, clear rights over access to and use of fishing grounds; (ii) approaches to reducing high exclusion and transactions costs in coastal fisheries; and (iii) the development of effective institutions for fishery governance.

1.1 From open access to fishery use rights

Open access fisheries – those in which there are no limits to access, so that anyone can go fishing – are still common in LAC countries. However, it has become accepted wisdom, based on experiences of fishery collapses worldwide, that open access is likely to result in overexploitation and overcapacity, thereby threatening the long-term sustainability of fisheries. The overall need for and desirability of restricting the access and use of fishery resources is now accepted as a basic premise in fishery management (Ostrom and Hess, 2007; FAO, 2006; OECD, 2006).

Such restrictions in fisheries are related to 'use rights' that define who can access a fishery and how much fishing each can undertake (Charles, 2001, 2002, 2004; Ostrom and Hess, 2007). As indicated in other chapters of this document, various forms of use rights are to be found in the small-scale fisheries of LAC (Salas *et al.*, 2007; Agüero and Claverí, 2007, and references therein; Sosa *et al.*, 2008), fitting within an overall diversity of governance arrangements and institutional designs.

Use rights are key tools for the fishery manager not only in resolving open access problems, but also in helping to clarify who the stakeholders are in a certain fishery. They are essential as well to stakeholders – whether fishers, fishers' organizations, fishing companies or fishing communities – who are provided with some security regarding access to fishing areas, use of an allowable set of fishing inputs, or harvest of a certain quantity of fish. In addition, with secure and durable use rights, conservation measures to protect 'the future' become more compatible with the fishers' own long-term interests, which may encourage adoption of responsible fishing practices and greater compliance with regulations. Finally, use rights are seen as a mechanism to promote 'responsible fisheries' – indeed, as the FAO Code of Conduct for Responsible Fisheries notes, "The right to fish carries with it the obligation to do so in a responsible manner…" (FAO, 1995).

The key element of use rights in coastal fisheries is typically 'access rights', which deal with participation in the fishery, specifically relating to entry ('access') into the fishery or a specific fishing ground. A fishing licence would be an example of an access right as would the Customary Marine Tenure (CMT) and Territorial Use Rights in Fishing (TURFs), which determine the locations where community members can access fishery resources. Another form of use rights is an individually-set numerical right, whether to use a specific amount of fishing effort or to take a specific catch. There are some instances in Latin America of individually-based rights in small-scale fisheries, e.g. in some Chilean and Peruvian fisheries (CeDePesca, 2005; FAO, 2000; Castilla and Gelcich, 2008).

Just as use rights serve to specify and regulate who is to be involved in resource use, there is a parallel need to specify who is involved in fishery management – through 'management rights'. While the state has the general responsibility for management, it can delegate management functions. The question arises as to who else should be involved in fishery management, whether alongside government or delegated by government.

Both management rights and use rights reflect a trend toward rights-based management approaches, including systems of co-management as a key form of management rights. Indeed, as reported by Sutinen (1999), countries that utilize use rights tend also to move towards co-management, since the latter tends to reduce administrative costs and improve compliance with management regulations. Many small-scale fisheries in LAC involve some form of community-based management or co-management rights (FAO, 2000; McConney and Baldeo, 2007; Salas *et al*., 2007; Sosa *et al*., 2008).

Much has been written about the need for rights in fisheries, but there is much less discussion of the process for assessing and (if necessary) implementing a rights system. There is a diversity of approaches to considering the role of use rights, and of steps in the process of assessing and developing a use rights system. For an examination of the sequence of events in such a process, see Charles (2002).

1.2 Overcoming exclusion costs and transactions costs

Small-scale fisheries in LAC share many of the same issues of all marine fisheries, notably high exclusion costs, high information costs and high enforcement costs. These key challenges and how they can be addressed are described here.

First, an inherent characteristic of a fishery with exploited fish stocks is the high cost of excluding unauthorized fishers from exploiting the resource and enforcing regulatory compliance on those authorized to fish. High *exclusion costs* (sensu Schmid, 1987, 2004) mean that the use of an existing fish stock is difficult to limit to only those who have the right to fish it. Just because fishers have the nominal right to exclude others from harvesting a resource (i.e. through use rights) does not mean that the exclusion can be done effectively. Furthermore, the mobility and migratory nature of most fish resources, combined with high uncertainty as to stock magnitude, means that an individual fisher is unlikely to benefit from postponing capture of a fish with the expectation of taking it at a larger and more valuable size later, since others are likely to have caught it in the meantime; that is, unless all or most fishers also agree to abstain. Consequently, each fisher tends to maintain a high rate of harvesting, and thus generates high exclusion costs to the other fishers who tend to behave likewise.

Options for avoiding the effects of high exclusion costs in small-scale fisheries involve institutional structures and rights systems (Berkes, 1989; Seijo, 1993; Castilla and Defeo, 2001) such as: (i) implementation of community-based and co-management systems where the right to harvest the commons during the fishing season is allocated by the community to small-scale fishers; (ii) pecification of individual rights through allocation within the fishing community; and (iii) community-allocated fishing grounds which can be transferred or leased among members of the voluntary collective organization of small-scale fishers (Seijo, 1993). All of these approaches involve varying degrees of transactions costs that are faced by small-scale fishers, costs which may or may not be shared with government.

Second, marine fisheries involve high *transaction costs*, which also diminish the efficiency of resource allocation over time. Transaction costs in most fisheries involve (i) costs of information; and (ii) enforcement or policing costs. First, efficient fisheries management implies high information costs, to cope with the major uncertainties inherent in natural systems, as well as a range of other biological, social, political and economic factors requiring a precautionary approach to fisheries management (Hilborn and Peterman, 1996). Second, fisheries management involves high enforcement or policing costs if management schemes are implemented and/or fishery use rights allocated and policed. For many shelf fisheries, the areas to be policed are extensive and conventional patrol vessel operations are ineffective and costly. Under these circumstances, a non-enforceable right becomes an empty right.

The complexities of managing small-scale fisheries that are subject to high exclusion costs and high information and enforcement costs are further exacerbated by a naturally fluctuating environment, changing coastal ecosystem dynamics, and a lack of solid governance. A set of mitigating strategies is required to deal with these complexities and move towards fishery sustainability, as described above (Caddy and Seijo, 2005). To deal with these costs that prevent optimal harvesting of the resources, some strategies are presented in Table 1 for small-scale fisheries that target species with different degrees of stock mobility.

TABLE 1

Some strategies for mitigating the effects of high exclusion, information and enforcement costs in small-scale fisheries, targeting stocks with different degrees of mobility

Stock mobility	Exclusion costs	Information costs	Enforcement costs
Sedentary or low mobility Resources such as some invertebrates (bivalves, lobster)	Establish area-based use rights or leases among community members	Costs of stock assessment and bio-economic analysis are shared between those deriving resource rent and the government	Emphasis on self-policing Community-managed MCS[1] Co-management with government
Mobile (transboundary or shared stocks) Resources found in waters of multiple neighbour nations (e.g. Caribbean area). These include metapopulations	Limited entry agreed bilaterally or multilaterally with allocation of a shared total allowable catch	Bilateral/multilateral cooperation among parties, along with standardized data collection and stock assessment, and coordinated MCS, plus cost allocation proportional to use rights (e.g. quota)	Bilateral/multilateral cooperation in management and enforcement of common or harmonized regulations
Highly migratory Resources that pass nearby coastal areas targeted or incidentally harvested by small-scale fisheries	Harvest quotas are established by a commission Members of the commission set rules for entry to the fishery, and arrange allocation negotiations	Data collection and stock assessment are organized by the commission. Costs are shared proportionally to catch quotas	Commission members share enforcement costs proportional to annual harvest by individual countries

Adapted from Caddy and Seijo, 2005.

[1] MCS: monitoring, control and surveillance.

1.3 Developing effective fishery institutions

Latin American and the Caribbean fisheries are by no means alone in needing to improve their institutional arrangements in order to enhance the efficiency, equity and overall effectiveness of fishery management. Uncertainty as to future stock availability, particularly related to a common unsustainability of resources discussed earlier, has meant that attention tended to focus less on achieving long-run results and more on short-run benefits.

There are, however, positive measures that could improve governance. Some small-scale fisheries in the LAC region are very suitable for participatory institutional arrangements, such as the co-management and community-based management approaches noted above. Indeed, there are various such fisheries that already operate using traditional management systems and have established informal agreements within communities about access to fishing grounds. For such fisheries, three specific directions noted in Chapter 14 – incorporating social, economic and livelihood considerations; adopting alternative management schemes; and promoting equity, rights and self-regulation – are especially relevant.

Geographical remoteness of small-scale fishing communities, while often resulting in marginalization of this sector (especially in terms of the ability to influence management and decision-making) can, in some cases, be the incentive for self-help approaches to fishery sustainability. Whether small-scale fishing communities have the potential for community-based approaches to fisheries management, it is recognized that careful discussion is required for the design and arrangement of appropriate institutions. Discussion about the suitability of such a management scheme is also needed. As suggested by Chuenpagdee and Jentoft (2007), how the idea is conceived, communicated and discussed is as important to success in implementing co-management and community-based management systems as is the implementation itself.

The main principles for solid and lasting community management institutions in small-scale fisheries and the factors which contribute to successful implementation are well captured in Ostrom (1990). For example, clear boundaries and 'rules of the game' for the operation of the community managed fishery need to be identified. Fishers and other community members need to know who has the right to withdraw resources and from what areas. Appropriation rules and restrictions such as closed season and closed area need to correspond with the local environmental and social conditions, and fit within the capacity of the governing institutions to monitor and control. The complexity and the dynamics of the ecosystems and the human components within fishery systems require that these rules are amenable to being modified through a collective decision-making process.

In such institutional development, a key goal is to overcome individual incentives that operate counter to desired fishing behaviour. For example, in the absence of a consensus to respect rules such as catch limit, any single fisher's decision to increase their individual catch rate will benefit that individual while also increasing costs of other fishers. Using Shelling's (1978) terminology, this constitutes a social trap, because the micro-motives of an individual fisher in the short-run are not consistent with the macro-results that this fisher, and others, desire in the long run. The short-run micro-motives consist of catching as many fish as possible in order to increase individual marginal benefits, while the long-run desired macro-results may involve achieving the maximum economic yield and/or sustaining the flow of protein-rich seafood. Another incentive to overcome is that of free rider behaviour, defined as participation in the harvest without participation in the costs and constraints imposed by management of the stock, which tends to be present in small-scale fisheries where the number of fishers is very large and fishing grounds extend widely in the coastal area, making self-policing unfeasible.

Allowing for temporal fluctuations in resource productivity and preferences of resource use, a sustainable yield from a fishery will tend to be attainable only when the number of fishers is limited, and they act together to implement a form of effort regulation. Co-management and community-based management schemes provide a platform for collective regulatory actions to take place. Furthermore, the participatory nature of co-management creates an expectation among fishers of a legitimate process, thus encouraging compliant behaviour (Chuenpagdee and Jentoft, 2007; Jentoft, 2007). A successful co-management plan requires that the design of institutions is decided through meaningful participation and representation of a broad range of stakeholders. For small-scale fishers, this implies that their rights to locally organize and to devise their own institutions are not challenged by the government authorities (Ostrom, 1990).

Other factors that may contribute to successful community management and co-management of small-scale fisheries are robust and transparent leadership, which also fosters cooperative behaviour, effective and timely conflict resolution mechanisms at the local level, and access to training and technical assistance to improve knowledge about ecosystems, use of habitat friendly and selective gears, and quality control during the harvesting and post-harvesting processes.

2. FISHERY ASSESSMENT AND THE ECOSYSTEM APPROACH

The Ecosystem Approach to Fisheries (EAF) is rapidly becoming one of the most prominent frameworks with which to assess and manage the world's fisheries. The EAF is a fundamentally 'integrated' approach that connects ecological, socio-economic and institutional considerations and which, in turn, requires an integrated approach to the assessment of fishery systems. The challenge then lies in simultaneously developing an ecosystem approach to fisheries management and an integrated approach to fisheries assessment.

These two approaches are described in this section, with a focus on coastal fisheries, particularly in LAC, where many coastal states are already exploring ecosystem approaches to improving fisheries management, and corresponding mechanisms for a comprehensive assessment of the fishery systems and the corresponding coastal ecosystems. Moves toward EAF draw strongly on the range of policy and management directions described in Chapter 14 – certainly the use of comprehensive fisheries assessment and the adoption of alternative management schemes, but also efforts to build capacity for fishery data collection, assessment and management, and the incorporation of social, economic and livelihood aspects into management decision-making.

2.1 Fishery assessment

As noted in Chapter 14, effective management requires integrated approaches to the assessment of fisheries. However, meeting this need becomes especially challenging when considering the uncertain conditions faced by coastal small-scale fisheries (environmental variability, market demands, etc.) and the complexity involved (multigear, multispecies, resources and fleet interactions). In addition, application of integrated fisheries assessment and permanent programmes for the evaluation of stocks is greatly limited in many countries in the LAC region by lack of both financial support to conduct research and sufficient personnel with the skills required for that task in many countries in the LAC region.

Several key components of coastal fisheries assessment are important, among them: (i) assessment of the resource itself; (ii) assessment of habitat and stock distribution; and (iii) assessment of fishing effort, selectivity and impact of different fishing gears on resources.

Stock assessment in small-scale fisheries

Two fundamental approaches to evaluate the conditions of the fisheries and the stocks they depend on are: (i) using data from the fishery itself; or (ii) using fishery-independent data – and in a few LAC cases – both (Puerto Rico, Argentina, Mexico). Data collection methods in fisheries involve on-site as well as off-site methods. The former includes sampling of commercial fisheries and on-board observers on fishing vessels; the latter comprises reports of fishers about their landings. Biological sampling of size, age, sexual maturity, etc., of commercial fisheries is a task most countries in the LAC region report as part of their strategies to evaluate fisheries, generally because this is relatively cheaper than independent surveys and on-board observer programmes. The method involving on-board observers is less common in small-scale fisheries, but involvement of fisheries in research programmes is becoming more frequent in the LAC area.

Data reported by fishers could at times contain biased reports; however, it is becoming clearer that information derived from fishers' logdocuments, especially if those logdocuments are used for their internal accounting, could be very useful for fishery analysis, including that involving spatial stock distribution. In some cases fishers' logdocument data are recorded by species (Mexico, Salas *et al*., 2004) and gear (Costa Rica, Chacon *et al*., 2007). Other approaches that integrate catch records at a mostly global level are reported by Chuenpagdee *et al*. (2006).

As indicated in Chapter 14, the level of fisheries analysis in different countries varies from the simple catch and effort trend analysis and some aspects of population dynamics to more complex and sophisticated age structured analyses using numerical and acoustic methods. For instance, analytical methods, including acoustic studies combined with development of assessment models (Erhardt and Deleveaux, 2007), provide applications in the context of constrained data sources.

Complexity of some stocks like small pelagic fishes will necessarily demand reliable spatial data in order to incorporate the dynamic behaviour of fishes. A less complex analysis, including size data and reproduction indicators, has been applied to demersal or benthic species. For example, fisheries indicators proposed by Froese (2004) to evaluate overfishing conditions include: percentage of specimens with optimum length in catch, percentage of mature fish in catch, and percentage of mega-spawners in catch. The author argues that such simple indicators have the potential to involve more stakeholders in the evaluation and management of fishery resources and could easily be considered for small-scale fisheries. Assessment of time series data, including size distribution, have shown overfishing patterns where fishing intensity has increased over time (Bené and Tewfik, 2004).

Habitat assessment and spatial analysis

Habitats are particularly crucial to fishery sustainability, and spatial distribution of stocks can vary widely if changes occur in their habitat (Caddy, 2007). In this context, spatial analysis to evaluate the distribution or connectivity of stocks becomes relevant, especially in cases where meta-populations have been identified. Studies focused on stock distribution based on habitat characteristics through survey studies and fishery-dependent data have recently been reported for the region (Ríos *et al*, 2007; Jaureguizar *et al*., 2006). Other research has been designated to evaluate the effect of port location when spatially managing coastal fisheries (e.g. Seijo and Caddy, 2008).

It should be pointed out that spatial analysis and sophisticated laboratory techniques may be prohibitive for scientists in some countries in the LAC region. Modelling, however, could use simple spreadsheets through to more complex programming languages without necessarily requiring high technology. In both cases, improvement of skills for the personnel in charge of stock assessment may be required. Support from international agencies has been oriented in this direction (FAO, CIDA, IDRC, WWF, World Bank, UNDP); however, it is the commitment from the agencies in charge of management in the various countries that is essential in order to maintain the effort supporting detailed research once the agencies leave.

Fishing effort, methods and gear

In most cases, the need to properly assess and control the fishing effort of small-scale fleets has been recognized in the LAC region. Nevertheless, the wide distribution of fishers along coastal areas makes proper evaluation difficult. An important consideration when assessing fisheries is the dynamics of small-scale boats. The operators of these coastal boats make short-run decisions concerning *what* to fish for, *where* to allocate the corresponding fishing effort, matters of bycatch and discarding, and long-run entry and exit decisions, which may or may not include changes in fishing power. Studies concentrating on bycatch seem to be more common in industrial fisheries than in small-scale coastal fisheries.

The assessment of fishing effort allocations and investment was not common within the evaluations in this publication, nor among the participants at the CoastFish conference. However, some work in the LAC region has been reported (Bené and Tewfik, 2001; Cabrera and Defeo, 2001; Salas *et al*., 2004; Salas and Charles, 2008). On the other hand, evaluation of fishing power and gear selectivity appear to be the most common of the categories referred to above, and seem to be used especially in those cases where deterioration of fisheries resources has been acknowledged.

Given the high diversity of fishing methods and gear employed in coastal small-scale fisheries in LAC, assessment of these fishing gears is particularly relevant. In addition, the need to improve selectivity – something more than fishing efficiency – due to the level of deterioration of stocks in many parts of the region requires studies dealing with the effects of alternative fishing gear on species and size selectivity. These evaluations involve experiments to test different types of gears and methods, which can be demanding in terms of time and money. However, participatory research can be undertaken with small-scale fishers genuinely interested in sustaining the yield of their fishery (Chuenpagdee *et al*., 2003; Rueda, 2007).

To support management decision-making (in addition to supporting bio-ecological analysis and stock assessment), detailed information on the social and economic circumstances of the fishers and their communities, marketing patterns or conservation needs must be gathered in future research efforts in this field. It should be pointed out that a recent study by Garcia *et al*. (2008) indicates that conventional frameworks for fishery assessment do not provide an adequate basis for informed management decisions and development planning in small-scale fisheries.

2.2 Ecosystem approach to coastal fisheries

A particularly significant move globally, to build alternative management schemes in fisheries and to incorporate the other directions noted in Chapter 14, is that of the EAF. There is international pressure on all fishing nations to implement an ecosystem approach in their domestic fisheries and in any international fishery in which they participate. The importance of the EAF was recognized in 2001 by 47 countries participating in the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. The signing parties declared "that in an effort to reinforce responsible and sustainable fisheries in the marine ecosystem, we will individually and collectively work in incorporating ecosystem considerations into that management…" (FAO, 2001).

The vision of an ecosystem approach to fisheries management is summarized in Chapter 17 of Agenda 21: "The marine environment – including oceans and all seas and adjacent coastal areas – forms an integrated whole that is an essential component of the global life-support system and a positive asset that presents opportunities for sustainable development. International law … sets forth rights and obligations of states and provides the international basis upon which to pursue the protection and sustainable development of the marine and coastal environment and its resources". As pointed out by Cochrane *et al*. (2004) and Ward *et al.* (2002), a number of attempts have been made to translate this ideal into a practical and feasible approach, including those of the United States National Research Council (1999), the Convention of Biological Diversity and the World Wide Fund for Nature.

FAO (2003) developed an interpretation of these and other efforts in the form of a rationale and a definition. The rationale: "The purpose of an ecosystem approach to fisheries is to plan, develop and manage fisheries in a manner that addresses the multiplicity of societal needs and desires, without jeopardizing the options of future generations to benefit from the full range of goods and services provided by the marine ecosystem." And the definition: "An ecosystem approach to fisheries to balance diverse societal objectives by taking account of the knowledge and uncertainties about biotic, abiotic and human components and applying an integrated approach to fisheries within ecological meaningful boundaries". As recognized by Cochrane *et al*. (2004), the implementation of the EAF is likely to be slow, and many countries, agencies and individuals are still in the process of understanding and interpreting just what is intended by the term EAF. One agreement that is emerging from the discussion is the need to capture the human and ecological interdependencies relevant for wise management of coastal ecosystems (De Young *et al.,* 2008). This is particularly relevant in the context of small-scale fisheries.

Ecosystem considerations in assessment and management of coastal fisheries

Integrated management of marine ecosystems is an approach required to manage multiple and competing uses (including fish harvesting in this case) of certain designated marine areas, including managing multiple stakeholders. It also requires, like EAF, processes of participatory decision-making and conflict resolution. It requires estimation of externalities involved in using the ecosystem and valuation of the goods and services of the marine ecosystem. For the valuation of goods and services of coastal ecosystems, it is important to acknowledge that human welfare can be derived from them by direct use or by consumption of fish products, by recognition of the indirect value of a marine ecosystem ecological service to the production of other goods and services, by the use or consumption of goods and ecological services by future generations, and by the inherent existence of such goods and services (De Young *et al*., 2008).

Two aspects of ecosystems considerations that require attention are the time needed to learn and acquire knowledge on the ecosystem, including the knowledge from fishers, and the need to carefully assess the impacts EAF interventions may have over the distribution of benefits and costs. A recent expert consultation on the economic and social implications of EAF acknowledged that EAF objectives and principles needed to be revised and expanded to better reflect social, economic and institutional implications (De Young *et al.*, 2008). It has also been recognized that an understanding of EAF in the context of co-management and community-based management is a priority (Seijo, 2007).

Because of the greater uncertainties involved in considering ecosystem dimensions as opposed to the single species approach, application of decision theory to address situations of limited information seems to be the way to proceed while continuing to build appropriate ecosystem information systems. These require more extensive coverage of capacity building and also training mechanisms for applying EAF with appropriate parsimony.

Some of the main issues that will need to be dealt with in small-scale fisheries in the process of establishing ecosystem approaches for management are the following (Seijo, 2007):

- Changes in management measures to implement an EAF are likely to lead to potential conflicts with stakeholders; this reality needs to be considered and allowances made in the process of developing an EAF for specific fisheries.
- Data collection requirements are greater with the EAF than with single target species analysis of fisheries.
- In developing coastal states where it is already difficult to implement adequate data collection for single species, obtaining scientifically-valid data in support of fisheries management, following an ecosystem approach, could pose major problems.
- Costs of building and maintaining data collection and analysis systems for entire marine ecosystems and their users (i.e. artisanal and industrial fishers, eco-tourists and non-consumptive users) are likely to be substantial.
- Information costs may need to be paid for by the multiple users of the ecosystem in order to meet the basic requirements for implementing an operational EAF.
- Managing fisheries, while taking into account limited knowledge and uncertainties on biotic, abiotic and human components, will require the development of adequate monitoring approaches.
- The focus cannot be exclusively on biological monitoring but should also include the human dynamics involving institutional, economic and social dimensions.

Data and indicators for an ecosystem approach to fisheries

The complexities of managing fisheries within an ecosystem framework will require the best science available and sustained input of fishers who have valuable empirical knowledge of the marine ecosystem with which they interact. In the transition from single species management approaches to EAF, while there will remain an inevitable focus on collecting basic data for the economically most important species, fisheries assessments should also monitor: (i) changes in the abundance of their prey and predators through appropriate survey-based indicators; (ii) changes in those environmental factors of importance to their life histories; and (iii) social, economic and institutional considerations that bear on the goals of management, and affect its chances of success.

This broadening of management raises some practical research questions to be considered in managing small-scale fisheries with a scope that goes beyond the stock assessment of target species. For example: What are the critical habitat requirements for targeted marine resources and at what life stage and to what areas of restricted habitat do they apply? What is the variable extent and status of such critical habitats and how are these impacted by multiple human activities? What are the use and non-use values of the ecosystem where species are harvested by small-scale boats? How should the costs of ecosystem monitoring and surveillance be distributed among users and coastal states? These and other related questions could be addressed in the future to enhance the importance of ecosystem considerations in the management of coastal small-scale fisheries.

A fundamental step in the process of extending beyond the single species approach to fisheries management is that of building an operational and useful system of indicators and corresponding reference points. In order for fishery indicators to become more meaningful, they should explicitly account for changes in the ecosystem in which they occur, which can arise from such causes as climate changes, overfishing, environmental degradation due to human activities, or the destruction of critical habitats. Pikitch *et al.* (2004) note in particular that "...we need to develop community and system level standards, reference points and control rules similar to single species decision criteria".

It should be pointed out, however, as indicated by Sainsbury and Sumaila (2003), that before specifying indicators and reference points, there are two basic questions to answer: (i) Is there a need for explicit reference points for the ecosystem, such as food web dynamics, ecological community structure and biodiversity, or are species-based reference points sufficient? (ii) If ecosystem reference points are needed, should they be based on properties of the undisturbed coastal ecosystem? There seems to be an additional question: How to proceed in the absence of baseline studies of early stages of coastal development? The latter is a common situation in many LAC countries.

Spatial dimensions in an ecosystem approach

In managing fisheries cost effectively and in a way that maintains the integrity of coastal ecosystems, countries in the LAC region may have to incorporate spatial structure and dynamic environmental processes to properly account for changes in habitat and ecosystem function in the context of dynamic change.

Small-scale fishers respond spatially to resource distribution when allocating their fishing activity over space and time. This should be accounted for when assessing how small-scale fisheries are targeting species where seasonality in the spatial distribution of the resource is relevant, and when targeting sedentary resources with heterogeneous spatial distributions. In this respect, fishery indicators should be disaggregated over space and time to provide meaningful information to decision-makers. To progressively move in the direction of spatial management of fisheries, issues like the setting of an MPA with respect to source and sink areas would need to be considered (Ríos *et al.*, 2007; Seijo and Caddy, 2008).

3. CONCLUDING REMARKS

Coastal fisheries in Latin America and the Caribbean are remarkably *diverse*. As a result, there can be no "one size fits all" answer to the specifics of assessment or management. Instead, it is crucial to seek out broadly-applicable frameworks and approaches. Therein lies the importance of moving toward innovative governance systems, effective institutions, integrated assessment frameworks and broad-based ecosystem approaches, as described in this chapter.

Along with their diversity, coastal fisheries are also inherently *complex*. In developing frameworks and approaches for effective assessment and management of small-scale fisheries, we must acknowledge the human, ecological and technological interdependencies present in the multiple use of coastal ecosystems. This will often require expanding beyond single species thinking into multispecies and multifleet approaches (Van den Bergh *et al*., 2007). It is also important to take into account fisher decision-making in small-scale fisheries, the complexities of which include flexible switching of target species that may occur seasonally by artisanal fleets as a function of species availability (catch rates) and markets/demand. A third key source of complexity in coastal fisheries is spatial heterogeneity – this suggests the need to pay attention to spatially-explicit management, such as through seasonally-closed areas or permanently closed areas (marine protected areas) in areas of particular sensitivity, such as nursery grounds and critical habitats.

In seeking new directions to cope with the above-noted diversity and complexity in coastal fisheries, it was noted in Chapter 14, and emphasized throughout this chapter, that there is a need to broaden the perspective on management. This includes suitable governance frameworks (including development of alternative management schemes), more comprehensive fisheries assessments, as well as a framework for an Ecosystem Approach to Fisheries that is specifically relevant to small-scale fisheries management. These moves require incorporating social, economic and livelihood considerations and paying attention to capacity-building needs.

Suitable frameworks and approaches for assessment and management must focus on coping under conditions of uncertainty, through a systematic process over time. This could be envisioned as including several major steps, such as the following:

(i) Define fisheries management questions in the context of the multiple users of the marine ecosystem, and of relevant ecological and technological interdependencies among species, habitats and fisheries within the ecosystem.

(ii) Determine suitable performance variables (biological/ecological, economic, social, cultural and institutional) as well as corresponding performance indicators and their limit and target reference points.

(iii) Identify alternative management, co-management or community management strategies for the fishery within a coastal ecosystem context.

(iv) Design, adapt or select a suitable assessment framework within which to evaluate management alternatives; this may range from intuitive approaches through to dynamic models of ecologically and technologically interdependent fishery systems along with suitable collection of data to estimate model parameters.
(v) Identify the key sources of uncertainty and risk (including, where possible, states of nature in uncertain and sensitive parameters, and probabilities relating to these) and apply decision criteria that take uncertainties into account.

This process should be adapted and made as simple as possible to facilitate data collection systems and management frameworks that can progressively deal with the added complexities of decision-making implied by new governance systems and ecosystem approaches.

Attention to effective governance and healthy ecosystems, as highlighted in this chapter, is urgently needed in many coastal fisheries of the LAC region, facing a combination of difficult problems including depleted stocks, degraded coastal habitats, excessive catching capacity, a shortage of local livelihood alternatives, and a lack of empowerment among fishers and fishing communities to participate in management decision-making. As noted earlier, there is no magic answer to this set of challenges. However, as pointed out in a number of contributions in this document, there are some promising mitigating strategies to the overexploitation syndrome in coastal fisheries. Among those raised herein, related either to governance or to ecosystem well-being, are management measures such as: (i) community and co-management approaches; (ii) self-regulation and self-policing; (iii) increased use of habitat-friendly fishing methods and selective gear, to protect the ecosystem that sustains the fishery; and (iv) a systematic planning approach to capacity management, aiming to ensure a desirable 'mix' in the fishery. In combination, such measures have various implications; for example, capacity management in a multispecies fishery might favour maintaining small- to medium-sized multipurpose vessels, which would more easily allow for flexible switching among target species, reducing the incentive to fish depleted species and thus giving the stocks time to recover.

Whatever the particular management interventions – the choice of which will be context-specific – adoption of suitable policy frameworks and approaches, as outlined in this chapter, is crucial. These provide pathways that build on existing success stories, providing positive directions toward a future of sustainable and resilient coastal fisheries across LAC.

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16. Concluding thoughts: coastal fisheries of Latin America and the Caribbean

Anthony Charles*, Silvia Salas, Juan Carlos Seijo and Ratana Chuenpagdee

Charles, A., Salas, S., Seijo, J.C. and Chuenpagdee, R. 2011. Concluding thoughts: coastal fisheries of Latin America and the Caribbean. *In* S. Salas, R. Chuenpagdee, A. Charles and J.C. Seijo (eds). Coastal fisheries of Latin America and the Caribbean. *FAO Fisheries and Aquaculture Technical Paper.* No. 544. Rome, FAO. pp. 423–426.

This document has sought to accomplish three goals: (1) to highlight the diverse nature of coastal fisheries in the Latin America and the Caribbean (LAC) region; (2) to examine how these fisheries are currently assessed and managed; and (3) to explore future directions – in policy, management and assessment – that can improve the state of LAC fisheries. The first two of these goals have been met largely thanks to the impressive work of colleagues in twelve LAC countries, spread out across the region. The authors of our 'country chapters' have worked over the past several years to produce a body of material that together paints a picture of the wide range of coastal fisheries found in the region. This set of chapters in the document at the same time provides a strong base for the integrated analysis of fishery assessment and management in the region in Chapter 14 – an analysis which, to our knowledge, is a first for the region. Finally, the third goal of the document, to examine options for the future of LAC coastal fisheries, was met, we hope, in the discussions of Chapter 15, which focuses on linking global trends in fishery thinking with the specific realities of the LAC region.

The focus on coastal fisheries has represented another unique feature of this document. Throughout the document, such fisheries have included three main subtypes: subsistence fisheries, traditional fisheries (artisanal), and advanced artisanal (or semi-industrial) fisheries. While there are always differences in perspective – between analysts as well as among countries – over what constitutes each of these subtypes, the key distinction we have sought to make here is between coastal fisheries on the one hand and industrial or recreational fisheries on the other hand. Thus, while some coastal fisheries may involve more capital-intensive fleets than might be typically seen as 'small scale', there is, in many cases, a reasonable equivalency of coastal and small-scale fisheries. The importance of focusing on

* *Contact information*: Saint Mary's University, Halifax, Nova Scotia, Canada. E-mail: tony.charles@smu.ca

such fisheries has been increasingly highlighted on a global scale – for example, through FAO's Small-Scale Fisheries Conference (2008) and the forthcoming World Small-Scale Fisheries Congress (2010).

A key rationale for this focus on 'coastal' and small-scale fisheries lies in their typically close connections to coastal communities, and thus the crucial role they play in supporting community well-being and household livelihoods along the coasts of the LAC region. In Chapter 1, it was noted that "The major contribution to the region's total landings comes from pelagic species landed by the industrial fisheries", so in terms of quantities alone, coastal fisheries are not typically the biggest contributors. But the value added that comes from these fisheries goes far beyond the size of landings or of GDP figures. This reality calls out for new or enlarged measures of fishery contributions – ones that involve livelihoods, regional economic development, community welfare, and so on – if we are to properly understand the value of coastal fisheries globally.

As noted at the outset, the fishery information presented in this publication is certainly not exhaustive, since it reflects but a sample of the region's fisheries. However, the twelve countries included provide reasonable geographical coverage of Latin America and the Caribbean, including each of the main subregions:

- The Caribbean islands (Barbados, Cuba, Grenada, Puerto Rico, Dominican Republic, Trinidad and Tobago);
- North and Central America (Mexico, Costa Rica); and
- South America (Argentina, Brazil, Colombia, Uruguay).

Furthermore, as described in Chapter 14, our analyses indicate that the coverage herein does indeed reflect many issues and challenges shared by fisheries more widely in the region, especially regarding assessment and management. The overall state of coastal fisheries in the LAC region was described in Chapter 1, while Chapter 14 describes the broad features of coastal fisheries globally and the particular characteristics of such fisheries in each of the twelve countries covered in the document. Chapter 14 then summarizes both the fishery data available in each country (from catch and effort data through to institutional and benefit/cost information), as well as the management methods (from catch limits and access rights to gear restrictions and closed areas). There are clear indications of which forms of data, and which management approaches, tend to be most prevalent in the region – and which are less uncommon or even rare. A synthesis is provided of these results, including the extent to which each subregion (Caribbean, Central America and South America) has the four main forms of information discussed (basic fishery data, bio-ecological, socio-cultural and economic).

In exploring future directions for LAC coastal fisheries, Chapter 14 drew on the above analysis to highlight five specific fishery assessment and management approaches to improve the state of these fisheries:

1. Comprehensive fisheries assessment.
2. Building capacity for fishery data collection, assessment and management.
3. Incorporating social, economic and livelihood considerations.
4. Adopting alternative management schemes.
5. Promoting equity, rights and self-regulation.

Options for implementing each of these approaches in a coastal fisheries context were discussed in Chapter 14, while Chapter 15 moved to a broader policy analysis, noting that the five themes above all fit into two major policy frameworks being advocated globally as essential to the future of fisheries:

- Development of new innovations in fishery governance and institutional design.
- Adoption of an ecosystem approach to fisheries.

Chapter 15 explored these two major frameworks in some detail, with emphasis on how they can be effectively applied in the context of coastal fisheries management, particularly in the LAC region. It was noted that taking the right moves toward implementing these approaches, within an appropriate context, would increase the likelihood of success in efforts to improve the conditions of coastal fisheries across Latin America and the Caribbean.

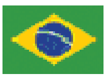
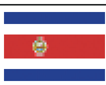
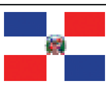
A recurring theme in this document has been the reality that effective assessment and management of small-scale fisheries – and the success of moves to meet governance and ecosystem challenges – must acknowledge the human, ecological and technological interdependencies present in the various uses of coastal ecosystems. This requires an appreciation of the goals, the motivations and the decision-making patterns of coastal fishers and communities.

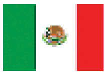
As a concrete example of this, consider the switching behaviour that fishers commonly practice among target species along the coast – often seasonally as a result of species availability, catch rates and markets. Such behaviour needs to be taken into account in analysis of these fisheries, as well as in management actions. From a policy perspective, it may be important (i) to allow fishers to change target species in relation to abundance and demand, to avoid the incentive to fish depleted species, and thereby give the stocks time to recover; and (ii) to encourage the fleets made up of small- to medium-sized multipurpose vessels that are capable of such flexible switching among species. It is also important to ensure that coastal ecosystems are kept healthy. Thus it is important that while encouraging switching behaviour, there is avoidance of unselective fishing gears and/or habitat-unfriendly gear. Finally, there may be a need to build bio-ecological safeguards as mechanisms to cope with the complexities of human activity on the coast – such as seasonal closures, technical measures to avoid capture of unwanted or protected species, and permanently closed areas (marine protected areas) in areas of particular sensitivity such as nursery grounds and critical habitats.

Such situations highlight the complex nature both of human uses along the coast and of coastal ecosystems. There is undoubtedly a challenge to be faced in the assessment and management of coastal fisheries, given that complexities such as these arise typically in situations where there are also major limitations on data availability – a reality that has been emphasized in Chapter 14 as well as throughout the country chapters of this publication.

Fortunately, however, the challenge is not insurmountable. Shifts in the directions summarized above – including appropriate governance arrangements and an ecosystem approach – can work successfully for the coastal fisheries of Latin America and the Caribbean, as well as those elsewhere, by drawing on a key strength – the capabilities of coastal fishers and coastal communities. Their energy, experience and local knowledge base make fishers and communities crucial partners in assessment and management, through participatory research and data collection, as well as community-based and co-management arrangements. This partnership with scientists and managers can help overcome the range of shortcomings in 'official' data sources and in conventional fisheries management. In small-scale fisheries around the world, and specifically in the LAC region, if governmental policy places value on (and shows respect for) the integrity and well-being of coastal fishers, communities and ecosystems, this will go a long way to ensuring the health of these coastal systems into the future.

List of contributors

 Argentina	Claudia Carozza	Instituto Nacional de Investigaciones y Desarrollo Pesquero
	Inés Elías	Centro Nacional Patagónico (CONICET)
	Edgardo E. Di Giácomo	Instituto de Biología Marina y Pesquerías "Almirante Storni"
	Miguel S. Isla	Secretaría de Promoción Económica y Fiscal
	J.M. (Lobo) Orensanz	Centro Nacional Patagónico (CONICET)
	Ana María Parma	Centro Nacional Patagónico (CONICET)
	Raúl C. Pereiro	Universidad del Trabajo del Uruguay (UTU)
	Raquel Perier M.	Instituto de Biología Marina y Pesquerías "Almirante Storni"
	Ricardo G. Perrottau	Instituto Nacional de Investigaciones y Desarrollo Pesquero
	María E. Ré	Centro Nacional Patagónico (CONICET)
	Claudio Ruarte	Instituto Nacional de Investigaciones y Desarrollo Pesquero
 Barbados	Patrick McConney	Centre for Resource Management and Environmental Studies, University of the West Indies
 Brazil	Daniela Coswig Kalikoski	Universidad Federal de Río Grande
	Antonio Carlos Diegues	Universidade Estadual de Sao Paulo (usp)
	Marcelo Vasconcellos	Universidade Federal do Rio Grande (FURG)
 Canada	Anthony Charles	Saint Mary´s University
	Ratana Chuenpagdee	Memorial University of Newfoundland
 Colombia	Claudia Stella Beltrán	Consultora Independiente
	Jacobo Blanco	Universidad del Magdalena
	Juan Carlos Narváez	Universidad del Magdalena
	Mario Rueda	Instituto de investigaciones Marinas y Costeras
	Efraín Vitolia	Instituto de investigaciones Marinas y Costeras
 Costa Rica	Angel Herrera-Ulloa	Universidad Nacional de Costa Rica
	Guillermo Oro-Marcos	Instituto Nacional de Aprendizaje
	José Palacios-Villegas	Universidad Nacional de Costa Rica
	Luis Villalobos-Chacón	Universidad Nacional de Costa Rica
	Rigoberto Viquez-Portuguéz	Universidad Nacional de Costa Rica
 Cuba	Regla Duthit	Centro de Investigaciones Pesqueras
	Luis Font	Centro de Investigaciones Pesqueras
	Rafael Puga	Centro de Investigaciones Pesqueras
	Mireya Sosa	Centro de Investigaciones Pesqueras
	Servando V. Valle	Centro de Investigaciones Pesqueras
 Dominican Republic	Liliana Betancourt	Programa EcoMar
	Alejandro Herrera	Programa EcoMar
	Patricia Lamelas	Centro para la Conservación y el Ecodesarrollo de la Bahía de Samaná y su Entorno
	Alba Melo	
	Miguel Silva	

 Grenada	Roland Baldeo	Fisheries Division, Ministry of Agriculture and Fisheries
 Mexico	Porfirio Álvarez-Torres	Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT)
	Enrique Arcos-Huitrón	Centro Interdisciplinario de Ciencias Marinas del IPN
	Francisco Arreguín-Sánchez	Centro Interdisciplinario de Ciencias Marinas del IPN
	Antonio Díaz-de-León	Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT)
	Pablo del Monte-Luna	Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT)
	José Ignacio Fernández	Instituto Nacional de la Pesca-SAGARPA
	Luís G. López-Lemus	Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT)
	Germán Ponce	Centro Interdisciplinario de Ciencias Marinas del IPN
	Silvia Salas	CINVESTAV del IPN
	Juan Carlos Seijo	Universidad Marista de Mérida
 Puerto Rico	David J. Die	Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science, University of Miami
	Daniel Matos-Caraballo	Puerto Rico Department of Natural and Environmental Resources
	Manoj Shivlani	Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science, University of Miami
	Mónica Valle-Esquivel	MRAG Americas, Inc., St. Petersburg, Florida
 Trinidad and Tobago	Christine Chan A. Shing	Ministry of Food Production, Land and Marine Affairs
	Lara Ferreira	Ministry of Food Production, Land and Marine Affairs
	Elizabeth Mohammed	Ministry of Food Production, Land and Marine Affairs
	Suzuette Soomai	Ministry of Food Production, Land and Marine Affairs
	Louanna Martin	Ministry of Food Production, Land and Marine Affairs
 Uruguay	Anita de Álava	UNDECIMAR, Facultad de Ciencias
	Omar Defeo	UNDECIMAR, Facultad de Ciencias and DINARA
	Sebastián Horta	UNDECIMAR, Facultad de Ciencias and DINARA
	Pablo Puig	DINARA

Editors' profile

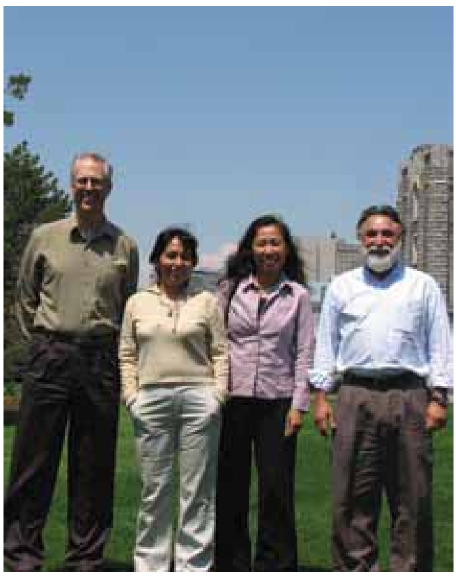
Dr Silvia Salas is a professor at the Yucatán research centre of the Centro de Investigación y de Estudios Avanzados (CINVESTAV) in Mexico. She has worked on various projects relating to bio-economic analysis and assessment of fisheries in Canada and Mexico, and has taught courses on fisheries biology and fisheries bio-economics in Mexico and Costa Rica. She is engaged in connecting research to management, ranging from coastal community initiatives to general management programmes, and by participating in advisory committees of governmental agencies in Mexico. She is a member of the advisory scientific board for the FAO WECAF region, and has participated as an expert in several scientific meetings organized by FAO. She has worked as a consultant for the National Commission of Fisheries in Mexico and the main oil company in Mexico, looking at different types of impacts of anthropogenic activities on fisheries. Her current research involves bio-economic analysis of small-scale fisheries, evaluation of fishing strategies of fishers, dynamics of fishing fleets and implications for management, as well as evaluation of perceptions concerning the use and management of coastal resources.

Dr Ratana Chuenpagdee is Canada Research Chair in Natural Resource Sustainability and Community Development at Memorial University of Newfoundland, Canada. Her research emphasizes interdisciplinary approaches to fisheries and coastal ecosystems management, focusing particularly on small-scale fisheries, marine protected areas, community-based management, food security and fisheries governance. Dr Chuenpagdee has developed two tools for integrated coastal management, i.e. the 'damage schedule approach' for non-monetary valuation of natural resources and the 'Coastal Transects Analysis Model' (CTAM), an online visualization and interactive decision-support software. As a member of the Fisheries Governance Network based in Amsterdam, the Netherlands, she has contributed to the production of the book *Fish for Life* as well as to the practitioner handbook *Interactive Fisheries Governance: A Guide to Better Practice*. Dr Chuenpagdee is also co-director of the Coastal Development Centre in Thailand, which serves as a secretariat for the Coastal Zone Asia-Pacific Association and is responsible for the organization of its biennial conferences.

Dr Juan Carlos Seijo is a professor of Fisheries Bio-economics at the School of Natural Resources, Marista University of Mérida, Mexico, where he was university president from 1996 to 2004. His academic work has been published in scientific journals that include *Marine Resource Economics*, *Journal of Aquaculture Economics and Management*, *Fisheries Research*, *Marine and Freshwater Research*, *Philosophical Transactions of the Royal Society*, among others. He is author and co-author of three documents in his field of specialization, and is currently working on spatial modelling and management of marine fisheries, and risk and uncertainty in fisheries associated to climate change. He has taught specialized courses in fisheries bio-economics in Chile, Peru, Uruguay, Taiwan Province of China, Colombia, Venezuela (Bolivarian Republic of), Panama, Trinidad and

Tobago, Costa Rica, Cuba and Guatemala, and has participated in a number of international expert consultations. He is currently Chairman of the Scientific Advisory Group of WECAFC (Western Central Atlantic Fishery Commission of FAO), Board Member of the International Institute of Fisheries Economics and Trade (IIFET) and President Elect of the North American Association of Fisheries Economists (NAAFE).

Dr Anthony Charles is a professor of Management Science and Environmental Studies at Saint Mary's University, in Halifax, Nova Scotia, Canada, where he focuses on interdisciplinary research in fisheries and coastal management. Dr Charles' work ranges from fishery policy analysis, to socio-economic studies, to bio-economic modelling of fishery and aquaculture systems. Current research interests include community-based fishery management, integrated fishery and marine indicators, and analysis of sustainability approaches in fisheries. He is the author and co-author on a range of publications, including the documents: *Sustainable Fishery Systems* (Blackwell Science), *Integrated Fish Farming* (CRC Lewis) and *Community Fisheries Management Handbook* (Gorsebrook Research Institute). Dr Charles has a longstanding interest and involvement in fishery, aquaculture and coastal projects in developing regions, notably Latin America and the Caribbean. He has worked as a visiting scientist with FAO, as a consultant with FAO and OECD, as director of Canada's Ocean Management Research Network, and as an adviser to community fishery organizations and to First Nations in Atlantic Canada. Dr Charles has received a Pew Fellowship in Marine Conservation and a Gulf of Maine Visionary Award in recognition of his work.



From left to right: Anthony Charles, Silvia Salas, Ratana Chuenpagdee, Juan Carlos Seijo.

This state-of-the-knowledge document examines the assessment and management of coastal small-scale fisheries in Latin America and the Caribbean (which are inherently interdisciplinary and integrated in approach), covering biological, socio-economic and policy aspects. It includes an introductory overview chapter, a set of 12 chapters each examining fisheries of a particular country, and two major conceptual and analytical synthesis chapters. The country chapters cover the main subregions of Latin America and the Caribbean: the Caribbean Islands (specifically Barbados, Cuba, Dominican Republic, Grenada, Puerto Rico, Trinidad and Tobago), Central America (Costa Rica, Mexico) and South America (Argentina, Brazil, Colombia, Uruguay). The analysis in the document contributes to a better understanding of these coastal fisheries, of the information available on them, of the gaps that exist in fisheries assessment and of trends in fisheries management. Through its knowledge sharing, the document will lead to more effective approaches to managing coastal fisheries in the region, as well as identification of priorities for information collection and research – thus leading to more sustainable fisheries across Latin America and the Caribbean.

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