CHAPTER 7.
FISHERIES SECTOR

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This report seeks to highlight the economic contribution of biodiversity conservation and ecosystem services to development and equity in the Latin American and Caribbean region, hence, making an economic case for mainstreaming biodiversity and ecosystem conservation into national policies and development strategies.

7.1 INTRODUCTION AND OBJECTIVES

The fisheries sector is economically important in Latin America and the Caribbean (LAC), contributing to food security, employment, domestic income, foreign exchange earnings, and fiscal revenues. Fisheries are especially important to the livelihoods of the poor in coastal regions or near inland waters in LAC.

Fisheries depend, in turn, on the natural services provided by ecosystems, from provisioning of habitats critical to each life stage of targeted species and the food chains that sustain them, to regulation of ambient conditions and maintenance of essential metabolic, growth, and reproduction processes. Degradation or loss of such ecosystem services contributes to fisheries depletion or collapse, especially under pressure of overfishing.

The pattern of marine fisheries development in LAC parallels that in the rest of the world. Marine capture fisheries production has probably reached a plateau, despite increases in fishing capacity (FAO 2008). Further development is, thus, likely to be achieved through rebuilding depleted fisheries, restoring essential habitats, and increasing economic efficiency (Hilborn et al. 2003; Worm et al. 2009; World Bank 2009).

Recognizing this, several countries in LAC have started to reorient their fisheries toward sustainable ecosystem management (SEM). The goal of SEM in fisheries is to generate optimal sustainable yields, while safeguarding the capability of ecosystems and biodiversity to provide the ecosystem services (ES) upon which fisheries and other economic activities depend. The SEM approach involves investing in natural capital for fisheries, by maintaining or restoring the productivity, structure, and function of aquatic ecosystems. Maximizing economic rather than biological yields in fisheries will generally require larger stock biomass, meaning that economic and ecological objectives often point in the same direction (Grafton et al. 2006).

In many fisheries around the world, responsible management has succeeded in reducing excessive exploitation, in rebuilding depleted fisheries, and in sustaining those that contribute to national economies (Worm et al. 2009). There is growing consensus about the policy frameworks and management tools required, especially for high-value industrial fisheries. Several countries in LAC are at the forefront of developing and adapting these tools and approaches. A major challenge in the region is that many economically-important fisheries are characterized by large numbers of small vessels targeting multiple species. The tools that have been developed for industrial fisheries management are less well-suited to these small-scale fisheries. Several countries in LAC are pioneering new approaches and tools for managing them.

The goal of this chapter is to foster further progress towards\ SEM by providing policy makers with information on the economic value of taking an ecosystem approach to fisheries management. Case studies are used to highlight the economic costs of Business as Usual (BAU), the potential net benefits of moving toward SEM, and key policies and strategies for transition. In doing so, the focus will be on marine-capture fisheries as opposed to freshwater ones and aquaculture systems, which also offer many examples.

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The BAU approach in fisheries refers to management strategies that maximize short-run returns without considering external or long-run costs. Research shows that BAU practices deplete fish stocks and degrade essential fish habitat and other key ES, leading to loss of economic value. This situation undermines the long-term, ecosystem-wide economic potential of fisheries and related resources. In addition, BAU has direct costs, in terms of lost yields, and indirect costs associated with fishing overcapacity, subsidies, and illegal or unregulated (IUU) fishing. Furthermore, BAU does not take into account external impacts on broader ecosystem function and services, nor on other economic and non-economic activities and values (like coral reef-based tourism and social norms on biodiversity preservation).

Key Findings

The chapter examines the contribution of responsible fisheries management to key facets of development:

- **Depleted fisheries can be rebuilt under SEM** (usually); production is higher following rebuilding and the risks of collapse are lower than during the overfishing that led to depletion.
- **Returns on investment** are expected to rise as SEM maximizes economic yields and reduces fisheries overcapacity and over-investment, avoiding unbridled, self-defeating competition under BAU.
- **Employment** may rise or fall under SEM depending on the situation. Fisheries with overcapacity may see an interim reduction followed by restructuring in favor of fewer but more permanent, stable jobs.
- **Fiscal impacts** will depend on measures to recover fisheries management costs and to capture part of the increases in economic rent.
- **Equity** will be served by stakeholder engagement at all levels, more transparent decision-making, and, in some cases, by co-management of common property resources — all enhancing sustainability of ES.

Where possible, this chapter develops comparative scenarios of the future of specific fisheries under BAU versus SEM. The text highlights a series of steps to develop the policy framework and sustainable management strategies that can support further transition toward SEM in LAC fisheries, maximizing the economic value of marine ES in the fisheries sector.

Specific observations include the following:

- The role of fisheries in LAC and their economic relevance is substantial: contributions to GDP, exports, employment, food security, fiscal revenues, and social safety nets. In 2004, four countries derived more than $2 billion annually from fisheries, and five more over $100 million, playing a part in industrial development as well as in the livelihoods of many impoverished communities.
- Maintenance of the ecological services and habitats that allow targeted stocks to thrive, along with the ecosystems that support them, is a critical consideration in fisheries governance.
- A number of countries have begun to reorient their fisheries toward SEM to improve and sustain yields while safeguarding the capability of ecosystems to provide the services upon which fisheries and other economic activities depend.
- Responsible management of single species and multi-species fisheries is integral to SEM. SEM builds on the FAO Code of Conduct for Responsible Fisheries and the Ecosystem Approach to Fisheries, widely accepted as the appropriate framework to manage marine-capture fisheries. This can include temporary or spatial refugia.
- Fisheries managers and authorities can compare current versus potential sustainable economic rent for fisheries to identify promising candidates for transition to SEM.
- Maximizing economic yields and reducing risks in fisheries generally requires larger stock biomass than maximizing biological yields. Economic and ecological goals both point in the same direction.
- A major challenge is that many fisheries are composed of large numbers of small vessels targeting multiple species. Some tools that have been developed for industrial fisheries management are less well-suited to small-scale fisheries. Several countries in LAC are pioneering alternative approaches and have developed innovative and effective tools for managing small-scale fisheries.
- When access to fisheries resources is insecure, fishers have strong incentives to maximize short-term profits, often leading to overfishing, development of overcapacity, and a 'race to fish' — both economically wasteful and destructive of ecological services. Catch shares, territorial use rights and related management systems are designed to provide actors with greater security over resource access and, hence, incentives to invest in maintaining or restoring stocks.
- The LAC region is home to a wide variety of catch share systems, with examples in Argentina, Chile, Mexico, and Peru among others. These approaches often require legislative

change but result in sustainable benefits: increased catches, improved economic performance, and steady livelihoods for fisher populations and coastal communities.

7.2 CONTRIBUTION OF FISHERIES TO NATIONAL ECONOMIES IN LAC

Fisheries are a vital part of the natural resources sector in LAC, contributing to gross domestic product (GDP), employment, food security, and the livelihoods of the poor. LAC is one of the world's most important fishery regions, with Peru the second largest fish producer in the world, and Chile also regularly in the top ten. Brazil features in the top ten inland capture fisheries (FAO 2008).

Gross Domestic Product (GDP)

In 2004, fisheries in Chile, Mexico, Colombia, and Brazil contributed more than $2 billion to GDP, and in Venezuela, Panama, Argentina, Guyana, and Peru, more than $100 million (Catarci 2004; Tietze et al. 2006; FAO 2008; World Bank 2008). The relative importance of fisheries to national economies is reflected in their contribution of 1% or more of GDP in 11 of the 25 LAC countries for which data are available (Figure 7.1, Appendix 7.3). Fisheries contribute 6.3% of GDP in Ecuador, 5.0% in Belize, 3.9% in Colombia, 3.2% in Chile, and 2.0% or more in the Bahamas, Grenada, Guyana, Panama, Peru, and St. Vincent and the Grenadines. National statistics may conceal the contribution of fisheries at a sub-national level. For example, fisheries account for 0.8% of Mexico's GDP, but 2.3% of GDP in the state of Sonora (FAO n.d.; FAO 1996). Most of these contributions to GDP have been made under BAU management practices.

Structure of the Fisheries Sector in LAC

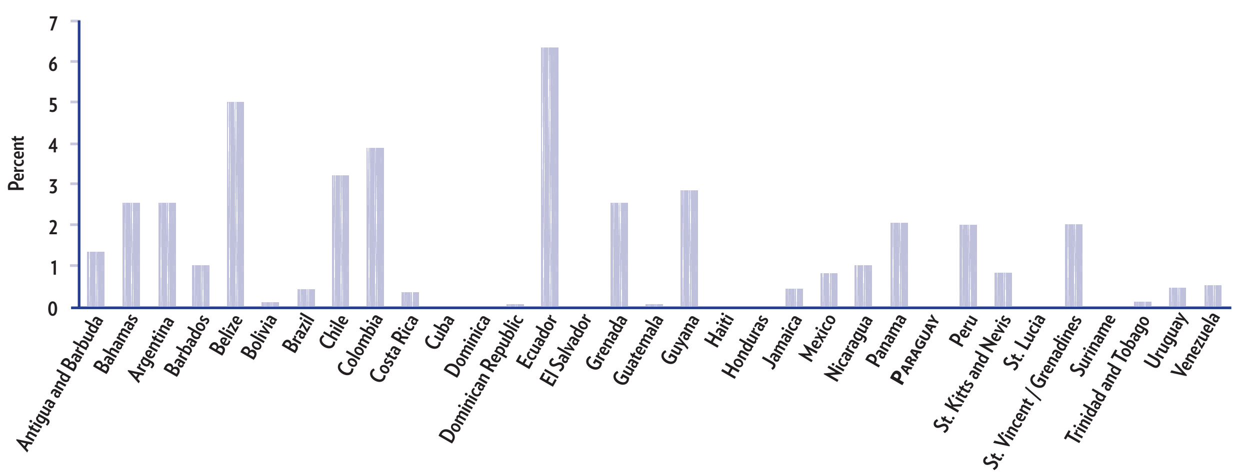
Fisheries production in LAC is dominated by marine pelagic capture fisheries: anchovy, sardines, and other schooling fish. These species provided 85% of regional production by volume in 2004 (Figure 7.2), primarily as raw material for the production of fish meal and oil (FAO 2004). However, lower volume fisheries may have higher values, as is reflected in Figure 7.3.

Demersal, pelagic, and shrimp fisheries each contribute one fifth or more of total value, followed by lobster and crab, benthopelagic, and cephalopod fisheries (Figure 1.2.3). This pattern varies by country. Pelagics are the most important contributor by value in Peru and Chile; benthopelagics in Argentina; demersals in Uruguay and Brazil' demersals and shrimps in Guyana, Venezuela, and Colombia; shrimps in Mexico, Guatemala, Honduras, and Costa Rica; lobster and crabs in Cuba, the Bahamas, and Nicaragua; and reef fish in Grenada, and St Kitts and Nevis (SAUP Database). The different fisheries present distinct challenges from both an ecological and management perspective (Table 7.1).

Foreign Exchange Earnings

Fisheries are major generators of exports in some LAC countries. In 2007, fisheries products contributed more than $3 billion to exports in Chile and more than $1 billion in Argentina, Ecuador, and Peru (FAO 2008). The share contributed by fisheries to total merchandise exports highlights their importance to a range of countries. In

Figure 7.1. Percentage Contribution of Fisheries Sector to GDP



Source: Fishery and Aquaculture Country Profiles http://www.fao.org/fishery/countryprofiles/search/en [multiple years]

Figure 7.2 Catches by LAC Fleet in Their Own EEZs *by Volume (tons)

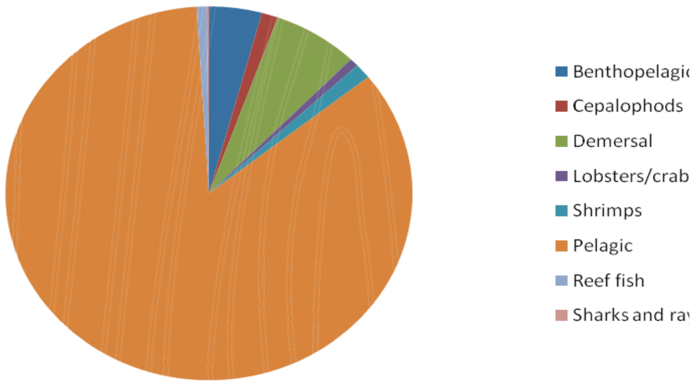
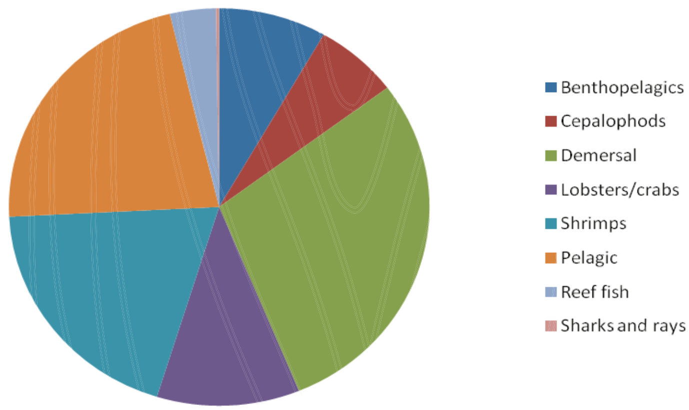


Figure 7.3 Catches by LAC Fleet in Their Own EEZs *by Value ($ of 2000)



2006, fisheries contributed 33% of merchandise exports in Panama and between 10% and 16% in the Bahamas, Belize, Ecuador, Grenada, Guyana, and Nicaragua (Figure 7.4).

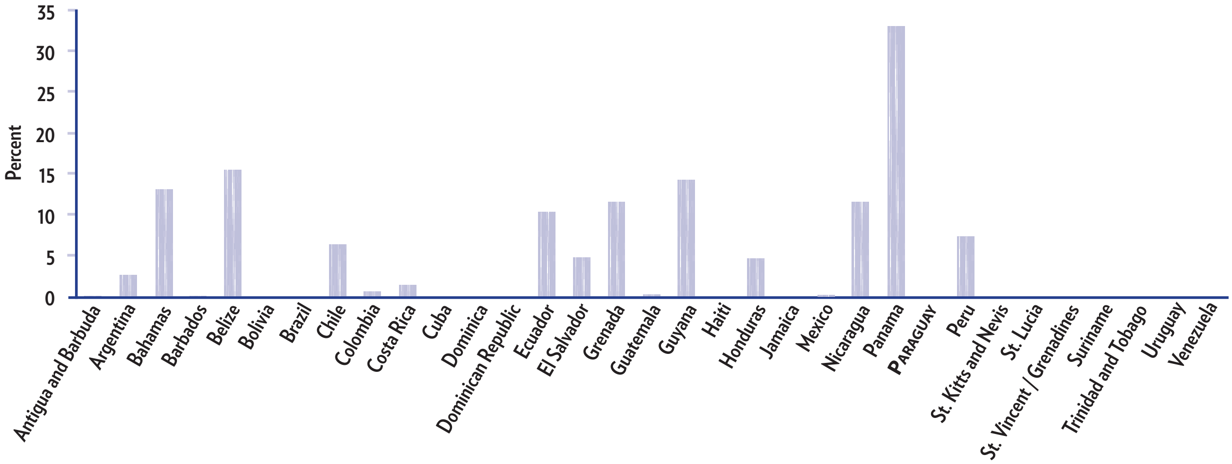
Employment

Across the region, fisheries provide about 1% of total employment; they employ more than 5% in Dominica, Suriname, St Vincent and the Grenadines, Brazil, the Bahamas, and Guyana (Figure 7.5). In 2008, this represented over 1.64 millions jobs directly in the sector and an additional 731,000 in associated secondary employment (table and sources in Appendix 7.4). More than 1 million are employed in fisheries in Brazil, and over 100,000 in each of the fisheries of Mexico, Chile, Peru, Ecuador, and Argentina. Total employment may be underestimated, given evidence that for each fisher, three persons are employed in processing, marketing, or distribution (Macfadyen and Corcoran 2002 cited in Reid et al. 2005). Nor is

Table 7.1. Challenges to Different Types of Fisheries

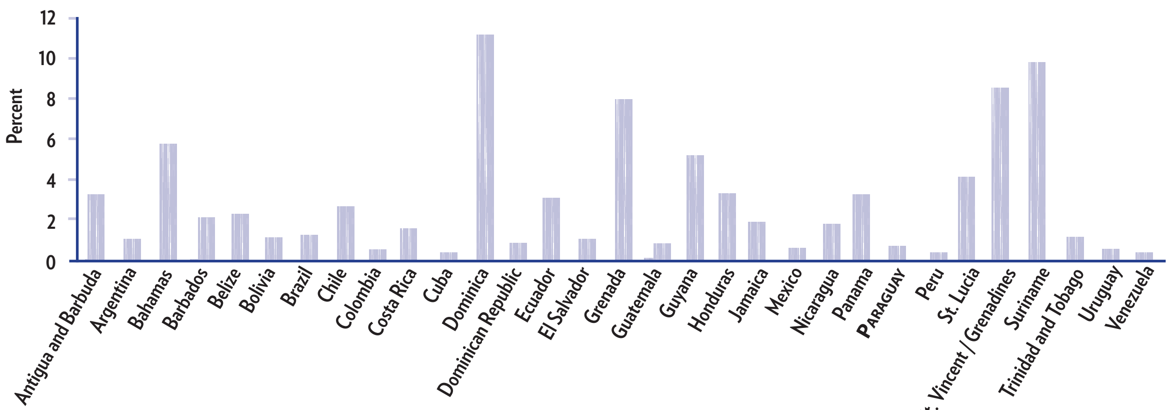
Fishery Resource	Major Concerns
Demersals (e.g., hake, grouper) [= bottom dwellers]	Threats to spawning and recruitment through overfishing Degradation of habitat and ecological services, especially in reef fisheries
Pelagics (anchoveta, sardinella, jack mackerel) [= swimmers in the water column]	Threats to recruitment through overfishing
Benthopelagics (Chilean seabass) [= deep swimmers]	Often slow-growing and long-lived so vulnerable to overfishing
Shrimp (crustaceans)	Loss of essential nursery habitat and ES; impacts of by-catch/discards on other fisheries and impacts of trawling on essential fish habitat
Lobster and crab (crustaceans)	Threats from loss of nursery habitat; overfishing
Cephalopods (squid, octopus)	Threats from destruction of spawning habitat and structures, especially for restricted range species

Figure 7.4 Fishery Exports as a Percent of Total Merchandise Exports (2006)



Source: FAO 2007?

Figure 7.5 Employment in Fisheries Sector as a Percent of Total Employment



it clear how the 2.4 millions jobs listed are split between industrial and small-scale fisheries. A separate, perhaps overlapping source estimates over a million employed in the small-scale sector (Appendix 7.4). The informal economy may also have additional fisheries jobs, especially part-time or seasonal, not reflected in those figures. Clearly, many more people are engaged in fishing in the region than there are formal fisheries jobs.

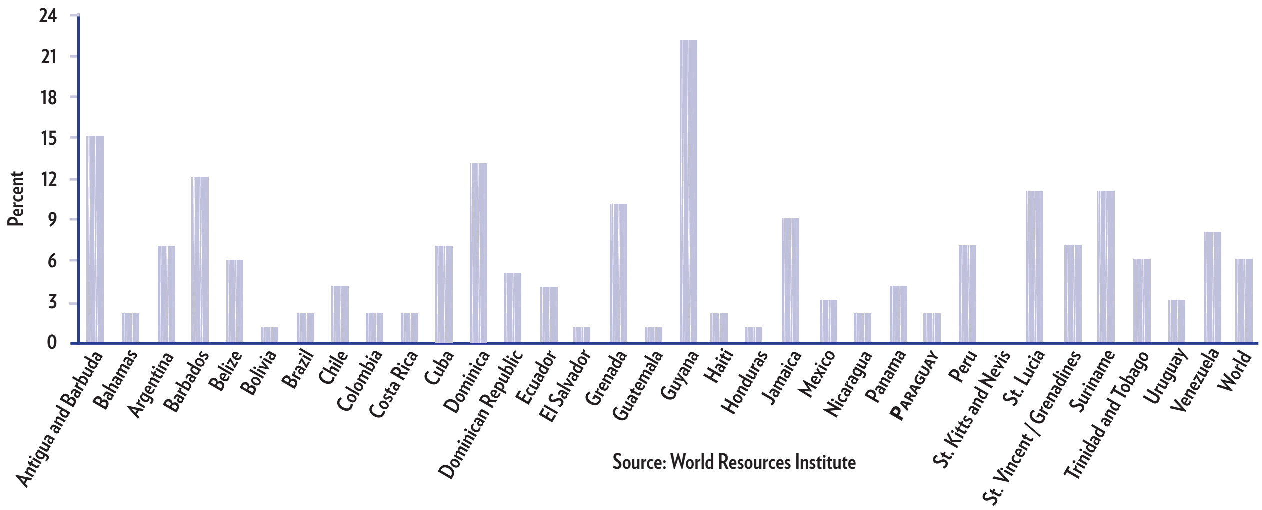
Employment. Small-scale fisheries tend to be labor intensive (FAO 2005). In a study of Pacific marine capture fisheries, FAO (2007) found that small-scale fisheries involved 2.5 times more participants per unit of product than large-scale fisheries. In the 22 LAC countries with data available, there are approximately 1.035 M small-scale fishers (Chuenpagdee et al. 2006). Many of these fishers work in fisheries on a part-time or temporary basis to supplement other food and income sources. Fishing as a secondary or complementary activity, including seasonal fishing, is essential to many rural and coastal households (FAO 2005). These opportunities are particularly important if they are a main source of food or cash to households, or if they come in periods of low labor demand for other activities such as agriculture.

Food Supply

Fisheries provide an important contribution to food supply at the national level. In 13 of 33 LAC countries for which data is available, the percentage of protein supply from fish products equals or exceeds the world average of 6% (Figure 7.6). Global population growth and corresponding increases in demand for food suggests that the need to build food security may be expected to continue (FAO 2005).

Food Security. Worldwide, fish can exceed 25% of the total animal protein used in the poorest countries, reaching as much as 90% in isolated inland and coastal areas. Fish is particularly valu-

Figure 7.6 Fish Protein as a Percentage of Total Protein Supply (2000)



Source: World Resources Institute

able where other sources of animal protein are scarce or expensive (FAO 2005). Small-scale fisheries often supply local markets as well as support subsistence consumption (Thorpe et al. 2000). Poor households may sell much of their catch and use the cash to purchase cheaper foods. Increases in fish prices, attributable to rising demand, will benefit households that are net producers of fish, but will harm those that are net consumers.

Global increases in aquaculture production, though significant, have not offset the stagnation in total fish production (Liu and Sumaila 2008). Excluding China, population growth has outpaced the growth of total food fish supply, resulting in a decrease in per capita fish supply (FAO 2002). Stable or declining catches in the face of growing demand have led fish prices to rise dramatically in some local markets, placing an essential source of protein out of reach for many low income consumers (Ovetz 2006).

Fisheries as Factors in Poverty Allieviation

There have been growing efforts to understand poverty and vulnerability in fishing communities and the potential of fisheries to contribute to poverty alleviation. Research has focused on small-scale fisheries, with little data on poverty among industrial fishery workers. Small-scale fishers are vulnerable because of the unpredictable nature of fishing and because most of these fishers lack tenure over the resources they exploit. Many small-scale fishing communities are remote and isolated, with limited access to basic infrastructure, capital, and technology, and few economic alternatives (FAO 2005). Many small-scale fisheries in LAC are being degraded rapidly; concern about overfishing is widespread (Chapman et al. 2008). Small-scale fishing communities, traditionally reliant on near-shore marine resources, are affected by reduced access to seafood for subsistence, underemployment, and income reduction (Defeo and Castilla 1999).

On the other hand, well managed small-scale fisheries can contribute to poverty reduction by generating prosperity at the household level or by acting as an engine for local economic growth (Thorpe 2005; FAO 2005). Small-scale fisheries can be economically efficient and generate jobs and profits. For example, the spiny lobster (*Panulirus argus*) fishery along the Yucatan Peninsula represents one of the world's most important artisanal fisheries (Defeo and Castilla 2005). Modernization, technological innovation, and export orientation have become features of many small-scale fisheries in recent years. In Chile, Argentina, Mexico, and Costa Rica, small-scale fishers directly export their products (FAO 2005).

Fisheries can be an important source of food security, employment, cash income, and improved equity for impoverished populations in coastal areas and near inland water bodies (FAO 2005).

Gender Equity. Fisheries jobs can employ women as well as men in both the harvesting and processing sectors (FAO 2005). In the state of Bahia, Brazil, approximately 20,000 women harvest shellfish for sale. Women represent 39% of labor employed in Chile's industrial fishing sector (Gallardo Fernández 2008).

Fisheries as a Safety Net. Small-scale fisheries, like other open access or common property resources, can provide an important safety net that may be critical to a large proportion of the poor in coastal and rural areas. In these cases, open access is the key factor that enables fisheries to fulfill this safety-net function (FAO 2005). This has implications for the design of systems to provide more secure tenure in small-scale fisheries. For many fishing communities, diversification of target species is an important risk management strategy for maintaining income and employment in the face of variable resource availability.

7.3 DEVELOPMENT AND CURRENT STATUS OF FISHERIES IN LAC

Development of fisheries in LAC Under BAU

World production from capture fisheries leveled off in the late 1980s, despite technological advances and increases in fishing effort (Hilborn et al. 2003; Gelchu and Pauly 2007). The data suggest that marine capture fisheries production has reached a maximum (FAO 2008). For marine capture fisheries, further development is most likely to be achieved through rebuilding depleted fisheries, investing in the natural capital on which productivity depends, and increasing the economic efficiency of fishery exploitation (Hilborn et al. 2003; Worm et al. 2009; World Bank 2009).

Available data on fisheries production in LAC are consistent with this global pattern. In LAC, fisheries development was limited until the post-war period, when increasing world demand for fish products stimulated investment in export-oriented fisheries in some places (Gelchu and Pauly 2007). Fisheries development was further advanced by the establishment of Exclusive Economic Zones (EEZs) in the 1970s, with substantial government investment and subsidies in many countries (Khan et al. 2006; Gelchu and Pauly 2007; Abdallah and Sumaila 2008). But this expansion led to the collapse or near-collapse of several fisheries, including the Peruvian anchoveta, Brazilian sardinella, and Argentinean hake, among other fisheries (Christy 1997). The volume of fisheries production in LAC expanded steadily through the 1980s, peaked in the 1990s, and has been stabilizing or declining thereafter (Figure 7.7) (Thorpe et al. 2000). The sector has been built largely under BAU conditions and practices. Since this led to collapse of a growing number of fisheries, a shift toward SEM approaches has occurred in some cases, usually focused narrowly on particular stocks. In other cases, adjustments were made within the BAU scenario, such as serially depleting species down the trophic chain.

Box 7.1. Fisheries sub-sectors in LAC

The fisheries sub-sectors of LAC economies are characterized by a diversity of scales of operation and modes of organization. Jopia and Yazigi (2009) describe the main sectors in Chile in terms that are broadly applicable to the entire region (to which recreational and sport fisheries have been added):

Industrial Fisheries. Purse-seine, trawl, long-line, or other harvesting operations that use boats and equipment that exceed a threshold size (e.g., for Chile, the industrial sector is characterized by the use of vessels with a hold capacity above 50 t and a length over 18 m). Large corporate fishing enterprises often co-exist with single vessel owners.

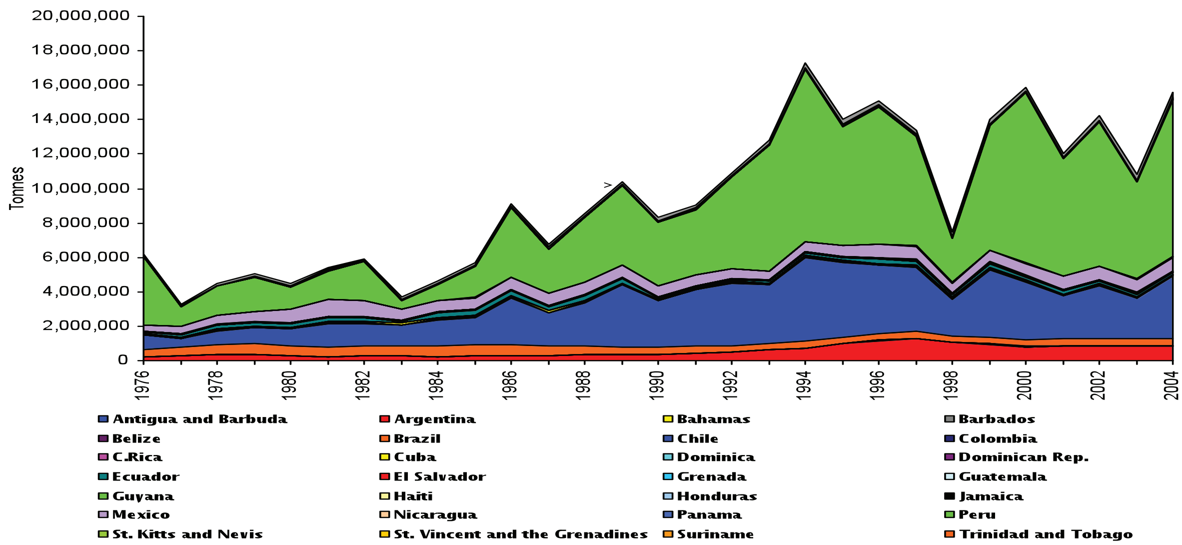
Small-scale Fisheries. Small-scale or artisanal fisheries are generic terms for fishing operations not classified as industrial. They cover a range of activities from subsistence to commercial fishing, from individuals gathering shellfish to multi-vessel fleets using a variety of technologies. Small-scale fisheries may include owners with multiple vessels, but they typically have local ownership. Some are traditional indigenous fisheries; many operate in the informal sector. They are often constrained by limited access to technology and capital. While industrial fisheries contribute the mass of fishery production in the region, some 90% of the region's fishers are small-scale (Reid et al. 2005; Chuenpagdee et al. 2006). Small-scale fisheries often present challenges for fisheries managers due to the large number of small vessels operating out of numerous harbors, often targeting multiple species.

Recreational and Sport Fisheries. These make significant contributions to local income and employment in some places, as well as contributing to foreign exchange earnings through international tourism.

Processing. The processing sector is defined as all 'facilities where raw materials (coming from fleet catches and aquaculture) are changed into final or intermediate products.' The largest and most capital intensive processing operations in Chile are the fishmeal factories. Processing for human consumption is generally more labor intensive. In many cases, processing is vertically integrated with harvesting.

Support Services. Fisheries rely on suppliers of a wide range of products, transport, and marketing services, and other inputs that are not identified as part of the fishery sector. The need for sustainable fisheries and ecosystem management involves government agencies, technical advisory groups, and NGOs as well.

Figure 7.7. Volume of Catches by LAC Fleet in Their Own EEZs (tons)



Source: Sea Around Us Database.

The inherent volatility of the anchoveta fishery can make fisheries time series difficult to interpret, but the long-term smoothed pattern is similar with or without Peru. The value of fisheries production shows a similar pattern from 1976 to 2004, albeit with slower growth and less apparent variability (Figure 7.8).

Figure 7.8. Dollar Value of Catches of LAC Fleet in Their Own EEZs

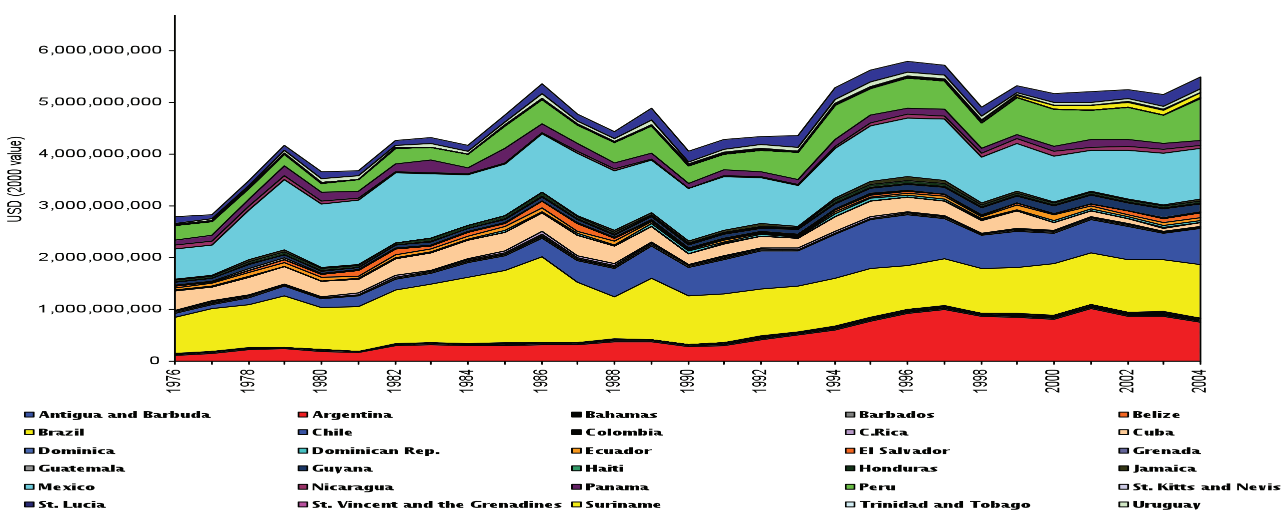


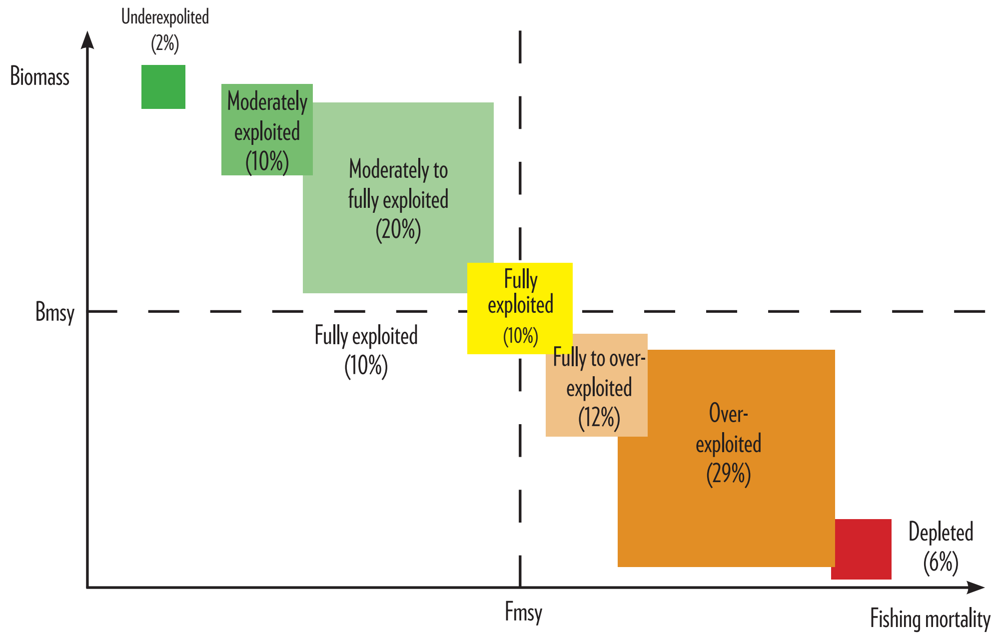
Figure 7.7. Volume of Catches by LAC Fleet in Their Own EEZs (Regional fishing effort roughly doubled from 1970 to 1996, leading to concerns about over-capacity and over-capitalization in many fisheries (Gelchu and Pauly 2007). In 1995, the largest fishing fleets in the region by tonnage were held by Mexico, Panama, Peru, Argentina, and Chile.

Current Status of Fisheries in LAC

There are several ways to evaluate the status of fisheries, each with its limitations (Hilborn et al. 2003). Examining trends in landings alone can be seriously misleading (Worm et al. 2009). Apparent stability in landings may mask sequential depletion of individual stocks (Hilborn et al. 2003); whereas changes in landings may reflect changes both in the availability of fish and in fishing effort. Availability likely depends on a combination of past fishing mortality and variable environmental conditions. Fishing effort responds to changes in technology, economic incentives, regulation, and net revenue from previous periods. There is wide variation among species in landing trends; no two species have trajectories alike.

Stock assessments and fishery-independent surveys provide more reliable insights into stock status than landing data alone (Worm et

Figure 7.9. Status of 49 selected fisheries in LAC



Source: After Garcia and Newton 1995, using data in Appendix 5, Status of fisheries in LAC.

al. 2009). Another widely-used approach is to assess the portion of fisheries that are overfished. In LAC, of 49 stocks for which data are available (Appendix 7.5), 2% are considered under-exploited and 10% moderately exploited, with some potential for increased production. About 30% of stocks are moderately to fully exploited, and, therefore, close to their maximum sustainable limits, with a further 12% fully to overexploited. About a third (35%) of fisheries are overexploited or depleted, while 10% are recovering (Figure 7.9). These percentages imply that in the long-term, higher catch levels in these fisheries could be achieved with less fishing effort, and some inputs could be used otherwise. With most fishery resources fully exploited or overexploited, opportunities for development lie primarily in restoring depleted stocks and harvesting all stocks more efficiently (Hilborn et al. 2003).

These LAC data are mainly for industrial fisheries for which stock assessments have been conducted; thus, the data are not representative of all the fisheries in the region. (See Appendix 7.5 for information on specific fisheries and data sources.). Also this data is 15 years old and evidence suggests that the current situation of stock is significantly worse than in 1995. Stock assessments do not provide direct information on the economic and environmental impacts of current fishing rates; these may vary significantly among fisheries (see Hilborn 2007 for further discussion). In terms of economic impacts, sector data, such as the contribution of fisheries to GDP and to exports, reflect the economic importance of fisheries but do not provide insight into their economic health (Hilborn et al. 2003). A better approach is to estimate the difference between actual and potential economic rent in specific fisheries (Hilborn 2007; World Bank 2009). (See Part II of this chapter for some examples, and Part III for recommendations on assessing the ecological effects of fisheries.)

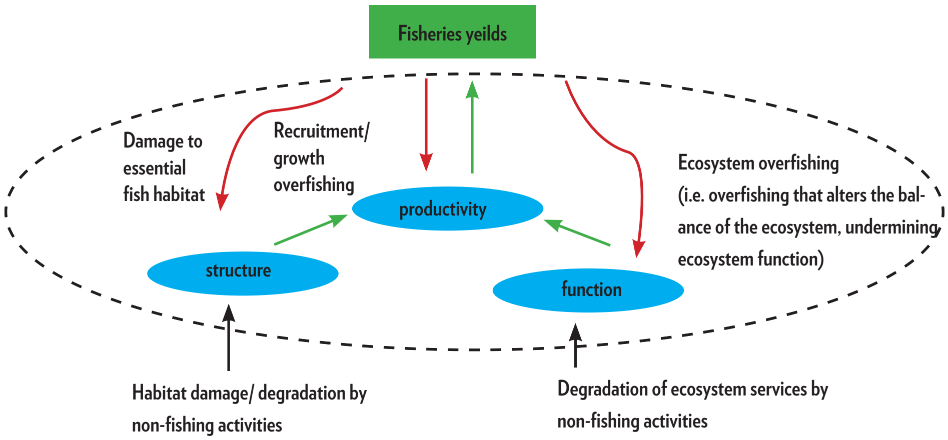
7.4 BUSINESS AS USUAL VERSUS SUSTAINABLE ECOSYSTEM MANAGEMENT

Business as Usual (BAU)

BAU fisheries are those that focus on maximizing short-term gain, externalizing impacts that are long run, indirect, or off the production chain. Thus, these practices tend to deplete fish stocks and degrade essential fish habitat and key ES, leading to loss of economic value. Figure 7.10 outlines some of the feedback loops that effect productivity and yields, including the negative ones (in red) from overfishing, habitat damage, and the undermining of ecosystem function.

Typically, natural resources are exploited at a level that undermines the productive potential of the fishery, drives the fishery to overexploitation, and/or prevents recovery. Depletion of natural capital in fisheries imposes economic costs on society through lost yields and reduced employment, income, and food security. The underlying causes of resource depletion in BAU fisheries include fishing fleet overcapacity, subsidies that stimulate the development of overcapacity and/or excess fishing effort, and a failure to control illegal,

Figure 7.10. Business As Usual In Fisheries: Feedback Loops



unregulated, and unreported (IUU) fishing. These underlying factors generate additional economic costs to society. BAU practices in fisheries can undermine ecosystem structures and functions by overfishing, damaging essential fish habitat, and by weakening ecosystem services. This leads to negative feedback loops that undermine the productivity of the resource and threaten future yields of the exploited stocks and others. Threats to ES upon which fisheries depend may also derive from outside the sector, as where land-use change leads to sedimentation or eutrophication. Combined, these costs and threats entail a strong mandate on fisheries authorities and national governments to address BAU fisheries to ensure that they remain net contributors to national wealth rather than drains on society (World Bank 2009).

This definition of BAU does not imply that all fisheries in LAC meet this description — BAU refers to poorly-regulated fisheries at the opposite end of the spectrum from SEM, rather than a uniform status quo. Several countries in LAC have started to tackle the challenges presented by BAU practices, implementing strategies to increase the economic contribution of their fisheries and to preserve the ES that underlie them, making progress toward SEM. The impacts of BAU differ among types of fisheries: Table 7.1 (above) lists some threats to the major types of marine capture fisheries in LAC.

Sustainable Ecosystem Management (SEM)

In contrast, SEM practices safeguard ecosystem capacity to provide the ES upon which fisheries and other activities depend, for the purpose of generating optimal sustainable economic yields. In effect, SEM is the set of management practices that maintain marine ES needed to attain those yields.

Fish stocks, underwater habitats and biota, fishing fleets, and fishing communities are all components of exploited marine ecosystems. SEM in fisheries entails regulating and rebuilding fisheries to maintain and restore productivity. SEM, therefore, builds on both the FAO Code of Conduct for Responsible Fisheries (FAO) and the Ecosystem Approach to Fisheries (EAF) (Garcia et al. 2003; Pikitch et al. 2004), both of which are broadly accepted as the appropriate framework for managing marine capture fisheries.

Ecological Services that Sustain Fisheries

Marine ecosystems (including estuaries, mangrove and seagrass communities, coral reefs, the continental shelf, and the ocean) provide a wide range of goods and services through economic processes. In turn, the economic processes depend on natural services or ES that provision, regulate, and maintain the productive processes exploited by fisheries.

Fisheries depend most directly on the provisioning services of marine ecosystems, but these systems are underpinned by a complex web of regulatory and support functions. Sediment retention is important in reducing sedimentation of near-shore habitats (such as coral reefs), which reduces their productivity. Water filtration services help ensure health of the biota and survival of gametes, fry, corals, and other sensitive organisms, while minimizing accumulation of pollutants up the food chain. Disruption of nutrient cycling services through excessive nutrient loading may lead to low oxygen conditions and dead zones. Degradation of marine ecosystems threatens fisheries and other economic activities that depend on them for many ES. Fisheries management may maintain natural capital or erode this capital through resource depletion and ecosystem degradation; sound management may build up this natural capital through investment in sustaining or rebuilding fish stocks and safeguarding essential fish habitats.

SEM in fisheries provides for safeguarding critical life stages of species and essential fish habitats. This safeguarding requires integration of population and spatial management approaches. Fisheries management to date has focused mostly on maintaining fishery yields through population management, whereas spatial management has focused on identifying areas important for biodiversity conservation and representation of habitats or ecosystems. In many cases, there is limited information on the role of habitats in sustaining fisheries (e.g., which habitats are essential to critical stages of fish life-cycles). Yet safeguarding key habitats may enhance the resilience of fisheries to high levels of fishing effort. The idea of 'fisheries refugia' is to safeguard habitat areas that are essential at critical life history stages of targeted stocks (such as spawning and recruitment), so as to sustain or improve fisheries yields (SEAFDEC 2006). However, even globally, there is limited experience on integrating fisheries management with habitat management or broader ecosystem considerations. This limited information is highlighted by the case studies in this report, which focus primarily on responsible single-stock fisheries management as a foundation for SEM.

SEM also involves attention to maintaining marine biodiversity and the key ES upon which fisheries and other economic activities depend. This attention includes provisioning services (especially fish, molluscs, and other elements of the food chains that sustain capture fisheries and aquaculture, which, in turn, provision humans), regulating services (such as water purification and control of fish population sizes), cultural services (such as cultural heritage, recreation, and ecotourism), and supporting services (such as the water cycle, nutrient cycling, primary production, or fish metabolic, growth, and reproductive processes).

Safeguarding Essential Fish Habitats

Protection of the natural resource base and of the ES that support this base is fundamental to underpinning SEM. The ecosystems and ES that give rise to fisheries are dispersed and not well characterized; fish habitat is a convenient proxy that will encompass many critical elements of the ecosystems.

Essential fish habitats are those crucial for the different life stages of fish species. Of particular concern to fisheries is the loss or degradation of habitats that are critical to spawning and/or recruitment. Mangroves, seagrass beds, coral reefs, and wetlands support a wide range of commercial, recreational, and subsistence fisheries (Postel and Carpenter 1997; Peterson and Lubchenco 1997; McLeod and Leslie 2009). Fishing can contribute to loss of some of these habitats via damage by destructive fishing gear. Bottom trawling, dredging, and trapping can have destructive effects on hard and soft habitats by disturbing soft sediments, simplifying bottom topography, degrading seagrass beds, and destroying corals, oyster reefs, the tops of seamounts, and other hard bottom features (Hilborn et al. 2003). Ecosystem overfishing may also lead to habitat transformation.

In addition, essential fish habitat may be degraded by activities originating outside capture fisheries, including direct habitat destruction (such as clearing of mangroves) and degradation of essential ES such as sediment retention, nutrient cycling, water filtration, and both current and tidal flow regimes. While many studies assess the value of different habitats to fisheries (see Appendix 7.2), relatively few studies apply a cost-benefit approach to compare the economic contribution of these areas under alternative uses. This section highlights the findings of several studies that do.

MANGROVES

Mangroves are one of the world's most threatened tropical ecosystems. For countries in the Americas with data, 38% of mangrove areas have been lost since 1980 (Valiela et al. 2001). Mangroves act as nurseries for valuable species such as shrimp. Numerous studies have shown the market value that arises from mangrove-dependent capture fisheries. Production of fish and blue crab in the Gulf of California was valued at $19 million/year in 2001-2005. Mangrove-dependent species account for 32% of small-scale fisheries landings in the region, with landings directly related to the length of mangrove fringe (Aburto-Oropeza et al. 2008). Still, mangroves there are disappearing at 2% annually, due to sedimentation, eutrophication, and deforestation (INE 2005). The annual cost to local fisheries of lost yields of fish and blue crab alone is estimated at $33,000 / ha of mangrove annually (Aburto-Oropeza et al. 2008).

Gammage (1997) used a cost-benefit framework to compare SEM with alternative use scenarios ('do nothing', and partial conversion to semi-intensive shrimp farming) for mangrove ecosystem services in the Gulf of Fonseca, El Salvador. Results showed that the net present value (NPV) was higher under SEM than in the partial conversion option over a 56-year time frame, with a discount rate of 7%. The main beneficiary of sustainable mangrove management was the industrial shrimp fishery. The study clearly demonstrated the value of protecting the mangrove ecosystem as a nursery ground for shrimp fisheries.

CORAL REEFS

Coral reefs make an important contribution to both fisheries and tourism (Conservation International 2008). They supply only about 2%-5% of the global fisheries harvest, but are a key source of employment, income, and food in the developing world (Chapman et al. 2008). Several studies have assessed the value of healthy coral reefs to fisheries (see Conservation International 2008).

Burke and Maidens (2004) looked at productivity differentials between fisheries located on healthy and degraded reefs. Based on a literature review, it was estimated that healthy reefs in the Caribbean would support a maximum sustained yield of 4 tons of fish per km2 per year. Yields from degraded reefs were estimated at between 0.7 and 2.9 tons per km2 per year. Based on these assumptions, maximum sustained yields for 26,000 km2 of Caribbean reef were estimated at just over 100,000t of fish per year. It was further estimated that annual fisheries production could decline from 100,000t to 60,000t or 70,000t by 2015 under BAU, representing lost yields of 30%-40%. At market prices of $6 per kg on average, gross fisheries revenue was estimated at $625 million/year if all reefs were healthy, declining by $190 million-$250 million under BAU by 2015. Net revenues may be only 50% of gross revenues, after accounting for the costs of vessels, fuel, gear etc. The study, therefore, estimated the potential annual net benefits from healthy reefs at $310 million, with BAU leading to a loss in net income from fisheries of $95 million-$125 million/year.

A recent analysis of the regional environmental patterns of and human influence on coral reefs found that coral reef degradation in the Caribbean is reaching thresholds that are probably irreversible, with as little as 10%-30% coral cover remaining in reefs studied (Knowlton and Jackson 2008).

Part II. Economic Analysis

7.5 COSTS OF BUSINESS AS USUAL

BAU management strategies that lead to resource depletion, degradation of essential fish habitat, and loss of ES undermine the economic potential of fisheries.

Part II focuses on the direct costs of BAU, in terms of yields foregone through resource depletion, but also highlights the indirect costs associated with fishing overcapacity; illegal, unregulated, and unreported (IUU) fishing; and ecosystem degradation. Subsidies, intended to augment short-term gains, are examined as drivers of overcapacity, overfishing, inefficiency, and waste that lead to these longer-term losses. Investigation of a range of cases within the region suggests the high costs of these conditions: resource depletion, discarding, fishing overcapacity, inappropriate subsidies, and IUU fishing. Also investigated are the costs of BAU from degradation of essential fish habitat, whether attributable to fishing or not. Case studies from the region that evaluate the costs to fisheries associated with the degradation of regulating and supporting services (such as sediment retention, nutrient-cycling, and water filtration) have not been found. Finally, the emerging issue of the potential impact of climate change on LAC fisheries is explored.

Lost Productivity

The World Bank and FAO recently quantified the total cost to the world economy of lost yields in global marine capture fisheries at two trillion dollars over the past three decades, with losses continuing to accumulate at a rate of $50 billion per year (World Bank 2009).

Resource depletion is an economic term referring to the exhaustion of a resource, such as a fish stock, within an ecosystem or region. Resource depletion implies that fish stocks are reduced to such low levels that long-term yield is much lower than possible or profitability is much less than it could be (Hilborn et al. 2005). Resource depletion reduces the natural capital (e.g., fish stocks) and the ES that sustain this capital. Together, natural capital and ES are a major contributor to coastal economies . If not addressed, resource depletion leads to low stocks and lowered annual catch levels, with economic rent declining to zero or below. In the extreme, resource depletion can lead to fishery collapse, providing a dramatic illustration of the costs of BAU. Most countries in LAC committed to the recovery of depleted fish stocks at the World Summit on Sustainable Development in 2002 (Beddington et al. 2007).

Resource depletion can be operationally defined in biological terms, with respect to single-species or multi-species maximum sustainable yields (MSY), or in economic terms with respect to maximum economic yield or rent (MEY). Losses from resource depletion may be estimated by comparing yields at current stock sizes with MSY or MEY (Hilborn et al. 2005). From an economic perspective, MEY is a more appropriate target than MSY (Hilborn 2007). MEY is usually achieved at higher stock levels and lower exploitation rates than MSY, because this 'measure' takes into account the costs of fishing (Grafton et al. 2006).

Case studies (Sections 2.3-2.7) show declining yields, and collapse or near collapse under BAU management in LAC fisheries including Argentinian hake, Peruvian anchoveta, and Chilean loco abalone.

DISCARDS, BYCATCH, AND WASTE

Discards of targeted species, bycatch of non-targeted species (including species of commercial value in other fisheries) and ghost fishing by abandoned gear may also contribute to loss of productivity (Crowder and Murawski 1998; Hilborn et al. 2003). Discards and bycatch of commercially-important species are part of the overall catch. These conditions can contribute to growth or recruitment overfishing and reduce future yields; thus, they need to be taken into account into stock assessments. Discarding can cause considerable conflict among different fisheries. Bycatch of non-target species may have significant impacts on the population viability of globally-threatened species or other species of conservation con-

Box 7.2. Maximizing Yields vs Overfishing

Unfished stocks tend to have high biomass levels at which population growth and reproduction rates are low. Fishing at levels that support MSY or MEY lead to the deliberate reduction of stock biomass to levels such as 25%-50% of unfished biomass (Worm et al. 2009). This situation raises population growth rates so that annual increments are maximized and can be sustainably harvested. Resource depletion is caused by overfishing (i.e, fishing mortality in excess of MSY or MEY). It is important to note that fishing inevitably leads to a reduction in stock biomass. As biomass drops, there are fewer conspecific fish with which to compete, and growth and reproduction rates rise, until the MSY biomass is reached. At that point, a further fall in biomass will lower the rate of population resurgence. Overfishing depletes stocks beyond this point and reduces yields and profits.

Overfishing can occur in open access and unregulated fisheries or when the total allowable catch (or other target) is set too high (i.e., strategy failure), when the tactics designed to implement harvest strategies are inadequate (i.e., regulatory failure), or when regulations are not effectively enforced (i.e., enforcement failure). Strategy failure often occurs when there is pressure on fisheries managers to increase or maintain harvest rates above optimal levels, in the context of insecure fishing rights and fishing overcapacity. Scenario analysis indicates the costs of overfishing in the Argentinean hake fishery (Section 2.3). Part III outlines a management system that would reduce this pressure.

Growth overfishing is harvesting fish before they reach the size to maximize yields; recruitment **overfishing** refers to harvesting of adults before they have had sufficient opportunity to contribute to reproduction. Chronic overfishing occurs when stocks are maintained at a low biomass that produces relatively stable catches, but at a level far below the potential productivity of the stock. Under these conditions, fishers face higher harvest costs than would be necessary to harvest more fish from a larger stock with less fishing effort (Grafton et al. 2006). If the fishery remains relatively stable, fishers and managers are likely to regard the current state of affairs as normal and acceptable, succumbing to the 'shifting baseline' phenomenon (Pauly 1995).

cern. This can lead to severely-curtailed international markets for fisheries products. For example, the United States prohibits import of shrimp caught without turtle excluder devices and several major international fish buyers that source fish from LAC have pledged to source seafood from sustainable sources that limit bycatch (e.g., WalMart has announced that it will only sell MSC-certified fish beginning 2011, in the U.S.).

Discarding is usually caused by economic or regulatory constraints — fish are discarded because they are too small or unmarketable, or because they are in excess of a regulatory quota. Discarding is a major problem in many fisheries, with 8% of the world's catch discarded annually (Kelleher 2005). Discard rates vary substantially by fishery and by gear. It is especially high in shrimp and prawn trawl fisheries (Hilborn et al. 2003). In Peru, the average discard rate is about 3.3%, but 81% in the industrial shrimp trawl; in Argentina, discarding is 15% overall, but 24% in the southern hake otter trawl fishery, and 50% in shrimp trawls (Kelleher 2005).

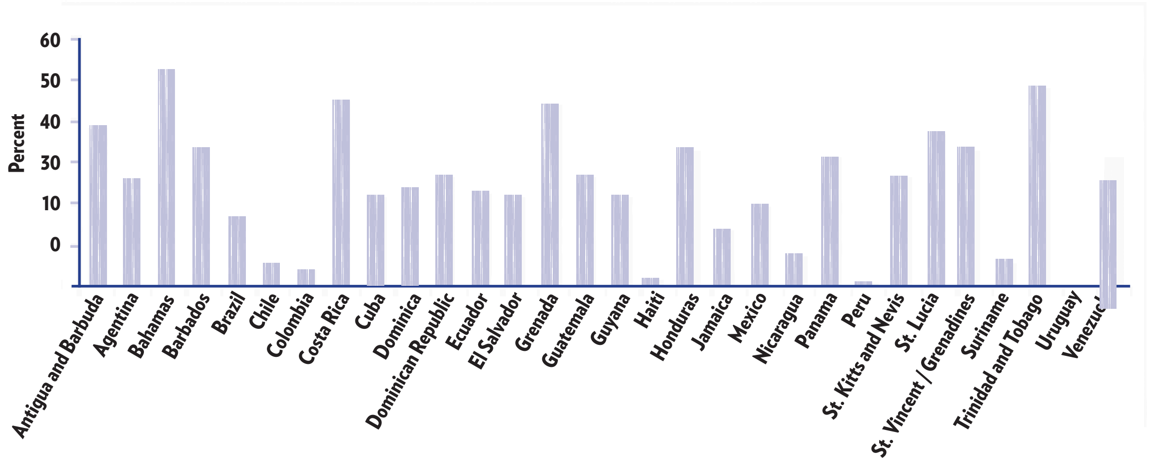
FISHING OVERCAPACITY

Fishing fleet overcapacity is a major driver of overfishing and resource depletion (Gelchu and Pauly 2007; Villasante and Sumaila 2010). Fleet overcapacity is often a source of pressure to set the total allowable catch (or other target) too high. Overcapacity can fuel an economically wasteful 'race to fish', in which vessels compete to catch the most fish before a fishery-wide quota is achieved (Hilborn et al. 2003). Fishing overcapacity occurs when the fleet size and fishing power is greater than required to achieve the total allowable catch in the time available. It is a long-term phenomenon, distinct from the temporary excess capacity that may occur in any industry subject to fluctuations in the supply of raw materials. Fishing overcapacity is economically inefficient, since capital is tied up unproductively (Garcia and Newton 1995; Stump and Batker 1996; Clark et al. 2005). Fishing overcapacity is characteristic of open access fisheries (Thorpe et al. 2000; Gelchu and Pauly 2007), but may also evolve in limited access fisheries with inadequate control. Overcapacity can develop through overinvestment in fishing capacity, especially during the development phase of fisheries (when fishing down the stock leads to high initial landings). It is often catalyzed by subsidies to fleet development (Hilborn et al. 2003; Beddington et al. 2007). For example, from 1985-1990, Mexico's fleet expansion program included subsidies of $5 billion (Anon 2005a cited in Gelchu and Pauly 2007). The Peruvian anchoveta case study provides a clear example of the potential scale of costs of fishing overcapacity.

INAPPROPRIATE SUBSIDIES

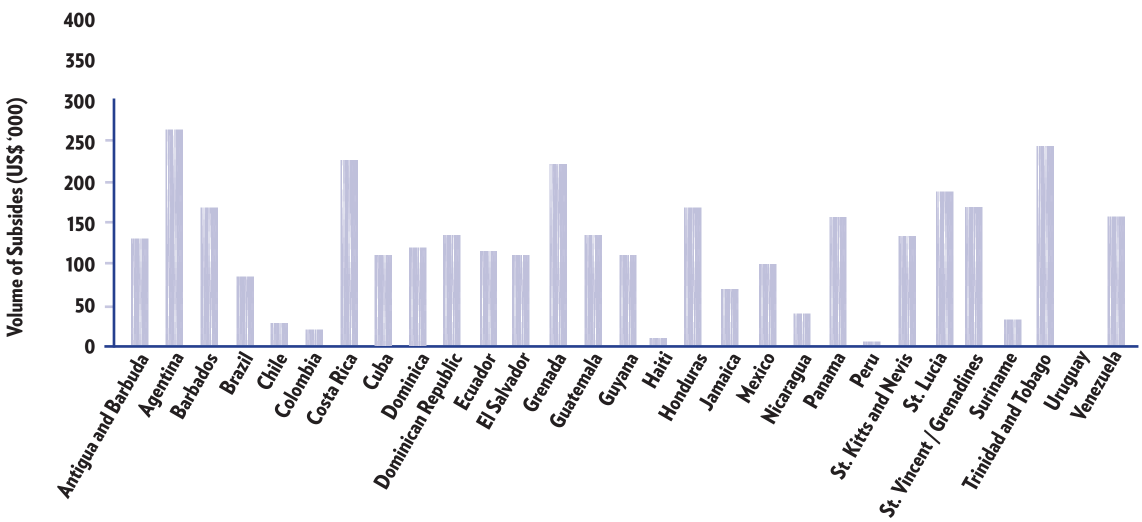
Inappropriate subsidies represent a direct cost of BAU and often promote fishing overcapacity and/or excess fishing effort. If subsidies cover a portion of fishing costs, fishers and fishing firms can continue to make money even if their fishing operations are not

Figure 7.11. Percent Contribution of Fisheries Subsidies to Landed Value by Country



Source: Sea Around Us Database

Figure 7.12. Absolute Contribution of Fisheries Subsidies to Landed Value (Good, Bad, And Ugly) By Lac Country ($ 000)



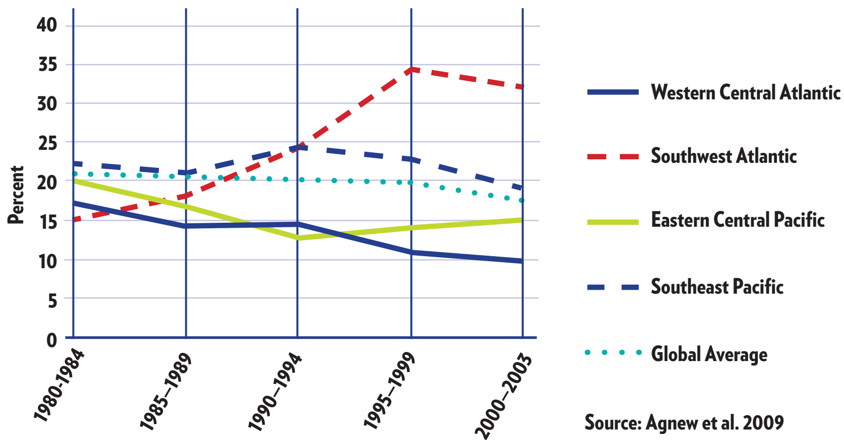
Source: Sea Around Us Database

truly profitable (Khan et al. 2006; Beddington et al. 2007). In the absence of subsidies, the cost of fishing must be paid for from fishing revenues. Subsidies may take the form of exemption from fuel and trade taxes, access to low-cost credit, and direct grants for vessel purchase and replacement. Subsidies may provide a useful indicator of economic health — with high subsidies indicating an economically fragile fishery (Hilborn et al. 2003). As a region, LAC is third in the world in terms of total subsidies for fisheries, at $1.9 billion per year (Khan et al. 2006). Figure 7.11 gives the percent subsidized by countries and Figure 7.12 for the absolute amounts in each country. However, not all fisheries subsidies are inappropriate. Khan et al. (2006) distinguishes between 'Good', 'Bad' and 'Ugly' subsidies. 'Good subsidies' lead to investment in natural capital assets, through government-funded fisheries research, management, monitoring, surveillance, and enhancement. Good subsidies include short-term interventions like habitat restoration efforts or license reduction schemes, designed to alter a system fundamentally so that fishery can be managed sustainably in the future. 'Bad subsidies' lead to continued depletion of natural capital, after fishing capacity develops to a point where resource exploitation exceeds the MEY. 'Ugly subsidies' have the potential to lead to either improvement or depletion of the fishery resource (Figure 7.12).

ILLEGAL, UNREPORTED, AND UNREGULATED FISHING

Under BAU, IUU fishing contributes to resource depletion and impedes recovery of fish populations and ecosystems at significant

Figure 5.14. Illegal, Unreported, and Unregulated Fishing in LAC Sub-regions



Source: Agnew et al. 2009

cost to legitimate fishing communities as well as public revenues (MRAG 2005; Agnew et al. 2009). Efforts to reduce fishing overcapacity are often undermined by IUU fishing. In a worldwide analysis of IUU fishing in 54 countries and on the high seas, Agnew et al. (2009) estimated the total losses attributable to IUU fishing at between $10 billion and $23.5 billion annually. The level of IUU fishing is inversely correlated with fishery governance, with developing countries most at risk (Agnew et al. 2009). If fisheries management targets and the science behind them are not respected by fishermen and not adequately enforced, widespread illegal fishing can occur (Beddington et al. 2007). This adds significantly to overfishing, depletes fish stocks, and undercuts ES, but — worse — it undermines the rational basis for fisheries management and threatens the development of SEM.

The level of IUU fishing in the Southwest Atlantic ranked second worldwide, comprising about 32% of legal catches (Figure 7.13). Estimates of economic benefits lost through IUU fishing in 2003 are $117million-$251 million in the Eastern Central Pacific, $205 million-$606 million in the Southwest Atlantic, $265 million-$506 million in the Western Central Atlantic, and $1.08 billion-$2.31 billion in the Southeast Pacific (Agnew et al. 2009). Many of these losses to IUU fishing occur outside the national EEZs.

Ecosystem Overfishing

Ecosystem overfishing occurs when the balance of the ecosystem is altered, undermining the ES upon which fisheries and other economic activities depend. Overfishing leads to significant and potentially irreversible changes in the structure and functioning of aquatic ecosystems (Murawski 2000 reviews definitions) (Box 5.3).

RISKS OF EXTINCTION AND BIODIVERSITY LOSS IN AQUATIC ECOSYSTEMS

There are growing concerns about biodiversity loss attributable to BAU fisheries in aquatic ecosystems. Such questions have to do with the externalization of costs typical of BAU practices. In marine systems, few global extinctions have been documented, but there is a growing record of species loss on a regional scale (Dulvy et al. 2003). Threats associated with BAU fisheries include overexploitation, bycatch, habitat degradation, and loss of key ES. Such threats to global biodiversity and their solutions are only just beginning to come into focus, as in the case of the development of turtle excluder devices.

Several species at high risk of global extinction are threatened by bycatch in the region, including the vaquita, a harbor porpoise endemic to the upper Gulf of California (Rojas-Bracho et al. 2006), the Waved Albatross, which breeds in the Galapagos and forages over the Ecuadorian and Peruvian continental shelf (Awkerman et al. 2006), and the leatherback and loggerhead turtles (Lewison et al. 2004).

In the Galapagos, the severe 1982/83 El Niño event triggered a major transformation from macroalgal and coral habitats to heavily grazed reefs and urchin barrens. The removal of large lobsters and predatory fish by fisheries leading to reduced predation pressure on herbivorous urchins may have exacerbated this transformation and contributed to the loss of dependent biodiversity. Following this event, the endemic Galapagos damselfish (*Azurina eupalama*) is considered probably extinct and it is likely that a number of other species dependent on macroalgal and coral habitats have seen severe declines (Edgar et al. 2009).

Box 7.3. Ecosystem Effects of Fishing

Marine ecosystems had already been substantially transformed by fishing even before the development of modern industrial fisheries (Jackson et al. 2001). Under BAU, there has been growing concern about the direct effects of loss of top predators by fishing, and the indirect effects of their removal on aquatic ecosystems through trophic cascades (Myers and Worm 2003),1 or the removal of entire guilds that can have significant negative effects on ES important for fisheries. For example, overfishing of great sharks in the northwest Atlantic led to the release of a mesopredator, the cownose ray (*Rhinoptera bonasus*), and the collapse of the scallop fishery (Myers et al. 2007).

There is also increasing evidence of the effects of overfishing on the structure and function of coral reef systems under BAU. Reef overfishing is generally correlated with substantial changes in ecosystem function, which may lead to losses in the production of fish, shellfish, and other marine goods (Jennings and Polunin 1996). Hughes (1994) describes how a decline in the grazing fishes of coral reefs due to overfishing altered the taxonomic composition of coral reefs in Jamaica, modifying the composition from coral-dominated to algae-dominated reefs.

In general, the effects of fishing on top predators will depend on the decline in their abundance, the extent to which declines are offset by increases in competitors, and the extent to which predation regulates prey populations (Kaiser and Jennings 2001). The same applies to grazers and other guilds. It is generally accepted that an ecosystem approach to fisheries should take the ecosystem effects of fishing into account (e.g., Pikitch et al. 2004). Given the complexity of interactions and responses, experimental management (which may incorporate marine reserves as controls) or ecosystem models are necessary to identify and predict these effects and develop appropriate management strategies.

At the global level, concern has arisen about the process of 'fishing down marine foodwebs', in which fisheries development involves a gradual but possibly unsustainable transition in target species from upper-level predators like tunas and billfish to lower-level species such as sardines and anchovy (Pauly et al. 1998). Heavy exploitation of large predators may lower their abundance, making them less efficient to fish, and, at the same time, releasing growth in their prey populations, making these species a more attractive target. Alternatively, fisheries development may be better characterized as 1) the sequential addition of fisheries for lower trophic level species, while continuing to fish upper trophic level species (Essington et al. 2006), or 2) driven by profits, initially targeting shallow-ranging species with high prices and large body sizes, and, then, gradually adding less desirable species to the mix (Sethi et al. 2010).

Many lower trophic level groups, such as shellfish and invertebrates, support relatively high-value, low-volume fisheries. Within LAC, fisheries-scale case studies reveal a complex pattern. For example, in the Argentinean-Uruguayan Common Fishing Zone, there has been a decline in mean trophic level attributable to reduced landings of traditional fisheries resources (such as Argentinean hake), and increases in crustaceans, molluscs, and other fish species such as red crab, scallops, and the slow-growing deep water Patagonian toothfish (Jaureguizar and Milessi 2008). In contrast, off southern Brazil, Vasconcellos and Gasalla (2001) found no evidence of decreasing trophic level in fisheries, due to the collapse of the sardine fishery (relatively low trophic level) and increase in offshore fishing for upper trophic level sharks and tunas. In the Gulf of California, interviews with local fishers indicated a decline in the trophic level of inshore fisheries, attributable to reduced abundance of sharks and grouper, compensated by an increase in offshore shark fisheries (Sala et al. 2004). The economic implications are also likely to be complex. For example, the first case suggests a shift toward lower volume but higher value resources; but the decline in inshore resources and the shift of fishing effort offshore or into deeper waters may raise costs and exclude some fishers.

Fishing may also lead to increased volatility in aquatic ecosystems (Apollonio 1994). Fishing may shift individual species toward faster-growing configurations (higher growth rates, younger at maturity, and truncated age classes) and may disproportionately remove upper trophic level species, which tend to be slower-growing and longer-lived. As a result, fish communities may, in time, become less stable and predictable, with high variability in species biomass. This makes fisheries harder to manage and has economic implications for fisher communities.

Note: Trophic cascades occur when removal of a top predator releases prey populations (second level) that then deplete their own prey (third level), releasing the next level down, and so on (Paine 1980). Evidence for trophic cascades is stronger for freshwater freshwater systems that have fewer species. In marine ecosystems, with many generalist species at each level that may switch from prey to predator during their life history, there is limited evidence of trophic cascades (Kaiser and Jennings 2001).

There is also concern about the threats to upper trophic level consumers such as seabirds and pinnipeds from competition with fisheries for forage fish (Duffy et al. 1984). For example, populations of the Peruvian Tern, endemic to Peru and northern Chile, were severely impacted by the 1972 collapse of anchoveta, attributed to a combination of environmental change and fisheries pressures (Schlatter 1984).

TARGET SPECIES VULNERABILITY TO EXTINCTION

For commercial species, it is often argued that economic extinction of exploited populations will occur before biological extinction, and that marine species are less vulnerable to extinction than terrestrial species because of high fecundities and large global ranges (Dulvy et al. 2003). Yet, the high fecundities that typify many marine species do not always translate into high reproductive rates. In commercial fish, adult spawners, generally, produce one to seven replacements per year (Myers et al. 1999), comparable to terrestrial vertebrates. For highly fecund species, the vast majority of larvae fail to survive in most years. Population structures of many commercially-important fish species are characterized by episodic recruitment – low in most years, with strong cohorts in occasional years when conditions are right. Fisheries depend on such strong cohorts, but truncating the age structure of populations by fishing may jeopardize their persistence if short-lived adults have few opportunities to reproduce successfully (Dulvy et al. 2003). While there is limited evidence of recruitment failure at low densities in commercial fish species (often fairly mobile) (Myers et al. 1995), sedentary species that rely on broadcast spawning, such as the white abalone, are vulnerable to recruitment failure when fished to low densities (Hobday and Tegner 2000).

Long-lived, late-maturing species with low reproductive rates are also inherently vulnerable to overfishing (Reynolds et al. 2001). These characteristics are shared by a number of large predatory fishes, such as sharks and sturgeons (Musik 2001). Following a global assessment of cartilaginous fishes such as sharks and rays, 67 species of out of 365 in the oceans surrounding South America (i.e. 18%) are listed as globally threatened (IUCN 2010). Late-maturing species are especially vulnerable when targeted in multispecies fisheries in which other target species are more productive (Myers and Worm 2005).

Restricted-range species are also inherently more vulnerable to both overfishing and habitat degradation than similar wide-ranging species, as highlighted in a recent analysis of threatened species in the Galapagos (Edgar et al. 2009). Among coral reef fish, 9% have a global range of less than 50,000 km2 (Roberts et al. in press cited in Hawkins et al. 2000), and most of these populations occupy only a small fraction of this area that provides suitable reef habitat. For restricted-range species, even localized threats may impact their entire global range. For example, the totoaba is endemic to the upper Gulf of California, and is threatened throughout this restricted range by a combination of past overfishing, habitat degradation, and bycatch of juveniles (Roberts and Hawkins 1999). This vulnerability also applies to species that only depend on specific locations or limited habitats for specific stages in their life cycles, such as species dependent on particular spawning locations, or estuaries and wetlands for nursery habitat. Species that aggregate in large numbers to spawn are often targeted by fishers and may be at risk of local or even regional extinction, as in the case of the Nassau grouper (Sadovy and Eklund 1999).

7.6 CASE STUDIES

Case studies 1 through 3 use three examples from LAC to explore overfishing and resource depletion in specific contexts; the roles of subsidies, overcapitalization, and regulation in regard to common property resources; and measures to facilitate transition from BAU to SEM. These cases have been selected to represent contrasting kinds of fisheries and situations (industrial-artisanal, marine-intertidal, catch shares-none, public sector vertical management-community oriented co-management, etc.).

Case Study 1. Argentinean Hake (*Merluccius hubbsi*), Argentina[1]

The Argentinean hake (*Merluccius hubbsi*) is a demersal and benthopelagic species distributed along the continental shelf off Argentina and Uruguay, occasionally reaching Brazilian waters (Aubone et al. 2000). The Argentinean hake fishery is one of the most important commercial groundfish fisheries in LAC. Due to the abundance, broad distribution, and the scale of landings, hake is a driver of fisheries sector development in Argentina. The hake fishery includes more than 50% of Argentinean fishing vessels, about 12,000 direct jobs, and 40% of fisheries exports in recent years, with landings on the order of 400,000 to 600,000t/year (2001-2008) and a landed value of $146/t in 2004 (Fundación Vida Silvestre 2008; Figure 7.14). This case study summarizes BAU in the Argentinean hake fishery and then explores the potential economic benefits of SEM, based on scenario analysis.

[1] Case study author: Sebastián Villasante, University of Santiago de Compostela and Beijer Institute of Ecological Economics, <sebastian.villasante@usc.es>. The complete case study is available from the author. Data are derived from the RAM II Stock-Recruit database http://www.marinebiodiversity.ca/RAMlegacy/srdb/updated-srdb/srdb-resources. The author acknowledges Ana Parma and Daniel Ricard for support in making the data available.

BUSINESS AS USUAL

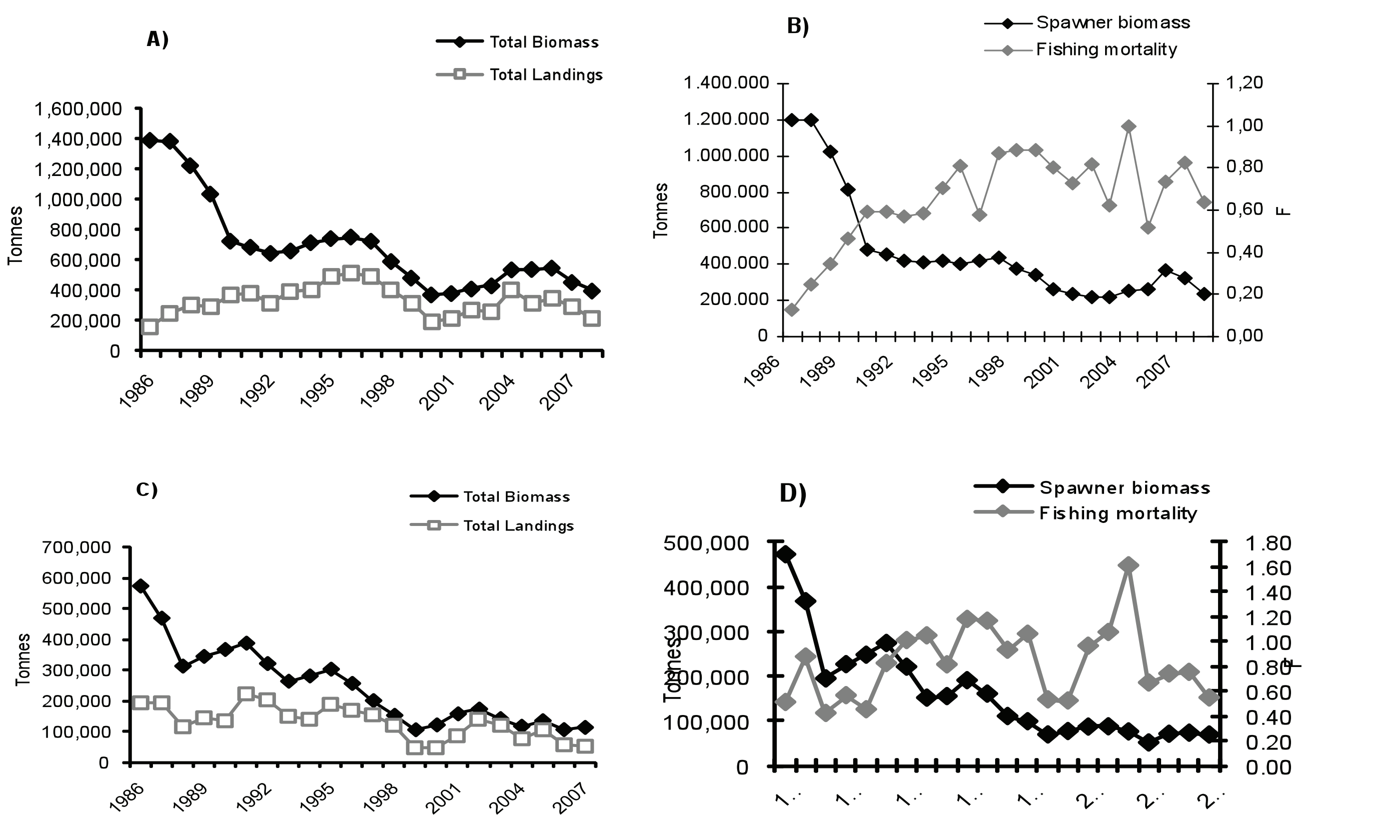
During the period 1987-1997, landings of Argentinean hake in Argentina increased from 435,000t to 645,000t. Fishing mortality increased from 0.536 to 0.949 north of parallel 41oS and from 0.130 to 0.455 south of parallel 41oS between 1990 and 2003. In response to the growing risks of collapse, the Federal Fisheries Council reduced the total allowable catch (TAC) to 189,000 tons in 1999, compared to 298,000 tons in the previous year. However, ineffective surveillance and control led to continued overexploitation of the stocks (Cedepesca 1999), with recorded landings exceeding the TAC by 87% in 1999 and 93% in 2000. As a result, both the total biomass and landings continued to decline (Figure 7.14).

The increase in landings is also attributed to policies of liberalization and opening of the fishing grounds to foreign fleets, largely through an access agreement between Argentina and the European Union (1993-1997). The fishery for Argentinean hake is divided into two fleets. The freezer trawler fleet operates primarily south of parallel 41oS; the fresh fish fleet concentrates north of parallel 41oS. From 1984 to 1997, the fresh fish fleet grew from 126 to 137 vessels, while the freezer fleet went from 44 to 282 (Bertolotti et al. 2001) and saw landings multiply by a factor of 6.6 during 1987-1997 (Irusta et al. 2001). Recent analysis of fishing capacity indicates overcapacity of 120% (Godelman 2004). At the same time, there has been an increase in discards, mainly juveniles, which represented between 11% and 24% of total landings during the period 1990-1997 (Dato et al. 2006). In economic terms, this represents annual losses of $11 million-$77 million. Landings of juveniles increased to 60% of the total catch by 1997. In response to the high percentage of juveniles in landings, a no fishing zone was created in 1997 to safeguard the nursery grounds around Isla Escondida, but this act has had limited impact due to lack of effective surveillance and control. The freezer fleet continued to concentrate around the limits of this zone, therefore, in 1999 the Federal Fisheries Council forced the freezer fleet to move to a zone of lower productivity.

SUSTAINABLE ECOSYSTEM MANAGEMENT

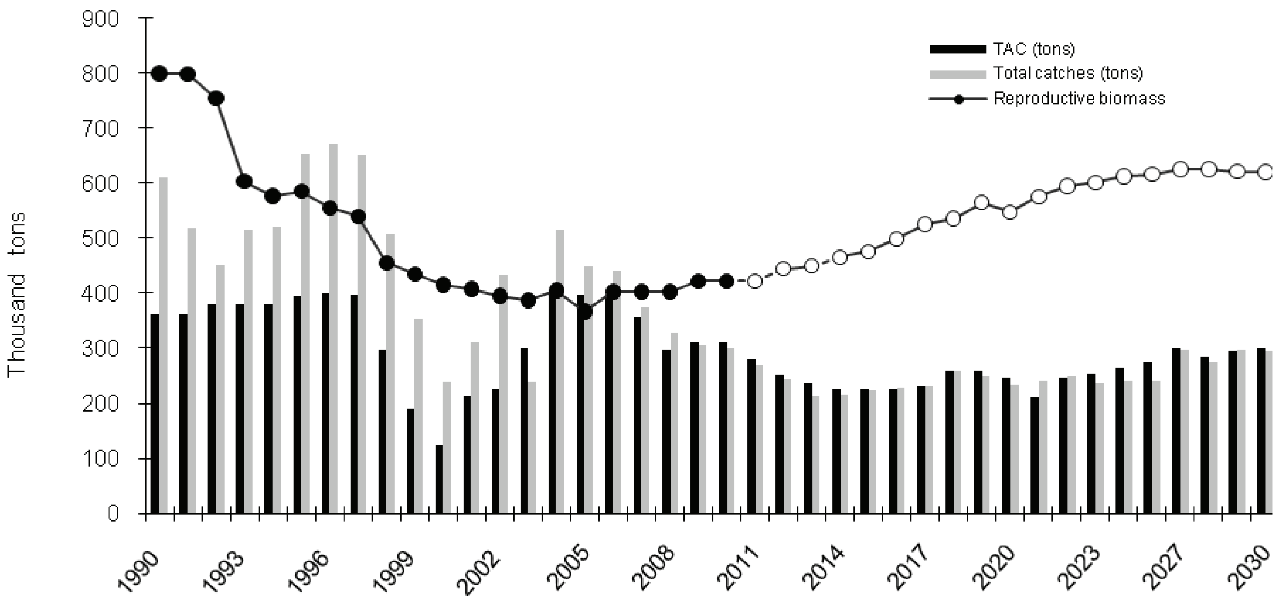
Scenario analysis is useful to explore the potential to increase net economic benefits through responsible management of the Argentinean hake fishery. Two scenarios are contemplated: the current BAU scenario, and a proposed recovery strategy. Currently, the stock biomass is at critical levels, close to the lowest values considered acceptable for the sustainability of the fishery (Aubone et al. 2000). A strategy is proposed that would allow stock to recover to at least an average of 8 million -1.2 million individuals by the year 2030

Figure 7.14. Estimated Biomass and Landings of Argentinean Hake Stocks South (A-B) and North (C-D) of Parallel 41°S



Source: RAM II Stock-Recruit database.

Figure 7.15. Adaptive Recovery Plan for Argentine Hake Fishery, 2010-2030



Sources: RAM II Stock-Recruit database; Villasante et al. (2009).

(the average value observed during the period 1987-1999) (Aubone et al. 2000). This proposal is simply an example for discussion — in practice however, a range of alternative strategies should be evaluated using decision analysis (see Part III on strategy development).

For the recovery strategy, it is assumed that actual landings correspond to the TAC (i.e., that surveillance and control are effective). Increased returns on investment would be supported by the progressive reduction of fishing capacity by 25% in the fresh fish fleet and by 50% in the freezer fleet. This reduction policy would allow for a gradual increase in technological efficiency of 4.4% per year (as per Gelchu and Pauly 2007). Further, a reduction in the discard rate to 8%-20% between 2010 and 2015, and to 3% between 2015 and 2030 is assumed. The scenario analysis is based on an ecosystem model (Ecopath with Ecosim) combined with economic valuation (Villasante et al. 2009). The net present value (NPV) is calculated based on the difference between the value of landings and costs, over a 20-year time frame with a discount rate of 4%. Constant prices are assumed throughout. For the freezer fleet, a cost of fishing of 85.2% of the landed value in the current BAU scenario is assumed (García-Negro 2003) and 72% by the end of the recovery plan. For the fresh fish fleet, costs of fishing of 92% and 85%, respectively, are assumed, in line with similar fisheries (Bertolotti et al. 2001). The reduction in costs takes into account an anticipated increase in catch per unit effort at higher stock levels. The case study focuses on operating costs and treats fishing vessels and processing capacity as sunk costs. The cost of the increased surveillance and control necessary to ensure that landings do not exceed the TAC and that discards are reduced is not included, due to the lack of estimates. Also, the case study does not take into account the effects on related processing and marketing sectors.

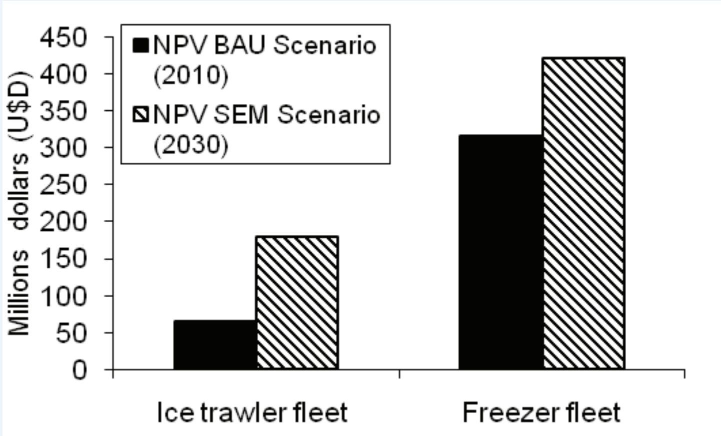
YIELDS AND RETURNS ON INVESTMENT

Under the recovery scenario, the volume of landings is reduced from about 300,000 metric tons in 2010 to 213,000 in 2013, and then rises to 294,000t in 2030 as the stock recovers (Figure 7.15). Yields of the fresh fish fleet rise from about 50,000t in 2010 to 88,000t in 2030; those of freezer fleet fall from 250,000t in 2010 to 206,000t in 2030.

However, despite a reduction in landings from pre-2010 levels, economic yields increase as stocks are allowed to recover through tight control of the TAC and effective implementation of measures to reduce capture of juveniles. Based on a discount rate of 4%, the NPV under the current BAU scenario is $66 million for the fresh fish fleet and $317 million for the freezer fleet. In the recovery scenario, the NPV for the fresh fish fleet rises to $181 million, and for the freezer fleet, $422 million (Figure 7.16). This increase in economic yields is a function of the reduced costs of fishing (per ton of landed fish) anticipated from the combination of stock recovery and reduced fishing effort (that implies lower labor and capital needs). This enhanced economic yield represents substantial increases in returns on investment, especially as the capital invested in each of the two fleets is reduced over time (by 25% and 50%, respectively). Also, stock recovery is likely to reduce the risk of collapse of this economically-important fishery.

Given the anticipated increase in yields, implementation costs that

Figure 7.15. Adaptive Recovery Plan for Argentine Hake Fishery, 2010-2030



Case Study 2: Peruvian anchoveta (*Engraulis ringens*), Peru[1]

The Peruvian anchoveta (Engraulis ringens) is a small pelagic fish distributed off the coast of Peru and northern Chile. The Peruvian anchoveta fishery is the largest single species fishery in the world, accounting for approximately 10% of global marine landings (with annual yields between 6 and 8 million tons) (Hatziolos and de Haan 2006). The fishery has long been characterized by extreme variability associated with inter-annual and inter-decadal oscillations and occasional collapse (Fréon et al. 2008).

Fishery management for the northern stock of Peruvian anchoveta (north of parallel 16oS) is based on a TAC set with reference to a constant escapement strategy. Each year, acoustic surveys are used to assess current biomass, and the TAC is set to ensure escapement of 5,000,000t (Fréon et al. 2008). In addition, fishing is banned during the two main reproductive seasons and when a high percentage of juveniles are found in the catch. Industrial fishing is also banned within five miles of the coast to protect anchoveta spawning and the habitat of other commercially-valuable species. Together, these measures have served to avoid resource depletion in recent years and reduce the risk of collapse; thus, these measures already represent substantial progress toward SEM. However, the aggregate TAC has also stimulated an economically inefficient 'race to fish' and massive overcapacity in both the harvest and processing sectors. In 2009, individual catch shares were introduced to address these problems. This case study focuses on the transition of the fishery from an aggregate TAC to a system of individual catch shares. The first fishing season under the new regime took place in April-June 2009.

[2] Case study author: Carlos E Paredes, Instituto del Perú, cparedes@intelfin.com.pe. The complete case study is available from the author.

are not included in this analysis should be recoverable from the fishery, while still allowing profits to increase. A more detailed analysis of costs under various scenarios would be required. (See the Peruvian anchoveta case study for an example of capacity reduction and cost recovery to cover the costs of reduced employment in fisheries.)

BUSINESS AS USUAL

The first major crisis in the industrial fishery for Peruvian anchoveta occurred in the early 1970s. Overfishing, resulting from exponential growth of the fleet and inadequate regulations, was exacerbated by the effects of the severe 1972-73 El Nino (Hilborn and Walters 1992). This crisis led to the nationalization of the industry. Following a period of stagnation, the fishery was re-privatized in the early 1990s. Despite efforts to limit fishing capacity, including the 1992 General Fishing Law that explicitly prohibited expansion of the fishing fleet and processing capacity, privatization led to substantial new investment in construction of new vessels and plants, as well as modernization of existing capacity. The 1997 El Nino left the highly-indebted industry on the brink of collapse once again. This crisis set off a process of mergers and acquisitions that led to increased vertical integration and concentration within the industry. Seven companies now account for approximately two thirds of the storage capacity of the steel-hulled fleet and 70% of the processing plant capacity.

By the end of 2007, the industrial fleet boasted a total storage capacity of approximately 210,000 cubic meters, while fish meal and fish oil plants had a total processing capacity of 8,909 tons per hour. To demonstrate the magnitude of the industry's overcapacity, it is worth noting that under 'normal' conditions (i.e., without the presence of the El Nino phenomenon), total anchoveta landings fluctuate between 6 and 8 million tons per year (for example, in 2006-2008,

Table 7.2. Estimates of Fleet and Plant Excess Capacity

Measured in reference to:	2006-2008 average		2006 TAC	
Fleet and plant efficiency	60%	80%	60%	80%
Fleet's excess hold capacity	60.5%	70.4%	70.9%	78.2%
2006 fleet's hold capacity/optimal capacity	2.5	3.4	3.4	4.6
Plants' excess processing capacity	65.3%	74,0%	74.4%	80.8%
2006 plant capacity/optimal capacity	2.9	3,8	3.9	5.2

Source: Paredes and Gutiérrez (2008).

anchoveta landings averaged 6.02 million tons). In 2006, the TAC was set at 5.9 million tons. If the fishing efficiency coefficient (which corresponds to the portion of the vessel's hold capacity that is filled in each fishing trip) is set in the 60%-80% range, then the excess fleet capacity was between 60% and 78% in 2006. In other words, the actual size of the fleet's hold capacity was between 2.5 (assuming a 60% fishing efficiency coefficient and TAC of 6.02 million tons) and 4.6 times (assuming an 80% fishing efficiency coefficient and TAC of 5.9 million tons) its optimal size (see Table 7.2). Because take drives processing rates, the excess processing capacity of the associated fishmeal plants fell within a range of 65% to 80%. This implies that the installed plant capacity represented 3 to 5 times its optimal level.

Thus, BAU in the Peruvian anchoveta fishery was characterized by overcapacity in both the harvesting and processing sectors, with progressively larger capital stock lying idle over progressively longer periods. Using detailed cost structure data for 2006, Paredes and Gutierrez (2008) estimated that foregone profits in the sector exclusively attributable to excess fleet and plant capacity were significant. They concluded that cutting the fleet's hold capacity and the plants' processing capacity by half (which would have not sufficed to eliminate excess capacity in the sector) would have led to doubling the sector's aggregate profits — a net gain of approximately $400 million per year. The economic inefficiencies associated with overcapacity in the harvest and processing sectors substantially reduced returns on investment, and as a result, the sector currently makes a relatively small contribution to Peru's tax revenues. According to official figures, the fishing sector's fiscal contribution under BAU was extremely low — only $68 million in 2006, or 4.8% of the value of fishmeal and fish oil exported that year.

SUSTAINABLE ECOSYSTEM MANAGEMENT

In 2008, the Peruvian Government introduced individual fishing rights over the anchoveta biomass by setting a maximum catch limit per vessel based on a percentage of the TAC. The main goals were to address the issue of fleet overcapacity and eliminate the race to fish, as fishers would no longer try to catch as much fish as could fit in the vessels' holds as fast as possible before the TAC was reached.

Quotas for each vessel were set based on its average catch during the 2004-2008 period and by the hold capacity (for steel-hulled vessels). Rights are non-transferable, but several provisions in the new legal framework allow consolidation of catch shares by vessel owners (for example, owners may temporarily consolidate quotas among vessels during a fishing season and permanently, if one is scrapped) (Aranda 2009). This is a necessary condition for the least efficient vessels to retire from the fleet. To prevent displacement of fishing effort, a further decree in March 2009 extended the system to the southern fishing zone (south of parallel 16°S). This represented the first time that a TAC was applied to this fishing area.

To mitigate the social costs of transition, the legislation established three programs: (a) worker retraining incentives, (b) development and promotion of micro and small-sized companies for displaced workers, and (c) early retirement provisions. These programs are financed by two mandatory contributions payable by the beneficiaries of the new fishing rights: (i) an annual adjustable fee imposed on the holders of fishing permits, fixed for the first year at about $12 for each 0.001% share of the TAC (for steel-hulled vessels) and (ii) a fee of $1.95 per ton of fish landed in processing plants. To put these fees in perspective, the first would raise about 0.12% of the value of the landed anchoveta, while the second would account for 0.2% of fishmeal sales. These contributions are small when measured against the increase in profits under the new regime, but demonstrate the potential for financing programs to address the social costs of transition by recovering a portion of the economic benefits of improved fisheries management.

IMPACTS ON YIELDS

There was no change in the procedure for setting the TAC north of parallel 16°S, thus no change in yields was anticipated. As discussed in Part III, catch shares are designed to strengthen incentives to guard against resource depletion. The Peruvian anchoveta fishery has long suffered from overcapacity, which places pressure on management to increase the TAC despite the risks of eroding the natural capital upon which the fishery depends. The introduction of secure catch shares is expected to reduce this pressure.

The catch share system has effectively eliminated the race to fish, with an increase in the length of the fishing season, and lower average and maximum daily fish landings. (Under the new catch shares regime, the first fishing season in 2009 was 102 days, versus 33 days in 2008.) This has led to increased selectivity (evidenced by a lower percentage of juveniles in the catch), improvements in the quality of the fish, and a greater share of high-protein fishmeal (prime and super-prime) in total fishmeal production.

One emerging concern is that individual quotas may have created new incentives to under report landings. The surveillance and control system probably needs to be strengthened to address this reporting problem. If not, otherwise successful efforts to avoid resource depletion may be undermined.

IMPACTS ON EMPLOYMENT

The industrial fleet currently employs approximately 18,000 fishers for about four months per year over two fishing seasons (Aranda 2009). Legislative Decree 1084 included a series of measures to prevent massive and uncompensated crew layoffs during the first two years of the new regime. Therefore, it is still too early to assess the impact on employment. However, expected is this: that reductions in overcapacity for both the harvesting and processing sectors will lead to a decline in the total number employed. Catch shares have led to a significant increase in the length of the fishing season. This will probably lead to a restructuring of employment in the harvesting sector, with a reduction in the total numbers employed at the peak of the season, but longer-term and more secure employment for those who remain.

IMPACTS ON RETURNS ON INVESTMENT

Returns on investment are expected to greatly improve by reduction of overcapacity in both the harvesting and processing sectors (on the order of 60-80%). Reducing fixed costs (capacity) is fostered by quotas that let production be spread over a longer period. That production time frame change allows for smaller investments in vessels and factories, which can be used more fully during the year. In the harvesting sector, the quota mechanism works directly by allowing fewer vessels to be used to fill each quota — the result is that the vessels used are more efficient. As fleet overcapacity declines and catch shares are consolidated among fewer, more efficient vessels, returns on investment for vessel owners should increase.

In processing, the effect of the quotas will also be to consolidate the sector, in turn, reducing fixed costs and raising returns on investment. This outcome will happen in two ways: (1) by spreading production over a longer period, so that owners of multiple facilities can use the more efficient facilities and eliminate the rest, and (2) by competition for raw material. The introduction of catch shares led to a hefty increase in the price of anchoveta — a rise of nearly 50% in 2009 over 2008, despite a drop in fishmeal prices of more than 25%. With a guaranteed catch share, fishers are now able to time their fishing trips to match demand, thus avoiding the traditional glut at the beginning of the season. This has increased the price of fish to vessel owners, even though there was no change in overall supply or demand (represented by the TAC and the installed processing capacity). In contrast, the price of fishmeal is determined in global markets which integrate the supply of fishmeal from Peru with a wide range of other factors. This price competition for raw material implies a reduction in profits for processors, especially independents (those not vertically integrated with fleets), which should lead to the exit of the least efficient processors, a reduction in total processing capacity, and rising returns on investment for the remaining processors — given that the TAC will be shared among fewer plants operating for longer periods.

FISCAL IMPACTS

At present, there are no documented fiscal impacts from the introduction of catch shares. Given that returns on investment for vessel owners are expected to increase substantially, a part of these returns could be recovered through increased license costs and other cost-recovery measures as well as increased revenues from corporate income taxes. Some of the additional revenue may need to be invested in adapting the existing surveillance and control system to the new quota-based harvesting system.

EQUITY

In contrast to the fishing sector, the new legal framework did not provide additional incentives to reduce overcapacity in the processing sector. This framework reflected the belief that reduction in the processing capacity would take place smoothly as a byproduct of the change in the harvesting regime. There is considerable vertical integration in the industry, implying that, for several processors, the costs are offset by benefits to the fishing arm, but companies with a low fleet/processing capacity ratio are at risk. Industry concentration has grown and is likely to increase further, as firms with low fleet/plant ratios are absorbed by larger ones and/or become insolvent. The legislation does not include provisions to address social costs in this sector, and those negatively affected are seeking to revoke the legislation. This issue clearly needs to be addressed. One way would be to establish a fund to cover transition costs in the processing sector, financed by the processing plants that remain and benefit from increased returns on investment. This impact highlights the need to consider the downstream effects of fisheries reform during the transition towards SEM. Opposition from the processing sector has created uncertainty about the permanence of the reform, and may jeopardize some of the expected benefits until resolved — such as reduction of fleet capacity.

CHALLENGES

A significant consequence of the change in the fishing regime, boosted by higher anchoveta prices, is the substantial increase in the incentives to evade regulation and to under-report fish landings, in order to avoid exhausting the individual legal quota. In addition, the small-scale fishing fleet that is not legally allowed to land fish for indirect human consumption, is landing anchoveta for fishmeal production and expanding rapidly. This highlights the need to take into account the likely responses of other fishing fleets when moving toward SEM. An increase in IUU fishing is indicated by the apparent reduction in the fish-to-fishmeal conversion factor — most plausibly explained by an increase in unreported landings. If that is the case, this situation would jeopardize the success of the new management system, leading to overages of the TAC that might threaten sustainability of the fishery. The expected benefit of a catch share system is predicated on effective surveillance and control. Peru's system will need to be adapted and strengthened to deal with these new incentives. The anticipated growth in returns on investment within the industry suggests the potential to finance strengthened surveillance and control through cost recovery.

A remaining policy challenge is to catalyze reduction in overcapacity in the processing sector that will lead to a higher return on investment for remaining processors and reduce incentives for IUU fishing.

This case study has focused on efforts to reduce overcapacity and eliminate the race to fish in the Peruvian anchoveta fishery. These measures do not directly address fishery impacts on the broader ecosystem, such as possible competition between the fishery and top predators dependent on anchoveta, including upper trophic level fish, seabirds, and marine mammals. However, the reforms provide an essential platform on which appropriate interventions may be built, given that introducing measures to safeguard ecosystems in fisheries characterized by overcapacity and excess competition can be extremely difficult.

Case Study 3. Chilean abalone (*Concholepas concholepas*), Chile

The loco abalone (Concholepas concholepas) is a benthic gastropod which inhabits the intertidal zone. Artisanal benthic shellfisheries have played an important role in the socio-economic development of Chilean coastal communities (Castilla and Defeo 2001). During the 1970s and 1980s, the fishery evolved from one primarily oriented toward domestic consumption with annual landings averaging 3,000-6,000t to one oriented primarily towards Asian markets, with a rapid increase in annual landings to a peak of 24,800t in 1980. This transition led to growing pressure on the resource, overharvesting stimulated by price increases, and, finall,y closure of the fishery from 1989 to 1992 (Castilla 1994). This case study summarizes the economic benefits associated with transition of the loco fishery from one of open access to one managed through territorial use rights in fisheries (TURFs) and co-management.

[3] Case study author: Sebastián Villasante, University of Santiago de Compostela and Beijer Institute of Ecological Economics, The Royal Swedish Academy of Sciences, <sebastian.villasante@usc.es>. from whom the complete study is available.

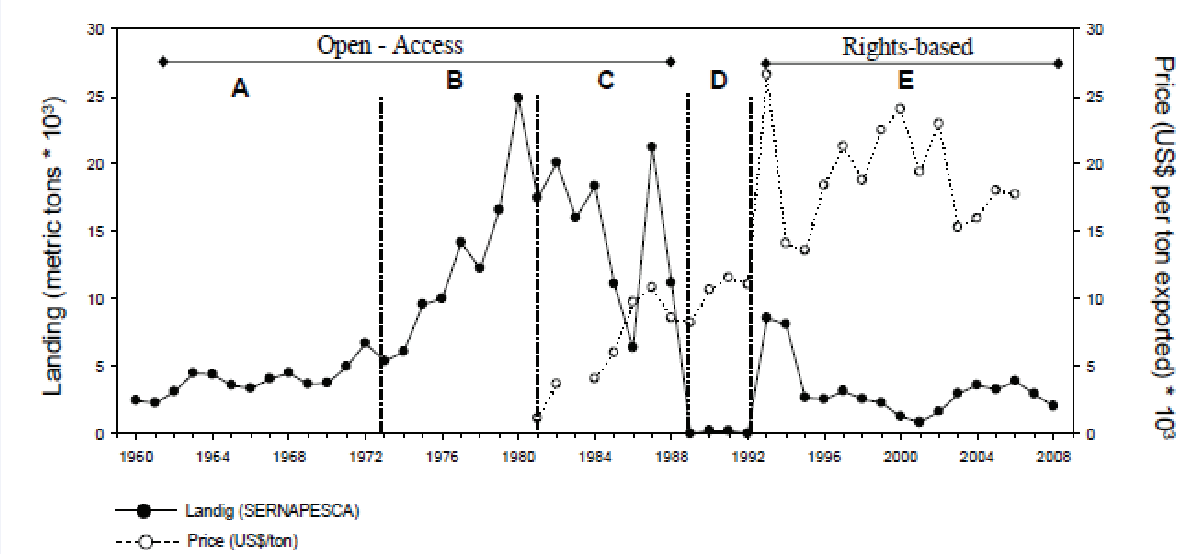
BAU

BAU in the loco fishery was characterized by open access, overharvesting as prices increased, and eventual collapse. The open access regime enabled artisanal fishers to migrate along the coast in search of viable resources, often leading to conflict between locals and outsiders (Castilla and Gelcich 2008). The evolution of the fishery is traced in Figure 7.17.

SEM

The 1991 Fisheries and Aquaculture Law enabled the creation of areas for the management and exploitation of benthic resources, known as AMERBs. Exclusive non-transferable use rights over benthic resources up to five nautical miles from the coast could now be granted to registered artisanal fishing associations. The law also imposed a moratorium on new entrants to the fishery and restricted artisanal fishers to working in the area of their residence. Harvesting of loco is restricted to areas managed by AMERBs (Castilla and Gelcich 2008). The new management regime reoriented incentives toward sustainable management. The benefits of responsible management extend beyond the loco abalone to cover other species managed by the AMERBs (Defeo and Castilla 2005). By 2005, there were 547 AMERBs established in Chile, of which 301 had approved management plans and were fully operational (Defeo and Castilla 2005).

Figure 7.17. Landings and Exports of Loco Abalone (1960-2008)



Source: Gelcich (2009).

AMERBs are founded on the principle of co-management. Harvest quotas are fixed based on scientific assessments and harvest plans developed collaboratively by fishers, scientists,and management authorities (Castilla and Gelcich 2008). Concerns have been raised about the ecological effects of harvesting invertebrates on the structure and diversity of intertidal and near-shore subtidal communities (Leiva and Castilla 2002). While the focus of co-management has been on sustainable management of targeted resources, ecological knowledge gained from experimental management of AMERBs has been used to inform management strategies (Defeo and Castilla 2005).

YIELDS

During the AMERB phase from 1993-2005, landings have fluctuated around 2000-5000t — levels similar to those before the export phase and collapse — and are considered sustainable (Castilla et al. 2007). Population densities inside AMERBs were found to be higher than in neighboring open access areas, and the catch per unit effort has increased from 15-143 to 280-540 individuals per day. Also, the size of individuals has grown from 103-108cm in the open access period to 110-117cm under co-management (Defeo and Castilla 2005).

FISCAL IMPACTS

Some of the costs of transition to the new regime have been absorbed by fishing associations. In particular, fishing associations must cover the costs of baseline studies upon which TACs and management plans are based, and pay external consultants to undertake annual stock assessments. They also pay an annual fee to the government in return for the rights to management areas (Castilla and Gelcich 2008). AMERBs have catalyzed active participation by fishers in surveillance and control within each association, and have led to a reduction in illegal fishing, which is attenuating government enforcement costs (Castilla and Fernandez 1998; Defeo and Castilla 2005).

7.8 NET ECONOMIC BENEFITS OF SEM

"With effective economic incentives, rather than being a net drain on the global economy, sustainable fisheries can create an economic surplus, be a driver of economic growth and a basis for livelihood opportunities." (World Bank 2009)

For some fisheries, the net economic benefits of SEM are evident and transition costs are relatively low, whereas in other fisheries, the benefits are less clear and/or the costs are high. The priority placed on transitioning fisheries toward SEM depends on the significance of expected economic and environmental impacts.

Yields

Depletion and fisheries collapse can incur high costs in terms of lost yields, as well as impacts on employment and other indicators. SEM aims to avoid these costs by investing in maintaining or restoring natural capital and reorienting fisheries management toward MEY.

For fisheries currently managed for MSY, net economic benefits will increase at MEY, even with slightly lower yields. Maintaining stock biomass at the higher level associated with MEY is also likely to promote greater stability with respect to both biomass and yields (Worm et al. 2009). In this context, the costs of SEM are likely to be less than the costs of chronic overfishing and risk of collapse followed by a long and uncertain period of recovery.

For fisheries characterized by severe resource depletion, moving toward SEM will involve a temporary reduction in yields (and other economic indicators), but successful rebuilding will lead to increased yields over the long term. Alternative rebuilding plans (such as complete cessation of fishing over a shorter time-frame versus a reduction in fishing effort over a longer time-frame) can be evaluated in terms of their cost-effectiveness under different discount rates. The case studies of Chilean loco abalone and pirarucú in Brazil provide clear evidence of the potential for improvements in yields from SEM. In each case, BAU led to the collapse and closure of the fishery. SEM has enabled both fisheries to reopen, with annual yields that are considered sustainable (Castilla et al. 2007; Viana et al. 2007).

Employment

As with production, restructuring national fisheries to be more economically efficient may require an initial reduction in employment, given that overcapacity (including labor capacity) is a major aspect of inefficiency in the sector. Specific effects on employment will depend on the issues to be addressed. For example, elimination of the race to fish may lead to a restructuring of employment to fit the need for a lower level of human-power over a longer fishing season. In Peru, the introduction of catch shares led to an increase in length of the first fishing season in 2009 to 102 days from 33 days in 2008. Temporary measures to prevent high unemployment, funded from gains in earnings, have buffered the transition. Addressing cases of chronic overfishing may lead to an increase in employment, sometimes in relatively short times. In the Brazilian Amazon, BAU led to closure of the pirarucú fishery. SEM has led to an increase of 75% in the number of fishers employed in the fishery (from 1999 to 2005; Viana et al. 2007). In general, SEM practices were seen to lead to employment opportunities that are more durable than those seen under BAU.

The costs of transition are likely to be lower in regions where the local economy is growing and alternative employment opportunities are already available. Reduced direct employment in the harvesting sector may be compensated for by additional employment in the processing sector, if investment in value-added post-harvest processing forms part of the steps towards SEM, or in other industries that benefit from SEM (such as tourism or other recreational activities). Such adjustments could create a more diversified employment base and reduce overall vulnerability.

Returns on investment

SEM reorients fisheries management objectives toward maximizing net economic benefits. Under BAU, resource depletion, fishing overcapacity, inappropriate subsidies, and the race to fish create fisheries that are economically inefficient. Under SEM, the rebuilding of fish stocks, the reduction of fisheries capacity to levels that match the productivity of the resource, reorientation of subsidies, and (where possible) an elimination of the race to fish all serve to increase returns on investment over the long-term. In the long-term, SEM fisheries will reduce fishing effort, increase catch per unit effort, and improve the economic efficiency of fisheries.

Scenario analysis of the Argentinean hake fishery indicates the increase in economic yield that may be attained by reduced fishing effort and reduced harvesting of juveniles. The Peruvian anchoveta case study shows how better returns on investment may be realized by eliminating the race to fish. In this second example, the mechanism involved — the potential decrease in fixed costs with reduction of overcapacity (estimated at 60%-80%) in both the harvest sector and the processing section plays out in two ways: directly in the case of the harvesting component, and indirectly for the processors. The dynamics of the latter are reflected in a sharp increase in the price for anchoveta offered to independent vessel owners, implying a reduction in profits for independent processors that should lead to elimination of excess processing capacity.

Fiscal Impacts

SEM emphasizes increased investment in science and management capacity (including surveillance and control). At the same time, SEM often involves the reduction of inappropriate subsidies, which can release funds for investment in fisheries management. In addition, moving fisheries toward MEY generates increased returns on investment in the fishery, provides new opportunities for cost recovery, and improves the tax base. Case studies of the Peruvian anchoveta and Chilean abalone fisheries provide examples of increased public cost recovery under SEM. (See those case studies and Section 3.4 on financing SEM.)

The net economic benefits of SEM are likely to be higher if BAU subsidies represent a substantial fiscal cost and where the additional costs of management and control are offset by improvements in yields and a reduction in IUU fishing, both of which increase taxable business income.

Equity

It is difficult to generalize about the equity impacts of transition toward SEM. In the near term, management changes are likely to create both winners and losers. Successful transition may depend on finding ways to limit economic hardship during the transition and mitigate costs to those who lose. The case study of Peruvian anchoveta provides some insights into the complex equity issues of transition to SEM.

Fisheries can be an essential source of food security, employment, and income; fisheries may provide a critical safety net for the vulnerable. Mining the resource base may be an effective short-term strategy for individuals (and countries) to move out of poverty, but sustainable resource use is a necessary condition for fisheries to contribute to poverty reduction over the long run (FAO 2007). The poor are disproportionately vulnerable to fisheries depletion and collapse because they lack economic alternatives; thus, they poor may benefit from the increased security of fisheries-based livelihoods associated with SEM. The distributional implications of fisheries management options, in particular changes to access rights, must be considered when developing SEM strategies. (See Box 5.5 below on options for pro-poor fisheries management).

7.9 CLIMATE CHANGE CLEAR CHALLENGE, UNCERTAIN CONSEQUENCES

The Inter Governmental Panel on Climate Change projects that the global temperature of the Earth will rise by 1.1–6.4 C° by 2100 (IPCC 2007a). Temperature changes projected for ocean surface waters vary greatly (Nicholls et al. 2007). Global ocean-atmosphere models that forecast oceanographic changes are too broad to predict impacts on specific aquatic ecosystems or fish stocks. Development of regional models at scales relevant for fisheries management is an active area of research, but there is still great uncertainty. For example, various authors have predicted that El Nino events may become more frequent and severe under global warming, while others have suggested that increased upwelling in the Humboldt Current system might make El Nino less severe (Bakun and Weeks 2008).

The direction and scale of impacts of climate change on specific fish stocks and fisheries is thus uncertain (Allison et al. 2009). Long-term climate fluctuations and shorter-term climate variability clearly affect fish stocks and ecosystems (Cushing 1982; Peterson et al. 2002). Under global warming, ecosystem productivity is likely to be reduced in most tropical and subtropical waters, and increased in high latitudes (FAO 2009). Changes in ocean circulation may disrupt patterns of reproduction, migration, and connectivity, as well as community and ecosystem relationships (IPCC 1998). Empirical observations show that marine species respond to environmental variations by modifying their latitudinal distribution and depth (Dulvy et al. 2008). Local shifts in production and species mixes are anticipated. Ocean acidification will affect calcareous corals and shellfish, and reef-based fisheries, with crustaceans and molluscs especially vulnerable (Hoegh-Guldberg et al. 2007; Guinotte et al. 2008). Species with large populations, high reproductive rates, short generation times, and high ecological flexibility, are likely to adapt most rapidly (Ferrière et al. 2004). The effects of fishing will interact with those of climate change as fishing reduces the size of stocks, lowering their capacity to adapt. Reducing fishing mortality in overexploited fisheries is one of the main ways to reduce the impacts of climate change (Brander 2007).

At a country level, the vulnerability and adaptability of national economies to climate change depends on the economic importance of the fishing sector, the economic dynamics of fishing fleets and fishing communities, and their capacity to adapt. A recent global study identified the economies of Peru and Colombia as highly vulnerable to the impacts of climate change on fisheries (Allison et al. 2009). A study by the Central Bank of Chile (Medel 2009) emphasized the potential negative impacts of increased variability in fish stock biomass associated with climate change, especially if rates of ecological change are faster than rates of capital conversion and / or are unpredictable. Fisheries management will need to be adaptive and capable of responding rapidly to changes in the resource base (Allison et al. 2009). See Part III for further discussion of adaptive and responsive management systems.

Part III. Conclusions and Recommendations: Moving Toward SEM

The principal conclusions of this chapter are that

- Further economic growth in LAC fisheries is likely to come through rebuilding depleted fisheries, restoring essential fish habitat and ES, and improving economic efficiency. This implies continuing and extending the switch toward SEM.
- BAU in fisheries causes economic losses through stock deletion, habitat damage, and degradation of ES. In some cases, the same or higher yields could be captured with less effort, thereby freeing up capital and other resources, and raising rates of return.
- SEM in fisheries addresses these problems through responsible management of single and multispecies fisheries. In particular,

SEM reduces overfishing and overcapacity, cuts harmful subsidies, realigns incentives, and safeguards essential ES and fish habitats. SEM in fisheries, thus, enhances the economic contribution of fisheries through provision of food, employment, and income on a lasting basis.

The main recommendation is to foster the transition to SEM, which in fisheries requires several steps:

1) An enabling policy and legislative framework;
2) Stakeholder involvement to ensure buy-in and transparency;
3) Responsive management strategies based on the best available science, adaptive management, and a precautionary approach;
4) Effective implementation that combines incentives to align private interests with policy objectives, with regulatory controls and with effective enforcement; and
5) Stable, well-managed institutions with secure, adequate funding.

These recommendations are further developed in the following sections, with an eye to guiding formulation of specific policies and tools to facilitate a switch to SEM. Responsible management of single and multispecies fisheries is integral to SEM, a necessary first step toward wider goals. If systems are inadequate for the management of single species fisheries, then they will not be able to cope with the demands of ecosystem management. Fisheries may be prioritized for transition to SEM based on expected economic and environmental benefits. Successful transitions will, generally, be incremental.

7.10 DEVELOPING MANAGEMENT STRATEGIES OF SEM

The following sections set out a framework for building fisheries management systems that enable and encourage fisheries to be managed consistent with SEM.

Goals and Objectives of Fisheries Management

The purpose of this section is not to define appropriate objectives for specific cases, but to explore approaches to attaining both economic and ecological ends by improving economic efficiency, while protecting against negative feedback loops and safeguarding aquatic biodiversity and ecosystems. Many well managed fisheries are both biologically sustainable and economically profitable (Hilborn et al. 2005).

Fisheries management goals have been evolving and broadening, from maximizing yield and employment to improving economic efficiency and reducing impacts on ecosystems. Traditionally, biological goals cover maximum sustainable yield (MSY) and, more recently, protection of non-target species and ecosystems. Economic goals usually focus on maximizing returns. Social goals include employment, income distribution, food production, and maintaining livelihoods. Economic and ecological goals may be compatible in that both are achieved at exploitation rates lower than MSY (Grafton et al. 2006; Hilborn 2007).

Different stakeholders — industrial, traditional, and recreational fishers — will have different objectives (Hilborn 2007) and perceive the condition of ecosystems differently, depending on the value they attribute to distinct services and outputs. A crucial intermediate goal is to reduce pressure by fishers to maintain high harvest rates even at the risk of depleting resources and degrading ES. This means ensuring that stakeholders have a long-term interest in productivity and that the needs for effective surveillance and control, as well as management capacity, research, and funding needs are met.

Broad goals for fisheries management should be set in national-level legislation (FAO 2007). In Argentina, for example, the Federal Fisheries Law aims to maximize value from the fishery, maximize the employment of Argentinean labor, and provide incentives for the long-term conservation of fisheries resources. Legislation should also provide guidance on priorities. Strategy development will require trade-offs — if these trade-offs are not clear in law, they will be made by decision makers. Strategies need to be translated into operational objectives, such as preventing resource depletion, rebuilding fisheries, reducing overcapacity, realigning incentives, controlling IUU fishing, and limiting discards, by-catch, waste, and habitat damage.

Performance indicators to monitor progress should also be defined. If fisheries managers are to adopt SEM practices, then this professional practice needs to be reflected in their performance frameworks. A fisheries manager whose performance will be evaluated only against MSY and job numbers cannot be expected to invest scarce resources in broader ecosystem management.

Enabling Legislation

Many LAC countries already have strong legal frameworks that provide an enabling environment for SEM (Pitcher et al. 2009). However, in some cases, high-level legislative change may be necessary to support and stimulate progress toward SEM. Purposes to be pursued may include the following:

1) Establish the goals for fisheries management (e.g., improve economic returns, avoid irreversible ecosystem harm).

2) Provide guidance on translating fisheries goals into quantitative management objectives (e.g., whether fisheries management should be oriented towards MSY, MEY, or some other measure).

3) Incorporate the principles of the FAO Code of Conduct for Responsible Fisheries and other relevant instruments.

4) Require authorities to prioritize fisheries that are not meeting those goals (e.g., economically-inefficient fisheries or those that have negative ecosystem impacts) and to develop effective strategies and management plans for them.

5) Require that management authorities take action to protect threatened species, to identify and safeguard essential fish habitat, and to minimize by-catch and habitat damage;

6) Require a precautionary approach — management systems that move conservatively and respond adaptively to changes in the resource base.

7) Clarify institutional mandates and jurisdictions, and establish both responsibilities and accountability standards, with appropriate levels and spatial scales of decision making.

8) Set high standards of stakeholder participation, oversight, and transparency.

9) Require other agencies to consult fisheries authorities on activities that would impact productivity, critical fish habitat, and essential ES.

10) Define access rights and provide the legal basis for privileged access schemes (e.g., catch shares) and co-management, if appropriate.

11) Establish adequate and secure funding for fisheries management activities by public agencies, including stock assessment, monitoring and research on fisheries, and ecosystem management. Revenue generation and retention through license fees and other cost-recovery mechanisms may require legislative support.

12) Ensure that fisheries authorities have adequate authority and resources for effective surveillance and control. Strengthen measures to control IUU fishing, including improved prosecution procedures and increased sanctions. Legally mandating compliance with the FAO Code of Conduct on Responsible Fisheries would provide an international legal basis for economic and other sanctions to discourage illegal fishing (Agnew et al. 2009), and support cooperation among countries and agencies. In addition, it may be useful to set standards and procedures at a regulatory level for the process of strategy development, the formulation of management plans, stakeholder participation, and the development of accountability and transparency measures.

Prioritization of fisheries

Successful transition to SEM will generally be step-wise, fishery by fishery. This incremental transition can be effective if resources and capacity are scarce. Such a transition enables lessons learned in previous rounds to be applied to the next. As new fisheries are added, it is essential to ensure that objectives and strategies are consistent, taking into account interactions among stocks, and the cumulative impacts on biodiversity and ES.

Economic health, ecosystem impact, data availability, and institutional capacity can provide the basis for prioritizing fisheries for transition toward SEM. The World Bank/FAO study “Sunken Billions” (WB 2009) recommends that countries conduct economic health checks of fisheries. Information on the ecosystem effects of different fisheries should also be taken into account to prioritize them for transition toward SEM. Smith et al. (2007) outline a qualitative approach to ecological risk assessment. Fisheries with potentially calamitous impacts should be high priorities for transition to SEM. Prioritizing fisheries where gains clearly outweigh the costs and a constituency for reform can be built will be critical to success.

Strategy Development

Responsible fisheries management is undermined by the ratchet effect, leading to strategy failure. Fisheries managers often face substantial pressure to increase harvest rates when productivity is high, but also to maintain harvest rates in the face of declining productivity (Ludwig et al. 1993). A key move toward responsible fisheries management is to establish a process for strategy development that enables and encourages fisheries managers to set appropriate controls despite this pressure (Botsford et al. 1997). Once a strategy is set, it is important to fix quantitative targets, limits, and a timeframe for the operational results.

MSY is no longer considered an appropriate target (Punt and Smith 2001). For most fish stocks, the yield is similar over a range of stock sizes near the MSY point, but with very different consequences. Lower stock levels dramatically increase the risk of collapse, without substantial gain in long-term yields. Greater stock sizes are often favored because yields are only slightly lower while the economic performance of the fishery is usually better. At higher stock levels, catch per unit effort may rise, reducing fishing costs and raising profits (Hilborn et al. 2003; Worm et al. 2009). Larger stocks also provide a buffer against environmental variation, and mitigate impacts on the ecosystem. Thus, targets may be set at biomass levels that support MEY or above, taking into account the ecological role of fished resources.

Pre-defined decision rules based on a combination of targets and limits can enable fisheries managers to resist pressure to set inappropriate harvest rates for depleted resources. Harvest control rules, such as constant fishing mortality and constant escapement are examples of strategies that aim to achieve the management objectives of fisheries. These simple rules can be agreed in advance and applied semi-automatically. Once agreed upon, decision rules can reduce conflict over annual quotas and avoid delaying action to recover depleted stocks (Beddington et al. 2007). Given the uncertainty inherent in fisheries management, the precautionary approach implies that responsible fisheries management be designed to respond effectively to changes in the resource (Hilborn and Walters 1992). Harvest control rules can be devised to achieve this ‘automatically’ by adjusting the TAC to changes in biomass.

For example, the Peruvian anchoveta fishery is now managed through a constant escapement harvest control rule — the fishery is closed when spawning biomass is estimated to have been reduced to the level needed to support adequate recruitment for the next season (Fréon et al. 2008). Each season, the TAC is set by applying the harvest control rule to estimates of current stock biomass. Where fisheries-specific data is not available, rules of thumb can be used to set limits. For example, fishing effort may be automatically reduced if biomass falls below the level of MSY or MEY, or a moratorium established if biomass falls to levels likely to incur serious risks of low recruitment and possible stock collapse (Hilborn et al. 2003).

Decision analysis can be used to assess the possible outcomes of different decision rules and other management strategies (Seijo 2007). Where significant uncertainty exists about the state of the resource or other factors likely to influence outcomes, decision analysis defines alternative ‘states’ (e.g., IUU fishing is controlled or not) by assigning relative probabilities to each possible state (e.g., 50:50). Possible decision rules or management strategies are identified and outcomes for each of the proposed states are predicted. This analysis can, of course, include outcomes related to the objectives of SEM, including impacts on essential fish habitats and ES. The results provide guidance on the expected outcomes from different strategies (see Box 7.4). Decision analysis is most often applied to single species or multispecies fisheries, but can be applied to entire ecosystems (Smith et al. 2007), especially by using more qualitative approaches.

Fisheries management requires knowing the status of exploited stocks (Beddington et al. 2007; Seijo 2007). Investment in stock assessments and independent surveys is critical to track stock status, set evidence-based targets and limits, and manage adaptively. Assessments of current stock status can strengthen the efforts of fisheries managers to set appropriate harvest rates and foster support among stakeholders. It is much harder for fishery managers to restrain harvest rates when the status of the stock is poorly known (Botsford et al. 1997). As far as possible, fishers should be involved in fisheries research. Under the precautionary approach, greater care should be applied in managing fisheries when information is uncertain. This gives fishers an incentive to reduce uncertainty through investment in research. The effects of management on stocks should be monitored and strategies changed as appropriate. Ideally, this would involve a process of active adaptive management (e.g. Sainsbury 1991), but for many non-spatially-structured fisheries experimental management is infeasible. Alternatively, strategies can be tested via computer simulation in management strategy evaluation, a form of decision analysis (Smith et al. 1999).

Box 7.4. Decision Analysis

Anda-Montañez and colleagues (2010) recently explored different management strategies for the Pacific sardine (*Sardinops sagax*) off Mexico. To address environmental uncertainty, they defined four 'states of nature' in relation to the multivariate ENSO index — 'normal' conditions prevail, El Nino-type conditions prevail, La Nina-type conditions prevail, and conditions cycle between normal, El Nino, La Nina, and back to normal — and set probabilities for each of these states occurring. They then explored five different management strategies: open access, effort set at MEY, catch set at MSY, constant effort (2004 levels), constant catch (2001 levels). They then evaluated fishery performance using each of the management strategies under each of the states of nature, with Net Present Value (discount rate = 4%) as the performance indicator. The table below summarizes the results.

STRATEGY	STATE 1: NORMAL	STATE 2: EL NINO	STATE 3: LA NINA	STATE 4: CYCLE	EXPECTED VALUE	VARIANCE
	P1=0.36	P2=0.18	P3=0.18	P4=0.28		
OPEN ACCESS	246,608	35,612	451,107	194,891	230,958	1.60E+10
MEY	222,709	113,896	368,655	190,902	220,487	6.24E+09
MSY	95,507	-9,650	78,179	83,492	70,096	1.43E+09
CONSTANT EFFORT	235,841	113,434	399,223	199,104	**232,930**	7.87E+09
CONSTANT CATCH	26,437	-44,347	21,488	22,997	11,842	6.96E+08

The results of this analysis indicate that a risk-neutral decision maker (i.e. on who seeks to maximize the expected value and is not concerned about variance) would select the constant effort strategy. (Fisheries scientists can develop and present such analyses, but decisions remain the responsibility of decision-makers.)

A study by Hasenclever et al. (2002) shows the potential for using decision analysis even in a data-poor context. The analysis was on the freshwater pacu (*Piaractus mesopotamicus*), one of the most intensively harvested fish in Brazil's Pantanal. It represents about 40% of the commercial harvest, and is caught by nearly 80% of tourists to the region. Landings have been declining by approximately 18% per year under BAU management. This study focused on estimating species economic value and the loss in future values if it disappeared. Decision analysis was used to evaluate alternative strategies. The value of the commercial fishery was estimated by multiplying the average annual landings per fisher by the number of registered fishers. For the recreational fishery, the net value of each visit was estimated based on survey data, taking into account indirect effects through the tourism industry. The study used this to compare the value under BAU and under sustainable management. In the absence of data on maximum sustainable yields of pacu, two alternative 'states' were considered: MSY occurs at 50% of current harvest rates, and MSY occurs at 75% of current harvest rates. The expected economic value over 20 years with a discount rate of 6% is presented in the Table. Lacking data on the likelihood of the alternative states, equal probabilities are assumed.

Decision Analysis For PACU

	STATE 1: MSY @ 50% OF CURRENT YIELDS	**STATE 2: MSY @ 75% OF CURRENT YIELDS**	**EXPECTED OUTCOME**
	PROBABILITY = 50%	PROBABILITY = 50%	
BAU	R$37,160,000	R$37,160,000	R$37,160,000
SEM	R$70,540,000	R$105,810,000	R$88,175,000

Source: Modified from Hasenclever et al. (2002).

Even with limited data on the economic contribution of the fishery, and despite uncertainty about MSY, the analysis provides clear guidance to decision-makers on the relative value of expected outcomes under BAU versus SEM.

Management Plan Development: Clarity, Buy-in, Accountability

A formally adopted management plan with predefined decision rules for how to respond under different circumstances is an important component of successful fisheries management (Beddington et al. 2007). Most management plans aim to achieve the following:

- set out the operational objectives, performance indicators, targets, and limits;
- specify the decision rules or management strategies (e.g. constant harvest rate);
- establish the tools (e.g. quotas, gear restrictions, incentives for reducing bycatch) to be used in implementing the strategy;
- provide fishery-specific details on user rights and responsibilities, and allocation instruments;
- set out the monitoring and research plan and the process for evaluation and adaptive management;
- provide fishery-specific details on enforcement mechanisms.

Effective participation by stakeholders in development of operational objectives and in evaluation of alternative management strategies is likely to be important for success. Management systems that exclude fishers are more likely to overlook practical options and encounter resistance to change than those that actively involve fishers (Hilborn et al. 2003). As far as possible, stakeholders should have a long-term interest in the resource. For SEM, it is important that all affected by fishing have a voice, including those outside the fishery. The process of identifying the full range of stakeholders and facilitating their participation needs to be defined prior to strategy development.

Orensanz et al. (2005) describes participation by federations of artisanal fishers from two regions in the development of a five year management plan for the sea urchin (*Loxechinus albus*) fishery in southern Chile. Formal interviews with a range of stakeholders were used to identify key aspects of the fishery that could help in strategy design, including the potential to manage by combination of measures: rotating harvest areas, monitoring recovery rates, using a size limit to balance reproductive contribution with market demand, and extensive fisheries refugia. The government then brought major stakeholders (fishers, processors, managers, scientists) together to discuss the fishery's future. This led to formation of a technical committee representing all stakeholders. A small technical advisory team drafted a management plan, to which stakeholders agreed, based on access control, experimental rotation, and refugia creation.

Box 7.6. Pro-poor fisheries management

InFAO (2005) describes several measures to support pro-poor fisheries management:

- Ensuring that fisheries management goals are consistent with pro-poor management: In developing countries, high employment may be a legitimate goal, as long as it is compatible with sustainability of the resource (Beddington et al. 2007). But, maximizing employment is likely to involve trade-offs with economic efficiency. Appropriate balance between objectives may vary by fishery and should be made clear in legislation.
- Developing access and allocation systems that enable the participation of the poor in fisheries: Countries may consider zoning systems that provide preferential access to some fishing grounds to small-scale fisheries. In Peru, for example, the industrial purse-seine fleet is restricted from fishing within five miles of the coast. Community-based access management may be one way to regulate access without eliminating the valuable safety net role played by open access fisheries.
- Facilitating effective participation by low income and marginalized fishing communities in decision-making, and decentralizing management responsibilities (including co-management where appropriate).
- Investing in improved post-harvest processing and marketing capacities: Inadequate infrastructure and limited access to credit are major constraints preventing fishers in remote regions from securing the full market potential of their products. Investments in these areas could not only improve incomes associated with fisheries but contribute more broadly to rural development and economic empowerment, especially of women who are often involved in post-harvest processing and marketing.
- Fostering research and development programs that are oriented toward the needs of low-income fishers and that involve them as participants.000).

7.11 REALIGNING INCENTIVES FOR SEM

For SEM, it is essential that fishers and other stakeholders have a long-term interest in the resource. Achieving this will require a three-pronged approach: incentive-based approaches, complemented by more traditional regulatory tools (in particular, access control), and effective surveillance and control measures.

One of the main factors underlying fisheries resource depletion is the frequent misalignment between the private incentives of fishers and the incentives that reflect public economic and ecological objectives. Thus, one way to reduce resource depletion is to re-align private incentives with public objectives, by providing secure user rights, removing perverse incentives, and creating positive incentives for SEM (e.g., via market certification).

Regulatory Tools

The regulatory tools used to implement fisheries management strategies include access controls (below), area management (such as refugia), input controls (like gear restrictions, season lengths, and effort limits) and output controls (annual catch quotas, size limits). In most fisheries, a combination of tools is applied — a system of checks and balances to achieve fisheries management objectives and mitigate risk (Grafton et al. 2006; Beddington et al. 2007). The appropriate combination will depend on context, especially the feasibility of surveillance and control for different tools. Fishers often respond to one type of restriction by expanding effort in other ways. For instance, a major tool for industrial fisheries management is the TAC within some time period. In some cases, setting a TAC has led to a race to fish that is both economically inefficient and damaging to ecosystems. Catch shares is a tool that addresses this issue, as was the case with the Peruvian anchoveta. Another well-established form of output control is size limits, although effectiveness depends on selective fishing practices that avoid catching and discarding individuals outside the size limits. These measures are often used to the prevent harvesting of juveniles or the harvesting of mature females that are important for recruitment.

ACCESS CONTROLS

Access control plays a key role in generating incentives for sustainable management. The economic interests of fishers depend critically on access rights (Hilborn 2007). Without access control, the future benefits of sustainable management are likely to be dissipated, thus undermining sustainability.

Open access regimes have also been a major factor in developing overcapacity (Gelchu and Pauly 2007). However, if the number of vessels in a fishery is limited but individual catches are not, then fishers often find other ways to increase fishing power (Hilborn et al. 2003).

Access to most industrial fisheries in LAC is formally controlled through licenses. For example, Chilean law defines four fisheries regimes: general access, full exploitation, fishery recovery, and fisheries in development. The first two require a fishing permit for the vessel owner. For fisheries under full exploitation, a catch limit per vessel owner is in place. The last two regimes are based on fishing permits obtained through public auction under a transferable quota system (Gelcich 2009). In some cases, such as the Peruvian anchoveta fishery, efforts to limit the number of licenses have been circumvented. Access to small-scale fisheries with many vessels operating out of multiple ports is difficult to control and is often effectively open access (Salas et al. 2007). In the absence of legal limits, traditional access limitations may exist and can provide a valuable basis for management (Orensanz et al. 2005; Castilla and Defeo 1998).

Incentive-based approaches

CATCH SHARES AND TURFS

In theory, incentives-based or rights-based approaches to fisheries management realign private incentives to fit national economic interests. The private incentives arising from competition for a common property resource lead actors to use the resource fully in the short-term with no concern for its future. If future access to a fishery resource is insecure, private incentives promote overfishing, overcapacity, and a race to fish (Beddington et al. 2007). In contrast, once each actor knows what its share of the catch will be, improved income will be achieved not by catching more, but by guarding against resource depletion and economic inefficiency. Secure tenure creates an incentive to invest in the underlying fish stock and maximize fishing revenues over a longer time-frame, by eliminating excess capital and fishing effort. Thus, rights-based approaches are used as a tool to reduce capacity and build efficiency.

Incentives-based approaches are not usually based on true property rights — marine resources are typically held in public trust under national laws — but on access privileges that allow individuals or groups to use the resource. These privileges may be subject to performance standards and accountability. They include catch shares (individual quotas, individual transferable quotas [ITQs], community development quotas, enterprise allocations) and territorial use rights in fisheries (TURFs) (Branch 2009). LAC is home to a variety of catch share systems. Chile has made extensive use of them, with catch share systems now in place for squat lobster (since 1992), black hake (1992), yellow prawn (1997), orange roughy (1997), anchovy, common sardine, and jack mackerel (all 2001) (Aranson 2002; Costello et al. 2008). The early biological performance of the Chilean ITQs has been promising. After four years of ITQ management, exploitable biomass in the squat lobster fishery increased from 15,500t to more than 80,000t, with parallel growth in TACs (Bernal et al. 1999; Cerda-D'Amico and Urbina-Veliz 2000). In terms of economic performance, Gomez-Lobo and colleagues (2007) estimate that over a 20-year horizon, ITQs will produce additional benefits between $123 million and $366 million, compared to less efficient management schemes. This magnitude of lost value to be recaptured by ITQs is in line with estimates of $50 billion lost in fisheries worldwide by mismanagement (World Bank 2009). Catch shares have also been initiated for the Peruvian anchoveta (see Section 2.3), and Argentinean San Jose Gulf scallop fishery (Orensanz et al. 2007).

Typically, small-scale fisheries in LAC have a large number of operators based at many ports, often targeting multiple species. In this context, individual catch shares may not be practical, and area-specific community-based management, such as TURFs, may be more appropriate (Orensanz et al. 2005). Examples include Chilean loco abalone (see Section 2.4), Mexico's red rock lobster (discussed below under certification), and Mexico's Punta Allen spiny lobster. The latter is run by a local fishing cooperative, as are other spiny lobster fishing grounds. The Punta Allen cooperative created private incentives for responsible management by allocating areas to individual fishers. The result has been a long-term trend of stable catch, while data for the other cooperatives show drastic fluctuations. The spiny lobster fishery still lacks a firm harvest quota, instead relying on a seasonal closure and fishers' own incentives not to overharvest their areas.

The potential for displacement of fishing effort to other fisheries can be addressed by introducing catch shares across multiple fisheries (as in Chile and Peru), or by ensuring that adequate measures are

Box 7.7. Fisheries Co-Management: Attributes for Success

Co-management systems engaging multiple stakeholders have been developed in a wide range of fisheries in LAC. A variety of fisheries management tools have been used under them, such as TURFs (e.g., Chilean loco abalone), fisheries refugia (e.g., sea urchin reproductive refugia in Chile [Orensanz et al. 2005]), and other area-management systems, as with pirarucú. Co-management can pursue resource management objectives (such as reduced resource depletion, rebuilt stocks, and improved yields), economic objectives (increased contribution of fisheries to local livelihoods and the broader economy) and social objectives (equity, coastal community development). Gutierrez et al. (in review) have analyzed factors that contribute to success of co-management initiatives in LAC and elsewhere.

Success factors vary by ecosystem, resource type (e.g., benthic, demersal, pelagic; single or multi-species), type of users (small-scale or industrial fishery), co-management framework (consultative, cooperative, delegated), and management attributes (monitoring, control and surveillance, local agency support, etc.). Salient factors, especially for meeting socio-economic goals in small-scale fisheries of developing countries, include social attributes such as leadership, community cohesion, and trust. Effective co-management requires time and resources. Participants need assurance that benefits outweigh costs. Tracking effects on fisheries resources and other targets can contribute. For example, monitoring populations of pirarucú has helped prove the benefits of SEM to both fishers and management authorities (Viana et al. 2007). Building on existing institutions may facilitate development of effective co-management. Capacity-building for stakeholder organizations (e.g., fisheries associations) and staff of participating agencies may be needed. Low-cost conflict resolution mechanisms may need to be set up. Boundaries of managed areas should be well-defined.

The scale of intervention should match that of the resource (Hilborn et al. 2005). Local management is more appropriate for sedentary and/or spatially-structured resources (Castilla and Defeo 2001), such as abalone and lobster. However, coordination among local organizations is essential for managing meta-populations (Orensanz et al. 2005). Pelagic resources that mix over large areas need to be managed at broader scales. A supportive legal framework is also essential for empowering fisheries associations or local organizations to set and enforce resource management rules. Local surveillance and control may need to be backstopped by government enforcement, especially to prevent encroachment from outsiders (Castilla and Gelcich 2008). Simple institutional structures with clear lines of responsibility are important for successful fisheries management (Hilborn et al. 2005). To build confidence, transparency is important; public annual reports on the status of the fisheries managed can be helpful.

Box 7.8. Reduction of Subsidies and Capacity Reduction

Co-management systems engaging multiple stakeholders have been developed in a wide range of fisheries in LAC. A variety oHarmful subsidies and overcapacity in fisheries both serve to distort incentives. Addressing these issues should be integral to any incentives-based approach to fisheries management.

Many fisheries in LAC are heavily subsidized (Figures 2.1.1, 2.1.2; Khan et al. 2006). Some subsidies, such as tax exemption on fuel or access to low-interest credit for fleet development, create perverse incentives that directly contribute to overfishing and development of overcapacity (Seijo 2009). Reducing such perverse subsidies is an essential step to re-aligning private incentives with national economic interests. While subsidy reduction is often unpopular, opposition can be mitigated by reorienting subsidies toward investment in responsible fisheries management, including efforts to reduce IUU fishing (especially by foreign fleets).

When a fishery is characterized by fleet overcapacity, capacity reduction may be achieved directly through licensing or vessel buyback schemes, or indirectly through the creation of secure use rights that stimulate fleet reduction. However, vessel buyback programs have been less effective than expected. Often, only the least efficient vessels are removed from the fishery thus increasing the overall efficiency of the remaining fleet, and the programs do not address the underlying incentives that led to fleet overcapacity in the first place (Beddington et al. 2007).

Catch shares and territorial use rights (TURFs) encourage fishers to adjust capacity to optimize economic yield (assuming no distortion by inappropriate subsidies) (Beddington et al. 2007; Grafton et al. 2006). ITQs can provide compensation to those who choose to leave the industry, stimulating fleet reduction without recourse to public funds (Hilborn 2007d). For example, introduction of catch shares in the majority of Chilean fisheries has led to a major reduction in fishing capacity in these fisheries, without recourse to costly decommissioning programs (OECD 2009).

Box 7.9. Small-scale Fisheries

Globally, there is growing consensus on the strategies and tools required to manage high-value industrial fisheries, but managing small-scale fisheries presents distinct challenges (Salas et al. 2007; Gelcich et al. 2009). For instance, output controls may be the best option for single species industrial fisheries with a limited number of vessels and ports, but may not be feasible for small-scale fisheries that involve numerous vessels operating out of many ports and targeting multiple species (Salas et al. 2007). In LAC, many small-scale fisheries are effectively open access, leading to overexploitation and livelihood decline. Simple input and output controls, such as gear restrictions, closed seasons, and size limits, are commonly used because they are easier to monitor than aggregate catches, especially for multi-species fisheries. Catch quota systems are undermined by unreliable estimates of stock sizes, high rates of IUU fishing, and the high cost of surveillance and control in a mobile, spatially-dispersed fishery (Salas et al. 2007). Marine reserves are often used to protect species of concern and/or valued habitats, but they are not effective to reduce fishing effort overall. Fisheries refugia, to protect spawning aggregations and recruitment, may help sustain productivity (Appeldoorn 2008). Approaches based on defining fishing rights and increased co-management are more promising, where feasible.

The challenges of sustainably managing small-scale fisheries of mobile species need greater attention. LAC has pioneered development of approaches to manage sedentary and spatially-structured resources in small-scale fisheries (Orensanz et al. 2005), but tools to manage small-scale fisheries of more mobile resources remain elusive. Orensanz et al. (2005) emphasize that no method is a panacea; appropriate strategies and tools need to be designed for each context. Recent research on socio-ecological systems has highlighted the need to engage local stakeholders in developing socially and culturally appropriate solutions instead of imposing generic ones from the top down (McClanahan et al. 2009).

in place to prevent the build-up of capacity and effort in alternative fisheries (such as effective access controls).

There have also been concerns about equity in catch share systems, in that these shares represent real wealth and economic opportunities from which others are excluded. The system for assigning shares should be developed with transparency and stakeholder involvement from the beginning. A particular concern is the removal of the social safety net provided by open access fisheries. This can be mitigated through community rather individual use rights where appropriate (as in most TURF systems)

Dedicated access privileges are designed to promote sustainable fisheries management. They do not deal directly with ecosystem issues such as by-catch and habitat damage (Beddington et al. 2007), though reducing fishing effort and stopping the race to fish may diminish these impacts (Branch 2009; Essington 2010). Other tools may be needed to deal with these problems (Hilborn 2007).

CERTIFICATION AND MARKET INCENTIVES

Certification schemes can provide incentives for SEM by granting privileged access to high-value markets and enabling fishers to differentiate their product in return for commitment to responsible fisheries management and reduced ecosystem impact. Two fisheries in the LAC region have been certified by the Marine Stewardship Council (MSC): Patagonia Scallop (Argentina) and Baja California red rock lobster (Mexico). Both fisheries are limited in size, which provides clear incentives and facilitates surveillance and control. Fisheries being assessed for certification include the Sian Ka'an and Banco Chinchorro Biosphere Reserves spiny lobster (Mexico), the Gulf of California sardine (Mexico), and the Suriname Atlantic seabob shrimp.

The Patagonia scallop fishery provides an example of a fishery that has been managed to avoid excess fishing effort and overcapitaliza-

Box 7.10. Reduction of Discards, Bycatch, and Waste

Discards here comprise individuals of targeted species that are rejected, bycatch (non-targeted species, including some of commercial value to other fisheries), and ghost-fishing. Discarding may be exacerbated by regulations such as size restrictions or quotas that encourage high-grading (Hall and Mainprize 2005). Discard reduction can be achieved through regulatory tools (such as gear specifications or area management (e.g., permanently or temporarily closing areas with unacceptably high discard rates), or incentive-based approaches (bycatch quotas, certification).

All gears can produce discards, but some are more selective than others. Input controls have been used to increase the selectivity of fishing gear (e.g., minimum mesh size to reduce pressure on juveniles) and reduce habitat damage (e.g., low-impact trawls instead of destructive gear). Gear can be made more selective with bycatch reduction devices and other measures (Hall and Mainprize 2005). Closed areas and seasons can be effective in reducing negative impacts during spawning and other sensitive periods (Salas et al. 2007). For instance, the Peruvian anchoveta fishery may be closed in specific areas if the proportion of juveniles in the catch is unacceptably high. Discard rates may also be reduced through initiatives to increase use of non-targeted species (Kelleher 2005).

Incentive-based approaches include adjusting catch shares to favor vessels with low discard rates, penalties on vessels for discards, and fleet-wide discard reduction quotas. Estimates of fishing mortality in stock assessments should include mortality from all sources, not just targeted fisheries (Crowder and Murawski 1998). Access to high value international markets (for example, through certification) may also be dependent on reducing discards and provide significant incentives. These approaches can provide strong incentives to avoid high bycatch areas and stimulate technological innovation by fishers seeking to reduce bycatch cost-effectively (Hilborn 2007d; Branch 2009). Such measures require adequate surveillance and control systems, perhaps even comprehensive observer coverage; thus, these measures may be costly. Catch share systems can also reduce discards by lowering the pressure to fish as fast as possible and reducing ghost fishing due to lost gear (Hilborn 2007d; Branch 2009).

Solutions need to be technically feasible, financially and economically viable, and enforceable. Participatory research can play an important role in developing such solutions (e.g., Peckham et al. 2007). Incentives-based approaches generally require onboard observers and are, therein, often expensive to implement (Hilborn 2004). A major concern is that tighter regulations on one fishery may displace the problem to fisheries elsewhere with less strict enforcement.

Box 7.11. Fisheries Refugia to Safeguard Critical Life Stages and Essential Fish Habitat

Discards here comprise individuals of targeted species that are rejected, bycatch (non-targeted species, including some of comZoning is used to balance multiple objectives in marine ecosystems and reduce conflict between multiple users (Rivera-Arriaga 2005). Often a feature of integrated coastal zone management (Suman, 2002; Rivera-Arriaga 2005; Edwards, 2009), zoning may also be extended beyond the continental shelf to manage the broader EEZ. Marine protected areas (MPAs), including no-take marine reserves, are one form of spatial zoning that can contribute to SEM.

Marine reserves are sometimes adopted to control exploitation rates. However, they do not reduce fishing effort per se, but shift fishing effort to other areas (Hilborn et al. 2004). In the absence of complementary measures, marine reserves may simply result in more intense fishing outside their boundaries. Conventional measures may provide a more direct tool for reducing fishing effort (Beddington et al. 2007).

Marine reserves have a greater role to play in managing mult-ispecies fisheries, when conventional approaches will lead to some stocks being overfished at multispecies MSY, and in small-scale fisheries where management by output controls is more challenging (Salas et al. 2007). In these cases, marine reserves can protect stocks in specific sites against overexploitation. The contribution to fisheries management will depend on the location and size of the marine reserve in relation to the spatial structure and mobility of the stock. For spatially structured stocks, rotation of closed areas has proven successful in Chile (Castilla et al. 1998; Castilla and Fernandez 1998). As in terrestrial systems, the success of conservation inside marine reserves is often dependent on how resources are managed outside reserves. Marine reserves may not rescue stocks that are poorly managed in the rest of their range.

Fisheries refugia are marine reserves designed to protect habitat essential to critical life history stages of targeted populations (e.g., spawning and recruitment areas)). For fisheries that suffer from recruitment overfishing, fisheries refugia may increase recruitment and yields within a fishing area if they protect critical life stages or habitats, such as spawning aggregations or nurseries. Refugia effectiveness will depend, in part, on the mobility of species. For example, in Chile, marine reserves are reproductive refuges, designed as a tool for fisheries management. They are distinct from MPAs, designed to protect biodiversity for conservation or research (Orensanz et al. 2005). For each fishery, known spawning and nursery grounds should be identified as part of the management planning process. Sites key to productivity may then be protected to reduce interference with recruitment or growth. Measures may include restricting gear, methods, seasons, and access or use rights. The location and size of refugia or networks of them are critical to success, especially in the context of populations with source-sink configurations (Sale et al. 2005; Seijo and Caddy 2008). Adaptive management approaches may help address the challenges associated with refugia design (Sale et al. 2005).

In some cases, area management may be easier to enforce than other regulations. Area closures are facilitated by the growing use of vessel monitoring systems (VMS) in LAC. For example, all vessels with catch shares in the Peruvian anchoveta fishery, including the artisanal fleet, are required to have VMS.

tion. Two companies have harvesting authorization for the Patagonian scallop, operating a total of four freezer-trawlers and landing approximately 50,000t. Trawling is restricted to areas known to be primarily sand and mud. Size regulations are designed to ensure that individuals are not harvested until after they have already spawned three times. The fishery benefits from 100% observer coverage. One of the companies emphasizes that MSC certification has differentiated their product from the competition and opened access to high-value markets in Europe (MSC 2009).

The Baja California red rock lobster was certified sustainable in April 2004. At the time of writing, the 5-year certificate has expired and the fishery is being re-assessed. The fishery involves nine cooperatives, each fishing an exclusive area under a long-term concession. A biologist for the cooperatives argued that even though 95% of the lobster is currently sold to Asia without the MSC label, demand for MSC products is expected to increase and the label will eventually become essential for accessing markets (MSC 2009).

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7.13 MANAGEMENT CAPACITY, FUNDING, AND RESEARCH FOR SEM

Management Capacity

SEM requires management capability to design, evaluate, and adapt science-based strategies, rationalize the incentives framework, and ensure effective surveillance and control. Investment in an appropriate institutional structure to pursue these ends is fundamental.

Effective Surveillance and Control

IUU fishing is a major factor in overfishing. It occurs when strategies and regulations are weak or not effectively enforced (Beddington et al. 2007). Surveillance and control is vital to incentive-based management as well as to traditional regulation. The efficacy of catch shares depends on it, for example. In Chile's black hake ITQ, the TAC increased from 5,000t to 7,500t in the first four years, but then declined to 6,000t in the fifth year. Illegal fishing has been blamed for a downturn in the stock, with IUU harvest estimated as equal to the legal one (Bernal et al. 1999). Catch shares do not in themselves remove the incentive to cheat and can increase incentives to underreport, as seen in the Peruvian anchoveta case. The fact that cheating reduces the value of other fishers' quotas has in some cases stimulated fishers to invest in surveillance and enforcement themselves, as in several Chilean TURF fisheries (Defeo and Castilla 2005). But fishers and their associations may need support from government agencies (Castilla and Gelcich 2008), especially against powerful outside interests. Surveillance and control systems need to be agreed and in place prior to starting ITQs (Branch 2009).

Design of fisheries regulation and incentives systems needs to consider the feasibility of surveillance and control. Input measures like restrictions on vessel numbers or on fishing seasons may be easier to enforce than output measures, such as catch quotas (Beddington et al. 2007). Fishers will be deterred from breaking fishing regulations if the loss expected from detection and successful prosecution exceeds the expected gain (Beddington et al. 2007). Enforcement failure may be attributed to low detection and conviction rates, and/or inadequate penalties in relation to expected rewards. Countries impacted by IUU fishing need to strengthen governance (Agnew et al. 2009), by investing in capacity to undertake surveillance and enforcement, improved procedures to prosecute IUU fishing, and stronger sanctions.

Estimates of unreported catches need to be included in stock assessment models and taken into account when setting the TAC. Otherwise, unreported catches over and above the TAC will lead to stock depletion. This creates a strong incentive to control IUU fishing. Addressing IUU fishing is needed under SEM to ensure that registered fishers have a stake in improved fisheries management.

Funding: Financing the Costs of Transition to SEM

In principle, moving toward SEM should bring an increase in the economic rent captured from fisheries. The additional long-term costs of fisheries development under SEM can be financed by reorienting funds that support harmful subsidies toward the support of critical facets such as strengthened surveillance and control, and by capturing part of the increased economic rent through taxes or license fees, or via other cost recovery mechanisms. Funding sources for management plans should be identified before launching them.

In Chile, the national treasury captured value at the start of the new ITQ systems by auctioning quotas, with subsequent annual re-auctioning of 10% of the total quota. AMERBs must also pay an annual fee in return for territorial use rights (Castilla and Gelcich 2008). License fees account for only 5% of the public income generated by these fisheries (Cerda-D'Amico and Urbina-Veliz 2000), in contrast to the pattern in many fisheries worldwide, where license fees are the main way costs are recovered. Chilean fisheries have been able to absorb these costs due to a combination of higher catches, greater efficiency, smaller fleets, and the elimination of overcapitalization, all increasing realized value (Gomez-Lobo et al. 2007). The Peruvian anchoveta case also shows that increased returns on investment can be generated by SEM. Two new levies have been designed so that beneficiaries of the reform fund the social costs of transition.

Many countries in LAC do not attempt to recover fisheries management costs from the industry; in at least some cases, this may amount to a perverse subsidy. However, in some instances, the industry has covered some of the costs of transition to or management under SEM, based on expectations of increased returns on investment. Pena-Torres (2002) discusses ITQ fisheries in which surveillance and control are funded wholly or in part by the industry, and suggests such an approach for Chile. The contribution of the fishery to the national treasury will increase via corporate income tax revenues, even without restructuring the tax and cost recovery regime. Making SEM in fisheries self-financing should be encouraged.

In Chile, fisheries associations cover the costs of baseline studies and annual stock assessments for AMERBs. They also take responsibility for surveillance and control within their own organizations, thus reducing the costs of enforcement incurred by public agencies (Castilla and Gelcich 2008). Cost recovery is more likely to be achieved where fishers have incentives to engage constructively in fisheries management (Beddington et al. 2007).

Research to Support SEM

In many LAC countries, fishery research institutes have limited capacity (Salas et al. 2007), due to shortage of trained personnel, insufficient financial support to gather fisheries-independent data and carry out operational research programs, and lack of a clear mandate to lead toward improved fisheries.

To attain responsible fisheries management in the context of the pervasive uncertainty inherent in fisheries, much greater capacity for risk assessment, decision analysis, and strategy evaluation is required.

To support progress toward SEM, essential fish habitats need to be identified and mapped as a basis for establishing fisheries refugia. Further research is also required to assess the ecosystem effects of fishing; marine reserves may play a useful role as control sites. The results of ecological risk assessment can help identify priorities for the study of fishing pressures on ecosystems..

Ecosystem models (such as Ecopath with Ecosim, and Atlantis) provide a framework for exploring the ecosystem impacts of alternative fisheries management options. A range of ecosystem models are available (Plagányi 2007). It will probably be sensible to start with relatively simple models that focus on key interactions rather than full ecosystem models. In the early stages, these models should be considered exploratory – they will help to identify important interactions, provide new insights into the ecosystem effects of fishing, and guide further empirical research, but some time is required before ecosystem models can be used as predictive management tools. The data demands of multispecies ecosystem models are substantial (Beddington et al. 2007; Seijo 2007). The wide range of possible relationships for key functional responses such as those between predators and prey generates a great deal of uncertainty in model output. An incremental exploratory approach, starting with relatively few ecosystem elements and then building on this, offers a way forward.

Appendices

Appendix 7.1. General principles of the FAO Code of Conduct for Responsible Fisheries

6.1 States and users of living aquatic resources should conserve aquatic ecosystems. The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources.

6.2 Fisheries management should promote the maintenance of the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development. Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species.

6.3 States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization. States should take measures to rehabilitate populations as far as possible and when appropriate.

6.4 Conservation and management decisions for fisheries should be based on the best scientific evidence available, also taking into account traditional knowledge of the resources and their habitat, as well as relevant environmental, economic and social factors. States should assign priority to undertake research and data collection in order to improve scientific and technical knowledge of fisheries including their interaction with the ecosystem. In recognizing the transboundary nature of many aquatic ecosystems, States should encourage bilateral and multilateral cooperation in research, as appropriate.

6.5 States and subregional and regional fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.

6.6 Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to conserve the population structure and aquatic ecosystems and protect fish quality. Where proper selective and environmentally safe fishing gear and practices exist, they should be recognized and accorded a priority in establishing conservation and management measures for fisheries. States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species.

6.7 The harvesting, handling, processing and distribution of fish and fishery products should be carried out in a manner which will maintain the nutritional value, quality and safety of the products, reduce waste and minimize negative impacts on the environment.

6.8 All critical fisheries habitats in marine and fresh water ecosystems, such as wetlands, mangroves, reefs, lagoons, nursery and spawning areas, should be protected and rehabilitated as far as possible and where necessary. Particular effort should be made to protect such habitats from destruction, degradation, pollution and other significant impacts resulting from human activities that threaten the health and viability of the fishery resources.

6.9 States should ensure that their fisheries interests, including the need for conservation of the resources, are taken into account in the multiple uses of the coastal zone and are integrated into coastal area management, planning and development.

6.10 Within their respective competences and in accordance with international law, including within the framework of subregional or regional fisheries conservation and management organizations or arrangements, States should ensure compliance with and enforcement of conservation and management measures and establish effective mechanisms, as appropriate, to monitor and control the activities of fishing vessels and fishing support vessels.

6.11 States authorizing fishing and fishing support vessels to fly their flags should exercise effective control over those vessels so as to ensure the proper application of this Code. They should ensure that the activities of such vessels do not undermine the effectiveness of conservation and management measures taken in accordance with international law and adopted at the national, subregional, regional or global levels. States should also ensure that vessels flying their flags fulfil their obligations concerning the collection and provision of data relating to their fishing activities.

6.12 States should, within their respective competences and in accordance with international law, cooperate at subregional, regional and global levels through fisheries management organizations, other international agreements or other arrangements to promote conservation and management, ensure responsible fishing and ensure conservation and protection of living aquatic resources throughout their range of distribution, taking into account the need for compatible measures in areas within and beyond national jurisdiction.

6.13 States should, to the extent permitted by national laws and regulations, ensure that decision making processes are transparent and achieve timely solutions to urgent matters. States, in accordance with appropriate procedures, should facilitate consultation and the effective participation of industry, fishworkers, environmental and other interested organizations in decision making with respect to the development of laws and policies related to fisheries management, development, international lending and aid.

6.14 International trade in fish and fishery products should be conducted in accordance with the principles, rights and obligations established in the World Trade Organization (WTO) Agreement and other relevant international agreements. States should ensure that their policies, programmes and practices related to trade in fish and fishery products do not result in obstacles to this trade, environmental degradation or negative social, including nutritional, impacts.

6.15 States should cooperate in order to prevent disputes. All disputes relating to fishing activities and practices should be resolved in a timely, peaceful and cooperative manner, in accordance with applicable international agreements or as may otherwise be agreed between the parties. Pending settlement of a dispute, the States concerned should make every effort to enter into provisional arrangements of a practical nature which should be without prejudice to the final outcome of any dispute settlement procedure.

6.16 States, recognising the paramount importance to fishers and fishfarmers of understanding the conservation and management of the fishery resources on which they depend, should promote awareness of responsible fisheries through education and training. They should ensure that fishers and fishfarmers are involved in the policy formulation and implementation process, also with a view to facilitating the implementation of the Code.

Appendix 7.2. Case Studies on the Contribution of Aquatic Ecosystem Services to Fisheries, Tourism, and Other Sectors

COUNTRY (REGION)	MARINE/ FRESHWATER	ECOSYSTEM(S)	SECTOR(S)	USES COST-BENEFIT ANALYSIS APPROACH?	REFERENCE(S)
ARGENTINA	MARINE	SEVERAL COASTAL HABITATS	FISHERIES	NO	UNEP 2002
ARGENTINA (SAN JOSÉ GULF)	MARINE	DIVING FISHERY	FISHERIES	YES	ORENSANZ ET AL. 2007
BELIZE (GLADDEN SPIT AND SILK CAYES MARINE RESERVE)	MARINE	CORAL REEF, MPA, WHALE SHARK	TOURISM	YES	HARGREAVES-ALLEN 2009
BELIZE, HONDURAS, MEXICO (MESOAMERICAN REEF)	MARINE	CORAL REEF, MPA	FISHERIES	YES	TALBOT AND WILKINSON 2001
BRAZIL (PANTANAL)	FRESHWATER	WETLAND	TOURISM, FISHERIES	NO	SHRESTHA, SEIDLE, AND MORAES 2002
CARIBBEAN SEA	MARINE	MPA	TOURISM	NO	GREEN AND DONNELLY 2003
CARIBBEAN SEA	MARINE	CORAL REEF	FISHERIES, TOURISM, COASTAL PROTECTION	YES	CESAR, BURKE, AND PET-SOEDE 2003; BURKE AND MAIDENS 2004
CARIBBEAN SEA	MARINE	CORAL REEF	TOURISM, FISHERIES, COASTAL PROTECTION	YES	BURKE AND MAIDENS 2004
CHILE	MARINE	SEA URCHIN FISHERY	FISHERIES	YES	MORENO ET AL. 2007
COSTA RICA (TERRABA-SIERPE WETLANDS)	MARINE	WETLAND, MANGROVE	FISHERIES	NO	REYES ET AL. 2004
COSTA RICA (TORTUGUERO NATIONAL PARK)	MARINE	SEA TURTLE	FISHERIES, TOURISM	YES	TROËNG AND DREWS 2004
COSTA RICA, CUBA, MEXICO, BRAZIL	MARINE	BEACH, SEA TURTLE	FISHERIES, TOURISM	YES	TROËNG AND DREWS 2004
ECUADOR (GALAPAGOS ISLANDS)	MARINE	MPA	TOURISM, FISHERIES	YES	WILEN, STEWART, AND LAYTON 2000
EL SALVADOR (GULF OF FONSECA)	MARINE	MANGROVE	AQUACULTURE, FISHER-IES	YES	GAMMAGE 1997
JAMAICA (MONTEGO BAY)	MARINE	GENETIC/MEDICINAL RESOURCES, BIODIVER-SITY, MPA	PHARMACEUTICAL, TOURISM, FISHERIES, COASTAL PROTECTION	YES	CESAR, ÖHMAN, ESPEUT, AND HONKANEN 2000; GUSTAVSON 1998; RUITENBEEK AND CARTIER 2001
LATIN AMERICA AND THE CARIB-BEAN SEA	MARINE	RESILIENCE	FISHERIES	YES	CHAPMAN ET AL. 2008
MEXICO (GULF OF CALIFORNIA)	MARINE	SEVERAL COASTAL HABITATS	FISHERIES	YES	EZCURRA ET AL. 2009
MEXICO (GULF OF CALIFORNIA)	MARINE	DEEP SEA, WHALE SHARK	TOURISM	YES	LOW-PFENG, DE LA CUEVA, AND ENRÍQUEZ 2005
MEXICO (GULF OF CALIFORNIA)	MARINE	MANGROVE	FISHERIES	YES	ABURTO-OROPEZA ET AL. 2008
MEXICO (PACIFIC COAST)	MARINE	MANGROVE	FISHERIES	YES	SANJURJO, CADENA, AND ERBSTOESSER 2005
MEXICO (SONORA)	FRESHWATER	STREAM	WATER MANAGEMENT	YES	OJEDA, MAYER & SOLOMON 2008
PANAMA (COIBA NATIONAL PARK)	MARINE	MANGROVE, MPA	FISHERIES, TOURISM	YES	MONTENEGRO 2007
PANAMA (PACIFIC COAST)	MARINE	MANGROVE	FISHERIES	YES	TALBOT AND WILKIN-SON 2001
TRINIDAD AND TOBAGO, ST. LUCIA	MARINE	CORAL REEF	TOURISM, FISHERIES	YES	BURKE ET AL. 2008
TURKS AND CAICOS ISLANDS	MARINE	CORAL REEF	TOURISM, FISHERIES, COASTAL PROTECTION	NO	CARLETON AND LAW-RENCE 2005
VENEZUELA (MORROCOY NATIONAL PARK)	MARINE	MANGROVE; MPA	FISHERIES, TOURISM	YES	CARTAYA FEBRES AND PABON-ZAMORA 2009

Appendix 7.3. Size of the Fisheries Sector (Contribution to GDP), Size of National Economy (GDP), and % Contribution of Fisheries to GDP

FAO FISHERIES PROFILE			
COUNTRY	**FISHERIES ($)**	**OVERALL GDP ($)**	**FISHERIES SECTOR/GDP (%)**
ANTIGUA AND BARBUDA	13,300,000	1,000,000,000	1.33
BAHAMAS	173,375	6,935,0001	2.50
ARGENTINA	192,000,000	151,298,000,000	0.13
BARBADOS	26,000,000	2,600,000,000	1.00
BELIZE	49,050,000	986,500,000	4.97
BOLIVIA	7,510,000	8,100,000,000	0.09
BRAZIL	2,382,000,000	595,500,000,000	0.40
CHILE	5,422,656,000	169,458,000,0001	3.20
COLOMBIA	3,172,920,000	82,200,000,000	3.86
COSTA RICA	53,810,000	16,818,000,000	0.32
CUBA		27,686,000,000	0.00
DOMINICA		266,670,000	0.00
DOMINICAN REPUBLIC	3,060	30,600,000	0.01
ECUADOR	1,055,195	16,749,124	6.30
EL SALVADOR		14,950,000	0.00
GRENADE	13,000,000	520,000,000	2.50
GUATEMALA	8,276	27,589,000	0.03
GUYANA	157,000,0002	5,587,000,000	2.81
HAITI		29,000,000,000	0.00
HONDURAS		5,900,000,000	0.00
JAMAICA	4,084,000	1,021,000,000	0.40
MEXICO	4,991,200,000	623,900,000,000	0.80
NICARAGUA	48,400,000	4,900,000,000	0.99
PANAMA	342,000,000	17,100,000,000	2.00
PARAGUAY		15,977,0001	0.00
PERU	112,377,500	5,690,000,000	1.98
ST. KITTS AND NEVIS	3,800,000	453,000,000	0.84
ST. LUCIA		825,000,000	0.00
ST. VINCENT AND THE GRENADINES	4,980,000	249,000,000	2.00
SURINAME		1,600,000,000	0.00
TRINIDAD AND TOBAGO	13,320,000	14,800,000,000	0.09
URUGUAY	41,360,840	9,618,800,000	0.43
VENEZUELA	427,000,000	85,400,000,000	0.50

Sources: Fishery and Aquaculture Country Profiles http://www.fao.org/fishery/countryprofiles/search/en
1. Data from World Bank 2008
2.In Guayanese dollars
3. Includes aquaculture

http://www.caricom-fisheries.com/ Catarci, C. (2004) World Markets and Industry of Selected Commercially-Exploited Aquatic Species with an International Conservation Profile. FAO Fisheries Circular No. 990
Tietze, U.; Haughton, M.; Siar, S.V. (eds.) Socio-economic indicators in integrated coastal zone and community-based fisheries management – Case studies from the Caribbean. FAO Fisheries Technical Paper. No. 491. Rome. FAO. 2006. 208p.

Appendix 7.4: Employment in Primary, Secondary, Tertiary Sectors, and in Small Scale Fisheries

	PRIMARY1	SECONDARY1	TERTIARY1	TOTAL PRIMARY AND SECONDARY1	OVERALL EMPLOYMENT2	FISHERIES AS % OF OVERALL EMPLOYMENT	SMALL-SCALE FISHERIES3
ANTIGUA AND BARBUDA	864	50	0	914	28,000	3.26	1,088
ARGENTINA	0	100,0004	0	100,000	9,639,000	1.04	1,690
BAHAMAS	9,300	0	0	9,300	161,000	5.78	
BARBADOS	2,000	825	0	2,825	132,000	2.14	2,200
BELIZE	1,672	123	0	1,795	78,000	2.30	
BOLIVIA	3,600	19,560	2,000	23,160	2,091,000	1.11	
BRAZIL	790,000	250,000	4,000,000	1,040,000	84,596,000	1.23	553,872
CHILE	77,928	80,424	0	158,352	5,905,000	2.68	27,876
COLOMBIA	66,000	28,485	26,700	94,485	18,217,000	0.52	26,000
COSTA RICA	8,567	19,033	6,000	27,600	1,777,000	1.55	4,000
CUBA	11,890	4,820	18,930	16,710	4,642,000	0.36	
DOMINICA	2,843	60	0	2,903	26,000	11.17	3,985
DOMINICAN REPUBLIC	11,138	17,707	0	28,845	3,315,000	0.87	
ECUADOR	95,200	24,800	0	120,000	3,892,000	3.08	82,000
EL SALVADOR	26,260	0	0	26,260	2,526,000	1.04	13,000
GRENADA	2,400	400	0	2,800	35,000	8.00	1,931
GUATEMALA	32,320	9,500	0	41,820	4,769,000	0.88	10,269
GUYANA	6,500	6,000	0	12,500	240,000	5.21	5,644
HONDURAS	36,008	47,686	0	83,694	2,544,000	3.29	11,700
JAMAICA	20,000	480	0	20,480	1,063,000	1.93	20,000
MEXICO	247,765	20,962	0	268,727	41,321,000	0.65	138,941
NICARAGUA	33,840	1,546	0	35,386	1,953,000	1.81	13,439
PANAMA	1,500	37,500	0	39,000	1,188,000	3.28	13,062
PARAGUAY	7,064	8,000	1,200	15,064	2,247,000	0.67	
PERU	80,000	45,000	0	125,000	34,000,000	0.37	56,800
ST. LUCIA	2,319	120	40	2,439	59,000	4.13	2,059
ST. VINCENT AND THE GRENADINES	2,500	500	0	3,000	35,000	8.57	2,500
SURINAME	4,420	2,759	10	7,179	73,000	9.83	
TRINIDAD AND TOBAGO	5,100	1,225	760	6,325	525,000	1.20	2,146
URUGUAY	3,000	3,200	0	6,200	1,115,000	0.56	1,400
VENEZUELA	44,302	0	0	44,302	9,994,000	0.44	40,000
TOTAL	**1,636,300**	**730,765**		**2,367,065**	**238,186,000**	**0.99**	**1,035,602**

Sources:
1. Fishery and Aquaculture Country Profiles 2008
2. 2007/2008 Human Development Report (data 1996-2005)
3. Chuenpagdee et al. 2006
4. Onestini and Gutman 2002

Appendix 7.5. Status of Fisheries in LAC

COMMON NAME	SCIENTIFIC NAME	STATUS OF EXPLOITATION	FAO STATISTICAL AREA	SOURCE	REFERENCE(S)
1.	PACIFIC ANCHOVETA	CETENGRAULIS MYSTICETUS	FULLY EXPLOITED	EASTERN CENTRAL PACIFIC	CSIRKE AND TANSDTAD 2005
2.	JAMAICA WEAKFISH	CYNOSCION JAMAICENSIS	OVEREXPLOITED§	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
3.	SOUTH AMERICAN STRIPED WEAKFISH	CYNOSCION STRIATUS	FULLY TO OVEREXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
4.	GREEN WEAKFISH	CYNOSCION VIRESCENS	OVEREXPLOITED§	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
5.	PATAGONIAN TOOTHFISH	DISSOSTICHUS ELEGINOIDES	MODERATELY TO FULLY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
6.	PATAGONIAN TOOTHFISH	DISSOSTICHUS ELEGINOIDES	MODERATELY EXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
7.	JUMBO FLYING SQUID	DOSIDICUS GIGAS	MODERATELY EXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
8.	JUMBO FLYING SQUID	DOSIDICUS GIGAS	MODERATELY TO FULLY EXPLOITED	EASTERN CENTRAL PACIFIC	CSIRKE AND TANSDTAD 2005
9.	ARGENTINE ANCHOITA	ENGRAULIS ANCHOITA	UNDEREXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
10.	CALIFORNIAN ANCHOVY	ENGRAULIS MORDAX	DEPLETED	EASTERN CENTRAL PACIFIC	CSIRKE AND TANSDTAD 2005
11.	PERUVIAN ANCHOVETA	ENGRAULIS RINGENS	FULLY TO OVEREXPLOITED	SOUTHEAST PACIFIC	FAO 2009
12.	GOLIATH GROUPER	EPENEPHELUS ITAJARA	RECOVERING	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
13.	RED GROUPER	EPINEPHELUS MORIO	OVEREXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
14.	NASSAU GROUPER	EPINEPHELUS STRIATUS	RECOVERING	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
15.	SOUTHERN PINK SHRIMP	FARFANTEPENAEUS DUORARUM	MODERATELY TO FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
16.	SOUTHERN BROWN SHRIMP	FARFANTEPENAEUS SUBTILIS	FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
17.	PINK CUSK-EEL	GENYPTERUS BLACODES	MODERATELY TO FULLY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
18.	ROYAL RED SHRIMP	HYMENOPENAEUS ROBUSTUS	MODERATELY TO FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
19.	WESTERN ATLANTIC SAILFISH	ISTIOPHORUS PLATYPTERUS	MODERATELY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
20.	NORTHERN WHITE SHRIMP	LITOPENAEUS SETIFERUS	MODERATELY TO FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
21.	OPALESCENT SQUID	LOGILO OPALESCENS	MODERATELY TO FULLY EXPLOITED	EASTERN CENTRAL PACIFIC	CSIRKE AND TANSDTAD 2005
22.	RED SNAPPER	LUTJANUS CAMPECHANUS	RECOVERING	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
23.	KING WEAKFISH	MACRODON ANCYLODON	OVEREXPLOITED§	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
24.	PATAGONIAN GRENADIER	MACRURONUS MAGELLANICUS	MODERATELY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
25.	PATAGONIAN GRENADIER	MACRURONUS MAGELLANICUS	FULLY TO OVEREXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
26.	ATLANTIC BLUE MARLIN	MAKAIRA NIGRICANS	OVEREXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
27.	SOUTHERN HAKE	MERLUCCIUS AUSTRALIS	FULLY TO OVEREXPLOITED*	SOUTHEAST PACIFIC	CSIRKE 2005

Appendix 7.5. Status of Fisheries in LAC (*continued*)

COMMON NAME	SCIENTIFIC NAME	STATUS OF EXPLOITA-TION	FAO STATISTICAL AREA	SOURCE	REFERENCE(S)
28.	SOUTHERN HAKE	MERLUCCIUS AUSTRALIS	FULLY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
29.	SOUTH PACIFIC HAKE	MERLUCCIUS GAYI GAYI	FULLY TO OVEREXPLOITED*	SOUTHEAST PACIFIC	CSIRKE 2005
30.	ARGENTINEAN HAKE	MERLUCCIUS HUBBSI	OVEREXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
31.	SOUTHERN BLUE WHITING	MICROMESISTIUS AUSTRALIS	OVEREXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
32.	WHITEMOUTH CROACKER	MICROPOGONIAS FURNIERI	MODERATELY TO FULLY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
33.	WHITEMOUTH CROACKER	MICROPOGONIAS FURNIERI	OVEREXPLOITED§	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
34.	SMALLEYE CROAKER	NEBRIS MICROPS	OVEREXPLOITED§	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
35.	MEXICAN FOUR-EYED OCTOPUS	OCTOPUS MAYA	OVEREXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
36.	PACIFIC THREAD HERRING	OPISTHONEMA LIBERTATE	FULLY EXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
37.	ARGENTINE RED SHRIMP	PLEOTICUS MUELLERI	FULLY EXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
38.	EASTERN PACIFIC BONITO	SARDA CHILIENSIS	DEPLETED	SOUTHEAST PACIFIC	CSIRKE 2005
39.	BRAZILIAN SARDINELLA	SARDINELLA BRASILIENSIS	OVEREXPLOITED	SOUTHWEST ATLANTIC	CSIRKE 2005
40.	SOUTH AMERICAN SARDINE	SARDINOPS SAGAX.	DEPLETED	SOUTHEAST PACIFIC	CSIRKE 2005
41.	RED DRUM	SCIAENOPS OCELLATUS	RECOVERING	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
42.	CHUB MACKEREL	SCOMBER JAPONICUS	MODERATELY EXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
43.	CHUB MACKEREL	SCOMBER JAPONICUS	RECOVERING	EASTERN CENTRAL PACIFIC	CSIRKE AND TANSDTAD 2005
44.	KING MACKEREL	SCOMBEROMORUS CAVALLA	MODERATELY TO FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
45.	ARAUCANIAN HERRING	STRANGOMERA BENTINCKI	OVEREXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
46.	WHITE MARLIN	TETRAPTERUS ALBIDUS	OVEREXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
47.	ATLANTIC BLUEFIN TUNA	THUNNUS THYNNUS	OVEREXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
48.	CHILEAN JACK MACKEREL	TRACHURUS MURPHYI	FULLY TO OVEREXPLOITED	SOUTHEAST PACIFIC	CSIRKE 2005
49.	NORTHERN ATLANTIC SWORDFISH	XIPHIAS GLADIUS	MODERATELY TO FULLY EXPLOITED	WESTERN CENTRAL ATLANTIC	COCHRANE 2005
SERRA SPANISH MACKEREL	SCOMBEROMORUS BRASIL-IENSIS	UNKNOWN	WESTERN CENTRAL AT-LANTIC	COCHRANE 2005	

Primary Source: FAO 2005. The chapters on SE Pacific, SW Atlantic, West Central Atlantic, and East Central Pacific are cited in Column 5 above.
Notes: This follows the FAO classification of status between depleted, fully to overexploited, moderately to fully exploited, overexploited, recovering, and underexploited.
This table only includes those resources for which scientific data exist. Those resources for which the status is unknown are not included here.
§ Preliminary data.
* The Chilean stock is "fully to overexploited", and the Peruvian stock "recovering from overexploitation