THE APPLICATION OF ECONOMIC INSTRUMENTS TO THE MANAGEMENT OF THREATENED SPECIES: A FISHERIES CASE STUDY IN THE GALÁPAGOS ISLANDS

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF APPLIED SCIENCE (NATURAL RESOURCE ECONOMICS)

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ABSTRACT

Under open access conditions fisheries tend to suffer from overexploitation and rent dissipation. This situation makes regulation necessary to achieve sustainability. In the Galápagos Marine Reserve, ineffective fisheries management has created a 'regulated' open access situation. The major fisheries, sea cucumber and spiny lobster, have been exploited beyond sustainable levels and catches have decreased significantly. Given the state of the resources, fisheries management in Galápagos needs to effectively limit catch and effort to sustainable levels. This research analyses the feasibility of an individual transferable quota (ITQ) scheme in Galápagos, evaluating the suitability of the context and assessing the expected economic benefits and equity implications from such a regulatory instrument.

The spiny lobster fishery is considered to be suitable for an ITQ scheme while the sea cucumber fishery is not, given that the resource is on the verge of commercial extinction, the difficulties in monitoring exports and the variability of prices. The optimal management scenario for the spiny lobster fishery, of those evaluated in this study, is an ITQ scheme where the total allowable catch is set at the maximum economic yield. This scenario resulted in the largest economic benefit and efficiency gains. Major equity implications are expected from an ITQ scheme in this fishery also. These, however, are consistent with the amount of catch that needs to be reduced in order for the fishery to operate sustainably. With this in mind, it is concluded that the Galápagos National Park Service and other stakeholders that participate in fisheries management in the archipelago should consider the adoption of an ITQ scheme to manage the spiny lobster fishery. The sea cucumber fishery on the other hand, needs to remain closed until the stock recovers.

Current challenges to more effective fisheries management are limited monitoring and enforcement and weaknesses within fishing cooperatives. An enhancement of the monitoring and enforcement component, and a strengthening of fishing cooperatives through more meaningful grassroots participation in fisheries management are necessary to improve the current situation. Complementary restrictions and policies to achieve particular socio-economic and environmental objectives will also be necessary in order to reduce potential negative impacts from an ITQ scheme.

Table of Contents

ACKNOWLEDGEMENTS ii

ABSTRACT iii

LIST OF FIGURES vi

LIST OF TABLES vii

LIST OF PHOTOGRAPHS viii

ABBREVIATIONS ix

CHAPTER 1 ~ INTRODUCTION: PROBLEM AND OBJECTIVES 1

1.1 THREATENED FISHERIES IN THE GALÁPAGOS MARINE RESERVE AND THE NEED FOR IMPROVED MANAGEMENT 1
1.2 AIM OF THE RESEARCH 5
1.3 CHAPTER OUTLINE 7

CHAPTER 2 ~ FISHERIES MANAGEMENT, REGULATION AND REGULATORY INSTRUMENTS: A LITERATURE REVIEW 8

2.1 INTRODUCTION 8
2.2 OPEN ACCESS AND THE ECONOMICS OF FISHERIES MANAGEMENT: WHY IS REGULATION NECESSARY? 9
2.3 MARINE PROTECTED AREAS 12
2.4 COMMAND-AND-CONTROL REGULATION 13
2.5 PROPERTY RIGHTS: COMMUNITY-BASED FISHERIES MANAGEMENT 14
2.6 PROPERTY RIGHTS AS ECONOMIC INSTRUMENTS: INDIVIDUAL TRANSFERABLE QUOTA SCHEMES 16
2.6.1 Efficiency and Sustainability *17*
2.6.2 Do ITQ Schemes Meet Conservation Objectives? *20*
2.6.3 Contentious Equity Implications *21*
2.6.4 Limitations to Administration, Monitoring and Enforcement *24*
2.6.5 Context Requirements *24*
2.6.6 Experiences with ITQ Schemes *26*
2.6.7 ITQ Markets *30*
2.7 CONCLUDING REMARKS 32

CHAPTER 3 ~ THE SEA CUCUMBER AND SPINY LOBSTER FISHERIES IN THE GALÁPAGOS MARINE RESERVE: SUITABLE FOR AN ITQ SCHEME? 35

3.1 INTRODUCTION 35
3.2 FISHING AND FISHERS IN GALÁPAGOS 36
3.3 CURRENT MANAGEMENT OF THE FISHERIES 39
3.3.1 Administration *40*
3.3.2 Research *42*
3.3.3 Monitoring, Control, Surveillance and Enforcement *42*
3.3.4 Regulations for the Sea Cucumber Fishery *44*
3.3.5 Regulations for the Spiny Lobster Fishery *47*
3.3.6 Management Costs *48*

3.4 STATE OF THE FISHERIES 49
3.4.1 Sea Cucumber *50*
3.4.2 Spiny Lobster *53*
3.5 CHAPTER SUMMARY AND CONCLUDING REMARKS 55

CHAPTER 4 ~ DATA AND METHODOLOGY 57

4.1 INTRODUCTION 57
4.2 SETTING A TOTAL ALLOWABLE CATCH 58
4.3 ESTIMATION OF ECONOMIC BENEFITS FROM AN ITQ SCHEME 60
4.4 ASSESSMENT OF EQUITY IMPLICATIONS FROM AN ITQ SCHEME 64
4.4.1 Estimation of Lorenz Curves and Gini Coefficients *64*
4.4.2 Estimation of Implicit Quota Prices *66*
4.5 CONCLUDING REMARKS 67

CHAPTER 5 ~ RESULTS AND DISCUSSION 69

5.1 INTRODUCTION 69
5.2 TOTAL ALLOWABLE CATCH 69
5.3 ECONOMIC BENEFITS FROM AN ITQ SCHEME 73
5.4 EQUITY IMPLICATIONS FROM AN ITQ SCHEME 77
5.4.1 Lorenz Curves and Gini Coefficients *77*
5.4.2 Implicit Quota Prices *78*
5.5 DISCUSSION AND CONCLUDING REMARKS 80

CHAPTER 6 ~ SUMMARY AND CONCLUSIONS 84

REFERENCES 93

APPENDIX 1 FISHERIES MONITORING PROGRAMME DATASETS 102

APPENDIX 2 SUSTAINABLE CATCH FUNCTION 106

APPENDIX 3 IMPLICIT QUOTA PRICES, PUERTO BAQUERIZO MORENO 108

LIST OF FIGURES

Figure 1.1 – Location and Map of the Galápagos Islands 2

Figure 2.1 – A Fishery's Growth Function 10

Figure 2.2 – Bio-economic Model of a Fishery 10

Figure 2.3 – Quota Exchange (Source: Squires, 1990, p. 35) 31

Figure 3.1 – Distribution of the Galápagos Marine Reserve's Management Costs, 2003 (Source: Galindo & Suarez, 2006). 49

Figure 3.2 – Catch and CPUE for the Galápagos Sea Cucumber Fishery (Source: Toral-Granda et al., 2005). 50

Figure 3.3 – Average Population Density of Sea Cucumber in the Galápagos Marine Reserve (Source: Avendaño et al., 2006, p. 6). 51

Figure 3.4 - Catch and CPUE for the Galápagos Spiny Lobster Fishery (Source: Hearn et al., 2005a; Hearn et al., 2006; Murillo et al., 2004) 54

Figure 4.1 – Lorenz Curve Diagram 65

Figure 5.1 – Estimated Sustainable Catch, Effort and Legally sized Catch 1997-2005, Galápagos Spiny Lobster Fishery 70

Figure 5.2 – Maximum Sustainable Yield and Maximum Economic Yield Estimations, Galápagos Spiny Lobster Fishery 71

Figure 5.3 – Estimated Sustainable Catch, Effort and Total Catch 2001-2005, Galápagos Spiny Lobster Fishery 72

Figure 5.4 – Estimated Net Income of the Galápagos Spiny Lobster Fishery, 2005 vs. 2007 under different Management Scenarios (Red Lobster only) .. 74

Figure 5.5 – Lorenz curves & Gini coefficients, Catch and Effort Distribution: 2005 Spiny Lobster Fishery, vessel-owners based in Puerto Baquerizo Moreno 78

Figure 5.6 – Expected Implicit Quota Prices and CPUE (diver-days), vessel-owners based in Puerto Baquerizo Moreno 79

Figure 6.1 – Economic Benefits per Management Scenario 87

Figure A2.1 – Catch and Effort, Galápagos Spiny Lobster Fishery (Source: Toral-Granda et al., 2005) 106

Figure A3.1 – Implicit Quota Prices and Effort, Catch and CPUE 109

LIST OF TABLES

Table 5.1 – Expected Economic Benefits: Scenario A, Current Management Model 73
Table 5.2 – Expected Economic Benefits: Scenario B, ITQ Scheme with TAC set at MSY 73
Table 5.3 – Expected Economic Benefits: Scenario C, ITQ Scheme with TAC set at MEY 74
Table 5.4 – Sensitivity Analysis: Discount Rate 76
Table 5.5 – Sensitivity Analysis: Domestic Cost Inflation 76
Table 5.6 – Sensitivity Analysis: Output Price 76
Table 5.7 – Sensitivity Analysis: Quota Allocation Period 76
Table 6.1- Economic Benefits per Management Scenario 87
Table A1.1 - Sea Cucumber Fishery Monitoring Programme Summary 102
Table A1.2 – Spiny Lobster Fishery Monitoring Programme Summary 103
Table A1.3 – 2005 Spiny Lobster Fishery Output Price and Operating Costs (Source: Hearn et al., 2006) 103
Table A1.4 – Puerto Baquerizo Moreno Fishing Cooperatives Monitoring Database Summary (as reported by cooperatives to National Park Service) 104
Table A2.1 – Spiny Lobster Fishery Sustainable Catch Function Summary Output 106
Table A2.2 – Revenues and Costs Resulting from Sustainable Effort and Catch, Spiny Lobster Fishery 107
*Table A3.1 – Implicit Quota Price per Vessel Owner** 108

LIST OF PHOTOGRAPHS

Photograph 1 – Galápagos Lobsterman 3

Photograph 2 – Hookah Diving in Galápagos 36

Photograph 3 - Bote 38

Photograph 4 – Pangas 38

Photograph 5 – Valuable Catch: Galápagos Sea Cucumber 53

ABBREVIATIONS

CBFM	Community-based Fisheries Management
CDF	Charles Darwin Foundation
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch per Unit of Effort
COPAHISA	*Artisanal Fishing Cooperative 'Horizontes de Isabela'*
COPESAN	*San Cristóbal Fishing Cooperative*
COPES-PROMAR	*Fishing and Sea Products Cooperative 'San Cristóbal'*
COPROPAG	*Artisanal Fish Production Cooperative 'Galápagos'*
GMR	Galápagos Marine Reserve
GNP	Galápagos National Park Service
IMA	Inter-institutional Management Authority
ITQ	Individual Transferable Quota
IUCN	International Union for Conservation of Nature and Natural Resources
MEY	Maximum Economic Yield
MSY	Maximum Sustainable Yield
NTZ	No-take Zone
PMB	Participatory Management Board
SLG	*Special Regime Law for the Conservation and Sustainable Development of the Province of Galápagos, Ecuador, 1998*
TAC	Total Allowable Catch
UCOOPEPGAL	*Union of Fishing Cooperatives of Galápagos*
UNESCO	United Nations Educational, Scientific and Cultural Organisation

CHAPTER 1 ~ INTRODUCTION: PROBLEM AND OBJECTIVES

"Reviewing the facts here given, one is astonished at the amount of creative force, if such an expression may be used, displayed on these small, barren, and rocky islands; and still more so, at its diverse yet analogous action on points so near to each other".

~ Charles R. Darwin (1845, p. 398)

Geographic isolation and a unique combination of oceanographic characteristics have created a network of ecosystems of great natural, scientific and recreational value in Ecuador's Galápagos Islands (Figure 1.1). This has made the archipelago worthy of the title of 'living laboratory of evolution'. UNESCO recognised these values by declaring the Galápagos National Park as a World Heritage site in 1974 and what is now the Galápagos Marine Reserve (GMR) as a World Biosphere Reserve in 1984. Conservation of these ecosystems is a priority; however, various pressures on the natural resources and the environment, resulting to a large extent from unprecedented population growth, currently threaten the stability of the archipelago's ecosystems. Population in Galápagos almost doubled between 1990 and 2001 (Instituto Nacional de Estadística y Censos, 2001), mainly due to migration from the continent (Kerr et al., 2004). Unfortunately, the majority of these migrants have failed to engage effectively in the lucrative tourism industry. A considerable percentage of the local population has consequently opted for alternative economic activities, among those fishing.

1.1 Threatened Fisheries in the Galápagos Marine Reserve and the Need for Improved Management

The history of fishing in Galápagos goes back to whaling and sealing operations in the late 19th century. Later, in the 1930s, foreign industrial vessels extensively fished for tuna around Galápagos. In the 1940s, local fishing activities increased significantly with the establishment of a North American military base in

Baltra Island. Local fishers traditionally focused on grouper and lobster. The scale of these fisheries was relatively small, enough to satisfy self-consumption demands and to sell occasional surpluses to continental Ecuador. Nevertheless, a progressive decrease in the abundance of grouper was noticeable then. This, in addition to increased access to foreign markets in the 1980s, led to a boom in the lobster fishery, the profits of which attracted many immigrants from continental Ecuador. Likewise, in the early 1990s the boom in the sea cucumber fishery, following the opening of non-traditional export markets in Asia and the reallocation of trading companies to the archipelago after the resource collapsed in the continent, caused another wave of migration to the islands (Ramirez Gallegos, 2004).

Figure 1.1 – Location and Map of the Galápagos Islands

(Excludes Darwin and Wolf Islands)
Maps retrieved from:
http://www.oars.com/htdocs/images/maps/GALAPAGOS.gif
http://plasma.nationalgeographic.com/mapmachine/index.html

Over the last decade, the major fisheries have been sea cucumber (*isostichopus fuscus*), and red and green spiny lobster (*panulirus penicilatus* and *p. gracilis*). Other species currently targeted by local fishers include slippery lobster (*scylarides astori*), grouper and, illegally, shark for the Asian fin market. The number of species landed has increased substantially over the years (Gravez & Gelin, 2003).

The Galápagos fisheries are important to the local economy, with gross incomes of up to US$ 6.2 million[1] in 2000 (Murillo, 2002) and nearly 25% of the local population being dependent on them for employment (Gravez & Gelin, 2003). Occasionally, fishing itself has become a major driver for migration, particularly during the lobster and sea cucumber booms.

Photograph 1 – Galápagos Lobsterman

Photo by Andoni Canela

Because of population growth and ineffective management, the effort devoted to the fisheries in the archipelago has grown considerably over the years. As a result, overcapitalisation and overfishing in most fisheries are now evident and threaten their sustainability. An eventual collapse of these fisheries would have major implications for both the welfare of the local population and the stability of unique ecosystems.

[1] In 2000, the Ecuadorian government applied a 'dollarisation' policy, setting a fixed exchange rate and adopting the US dollar as the official currency in order to halt currency depreciation, speculation and inflation, all of which previously increased at rampant levels. All values in this study are therefore expressed in current US dollars.

The sea cucumber and spiny lobster fisheries in particular show signs of continuous overfishing such as catch and catch per unit of effort (CPUE) dropping steadily. Information on the fisheries' costs of production is limited, although a reasonable expectation is that these would have been increasing over the years. This, in addition to decreasing catches, has resulted in decreasing net benefits. Thus, the biological and economic performance of the major fisheries is poor and will continue to deteriorate if significant changes in fisheries management do not take place soon. The situation of the fisheries in Galápagos is no different to the situation of many other fisheries around the world where the lack of clearly defined property rights, or effective regulation, turns capture fisheries into open access resources that suffer from rent dissipation and overfishing.

In 1998 the Special Regime Law for the Conservation and Sustainable Development of Galápagos was introduced. Recognising the multiple uses of the GMR, mainly fishing, tourism and scientific research, this legislation outlined an integrated management approach with the objective of protecting the marine resources. It also assigned the ruling of fisheries management, among other responsibilities, to an Inter-institutional Management Authority (IMA). Participatory and adaptive management was also introduced with this legislation by vesting decision-making in the Participatory Management Board (PMB), composed of fishers, scientists, conservationists, and representatives from the tourism industry and the government. The PMB must decide by consensus, and subject to the approval of the IMA, the specific regulations under which the fisheries will be managed each year. This arrangement has the merit of being participatory, representing an improvement on the typically confrontational relationship between fishers and authorities, although it has not led to sustainable outcomes. The prescriptive regulations emerging from the PMB are frequently violated and total catch in the major fisheries is consistently beyond sustainable levels. The major fisheries are therefore being 'conveniently overfished'. Froese (2004) defined convenience overfishing as the situation in which users and managers of a fishery deliberately risk its collapse by maintaining unsustainable catch levels in order to avoid social and political conflict.

The GMR's fisheries have been in crisis for several years and, although some significant changes in fisheries management have taken place, the underlying causes of overfishing remain unresolved. In this context, a radical change in the management strategy is needed to reduce the effort currently devoted to the fisheries and to effectively limit catch and entry to sustainable levels.

An individual transferable quota (ITQ) scheme is an alternative to the current command-and-control management system. By vesting the quota-owner with a transferable right to harvest a share of a set total allowable catch (TAC) of a particular species, ITQ systems can, in theory, achieve the objectives of limiting entry and catch. This will occur if the regulations imposed are consistent with sustainability and are enforced appropriately. However, the success of an ITQ scheme, like that of any regulatory instrument, depends on the particular context.

The use of property right instruments for fisheries management in the Galápagos Islands has been considered in the past but except for the sea cucumber ITQ system applied in 2001, a comprehensive property rights scheme has not been adopted. In July 2005 an informative forum on this topic was held in Galápagos, with the participation of the local fishing community and authorities. Besides the use of ITQ schemes, the application of territorial use rights for fisheries was also discussed in this forum (FUNDAR Galápagos, 2006; IFQs, 2005). This latter discussion arose since trials with fish aggregating devices had been initiated in the management of the high sea fisheries in the archipelago (Pescadores de Galápagos, 2005). Ownership of these devices by each cooperative would determine access rights to the fishing grounds where these are installed.

Kerr et al. (2004) and Stone et al. (2006) have recommended an analysis of the feasibility of an ITQ scheme in Galápagos, given the problems of the local fisheries and the potential effects of this fishery management instrument. In spite of these recommendations, no major study of the feasibility of such a management scheme, or evaluation of the 2001 experience, has been undertaken.

1.2 Aim of the Research

The purpose of this research is to determine, through economic analysis, a way to improve fisheries management in the GMR. More specifically, **this research aims to determine whether or not an ITQ scheme would be a desirable management strategy to rationalise the sea cucumber and spiny lobster**

fisheries of the archipelago. To achieve this, three research questions are addressed.

First, would an ITQ scheme be a suitable management instrument in the context of the GMR sea cucumber and spiny lobster fisheries? For various reasons, ITQ systems have been applied mainly in developed countries and on industrial fisheries. Small-scale and artisanal fisheries in developing countries have generally been managed through other means. However, the GMR has various traits that have led managers and other stakeholders to consider the use of right-based management instruments in the past. As part of the literature review of this study, alternative regulatory instruments and the contexts in which these are appropriate are described. By comparing these with the GMR sea cucumber and lobster fisheries, the practicability of an ITQ scheme for these fisheries is determined.

Second, what will be the economic benefits resulting from an ITQ scheme in the GMR? The value of a fishery depends, among other factors, on its profitability and sustainability, and therefore on the effectiveness of the management regime it is subject to. An ITQ scheme is expected to enhance profitability and sustainability. Thoroughly assessing the costs and benefits involved in implementing an ITQ scheme is complex, however, some understanding of the potential economic benefits and value of the fishery under different regulatory scenarios is essential to justify considering its application and altering the current management framework.

Third, if an ITQ scheme is deemed suitable, what would be the equity implications of using an ITQ scheme in Galápagos? Some of the unavoidable consequences of an ITQ scheme are quota concentration and the exclusion of the less efficient fishers. This effect can have serious implications on an economically and socially heterogeneous industry that operates in a situation where few, if any, viable alternative economic activities exist. That is the case in Galápagos. For this reason, it is important to determine the likely extent of these effects prior to pursuing a resource management instrument of these characteristics.

The value of this research is to demonstrate the viability, or otherwise, of an ITQ system in the context of the GMR's fisheries. The outcomes of the study outline the likely effects of a management scheme that is an alternative to current regulation for the major fisheries in Galápagos. This can provide grounds for the fisheries' stakeholders to consider a concrete management option for improving actual conditions. In this way, the debate on the subject and the decisions that emerge from it are likely to be better informed.

1.3 Chapter Outline

This thesis is organised as follows. In chapter 2, literature on fisheries management and the different regulatory instruments available to resource managers is reviewed, with particular emphasis on ITQ schemes. The observed benefits, limitations and context requirements of ITQ schemes are described. In chapter 3 the GMR's fisheries, the state of the resources, the current management strategies and challenges for improved management are described. The concluding remarks from this chapter, in addition to the background developed in chapter 2, allow answering the first research question of this study. In chapter 4 the methodologies used to determine the economic benefits and equity implications from an ITQ programme are described. In chapter 5 the analytical results are presented and discussed, answering the second and third research questions of the study. Finally, chapter 6 concludes the study with a summary of the findings and policy recommendations, addressing the central aim of the thesis.

Chapter 2 ~ Fisheries Management, Regulation and Regulatory Instruments: A Literature Review

"The economic problems bedevilling many of the world's capture fishery resources are seen to lie, not in fishers' 'greed', but rather in the existence of a perverse incentive system arising, in turn, from ill-defined or nonexistent property rights".

~ Munro et al. (1998, p. 12)

2.1 *Introduction*

Like national defence, fisheries management can be considered a public good. The benefits resulting from the application of regulatory instruments to fisheries, and the administration, research, monitoring and enforcement of fishing activities, are non-excludable and non-rivalrous. These benefits include sustainability, conservation and knowledge creation. Because of non-excludability, non-rivalry and relatively high costs involved in providing these services, the market will generally not provide them because the benefits cannot be effectively captured by the provider. However, fisheries management, like other public goods delivered through the intervention of government or alternative institutions, is essential to ensure a rational use of resources.

Fishery managers can regulate fishing activities by using one, or a combination, of several regulatory instruments to limit catch, entry into the industry and fishing effort to sustainable levels. These instruments can broadly be divided into those that impose highly prescriptive rules and those that define and allocate property rights. A policy of marine protected areas may often be complementary to these instruments.

Regardless of the regulatory instrument used, fisheries regulation should ideally meet several objectives, reflecting integrity and sound natural resource management. Conservation of the resource base, sustainability of fishing communities, economic efficiency, stakeholder participation and a fair distribution of benefits are some of these objectives (Troadec, 1983). More importantly, regulatory instruments in fisheries management should be consistent with the ecosystem's sustainability as that is the basis of a fishery's productivity (Pikitch et al., 2004). Acceptance by the industry of the regulatory framework is also an important criterion and often is a consequence of achieving some of the previous objectives in the first place.

This chapter outlines the advantages, limitations and context requirements of different regulatory instruments, focusing particularly on ITQ schemes. Prior to this, in the next section the open access situation and the economics of fisheries management are described, showing why regulation is necessary to make capture fisheries sustainable. The aim of this chapter is to provide a background necessary to determine whether or not an ITQ scheme is suitable in the context of the GMR's fisheries. This will also help to demonstrate why such a regulatory instrument would be better than the command-and-control approach currently applied in Galápagos.

2.2 Open Access and the Economics of Fisheries Management: Why is Regulation Necessary?

The growth of a fish stock generally follows a function as that illustrated in Figure 2.1 (Clark, 1976, p. 16). Growth of the stock is positive if the biomass is greater than a minimum stock level (S_{min}). Growth of the stock increases together with the biomass until a maximum sustainable yield (MSY) is reached. Beyond this stock level (S_{MSY}), the growth of the fish population decreases as biomass continues to increase, reflecting greater competition within the ecosystem, until net growth ceases. This is the maximum stock level (S_{max}), or the carrying capacity. At this level natural mortality is offset by new generations of offspring; in the absence of harvesting, it is the natural equilibrium of a fish stock. This growth function determines the sustainable catch level of a fishery, the maximum amount of fish that may be extracted at every stock level without reducing the availability of fish in the future (Schaefer, 1954).

By multiplying the growth function by output price, a sustainable total revenue function (TR) can be estimated. In the same way, the more effort that fishers devote to the industry, the lower the biomass left and the higher total cost (TC) will be. As shown in Figure 2.2, in the absence of regulation, positive profits will attract additional fishers that target a limited stock of fish, increasing effort until all rent is dissipated at a level of effort equal to $f_{b\text{-}e}$. This point is known as the bio-economic equilibrium and, in the absence of effective regulation or clearly defined property rights, is the outcome towards which the fishery heads. This is clearly an inefficient outcome as the same amount of fish can be caught with a much lower level of effort. Furthermore, given that at the bio-economic equilibrium rent is dissipated, it is likely that fishers will catch more than what is sustainable in order to obtain positive profits, at the expense of the fishery's sustainability. This situation can turn into a 'race for fish', where fishers aim to catch as much as they can in the shortest possible time, potentially causing the collapse of the fishery.

Figure 2.1 – A Fishery's Growth Function

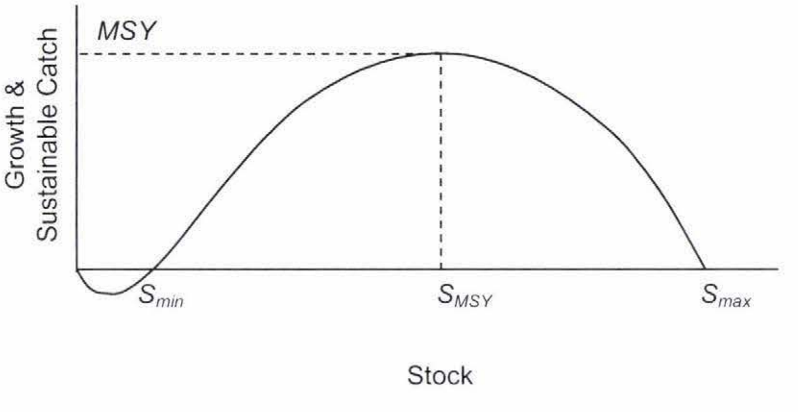
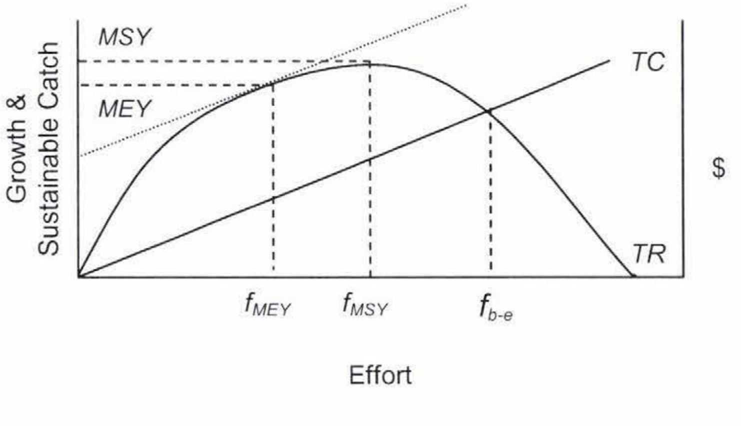


Figure 2.2 – Bio-economic Model of a Fishery



The level at which the bio-economic equilibrium is reached will change as output prices and production costs change. In fisheries with highly variable prices or costs it is difficult to assess when the bio-economic equilibrium is reached and thus when the fishery is economically overexploited. If prices and costs remain constant, or change at a predictable rate, a bio-economic equilibrium can be determined.

Even though fisheries are a renewable resource, they are also an open access resource and in the absence of clearly defined property rights, they can be amongst the most tragic cases of what Hardin (1968) described as the "Tragedy of the Commons". Hardin claimed that under open access conditions self-interested individuals maximise their payoffs in the short run at the expense of the resource's sustainability, the environment and everyone else's interests.

> "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all" (Hardin, 1968, p. 1244).

For this reason, it is today widely agreed that management and regulation, through the intervention of government or other institutions, is necessary to achieve a sustainable fishing sector, to meet environmental objectives, and to prevent biological and economic overexploitation (OECD, 1997). For fisheries, renewable is therefore not a synonym of inexhaustible. Clark & Munro (1994, cited in Munro et al., 1998) pointed out that if the fishery is seen as mere natural capital, ill-defined property rights to fishery resources give fishers a powerful incentive to heavily discount future returns, leading to overexploitation rather than conservation: the classic open access situation described above. An effective regulatory instrument in this context should replace the incentives that encourage overexploitation with incentives that encourage stewardship.

According to economic theory, the optimal level of effort towards which management should aim is that which results in marginal revenue being equal to marginal cost and therefore where rent is maximised, f_{MEY} in Figure 2.2. The sustainable catch achieved at this effort level is the maximum economic yield (*MEY*) of a fishery (Conrad, 1999; Field, 2001; Perman et al., 2003). To determine the MEY is a complex process. A fishery is affected by various biological, ecological, and socio-economic conditions that modify the MEY, most of which involve a fair amount of uncertainty and risk. The determination of a sustainable catch level will always be contentious, but necessary to achieve sustainability in a fishery. The remainder of this chapter reviews various regulatory instruments used to limit catch to a sustainable level.

2.3 Marine Protected Areas

Marine protected areas or no-take zones (NTZs), although not fishery management schemes *per se*, are often complementary to regulatory instruments because they offer different types of protection to marine ecosystems. NTZs protect critical areas and non-target species and in that way prevent overfishing and improve biological parameters in adjacent fisheries. NTZs also provide opportunities for enhancing scientific understanding of marine systems and non-consumptive uses by sheltering areas of high aesthetic and recreational value. In addition to effective management and regulation of fisheries, NTZs are essential for the conservation of marine resources.

The benefits of NTZs with regards to enhancement of fisheries derive from the protection of spawning and nursery grounds and areas of high species diversity. If adequately enforced, marine protected areas have the potential to increase the spawning biomass and to boost recruitment. Recruitment occurs when juvenile fish become part of the exploitable stock when reaching sexual maturity for instance. There is empirical evidence of stock abundance in fisheries, triggered by adjacent marine protected areas. Furthermore, NTZs reduce mortality, decrease habitat and environmental damage and help maintain viable fish populations, containing to some extent the negative effects from overfishing. These characteristics make NTZs a form of insurance against management and recruitment failures (Rowley, 1992). Regardless of the short-term social, economic and political costs of establishing NTZs, the above benefits can generate positive economic payoffs in the long run (Grafton et al., 2004).

In general, marine protected areas are complementary to regulatory instruments that explicitly manage fishing pressure, such as those described in the following sections. "Marine reserves are a critical component of a conservation strategy but must be coupled with other, complementary efforts" (Allison et al., 1998, p. S88). Marine reserves are therefore necessary but not sufficient for successful fisheries management and conservation. The poor performance, in biological and economic terms, of fisheries in the GMR, where a network of NTZs exists, demonstrates this. Socio-political biases affecting the NTZ zoning process and regular violations of these areas in Galápagos (Edgar et al., 2004) also demonstrate that active management of fisheries outside reserves, together with robust monitoring and enforcement, are necessary.

2.4 Command-and-control Regulation

Command-and-control regulation of fishing activities, such as imposing limitations on output, inputs, fishing seasons, number of vessels and zoning, is a common approach to reduce effort and to protect stocks. This type of control is the default when alternative management schemes are not suitable or when urgent action is necessary to prevent the collapse of critically threatened fisheries.

Highly prescriptive controls, although somewhat successful in some cases, have been blamed for management failures, particularly due to their inability to deal with excessive fishing capacity. It is impossible for the resource manager to control the entire bundle of inputs in the industry as fishers naturally substitute unregulated inputs for regulated ones. "It is impossible to overestimate the ingenuity of fishers in circumventing fisheries regulations" (Munro & Pitcher, 1996, p. 1). Prescriptive regulation often fails to take full account of fishers' motives, incentives, interests and values. Generally, command-and-control regulations are highly inefficient because they tend to increase costs, as fishers switch to unregulated inputs, and cause overcapitalisation in the industry, compromising efficiency, rather than actually decreasing effort.

> "Fishery managers regulate fisheries to help ensure sustainability of the resource and to meet socio-economic objectives. Input and effort controls have been the traditional method of regulation with limits on the total harvest in the form of a total allowable catch (TAC). While such approaches can be effective in preventing biological overfishing, they have often proved ineffective in preventing economic overfishing. Fisheries managed with input and effort controls have all too frequently been characterized by overexploitation and excess competition among fishers that reduce the net return to fishers and the resource owners" (Grafton, 1996b, pp. 5-6).

To a large extent this has been the case in Galápagos too.

An example of how command-and-control guidelines lead to inefficiency is the application of a global quota. If resource managers restrict total harvests in a fishery to prevent overexploitation but do nothing further, the TAC becomes the 'common pool', resembling on a limited scale, the open access situation described previously. The inevitable consequence is, once again, an excessive fleet capacity which undermines the economic viability of the fishing industry and conservation efforts as fishers continue to 'race for fish' (Munro et al., 1998). In this case, if entry to the fishery is not limited effectively, the costs of prescriptive regulation to society may outweigh the benefits (Burton, 2003). The Galápagos sea cucumber fishery for instance, has been managed with a TAC and a limited season that have exacerbated the 'race for fish' and failed to improve the state of the resource.

Landing taxes, although not used extensively today because of limited acceptability, are another prescriptive way of reducing catch. Landing taxes reduce fishers' rent and net returns, encouraging lower catches. They have a similar effect to command-and-control regulation by causing inefficiency, decreasing rent and leaving the causes of overfishing largely unresolved.

Nonetheless, prescriptive regulations and landing charges in conjunction with broader management schemes are often necessary to ensure the achievement of particular environmental and socio-economic objectives. In this regard, and where immediate action is needed to prevent resource collapses, there are no substitutes for prescriptive directives.

2.5 Property Rights: Community-based Fisheries Management

The allocation of property rights, key to encourage stewardship of natural resources (McCay, 2004), is another approach to resolve the issues caused by open access. The allocation of property rights to non-readily divisible public resources such as fisheries, although a logical solution, is not straightforward. The use of property rights in fisheries management can take diverse forms, ranging from individual quotas to communal rights in community-based fishery management (CBFM) regimes.

With regards to the latter, Ostrom (1990) criticised Hardin's argument claiming that it fails to distinguish between open access and common property resources. Unlike open access, common property resources are used according to socially accepted norms given that a clearly defined community holds the property rights. These rules, developed through active user participation, are tailored to the specific social context. Monitoring, which is often a by-product of use in these regimes, enforcement and conflict-resolution mechanisms are imbedded in the communal institutions. This makes these regimes cost-effective, stable, resilient and robust. The outcomes from CBFM regimes are often more equitable than alternative schemes as they are better suited to local, labour-intensive, small boat operations. Communal objectives within CBFM tend to be more focused on long term objectives such as the continued stewardship of resources (Copes & Charles, 2004; Gwazani, 2000; Kallie et al., 2000; Neher, 1996; Ruddle, 1989; Steelman & Wallace, 2001).

There are obviously limitations and objections to CBFM regimes. Many of these limitations refer to the limited applicability of these regimes in particular contexts of many modern day fisheries (Munro et al., 1998; Steelman & Wallace, 2001). For instance, lack of community organisation and scarce governmental support have precluded the success of community-based fishery systems in various Latin American fisheries (Defeo & Castilla, 2005, p. 275). Additionally, the failure of resource managers to recognise heterogeneity and dynamism in the resource-using community and in the ecological processes that affect the resource (Burton, 2003; Leach et al., 1999) have also affected the successful development of CBFM regimes. Decreased access to credit due to the relegation of private property rights, which act as collateral, to the community is also an objection against community-based resource management regimes.

In spite of these, for a CBFM regime to be applicable in a particular context various characteristics should be met. A well-defined community and a well-defined resource are essential for successful CBFM regimes. There needs to be respect for the traditional social institutions and active participation in the creation of the norms that guide resource use. Local cultural norms are more likely to support rules that are self-imposed, increasing compliance and reducing enforcement costs, than rules that are imposed by outsiders (Burton, 2003; Townsend, 1995). Panayotou (1989) and Steelman & Wallace (2001) indicated that small numbers of participants, limited geographic reach, social cohesion, a non-dichotomy between economic and social activities, significance of historical rights and hierarchy, and the use of taboos and social sanctions to enforce fishing rights and regulations are all important for the development of these regimes. These characteristics are common in groups with a strong sense of community, developed frequently by a common historical or cultural background. As described in the following chapter, these characteristics are to a large extent not met in Galápagos. Instead, very disorganised, young, heterogeneous and highly politicised fishing cooperatives occur there.

2.6 Property Rights as Economic Instruments: Individual Transferable Quota Schemes

A second way of assigning property rights in a fishery is through the allocation of individual harvest shares within an ITQ scheme, another regulatory instrument that can be used to rationalise the use of fisheries. An ITQ scheme is essentially a cap and trade system applied to fisheries, first described by Christy (1973). Various successful experiences with ITQ programmes have brought considerable attention to them. New Zealand, for instance, is considered today the world leader in fisheries management in both environmental and economic terms. Its successful application of ITQ programmes has not gone unnoticed. The use of ITQs has established a paradigm shift in fisheries management, as Pauly (1996) suggested.

ITQ systems, vesting the quota-owner with a transferable right to harvest a percentage of a TAC of a particular species, have the potential to efficiently allocate resources in a fishery and to make their operation sustainable. Harvesting rights are usually allocated on the basis of historical catch, although they may also be auctioned, or granted according to customary ownership. The property right in this case is to a share of the total permitted harvest rather than to the resource itself; users still have to devote effort and compete for extraction. ITQ schemes therefore are not a complete privatisation of fisheries (Hannesson, 2005), as critics suggest.

If quota allocations are regarded as genuine property rights that promise to deliver a stream of economic benefits over time, conservation of resources through self-interest, given that the value of quota depends on the state of the resource, will be encouraged (Grafton, 1996b; Munro & Pitcher, 1996). In this way, ITQ schemes can remove the drive to 'race for fish' and create an incentive for fishers to regard fishery resources as assets. The management goals of resource conservation, economic efficiency, sustainability, and even harvester cooperation can be achieved from a strong synergy between economic success and responsible biological management (Hilborn et al., 2005). ITQ schemes therefore provide economic incentives for fishers to develop a form of stewardship and husbandry of fishery resources.

ITQs will generate effective incentives only if fishers believe that they qualify as complete and genuine rights. In order for quotas to be perceived as genuine rights they must have various characteristics such as divisibility, enforceability, security, durability, exclusivity and transferability (Arnason, 2000; Grafton, 1996b; Scott, 1989, 2000). These attributes should become distinguishable to reduce transaction costs and to maximise the expected benefits (Townsend et al., 2006). ITQs that are divisible, transferable and valid for long periods, ideally in perpetuity, provide holders with security when making long-term investment decisions. Transferability provides flexibility and the opportunity to enter and exit the fishery in any fishing season. "Quotas stripped of the essential qualities of genuine fishing rights are worse than no quotas at all" (Neher, 1996, p. 114). The quality and completeness of harvesting rights is vital for their success in fishery management.

This also highlights the importance of monitoring and enforcement to the success of ITQ schemes. If illegal fishing is allowed, the quality of the rights will be severely reduced, affecting the entire scheme. If the means to monitor and enforce regulations are insufficient, an ITQ scheme should not be pursued and alternative regulatory instruments would be preferable (Hannesson, 1996, p. 92). However, if monitoring and enforcement are reasonably addressed, quota will not lose value and ITQ holders will develop a strong vested interest in the programme and in resource conservation. In this case, the achievement of resource management objectives will be more feasible (Rettig, 1989).

2.6.1 Efficiency and Sustainability

ITQs are primarily an instrument for promoting economic efficiency (Hannesson, 1996, p. 91) which, as described earlier, is not achieved solely by setting a TAC. Transferability is essential for economic efficiency. If current quota-owners are tempted to overexploit the resource, risking future stock levels, potential owners with more concern for the future, and hence with lower discount rates, will place a higher value on the resource. Quota trade between fishers that place different values on the harvesting rights results in increased economic efficiency. If the TAC is set at sustainable levels, ITQ schemes can enhance conservation also. Conservation and sustainability will be therefore indirect results of higher efficiency when the resource is effectively seen as an asset, forcing people to bear the future consequences of their current actions (Neher et al., 1989).

Efficiency, enhanced by ITQ schemes, is reflected in increased profitability. In the short run, fishers that sell their allocated quota to others who value it more exit the industry. This allows the retirement of excess capital and a reduction of effort and competition for a given level of output in an orderly fashion (Dupont, 2000). Additionally, common to the introduction of ITQ schemes is a relaxation of other prescriptive regulations such as season or gear restrictions. This allows for safer fishing practices and may reduce operating costs also. Furthermore, increased prices for the landed product often result from ITQ schemes due to improvements in product quality. Quality improvements result from longer fishing seasons and fewer constraints that permit better handling of the product. Lower operating costs and higher output prices increase profitability in the fishery. In the long run, technological innovation, adjustments to fishing operations, value adding and other benefits may also occur as a result of the entry of more efficient fishers. Improved allocative efficiency thus also increases the industry's profitability (Grafton et al., 2000b; Salgado & Aliaga, 2002). This improvement in efficiency and profitability is eventually reflected in increasing quota prices.

Taking this into account, Arnason (1990; 1998) points out that the price of quota, reflecting the state of the stock, can be used as a single indicator to simplify fisheries management. According to Arnason, by observing the price of quota, the fisheries management authority will not have to collect a vast amount of information to set specific regulations, unlike in alternative schemes. Batstone & Sharp (2003) corroborate Arnason's hypothesis using the New Zealand snapper fishery as an example. The advantage of reducing data requirements to indicators that are observable from quota markets, although perhaps not applicable to every fishery, can potentially reduce management costs significantly. In alternative management regimes the authority has to collect a vast amount of biological and socio-economic information in order to determine the necessary regulations. This is often a very expensive undertaking.

From government's point of view, ITQ schemes also increase efficiency in the long run through reduced fisheries management costs as the industry participates more actively in the management process (Dupont, 2000, p. 291). In this way, ITQ schemes may also lead to the adoption of more cost-efficient governance structures (Townsend et al., 2006). The industry has an incentive to take an active role in the management of the fishery under ITQ schemes because the value of quota depends on the state of the resource and hence on the integrity of the system's design and implementation. It is in the fishers' interest to participate in the research and assessment of the resource in order to ensure that the regulatory framework, on which the ITQ system relies, meets their objectives. This tends to take management out of the political sphere to some extent (Hannesson, 1996). As mentioned above, this is positive for government and taxpayers since they will no longer have to bear the brunt of expensive fisheries management costs. Less government intervention also reduces transaction costs, enhancing efficiency, and reduces the chances of politically motivated regulations being implemented.

To sum up, ITQ management has two major advantages over alternative approaches. First, by increasing net economic returns for the industry and the government they enhance efficiency. Second, provided that the ITQ scheme's regulatory framework is consistent with the state of the resource and is properly enforced, the scheme will also lead to conservation, sustainability and will encourage fishers to become stewards of the resource. In practice, it is difficult to isolate the benefits of ITQs from the range of other factors that affect fisheries but nevertheless, these benefits have been observed in, and are expected to result from, effective ITQ regimes. If designed and implemented correctly, ITQ programmes can address conservation and economic performance issues more effectively than alternative schemes as they do take into account fishers' motives and incentives.

Nonetheless, ITQ regimes invite challenge particularly because they are based on meeting a narrow set of economic objectives at the expense, it is argued, of considerable biological conservation and social equity values. A good analysis of these impacts was outlined by The Marine Fish Conservation Network (2004).

> "It is easy to understand initial acceptance of ITQs. The universal practice of offering quotas for free to current license holders, often accompanied by annual license fees that are well below the cost of fisheries management, constitutes an enormous bribe -- one that is sometimes worth hundreds of thousands of dollars to a recipient. Who wouldn't take it?! [*sic*] Yet, with evidence of conservation failure and social inequities, resistance to ITQ systems appears to be growing" (Copes & Pálsson, 2000, p. 1).

Fisheries management do tend to follow Murphy's Law: "If anything can go wrong with a new fisheries management scheme…it will" (Copes, 1986, p. 281). ITQ schemes are no exception.

2.6.2 Do ITQ Schemes Meet Conservation Objectives?

A first concern is that efficiency, promoted through the use of ITQ schemes, is not sufficient to meet conservation objectives. "ITQs are primarily an instrument for promoting economic efficiency rather than conservation" (Hannesson, 1996, p. 91). The achievement of conservation objectives under ITQ management depends on whether the regulatory framework necessary to operate the ITQ scheme clearly takes into consideration the current state of the resource and long term sustainability. Convenience overfishing, such as raising the TAC beyond sustainable levels to avoid economic or social impacts for instance, may prevail. That was the case with some of Iceland's (Arnason, 1996) and New Zealand's fisheries when ITQ schemes were first introduced there (Eggert, 1998). Furthermore, Pauly (1997a) argued that ITQs do not necessarily deal with ecological and environmental fluctuations. Given particular circumstances it could be possible, for example, to harvest all reproductive age females of a species while operating within ITQ parameters. This highlights the need to incorporate environmental objectives in the ITQ framework.

Additionally, Copes & Charles (2004) criticised the allocation of quotas on the basis of historical catch by arguing that it rewards vessel-owners for aggressive fishing. The fishers with the greatest catch receive larger amounts of quota, regardless of the negative impact on stock levels and other ecological damage they may have caused. This sends a negative message to fishers regarding overfishing of other fisheries that are not currently under quota management. It is argued that quota allocation based on historical catch would encourage overfishing of other fisheries that may potentially be managed through quota systems in the future, in order for fishers to maximise future individual quota allocations. As mentioned earlier though, overfishing would continue to occur anyway if ineffective regulatory instruments are applied instead.

ITQ schemes can also trigger unsustainable behaviour from the industry if quota is not perceived to be a genuine property right. In that case fishers will continue heavily discounting returns from the fishery and behaving accordingly (Munro et al., 1998). Copes (1986) described various forms of unsustainable behaviour that fishers tend to adopt when the perceived quality of rights in ITQ systems is poor. Quota busting, data fouling, high grading and excessive by-catch harvesting are some of these practices. As McCay (2004) pointed out, when fishers perceive their harvesting rights to be of a poor quality, this behaviour reflects 'rational' profit maximisation. Furthermore, Fujita (1999) indicated that whenever there are seasonal or spatial variations in a fishery, excessive effort and capital stuffing during the high yielding-season, or on the high-yielding fishing grounds, are observable. This can potentially take the fishery back to a 'race for fish' scenario, detracting from economic efficiency and sustainability. These arguments shed light on major limitations of ITQ schemes that may actually threaten the sustainability of the natural resource base instead of enhancing it.

Another aspect that hinders conservation is the irreversibility of the scheme. Once quota is allocated and trades have taken place, committed promoters are confident that an ITQ system would be almost impossible to reverse as compensation to buyers, and the political cost of such action, would be prohibitively expensive. If mistakes in the original implementation are not corrected early, the system may linger on until an eventual collapse. Irreversibility that results from maintaining economic efficiency as the ultimate objective is clearly against precautionary management and conservation (Copes & Charles, 2004). The use of proportional quota, allocated as a share of a set TAC, as opposed to a fixed weight, does provide more flexibility by allowing the authorities to reduce the TAC without having to compensate quota holders. However, the use of an ITQ system *per se*, regardless of the form of the quota allocation, is believed to be relatively rigid due to the high costs involved in reversing the scheme.

2.6.3 Contentious Equity Implications

A second concern arising from the application of ITQ schemes is that they cause adverse equity and social impacts. Orebech (2005) claimed that ITQ programmes have expelled the poor from open access fisheries and brought subsistence fishing to the brink of extinction, causing what McCay (2000) described as a "Tragedy of the Commoners". According to Arnason (2000) and Bess (2005), social opposition resulting from these concerns is the main reason why ITQ programmes have not been widely adopted. The benefits from ITQ schemes therefore seem to be inequitably distributed.

One of the important issues at stake is the initial allocation of quota. If quotas are allocated on the basis of historical catch there are windfall capital gains to the first generation of quota-owners. Quota is usually allocated to vessel-owners and given that the effort devoted to the fishery is likely to be reduced, quota concentration results in reduced employment opportunities for crew and shore support workers who are not generally allocated quota. This may also have adverse impacts on processors and processing labourers. Unless their interests are explicitly accounted for, these groups usually miss out on the benefits from ITQ schemes. As McCay (1995) pointed out, powerful processors may apply vertical integration by buying quota, which can in turn have various impacts on fishing workers too. Crew and other fishing sector labourers thus do not tend to support ITQ schemes. Vessel-owners, who on the other hand often are the quota-holders, tend to be more supportive of ITQ schemes. For this reason, the allocation of quota to vessel-owners on the basis of historical catch has been perceived as a means to ensure political support for the scheme rather than a way to meet environmental or socio-economic objectives (Copes & Pálsson, 2000).

Other users of fishery resources may also be adversely affected by historical catch-based quota allocations. Recreational and indigenous fisheries, for instance, may be excluded. These users fish for reasons other than profit so they will be affected even if financial compensation is paid (Steelman & Wallace, 2001). Furthermore, potential entrants will also be affected; they will face very high costs to buy quota and to enter the fishery. Empirical evidence from Norway shows that second generation quota-owners received significantly lower resource rents, if any, because of this (Orebech, 2005).

Major ethical and equity concerns are raised with regards to the claimed privatisation and free allocation of public natural resources too (Copes & Pálsson, 2000). These effects of ITQ schemes are perceived to unfairly promote the development of the industrial harvesting sector at the expense of social, economic and ecological sustainability.

> "These developments are interpreted by many social researchers as significant transgressions of social justice and equity within democratic society. Management systems such as ITQs treat a public resource as alienable and to be provided virtually free of charge for the exclusive use and benefit of a specific interest group – existing harvesters commonly enmeshed in corporate, accumulation sector enterprises" (Davis, 1996, p. 105).

This effect is particularly concerning when small-scale poor fishers are involved. Using Sen's entitlements discourse, Orebech (2005) claimed that ITQ programmes imply a robbery of fishery commons, one of the few entitlements that poor fishers usually have. It was also pointed out that the 'basket of assets' should not be emptied through the application of ITQ schemes without providing alternatives for those affected by the adoption of the scheme.

Following the allocation of quota, the consolidation of rights and market power in the hands of a selected few vessel-owners is an unavoidable effect from ITQ programmes, and another equity concern. The concern is that often the most efficient vessel-owners are also those with more resources and political power (Christy, 1997). Critics argue that ITQ regimes generally favour large commercial vessels, squeezing out small fishers (Steelman & Wallace, 2001). Quota concentration can take a geographical character as well. It has been observed that ITQs come together with concentration of activity in larger ports, causing smaller communities to miss out on the benefits (Copes & Charles, 2004, p. 180). This obviously has adverse implications for employment and the welfare of individuals and communities. Adelaja et al. (1998a; 1998b) showed these effects in the case of the surf clam and ocean quahog fisheries in the United States. As Anderson (1991) pointed out, ITQs may pave the way for monopoly market failures as the decrease in fishing capacity promoted with this regulatory instrument has no regard to equity.

These implications can erode the expected benefits of ITQ schemes, which is why many authors suggest exploring the use of different regulatory frameworks instead, where appropriate. Hannesson described this trade-off between efficiency, sustainability and equity in fisheries managed with ITQ systems quite accurately:

> "It is true that full employment is probably the most important means to achieve a more equitable distribution of income, but there is no way of escaping the hard fact that employment that adds nothing to the net production in a society [or a fishery] is of a highly doubtful value" (Hannesson, 1996, p. 93).

Nonetheless, if these concerns are addressed explicitly through complementary policies, ITQ programmes can become viable, as successful experiences around the world prove.

2.6.4 Limitations to Effective Administration, Monitoring and Enforcement

Thirdly, institutional limitations to effective administration, monitoring and enforcement of ITQ schemes are another significant impediment to their success. Monitoring and enforcement, as mentioned earlier, play a crucial role in ITQ schemes. The institutional capacity to monitor and enforce is therefore vital (Eggert, 1998, p. 409). In various circumstances, ITQ schemes are considered to be hard and costly to monitor and enforce, at least in the short run. Since most newly introduced ITQ schemes are likely to set the TAC below previous catch levels, enforcement activities will need to be extensive and hence expensive. When catch is restricted, political opposition and the temptation to fish illegally increase together with the number of unemployed fishers and vessels, particularly when the returns for the remaining active fishers rise. This may be the case in newly introduced ITQ schemes.

This argument takes a critical importance in developing countries where often institutional limitations to effective natural resource management, and the pressure exerted on these resources, are substantial.

> "[The] model of incomplete enforcement –a feature that is likely to be found in developing countries because of institutional weakness, budget constraints, and absence of expertise- might help to explain [ITQ schemes'] failure" (Chavez & Salgado, 2005, p. 321).

Quotas, either global or individual, are utterly useless when the administrative and scientific infrastructure does not allow for at least nearly real-time monitoring of catches and landings, as is the case in the stereotypical small-scale fisheries of many developing countries (Pauly, 1995, p. 5).

2.6.5 Context Requirements

Fishery management is highly context dependent and the application of ITQ schemes is no exception. There is a range of economic, social, biological and cultural features that increase the prospect of success for ITQ programmes. The political, institutional and legal environments of the countries that have applied ITQ schemes successfully are rather 'western' (Kurien, 2000). These countries have highly individualised property right systems, and their economies and social conditions display a high level of development. Keeping in mind that fishers were not deprived in these countries, the main concern of fisheries management was therefore to restrict effort without giving major consideration to priority access rights or social development objectives.

In view of that, Panayotou (1989) and Pauly (1996) pointed out that ITQ schemes are unlikely to be applicable in many developing country fisheries. These fisheries are notable for large numbers of geographically mobile, small-scale, part-time fishers scattered over large and remote areas. In this context, management and enforcement costs are likely to be prohibitively expensive. Furthermore, in developing countries there usually is minimal tradition of compliance with rules and regulations, bribing of local officials is pervasive, and the State's enforcement capacity is limited. There is empirical evidence of exceptions to these conditions where ITQ schemes have been successfully applied in developing countries though. The suitability and outcomes of ITQ schemes in developing countries therefore depend on the particular context of each country.

Given the above, minimum conditions necessary for ITQ implementation can be outlined. First, the cause of the decline in the state of the fisheries in question should not be biological but behavioural (Rettig, 1989; Steelman & Wallace, 2001). The allocation of property rights under an ITQ system cannot address biological causes of stock declines. It can however change the behaviour of fishers. Regardless of this, a minimum level of biological integrity of the resource, and availability of sound scientific information that proves it, are essential. Difficulties in estimating stock size and forecasting variations in sustainable yields will hinder ITQ programmes (Walters & Pearse, 1996). Fisheries with limited numbers of long-lived, non-migratory and widely distributed species, with stable and slowly changing stock levels, are more suited to ITQ management. There should be a proven relationship between size of catch and subsequent recruitment in order for ITQ schemes to be suitable. Despite the state of the resource, a relatively healthy fishery prior to the implementation of the regime is vital. This will ensure that the extraction of the resource will not outstrip biological productivity from the outset (Steelman & Wallace, 2001, p. 372). In other words, ITQ schemes will not be viable in a critically overexploited fishery that is on the verge of collapse.

Second, given that monitoring is essential for the success of an ITQ scheme, the relative smallness of the fishery is important. Smallness in the number of vessels, fishers, buyers, processors, marketing channels, landing ports and fishing area allows effective and efficient surveillance to take place, and make effective monitoring and enforcement feasible (Steelman & Wallace, 2001). Despite of this, the number of participants in the fishery should also be large enough to ensure the development of a competitive market for quota (MacGregor et al., 2004; Newell et al., 2005).

Third, the stakeholders and the fishery institutions implementing the ITQ scheme need to have had previous experience with limited access and private property structures and need to support them.

> "A rights-based management system can be a good idea in theory but it will only be a good system in the reality, if and only if, all the potential stakeholders, mainly the industry, agree on that (...). Besides this, much depends largely on the will of the government to head the transformation and on its effective ability to lead the process" (Verona, 2000, p. S 1.4).

Participants' acceptance and support is essential to create legitimacy, ownership and success in ITQ schemes.

2.6.6 Experiences with ITQ Schemes

It is not possible to directly compare the Galápagos Islands' situation with the situation in countries in which ITQs have been applied to date because the nature of the fishery is very different. Nonetheless, some significant features of well-documented ITQ schemes are summarised below.

Grafton (1996b) and Grafton et al. (2000a) suggested comparing various indicators, before and after the introduction of ITQ schemes, to assess their success. Changes in productivity and profitability are indicators of efficiency. Changes in the distribution of employment and harvesting shares may reveal the equity implications of the scheme. The compliance levels, the extent of cost recovery, the change in the capacity of the industry and its sustainability will also indicate if ITQ programmes have been successful. Besides these, the fishers' implied discount rates, which can be obtained when comparing quota prices with the yearly lease values of quota, reflect the fishers' planning horizon and indicate if the scheme has actually changed their perspective. Ideally, fishers' discount rates should be close to the market interest rate. In recently introduced ITQ schemes, discount rates are usually high, reflecting uncertainty about the system's future. That was the case at the start of ITQ programmes in Iceland and New Zealand. In general, in countries were the quality of title has been high, to a large extent as a result of effective monitoring and enforcement, ITQ schemes have been successful and the above indicators have proven that.

ITQ schemes were progressively introduced in New Zealand since 1986 in the context of broader economic reforms. After the original introduction there was a change from a fixed weight to a percentage-based allocation in order to reduce the set orange roughy TAC that was determined to be excessive and unsustainable after new scientific knowledge about the biology of the species emerged. Initially there were claims that the ITQ system failed to meet Treaty of Waitangi[2] obligations by excluding customary owners from accessing the resource. After some litigation, obligations were met successfully through the allocation of 20% of all quotas to Mäori users. Monitoring and enforcement in the New Zealand system are largely land based, founded primarily on a paper trail assessment, GPS surveillance and heavy penalties. Prices for quota in most fisheries have increased, demonstrating increased returns and efficiency. In general, stocks and the biological performance of most fisheries have improved. Active and growing industry participation in management is clear also (Harte, 2000; Hunter, 2006). Regardless of these achievements, the scheme has not been flawless. Limitations to quota ownership have been necessary to avoid excessive concentration. In spite of these limitations, there is evidence that small-scale fishers did not benefit as much as fishing companies. Additionally, violations to the regulatory system continue to take place. User conflicts continue to be an issue. On balance, however, the New Zealand experience with ITQ schemes can be considered to be amongst the most successful in the world. In comparison to other countries, New Zealand gives quota the highest legal protection, which would certainly explain the overall success of the scheme (Annala, 1996; Batstone & Sharp, 1999; Bess, 2005; Clark et al., 1989; Neher, 1996; Townsend et al., 2006).

In Iceland, income from fisheries represents up to 45% of GDP, thus the need for an efficient fishing industry and fisheries management system there. The Icelandic quota management system, first introduced in 1975 and covering all fisheries since 1990, has also been successful to a large extent. However, in several

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[2] Signed in 1840 by hundreds of Mäori chiefs and representatives of the British Crown, it is considered to be New Zealand's founding document.

aspects it exemplifies many of the weaknesses of this regulatory instrument. The ITQ scheme brought about higher efficiency and improvements in the state of most stocks. Exceptions include the capelin fishery which did not improve significantly, mostly because it is a short-lived species with unstable stocks. Similarly, demersal stocks did not recover either due to quota busting and the TAC being set above sustainable levels. Likewise, cod stocks have not increased apparently due to major discarding at sea. In fact, cod stocks reached their lowest levels in the 1990s, after a decade of ITQ management. These fisheries reveal how convenience overfishing and unsustainable behaviour can be triggered with ITQ schemes. Furthermore, equity issues regarding the allocation of rights were common. Limitations on quota holdings and transferability were necessary to meet social objectives. In 1998 the Icelandic Supreme Court declared ITQ schemes unconstitutional because of these concerns. Additionally, the calculated implicit discount rates which were between 10 and 25% revealed the fishers' perception of risk regarding the future of the scheme, and therefore its limited success (Arnason, 1996; Copes & Pálsson, 2000; Neher, 1996). Iceland's experience was not as successful as New Zealand's. As Copes & Pálsson (2000) pointed out, the final shape of Iceland's fisheries management system is up in the air, with ITQs under a cloud.

ITQ schemes in Chile were originally applied in two minor industrial fisheries, red shrimp and cod. Many other fishing grounds, including those exploited by artisanal fishers, were managed under command-and-control regulation or CBFM regimes. ITQs were initially allocated according to historical catch but each year 10% of quota was recovered and auctioned. In addition to this, the use of cost recovery mechanisms allowed for considerable rent capture, although less than what was hoped for initially due to thinness in the quota markets (Copes & Pálsson, 2000; Department for International Development, 2003; Peña-Torres, 1997). Legislation regarding ITQ schemes later allocated 80% of quota to the industrial sector, and 20% to the artisanal sector, which employs 80% of labour in the industry. The adverse equity implications deriving from this allocation resulted in claims for a change in the management strategy (Valenzuela, 2006). Quotas in the industrial sector were transferable and applied to recovering or underutilised stocks. Quotas for the artisanal sector, in contrast to those in the industrial sector, were not transferable and were implemented within broader CBFM regimes. The ITQ system in Chile has managed to recover industrial fisheries' stock successfully and has provided significant demonstration effects, although only less than 1% of total landings are managed through ITQs and despite the high concentration effects created. This has resulted in less opposition and a shift in the nature of management from confrontational and ideological to a more technical one. Given previous experiences, there currently is potential to expand the ITQ scheme to other Chilean fisheries (Bernal et al., 1999). The introduction of ITQ schemes in Chile was affected by an adverse historical context as it occurred during the transition from dictatorship to democracy in the early 1990s, when the political authority had limited bargaining power. There is also evidence that allocation on the basis of historical catch was not enough to secure the industry's support and instead raised opposition due to equity concerns, incomplete information and the perception of poor quality of rights. Copes & Pálsson (2000) described a similar situation in Argentina.

Experience from other countries also provides valuable lessons for the implementation of new ITQ schemes. The Australian experience for instance, has been largely successful despite some equity implications (Andersen, 1989; Aslin et al., 2001; Wesney, 1989).

Canada's experience on the other hand, demonstrates that poor quality of rights and insufficient enforcement result in the failure of the system and possibly even in the collapse of the fisheries. Poor economic and biological performance in the cod, herring, stockfish, ground fish and crab fisheries, managed with ITQ schemes in Canada, demonstrate this. Negative impacts on aboriginal interests and small fishing communities were also evident (Copes & Pálsson, 2000; Grafton, 1996a; Grafton et al., 2000b; Neher, 1996).

Experience in the European Union shows major difficulties resulting from shared stocks and highly heterogeneous fishing sectors (Adelaja et al., 1998a; 1998b; Spagnolo, 1993; Symes, 2000).

In the United States, a major concern was the equity implications of ITQ schemes. These led to an eight-year moratorium on new schemes development in 1996 (MacGregor et al., 2004; McCay, 2004). In the Alaskan halibut and sablefish fisheries, a community quota scheme was successfully applied to reduce some of the equity implications and to maintain the owner-operator character of the fisheries (McCay, 2004; National Marine Fisheries Service, 2002; Smith, 2000).

Likewise, Namibia uses non-transferable quotas in order to achieve various socio-political objectives. A very successful cost-recovery programme has made it one of the only countries were the government extracts a net revenue from fisheries (Department for International Development, 2003; Iyambo, 2000).

Mexico's Punta Allen spiny lobster fishery, one of the most important lobster fisheries in the world, has also been successfully managed with an ITQ scheme however, this is complementary to a CBFM regime and territorial use rights (Defeo & Castilla, 2005).

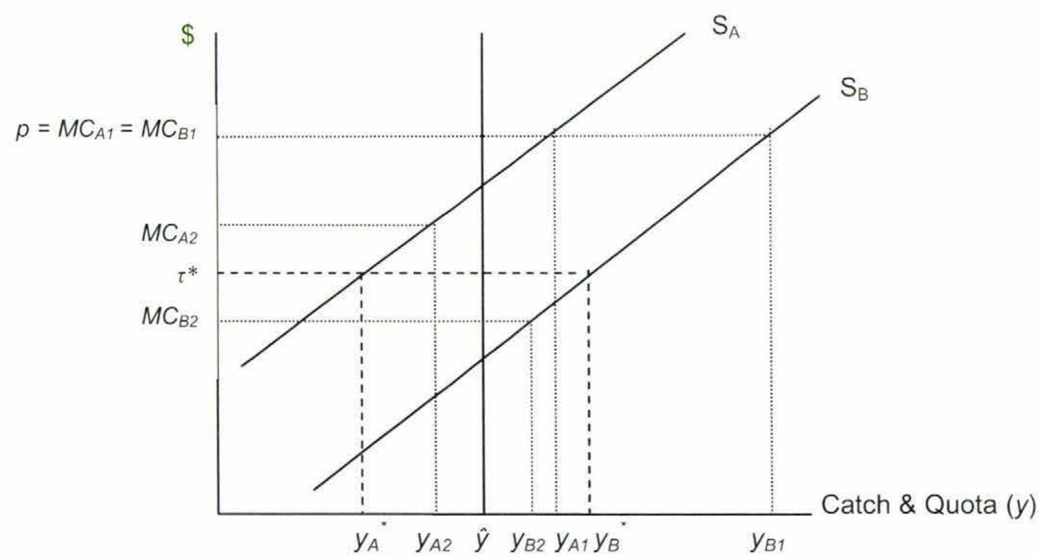
As has been noted, ITQ schemes have been applied in very different contexts, including some developing countries' contexts. Success has been achieved when the contexts were suitable and the quality of the rights developed was high. The negative implications of ITQ schemes were often addressed through complementary regulations, introduced to explicitly meet particular environmental and social objectives.

2.6.7 ITQ Markets

In order to understand how an ITQ scheme, like those described above, will improve the economic performance of a fishery, and to assess its equity implications, it is necessary to simulate how a quota market will develop. Fishers, through their trades, determine the market price for quota and how much of it is bought or sold. After quota allocation, but prior to exchange, each unit of quota has an implicit economic value to the quota-owner. This is equal to the present value of the net benefits of a unit of quota over the period of the allocation. This value varies among vessel-owners according to the output and input prices they face. Assuming all fishers face the same output prices, the more efficient vessel-owners, those with lower costs, will place a higher value on a unit of quota than inefficient ones. Quota exchange progressively narrows the value placed on quota between vessels until unit quota rents are equalised at the last unit traded, and an equilibrium quota price is formed. The equilibrium price of quota multiplied by the TAC is equal to the quota rent generated by the scheme. Likewise, by comparing the equilibrium price for quota with each quota-owner's implicit quota value, it is possible to determine who will sell quota and who will buy it, thereby providing an indication of the expected equity implications (Lanfersieck & Squires, 1992, p. 2315).

Figure 2.3 illustrates the quota exchange process for two vessel-owners, *A* and *B*. Vessel-owner *B* is more efficient than vessel-owner *A* as he or she can catch a given quantity at a lower cost, as depicted by their different supply curves, S_A and S_B. Prior to an ITQ scheme, both rational vessel-owners operate where the marginal benefit, i.e. unit price p, is equal to their respective marginal costs, *MC*. Vessel-owner *B* therefore catches more than vessel-owner *A*; y_{B1} and y_{A1} respectively. If a TAC is set, both vessel-owners will be allocated ITQs up to y_{B2} and y_{A2} respectively, as proportions of the set TAC and on the basis of their previous catch. The average of their quota allocations is $\hat{y}$, which is the average individual quota of the set TAC. Since vessel-owner *B* values quota more than vessel-owner *A* as a result of his or her lower costs, he or she will buy quota from vessel-owner *A* until their net marginal benefits are once again equal to their marginal costs. At this level, quota price is equalised at τ^* which is the unit quota rent of each individual allocation, and the TAC, $\hat{y}N$, where *N* is the number of vessel-owners in the market, is met (Lanfersieck & Squires, 1992; Squires, 1990). Therefore, τ^* can be expected to be close to the average of implicit quota prices.

Figure 2.3 – Quota Exchange (Source: Squires, 1990, p. 35).



Various authors have used this model together with linear programming to simulate ITQ markets prior to implementation. Lanfersieck & Squires (1992) assessed the impacts from an ITQ scheme in a long-line sablefish-harvesting fleet in the United States. Guyader (2002) used the same method to assess the changes resulting from a quota management system on the French driftnet albacore fishery. Likewise, Salgado & Aliaga (2002) applied the same technique to the Chilean jack mackerel fishery.

2.7 Concluding Remarks

Bio-economic models (see, among others, Clark, 1976 and Conrad, 1999) show that under open access conditions a fishery is likely to suffer from overfishing and overcapitalisation due to the lack of clearly defined property rights. Rent dissipation, inefficiency, and even the collapse of the resource are likely outcomes under open access. This situation makes management and regulation of the fishery by government, or alternative institutions, necessary in order for a sustainable fishing sector to flourish. Regulation consists in the application of a regulatory framework that aims to limit catch, effort and entry to sustainable levels. Various regulatory instruments can be used to do so.

Command-and-control regulation is a first approach. Prescriptive regulation is always necessary to explicitly address particular environmental or social objectives however, its use as a central management strategy often leads to inefficiency as it tends to increase costs rather than effectively restricting effort. A second regulatory framework is the development of CBFM regimes. This could be considered an ideal approach since it has positive environmental and social implications; however the contexts where these can be applied are rare given that a particularly strong sense of community, often developed through a shared historical or cultural background, is necessary. Besides these policy instruments, marine reserves are common complements as they provide a form of insurance against management failures outside protected areas. Marine reserves benefit fisheries and are essential for overall marine conservation; however they are not sufficient to achieve sustainable and efficient fisheries.

A third regulatory framework is the use of ITQ schemes, allocating a right to a share of a set TAC of a particular species to individual fishers who may trade their right as they see fit. If these rights are developed and perceived to be legitimate, benefits from these schemes include economic efficiency and increased participation of the industry in management. By putting a cap on the amount of catch, conservation and sustainability can also be benefits of these instruments, if that regulation is consistent with the state of the resource. Nonetheless, criticisms of ITQ schemes include the fact that these may result in unsustainable behaviour and unjust social outcomes. Limited applicability given institutional limitations to effective monitoring, enforcement and administration are also a drawback. Particular social or environmental objectives should be explicitly targeted within an ITQ scheme with the application of complementary restrictions. The success of ITQ schemes therefore depends on whether their implementation is sensitive to the context where these are applied.

There are no silver bullet or panacea regulatory frameworks in fisheries management. Besides careful assessment of contexts, active stakeholder participation in fisheries management is always desirable to make regulation legitimate, regardless of the regulatory instrument, and to tailor it to the local conditions.

> "Fisheries demand exceptional attention to contextual variation, and strategies rigidly applied are not likely to work. Consequently, more sustainable management strategies should look for the possible overlaps, mixes and matches that are offered by the [different] approaches" (Steelman & Wallace, 2001, p. 374).

Moreover, fisheries managers and the industry need to maintain an open mind to craft the scheme that would suit best, observing economic, environmental, political and social considerations in the process.

Command-and-control regulation in Galápagos has been ineffective and inefficient. The highly politicised and heterogeneous fishing cooperatives would make it very complex for an outright CBFM regime to develop in Galápagos, although the current management model can be considered to be a form of co-management, where users and authorities work together to formulate regulations. Likewise, the current extensive network of NTZs in Galápagos has not been sufficient to achieve sustainable fisheries, even though it provides a range of conservation benefits. Keeping this in mind, a different form of management may be more appropriate in that context. The following chapter describes the context of the

GMR fisheries in order to determine whether or not an ITQ scheme would be a suitable regulatory instrument to rationalise the use of the sea cucumber and spiny lobster resources.

Chapter 3 ~ The Sea Cucumber and Spiny Lobster Fisheries in the Galápagos Marine Reserve: Suitable for an ITQ Scheme?

'We recognise that all the users and authorities are responsible for the failure of fisheries management in the Galápagos Marine Reserve. That is why it is important to (...) change the management model (...) towards a more appropriate and sustainable one that distributes the fishing effort according to the capacity of the resource' [author's translation].

~ Autoridad Interinstitucional de Manejo de la Reserva Marina de Galápagos [IMA] *(31 May 2005, p. 1)*

3.1 Introduction

As mentioned in the previous chapter, the application of regulatory instruments to fisheries, a process necessary to develop a sustainable fishing sector, requires a careful assessment of contextual variation. Regardless of the regulatory instrument, various characteristics make fisheries management particularly complex in the context of the GMR. These include the surrounding network of highly sensitive ecosystems, the poor state of the resources, conflicting stakeholder interests and the lack of alternative economic activities in the archipelago for fishers to engage in.

Prior to 1998, fishery regulations for Galápagos were determined in mainland Ecuador. Local stakeholders had no input in the formal decision-making process and, as expected, the relationship between fishers and authorities was confrontational and violent. Fisheries management in the GMR has improved significantly over the last decade, although it still is ineffective to a large extent. Conservation and natural resource management in the Galápagos Islands are work in progress; the challenge is to find more effective ways of progressing. For fisheries, an ITQ scheme could be one way forward.

This chapter describes the context of the GMR sea cucumber and spiny lobster fisheries, their operation, the current management model, the regulations currently applied and the state of these resources. This description will help determine whether an ITQ scheme would be suitable in this context, addressing the first research question of this study.

3.2 Fishing and Fishers in Galápagos

The recent history of fishing in Galápagos starts with the lobster boom of the 1980s, when many people from continental Ecuador migrated to the archipelago attracted by the increasing profits of the fishery. Likewise, in the early to mid 1990s the opening of the 'experimental'[3] fishery for sea cucumber caused another fishing boom that triggered another wave of migration. These booms followed the increased access to export markets and the collapse of the sea cucumber fishery in continental Ecuador. With every wave of migration, the effort, technology and capital investment devoted to the fisheries increased significantly.

Photograph 2 – Hookah Diving in Galápagos

[3] This fishery was originally opened with the intention of exploring ways to improve the socio-economic conditions of artisanal fishers in Galápagos however this objective was not achieved due to the lack of preparation to exploit the fishery, chaotic institutional management and lack of trustable monitoring. The experimental character of this fishery was lost as changing economic and social conditions led to an ongoing process of excessive and irrational exploitation of sea cucumber (de Miras et al., 1996, p. 121).

The sea cucumber and spiny lobster fisheries are exploited in an artisanal manner with simple vessels and technology. The fishing technique used, hookah[4] and hand collection, is highly specific and does not cause unintended by-catch or direct disruptions to other species (Ruttenberg, 2001). In 2005, 703 fishers, including divers and vessel operators, and 273 vessels participated in the lobster and sea cucumber fisheries. There are three types of fishing vessels. *Pangas* and *fibras* are dinghies that make one-day fishing trips to sites close to the major ports. *Botes* are towboats, which make multi-day trips towing several dinghies to further fishing grounds, where resource abundance is usually higher (Bustamante et al., 2000). Increasing operating costs, however, have caused a decrease in the number of trips to remote fishing grounds.

Fishers are organised in four fishing cooperatives based on the three main ports: Puerto Ayora (COPROPAG), Puerto Villamil (COPAHISA) and Puerto Baquerizo Moreno (COPESAN and COPES-PROMAR). Together these cooperatives form the Union of Fishing Cooperatives of Galápagos, UCOOPEPGAL. Poor internal organisation, heterogeneity among fishers and the creation of parallel vessel-owner associations have all weakened cooperatives. The weakness of cooperatives is reflected in fishers' protectiveness of the fishing grounds they frequent. Fishers working only with close friends and family members and being hesitant to declare the area of their operation to fisheries monitoring staff to avoid having other vessels coming into 'their' spots demonstrates this (Ramirez Gallegos, 2004). This lack of trust has affected their bargaining position with trading companies (Fundación Natura & The Nature Conservancy, 2000, p. 80) and the legitimacy of their participation in management. As a result fishing cooperatives have become highly politicised and have failed to legitimately represent the interests of their members (Kerr et al., 2004, p. 101). Fishers in Galápagos want less government intervention and more independence in management and control of 'their own' fisheries also (E. Abudeye, personal communication, 26 January 2006)[5].

According to a study by Conservation International (Henderson et al., 2004), approximately 75% of fishers in Galápagos want to leave the industry and engage in alternative economic activities. With this in mind, Kerr et al. (2004, p. 99) pointed

[4] Diving mode where an air compressor on board the vessel provides air to the diver through a hose (see Photograph 2).

[5] E. Abudeye is a representative from COPAHISA and a former president of UCOOPEPGAL.

out that fishers may be open to policies that allow them to move out of fisheries and into other activities. This is positive for the prospects of an ITQ scheme, as one will allow an orderly exit from the fishery. The lack of access to alternative economic activities is a limitation though.

Photograph 3 - Bote

Gravez & Gelin (2003)

Photograph 4 – Pangas

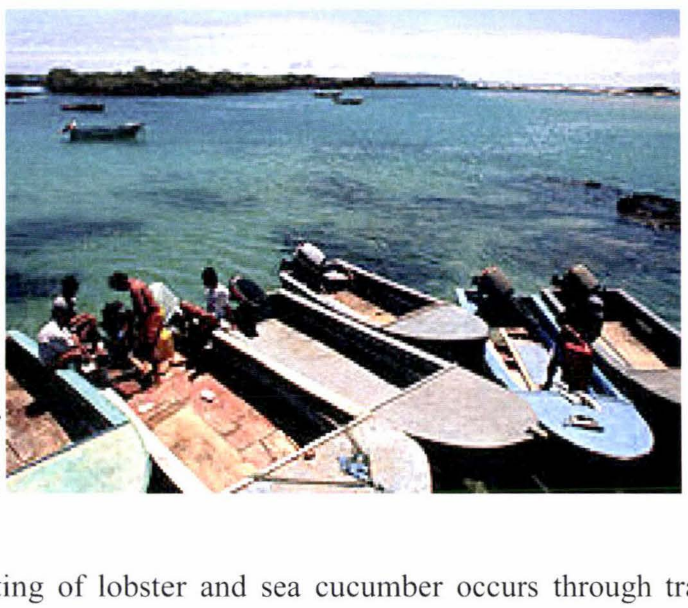


Photo by Pablo Corral

Marketing of lobster and sea cucumber occurs through trading companies that ship the product to continental Ecuador to then export it overseas. Lobster has been mainly exported to the United States (Hearn, 2004) while sea cucumber has been exported to Hong Kong, Taiwan and China (Toral-Granda et al., 2005). In these Asian countries sea cucumber is a valuable delicacy and an alleged aphrodisiac

(Camhi, 1995, p. 716). All lobster is exported frozen or chilled. Sea cucumber, on the other hand, is sold at different processing stages from fresh to fully dried and salted. Prices for sea cucumber vary according to the level of processing and have fluctuated significantly as a result of trading companies' demand and abundance of the resource. In contrast, prices for lobster seem to be determined in international markets and have increased marginally at a rate of 2% per year since 2000. During the 2005 season, the average price of lobster was $23.80 per kilogram of tail. For salted sea cucumber it was $30.64 per kilogram.

Particularly in the sea cucumber fishery, control of the market by unscrupulous trading companies has kept fishers impoverished, dependent and alienated, with little incentive to accept conservationist restraints. The fishers' need to pay for debts acquired for capital investments, sometimes with the trading companies themselves, has encouraged them to participate in the fishery even if the profitability obtained was minimal (de Miras et al., 1996; Ramirez Gallegos, 2004). This has also encouraged illegal fishing.

3.3 Current Management of the Fisheries

In 1998 the Special Regime Law for the Conservation and Sustainable Development of Galápagos (SLG) was introduced. Besides explicitly stating the objectives of maintaining ecological integrity and biodiversity, the SLG introduced for the first time principles of stakeholder participation, and adaptive and precautionary management to fisheries regulation in the archipelago. Local fishers were supposed to be particularly privileged with this legislation as it, in theory, limited entry into the fishery to artisanal fishers that were permanent residents of the archipelago and that were members of one of the local fishing cooperatives. A framework for zoning the GMR, according to the different uses, and with the objective of protecting vulnerable species, was also introduced under the SLG. Additionally, this legislation outlined penalties to be applied to those who violated the regulations established. By increasing stakeholder participation, the SLG significantly improved the legitimacy of fisheries management in the GMR. However,

> "...despite numerous efforts and a large investment by the Ecuadorian Government and the international community, fishery management in Galapagos remains highly conflictive and essentially ineffective. Biological monitoring by

> the Charles Darwin Station and subsequent reports on stock levels and acceptable catch are distrusted by the fishing community and rejected as biased, making consensus decisions on resource use in the Marine Reserve difficult. Levels of mistrust and lack of communication have eroded the governance mechanisms in place to resolve conflicts over competing uses in the Reserve" (Stone et al., 2006, p. 1).

Unfortunately, the application of this legislation has failed to limit entry of vessels and fishers into the industry, it has failed to limit catch to sustainable levels and therefore it has failed to improve the state of the resources also.

3.3.1 Administration

Since the SLG was introduced in 1998, fisheries management in the GMR has taken on a very different character. The SLG assigned the oversight of management of the GMR, including its fisheries, to a ministerial-level council, the Inter-institutional Management Authority (IMA). Decision-making was vested in the Participatory Management Board (PMB), composed of representatives from the fishing sector, the scientific and conservation community, the tourism industry and the Galápagos National Park Service (GNP)[6]. Operating within a 5-year fishing calendar, the PMB determines, by consensus and subject to the approval of the IMA, the specific regulations under which the fisheries will be managed each year. The implementation of these regulations is the responsibility of the GNP.

The management model introduced with the SLG significantly improved the administration of fisheries management in the GMR. It made the relationship between fishers and authorities more synergetic. The PMB and the IMA are fora for cooperation and debate among stakeholders; these fora were not available before. This has led to an apparent reduction in corruption and improved compliance (Shepherd et al., 2004, p. 107). This is consistent with Viteri & Chavez's (2004) findings, which showed that legitimacy, developed through active user participation in fisheries management, is an important factor in improving compliance with fisheries regulations in the GMR. Positive debate and discussion on alternatives to reduce effort in the coastal fisheries have also taken place within the PMB (S. Larrea, personal communication, 27 January 2006)[7].

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[6] The GNP is a government institution that administrates and manages the two protected areas of the archipelago: the National Park and the Marine Reserve.
[7] S. Larrea is the current facilitator of the Participatory Management Board.

Nonetheless, the administrative structure of fisheries management in the GMR has various weaknesses. First, fishing sector leaders have often seemed to pursue their own political agendas instead of legitimately representing their sector's interests (Toral-Granda et al., 2003). This reflects the poor organisation and weaknesses prevalent within the fishing cooperatives (E. Abudeye, personal communication, 26 January 2006). In part, this is due to a knowledge gap between fishers and managers, which helps explain why fishers are often sceptical about the outcomes of stock assessments (Ramirez Gallegos, 2004) and thus oppose conservationist regulations.

Second, social, economic and political arguments, based on the lack of alternative economic activities for fishers, have been given more importance than the state of the resources when setting regulations. The highly politicised decision-making process has therefore taken its toll on the fisheries.

> "According to some experts, the political nature of the PBM complicates sound policy making, where in most of the cases scientific information is absent or ignored. For example to define the 2003 global quota [for sea cucumber] the PBM was not able to reach a consensus position among users and the decision went to the IMA. The IMA in turn based its decision not on available scientific data but rather on 'socio-economic' considerations, reflecting the pressure of local fishermen to get a quota similar or lager than the last season. In this regard, although the decisions are apparently based on economic decisions, the resulting management policy may not benefit from full information or a complete analysis of trade-offs in present harvests and benefit streams over time" (Stone et al., 2006, p. 4).

These drawbacks have resulted in unsustainable outcomes. Except for the current closure of the sea cucumber fishery in 2006, drastic but necessary measures have not been taken. This has made convenience overfishing prevalent in the GMR.

Third, like any participatory institution, the success of the PMB depends on the strength and commitment of the different parties. Because of a weak fishing sector, among other reasons, the PMB is perceived to be closer to conservation interests than to fishers' interests (S. Larrea, personal communication, 27 January 2006). Furthermore, because of a relatively stronger commitment by the GNP, the PMB has lost some independence from the latter also (Galindo & Suarez, 2006).

Despite significant improvements in the decision-making and rule-setting processes for fisheries management in the GMR, the participatory management model has so far failed to produce sustainable regulations. Regardless of this, the PMB is a legitimate decision-making forum in Galápagos, it is held in high regard and any genuine change in fisheries management, like the decision to adopt an ITQ scheme for instance, will almost certainly have to come from within this forum.

3.3.2 Research

Biological research and monitoring of the fisheries has improved radically over the last decade. The Charles Darwin Foundation (CDF)[8] has led scientific monitoring of the fisheries, with increasing participation from the industry. This has provided clear indications of the state of the resources. Population density studies, before and after fishing seasons, have been performed for various years; these show that the fisheries are currently overexploited. The fishing sector, however, has often distrusted the outcomes from these studies, seeing the implications of the grim results as threats to their economic interests. Nonetheless, their increasing participation in these assessments is positive as it increases trust. The amount and quality of information accumulated is unprecedented and, as Altamirano et al. pointed out, there "is enough scientific information to guide the [management] process towards sustainability" (2004, p. 255); although there are still significant knowledge gaps, in particular with regards to ecological and biological traits of the species.

3.3.3 Monitoring, Control, Surveillance and Enforcement

There are several mechanisms in place to monitor compliance with fisheries regulations in the GMR. In theory, monitoring is based on a chain of custody assessment. First, port authorities record vessel sailings; then, on-board observers monitor catch and record fishing locations; finally, upon arrival to port, fishers report catch and fishing sites while monitoring staff record and monitor capture. Monitoring certificates and documents necessary to legally trade the product are issued. For sea cucumbers, these documents include a CITES permit. Additionally, the GNP, Environmental Police and the Navy perform regular surveillance operations around the GMR. In 2005 there were 98 staff, 11 vessels, 2 remote bases, and one airplane involved in control, surveillance and monitoring activities. Keeping in mind the limited resources available and that the GMR is one of the largest marine reserves in the world, there will never be full coverage of all activities.

[8] Founded in 1959 under the auspice of UNESCO and IUCN, conducts scientific research and environmental education for conservation in Galápagos.

Regardless of this, there is enough equipment and capacity in place for effective monitoring of fishery regulations in the GMR.

There have been, however, various loopholes in the system that have allowed illegal fishing to occur. First, monitoring by on-board observers and in port has not had full coverage. A significant number of vessels operate, and thus arrive in port, at night, as CPUEs for lobster tend to be larger then. However, prior to 2006 monitoring at the port used to take place only during the day. Fishers thus had to either return the following day or wait until monitoring personnel arrived in order to receive the necessary documentation. During this time, fishers had the opportunity to pre-select and hide individual animals that did not meet the established requirements. Only in the 2006 lobster season, 24-hour monitoring in port has been planned for, for the first time. Also, sailing permits have not always been issued, that means that not all fishing trips were recorded, which could distort effort estimations. Furthermore, not all fishers reported their operations accurately every time and there have been no legal mechanisms in place to force vessel-owners to carry on-board observers (Hearn et al., 2006). Besides, the vast geographical area of the GMR makes surveillance of remote fishing grounds very expensive and thus limited (Shepherd et al., 2004, p. 103). Furthermore, most monitoring and control occurs during fishing seasons, providing more opportunities for illegal activities to occur outside the season (Toral-Granda et al., 2003). All these flaws in monitoring could potentially allow a significant amount of catch to go unreported and unrecorded.

Second, the enforcement capacity has been generally weak as very few of the detected violations have actually led to sanctions other than catch confiscation and temporary gear and vessel seizures. There has been anecdotal evidence of corruption and conniving of monitoring officials to avoid sanctions (Shepherd et al., 2004). Moreover, the failure to enforce the entry requirements outlined in the SLG, such as being member of a cooperative to receive a fishing licence, led to the continuation of a 'regulated' open access situation. After the SLG was introduced many people, including non-fishers, joined cooperatives to retain the option of accessing the resource in the future. When access limits are not strong enough, gear requirements are simple and large numbers of non-fishers join fishing cooperatives, as was the case in the GMR, fishing turns into an occupation of last resort. As Weninger & Just

(1997) pointed out, this can lead to a catastrophic case of Malthusian overfishing[9], which is evident in the archipelago, and resource collapses, which have been observed in parts of the GMR with sea cucumber. As expected, impunity and poor enforcement decreases compliance (Viteri & Chavez, 2004) which is negative to the success of any fishery regulatory framework.

Regardless of this, in 2005 more than 100 infractions were detected during the sea cucumber and lobster seasons. These included fishing with no licence, fishing inside NTZs and harvesting undersized and egg-bearing animals or prohibited species. There is the perception among fishers that monitoring and enforcement unfairly picks on them and not on other users of the GMR, such as tourism operators (E. Abudeye, personal communication, 26 January 2006). However, the detection of these violations, in addition to the confiscation of large illegal shipments, including one in a tourist boat owned by a local politician, demonstrate that despite the weaknesses, the monitoring system can be effective and that it has been impartial (A. Hearn & M.V. Toral-Granda, personal communication, 26 January 2006)[10]. This, however, also gives an indication of the extent of illegal fishing.

3.3.4 Regulations for the Sea Cucumber Fishery

The experimental fishery for sea cucumber legally opened in 1994, although there was unregulated fishing in the archipelago since 1992. A TAC of 550,000 units of sea cucumber, to be caught within a 3-month season, was set. After only two months, catch was estimated to have reached between 6 and 12 million units, and the fishery was then closed (Camhi, 1995, p. 716). After that, an indefinite ban on sea cucumber fishing was imposed by the national fishing authorities as a response to lobbying from National Park administrators and local conservation organisations (Brenmer & Perez, 2002, p. 309). Illegal fishing continued to occur after the ban was introduced.

The ban was lifted in 1999 in the context of national economic and political crisis and as a result of pressure from the fishing community. Between 1999 and 2000 there was significant capital investment in the fishery, encouraged by wide

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[9] Overfishing that is driven by extreme poverty and the lack of alternative economic activities (Froese, 2004)

[10] A. Hearn and M.V. Toral-Granda are scientists at the Charles Darwin Research Station; both are involved in the Fisheries Monitoring Programme.

availability of credit and other commercial arrangements (Brenmer & Perez, 2002). The regulations determined under the new management model described by the SLG included minimum sizes, which restricted catch to animals larger than 20 centimetres of total length when fresh, a TAC, a two-month fishing season, and the establishment of NTZs. Minimum size restrictions are established according to the estimated dimensions of sexually mature animals in order to maintain the reproductive potential of the stock. Canal Bolivar (see Figure 1.1) has been set as a significant NTZ for the sea cucumber fishery due to the high abundance of resource there. Regardless of these measures, Okey et al. (2004, p. 394) indicated that catch levels in the first few years after the fishery re-opened where twice the sustainable levels.

In 2001 an ITQ scheme was applied to the sea cucumber fishery. A TAC of 4 million units was set and divided equally among registered fishers, each being allocated a quota of 3,174 units for a single fishing season. The application of this scheme was very effective in reducing catch as only 67% of the TAC was actually harvested. However, the economic impact on fishers who did not use their quota allocation as a result of this was significant. The number of active fishers and vessels decreased substantially as a consequence (Murillo et al., 2002b). The ITQ scheme permitted a voluntary exit from the fishery as many considered that their quota allocation would not satisfy their economic aspirations so decided to sell it and secure a lower profit instead (Toral-Granda et al., 2005).

Because of that experience in 2001, many fishers do not view ITQ schemes favourably today. The scheme however, had various flaws which seriously affected its performance. First, full time fishers received no more quota than occasional fishers. This was unfair on the former as it ignored their greater dependence on the activity and probably the higher investments they would have made. Second, the quota market did not work well due to the high variability of sea cucumber prices; it would have been difficult for fishers to assess the value of quota in advance. Some fishers felt that often, too much was paid for quota as a result. Consequently, a significant amount of quota was not used, which was a considerable economic loss to quota holders. Third, quota was allocated to all registered fishers, as opposed to active fishers only, and without regard to historical catch or installed capacity. This would have favoured inactive registered fishers at the expense of their active colleagues. Furthermore, quota was allocated for a single year, which would not have increased the security of rights or certainty about the future of fisheries management. Because of these flaws and the poor economic performance of the programme, fishers view the ITQ scheme as a bad experience (E. Abudeye, personal communication, 26 January 2006). Consequently, it was scrapped in 2002, together with the TAC, leading to a catch of more than 8 million sea cucumbers, more than double the TAC set in 2001 (Murillo et al., 2002a).

In 2003, sea cucumbers were included in Appendix III of CITES in order to discourage trade of illegal catch (Toral-Granda et al., 2003), which was estimated to be between 250,000 and 300,000 units per year (Shepherd et al., 2004). In 2004, the fishery was initially closed but due to increasing pressure and legal challenges from the fishing sector, it was opened again later in the year. As in 2001, the TAC of 4 million units set for 2004 was not met when the season finished; only 74% of it was actually harvested. In 2005, the set TAC of 3 million units was not met at the end of the fishing season either; only 45% of it was actually caught.

These outcomes from fisheries monitoring indicate that the management system was not effective. Limited seasons have not been determined on biological factors. Instead, they have been applied only as a way to limit effort. A rather inefficient way to limit effort as the use of a TAC with a limited season exacerbates the 'race for fish', as described in the previous chapter.

> "From all these criteria, the TAC has been the hardest to keep as a management tool, despite its widespread use. Galápagos artisanal fishers blame diving accidents (some fatal) and inequity of earning on the TAC. Total income from the fishery relies on the quality of the fishing vessel used, proximity to fishing location and time underwater. The TAC promotes higher competition amongst fishers, yielding longer diving times in order to catch as much as possible before other fishers arrive or the TAC is achieved" (Altamirano et al., 2004, p. 252).

A 'race for fish' is therefore evident in fishers' behaviour. In this context, there is not much hope for the sea cucumber fishery:

> "The likely outcome of the current management approach is the collapse of the only viable population of sea cucumbers remaining in the Archipelago. Users of the reserve agree overall that the resource is overexploited. However, fishers agree that in view of the lack of realistic alternatives for their overcrowded sector, they have no choice but to continue their activities. Reducing fishing effort on coastal resources is currently the area of major concern for the management of the Galápagos Marine Reserve" (Hearn et al., 2005b, p. 383).

The regulations established in 2005 were insufficient to avoid a progressive worsening of the state of the resource.

Besides this, TAC has been consistently set beyond sustainable levels. Because of this, overfishing occurred even when the TAC was not reached. TAC in 2005 was set at 3 million units, actual catch was 1.4 million (Toral-Granda et al., 2005) while, according to Stone et al. (2006), the sustainable catch level was only 1.3 million back in 2003, when the resource was more abundant. According to Stone et al., fisher behaviour in the sea cucumber fishery revealed a 70% discount rate, a very limited time horizon and very low security in the ownership of resources. As described by Garza Gil (1998), if the stock is severely overexploited, and at risk of an immediate collapse, a complete closure of the fishery until stocks recover is more appropriate before looking at alternative forms of management. In this context, the decision not to open the fishery in 2006 is correct.

3.3.5 Regulations for the Spiny Lobster Fishery

In 1994, the lobster fishery was also closed for five years; however, due to mounting pressure from the fishing sector it was re-opened 18 months later. Since then, both species of spiny lobster have been managed as a single fishery on the grounds that biological parameters allow that. With the introduction of participatory management, the fishery has been managed through a limited season, open for four months from September to December, a minimum size restriction of 26 centimetres of total length (or 15 centimetres of tail length), NTZs, and prohibition to harvest gravid[11] females. Like with sea cucumber, minimum size restrictions are established to ensure that the reproductive potential of the stock is not threatened. A TAC was not set because of poor compliance and enforcement in previous trials. Bustamante et al. (2000) in fact questioned the capacity of the GNP to administer, monitor and enforce a quota system, suggesting that these schemes are effective only in more developed management regimes.

After 1998, it was determined that if CPUE fell under 5.8 kg of tail per diver-day, very strict measures would be taken to manage the fishery, such as area closures and a TAC of 31 tons of tails. In spite of this, CPUE has been less than 5.8 kg of tail per diver-day for two consecutive years since 2004 and stricter measures to

[11] Egg-bearing

manage the fishery have not been applied. Instead, closer monitoring of the resource by the industry was agreed on (Hearn et al., 2006).

Catch of lobster is currently beyond sustainable levels. Stone et al. (2006) indicated that the catch of red lobster in 2003 was 37% in excess of its optimum sustainable level, revealing an implicit 30% discount rate. This high discount rate also indicates a short-term perspective resulting from low security of resource ownership and thus the prevalence of an open access character, although it is not as severe as in the sea cucumber fishery. Catch of red lobster in 2005 was 28.9 tons of tails, while the MSY is estimated to be much lower than that, as will be discussed in the following chapters. In 2006 a new lobster season has been opened, operating under the same regulations as in 2005. The outcomes of the 2006 lobster season are expected to show a continuous decrease in the availability of the resource, exacerbated by the closure of the sea cucumber fishery, which will possibly result in an increase in the fishing effort being devoted to lobster.

Like with sea cucumber, a limited season is also inconvenient for fishers, as one quoted in Ramirez Gallegos (2004, p. 114) describes: "the months they left us with are difficult, water is cold and the sea is very rough"[12]. Like in the sea cucumber fishery, the limited season is not set on biological grounds but only as a way to limit effort. This is a rather inefficient approach since capital is not being used as productively as it could be outside of the fishing season. In this context, an ITQ scheme could allow for more flexibility, longer seasons and more efficiency.

3.3.6 Management Costs

Galindo & Suarez (2006) explained that the total management cost of the GMR in 2003 was $5.76 million. Almost 75% of this budget was spent in monitoring, control and surveillance. Figure 3.1 shows the distribution of this amount among the different management components. A significant amount of the total expenditure was directed to fisheries management, although not exclusively.

Various entities fund the GMR's management. The GNP[13], the Ecuadorian government, through an Inter-American Development Bank loan, and the CDF funded up to 92% of the management costs between 2001 and 2003. Other sources

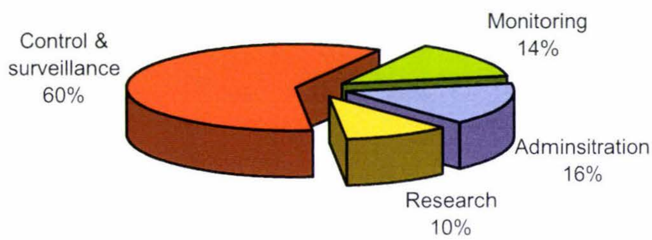
[12] Author's translation

[13] Currently 5% of visitor entrance fees to the National Park are assigned to the management of the GMR. This accounted on average for $300,000 per year between 2001 and 2003. The GNP allocates additional funds from other budgets also (Galindo & Suarez, 2006).

of funding included the Ecuadorian Navy and various environmental NGOs and foreign aid programmes. Besides the increasing participation of the fishing sector in research, there has been no formal mechanism of cost-recovery or rent capture.

Galindo & Suarez (2006) also estimated amounts required to finance three different management scenarios over the next decade. Average annual funding requirements were estimated to be $6.8, $9.1 and $10.4 million respectively for basic, improved and ideal management scenarios.

Figure 3.1 – Distribution of the Galápagos Marine Reserve's Management Costs, 2003 (Source: Galindo & Suarez, 2006).



The current management costs and prospective funding requirements presented by Galindo & Suarez (2006) are much higher than the value of the fisheries. In 2005 the gross income of the sea cucumber and spiny lobster fisheries added up to $2.5 million, much less than the total management costs of the GMR. Considering that a significant fraction of the overall management of the GMR involves developing and enforcing fisheries regulation, and keeping in mind the limited effectiveness of the latter, the scheme seems to be economically inefficient. Taking into account that the GMR has various other significant benefits and economic values (Wilen et al., 2000), the expenditure on management is justified. However, the fisheries management component could be improved to make it efficient, to enhance these benefits and to make them sustainable.

3.4 *State of the Fisheries*

The sea cucumber and spiny lobster fisheries, the most profitable of the GMR, are overexploited in biological terms and perhaps in economic terms also.

Catch and CPUE, which are indicators of abundance, have been dropping for various years in both fisheries and in 2005 they reached historically low values, showing that urgent action is necessary to reverse this trend.

3.4.1 Sea Cucumber

The sea cucumber fishery was closed in 2006 to allow for a recovery of the resource, considered to be on the limit of commercial extinction. Figure 3.2 summarises key findings from the Fisheries Monitoring Programme led by the CDF and the GNP. It is clear from the graph that there has been a decreasing trend in catch and CPUE, except for occasional fluctuations caused by particular environmental and socio-economic factors described below. Other information also shows that average sizes have been decreasing and that the percentage of undersized sea cucumbers captured has been increasing, confirming that the resource is overexploited. The state of the sea cucumber fishery is relatively worse than the state of the lobster fishery. The latter's typically lower profitability and dependence on skill and expertise for larger catches may explain this.

Figure 3.2 – Catch and CPUE for the Galápagos Sea Cucumber Fishery (Source: Toral-Granda et al., 2005).

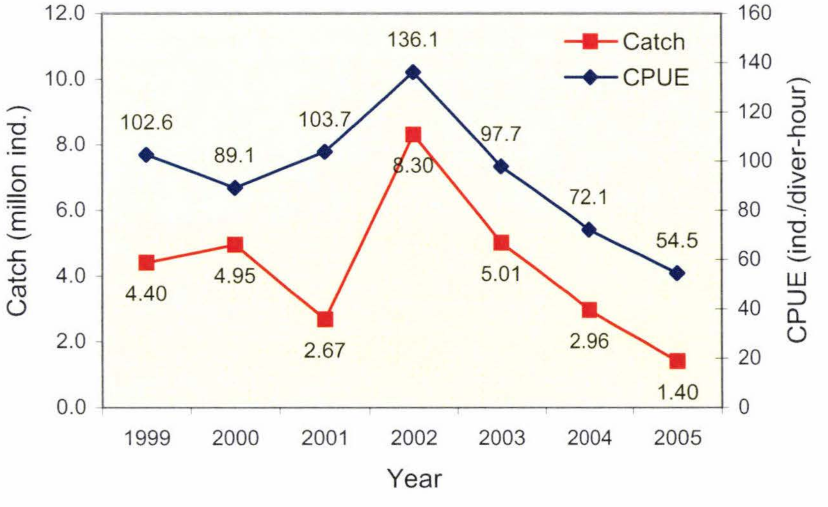
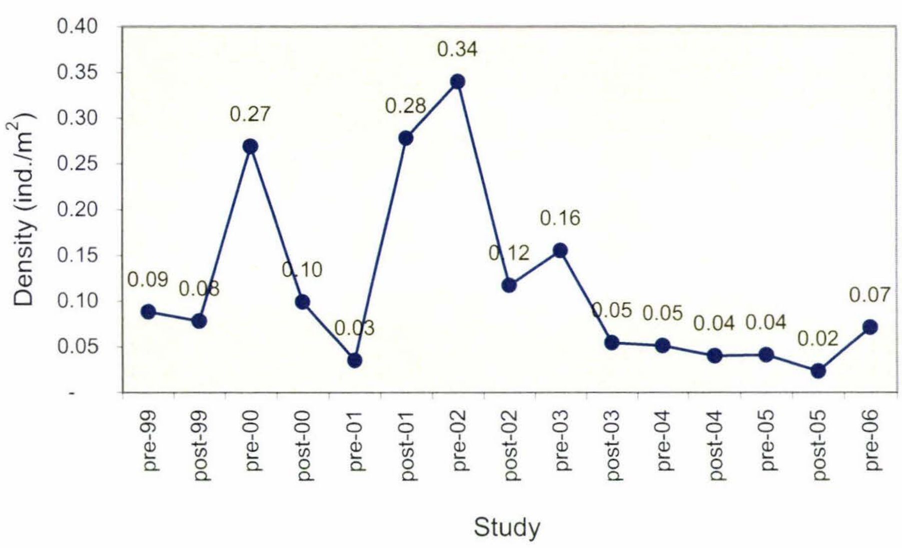


Figure 3.3 summarises the outcomes from population density studies performed by the CDF and UCOOPEPGAL. Besides normal fluctuations, the overall trend confirms the outcomes from fisheries monitoring: the abundance of the resource has decreased sharply. The latest population density study (Avendaño et al.,

2006) performed by the fishing sector to explore the possibility of opening the fishery in 2006 shows a slight recovery in density, most likely as a result of the current closure. As has been the case in the past, the highest concentrations of sea cucumber occur in the western part of the archipelago. Very low recruitment and densities in the rest of the archipelago suggest population collapses there. In previous population density evaluations, decreases in density have been observed in NTZs, which suggests the presence of illegal fishing there also (Toral-Granda et al., 2003).

Figure 3.3 – Average Population Density of Sea Cucumber in the Galápagos Marine Reserve (Source: Avendaño et al., 2006, p. 6).



The fishery was affected by low recruitment indices between 1994 and 1999, and then there was a mass recruitment process that peaked in 2001. After El Niño[14] in 1997-1998, there was a significant cool up-welling of nutrient rich waters in Galápagos that led to a phytoplankton boom. This, in addition to the slow growth of the species, may explain the recruitment pulse observed a couple of years later. However, the recruitment pulse took place only in the western parts of the archipelago, while exploited populations in other parts collapsed. Given the sporadic recruitment behaviour of sea cucumber, it is important to maintain a sufficient

[14] A periodic warming of the ocean surface in the equatorial Pacific Ocean caused by the absence of a normal up-welling of cold, nutrient-rich currents.

density in order to exploit favourable conditions when these arise (Hearn et al., 2005b; Toral-Granda, 2005).

Furthermore, in 2001 the use of an ITQ scheme for the sea cucumber fishery also led to a considerable reduction of effort devoted to the fishery. This is reflected in a lower catch level, despite the fact that the CPUE increased that year, and a higher population density after the 2001 season, as illustrated in Figures 3.2 and 3.3.

For external fertilisation species such as sea cucumber, decreasing densities of mature animals directly affect the reproduction potential. Hamel & Mercier (1996, cited in Toral-Granda & Martinez, 2004, p. 97) held that a density of 5 to 8 sea cucumbers per square metre is necessary for a 75% rate of success in reproduction. According to Shepherd et al. (2004), a density of 1.2 ind./m^2 is necessary for a 50% rate of success in reproduction. The extremely low densities observed in the GMR imply that recruitment would not have been high enough to compensate for fishing mortality if fishing rates continued at recent levels.

Taking this into account, previous fishing rates were clearly unsustainable and if these continue, the sea cucumber fishery would collapse throughout the archipelago. In this context, only a complete closure, as applied in 2006, or another recruitment pulse, would prevent the collapse of the fishery (Hearn et al., 2005b; Okey et al., 2004; Shepherd et al., 2004; Toral-Granda & Martinez, 2004; Toral-Granda et al., 2003). Martinez & Bustamante (1996) and Uthicke & Benzie (2000, cited in Toral-Granda et al., 2003) mentioned that sea cucumber fisheries around the world traditionally operate under a boom and bust cycle given that these animals are characterised by very slow movements and have no defence against harvesting. They can therefore be exploited up to the point of extinction in short periods of time. The sea cucumber fishery of continental Ecuador in the absence of any form of management, for instance, collapsed within only four years of it first being exploited. A possible total collapse of the GMR sea cucumber fishery will affect the stability of unique marine ecosystems (Martinez & Bustamante, 1996; Toral-Granda et al., 2003) and the livelihoods of hundreds of fishers.

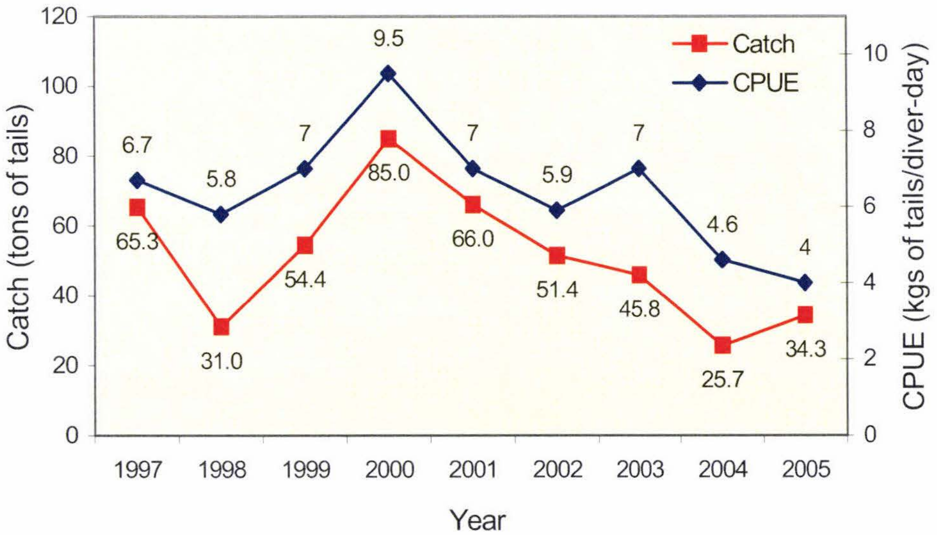
There is limited information on the operating costs of the sea cucumber fishery. However, a reasonable expectation is that these would have been increasing. The price of fresh sea cucumber has fluctuated between $0.33 and $1.50 per individual since the fishery re-opened in 1999. Prices in 2005 were on average the second highest since 1999 at $1.21 per individual. According to Shepherd et al. (2004, p. 106), prices have been high enough to maintain fishing pressure, causing recruitment overfishing and reducing the stock's reproductive capacity (Froese, 2004). Prices of sea cucumber increase when the resource's abundance and availability on the market declines, exacerbating overfishing and making the economic collapse of the fishery difficult to predict (A. Hearn & M.V. Toral-Granda, personal communication, 26 January 2006). Regardless of this, there is anecdotal evidence that a considerable number of vessel-owners made losses during the last season. The considerable reduction of active fishers and vessels in the last season also suggests this.

Photograph 5 – Valuable Catch: Galápagos Sea Cucumber

3.4.2 Spiny Lobster

Figure 3.4 summarises some of the findings from the Fisheries Monitoring Programme. Despite normal fluctuations, it is clear that catch and CPUE have been dropping steadily, demonstrating that the current fishing effort is beyond the self-regenerating capacity of the resource. The vast majority of catch is for red lobster. Like the sea cucumber fishery, El Niño in 1998 caused a drop in the availability of the resource, after which a recruitment pulse was triggered (Bustamante et al., 2000), peaking in 2000. This process does not seem to have been as intense as for sea cucumber though. Furthermore, a clash with the sea cucumber season in 2004 caused a reduction in the amount of effort devoted to the lobster fishery. For these reasons, catches in 1998, 2000 and 2004 differ from the overall decreasing trend. The average CPUE of 4 kg of tail per diver-day[15] estimated for 2005 is the lowest ever recorded for this fishery (Hearn et al., 2006). The average CPUE was estimated to be as high as 30.6 kg of tail per diver-day in the 1960s (Reck, 1983). Furthermore, there has been a progressive reduction in average size and increasing percentage of undersized and gravid lobsters within the catch, affecting the reproductive capacity of the population. This demonstrates the pervasiveness of overfishing (Hearn, 2006). In 2006 the fishing season has been opened for four months again with the same regulations as before; thus the decreasing trend in catches and CPUE is expected to continue during this year.

Figure 3.4 - Catch and CPUE for the Galápagos Spiny Lobster Fishery (Source: Hearn et al., 2005a; Hearn et al., 2006; Murillo et al., 2004).



The economic performance of the fishery is also believed to be deteriorating. A reasonable expectation is that the fishery's costs of production would have been increasing over the last few years, although information on these is limited (Hearn et

[15] In 2005, fishers' monitoring of the fishery resulted in a CPUE of 7.2kg of tail/diver-day, which differs significantly from that reported by the CDF. Bias and poor data collection would seem to explain this outcome, which is inconsistent with the catch of the fishery (Hearn, 2006; A. Hearn & M.V. Toral-Granda, personal communication, 26 January 2006).

al., 2006, p. 28). Nonetheless, the price paid to fishers has remained relatively constant over the last five years, increasing at a rate of 2% per year since 2000. For lobster, prices seem to be determined by international markets; commercial behaviour and resource availability seem to have no effect on price. This, in addition to decreasing catches, would have resulted in decreasing net benefits also.

3.5 Summary and Concluding Remarks

Despite considerable improvements in fisheries management in the GMR since the SLG was introduced, the process has failed to limit entry and catch to sustainable levels in the major fisheries. Particular limitations to effective management in the GMR have been weak fishing cooperatives, convenience overfishing and poor enforcement. The sea cucumber and lobster fisheries have been managed through prescriptive regulations, which included limited seasons, size restrictions and NTZs. A TAC was a major regulatory instrument applied to the sea cucumber fishery also, although it was consistently set beyond sustainable levels. Limited monitoring and the absence of major enforcement have affected this process. Consequently, the state of both fisheries, particularly sea cucumber, has deteriorated to a great extent. In 2006 the sea cucumber fishery was closed to allow for recovery of the stock and the lobster fishery was opened and is currently managed under the same prescriptive regulations as before.

Given the dismal state of the resource, sea cucumber can only be managed at present with a complete closure, as applied already. Regardless of this, an ITQ scheme is unlikely to be suitable to manage the sea cucumber fishery if the stock recovers. The high price variability would make it difficult for fishers to value quota in advance, as the 2001 ITQ scheme demonstrated. Furthermore, the highly sporadic recruitment behaviour of sea cucumber could hinder a sustainable TAC-setting process. Additionally, the fact that the resource can be transported to the continent by boat, unlike lobster that needs to be frozen and transported by air, is a major challenge to effective monitoring, which is essential for a successful ITQ scheme.

The state of the lobster fishery, on the other hand, demonstrates the need for an urgent improvement in active management. Given the failure of prescriptive regulations developed through the participatory management model, an alternative regulatory instrument is desirable. An ITQ scheme for the GMR spiny lobster fishery could be a viable alternative given the characteristics of the fishery. These characteristics meet the context requirements described in the previous chapter:

- The current state of the fishery is a result of behavioural rather than biological factors. Despite the latter, the state of the fishery is relatively healthy.
- The high-specificity of the fishing technique is not expected to cause high-grading, discarding or unintended by-catch, effects which are often exacerbated by ITQ schemes.
- Given the relative smallness of the fishery and the existing monitoring capacity of the GNP, effective monitoring is feasible.
- A reasonably accurate TAC can be set with the scientific information available.

In spite of these characteristics, many of the current limitations to management will also be limitations to an ITQ scheme:

- Limited monitoring, despite the capacity to do it, and practically absent enforcement would cause severe quota busting.
- Weaknesses within fishing cooperatives would affect the capacity of the sector to reach an agreement regarding their support to a change in the management strategy; could cause quota-busting and reduced compliance if the scheme is adopted without broad support from the industry.

These limitations can be addressed through a much-needed upgrade of the monitoring and enforcement component of fisheries management in the GMR and a robust effort to strengthen fishing cooperatives. Regardless of the regulatory instrument, these limitations need to be addressed to improve fisheries management in the GMR. As mentioned in chapter 2, complementary regulations to meet particular environmental or social objectives would be necessary also. Limits on quota ownership, size restrictions and prohibition to harvest gravid females, for instance, will still be necessary prescriptions if an ITQ scheme is adopted. If the current limitations are addressed appropriately, then an ITQ scheme could rationalise the use of the lobster fishery in the GMR.

The next chapter outlines the methodology used to assess the benefits and equity implications, which would result from an ITQ scheme for spiny lobster in the GMR.

CHAPTER 4 ~ DATA AND METHODOLOGY

"Several fundamental issues concern regulators and industry when planning or considering the feasibility of an ITQ program. First is the expected equilibrium price and economic rents (...). A second concern is the gains in economic efficiency from quota trade. Third, regulators are concerned about potential quota and industry concentration and competitiveness as well as thinness (number of participants) of the quota market. Resolution of these sources of uncertainty would enable better evaluation and planning of prospective ITQ programs".

~ Lanfersieck & Squires (1992, p. 2313)

4.1 Introduction

In the previous chapter it was concluded that an ITQ scheme would be suitable in the context of the spiny lobster fishery. The sea cucumber fishery, on the other hand, was considered to be unsuitable for an ITQ system at present, mainly due to the extremely poor state of the resource. Taking this into account, this chapter describes the methodology used to estimate the economic benefits and equity implications that are expected to result from an ITQ scheme for the spiny lobster fishery. This analysis answers the second and third research questions of the study and, together with the conclusions from chapter 3, allows determination of whether an ITQ scheme could be used to rationalise the lobster fishery in the GMR. As Lanfersieck & Squires (1992) mentioned, the resolution of these "sources of uncertainty" enables a better evaluation of prospective ITQ schemes, precisely what this study aims to achieve.

The data sources used in this analysis are yearly reports from the Fisheries Monitoring Programme, performed by the GNP, CDF and fishing sector since 1997, and a 2005 monitoring database for vessels based in Puerto Baquerizo Moreno, one of the main ports of the archipelago. The data available includes output prices (p), costs of production (C), catch (K) and fishing effort (f) per fishing season and port. In the reports this data is aggregated by port and is available for each fishing season from 1997 to 2005. In the database from Puerto Baquerizo Moreno, this data is disaggregated to individual fishing trips. Other variables are constructed from this data using also information from relevant literature on the production functions of lobster fishing, particularly Murillo (2002) and Wilen et al. (2000). The datasets used are included in Appendix 1. The information at hand allows for a reasonable appreciation of some of the issues that will arise with the introduction of an ITQ scheme in Galápagos.

In order to analyse these impacts a hypothetical ITQ scheme is constructed. Given the restricted amount of scientific and socio-economic information available, various assumptions are made in this process. The hypothetical ITQ scheme is assumed to be the central regulatory instrument to be implemented within the next 5-year fishing calendar, applicable from 2007 to 2011. Quota would be allocated as a percentage of a set TAC, on the basis of historical catch. Complementary regulations to address specific environmental objectives such as prohibition to harvest egg-bearing or undersized lobsters are assumed to hold also. Three scenarios are considered:

- **Scenario *A*:** No change in the management strategy; effort remains at a high level ('without' scenario).
- **Scenario *B*:** An ITQ scheme is adopted and the TAC is set at the estimated MSY (first 'with' scenario).
- **Scenario *C*:** An ITQ scheme is adopted and the TAC is set at the estimated MEY (second 'with' scenario).

The present values of the fishery under the three different management scenarios are estimated and compared, and the equity implications resulting from an ITQ scheme are also forecasted.

4.2 Setting a Total Allowable Catch

First, a sustainable catch function is estimated using the yearly effort and catch data available. This function is assumed to be consistent with a fishery's growth function and the respective bio-economic relationships explained earlier and described in detail by Schaefer (1954), Clark (1976) and Conrad (1999), among others. Because the spiny lobster fishery is a dive-search fishery, as opposed to a schooling fishery for instance, it is expected to reflect the relationships between catch, effort, revenue and costs outlined in section 2.2. Considering that in practice the fishery operates under a regulated open access situation, in a normal fishing season it is assumed that the catch of legally sized lobsters, which is only a fraction of the total catch as described in chapter 3, should reflect the sustainable catch function. As described in chapter 2, under open access conditions the fishery will operate at or close to the bio-economic equilibrium which, although being inefficient, can be sustainable. The excess catch of juvenile and undersized lobsters which occurred in the years for which data is available is therefore assumed to be beyond the sustainable threshold. An implicit assumption of this procedure is that the amount of legally sized catch harvested in the past was sustainable. With this in mind, sustainable catch is therefore given by the following function:

$$K_t = af_t + bf_t^2$$

Where K_t is sustainable catch (tons of legally sized tails) and f_t is effort (number of vessel-days), in season t (Murillo et al., 2004, p. 5). Parameters a and b are estimated; the resulting function shows the relationship between effort and sustainable catch, such as that illustrated in Figure 2.2, for the spiny lobster fishery.

Second, revenue and cost functions are estimated. By multiplying the estimated sustainable catch, resulting at different levels of effort, by output price (p), a sustainable total revenue (TR) function is obtained:

$$TR = \left(af + bf^2\right)p$$

Operating costs (Oc) of *pangas* and *fibras* include oil, fuel, batteries, transport and food, as detailed in Table A1.3, Appendix 1. In this case Oc also includes towboat hire fees, which are assumed to be equal to regular single vessel operating costs on average because various smaller vessels usually share towboat-hiring costs. Labour costs (Lc) are a percentage of total revenue as vessel-operators and divers usually receive a share of the fishing trip's revenue, 12.5% and 25% respectively. Consequently, total labour costs are equal to 37.5% of total revenue. Most capital investment for this fishery occurred during the sea cucumber season of 2000, maintenance costs are assumed to be minimal and undertaken outside of the lobster season (Murillo, 2002; Wilen et al., 2000). Taking this into account, the total cost (TC) function is equal to:

$$TC = (Oc + Lc)f$$
$$TC = (Oc + 0.375 \cdot TR)f$$
$$TC = \left(Oc + 0.375apf + 0.375bpf^2\right)f$$

Third, the MSY and the MEY are established. The effort associated with the MSY is achieved when $\delta K/\delta f = 0$, where δ is the derivative. The resulting level of effort, when the derivative of the total sustainable catch function in terms of effort is equal to zero, is that which results in the MSY of the fishery. This was described in section 2.2. In this case, the effort associated with the MSY can also be expressed as:

$$f_{MSY} = \frac{-a}{2b}$$

By replacing this level of effort in the equation for sustainable catch, an estimation of the fishery's MSY is obtained. Likewise, the effort associated with the MEY is that which results in marginal revenue being equal to marginal cost, maximising the resource rent, as described in section 2.2 and illustrated in Figure 2.2. The derivatives of total revenue and total cost in terms of effort are equal to the marginal revenue and the marginal cost respectively. In this case therefore the level of effort associated with the MEY is achieved when $\delta TR/\delta f = \delta TC/\delta f$, where δ is the derivative. This can also be expressed as:

$$f_{MEY} = \frac{0.625ap - Oc}{-1.25bp}$$

Once again, by replacing this level of effort in the equation for sustainable catch, an estimation of the fishery's MEY is obtained. In the hypothetical quota management system, TAC is set at the MSY in Scenario *B* and at the MEY in Scenario *C*.

4.3 Estimation of Economic Benefits from an ITQ Scheme

Economic benefits in this case refer to the present value of the net benefits of the fishery under the three different management scenarios. The value of the fishery will therefore depend on the effectiveness of the management regime. Only the net benefits derived from legally sized catch of red spiny lobster are considered. Excess catch is in fact a cost to the long term value of the fishery as it affects its reproductive potential and sustainability (Daníelsson, 2005). Catch that is in excess of the sustainable level is therefore not considered in the analysis. Likewise, green lobster is treated as 'incidental' catch because it generally would be more costly to harvest; the species is found in deeper habitats and is solitary, unlike red lobster (Bustamante et al., 2000). Except in Puerto Villamil, green lobster represented only a marginal percentage of the total catch of the fishery. In general, fishers do not target it specifically.

Other potential values of the fishery, besides its commercial use, are excluded from this analysis. The only current use of the fishery is commercial extraction; there is no recreational or customary harvesting of lobster. For a detailed framework of different ways to value fishery resources when different uses exist see Hundloe (2002). Because in this case there is a single use to the fishery, the framework described by Daníelsson (2005) is used instead.

First, the resource rent derived from the fishery in the 2005 season is estimated by subtracting estimated total costs from the total revenue. This provides a baseline against which the economic benefits of the three different management scenarios can be compared.

Second, to calculate economic benefits, the operation of the fishery during the period of the hypothetical quota management system, 2007 to 2011, is projected. Output prices, exogenously determined in export markets, are assumed to continue increasing at an average rate of 2% per year as they have over the last five years. Domestic inflation, affecting operating costs, is to increase also at a rate of 2% per year[16]. Production functions and cost structures are assumed to remain constant. Monitoring and enforcement are assumed to be effective, the GNP and other organisations are assumed to effectively utilise current capacity in the control of fisheries regulations.

In Scenario *A* effort is assumed to remain at the relatively high level where the normal equilibrium of the fishery has been. This is considered to be the average of the three highest effort levels monitored since 1997, which occurred in 2001,

[16] The national producer price index for September 2006 was 1198.85; in September 2005 it was 1168.58 (Base year: 1995). This results in an annual cost inflation rate of 2.52%. Up to 80% of this change is attributed to products from agriculture and fishing (Instituto Nacional de Estadística y Censos, 2006). Fishing cost inflation in Galápagos is therefore assumed to be 2% per year.

2002 and 2005. In practice it is unlikely that the fishery will actually reach its bio-economic equilibrium since fishers will continue to extract the resource only if there are overall positive profits. For that reason it is more appropriate to consider the level of effort to fluctuate on average around the highest effort levels observed previously. The sustainable catch achieved at that effort level is estimated by using the sustainable catch function determined earlier.

In Scenarios *B* and *C* catch is limited to the MSY and MEY respectively, and effort is assumed to drop from the current levels accordingly. Assuming that the TAC remains constant during the period of the analysis, at the MSY and MEY in each case, the quota rent generated is estimated. In reality, the MSY and MEY, and therefore the TAC under each scenario, would change in light of new scientific information, major climatic events or different variations in the change of prices and costs. These effects are impossible to forecast in this study so the above assumptions hold instead.

For the ITQ programme in Scenarios *B* and *C*, economic benefits are equal to the quota rent generated. As described by Squires (1990) and outlined in section 2.6.7, quota rent is equal to the equilibrium price of a unit of quota, τ^*, multiplied by the TAC. The τ^* is equal to the average net benefit of quota, in this case, a kilogram of legally sized lobster tail. This is the estimated equilibrium quota price that vessel-owners will be willing to pay, or accept, in order to buy, or sell, quota. In practice one unit of quota will be equal to a percentage of the set TAC however, in this study it is assumed that the TAC will be held constant throughout the 5-year allocation period therefore one ITQ can be expressed as the right to harvest a kilogram of legally sized red lobster tail.

The difference between the value of the fishery under the current management system (Scenario *A*) and under ITQ management (Scenarios *B* and *C*) is the net gain resulting from the latter in each case. This addresses the second research question of the study: to estimate the economic benefits resulting from an ITQ scheme.

Third, a sensitivity analysis will be performed to assess the impact of variability in the discount rate, output prices, domestic inflation and quota allocation period on the value of the fishery under each management scenario, and the net gain of the ITQ scheme. In practice, if prices and costs change by different rates, the

MEY and thus the TAC in Scenario *C*, will change in the subsequent year. However, in the sensitivity analysis TAC is held constant to reflect the economic impact of these changes on the original schemes.

The costs of implementing and running an ITQ scheme in Galápagos are excluded from this analysis for the following reasons: first, as outlined by Galindo & Suarez (2006), the 'ideal' funding requirement to manage the GMR exceeds the gross revenues of all the fisheries. This excess is justified on the grounds that the GMR provides a range of other services and values, besides those derived from fisheries (Wilen et al., 2000), the benefits of which are not always captured effectively. The GMR is amongst the largest marine reserves in the world; effective surveillance of this area is very expensive yet essential.

Second, the 'ideal' funding requirement outlined by Galindo & Suarez (2006) is assumed to be enough to implement an ITQ system by taking into account that many fisheries management services are already in place. An improvement in the monitoring and enforcement component of fisheries management is needed in Galápagos regardless of the scheme chosen. For this reason, it is assumed that monitoring and enforcement efforts will be upgraded and implemented to their full capacity in 2007, regardless of whether or not an ITQ scheme is introduced. If this does not hold, an ITQ system would not be viable in the first place. A considerable amount of research and administration services are already in place in Galápagos. What would still be needed is the development of an information system to track quota ownership and exchange, and to match this with individual catches. The increase in funding for management of the GMR, outlined by Galindo & Suarez, is assumed to cover the cost of upgrading these fishery management components.

Third, fisheries management services in Galápagos benefits various other fisheries besides lobster; the investment needed to develop an ITQ scheme for the spiny lobster fishery would indirectly benefit other fisheries also by encouraging a change of behaviour and by generating positive demonstration effects. There is no clear estimation of the value of these fisheries. In this case therefore, the cost of management is not based solely on the benefits derived from the fisheries and thus the choice of a fisheries management scheme should not be based solely on its costs.

4.4 *Assessment of Equity Implications from an ITQ Scheme*

The sample of fishing trips and vessels from the Puerto Baquerizo Moreno monitoring database (Table A1.4, Appendix 1) is used to assess the potential equity implications of an ITQ scheme in Galápagos. This dataset allows tracing Lorenz curves and Gini coefficients for the distribution of effort and catch in the sample. The Gini coefficients may help understand the equity implications of an ITQ scheme (Adelaja et al., 1998b). The sample also allows the estimation of implicit quota prices for each vessel-owner in the sample, providing an indication of the potential equity implications of the scheme too.

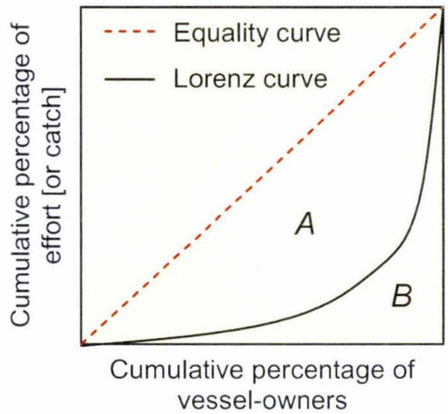
4.4.1 Estimation of Lorenz Curves and Gini Coefficients

Lorenz curves usually plot the relationship between cumulative income or wealth (or some other variable), on the vertical axis, and the cumulative population, on the horizontal axis. If every person's income or wealth is exactly the same, the curve is equal to the perfect equality curve, a 45-degree line between both axes. The greater the concentration of income, or wealth, the greater the area between the perfect equality curve and the actual Lorenz curve will be (Grafton et al., 2000a, p. 5). The Gini coefficient (G), measuring the concentration of income or wealth, is equal to the area between the Lorenz curve and the perfect equality curve divided by the sum of the total area under the perfect equality curve. The value of G will range between 0 and 1, 0 indicating perfect equality and 1 indicating perfect inequality (Todaro & Smith, 2003, p. 202).

Lorenz curves and Gini coefficients can be adapted to assess the equity implications of an ITQ scheme (Adelaja et al., 1998b). In this case, the distribution of income or wealth is replaced by the distribution of catch and effort, respectively, among vessel-owners, as illustrated in Figure 4.1. Referring to the latter, the Gini coefficient in this case is therefore equal to:

$$G = \frac{A}{A + B}$$

Figure 4.1 – Lorenz Curve Diagram



Two Gini coefficients are calculated, one for the distribution of catch and another one for the distribution of effort among vessel-owners. Once the Lorenz curves are traced the triangulation method is used to estimate area *B* and, with that, Gini coefficients for the distribution of catch and effort respectively. The triangulation formula used to calculate the area corresponding to each additional vessel-owner is:

$$B_i = [(CPV_i - CPV_{i-1}) \times CPK_{i-1}] + [(CPV_i - CPV_{i-1}) \times (CPK_i - CPK_{i-1}) \times 0.5]$$

Where B_i is the area under the Lorenz curve for the segment corresponding to vessel-owner *i*, CPV_i is the cumulative percentage of vessel-owners up to vessel-owner *i* and CPK_i is the cumulative percentage of catch up to vessel-owner *i*. The same formula is used to calculate the area under the Lorenz curve for effort. In that case the cumulative percentage of effort up to vessel-owner *i*, CPF_i, replaces CPK_i. This methodology is adapted to this context from that used by Anand (1983, p. 311).

Recalling the equation for the Gini coefficient, in this case it is equal to:

$$G = \frac{0.5 - \sum_{i=1}^{n} Bi}{\left[0.5 - \sum_{i=1}^{n} Bi\right] + \left[\sum_{i=1}^{n} Bi\right]} \; ;$$

Where $\sum_{i=1}^{n} Bi$ is equal to area B in Figure 4.1 and n is equal to the total number of vessel-owners in the sample. Expressed in a simpler fashion, the Gini coefficient is also equal to:

$$G = 2 \cdot \left[0.5 - \sum_{i=1}^{n} Bi \right]$$

4.4.2 Estimation of Implicit Quota Prices

As outlined in section 2.6.7 and described by Squires (1990) and Lanfersieck & Squires (1992), the less efficient vessel-owners will value quota allocations less than the more efficient vessel-owners. The implicit quota price of the former will therefore be less than the equilibrium quota price. As a result, less efficient quota-owners will sell their quota allocation and could potentially leave the industry. Using the mentioned database, individual implicit prices for quota are estimated to assess how many vessel-owners would be likely to sell quota.

A first step is to determine each boat-owner's implicit quota price, τ_i, the value that each vessel-owner will place on quota after allocation but prior to exchange. For a profit-maximising fisher, the value of a unit of quota is equal to the net benefit of the latter, in this case a single kilogram of lobster tail. Assuming competitive markets, asset-pricing theory suggests that quota prices should reflect the present value of expected rents in the fishery. Assuming quota is allocated for the hypothetical five-year fishing calendar, 2007-2011, the implicit quota price for vessel-owner i in 2007 is thus equal to:

$$\tau_i = \frac{p - c_i}{(1 + r)^5}$$

Where c_i is vessel-owner i's average cost of production and r is the discount rate, set at 20% to reflect the limited access to credit and the prevalent open access character of the fishery, as described by Stone et al. (2006).

Second, the equilibrium quota price, τ^* (see Figure 2.3), is expected to be close to, or at, the average of all individual implicit quota prices. Assuming that vessel-owners act rationally, by comparing τ_i with τ^*, predictions as to which of them will sell quota can be drawn (Lanfersieck & Squires, 1992; Squires, 1990). If τ_i is lower than τ^*, vessel-owner i would be likely to sell quota; when τ_i is greater than τ^* he or she would be likely to buy quota from other less efficient fishers. Therefore, τ^* is the cut-off that identifies those vessels with high costs and therefore lower willingness to pay for quota that would choose to sell their allocation and, potentially, exit the fishery (Dupont, 2000). An estimation of how many vessel-owners will sell quota is performed. The outcomes from this analysis can allow identifying potential losers of an ITQ scheme more effectively if one is eventually applied in Galápagos.

With the information available it is not possible to forecast how much quota each fisher will actually trade, as was described by various authors listed in section 2.6.7. It is therefore not possible to calculate Gini coefficients after quota trade to assess the actual change in resource use concentration, like Adelaja (1998b) does for instance. Nonetheless, the estimates of the current Gini coefficients, and the predictions of which vessel-owners will sell quota if an ITQ scheme is introduced, provide an indication of the potential equity implications of the hypothetical management scheme, addressing the third research question of the study.

4.5 Concluding Remarks

ITQ schemes can allow an orderly exit of excess capital from the fishery by permitting inefficient fishers to sell their allocated quota to those who value it more. This has positive effects in terms of conservation and sustainability. In this way, this management instrument is likely to lead to healthier stocks if TAC is set within sustainable levels. By enhancing efficiency, significant economic benefits are expected as ITQ schemes remove the open access character of capture fisheries. Nonetheless, ITQ schemes may also cause negative equity implications and industry concentration.

In this study the economic benefits and equity implications resulting from a hypothetical ITQ scheme for the GMR spiny lobster fishery are assessed. Economic benefits are estimated by forecasting the operation of the fishery under three different management scenarios: the current management scheme (Scenario *A*), an ITQ scheme in which TAC is set at the MSY (Scenario *B*), and an ITQ scheme in which it is set at the MEY (Scenario *C*). These estimations are based on data from the Fisheries Monitoring Programme.

The analyses to assess the equity implications of the scheme are based on monitoring data from a sample of vessels from Puerto Baquerizo Moreno. By calculating Gini coefficients, the current distributions of catch and effort for this sample are observed, and the implications from an ITQ scheme in this context are outlined. Furthermore, by predicting vessel-owners' decisions to trade quota on the basis of their estimated implicit quota prices, a second assessment of the equity implications of the hypothetical ITQ scheme is made. In addition to the suitability of an ITQ scheme in the context of the GMR, estimations of economic benefits and equity implications resulting from this management instrument are useful to determine whether such a management scheme is desirable in this case, answering the three research questions and addressing the main objective of the study.

CHAPTER 5 ~ RESULTS AND DISCUSSION

"When fishermen are impoverished by conservation measures, as is often the case under conventional management, they quite understandably oppose them. When fishermen are better off financially and can increase profits by behaving in a way consistent with conservation measures (typically the case for catch share fisheries), opposition to conservation is reduced and compliance increases in many cases".

~ Pauly (1997b, p. 42)

5.1 Introduction

In this chapter the results from the numerical analyses described previously are presented. As mentioned earlier, estimations of the expected equilibrium quota price, economic rent, efficiency gains and equity implications likely to result from a prospective ITQ scheme are important considerations to determine whether such a management instrument will be desirable to rationalise the GMR spiny lobster fishery. It was concluded earlier that the fishery meets the basic requirements for the implementation of such a management instrument however, prior assessment of the possible efficiency and equity impacts of implementing such an instrument is essential. In the next sections, first the results of the MSY and MEY are outlined after which the findings on the economic benefit and equity implications of the scheme under the three different management scenarios are presented. A discussion of these results is presented at the end of the chapter.

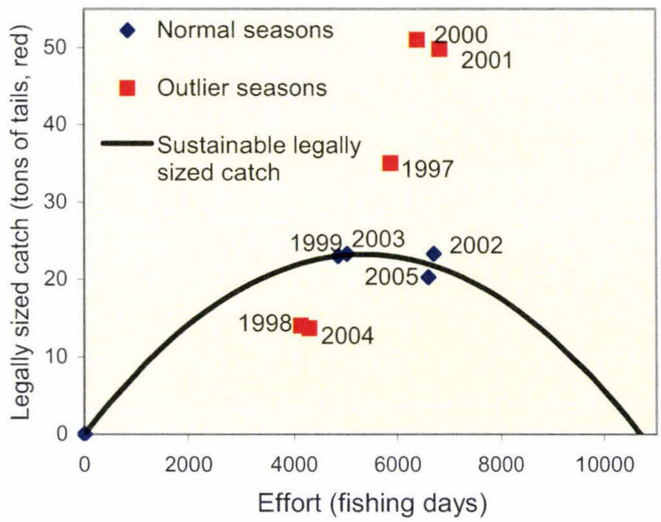
5.2 Total Allowable Catch

The summary output for the statistical analysis for the sustainable catch function is presented in Appendix 2. The sustainable catch model fitted best with four 'normal' fishing seasons: 1999, 2002, 2003 and 2005. 'Outlier' years were not included in the regression. These include 1997 because the sea cucumber fishery was closed in that year, which resulted in increased effort and catch in the lobster fishery. The 1998 fishing season was also considered to be an outlier because El Niño in that year reduced the availability of the resource and thus effort and catch also. A post-El Niño recruitment pulse that significantly increased the availability of the resource and thus effort and catch in that year, on the other hand, affected the fishing season of 2000. As a result of the ITQ scheme implemented in the sea cucumber fishery in 2001 more than normal effort levels were devoted to the spiny lobster fishery to compensate for losses in the former. For this reason 2001 is also considered to be an outlier. Finally 2004 is also regarded as an outlier because the clash with the sea cucumber season in that year resulted in lower than normal effort levels. Furthermore, as shown in Figure A2.1, Appendix 2, the relationship between vessel-days and diver-days has been relatively constant throughout the Fisheries Monitoring Programme therefore the form in which effort was expressed made no significant difference to the results of the analysis. In view of that, the parameter estimates are as follows:

$$a = 0.00868383$$
$$b = -8.123 \times 10^{-7}$$
$$K_t = 0.00868383 f_t - 8.123 \times 10^{-7} f_t^2$$

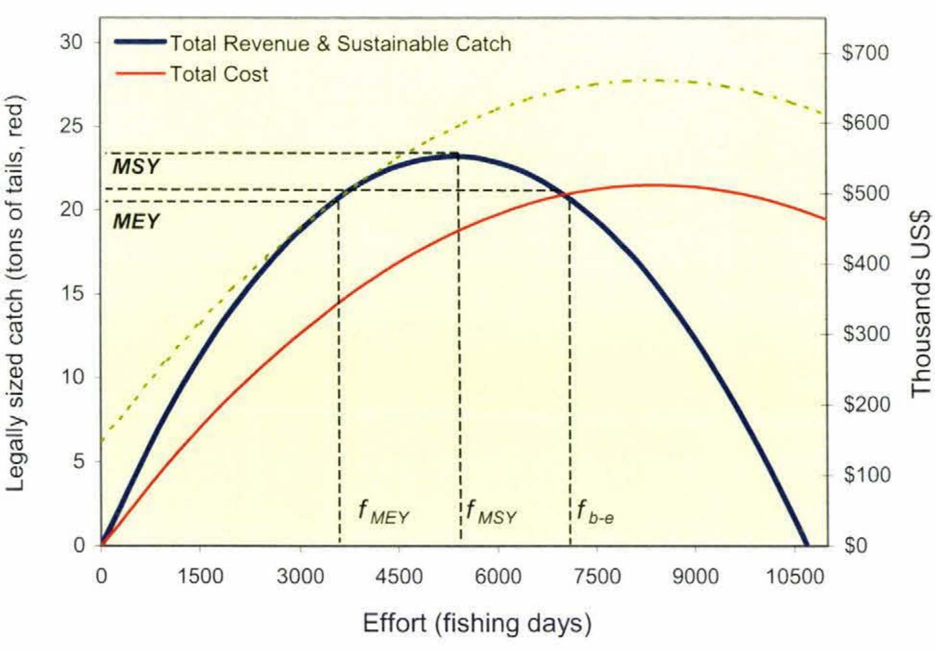
The indicators of goodness of fit suggest that this is an acceptable model. The effort and legally sized catches of all the fishing seasons in the data set, and the estimated sustainable catch function are illustrated in Figure 5.1.

Figure 5.1 – Estimated Sustainable Catch, Effort and Legally sized Catch 1997-2005, Galápagos Spiny Lobster Fishery



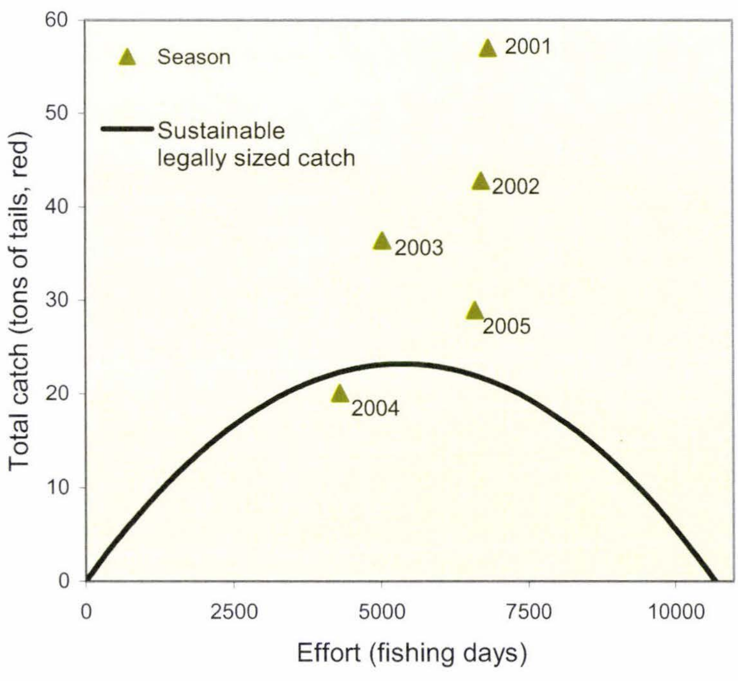
Using the above results, the MSY and MEY of the fishery are estimated to be 23,210 and 20,478 kilograms of legally sized red lobster tails respectively, as illustrated in Figure 5.2. The revenues and costs associated with Figure 5.2 are detailed in Table A2.1, Appendix 2. The total cost curve is not a straight line unlike in Figure 2.2, because labour costs in this fishery, as described in chapter 4, are a percentage of total revenue. The effort associated with these catch levels is 5,345 (f_{MSY}) and 3,512 (f_{MEY}) vessel-days respectively. The fishery's bio-economic equilibrium, where total revenue is equal to total cost, is estimated to occur when fishing effort reaches 7,023 vessel-days (f_{b-e}). It is clear from Figure 5.2 that at this level the sustainable catch attained is almost exactly that attained when the fishery operates at its MEY. Also evident from the graph is that rent, the difference between total revenue and total cost, is maximised at the MEY. This is the optimal catch and effort level. For the following part of the analysis, the TAC was therefore set at 23,210 kilograms (MSY) for Scenario *B* and at 20,478 kilograms (MEY) in Scenario *C*. The TAC corresponds to kilograms of legally sized red lobster tail to be harvested in accordance with ITQ allocations and complementary regulations in one fishing season.

Figure 5.2 – Maximum Sustainable Yield and Maximum Economic Yield Estimations, Galápagos Spiny Lobster Fishery



In Figure 5.3 the effort and total catch of red lobster for fishing seasons 2001 to 2005 are illustrated, together with the estimated sustainable catch function. The difference with Figure 5.1 is that in this case the total catch is illustrated here while in the former only the legally sized catch was considered. Only the legally sized catch was used in the MSY and MEY estimations. It is clear from Figure 5.3 that the catch has consistently been beyond sustainable levels, except for 2004. Fishing seasons 2001 and 2004 however, are considered abnormal due to the circumstances described above. Regardless of this, the sustainable catch function estimation confirms that the resource has been exploited unsustainably for various years. In 2005, actual catch of red lobster was 31.8% in excess of the estimated sustainable amount for that effort level. This is consistent with Stone et al.'s (2006) estimations, which included data up to 2003. Bearing in mind that a significant amount of the total catch has been under the legal size, the sustainability of the fishery would be threatened in terms of excessive catch levels and growth potential. Likewise, the fishing effort devoted in 2005 was more than 80% in excess of the economically optimal level. This also shows that the current operating level of the fishery is not only unsustainable but also highly inefficient.

Figure 5.3 – Estimated Sustainable Catch, Effort and Total Catch 2001-2005, Galápagos Spiny Lobster Fishery



5.3 Economic Benefits from an ITQ Scheme

The profit generated in the lobster fishery, associated with red lobster catch, for the 2005 season was estimated to be $137,995. This would have represented 20% of the total revenue of the fishery, associated with red lobster.

The outcomes from the analysis of the economic benefit likely to result from each different management Scenario are summarised in Tables 5.1 to 5.3 below. As expected, the largest benefit results from Scenario *C*, the ITQ scheme where TAC is set at the MEY. The present value of quota rent generated under such a scheme is estimated to be $479,272. The present value of the economic rent generated under Scenario *C* is $397,083 higher than the present value of economic rent generated under Scenario *A* and $130,711 higher than that generated under Scenario *B*. The net benefit per kilogram of tail, reported in Tables 5.1 - 5.3, is expected to be the yearly lease value of a unit of quota, in the case of an ITQ scheme. This value capitalised for the 5-year allocation period is equal to the equilibrium quota price.

Table 5.1 – Expected Economic Benefits: Scenario A, Current Management Model

Year	Total Revenue	Total Cost	Net Benefit/kg	Rent	Present Value
2007	$ 537,594	$ 511,000	$ 1.23	$ 26,594	$ 22,161.60
2008	$ 548,346	$ 521,220	$ 1.25	$ 27,126	$ 18,837.36
2009	$ 559,313	$ 531,645	$ 1.27	$ 27,668	$ 16,011.76
2010	$ 570,499	$ 542,278	$ 1.30	$ 28,222	$ 13,609.99
2011	$ 581,909	$ 553,123	$ 1.33	$ 28,786	$ 11,568.50
					$ 82,189.22

Table 5.2 – Expected Economic Benefits: Scenario B, ITQ Scheme with TAC set at MSY

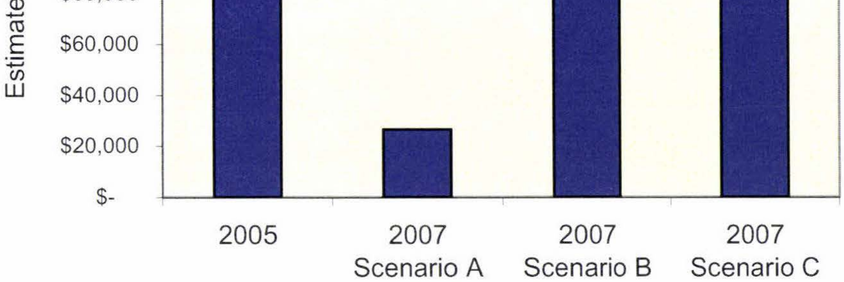
Year	Total Revenue	Total Cost	Net Benefit/kg	Quota Rent	Present Value
2007	$ 574,946	$462,162	$ 4.86	$ 112,784	$ 93,986.42
2008	$ 586,445	$471,406	$ 4.96	$ 115,039	$ 79,888.45
2009	$ 598,174	$480,834	$ 5.06	$ 117,340	$ 67,905.18
2010	$ 610,137	$490,450	$ 5.16	$ 119,687	$ 57,719.41
2011	$ 622,340	$500,259	$ 5.26	$ 122,081	$ 49,061.50
					$348,560.96

Table 5.3 – Expected Economic Benefits: Scenario C, ITQ Scheme with TAC set at MEY

Year	Total Revenue	Total Cost	Net Benefit/kg	Quota Rent	Present Value
2007	$ 507,289	$352,211	$ 7.57	$155,078	$129,231.51
2008	$ 517,435	$359,256	$ 7.72	$158,179	$109,846.78
2009	$ 527,784	$366,441	$ 7.88	$161,343	$ 93,369.76
2010	$ 538,339	$373,770	$ 8.04	$164,570	$ 79,364.30
2011	$ 549,106	$381,245	$ 8.20	$167,861	$ 67,459.65
					$479,272.00

The only management scenario where the yearly sustainable resource rent of the fishery is larger than the estimated net income for 2005 is Scenario *C*. In terms of yearly net income derived from sustainable catch, Scenarios *A* and *B* would result in lower values than the estimated net income of the 2005 season. A comparison of these values is illustrated in Figure 5.4.

Figure 5.4 – Estimated Net Income of the Galápagos Spiny Lobster Fishery, 2005 vs. 2007 under different Management Scenarios (Red Lobster only)



The assumptions made for this analysis are rather restrictive. As described in chapter 4, the discount rate used is 20% to reflect the very low sense of security in the ownership of resources in the GMR, as described by Stone et al. (2006). If an ITQ scheme is successful this rate is expected to decrease substantially as a result of increased security in the ownership of the resources. This would boost the present value of the fishery under ITQ management; a lower discount rate would decrease the discounting factor, increasing the present value. Furthermore, a 5-year quota allocation is too short for an ITQ scheme to realise its potential benefits. Ideally, property rights should be allocated in perpetuity or at least for a period long enough for fishers to change their behaviour with regards to the exploitation of the resource, as has been the case in New Zealand for instance. Management plans in Galápagos however have traditionally had a very short time span, as Ramirez Gallegos (2004) pointed out. Likewise the fishing calendar for the GMR was originally planned for 5-year periods, creating speculation and uncertainty about the future. For this reason it is unlikely that fishers will believe in any plan that is intended to last more than 5-years. Like with the discount rate, if the allocation period is extended, the economic benefit generated would increase accordingly but the circumstances in Galápagos may not allow for that initially. A progressive change in that direction is desirable instead.

If the assumptions were relaxed, the economic benefits of the management scheme would increase significantly. Likewise, if they become more restrictive, the economic benefits would decrease accordingly. The outcomes of the sensitivity analyses for discount rate, output prices, domestic cost inflation and the period of quota allocation are summarised in Tables 5.4 to 5.7. As expected an increase in the discount rate and in domestic inflation affecting production costs decrease the economic benefits of the scheme. Increases in output prices and quota allocation periods increase the economic benefits under each scenario. The inferior performance of Scenario *A* is also clear from its reliance on low inflation and increasing output prices for positive rent.

If domestic cost inflation is greater than the assumed increase in output prices the MEY will also change and thus the TAC for Scenario *C*. For the sensitivity analysis outlined in Tables 5.5 and 5.6 however, the TAC was held constant to observe the impact on the scheme as it was originally. Likewise, if there are adverse changes on output prices and inflation, the effort devoted under Scenarios *A* and *B* will be adjusted by fishers to minimise loses. These changes are not captured in the sensitivity analysis to observe the impact of these changes on the original schemes.

Table 5.4 – Sensitivity Analysis: Discount Rate

Discount Rate	Present Value Scenario *A*	Scenario *B*	Scenario *C*
10%	$ 104,532	$ 443,314	$ 609,558
15%	$ 92,276	$ 391,339	$ 538,092
20%	$ 82,189	$ 348,561	$ 479,272
25%	$ 73,794	$ 312,958	$ 430,317
30%	$ 66,735	$ 283,022	$ 389,156

Table 5.5 – Sensitivity Analysis: Domestic Cost Inflation

Inflation	Present Value Scenario *A*	Scenario *B*	Scenario *C*
1%	$ 116,138	$ 375,614	$ 497,045
2%	$ 82,189	$ 348,561	$ 479,272
3%	$ 47,157	$ 320,644	$ 460,932
4%	$ 11,011	$ 291,840	$ 442,009
5%	-$ 26,279	$ 262,125	$ 422,487
6%	-$ 64,744	$ 231,472	$ 402,350
7%	-$ 104,416	$ 199,858	$ 381,581
8%	-$ 145,329	$ 167,256	$ 360,162
9%	-$ 187,514	$ 133,639	$ 338,077
10%	-$ 231,008	$ 98,980	$ 315,307

Table 5.6 – Sensitivity Analysis: Output Price

Change in Price	Present Value Scenario *A*	Scenario *B*	Scenario *C*
-6%	-$ 182,391	$ 65,598	$ 229,607
-4%	-$ 122,455	$ 129,698	$ 286,163
-2%	-$ 58,535	$ 198,059	$ 346,480
0%	$ 9,600	$ 270,928	$ 410,774
2%	$ 82,189	$ 348,561	$ 479,272
4%	$ 159,486	$ 431,228	$ 552,211
6%	$ 241,752	$ 519,210	$ 629,840

Table 5.7 – Sensitivity Analysis: Quota Allocation Period

Quota Allocation	Present Value Scenario *B*	Scenario *C*
1 year	$ 92,144	$ 126,698
5 years	$ 330,679	$ 454,684
10 years	$ 463,571	$ 637,411
15 years	$ 516,978	$ 710,845
20 years	$ 538,440	$ 740,357
Perpetual	$ 552,861	$ 760,185

The sensitivity analysis for quota allocation periods summarised in Table 5.7 is for the present value based on the net benefit of a kilogram of lobster at the start of the first year of the scheme. The present values reported in Tables 5.1 – 5.6 allow the value of the net benefit to increase over the years together with the profitability of the fishery. It is not appropriate to assume that inflation and prices will continue changing as they have been over the last decade in the long run so the present value estimations for different quota allocation periods are based on the values of the net benefits from the first year of the scheme instead.

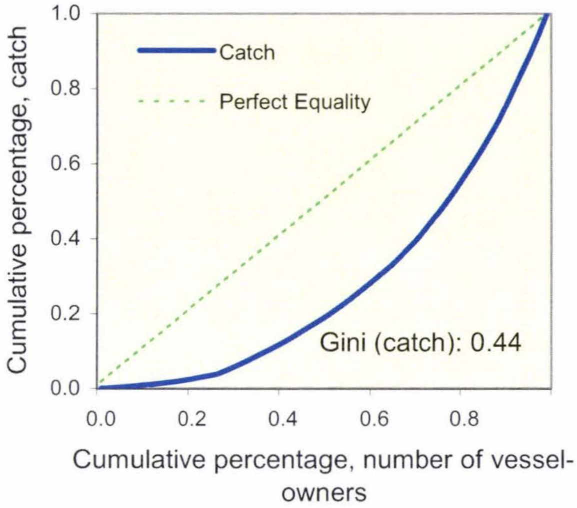
5.4 Equity Implications from an ITQ Scheme

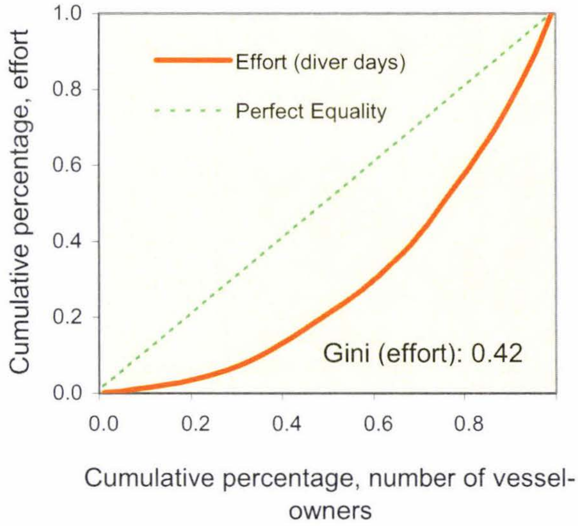
5.4.1 Lorenz Curves and Gini Coefficients

The Gini coefficient for catch is estimated to be 0.44 and the Gini coefficient for fishing effort devoted 0.42. From the analysis for vessel-owners based in Puerto Baquerizo Moreno, it can be concluded that catch and effort are highly concentrated. The respective Lorenz curves are illustrated in Figure 5.5.

A highly concentrated industry, in terms of the distribution of effort and catch, has particular implications for a prospective ITQ scheme. First, this suggests that those fishers who devoted the least effort, and therefore harvested the minority of the overall catch, would be relatively less efficient than those who captured the majority of the total catch. It would seem that a significant amount of these relatively inefficient fishers are part-timers or have complementary incomes. If that is the case the equity impacts of the quota scheme will not be as high as expected as these would fall on part-time vessel-owners or fishers that have other sources of income. These vessel-owners will not be left without a livelihood as a result of the ITQ scheme. Second, quota concentration in favour of the full-time fishers is likely to reduce the heterogeneity currently prevalent in the fishery. This would have positive effects with regards to the strength of fishing cooperatives and perhaps the development of self-governance organisations. Moreover, reduced heterogeneity may enhance the legitimacy of the participatory management model and thus voluntary compliance with the established regulations. These implications however, contrast with what the implicit quota prices suggest.

Figure 5.5 – Lorenz curves & Gini coefficients, Catch and Effort Distribution: 2005 Spiny Lobster Fishery, vessel-owners based in Puerto Baquerizo Moreno



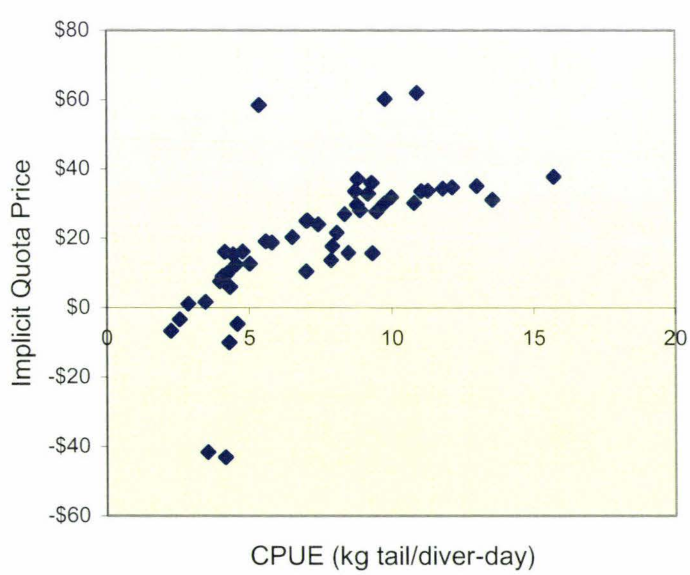


5.4.2 Implicit Quota Prices

The equilibrium price for a unit of quota, the right to harvest a kilogram of lobster tail over 5 years in this case, estimated from the sample of vessels from Puerto Baquerizo Moreno, is $21.50. Twenty-one out of the fifty-two vessel-owners included in the sample had positive implicit quota prices lower than the estimated equilibrium quota price[17]. In other words, up to 40% of the vessel-owners are expected to sell all or part of their quota allocation if an ITQ scheme is introduced. Table A3.1, Appendix 3, details the estimated implicit quota prices per vessel-owner.

In general, only those vessel-owners with low CPUE (diver-days) values had low implicit quota prices, as illustrated in Figure 5.6. The weak relationships illustrated in Figure A3.1 in Appendix 3 show that catch, effort and CPUE (vessel-days) have little influence on the implicit quota price. This contrasts with what was inferred from the Lorenz curves and Gini coefficients reported earlier, that a significant amount of part-timers could have been the potential losers of an ITQ scheme. Relatively low CPUE values for particular vessel-owners can be an indication of limited experience or skill. In this case, those fishers with limited experience or skill would be the potential losers of an ITQ scheme.

Figure 5.6 – Expected Implicit Quota Prices and CPUE (diver-days), vessel-owners based in Puerto Baquerizo Moreno



Based on 2005 monitoring data, it is estimated that up to 40% of the financially viable vessel-owners in Puerto Baquerizo Moreno would be selling part or all of their quota allocation. Even though this seems to be a major equity

[17] Originally there were 57 vessels in the sample however three of these are owned by the same person and are therefore treated as a single vessel. Three others were considered to be outliers due to extreme CPUE values and were removed from the sample (see Table A1.4, Appendix 1).

implication, it is important to bear in mind that catch was more than 30% in excess of sustainable levels for the effort level devoted in 2005 and more than 40% in excess of the economically optimal catch, as discussed in section 5.2. The equity implications of an ITQ scheme are therefore consistent with the amount of catch that needs to be reduced in order to make the fishery sustainable and efficient. The advantage of an ITQ scheme in this case is that those fishers who would be selling quota would receive compensation in the form revenue from quota sales to the relatively more efficient fishers. This will allow an orderly retirement of excessive effort and capital from the fishery, which as described earlier, is urgently needed at present, although it may have other longer-term impacts.

5.5 Discussion and Concluding Remarks

The estimations of MSY and MEY should be considered with caution. The amount of information available is large in comparison to other fisheries in the archipelago, although the Fisheries Monitoring Programme for lobster has only been operating since 1997. Furthermore, many of the monitored seasons have been affected by exogenous climatic events or socio-economic circumstances arising from the management of other fisheries. As a result, the dataset is rather limited. In addition, there is some uncertainty regarding the growth of the species and therefore sustainable catch estimates can only be based on the observed relationship between effort and catch. Regardless of this, new estimates of MSY and MEY should be re-drawn regularly as new scientific information from fisheries monitoring and biological research of the species becomes available. That in fact must become a yearly practice in any sustainable ITQ scheme.

The analysis of the sustainable catch function and the estimation of economic benefits derived from a hypothetical ITQ scheme are done at a general level. In other words, the MSY and MEY estimations and the economic benefits are calculated for the archipelago as a whole. In practice there would be differences between regions; different areas would have different TACs and different profitability. The information available for this research was not detailed enough to specify outcomes for individual areas or for individual vessel-owners. In practice regulations for specific areas will need to be outlined to avoid causing localised depletions or an undesirable reallocation of effort.

It is equally important to bear in mind that the economic benefits presented in this chapter are derived exclusively from sustainable legally sized red lobster catch. A considerable amount of the rent generated in the past has been from undersized catch or catch that is beyond the sustainable threshold. As described earlier, this excessive unsustainable catch is not a benefit in economic terms as it threatens the ecological integrity of the resource, and thus the financial viability of the fishery in the long run. It is also important to bear in mind that the benefit derived from 'unintended' green lobster catch will be additional to this. Additional rent from illegally and unsustainably harvested catch is however a financial gain for fishers who, as demonstrated by their high discount rates, have a limited regard for the future. This would make fishers doubtful about the potential benefits of an ITQ scheme; many may see it as a threat to their economic interests instead. In this context the challenge continues to be informing fishers of the current situation and of the consequences of overfishing if catch rates continue at unsustainable levels.

The estimation of the economic benefits ignores the possibility of fishers adjusting their production and 'becoming' more efficient as a result of the new regulations that would be introduced with an ITQ scheme. In reality fishers can adjust their production, as demonstrated with linear programming studies by Lanfersieck & Squires (1992), Dupont (2000) or Salgado & Aliaga (2002), to improve efficiency and profitability, minimising the losses they may face as a result of an ITQ scheme. For instance, if the fishing season is extended after the introduction of the ITQ scheme, fishers can choose to spread their effort more efficiently, fishing only when the sea conditions are favourable for instance and thus reducing costs. In this case however, the data used to calculate the economic benefits is not disaggregated to individual vessel-owners so their individual behaviour cannot be observed or analysed. Taking this into account, the economic benefit estimations presented above may in fact underestimate the real economic benefits that will arise if such re-structuring takes place as a response to an ITQ scheme. There are of course various sources of uncertainty that have not been accounted for such as substitutability between species (Anderson, 1989), weather, ecological and demographic patterns, and changes in equipment, knowledge or expertise. All these factors will affect the effectiveness of the regulatory instruments and these cannot be accurately forecasted with the available information.

With regards to the estimation of an equilibrium quota price, it is assumed that a perfectly competitive quota market will develop. However, in reality a single long-run equilibrium ITQ price does not immediately form. Instead, equilibrium ITQ prices form over short-run periods as individual fishers exchange quota. Different ITQ prices in different periods take place subject to how fast the industry re-structures. As Weninger & Just (1997) pointed out, when there is price uncertainty, inefficient fishers may increase their payoff by adopting a delayed-exit strategy. Moreover, the equilibrium quota price is likely to differ from fisher to fisher due to different transaction costs, access to information, or perceptions of risk and uncertainty. In practice, fishers "may make their quota value calculations on the back of an envelope, supported by rumour and guesswork" (Copes, 1989, p. 244), producing values that reflect interests other than profit. Regardless of these, calculations of economic benefits are not enough to predict the behaviour of fishers under an ITQ scheme (Orebech, 2005). Reality is therefore more complex than what is assumed in this study.

There is some ambiguity regarding the potential 'losers' of a hypothetical ITQ scheme for the GMR spiny lobster fishery. The Lorenz curves and Gini coefficients suggest the presence of a large amount of part-time fishers. A logical assumption was that these would be relatively less efficient than full-time fishers. This assumption however does not seem to hold as there is no evident relationship between effort or catch and implicit quota prices, as demonstrated in Figure A4.1. There is however a strong relationship between implicit quota prices and CPUE (diver-days) which indicates that those fishers with limited skill, experience or 'luck' even, are relatively less efficient and therefore could be potentially leaving the industry if an ITQ scheme is applied. Skill and experience (and 'luck') are hard to identify and therefore potential losers will be hard to identify also. For this reason the information available is not enough to recognise ex-ante whom the potential losers will be. More information from other ports and for other seasons would certainly be useful in clarifying this matter.

In spite of this, the results presented above are valid estimations of the sustainable catch of the fishery and the economic benefits and equity implications that are expected to result from the introduction of an ITQ scheme in the context of the GMR spiny lobster fishery. These results are what can be derived with the available data and are, as mentioned above, subject to some reservations. As has been noted, a similar analysis with more detailed, more extensive and more recent data will certainly reduce some of these reservations. In the final chapter the findings of the study are summarised and relevant conclusions and policy implications are outlined.

CHAPTER 6 ~ SUMMARY AND CONCLUSIONS

"Finally, an efficient long-term management of the fisheries in Galápagos requires fishermen to have secure property rights over the resources. In that sense, the development of a system of transferable individual quotas could contribute to achieve an efficient fishery management. If such a system is established, the fishing effort of each individual could be spread out more evenly in time, reducing the volatility of fisher income and alleviating the insecurity inherent in the race to attain the global quota".

~ Stone et al. (2006, p. 25)

The major fisheries of the GMR seem to be operating under 'regulated' open access conditions. Under such conditions, where there are no clearly defined property rights or adequate regulation, a fishery heads toward the bio-economic equilibrium. At this point resource rents are dissipated and any profitability, in theory, would be based on unsustainable catches. Fisheries in Galápagos are subject to regulations which have failed to limit entry, catch and effort to sustainable levels, demonstrating the prevalence of open access. These regulations have failed despite being developed through a participatory management model. Decreasing catch, CPUE and incomes in the sea cucumber and lobster fisheries result from a very limited planning horizon in Galápagos, a typical characteristic of open access fisheries. With this in mind, the purpose of this study, as established in chapter 1, is to determine the feasibility of an ITQ scheme in this context and to estimate the economic benefits likely to result from one, as well as assessing its equity implications.

From the literature reviewed in chapters 2, it was concluded that an ITQ scheme could be considered as an alternative to the current management instruments applied in Galápagos for the following reasons: first, command-and-control regulation has proven to be inefficient and ineffective in the context of Galápagos' major fisheries; second, the characteristics necessary to develop a CBFM framework are not present in Galápagos, mainly due to high heterogeneity and institutional weaknesses within fishing cooperatives; and third, although it is helpful and very necessary, the extensive network of marine protected areas in Galápagos is not sufficient to achieve a sustainable and efficient fishing sector; fisheries need to be explicitly and effectively managed outside of the NTZs also. Taking these into account and considering the inherent short-term perspective of fishers in Galápagos, the allocation of property rights through ITQs could rationalise the use of fisheries in the archipelago.

An ITQ scheme however would only be suitable in the context of the spiny lobster fishery, and not in that of the sea cucumber fishery, as concluded in chapter 3. Given the dismal state of the sea cucumber fishery, the only viable management measure is a complete closure, as established in 2006. For any other management regime to be sustainable, the catch of sea cucumber will have to be significantly restricted which could in fact trigger a 'race for fish', leading in turn to a total collapse of the resource. Besides, the high variability in sea cucumber prices would make planning under an ITQ scheme, both for fishers and authorities, highly complex. Moreover, the option to transport the product to the continent by boat could be a serious challenge to effective monitoring and enforcement if an ITQ scheme is applied. Quota busting and data fouling are more likely to occur in this fishery. The sea cucumber fishery therefore should remain closed until stocks recover. Even if stocks do recover, an ITQ scheme may not be the ideal regulatory framework for this fishery due its own characteristics.

The lobster fishery, on the other hand, is considered to be suitable for an ITQ scheme for the following: first, although the resource is over-exploited it is not critically endangered as sea cucumber is. This will allow the fishery to remain open, hopefully under more effective regulation in the near future. Second, the high-specificity of the fishing technique used will not lead to unintended impacts on the resource, other species or the broader ecosystem. Third, the relative smallness of the fishery allows for effective monitoring. In this context, the implementation of an ITQ scheme can be considered to be a viable management alternative.

Regardless of these, there are limitations to an ITQ scheme in this fishery also. Limited monitoring and enforcement, as has been the case in past fishing seasons, despite the capacity and feasibility to do them effectively, is a serious limitation. The security of the property right that an ITQ represents relies on effective monitoring and enforcement.

Another limitation could be the lack of essential support and acceptability from the fishing sector. This may arise because of weaknesses within fishing cooperatives and poor understanding of the implications of an ITQ scheme. The bad experience that the 2001 sea cucumber ITQ scheme was for many fishers has created negative perceptions and pre-judgements among the fishing community regarding this management instrument. Furthermore, the highly political character of fishing cooperatives is a weakness that could affect the development of a successful ITQ scheme too. Cooperative leaders have seen large numbers of fishers as the basis for their political strength. As described earlier, one of the objectives of an ITQ scheme is to reduce fishing effort to sustainable levels in an efficient manner, which in this case would mean a reduction in the number of fishers, cooperative members and thus perceived political power. Fishing leaders with political interests therefore may not see an ITQ scheme as a desirable alternative. If there is limited support from the fishing sector, it is unlikely to promote the scheme within the PMB. If an ITQ scheme is adopted without the support of fishers, its legitimacy will be affected; low compliance levels, quota busting and data fouling would be likely outcomes. These limitations can be addressed appropriately through an upgrade of the monitoring and enforcement components, by strengthening fishing cooperatives, and by enhancing stakeholders' participation in fisheries management.

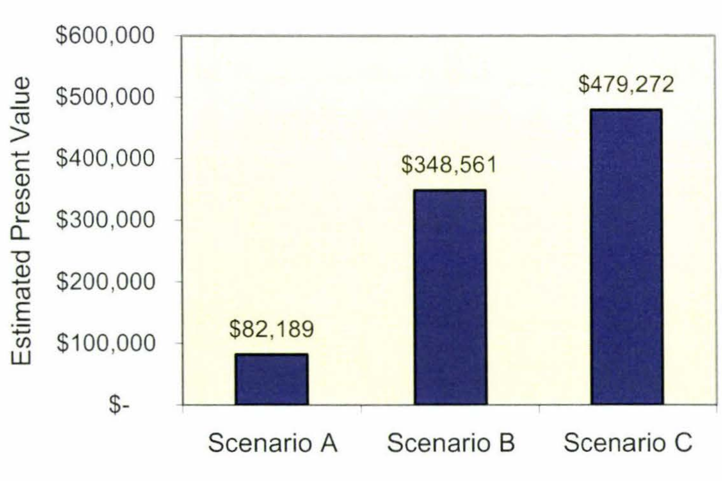
Having established in chapter 3 that an ITQ scheme would only be suitable for the spiny lobster fishery and having pointed out to potential limitations, the expected economic benefits from a hypothetical ITQ scheme for the latter were estimated, as described in chapter 4. Data from the Fisheries Monitoring Programme was used for this purpose. Additionally, the equity implications of the scheme are expected to be significant. These were assessed using data from a fisheries monitoring database for vessels based in Puerto Baquerizo Moreno. The methodology used to assess these impacts was also described in chapter 4.

The results of these analyses were reported in chapter 5. In this case the MEY, the optimal catch level at which the TAC should be set, was estimated to be 20,478 kilograms of legally sized red lobster tails. The MSY was estimated to be 23,210 kilograms of tails. The expected economic benefits, expressed as present values of resource rent, of each management scenario for a 5-year period are summarised in Table 6.1 and Figure 6.1. The present value of the resource rent, derived from sustainable catches of red spiny lobster, under a 5-year ITQ scheme is estimated to be $479,272. The difference between the value of the fishery under optimal ITQ management and the current management regime is $397,083.

Table 6.1- Economic Benefits per Management Scenario

Management Scenario	***Scenario A:*** Current management model ('without')	***Scenario B:*** ITQ scheme, TAC set at MSY	***Scenario C:*** ITQ scheme, TAC set at MEY
Catch (TAC) [legally sized red lobster tails]	21,702 kg	23,210 kg	20,478 kg
Effort (vessel-days)	6,708	5,345	3,512
Present Value of Resource Rent (5 years)	**$ 82,189.22**	**$ 348,560.96**	**$ 479,272.00**
Net benefit/kg of tail after 5 years	$ 1.33	$ 5.26	$ 8.20

Figure 6.1 – Economic Benefits per Management Scenario



These economic benefits are sensitive to changes in output prices, domestic cost inflation, the discount rate and the period of quota allocation. The results summarised above were calculated assuming that output prices and cost inflation continue to increase as has been observed over the last few years. It is also assumed that the discount rates of fishers continue to be high, at 20%, throughout the period of the analysis. Quota in the hypothetical ITQ scheme is allocated for 5-years. If these rather restrictive assumptions are relaxed, particularly the high discount rate and the short quota allocation period, the benefits of the scheme increase substantially.

Regardless of this, it is clear that the economic benefits of an ITQ scheme where TAC is set at the MEY, Scenario *C*, are much larger than those from the other management scenarios. Scenario *A*, the current management model, is inferior to the other two because in this case effort remains at excessive levels and sustainable catch decreases accordingly. As a result total costs remain high, sustainably derived revenue decreases, and so does the sustainable net benefit of the fishery. Scenario *B*, an ITQ scheme where the TAC is set at the MSY, is superior to Scenario *A* but inferior to Scenario *C*. In this case, effort decreases, and sustainable catch and revenue are maximised. Consequently, the sustainable net benefit of the fishery is greater than that from Scenario *A*. Scenario *C*, on the other hand, results in the highest sustainable net benefit as effort decreases to an optimal level, maximising resource rents. It is important to keep in mind that only the economic benefit derived from sustainable catch was considered in this analysis.

As reported in chapter 5 also, up to 40% of the vessel-owners who made positive profits in this sample had implicit quota prices lower than the $21.50 estimated equilibrium quota price and are therefore expected to sell part of, or their entire, quota allocation if an ITQ scheme is adopted. This seems to be a significant equity implication, although that impact is consistent with the reduction in catch needed to make the fishery operate at a sustainable level. With the available information it is difficult to identify whom exactly the potential losers of an ITQ scheme will be. More socio-economic information and research on the fishing operations is needed for this.

The latest 5-year fishing calendar expires at the end of 2006. It is therefore a great opportunity for the users of the GMR to evaluate the effectiveness of fisheries management since the SLG introduced the participatory management model in 1998 and to consider different management options for the future. In this context and given the outcomes from this analysis, the GNP and the various stakeholders that participate in fisheries management in Galápagos should seriously **consider the implementation of an ITQ scheme for the spiny lobster fishery**. An ITQ scheme in this context has the potential to bring **significant economic benefits** to the fishery and more importantly, to make it **sustainable**. These benefits will result from a more rational exploitation and a major reduction in effort. Additional benefits may also include changing the fishing sector's perspective on resource exploitation towards including longer-term, rather than immediate, objectives and enhancing their participation in fisheries management.

If the fishing sector is well informed about the potential benefits of an ITQ scheme, fishers will support its implementation and will behave accordingly. This will boost the economic benefits of the scheme and would be positive for the financial viability of the fishery and the sustainability of the resource. In order for fishers to be properly informed, meaningful grassroots participation in fisheries management and in the development and implementation of an eventual ITQ scheme is essential. Active participation would also be a way to circumvent the politicised leadership of the fishing sector and to develop fisher's ownership of the scheme and of their fishing rights under ITQ management. Developing effective and meaningful participation from the grassroots in natural resource management however is not an easy undertaking. Strengthening the role of fishing cooperatives in this way is necessary to improve fisheries management in the archipelago, regardless of the regulatory instrument. This would also make the participatory management process become more independent from the conservation sector, improving its legitimacy.

Allocation of quota on the basis of historical catch, as opposed to equal allocations, as in the 2001 scheme, would be another way to encourage the industry's support for the scheme. Alternative allocation methods would be seen as unfair as they may adversely distort the current distribution of rent among vessel-owners, although the overall gains in efficiency might be the same.

In the 2006 lobster season there has been a significant improvement of the monitoring system, at least in the planning stage. For the first time there are plans for 24-hour monitoring in port. If this actually occurs during the 2006 lobster season, the opportunity for illegal catch and quota busting, if an ITQ scheme is eventually adopted, would decrease greatly. Monitoring at other points of the production chain and the enforcement capacity of the control authorities also need to be boosted, regardless of the management instrument but particularly if an ITQ scheme is adopted. The security and value of the property rights depends on high compliance and effective enforcement.

For the fishery to become sustainable under an eventual ITQ scheme, management authorities will actually have to set a sustainable TAC and enforce it appropriately. In this study, an estimation of the MEY is recommended as the optimal catch towards which management should aim. The actual MEY level will require regular recalculations as new scientific information is obtained. Regardless of what the TAC is, it will certainly have to be in line with the self-regenerating capacity of the resource, at a level much lower than the current total catch. In the past it has been argued that relatively lax regulations, such as TAC being set beyond sustainable levels for the sea cucumber fishery, were applied to compensate for adverse socio-economic conditions. In this case, an ITQ system will permit setting regulations that are in line with sustainability because of the significant economic benefits that the scheme is expected to provide. Fishers who remain in the fishery under an ITQ scheme will benefit from increased efficiency, sustainability and profitability, and those who retire will benefit from quota sale revenues. In order for an ITQ scheme to change the current state of the fishery, catch needs to be limited to sustainable levels effectively; it is not enough to divide up the current unsustainable catch into ITQs.

Furthermore, if an ITQ scheme is adopted, particular social and environmental objectives will need to be explicitly addressed through complementary restrictions and policies. To minimise the equity implications of the scheme, constraints on quota concentration may be necessary. Likewise, support for the retiring fishers will be required also. This support may include a vessel-buyback programme as suggested by Conservation International. Training aimed at facilitating the transition of the retiring fishers into other sectors of the local economy, such as sustainable agriculture or eco-tourism, may also help to reduce the social impact of the scheme. Additionally, a programme to re-allocate retiring fishers on the continent may also be an option. If retiring fishers do not have a viable economic activity to invest the revenues from their quota sales in, the emergence of social problems is likely. That is usually the case when communities receive windfall economic gains, like revenues from vessel or quota sales for instance, and there are no alternative economic opportunities. Restrictions on quota holdings and governmental support for retiring fishers in their transition into other economic activities will be important to minimise the negative equity implications of the scheme. This can also increase the industry's support for a change in the management strategy and may be useful to reduce effort in other fisheries of the archipelago as well. If fishing cooperatives are strengthened and are better organised, more effective cooperation among their members may also help to mitigate some of the adverse equity implications of an ITQ scheme.

Regarding the possible adverse environmental impacts of an ITQ scheme, a prohibition to harvest gravid and juvenile lobsters (size restrictions), as in previous seasons, should still apply. This will ensure that recruitment and the reproductive potential of the fishery are not affected by the ITQ scheme. Ecosystem-based considerations that may arise as a result of new biological research on the species should inform the development of these regulations also. Many of these restrictions and policies are desirable regardless of the regulatory instrument but would be essential if an ITQ scheme is adopted.

Keeping in mind the potential benefits of property right allocations in fisheries management, if supported by the industry, a short-term ITQ scheme, like the 5-year scheme projected in this study, should be applied. This will allow the correction of initial mistakes in implementation before a long-term system is applied, although it may reinforce the perceived uncertainty about the future, which currently affects fisheries management in the GMR. An initial short-term scheme is necessary due to the inherent characteristics of the fishery described earlier. This scheme should be considered a transition with the objective of expanding it to a more permanent system in the future. This would encourage fishers to change their behaviour in the short run to allow for a more efficient scheme in the long run.

Rent-capture and cost-recovery mechanisms would eventually be desirable in the context of an ITQ scheme. These however should not be applied until the scheme is well established as they could erode the industry's support for the programme at first. The increasing participation of the industry in fisheries monitoring today is positive and could be considered a form of cost-recovery anyway.

Given the current data limitations it will be vital to collect more socio-economic information, disaggregated to individual vessel-owners, as part of the monitoring programme. Economic information by vessel-owner is essential for a more careful assessment and planning of prospective ITQ schemes. The scientific monitoring of the fisheries has been constantly improving, if that trend continues to include more detailed measures of the performance of the fishery, besides biological data, the analysis necessary to plan an ITQ program will become more robust.

As mentioned earlier, the fishing sector and management authorities have often justified excessive and unsustainable catch levels arguing that there are no alternative economic activities for fishers to engage in. However, if these unsustainable catch levels continue, there will simply be no economic activity for fishers to engage in at all because the fisheries will collapse. The closure of the sea cucumber fishery after only eight years since it legally re-opened, a result of the largely depleted state of the resource, is an example of what will happen with the other fisheries, including lobster, if the current exploitation of the resources is not rationalised. It is time for the fisheries' stakeholders to assume responsibility for their use of the archipelago's natural resources because not only their profits or political interests are at stake but also the stability of unique ecosystems of worldwide importance. The institutions that fund fisheries management in the GMR should pay particular attention to the quality and outcomes of this process. Prior to looking at new marketing opportunities or at the exploitation of other species, and besides encouraging the promotion of alternative economic activities, the use and management of fisheries in Galápagos needs to become sustainable. An ITQ scheme for the spiny lobster fishery could certainly be an avenue for users and managers of the GMR to take responsibility and to enhance fisheries management.

REFERENCES

Adelaja, A., McCay, B. J., & Menzo, J. (1998a). Market Share, Capacity Utilization, Resource Conservation, and Tradable Quotas. *Marine Resource Economics, 13*, 115-134.

Adelaja, A., Menzo, J., & McCay, B. J. (1998b). Market Power, Industrial Organization and Tradeable Quotas. *Review of Industrial Organization, 13*, 589-601.

Allison, G. W., Lubchenco, J., & Carr, M. H. (1998). Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications, 8*(1), S79-S92.

Altamirano, M., Toral-Granda, M. V., & Cruz, E. (2004). The application of the adaptive principle to the management and conservation of Isostichopus fuscus in the Galápagos Marine Reserve. In A. Lovatelli, C. Conand, S. Purcell, S. Uthicke, J.-F. Hamel & A. Mercier (Eds.), *Advances in sea cucumber aquaculture and management - Fisheries Technical Paper 463*. Rome: FAO.

Anand, S. (1983). *Inequality and Poverty in Malaysia: Measurement and Decomposition*. New York: Oxford University Press, The World Bank.

Andersen, P. (1989). Comments on Wesney's "Applied fishery management plans: ITQs and input controls". In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights-based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Anderson, L. G. (1989). Conceptual constructs for practical ITQ management policies. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Anderson, L. G. (1991). A Note on Market Power in ITQ Fisheries. *Journal of Environmental Economics and Management, 21*, 291-296.

Annala, J. H. (1996). New Zealand's ITQ system: have the first eight years been a success or a failure? *Reviews in Fish Biology and Fisheries, 6*(1), 43-62.

Arnason, R. (1990). Minimum information management in fisheries. *Canadian Journal of Economics, 23*(3), 630-653.

Arnason, R. (1996). On the ITQ fisheries management system in Iceland. *Reviews in Fish Biology and Fisheries, 6*(1), 63-90.

Arnason, R. (1998). Ecological Fisheries Management using Individual Transferable Share Quotas. *Ecological Applications, 8*(1 - Supplement), S151-S159.

Arnason, R. (2000). Property rights as a means of economic organization. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Aslin, H. J., Connor, R. D., & Fisher, M. (2001). Sharing in the catch or cashing in the share? Social impacts of individual transferable quotas and the South East Fishery. Canberra: Bureau of Rural Sciences.

Autoridad Interinstitucional de Manejo de la Reserva Marina de Galápagos. (31 May 2005). Resolución No. 001-2005. Puerto Baquerizo Moreno.

Avendaño, U., Llerena, S., & Gravez, V. (2006). *Evaluación poblacional del pepino de mar isostichopus fuscus en la Reserva Marina de Galápagos*. Puerto Ayora: UCOOPEPGAL.

Batstone, C. J., & Sharp, B. M. H. (1999). New Zealand's quota management system: the first ten years. *Marine Policy, 23*(2), 177-190.

Batstone, C. J., & Sharp, B. M. H. (2003). Minimum information management systems and ITQ fisheries management. *Journal of Environmental Economics and Management, 45*, 492-504.

Bernal, P. A., Oliva, D., Aliaga, B., & Morales, C. (1999). New regulations in Chilean fisheries and aquaculture: ITQ's and Territorial Users Rights. *Ocean and Coastal Management, 42*, 119-142.

Bess, R. (2005). Expanding New Zealand's quota management system. *Marine Policy, 29*, 339-347.

Brenmer, J., & Perez, J. (2002). A case study of human migration and the sea cucumber crisis in the Galápagos Islands. *Ambio, 31*(4), 306-310.

Burton, P. S. (2003). Community enforcement of fisheries effort restrictions. *Journal of Environmental Economics and Management, 45*, 474-491.

Bustamante, R. H., Reck, G. K., Ruttenberg, B. I., & Polovina, J. (2000). The Galápagos Spiny Lobster Fishery. In B. F. Phillips & J. Kittaka (Eds.), *Spiny Lobsters: Fisheries and Culture*. Oxford: Fishing New Books, Blackwell Science.

Camhi, M. (1995). Industrial Fisheries Threaten Ecological Integrity of the Galapagos Islands. *Conservation Biology, 9*(4), 715-719.

Chavez, C., & Salgado, H. (2005). Individual Transferable Quota Markets under Illegal Fishing. *Environmental and Resource Economics, 31*(3), 303-324.

Christy, F. T. (1973). *Fisherman quotas: a tentative suggestion for domestic management*. Kingston, Rhode Island: Law of the Sea Institute, University of Rhode Island.

Christy, F. T. (1997). Economic waste in fisheries: impediments to change and conditions for improvement. In E. Pikitch, D. D. Huppert, M. P. Sissenwine & M. Duke (Eds.), *Global Trends: Fisheries Management*. Bethesda, Maryland: American Fisheries Society Symposium 20.

Clark, C. W. (1976). *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*. New York: John Wiley & Sons.

Clark, I. N., Major, P. J., & Mollett, N. (1989). The development and implementation of New Zealand's ITQ management system. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Conrad, J. M. (1999). *Resource Economics*. Cambridge: Cambridge University Press.

Copes, P. (1986). A critical review of the Individual Quota as a device in fisheries management. *Land Economics, 62*(3), 278-291.

Copes, P. (1989). Comments on Ragnar Arnason's "Minimum information management with the help of catch quotas". In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Copes, P., & Charles, A. (2004). Socioeconomics of individual transferable quotas and community-based fishery management. *Agricultural and Resource Economics Review, 33*(2), 171-181.

Copes, P., & Pálsson, G. (2000). *Challenging ITQs: Legal and Political Action in Iceland, Canada and Latin America - A Preliminary Overview*. Paper presented at the International Institute of Fisheries Economics and Trade 2000 - Conference Proceedings, Corvallis, Oregon.

Daníelsson, Á. (2005). Methods for Environmental and Economic Accounting of Wild Fish Stocks and Their Applications to the Case of Icelandic Fisheries. *Environmental and Resource Economics, 31*, 405-430.

Darwin, C. R. (1845). *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the Command of Capt. Fitz Roy, R. N.* (2nd ed.). London: John Murray.

Davis, A. (1996). Barbed wire and bandwagons: a comment on ITQ fisheries management. *Reviews in Fish Biology and Fisheries, 6*(1), 97-107.

de Miras, C., Andrade, M., & Carranza, C. (1996). *Evaluación socioeconómica de la pesca experimental de pepino de mar en Galápagos*. Quito: Fundación Charles Darwin, ORSTOM.

Defeo, O., & Castilla, J. C. (2005). More than one bag for the world fishery crisis and keys for co-management successes in selected artisanal Latin American shellfisheries. *Reviews in Fish Biology and Fisheries, 15*, 265-283.

Department for International Development. (2003). *Management instruments and rent collection*. Retrieved 10 October, 2005, from www.keysheets.org/fisheries_4.html

Dupont, D. P. (2000). Individual Transferable Vessel quotas and efficient re-structuring of the primary sector. *Annals of Operations Research, 94*, 275-294.

Edgar, G., J., Bustamante, R. H., Fariña, J. M., Calvopiña, M., Martinez, C., & Toral-Granda, M. V. (2004). Bias in evaluating the effects of marine protected areas: the importance of baseline data for the Galápagos Marine Reserve. *Environmental Conservation, 31*(3), 212-218.

Eggert, H. (1998). Bioeconomic Analysis and Management. *Environmental and Resource Economics, 11*(3-4), 399-411.

Field, B. C. (2001). *Natural Resource Economics: An Introduction*. New York: McGraw Hill.

Froese, R. (2004). Keep it simple: three indicators to deal with overfishing. *Fish and Fisheries, 5*, 86-91.

Fujita, R. M. (1999). *Building conservation into individual transferable quota programmes*. Retrieved 11 March, 2006, from www.environmentaldefense.org/documents/534_oceans_building%20conservation.htm

Fundación Natura, & The Nature Conservancy. (2000). *Parque Nacional Galápagos: Dinámicas migratorias y sus efectos en el uso de los recursos naturales*. Quito.

FUNDAR Galápagos. (2006). *Foro sobre derechos de propiedad y pesquerías*. Retrieved 11 September, 2006, from http://www.fundargalapagos.org/portalj/index.php?option=com_content&task=view&id=24&Itemid=55

Galindo, J., & Suarez, P. (2006). *Identificación de Necesidades de Financiamiento de la Reserva Marina de Galápagos*. Quito: The Nature Conservancy & Parque Nacional Galápagos.

Garza Gil, M. D. (1998). ITQ Systems in Multifleet Fisheries. *Environmental and Resource Economics, 11*, 79-92.

Grafton, R. Q. (1996a). Experiences with individual transferable quotas: an overview. *Canadian Journal of Economics, 29*, S135-138.

Grafton, R. Q. (1996b). Individual transferable quotas: theory and practice. *Reviews in Fish Biology and Fisheries, 6*(1), 5-20.

Grafton, R. Q., Kirkley, J., Squires, D., & Weninger, Q. R. (2000a). *A guide to the economic evaluation of individual transferable quota fisheries*. Retrieved 19 March, 2006, from http://www.st.nmfs.gov/st5/documents/A_guide_to_the_economic_evaluation_of_Individual_Transferable_Quota_fisheries.pdf

Grafton, R. Q., Kompas, T., & Scheider, V. (2004). The bioeconomics of marine reserves: a selected review with policy implications. Dunedin: University of Otago Economics Discussion Papers No. 0405.

Grafton, R. Q., Squires, D., & Fox, K. J. (2000b). Private Property and Economic Efficiency: A Study of a Common-Pool Resource. *Journal of Law and Economics, 43*(2), 679-713.

Gravez, V., & Gelin, A. (2003). *La peche artisanale aux Galápagos*. Retrieved 4 September, 2006, from http://www.aquaticecology.org/article.php3?id_article=35

Guyader, O. (2002). Simulating the effect of regulatory systems in a fishery: An application to the French driftnet albacore fleet. *Environmental and Resource Economics, 23*(1), 1-28.

Gwazani, R. (2000). The creation of property rights along Lake Kariba through the formation of fishermen's associations. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Hannesson, R. (1996). On ITQs: an essay for the Special Issue of Reviews in Fish Biology and Fisheries. *Reviews in Fish Biology and Fisheries, 6*(1), 91-96.

Hannesson, R. (2005). Rights-based fishing: use rights vs. property rights to fish. *Reviews in Fish Biology and Fisheries, 15*, 231-241.

Hardin, G. (1968). The Tragedy of the Commons. *Science, 162*, 1243-1248.

Harte, M. (2000). Fisher participation in rights-based fisheries management: the New Zealand experience. In R. Shotton (Ed.), *Use of property rights in fisheries management*. Rome: FAO.

Hearn, A. (2004). *Evaluación de las poblaciones de langostas en la Reserva Marina de Galápagos: Informe Final 2002-2004*. Puerto Ayora: Fundación Charles Darwin.

Hearn, A. (2006). *Evaluación poblacional de la langosta roja en la Reserva Marina de Galápagos, después de la temporada de pesca 2005*. Santa Cruz: Fundación Charles Darwin.

Hearn, A., Castrejón, M., Reyes, H., Nicolaides, F., Moreno, J., & Toral-Granda, M. V. (2005a). *Evaluación de la pesquería de langosta espinosa (Panulirus penicillatus y P. gracilis) en la Reserva Marina de Galápagos 2004*. Puerto Ayora: Fundación Charles Darwin.

Hearn, A., Martinez, P., Toral-Granda, M. V., Murillo, J. C., & Polovina, J. (2005b). Population dynamics of the exploited sea cucumber *Isostichopus fuscus* in the western Galápagos Islands, Ecuador. *Fisheries Oceanography, 14*(5), 377-385.

Hearn, A., Murillo, J. C., & Reyes, H. (2006). *Evaluación de la pesquería de langosta espinosa (Panulirus penicillatus y P. gracilis) en la Reserva Marina de Galápagos 2005*. Puerto Ayora: Fundación Charles Darwin.

Henderson, S., Zurita, P., & Hardner, J. (2004). Alternativas económicas en Galápagos: Resultados de Encuestas: Conservation International.

Hilborn, R., Parrish, J. K., & Little, K. (2005). Fishing rights or fishing wrongs. *Reviews in Fish Biology and Fisheries, 15*, 191-199.

Hundloe, T. (Ed.). (2002). *Valuing Fisheries: An Economic Framework*. St. Lucia, Australia: University of Queensland Press.

Hunter, T. (2006, 4 June). 'Trust us' says fish industry. *Sunday Star Times*.

IFQs. (2005). *Property Rights in Fisheries Forum*. Retrieved 25 January, 2006, from http://www.ifqsforfisheries.org/project_report/pr_propertyrights_fisheries.php

Instituto Nacional de Estadística y Censos. (2001). *Población del Ecuador y de la provincia - Galápagos: Censo 1950-2001*. Retrieved 28 August, 2006, from http://www.inec.gov.ec/interna.asp?inc=cs_tabla&idTabla=456&tipo=p&idProvincia=20&idSeccion=&idCiudad=

Instituto Nacional de Estadística y Censos. (2006). *Indice de Precios al Productor: Informe Analítico - Canasta Nacional*. Retrieved 6 November, 2006, from http://www.inec.gov.ec/interna.asp?inc=enc_tabla&idTabla=654

Iyambo, A. (2000). Managing fisheries with rights in Namibia: A Minister's Perspective. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Kallie, J., Taua, A., & Faasili, U. (2000). Community-based fisheries management in Samoa. In R. Shotton (Ed.), *Use of property rights in fisheries management*. Rome: FAO.

Kerr, S., Cardenas, S., & Hendy, J. (2004). *Migration and the Environment in the Galapagos: An analysis of economic and policy incentives driving migration, potential impacts from migration control, and potential policies to reduce migration pressure*. Wellington: Motu Economic and Public Policy Research.

Kurien, J. (2000). Community property rights: re-establishing them for a secure future for small-scale fisheries. In R. Shotton (Ed.), *Use of property rights in fisheries management*. Rome: FAO.

Lanfersieck, J., & Squires, D. (1992). Planning Models for Individual Transferable Quota Programs. *Canadian Journal of Fisheries and Aquatic Sciences, 49*(1992), 2313-2321.

Leach, M., Mearns, R., & Scoones, I. (1999). Environmental entitlements: dynamics and institutions in community-based natural resource management. *World Development, 27*(2), 225-247.

MacGregor, J., Karovsakis, K., & Groom, B. (2004). Using economic incentives to conserve CITES-listed species. A scoping study on ITQs for sturgeon in the Caspian Sea, *EEP Discussion Paper 04-02*. London: International Institute for Environment and Development.

Marine Fish Conservation Network. (2004). *Individual Fishing Quotas: Environmental, Public Policy and Socioeconomic Impacts*. Washington, DC: The Marine Fish Conservation Network.

Martinez, P., & Bustamante, R. H. (1996). Criterios de evaluación sobe la reapertura de la pesquería de pepinos de mar en Galápagos. Puerto Ayora: Fundación Charles Darwin.

McCay, B. J. (1995). Social and ecological implications of ITQs: an overview. *Ocean and Coastal Management, 28*(1-3), 3-22.

McCay, B. J. (2000). Resistance to changes in property rights or, why not ITQs? In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

McCay, B. J. (2004). ITQs and community: an essay on environmental governance. *Agricultural and Resource Economics Review, 33*(2), 162-170.

Munro, G., Bingham, N., & Pikitch, E. (1998). Individual Transferable Quotas, Community-based Fisheries Management Systems, and "Virtual" Communities. *Fisheries, 23*(3), 12-15.

Munro, G., & Pitcher, T. J. (1996). Editorial. *Reviews in Fish Biology and Fisheries, 6*(1), 1-3.

Murillo, J. C. (2002). Indicadores socio-económicos de la pesca. In E. Danulat & G. Edgar, J. (Eds.), *Reserva Marina de Galápagos: Línea Base de la Biodiversidad* (pp. 440-449). Santa Cruz, Galápagos, Ecuador: Fundación Charles Darwin/Servicio Parque Nacional Galápagos.

Murillo, J. C., Andrade, R., Vizcaino, J., Bautil, B., Hearn, A., Chasiluisa, C., et al. (2002a). *Pesquería de pepino de mar en Galápagos durante el 2002. Análisis comparativo con las pesquerías 1999, 2000 y 2001*. Santa Cruz: Fundación Charles Darwin y Servicio Parque Nacional Galápagos.

Murillo, J. C., Nicolaides, F., Reyes, H., Moreno, J., Molina, L., Chasiluisa, C., et al. (2004). *Estado pesquero y biológico de las dos especies de langosta espinosa en el año 2003: Análisis comparativo con las pesquerias 1997-2002*. Puerto Ayora: Parque Nacional Galápagos and Fundación Charles Darwin.

Murillo, J. C., Vizcaino, J., Nicolaides, F., Moreno, J., Espinoza, E., Chasiluisa, C., et al. (2002b). *Informe técnico final de la pesquería del pepino de mar (stichopus fuscus) en las islas Galápagos 2001: Análisis comparativo con las pesquerías de 1999 y 2000*. Puerto Ayora: Estación Cientifica Charles Darwin & Parque Nacional Galápagos.

National Marine Fisheries Service. (2002). Gulf of Alaska Rationalization: Proposed Amendment to the Fishery Management Plan for the Groundfish of the Gulf of Alaska.

Neher, P. A. (1996). Fishing quota quality and fishery performance. *Reviews in Fish Biology and Fisheries, 6*(1), 113-116.

Neher, P. A., Arnason, R., & Mollett, N. (Eds.). (1989). *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Newell, R. G., Sanchirico, J. N., & Kerr, S. (2005). Fishing quota markets. *Journal of Environmental Economics and Management, 49*, 437-462.

OECD. (1997). Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources. Paris: Organisation for Economic Cooperation and Development.

Okey, T. A., Banks, S., Born, A. F., Bustamante, R. H., Calvopiña, M., Edgar, G., J. , et al. (2004). A trophic model of a Galápagos subtidal rocky reef for evaluating fisheries and conservation strategies. *Ecological Modelling, 172*, 383-401.

Orebech, P. (2005). What restoration schemes can do? Or, getting it right without Fisheries Transferable Quotas. *Ocean Development and International Law, 36*(2005), 159-178.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.

Panayotou, T. (1989). Comments on K. Ruddle's "The organization of traditional fishery management systems in the Pacific". In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights-based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Pauly, D. (1995). *When is fisheries management needed?* Paper presented at the Joint FF A/SPC Workshop on the Management of South Pacific Inshore Fisheries, Noumea, New Caledonia.

Pauly, D. (1996). ITQ: the assumptions behind a meme. *Reviews in Fish Biology and Fisheries, 6*(1), 109-112.

Pauly, D. (1997a). Putting fisheries management back in places. *Reviews in Fish Biology and Fisheries, 7*, 125-127.

Pauly, D. (1997b). Small-scale fisheries in the tropics: marginality, marginalization, and some implications for fisheries management. In E. Pikitch, D. D. Huppert, M. P. Sissenwine & M.

Duke (Eds.), *Global Trends: Fisheries Management*. Bethesda, Maryland: American Fisheries Society Symposium 20.

Peña-Torres, J. (1997). The Political Economy of Fishing Regulation: the Case of Chile. *Marine Resource Economics, 12*, 253-280.

Perman, R., Ma, Y., McGilvray, J., & Common, M. (2003). *Natural Resource and Environmental Economics* (3rd ed.). Harlow: Pearson - Addison Wesley.

Pescadores de Galápagos. (2005). *La Autoridad Interinstitucional de Manejo (AIM) resolve [sic] sobre la pesca vivencial, los plantados y el palangre*. Retrieved 30 November, 2006, from http://www.pescadoresdegalapagos.org/imprimersans.php3?id_article=54

Pikitch, E., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., et al. (2004). Ecosystem-based fishery management. *Science, 305*, 346-347.

Ramirez Gallegos, J. P. (2004). *La pesca artesanal en la Reserva Marina de Galápagos: dinámica laboral y conflictos socio-ambientales*. Unpublished Bachelor Thesis, Pontificia Universidad Católica del Ecuador, Quito.

Reck, G. K. (1983). *The coastal fisheries in the Galápagos Islands, Ecuador: description and consequences for management in the context of marine environmental protection and regional development*. Unpublished Doctoral Thesis, Christian-Albrects-Universität, Kiel.

Rettig, R. B. (1989). Is fisheries management at a turning point: reflections on the evolution of rights based fishing. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Rowley, R. J. (1992). *Impacts of Marine Reserves on Fisheries: A report and review of the literature*. Wellington: Department of Conservation.

Ruddle, K. (1989). The organization of traditional inshore fishery management systems in the Pacific. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights-based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Ruttenberg, B. I. (2001). Effects of artisanal fishing on marine communities in the Galápagos Islands. *Conservation Biology, 15*(6), 1691-1699.

Salgado, H., & Aliaga, B. (2002). Simulación de CIT en la pesquería del jurel en Chile. *Cuadernos de Economía, 39*(116), 27-50.

Schaefer, M. B. (1954). Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Bulletin of the Inter-American Tropical Tuna Commission, 1*(2), 27-56.

Scott, A. D. (1989). Conceptual origins of rights based fishing. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Scott, A. D. (2000). Introducing property in fisheries management. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Shepherd, S., Martinez, P., Toral-Granda, M. V., & Edgar, G., J. (2004). The Galápagos sea cucumber fishery: management improves as stocks decline. *Environmental Conservation, 31*(2), 102-110.

Smith, P. J. (2000). How privatisation can result in more government: the Alaska halibut and sablefish experience. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Spagnolo, M. (1993). Individual Transferable Quotas: The Italian Case. In *The Use of Individual Quotas in Fisheries Management*. Paris: OECD.

Squires, D. (1990). Individual transferable quotas: theory and an application. *Southwest Fisheries Center - Administrative Report, LJ-90-16*, 1-35.

Steelman, T. A., & Wallace, R. L. (2001). Property rights and property wrongs: why context matters in fisheries management. *Policy Sciences, 34*(3/4), 357-379.

Stone, S., Viteri, C., Conrad, J. M., Nøstbakken, L., & Franklin, H. (2006). *Fisheries Management in the Galapagos Marine Reserve: A Bioeconomic Perspective*. Washington, D. C.: Inter-American Development Bank.

Symes, D. (2000). Rights-based fisheries management: A European Union Perspective. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Todaro, M. P., & Smith, S. C. (2003). *Economic Development* (8th ed.). Harlow: Pearson - Addison Wesley.

Toral-Granda, M. V. (2005). Requiem for the Galápagos sea cucumber fishery? *SPC Beche-de-mer Bulletin, 21*, 5-8.

Toral-Granda, M. V., & Martinez, P. (2004). Population density and fishery impacts on the sea cucumber (isostichopus fuscus) in the Galápagos Marine Reserve. In A. Lovatelli, C. Conand, S. Purcell, S. Uthicke, J.-F. Hamel & A. Mercier (Eds.), *Advances in sea cucumber aquaculture and management - Fisheries Technical Paper 463*. Rome: FAO.

Toral-Granda, M. V., Murillo, J. C., Piu, M., Nicolaides, F., Moreno, J., Reyes, H., et al. (2005). La pesquería de pepino de mar (Isostichopus fuscus) en la Reserva Marina de Galápagos en el año 2005. Puerto Ayora: Fundación Charles Darwin/Parque Nacional Galápagos.

Toral-Granda, M. V., Vega, S., & Altamirano, M. (2003). *Estado poblacional del pepino de mar (Isostichopus fuscus) en la Reserva Marina de Galápagos en 2003*. Puerto Ayora: Parque Nacional Galápagos and Fundación Charles Darwin.

Townsend, R. E. (1995). Fisheries self-governance: corporate or cooperative structures. *Marine Policy, 19*(1), 39-45.

Townsend, R. E., McColl, J., & Young, M. D. (2006). Design principles for individual transferable quotas. *Marine Policy, 30*, 131-141.

Troadec, J. P. (1983). Introduction to fisheries management: advantages, difficulties and mechanisms. FAO Fisheries Technical Paper 224. Rome: FAO.

Valenzuela, J. J. (2006). *Pesca chilena atrapada en las redes industriales*. Retrieved 27 June, 2006, from www.elmostrador.cl/modulos/noticias/constructor/noticia_impresion.asp?id_noticia=190777

Verona, C. A. (2000). QMS in Argentina - The uncommon (?) tragedy of property rights. In R. Shotton (Ed.), *Use of Property Rights in Fisheries Management*. Rome: FAO.

Viteri, C., & Chavez, C. (2004). Legitimacy, local participation, and compliance in the Galápagos Marine Reserve. Working Paper. Chile: Universidad de Concepción.

Walters, C., & Pearse, P. H. (1996). Stock information requirements for quota management systems in commercial fisheries. *Reviews in Fish Biology and Fisheries, 6*(1), 21-42.

Weninger, Q. R., & Just, R. E. (1997). An analysis of transition from limited entry to transferable quota: non-Marshallian principles for fisheries management. *Natural Resource Modeling, 10*(1), 53-83.

Wesney, D. (1989). Applied fishery management plans: ITQs and input controls. In P. A. Neher, R. Arnason & N. Mollett (Eds.), *Rights based fishing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Wilen, J. E., Stewart, M., & Layton, D. F. (2000). *Economic Analysis of the Galápagos Marine Reserve Resources Management Plan*. Davis, California: University of California.

APPENDIX 1

FISHERIES MONITORING PROGRAMME DATASETS

Table A1.1 - Sea Cucumber Fishery Monitoring Programme Summary

Fishing Season	1999	2000	2001	2002	2003	2004	2005	2006
Season Outcomes								
CPUE (ind./diver hour)	102.6	89.1	103.7	136.1	97.7	72.1	54.5	
Total catch (millon ind.)	4.40	4.97	2.67	8.30	5.00	2.96	1.40	
Average size (cm)	25.2	22.5	22.8	22.4	21	24.2	22.53	
% Undersized	9.2%	22.2%	13.0%	19%	37%	6.9%	9.8%	
Density pre-season*	0.088	0.269	0.035	0.340	0.155	0.051	0.041	0.071
Density post-season*	0.078	0.099	0.278	0.117	0.054	0.040	0.023	
Fishing effort								
Active fishers	796	1,229	597	778	845	874	703	
divers	--	--	--	--	407	437	350	
others	--	--	--	--	438	437	353	
Active vessels	222	377	230	275	313	326	271	
pangas and *fibras*	170	323	199	230	271	284	243	
boats	52	54	31	45	42	42	28	
Diver hours	42,901	55,521	25,770	60,995	51,234	41,041	25,695	
Economic Indicators*								
Gross Income (millions)	$ 3,4	$ 3,6	$1,4	$ 2,7	$ 3,4	$ 4,4	$ 1,7	
Price ave $/ind. fresh	$ 0.80	$ 0.73	$ 0.56	$ 0.33	$ 0.99	$ 1.50	$ 1.21	
Price ave. $/lb salted	$ 10.40	$ 10.95	$ 5.60	$ 6.80	$ 10.40	$ 15.40	$ 13.90	
Main regulations								
Season (months)	2	2	2	2	2	2	2	Closure
TAC (million inds.)	nil	4,5	4,0	nil	4,7	4,0	3,0	N/A
Min. size (fresh/salted)	nil	nil	20/6 cm	20/6 cm	20/6 cm	20/6 cm	20/6 cm	N/A
ITQ/fisher (individuals)	nil	nil	3,174	nil	nil	nil	nil	N/A

*(individuals/m^2)
** US Dollars
--: Not available
N/A: Not applicable

Table A1.2 – Spiny Lobster Fishery Monitoring Programme Summary

Fishing season	1997	1998	1999	2000	2001	2002	2003	2004	2005
Season outcomes									
CPUE (kg tail/diver/day)	6.7	5.8	7	9.5	7	5.9	7	4.6	4
CPUE (kg tail/day)	11.10	7.50	11.20	13.30	9.68	7.67	9.10	5.98	5.20
Total Catch (ton tails)	65.3	31.0	54.4	85.0	66.1	51.4	45.8	25.7	34.3
Red Lobster	--	--	--	--	57.0	42.8	36.4	20.1	28.9
Average tail size (cm)	--	--	--	--	16.7	15.4	16.1	15.8	27.1[+]
% undersized	--	--	--	--	13%	46%	36%	32%	30%
% egg-bearing	--	--	--	--	--	--	--	8.9%	19%
Catch (ton tails)>15 cm	35.0	14.0	23.0	51.0	49.8	23.3	23.3	13.7	20.2
Green Lobster	--	--	--	--	9.0	8.6	9.5	5.6	5.4
Average size (cm)	--	--	--	--	17.9	18.8	17.9	17.0	29.2
% undersized	--	--	--	--	8.5%	9%	15%	26%	23%
% egg-bearing	--	--	--	--	--	--	--	10.7%	22%
Catch (ton tails)>15cm	--	--	--	--	8.2	7.8	8.1	4.2	4.1
Fishing effort									
Fishers	457	613	682	1,183	879	677	645	657	659
divers	--	--	--	--	442	352	334	355	318
others	--	--	--	--	437	325	311	302	340
Active vessels	--	--	--	--	323	304	248	309	272
pangas and *fibras*	78	67	138	286	287	276	228	280	245
boats	--	--	--	--	36	28	20	29	27
Vessel fishing day trips	5,883	4,133	4,857	6,391	6,827	6,701	5,031	4,301	6,596
Economic Indicators[*]									
Gross Income (millions)	$ 0,52	$ 0,40	$ 0,93	$ 1,70	$ 1,46	$ 1,20	$ 1,05	$ 0,59	$ 0,82
Price ave $/kg of tails	$ 7.92	$ 13.00	$ 17.16	$ 20.02	$ 22.05	$ 22.49	$ 22.93	$ 22.93	$ 23.81
Main Regulations									
Season (months)	7	6.5	4	3.2	4	4	4	4	4
Min. Size (tail)	15 cm	15 cm	15 cm	15 cm	15 cm	15 cm	15 cm	15 cm	15 cm

[+] Total length
[*] US Dollars
--: Not available

Table A1.3 – 2005 Spiny Lobster Fishery Output Price and Operating Costs (Source: Hearn et al., 2006)

	Price	***Operating Costs***					
Port	$/kg tail	Oil	Fuel	Batteries	Transport	Food	Total
Ayora	$ 23.10	$ 5.00	$ 22.00	$ 13.00	$ 2.00	$ 7.00	$ 49.00
Baquerizo Moreno	$ 25.70	$ 4.00	$ 25.00	$ 13.00	$ 2.00	$ 10.00	$ 54.00
Villamil	$ 20.10	$ 4.00	$ 16.00	N/A	$ 2.00	$ 8.00	$ 30.00
Average	*$ 22.97*	*$ 4.33*	*$ 21.00*	*$ 13.00*	*$ 2.00*	*$ 8.33*	*$ 44.33*

N/A: Not applicable

Table A1.4 – Puerto Baquerizo Moreno Fishing Cooperatives Monitoring Database Summary (as reported by cooperatives to National Park Service)

Vessel	Monitored fishing days	Monitored diver-days	CPUE (kg/diver/day)	Percentage of trips towed	Total Catch (kg tails)
A.B.C.	8	8	8.79	0.00	70.31
AIDEE	4	6	2.88	0.00	17.28
ALACRAN	14	14	8.71	1.00	122.02
ALKEN	16	27	4.33	1.00	117.03
ANITA II	2	2	9.30	1.00	18.60
ANITA NICOLE	14	20	8.48	1.00	169.65
AREANNA	12	21	7.41	0.75	155.58
BARRACUDA	16	32	6.99	1.00	223.62
BISMARK*	2	2	29.94	1.00	59.88
CRISTHEL	9	9	8.34	1.00	75.07
DANIELA	2	3	2.57	0.00	7.71
DANNY	17	23	11.04	0.94	253.88
DAYSI MAR	1	2	4.08	0.00	8.16
ESPERANZA	8	8	15.70	0.00	125.60
FERRY	9	9	9.17	1.00	82.51
GABRIELA	1	1	9.98	0.00	9.98
HANCOK	9	18	4.59	0.89	82.56
IRVIN	2	2	7.03	0.00	14.06
JESSICA JOEL	12	12	3.55	0.92	42.64
JOHANNA KATERINE	13	18	4.43	0.85	79.83
JUAMAR	19	24	4.30	0.84	103.15
LA RANA	9	9	11.26	0.00	101.38
LAURA DEL MAR	4	4	12.13	0.00	48.54
LICETT	1	1	10.89	0.00	10.89
LORENA	6	9	5.57	0.00	50.12
LORENITA*	2	2	1.81	0.00	3.63
LUZ DE AMERICA	4	4	11.79	0.00	47.17
MAR CARIBE, I, II+	3	4	4.76	0.00	19.05
MARIA DE LOS ANGELES	12	24	9.32	1.00	223.62
MARY	5	5	3.99	0.00	19.96

MARY ANGELICA	11	11	4.16	1.00	45.81
MORENA	16	16	10.79	0.50	172.64
NANDO I	2	2	4.20	0.00	8.39
NIÑA ANNETTE	7	7	9.46	1.00	66.23
NIÑA FLOR	3	3	3.48	0.00	10.43
NIÑA JHOSELIN	5	10	5.01	0.00	50.12
NIÑO JEI	9	18	7.90	1.00	142.20
NIÑO KEVIN	7	13	4.15	0.86	53.98
NUES. SRA. GUADALUPE	9	9	9.73	0.56	87.54
PEZ MARTILLO	13	13	4.24	0.00	55.11
PULPO	12	16	12.98	1.00	207.75
RAFAELA	6	10	6.51	0.00	65.09
ROSYMAR*	5	6	35.98	0.80	215.91
SAN PEDRO	6	8	8.90	0.00	71.22
SANTA FE	17	26	7.86	1.00	204.35
SANTA MARIA	7	7	8.81	1.00	61.69
SARITA	10	20	4.09	0.00	81.87
SIRENITA	18	33	5.35	0.28	176.45
STEPHANIA	3	3	4.54	0.00	13.61
TALO	1	2	2.27	0.00	4.54
TERESITA	10	18	8.06	1.00	145.15
TITANIC	11	18	5.78	0.00	104.13
TONGO REEF	9	9	7.00	0.00	63.01
TRIXI	11	11	13.55	0.91	149.01
YSHIRUS	1	1	9.75	0.00	9.75
Total	445	613			4629.47

*Outlier: extreme CPUE

⁺ Different vessels, same vessel-owner

APPENDIX 2

SUSTAINABLE CATCH FUNCTION

Figure A2.1 – Catch and Effort, Galápagos Spiny Lobster Fishery (Source: Toral-Granda et al., 2005)

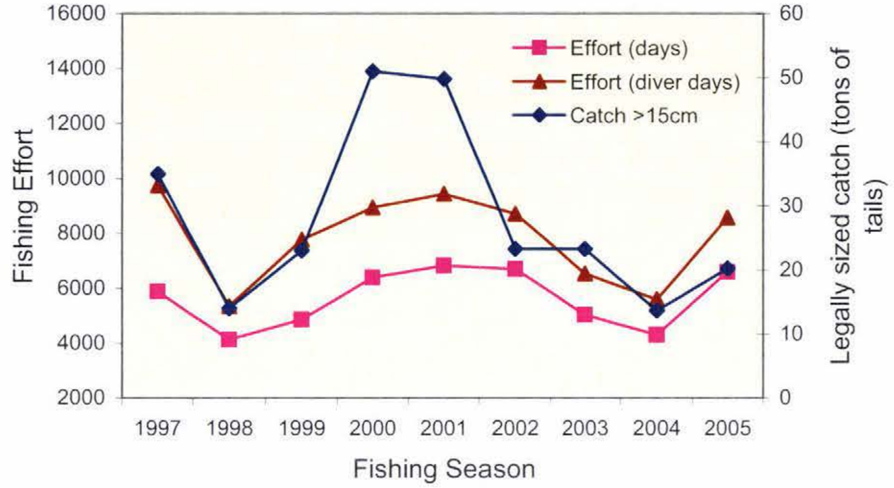


Table A2.1 – Spiny Lobster Fishery Sustainable Catch Function Summary Output

Dependent Variable: K
Method: Least Squares
Date: 10/09/06 Time: 10:44
Sample: 1 5
Included observations: 5

Variable	Coefficient	Std. Error	t-Statistic	Prob.
F	0.008684	0.000848	10.24217	0.0020
F2	-8.12E-07	1.39E-07	-5.842185	0.0100

R-squared	0.987003	Mean dependent var	17.96199
Adjusted R-squared	0.982671	S.D. dependent var	10.12217
S.E. of regression	1.332477	Akaike info criterion	3.701130
Sum squared resid	5.326483	Schwarz criterion	3.544905
Log likelihood	-7.252826	Durbin-Watson stat	2.017013

Table A2.2 – Revenues and Costs Resulting from Sustainable Effort and Catch, Spiny Lobster Fishery

Effort (fishing days)	Sustainable legally sized catch (tons of tails)	Revenue	Total Cost	Resource Rent	Marginal Cost	Marginal Revenue
0	0.00	--	--	--	--	--
500	4.14	$ 98,545.68	$ 59,121.29	$ 39,424.38	$ 114.62	$ 187.42
1000	7.87	$ 187,421.46	$ 114,616.38	$ 72,805.08	$ 107.36	$ 168.08
1500	11.20	$ 266,627.35	$ 166,485.26	$100,142.10	$ 100.11	$ 148.74
2000	14.12	$ 336,163.36	$ 214,727.93	$121,435.43	$ 92.86	$ 129.40
2500	16.63	$ 396,029.47	$ 259,344.38	$136,685.09	$ 85.61	$ 110.06
3000	18.74	$ 446,225.69	$ 300,334.63	$145,891.06	$ 78.35	$ 90.72
3500	20.44	$ 486,752.02	$ 337,698.68	$149,053.35	$ 71.10	$ 71.38
4000	21.74	$ 517,608.46	$ 371,436.51	$146,171.96	$ 63.85	$ 52.04
4500	22.63	$ 538,795.01	$ 401,548.13	$137,246.88	$ 56.60	$ 32.70
5000	23.11	$ 550,311.67	$ 428,033.54	$122,278.13	$ 49.34	$ 13.36
5500	23.19	$ 552,158.44	$ 450,892.75	$101,265.69	$ 42.09	-$ 5.98
6000	22.86	$ 544,335.32	$ 470,125.74	$ 74,209.57	$ 34.84	-$ 25.32
6500	22.13	$ 526,842.30	$ 485,732.53	$ 41,109.77	$ 27.59	-$ 44.66
7000	20.99	$ 499,679.40	$ 497,713.11	$ 1,966.29	$ 20.33	-$ 64.00
7500	19.44	$ 462,846.61	$ 506,067.48	-$ 43,220.87	$ 13.08	-$ 83.34
8000	17.49	$ 416,343.92	$ 510,795.64	-$ 94,451.72	$ 5.83	-$ 102.68
8500	15.13	$ 360,171.34	$ 511,897.59	-$151,726.24	-$ 1.42	-$ 122.02
9000	12.36	$ 294,328.88	$ 509,373.33	-$215,044.45	-$ 8.67	-$ 141.36
9500	9.19	$ 218,816.52	$ 503,222.86	-$284,406.34	-$ 15.93	-$ 160.70
10000	5.61	$ 133,634.27	$ 493,446.18	-$359,811.91	-$ 23.18	-$ 180.03
10500	1.63	$ 38,782.13	$ 480,043.30	-$441,261.17	-$ 30.43	-$ 199.37
Maximum Sustainable Yield:						
5345	23.21	$ 552,620.14	$ 444,215.97	$108,404.17	$ 44.33	$ -
Maximum Economic Yield						
3,512	20.48	$ 487,589.04	$ 338,534.06	$149,054.98	$ 70.93	$ 70.93
Bio-economic Equilibrium:						
7,023	20.92	$ 498,181.00	$ 498,181.00	-$ 0.00	$ 20.00	-$ 64.90

APPENDIX 3

IMPLICIT QUOTA PRICES, PUERTO BAQUERIZO MORENO

*Table A3.1 – Implicit Quota Price per Vessel-Owner**

Vessel	Imp. Quota Price
A.B.C.	$29.66
AIDEE	$1.05
ALACRAN	$33.62
ALKEN	$5.96
ANITA II	$35.98
ANITA NICOLE	$15.85
AREANNA	$24.02
BARRACUDA	$10.48
CRISTHEL	$26.99
DANIELA	-$3.46
DANNY	$33.55
DAYSI MAR	$9.04
ESPERANZA	$37.75
FERRY	$32.85
GABRIELA	$31.85
HANCOK	-$4.75
IRVIN	$25.07
JESSICA JOEL	-$41.70
JOHANNA KATERINE	$15.35
JUAMAR	-$10.12
LA RANA	$33.70
LAURA DEL MAR	$34.73
LICETT	$61.92
LORENA	$19.10
LUZ DE AMERICA	$34.34
MAR CARIBE, I, II	$16.20

Vessel	Imp. Quota Price
MARIA DE LOS ANGELES	$15.69
MARY	$7.58
MARY ANGELICA	-$43.10
MORENA	$30.16
NANDO I	$9.55
NIÑA ANNETTE	$27.72
NIÑA FLOR	$1.60
NIÑA JHOSELIN	$12.71
NIÑO JEI	$17.71
NIÑO KEVIN	$16.11
NUES. SRA. GUADALUPE	$29.98
PEZ MARTILLO	$9.94
PULPO	$35.02
RAFAELA	$20.34
SAN PEDRO	$28.03
SANTA FE	$13.72
SANTA MARIA	$37.07
SARITA	$9.10
SIRENITA	$58.43
STEPHANIA	$12.43
TALO	-$6.78
TERESITA	$21.63
TITANIC	$18.75
TONGO REEF	$24.97
TRIXI	$31.11
YSHIRUS	$60.18

*Outliers not included

Figure A3.1 – Implicit Quota Prices and Effort, Catch and CPUE