GALAPAGOS REPORT 2006 - 2007

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FOREWORD

The Galapagos Islands, an extraordinary world heritage site and national park in a developing country, present a significant management challenge to even the most engaged and sophisticated conservation authorities. Institutions responsible for setting and implementing the conservation and development agenda in Galapagos rely on a range of information to enable them to make thoughtful long-term policy decisions under the overarching mandate - the conservation of the Archipelago's unique biodiversity. Sound, objective data and analysis is essential for the development of coherent policies that will promote a sustainable society in Galapagos and conserve its unique biodiversity.

The 2006-2007 Galapagos Report provides these data and builds on previous reports produced by Fundación Natura and the World Wildlife Fund (WWF). From 1996 to 2002, these institutions and staff at the Charles Darwin Research Station established the first baseline socioeconomic and environmental indicators for understanding Galapagos. From that template, the 2006-2007 Galapagos Report provides a range of analyses on critical economic, social, and environmental topics and will continue to do so on an annual basis. In addition to serving as an instrument to monitor change over time, the Report will serve as an important tool to foster communication among various Galapagos stakeholders. It will provide a foundation for decision-making grounded in concrete data and a comprehensive understanding of the reality of Galapagos.

Building a sustainable society and conserving the ecological integrity and biodiversity of Galapagos will require greater interinstitutional collaboration and a shared vision among Galapagos stakeholders. The 2006-2007 Galapagos Report is a step along the path toward achieving these goals.

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We also thank the many institutions and their staffs that provided critical information for the analysis of various topics presented. We have received support from the Galapagos Chamber of Tourism (CAPTURGAL), from several tourism and dive operators and agencies, as well as from resident owners of tourist boats, tour guides, and members of Galapagos fishing cooperatives. Significant data and statistics were provided by the following institutions: Directorate of Civil Aviation (DAC), Ministry of Tourism, Ministry of Energy and Mining, National Institute of Statistics and Censuses (INEC), Ecuadorian Agricultural Health System (SESA), Quarantine Inspection System for Galapagos (SESA-SICGAL), PETROCOMERCIAL, Galapagos Electric Company (ELECGALAPAGOS), Provincial Transit Authority, and the Municipal Governments and Port Captaincies of the three cantons of Galapagos. We also thank the Galapagos community, who participated in the July 2006 opinion poll.

We are especially grateful for three long-term projects that have contributed significantly to our knowledge and understanding of Galapagos. The first project, "Control of Invasive Species in the Galapagos Archipelago," was funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Program (UNDP). The project "Conservation of the Galapagos Marine Reserve," funded by the United States Agency for International Development (USAID), included surveys, analysis, and monitoring of biological, ecological, fishery, and management indicators of the Galapagos Marine Reserve. We thank the Araucaria Program of the Spanish International Cooperation Agency for their specific contribution to the study of "Identities, Social Values, and Nature Conservation in Galapagos," which produced significant information on sociocultural issues in the archipelago.

The overall coordination, publication, translation to English, and distribution events for this important document were made possible by a generous grant from the Galapagos Conservancy, an organization based in the United States, which is part of the group of international Friends of Galapagos Organizations.

Several organizations and donors have made possible a series of projects and studies in Galapagos. Without their contributions, it would not have been possible to gather, analyze, and monitor critical information. Specifically, we express our sincere gratitude to:

Non-governmental Organizations

Durrell Wildlife Conservation Trust
World Wildlife Fund (WWF)
Frankfurt Zoological Society
Friends of Galapagos Netherlands
Friends of Galapagos Switzerland
Galapagos Conservancy
Galapagos Conservation Trust
Galapagos Darwin Trust
Japan Association for Galapagos

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Keidanren Nature Conservation Foundation
National Geographic Society
Ocean Fund
The Pew Charitable Trusts
Stanley Smith Horticultural Trust

Individuals

Talbot Family
Anonymous Donor

INTRODUCTION

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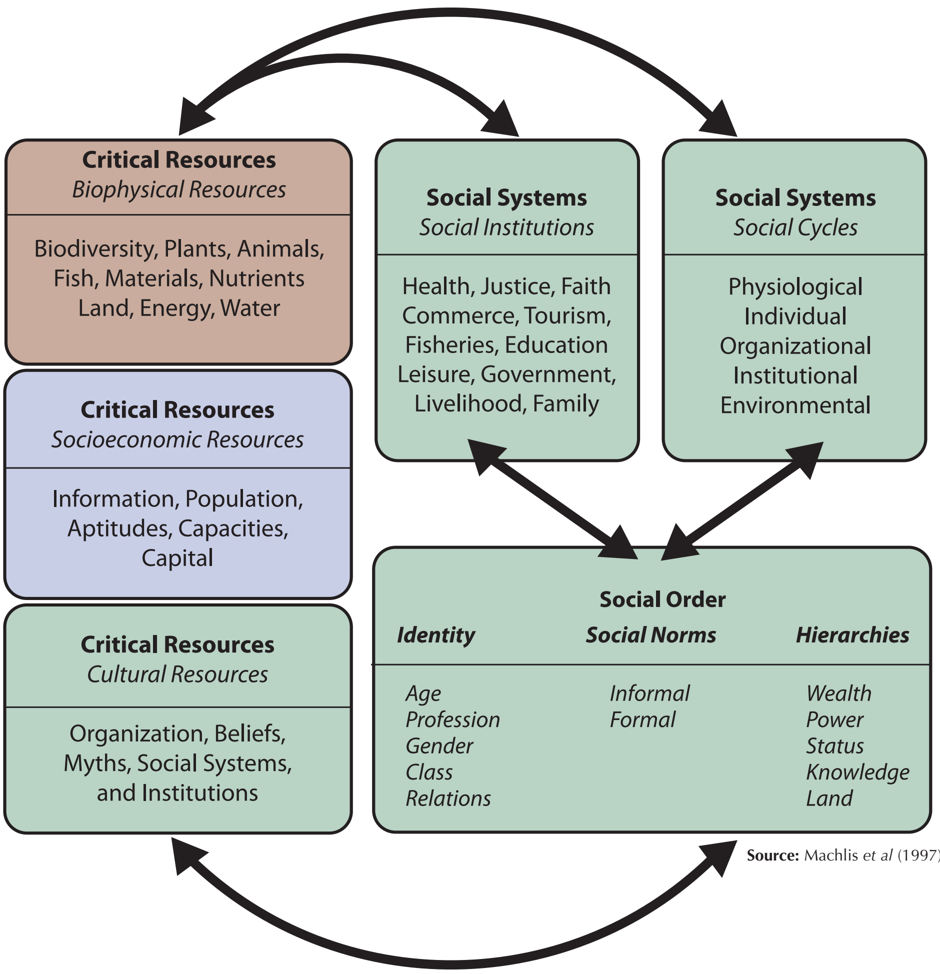
THE MODEL: GALAPAGOS AS A HUMAN ECOSYSTEM

Galapagos can be viewed as a complex system comprised of critical resources (biophysical, socioeconomic, and cultural) and social systems. The intersections between resources and social systems determine the course of development and the state of conservation in the archipelago.

The organizing framework for the 2006-2007 Galapagos Report is a **human ecosystem model**, which examines the complex and occasionally unexpected interactions of these different elements (Fig. 1).

Figure 1. Theoretical model of a human ecosystem showing flow patterns among systems and critical resources



Source: Machlis *et al* (1997)

The first section of the 2006-2007 Galapagos Report presents a series of articles that address important socioeconomic issues in the archipelago. They consider the flow of resources, such as investment capital, human resources, and energy, as well as issues such as waste management. Studies examine community perceptions of regulations and the Galapagos legal system as well as the key institutions in the islands.

The social systems and the socioeconomic and cultural resources of Galapagos have a profound impact on the archipelago's natural resources and biodiversity. The Report's second section examines the conservation status of the endemic biodiversity of Galapagos and its greatest threat - introduced species. The Report also includes an initial review of the status of the fresh water of the islands. This is one of the most critical natural resources and requires urgent attention.

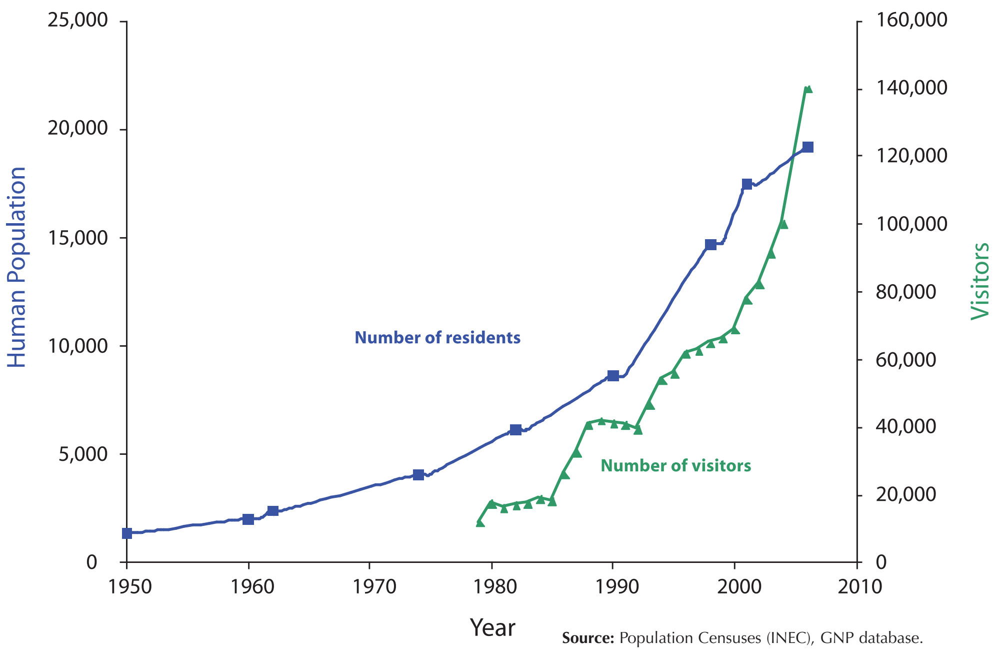
The interactions between critical resources and the social systems are ongoing and nonlinear, with all of the various elements influencing or interrelating with each other, directly or indirectly. For instance, the limited natural and socioeconomic resources of Galapagos lead to a dependence on outside resources – one of the most important characteristics of the Galapagos human ecosystem. Another example is the relationship between population growth and the growth in tourism, and the resulting impact on Galapagos social systems, the increased risk of introduction of exotic species, and increasing negative impacts on endemic and native species. These unique species and the environment that sustains them are the basis for the local economy and the main attraction for tourism – the primary economic driver in the Galapagos human ecosystem.

KEY STATISTICS AND TRENDS

Galapagos is undergoing a process of change and growth that began nearly two decades ago. Tourism is increasing at a staggering rate. The number of visitors has increased at a yearly average of 9% over the last 25 years, while tourism, in economic terms, has grown at an annual rate of 14% over the last 15 years. This growth has occurred despite the fact that the number of boats has remained relatively constant during the last decade (Fig. 2). The growth from 1991 to 2006 resulted from increased installed capacity, changes in certain aspects of tourism operations, and conditions in external markets. During this period, the passenger capacity of boats rose by 72%, the number of hotels by 97%, the number of hotel beds by 90%, and the number of cruise days by 45%.

Tourism is the primary economic driver in Galapagos and is fueling the current cycle of growth. The requirements, opportunities, and higher standard of living associated with a growing economy attract an ever-increasing number of immigrants to the islands. Official data from the National Institute of Statistics and Censuses (INEC) indicate that the regular resident population in Galapagos has increased from 8,611 in 1990 to 19,184 in 2006, which represents a 123% increase in population over the last 16 years (Fig. 2). Population growth generates an increase in economic activities (primarily in tourism

Figure 2. Population growth (regular residents) and visitors in Galapagos, 1950-2006



Source: Population Censuses (INEC), GNP database.

and fisheries), which in turn exerts pressure on the natural resources and increases the demand for improved public services. A clear example of this relationship is the continued pressure to extract coastal fishery resources (lobster and sea cucumber) despite the fact that their populations have been decimated by overfishing. From 2002 to 2005, the sea cucumber and lobster catches dropped by 83% and 43%, respectively. This had a direct impact on the profits of the fishing sector, with the gross income from both species dropping approximately 60%, from about US$ 8,000 per fisher in 2002, to only US$ 3,400 in 2006.

The use of and dependence on other natural resources has also increased along with the population. Over the last five years, the consumption of diesel and gasoline (fossil fuels) increased by 64% and 63%, respectively. The demand for electricity (number of clients) increased 35% in Santa Cruz alone, between 2001 and 2006. Another critical resource analyzed in this Report is fresh water. Inhabited areas in the Galapagos were developed and have grown significantly without thought to the integrated management of water supplies and quality. Each island has its own water needs and priorities, but the most serious problems are the same for all – pollution, waste, and scarcity of fresh water.

The relationship between energy resources in Galapagos is demonstrated by the dependence on fossil fuel for electricity. The greater the demand for electricity, the greater the demand for fossil fuels shipped from continental Ecuador, which poses a significant risk of environmental accidents. Historically, energy consumption in Galapagos has been subsidized by the national government. Over the last few years, efforts have focused on analyzing renewable energy options to reduce this dependence and the overall consumption of fossil fuels. In 2005, Floreana shifted to a hybrid system for power generation. The ERGAL Renewable Energy Project, carried out by the United Nations Development Program, the Galapagos Electric Company, and the Ministry of Energy and Mining, is now promoting such systems on the other inhabited islands. However, there is still no effort to reduce fossil fuel consumption on boats, which account for 61% of the total fuel demand in the archipelago. It was to serve this market that the Jessica oil tanker ventured into Galapagos waters in 2001 and caused the most significant human-caused environmental disaster in the archipelago.

The higher standard of living and overall growth of the Galapagos economy has led to increased consumption and greater buying power for goods and services. A related indicator examined in the Report is the number of motor vehicles in Galapagos. During the last eight years (1999-2006), 1211 motor vehicles were imported into Galapagos, representing 59% of the total number of vehicles in the archipelago. Regulations implemented in 2004 to curb the importation of vehicles resulted in an initial decrease in the number of vehicles per year (2005-06) and demonstrated that it is essential to improve these types of measures and ensure their implementation.

The growth in both tourism and the resident population has also resulted in an increase in the movement of air passengers and cargo to the islands. From 2001 to 2006, the number of commercial flights nearly doubled. Over that same period, total air traffic continued to increase, with the number of flights increasing by 59.2%, the number of passengers by 58.5%, and the amount of air freight by 94%. If effective control and inspection mechanisms are not in place, increased air traffic and the opening of new commercial routes and direct flights to Isabela will result in an increased risk of introduction of exotic species. In this context, it is critical to ensure the response capacity of the Quarantine Inspection System for Galapagos (SICGAL). One study in the Report assesses the capacity of SICGAL after its first seven years of operation. It finds that SICGAL lacks the resources to respond to the increasing demand for its services. For instance, from 2001 to 2006, the number of inspectors was reduced by 20% while the number of inspection units doubled.

The consequences of economic and population growth on the ecological integrity and biodiversity of Galapagos are well documented. Marine resources, including lobster, sea cucumber, and cod, have declined precipitously over the years. The disappearance of these overfished species could result in major ecological changes in the marine ecosystems. Preliminary findings of sub-tidal ecological monitoring studies indicate that some changes are already visible in Extractive Use Zones. Of the 383 endemic and native terrestrial species of Galapagos fauna that have been classified on IUCN's Red List, 52% of them are categorized as Critically Endangered, Endangered, or Vulnerable. Of the 180 species of endemic plants, 60% are categorized as "threatened" by the IUCN.

To date, 748 species of introduced plants have been recorded in Galapagos, compared to only 500 species of native plants. At least 490 species of insects and 53 other invertebrate species have been introduced into Galapagos, with 55 of them having the potential to cause serious damage to the native flora and fauna. As of May 2007, 36 species of introduced vertebrates have been recorded in Galapagos; 30 of them have become established while the other 6 were intercepted upon arrival. Of the 30 species of established introduced vertebrates, 13 are considered invasive and cause serious impacts in the island ecosystems. As of 2007, the number of introduced species recorded in Galapagos totaled 1321, versus 112 introduced species recorded in 1900 (Fig. 3). The growing number of introduced species recorded in recent years is, in part, a reflection of the greater interest and increased effort in locating and identifying them.

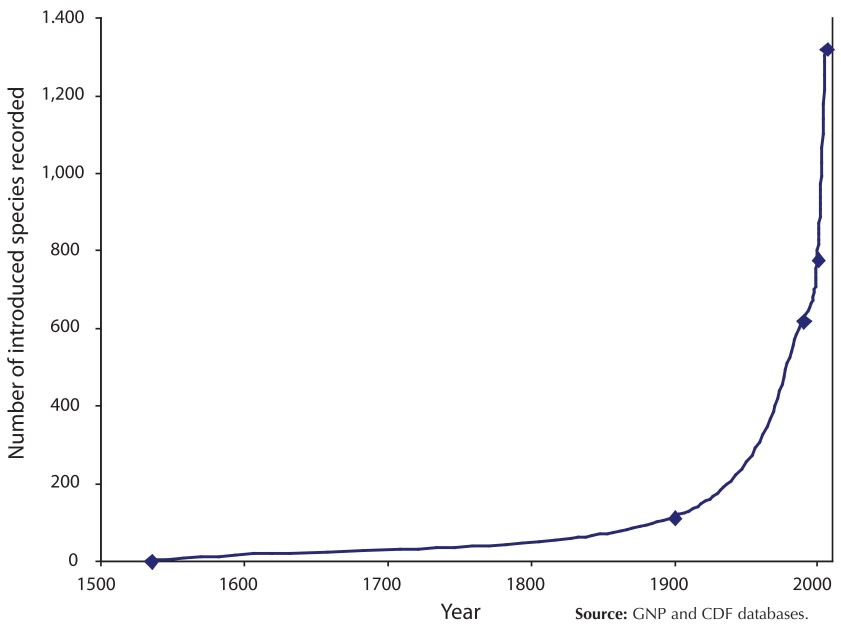
Management and conservation institutions have carried out major control and eradication projects over the last several years. Since 1999, Project Isabela, funded by the United Nations Foundation (UNF) and the Global Environment Facility (GEF), achieved the extraordinary result of eradicating goats from northern Isabela and Santiago. It represents the world's largest successful eradication project in terms of the land area cleared, and has attracted considerable international attention.

As of 2007, several islands and islets in the archipelago are now free of cats, goats, pigeons, donkeys, and pigs. A number of control methods for introduced land invertebrates have been developed, including the biological control of the cottony cushion scale. Current research on the distribution of two highly invasive fire ants will form the basis for future management actions. If current eradication of the little fire ant from Marchena is confirmed in the next few years, it will represent another major conservation success for the region and the world. Introduced species are more abundant and have a greater incidence on the inhabited islands, all of which are considered high priority for control and eradication efforts in the coming years.

THE CHALLENGE FOR THE FUTURE

Despite the challenges and problems identified in this Report, Galapagos is the only oceanic archipelago that still has 95% of its original biodiversity intact. Much of this success is due to far-reaching public policy, which, although erratically implemented, still creates a strong legal framework for conservation. Additionally, there are strong conservation institutions in Galapagos with an enviable record of significant achievements. Regulations have been established at the regional and island level to limit and control certain activities related to the growth and demands of the human population. Initiatives to help build institutional capacity at the local level, financed by multilateral and bilateral cooperation agencies and non-profit conservation and sustainable development organizations, are helping to prevent entry of exotic species and to control those that have been introduced. They are also promoting the use of renewable energy alternatives to decrease the dependence on fossil fuels and the associated risk of fuel spills.

Figure 3. Cumulative number of introduced species recorded in the Galapagos, 1535-2007. (Species are added in the year they are identified, which may be several years to a few decades after their arrival)



Source: GNP and CDF databases.

Sustainable businesses are being promoted, such as *Pescado Azul*, a company owned and managed by women from Isabela, which produces added-value sea food products. A number of recycling initiatives are underway, run by the municipal governments on the different islands. Unprecedented eradication efforts, such as Project Isabela, are resulting in the ecological recovery of large areas damaged by invasive species. These are just a few examples of projects and initiatives developed in Galapagos that should be further promoted and replicated.

Nevertheless, sustaining the human ecosystem of Galapagos and an acceptable level of conservation requires considerable additional commitment. Positive change will only be achieved through effective leadership that builds consensus, collaboration, and a shared vision among all Galapagos stakeholders. There are several socio-cultural issues (such as health, justice, and governance) that have yet to be examined and for which suitable monitoring indicators must still be defined. Future Galapagos Reports will seek to gain a deeper understanding of all aspects of the human ecosystem.

UNESCO and the World Conservation Union (IUCN) have expressed concern about the conservation status of Galapagos and its future. The President of Ecuador has declared Galapagos to be at risk (Executive Decree Nº 270) and a top national conservation priority. The President's Decree provides a crucial opportunity to change the present development model in Galapagos. A new vision of a sustainable, equitable society living in balance with the unique natural resources of Galapagos could be a model for the world.

SOCIOECONOMIC ISSUES

Social aspects of fisheries in Galapagos

Juan Carlos Murillo[a] , Harry Reyes[a] & Alex Hearn[b]

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The Galapagos Marine Reserve (GMR), covering approximately 138,000 km^2, was established in 1998 as part of the Special Law for Galapagos. As a multi-use reserve, economic activities, including tourism and what is classified as 'artisanal' fishing, are permitted within its waters, while industrial fishing and the fleet from continental Ecuador are excluded. The law restricts fishing activities to members of local fishing cooperatives who carry artisanal fishing licenses (PARMA license – *Pesca Artesanal de la Reserva Marina Galápagos*) issued by the Galapagos National Park Service (GNPS). Basic information on the current composition of the fishing sector on the inhabited islands and an analysis of fishing effort for the spiny lobster, one of the primary fisheries, are presented.

> The growth of the Sector and the overcapitalization of the fisheries have resulted in the collapse of the sea cucumber and decline of the spiny lobster populations.

The Fishing Register

The Galapagos fishing sector is made up of four cooperatives: COPESAN and COPESPROMAR in San Cristóbal; COPROPAG in Santa Cruz, and COPAHISA in Isabela. There are currently 1,006 fishers registered with the GNPS: 51.3% from San Cristóbal; 25.2% from Santa Cruz, and 23.5% from Isabela (Table 1).

The registration of new fishers in the GMR has decreased since 2002, when the Inter-Institutional Management Authority (IMA) closed the Fishing Register and established a five-year moratorium on new fishers. This coincided with the approval of the Five-Year Fishing Calendar. The small increase in the number of registered fishers in the last four years is a result of the incorporation of offspring of registered fishers from the different ports in the archipelago (Fig. 1). In December 2006, the IMA extended the moratorium for one more year. Over the last ten years, the activity of legally registered fishers varied depending on the season and the fishery (Fig. 1). For example, the sea cucumber fishery peaked at 1,229 fishers in 2000, when many members of the community who were not registered fishers were also observed harvesting sea cucumbers. In contrast, in 2001, only 597 fishers participated in this fishery. The spiny lobster fishery shows a similar pattern, with the number of active fishers rarely exceeding 700, except in 2000 and 2001. In almost every fishing season, fewer than 70% of the registered fishers participated.

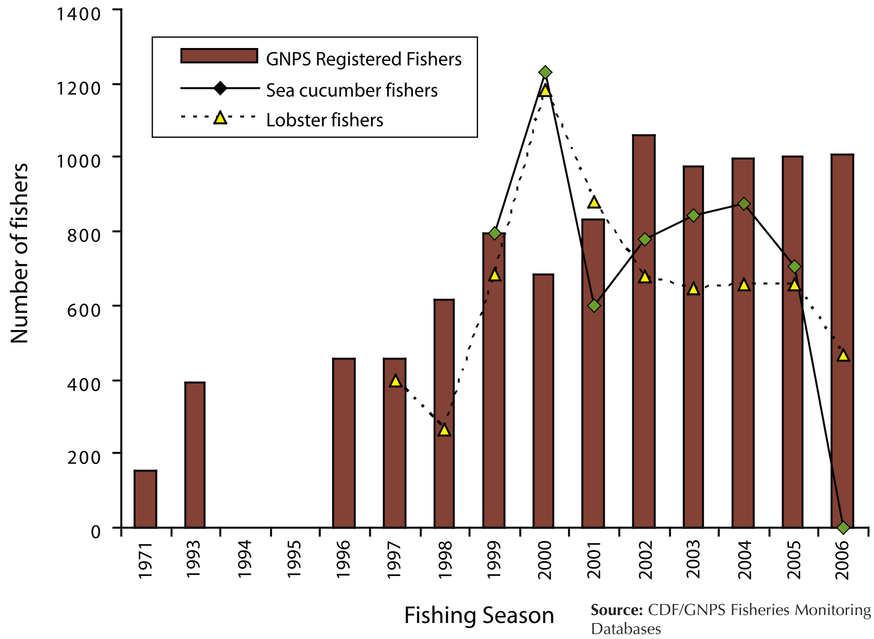
> Most trips (75%) are carried out by a third of the registered fishers, suggesting that fishing effort is concentrated in about 250 of the 1,006 registered fishers.

Table 1. Fishers registered with the GNPS by island.

Island	Number of fishers
San Cristóbal	516
Santa Cruz	254
Isabela	236
TOTAL	**1,006**

Source: CDF/GNPS Fisheries Monitoring Databases

Figure 1. Number of fishers on the GNPS Fishing Register and the number actively participating in the spiny lobster and sea cucumber fisheries, 1971-2006



Source: CDF/GNPS Fisheries Monitoring Databases

Fishing effort: The lobster fishery – a case study

One of the prominent aspects of the lobster fishery, evident from the reports of individual fishers in their inspection certificates, is that during 2003-05, nearly half the fishers from both Isabela and Santa Cruz undertook fewer than 10 fishing trips per year (Table 2). In San Cristóbal, the figure was even higher, with 79% of fishers participating in fewer than 10 trips. The data do not discriminate between large and small boats, so the total number of trips from each island includes dinghies, fiberglass launches, and larger fishing boats. Another important fact is that inspection certificates indicate that the majority of trips (75%) were undertaken by only one third of the active fishers, suggesting that fishing effort is concentrated in only 250 registered fishers.

Table 2. Proportion of active fishers over the last three lobster fishing seasons, as a function of the number of registered trips between 2003 and 2005.

	Isabela	Santa Cruz	San Cristóbal
Fishers who carry out 50% of all fishing trips.	17 %	20 %	15 %
Fishers who carry out 75% of all fishing trips.	35 %	39 %	32 %
Fishers who register less than 10 trips in the last three years.	54 %	49 %	79 %

Source: CDF/GNPS Fisheries Monitoring Databases

Vessel capacities and activities

The total number of fishing vessels registered with the GNPS remained constant during the 2002-2006 Fishing Calendar, while the number of active vessels has fluctuated within each fishery. The largest number of registered vessels occurred in 2000, when 377 active vessels were recorded for the sea cucumber fishery and 328 vessels for the lobster fishery (Table 3).

Table 3. Number of fishing vessels registered with the GNPS that were active in the sea cucumber and spiny lobster fisheries, 1999–2005.

Year	Fishery	Large boats	Dinghies and launches	Total active vessels	No. Registered with GNPS
1999	Sea cucumber Lobster	52 No data	170 138	222 No data	222
2000	Sea cucumber Lobster	54 42	323 286	377 328	417
2001	Sea cucumber Lobster	31 36	199 287	230 323	426
2002	Sea cucumber Lobster	45 28	230 276	275 304	446
2003	Sea cucumber Lobster	42 20	271 228	313 248	446
2004	Sea cucumber Lobster	42 29	284 280	326 309	446
2005	Sea cucumber Lobster	28 27	243 245	271 272	446

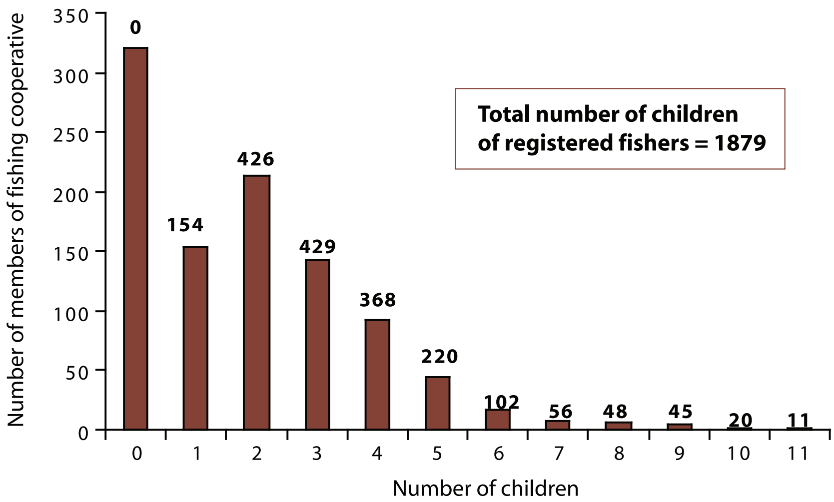
Source: CDF/GNPS Fisheries Monitoring Databases

Social aspects

Of the registered fishers, 983 are men (97.7%) and 23 are women. Over the last few years, none of the women have been recorded as having taken part in fishing activities. Most of the women on the register are vessel owners rather than active fishers.

An important fact that may help to predict the increase in fisher numbers over the next few years is that the members of the fishing cooperatives have 1,879 children among them (Fig. 2). According to the Fishing Regulations, the children of fishers may join the Fishing Register without completing any major requirements. This must be considered when developing projects or plans for the optimization of the fishing sector.

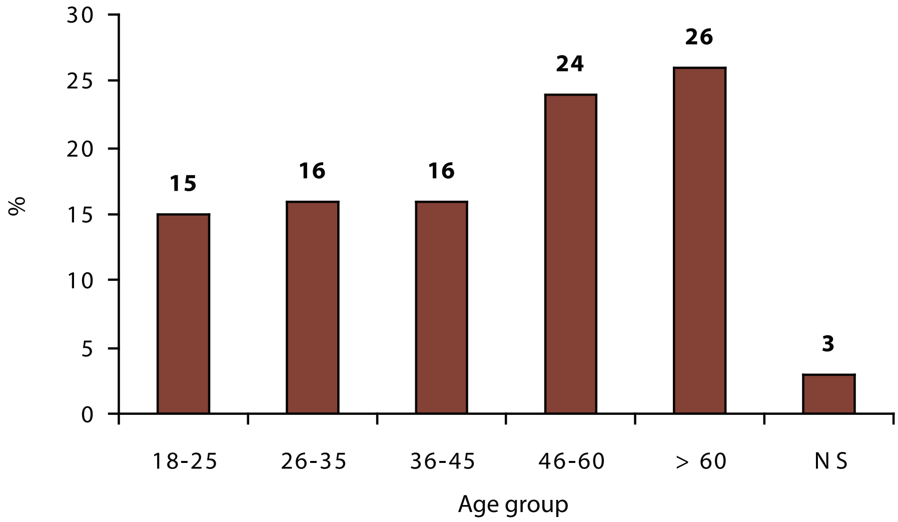
Figure 2. Number of children per fishing cooperative member. The numbers at the top of each bar indicate the total number of children represented by each column



Source: CDF/GNPS Fisheries Monitoring Databases

The age of fishers provides another indicator related to the performance and productivity of any fishing community. According to the Fishing Register, half of all members are over the age of 46 (Fig. 3), which suggests that few young fishers have joined the register in the last four years (potentially only 28 children of fishers).

Figure 3. Percentage of fishers by age group



Source: CDF/GNPS Fisheries Monitoring Databases

The future of fisheries in Galapagos

The Galapagos fishing sector experienced rapid growth in the latter half of the 1990s, primarily due to the boom in the sea cucumber fishery, which attracted a large number of immigrants, some of whom had experience with the sea cucumber fishery in continental Ecuador. The expansion of the sector and the over-capitalization of the fisheries have resulted in the collapse of the sea cucumber and decline of the spiny lobster populations. This has propelled a search for solutions for the sector. Among those being considered are a reduction and reorganization of fishing effort on current resources, the optimization of whitefish and open water fisheries, and new types of tourist-related activities.

Very few young people have joined the Fishing Register in the last four years.

First, however, it is important to identify the various interest groups within the sector, as it is unlikely that any one solution will satisfy everyone. Data from the lobster fishery, which indicate that apparently the majority of the fishing effort is concentrated in a few individuals, suggest that a large proportion of fishers have alternative sources of income.

Among the solutions being considered for the Fishing Sector are the reduction and reorganization of fishing effort on current resources, the optimization of whitefish and open water fishing, and new types of tourist-related activities.

It is important to identify those fishers who are dedicated to artisanal fishing, that is, those who consider fishing more than just a source of employment but also a way of life, and who wish to find solutions within the fisheries. It is also important to identify those fishers who are open to employment away from fishing, either in tourism or in other areas. With this analysis completed, specific projects can be targeted to smaller interest groups.

During 2007, the extension or lifting of the moratorium on new fishers must be discussed. The decision must be consistent with strategic planning for the fishing sector. This is the only sector where children of members are given automatic access to the activity. This privilege, given the large number of children of existing fishers, should be carefully analyzed in the context of reducing the size of the cooperatives.

Declining profitability of fisheries in the Galapagos Marine Reserve

Alex Hearn[a], Juan Carlos Murillo[b] & Harry Reyes[b]

[a]Galapagos National Park Service, [b]Charles Darwin Foundation

Although management decisions for the Galapagos Marine Reserve (GMR) have often been based on perceptions related to socioeconomic aspects of fisheries, there has been a historical void of good socioeconomic information related to Galapagos fisheries. To begin to fill this void, expenses and gross earnings for Galapagos fisheries over several seasons have been estimated through the use of logbooks of fishery observers and surveys of fishers at the home docks[1]. Annual fisheries reports, produced by the Charles Darwin Foundation and the Galapagos National Park, include information on price trends for the most important products. This article presents this information and compares the gross income per fishery for 1997-2006. It also presents an analysis of the net income from the lobster fishery, as a case study, taking into account the associated operational costs.

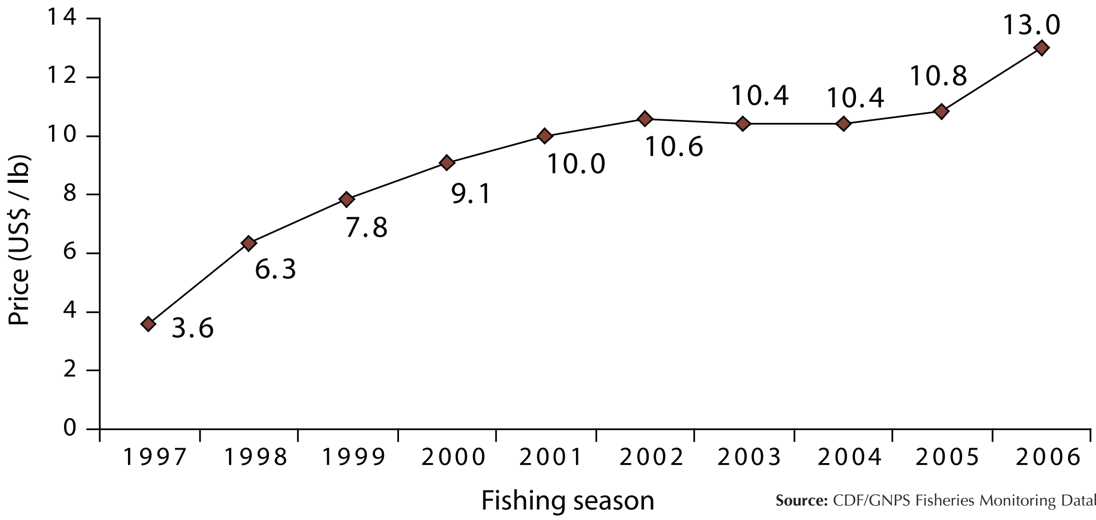
Price Trends

In 1997, the average price per pound of lobster tails was US$ 3.60. Since then, the price has steadily increased, nearly tripling in value by 2001 (Fig. 1). After that it remained relatively stable during 2002 to 2005, oscillating between US$ 10.40 and US$ 10.80 per pound. In 2006, the price reached its historical peak at US$ 14.00 per pound, while the average price was US$ 13.00.

During the same period, the price of sea cucumbers first declined then increased by a factor of five between 2002 and 2004 (from US$ 0.33 per individual to US$ 1.50 per individual) (Fig. 2), a much more rapid increase than that recorded for lobster tails. Due to the scarcity of the resource, the fishery was closed in 2006.

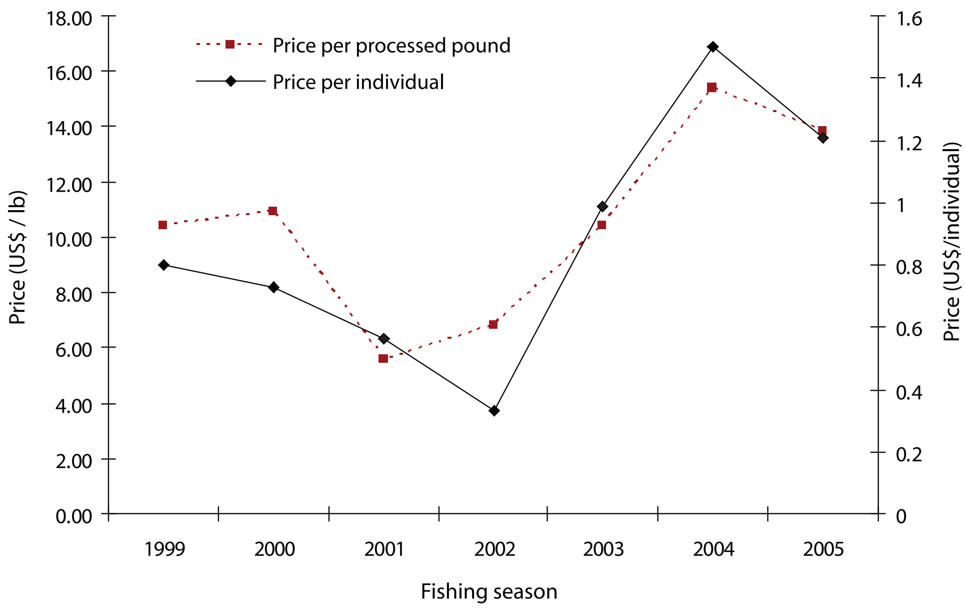
> Between 2002 and 2005, the price of sea cucumbers increased by 354%, while the catch declined by 83%; the price of lobster increased by only 2% and the catch declined by 43%.

Figure 1. Average lobster tail prices, 1997-2006



Source: CDF/GNPS Fisheries Monitoring Databases

Figure 2. Average sea cucumber prices per pound of processed catch and per individual, 1999-2005

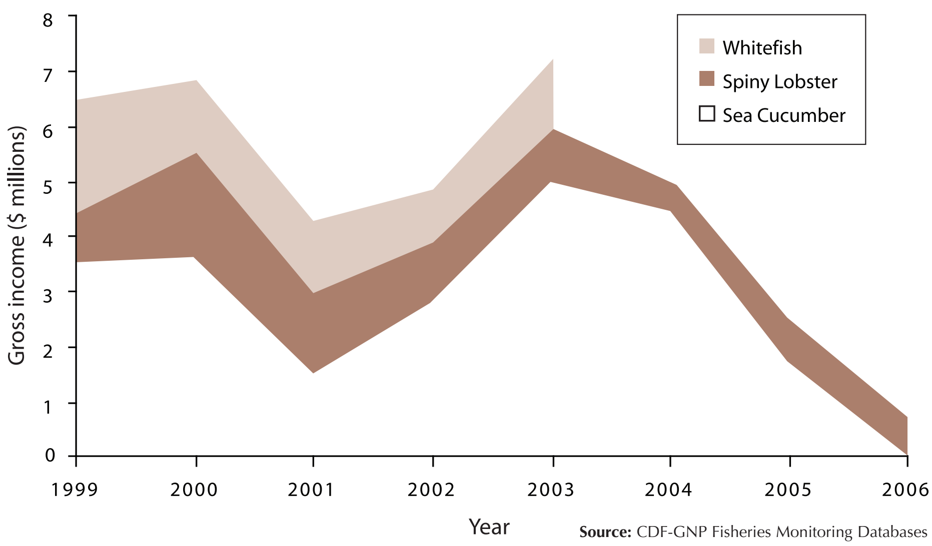


Source: CDF/GNPS Fisheries Monitoring Databases

Gross income

The maximum gross income generated by the fishing sector was a robust US$ 7 million in 2003. Although there is no information on total catch of whitefish after 2003, the income from lobster and sea cucumber fisheries dropped to less than half that value by 2005 (Fig. 3). Assuming that prices and volumes of whitefish did not change significantly during this period, the gross income for 2005 would not have exceeded US$ 4 million, indicating a critical decline in the profitability of fishing in Galapagos. The economic situation of fishers in 2006 was probably even more precarious due to the closure of the sea cucumber fishery. That year, the lobster fishery grossed US$ 900,000, which, when added to the estimated income from the white-fish fishery, totaled less than US$ 2.5 million. As a consequence, many fishers are currently involved in other activities such as tourism, inter-island transport, and construction.

Figure 3. Gross income for the major fisheries in the GMR (1999-2006)



Source: CDF-GNP Fisheries Monitoring Databases

Note

There is no information on whitefish fisheries from 2004 to 2006.

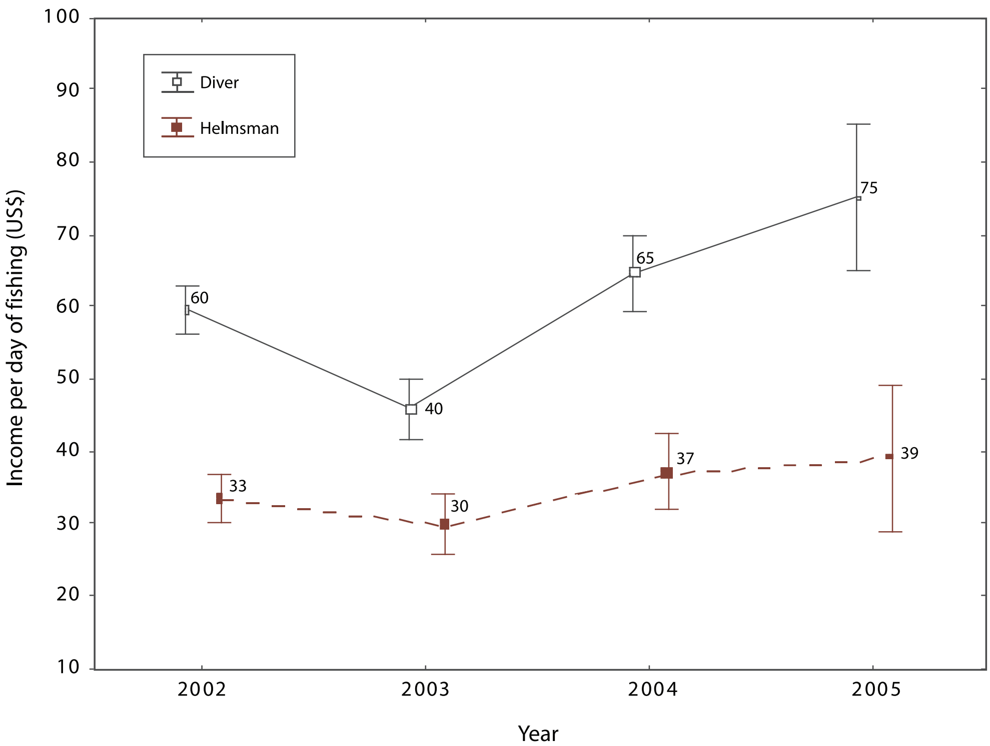
Net income and operational costs of the lobster fishery

From 2002 to 2005, lobster divers earned US$ 46-75 per fishing-day, while helmsmen earned between US$ 30-39 per fishing-day (Fig. 4). The variations are primarily due to differences among the port islands, namely varying resource abundance and significant price fluctuations. In 2005, fishers obtained the highest gross income in Puerto Baquerizo Moreno (San Cristóbal), US$ 244 per fishing-day, versus US$ 153 in Puerto Ayora (Santa Cruz) and US$ 104 in Puerto Villamil (Isabela). These differences are due to the Catch per Unit Effort (CPUE) being twice as high for San Cristóbal as for the other islands[2] and the price per pound of lobster tail also being higher. This was reflected in the earnings of crew members (helmsmen and divers) and the net income of boat owners. For example, the mean net income of owners of small boats (dinghies and launches) in Villamil and Puerto Ayora was only US$ 20 per fishing-day, whereas San Cristóbal boat owners earned more than triple that, approximately US$ 67 per fishing-day.

During the 2003-05 fishing seasons, the operational costs for the small vessels that operate on a daily basis without depending on mother boats oscillated between US$ 41-49 per fishing-day. The greatest cost was fuel, which represented 40% of total operational expenses (Table 1).

In conclusion, lobster prices have permitted the fishery to remain economically viable.

Figure 4. Average daily net income for divers and helmsmen during the spiny lobster fishery. (Bars show 95% Confidence Intervals)



Source: CDF/GNPS Fisheries Monitoring Databases

The gross income per fisher per year from the two main fisheries has declined, from approximately $8000 in 2002 to only $3400 in 2006.

Table 1. Costs for a one-day fishing trip for spiny lobster, 2002-2005.

	2002		2003		2004		2005		TOTAL	
Item	**N**	**Cost US$**	**N**	**Cost US$**	**N**	**Cost US$**	**N**	**Cost US$**	**N**	**Cost US$**
Motor oil	1097	4	1212	5	449	5	346	5	**3104**	**4**
Fuel	1138	15	1226	20	456	19	352	20	**3172**	**18**
Other	445	13	106	14	89	12	15	13	**655**	**13**
Transport	952	2	720	3	357	2	100	2	**2129**	**3**
Food	1097	7	697	7	295	6	122	8	**2211**	**7**
Total cost per fishing day		**41**		**49**		**44**		**48**		**45**

Source: CDF-GNP Fisheries Monitoring Databases

What happened to the profitability of Galapagos fisheries?

The two most important fishery resources, sea cucumbers and spiny lobsters, have shown similar tendencies in recent years, with their prices increasing at the same time that the resources began to decline. This pattern was more rapid and accentuated in the sea cucumber fishery. However, both cases are typical of rapidly growing boom-and-bust fisheries, with strong international demand and overcapitalization. The difference between them is the growth rate of each fishery and its respective international prices.

It is evident that the annual injection of several million dollars from fisheries into the archipelago contributes to the economy of many local families. However, a comparison between the economic value of Galapagos fisheries to the archipelago and their ultimate value in the USA (in the case of lobsters) and the Far East (in the case of sea cucumbers) has not yet been quantified.

It is evident that gross income has declined considerably in recent years, reaching the point in 2006 when there was no sea cucumber fishery and the lobster catch was the lowest registered since 1997, with the exception of 2004 when the two fisheries overlapped for a period of six weeks. There is little information on the contribution of whitefish to the local economy. However, with new initiatives for small local enterprises, such as Pescado Azul in Isabela, which produces smoked tuna from legally caught yellow-fin and blue-eye tuna, and the development of agreements between fishers involved in micro-enterprises and the tourism industry to supply tour boats, it is probable that the whitefish fishery is becoming more important for specific groups of fishers. For example, during the lobster fishing season of 2006, a large number of mother boats from San Cristóbal focused mainly on whitefish, indicating that this fishery is now sustaining the economy of part of the fishing sector for at least half the year.

Given the number of registered fishers (approximately 1000 since 2002), and the number actively involved in the sea cucumber and lobster fisheries (approximately 800 since 2002), you can estimate that the gross income per fisher from both resources has dropped from approximately US$ 8000 in 2002 to US$ 3400 in 2006. The current low cost-effectiveness of these fisheries leads to several important questions. How many fishers are carrying out other activities in order to supplement their income? What activities are these and how much money do they generate? While waiting for the implementation of new activities for fishers, such as demonstrational tourism fishing, sport fishing, diving, or other sustainable micro-enterprises, the greatest question remains: What role will fisheries play in Galapagos in the coming years?

> The economic situation of the fishing sector worsened as the resources declined, and this in turn reduced their capacity to implement corrective measures in the fisheries.

Efforts to control illegal fishing activities in the Marine Reserve

Harry Reyes & Juan Carlos Murillo

Galapagos National Park

Legal Framework

The Galapagos National Park Service (GNPS) is responsible for the administration and management of the Galapagos Marine Reserve (GMR) and has jurisdiction over the management of its natural resources. It coordinates patrolling activities in the GMR with institutions such as the Ecuadorian Navy, which provides the necessary personnel[1]. The Marine Control and Surveillance Unit of the GNPS carries out its activities in collaboration with the Navy within a 40-nautical-mile zone, measured from a baseline that surrounds the main islands and interior waters. This article presents information regarding the marine infrastructure of the GNPS, summarizes the results of interventions of illegal vessels in the GMR since its creation, and evaluates the success of seizures of important resources, such as sea cucumbers, sharks, and shark fins.

GNPS vessels and personnel dedicated to control of the Marine Reserve

The Marine Control and Surveillance Unit of the GNPS possesses three ocean-going vessels for long-range operations, two medium-range vessels, and six speed boats. It also operates two remote bases in the Bolivar Channel and Cartago Bay (Table 1). The vessels are distributed among the Technical Offices of the GNPS and the remote bases. At present, 49 crew members man the vessels; however, 81 are required, leaving a deficit of 32. Marine patrolling is also supported by an air unit – a *SeaWolf* hydroplane.

> Despite a good infrastructure for marine patrol and surveillance within the GNPS, there remains a major shortage of crew for the necessary level of patrolling.

Table 1. Vessels employed in the Marine Control and Surveillance Unit of the GNPS.

Naval/Air Unit	Category	Administrator
M/N Sierra Negra*	Ocean-going	Santa Cruz Office
M/N Guadalupe River	Ocean-going	Santa Cruz Office
M/N Yoshka	Ocean-going	Santa Cruz Office
L/P Sea Mar	Coastal-marine	Santa Cruz Office
L/P Araucaria	Coastal-marine	San Cristóbal Office
Sea Ranger 1	Coastal-marine	Canal Bolívar Base
Sea Ranger 2	Coastal-marine	Santa Cruz Office
Sea Ranger 3	Coastal-marine	Santa Cruz Office
Sea Ranger 8	Coastal-marine	San Cristóbal Office
Sea Ranger 9	Coastal-marine	Santa Cruz Office
Sea Ranger 10	Coastal-marine	San Cristóbal Office
Sea Ranger 11	Coastal-marine	Isabela Office
Canal Bolívar base	Operations base	Santa Cruz Office
Tiburón Martillo floating base	Operations base	Santa Cruz Office
Sea Wolf hydroplane	Air	Baltra Airbase

Source: Marine Control and Surveillance Unit databases, GNPS.

Note:

* Also carries out logistical and scientific activities.

Control of illegal sea cucumber fishing

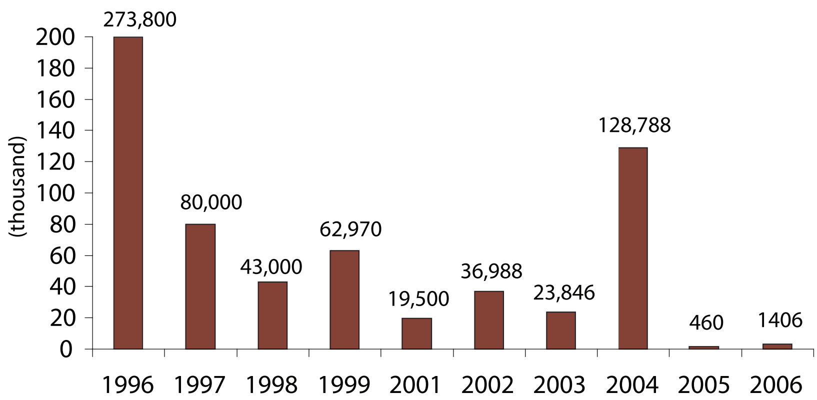
Pressure by local fishers to open sea cucumber fisheries has had ongoing support and financing from Asian merchants based in continental Ecuador who used a series of operational and technological methods to carry out illegal fishing and smuggling activities. The control of this fishery, both during fishing seasons and in closed seasons, was always complicated, conflictive, and costly.

Currently, control operations focus on preventing the illegal harvesting of species of sea cucumber other than *Isostichopus fuscus*, the only species that, to date, can be legally harvested. Operations are carried out on land and at sea, and at probable storage sites.

Illegal fishing of *I. fuscus* has been carried out by members of the fishing cooperatives as well as by poachers (unlicensed fishers). They process the sea cucumbers in illegal camps, store them at adjacent sites, and then transport them in fiberglass launches to strategic points. From there they are transferred to fishing vessels from the Manta industrial fleet (mainly longliners) and then to the continent where they are sold to Asian countries where this product is consumed. Some fishers also transport small quantities on commercial airlines, and then collect the product once on the continent. In some cases, sea cucumbers have been seized from private homes in the islands.

From 1996 to 2006, the highest number of sea cucumbers seized by the GNPS during a closed season was near 275,000 in 1996 (Fig. 1). The second highest number was in 2004, when almost 130,000 sea cucumbers were seized. In contrast, seizures in recent years declined, totaling 460 in 2005 and 1,406 in 2006.

Figure 1. Seizures of illegally harvested sea cucumber *Isostichopus fuscus* carried out by the GNPS, 1996-2006. No data are available for 2000



Source: Marine Control and Surveillance Unit databases, GNPS.

However, this reduction in seizures may be due to two reasons. Firstly, the collapse of *I. fuscus* populations led to merchants seeking out new areas; some merchants who used to purchase sea cucumbers in Galapagos are now known to buy *Holothuria atra* (another species of sea cucumber) in Nicaragua. Alternatively, over half the GNPS fleet was out of commission in 2006, resulting in a major decrease in patrolling efficiency and a subsequent decrease in seizures.

On the other hand, illegal harvests of another sea cucumber species, *Stichopus horrens*, known locally as *"cachudo"* (horned), has been detected since 2004, in both the central areas near Santiago and in Cartago Bay in Isabela (Table 2). This illegal fishery began due to the collapse of the *I. fuscus* populations (see the article in this report: "Declining profitability of fisheries in the Galapagos Marine Reserve").

Recently, the GNPS has detected the illegal harvesting of a third species of sea cucumber, *Holothuria atra*, which is a protected species in the GMR but is fished currently in Nicaragua. The first seizure of this species occurred on 12 January 2007. GNPS personnel and members of the Navy onboard the launch *Speed*, based at the Tiburón Martillo floating base, found an illegal campsite in the south of Isabela, designated "Santa Rosa," with 18,788 specimens of this species. Harvesting this species highlights the decline of the more commercially valuable *I. fuscus* population to the point that the black market for sea cucumbers is now accepting species of lower nutritional and economic value because of their greater abundance in the area.

Table 2. Seizures of illegally harvested *Stichopus horrens* by the GNPS, 2004-06.

Year	Units
2004	20,448
2005	20,168
2006	33,580
Total	**74,196**

Source: Marine Control and Surveillance Unit databases, GNPS.

Seizures of shark fins

Between 1989 and 2006 there have been 63 recorded seizures of sharks or shark fins in the GMR, carried out by ocean-going and coastal patrol vessels of the GNPS and Navy (see annex). The confiscated fishing equipment included nets, longlines, and purse seines. Since 1997, 22,727 shark fins and 686 shark bodies of various species have been impounded, resulting in an estimate of at least 5,000 coastal and pelagic sharks harvested in the GMR during the past nine years. These figures obviously do not include undetected illegal activities. In 2005, the Environmental Justice Foundation estimated that, in some parts of the world, illegal, unregulated, and unreported fishing made up a third of all catches.[2]

> During the last nine years, an estimated 5,000 coastal and pelagic sharks were harvested in the GMR, based only on those that were impounded.

Half of all seizures were carried out directly on vessels intercepted at sea, 19% at landing sites, and 14% at airports and on cargo ships.

Patrolling in the GMR and capture of industrial fishing vessels

In 1996, there were 42 sightings and captures of tuna vessels. In 2001, 20 vessels were captured, 19 of which were industrial fishing boats, with the majority (13) from the port of Manta on mainland Ecuador. Over the last three years however, the number of industrial vessels entering the GMR has declined, due to the increase in patrol vessels, air patrols by the Sea Wolf, and the enforcement of GNPS sanctions, including successfully auctioning off several impounded vessels (Table 3).

In 2002, seven industrial fishing vessels from continental Ecuador (Manta) were captured. The majority of sightings (72%) were off the coast of Española and to the south of Floreana, while 28% were northwest of Pinta and southwest of Fernandina. Nearly all these vessels were equipped with longlines (Table 3). In 2003, three of the seven vessels sighted escaped capture by GNPS launches, either because no members of the Navy were onboard at the time or because they escaped after pursuit by Park vessels. The remaining industrial fishing boats were detained and taken to the closest port to begin administrative actions (Table 4).

Table 3. Tuna fishing and longline vessels observed or captured in the GMR, 1996-2004.

Year	Tuna Boats	Longliners	Total No. of Sightings
1996	42		42
1997	40		40
1998	37		37
1999	3	2	5
2000	8	2	10
2001	3	17	20
2002	1	6	7
2003	2	5	7
2004	3	9	12

Source: Marine Control and Surveillance Unit databases, GNPS.

Table 4. Register of industrial vessels that have been captured while fishing in the Galapagos Marine Reserve, 2002-04.

Name	Port of Origin	Position	Date	Fishing Method	Infraction
B/P Abraham III	Ecuador	S 01° 21' W 091° 31'	08-mar-02	Longline	Illegal entry
B/P Sarita	Ecuador	S 01° 45' W 090° 07'	21-mar-02	Longline	Industrial fishing
B/P El Dorado	Ecuador	S 01° 36' W 090° 03'	31-mar-02	Purse Seine	Industrial fishing
B/P Sergio Gustavo	Ecuador	N 00° 38' W 092° 21'	30-jul-02	Longline	Industrial fishing
B/P Piliman	Ecuador	S 00° 58' W 089° 58'	13-aug-02	Longline	Industrial fishing
B/P Siempre Angelito VI	Ecuador	S 01° 51' W 090° 00'	06-sept-02	Longline	Illegal entry
B/P Adonai IX	Ecuador	S 00° 27' W 092° 21'	02-oct-02	Longline	Industrial fishing
B/P Don Daniel	Costa Rica	Pinta	17-jan-03	Longline	Industrial fishing
B/P Don Jhonny	Costa Rica	S 00° 052' W 091° 58'	06-feb-03	Longline	Illegal entry
F/M Industrial	Ecuador	S 01° 51' W 090° 02'	19-feb-03	Longline	Industrial fishing
B/P Adonay V	Ecuador	S 01° 40' W 090° 45'	19-mar-04	Longline	Industrial fishing
Industrial boat	No registration	Caleta Iguana	26-jun-03	Longline	Industrial fishing
B/P Mirian D	Ecuador	S 01° 59' W 092° 03'	16-aug-03	Purse Seine	Illegal entry
B/P Angel III	Ecuador	South of Fernandina	03-oct-04	Longline	Industrial fishing
B/P Don Antonio	Unknown	N 00º 37’ W 092º 16’	17-oct-04	Purse Seine	Illegal entry

Source: Marine Control and Surveillance Unit databases, GNPS.

The problem of sanctions

Before the creation of the GMR, fisheries were managed and controlled by the Fisheries Sub-Secretary, with policies and regulations introduced via Administrative Resolutions from that office. Since the creation of the GMR, the Reserve and fisheries have been managed by a participatory system consisting of a Participatory Management Board (PMB) of the users of the GMR, and the Inter-institutional Management Authority (IMA), the highest decision-making body for the GMR, consisting of ministerial delegates. The role of the GNPS in this system is to administer and manage the human uses of the protected areas, including tourism and fishing.

Despite a good infrastructure for marine control and surveillance in the GNPS, there remains a major shortage of crew to operate the vessels. However, since 1997, the institution has been relatively successful in detecting illegal activities related to fishing, both in coastal and pelagic areas. This is worthy of mention, because the law has been applied rigorously regarding industrial vessels, including impoundment and sale of vessels, as in the case of the ADONAY V from Manta, the INDIO from Costa Rica, and several other fiberglass vessels.

Strengthening the legal system, improving coordination of both internal and external mechanisms, and implementing sanctions are all vital to improving the efficiency of fishery control in the GMR.

Even so, this success has not been reflected in the number and type of sanctions imposed against local fishers, which have tended to be very weak. In 2001-02, the average fine for a local fisher was $214, and officials were unable to collect 48% of the fines issued.[3]

In 2006, the GNPS hired three lawyers to strengthen its legal department and this decision is beginning to show positive results. Since then, several fishers have received the maximum fine of $4,000 and their actions have been classified as serious offences in the GNPS Fishing Register. According to Article 36 of the Special Regulations for Artisanal Fishing in the GMR[4], fishing licenses will not be granted or renewed for any fishers who have three registered offenses classified as serious or very serious.

Steps towards strengthening control

The most alarming fishing practice in the GMR is shark finning. Sharks are protected in GMR waters and are symbols of the marine biodiversity of Galapagos. On a national level, shark finning and the sale and export of shark fins were banned in 2005. However, this law is being questioned in continental Ecuador not only by fishers, but primarily by merchants who continue to finance and encourage this illegal activity.

Finally, it is worth reflecting on measures needed to improve fishery control efficiency in the GMR. Firstly, the GNPS must continue to strengthen its legal department, and must place legal experts at its technical offices on Isabela and San Cristóbal, where over two-thirds of the fishers are based. At the same time, inter-departmental coordination must be strengthened so that legal experts are fully aware of the most fragile ecosystems and the species that are protected, overexploited, and illegally harvested. This will allow them to demand stronger sanctions against violators and ensure that administrative processes are carried out with greater justice and equity according to the infractions committed.

On the other hand, it is worth mentioning that inter-institutional coordination for the control of the GMR has improved greatly with the arrival of Navy personnel from continental Ecuador to work directly with the Marine Control and Surveillance Unit of the GNPS. It is hoped that this efficient and effective relationship will continue for the good of Galapagos. However, the Ecuadorian Government must be urged to hire more park wardens for the GMR. Additional personnel are desperately needed due to the increase in control and monitoring activities and in the GNPS fleet size over the last five years, during which time crew numbers have been insufficient.

In 2007, the GNPS is slowly putting into operation some of the vessels that were damaged and out of commission in 2006. These added vessels will increase the number of days of patrolling effort and improve the overall efficiency of the GMR control system. It is also important to improve the control and surveillance databases so that marine control efficiency can be properly evaluated. For example, on-going evaluation of indicators, such as the number of infractions detected per distance covered or amount of fuel consumed and park ranger efficiency, are needed. These indicators should be included in the new reports that are being designed as part of the restructuring of the database systems of the Marine Control and Fisheries Monitoring Units in the second half of 2007.

Annex. Sharks and shark products seized in the Galapagos Marine Reserve since 1989.

Date	Place	Vessel	Fishing Gear	Fins/Sharks
1989	Santa Cruz	S/A	Hooks	Galapagos sharks & fins
1989	Darwin Bay	S/A	Net	9 sharks
1989	Fernandina	Shoki Maru	Longline	Fins
1989	Darwin Bay	Sta. Fé	Net 100 yard	4 hammerheads
1989	S/A	Tenju Maru	S/A	Galapagos sharks & hammerheads
1989	S/A	Aleta Amarilla II	Hooks	Sharks
1997	Tortuga Bay	S/A	S/A	5 white tipped reef sharks
1997	Baltra Airport	S/A	S/A	57 fins
1997	Baltra Airport	S/A	S/A	85 fins
1997	Baltra Airport	S/A	S/A	83 fins (15 kg)
1998	S/A	Niño Dios	S/A	8000 fins
1999	Isabela & Fernandina	Cash Flow	S/A	Many sharks
1999	Southwest Isabela	Don Alvaro	Purse seine	2 whale sharks
1999	Isabela, Darwin & Wolf	Mary Cody	Longline	Many sharks
1999	S/A	S/A	S/A	249 fins, 213 lb meat, & 4 blue sharks
1999	S/A	S/A	S/A	15 sharks
1999	S/A	S/A	S/A	80-100 fins
2000	Bartolomé	S/A	Longline 200 m with 18 hooks	Sharks
2000	S/A	S/A	S/A	38 fins
2000	S/A	S/A	S/A	208 fins
2000	S/A	S/A	S/A	24 fins
2000	San Cristóbal	S/A	Longline	7 sharks
2000	S/A	S/A	S/A	440 fins
2000	S/A	S/A	S/A	2 sacks of meat and fins
2000	S/A	S/A	S/A	278 fins
2000	Genovesa	S/A	S/A	7 Galapagos sharks
2001	15 miles south of Isabela	B/P Dilsun	Longline	350 carcasses, 16 sacks of fins (1200 units) & 3 sacks of fillets
2001	18 miles east of Wolf	B/P Ma Canela II	Longline	78 carcasses, 2 sacks with livers & 1044 fins
2001	Baltra Airport	S/A	S/A	226 fins
2001	Villamil Airport	S/A	S/A	192 fins
2001	Guayaquil Airport	S/A	S/A	67 fins
2001	San Cristóbal Airport	S/A	S/A	161 fins
2001	Cargo Ship	Paola	S/A	300 fins
2001	Cargo Ship Marina 91	S/A	S/A	30 sacks (fillets)
2001	Darwin Arch	Indio I	Longline	119 carcasses & 856 fins
2001	Darwin Arch	Calima	Longline	1 carcass of thresher shark
2001	West of Floreana	Cruz Araceli	Longline	10 sharks
2002	S/A	Sarita	S/A	1 shark

Annex. Sharks and shark products seized in the Galapagos Marine Reserve since 1989.

Date	Place	Vessel	Fishing Gear	Fins/Sharks
2002	S/A	Sarita	S/A	1 shark
2002	S/A	Junior	S/A	Sharks
2002	S/A	Ananias	S/A	72 fins
2002	S/A	A. León	S/A	70 fins
2002	S/A	Poclay	S/A	50 fins
2002	Private car in Santa Rosa	S/A	S/A	303 fins
2002	Cartago, Isabela	Mercedes	Unattended net	37 fins
2003	Pinta	B/P Don Daniel (Costa Rica)	Longline	3 sharks (*Alopias* spp)
2003	Pinzón	F/M Cristel F/M Hno. Gregorio II F/M Soledad (Galapagos artisanal vessels)	Net	124 fins
2003	01º 51.623 S 090º 2.097 W	S/A	Longline	8 sharks
2003	Isabela (Punta Moreno)	Isabela artisanal vessels	Net	2 sharks
2003	Wolf	Galapagos artisanal vessels	Net	30 sharks
2003	Isabela	Galapagos artisanal vessels	S/A	4147 fins
2003	Bajo 90º Seamount	B/P Adionay V (F/M Siempre Carmelita, F/M Mari Luna) Pto. Manta	Longline	3 sharks (*Carcharinus falcformis*)
2003	Caamaño	Galapagos artisanal vessels	Net	46 fins, abandoned at the islet
2003	Puerto Villamil	Shark fin transport "F/M Canaima XI"	S/A	815 fins
2003	Puerto Baquerizo Moreno	Shark fin transport "M/N Virgen de Monserrate"	S/A	211 fins
2003	Darwin Arch	S/A	Net	1 shark
2004	Isabela (Cartago)	S/A	Net	409 fins
2004	Puerto Villamil	F/M Valentin (Isabela)	S/A	10 fins
2004	Puerto Villamil	Shark fin transport on the logistics flight of the Air Force by fisherman Oscar Flor	S/A	538 fins

Annex. Sharks and shark products seized in the Galapagos Marine Reserve since 1989.

Date	Place	Vessel	Fishing Gear	Fins/Sharks
2004	Puerto Villamil	Shark fin transport	S/A	1344 fins
2004	Puerto Villamil	S/A	S/A	15 fins
2004	Puerto Villamil	2 crates belonging to Sr. Andrés Palacios Lucio	S/A	52 fins
2004	Hancock Banks, northeast of Floreana	B/P Gregorio IV, with 5 launches from Pto. Manta) Vivianita, César Augusto, Gigi, Gigi Yael and San Ignacio	Longline	22 Galapagos sharks
2005	Puerto Villamil	F/M Blue Shark (Galapagos artisanal vessel)	Longline	10 fins
2005	Onboard vessel	Expedition (Tour boat)	S/A	4 juvenile sharks
2005		F7M Hermano Gregorio (Isabela)	Seine	14 sharks
2005	Puerto Villamil	Shark fin transport on the logistics flight of the Air Force by fisherman Sr. Andrés Patricio Lucio Bernaldino	S/A	52 inferior lobules of the caudal fin
2006	Puerto Baquerizo Moreno	Transport of shark fins on cargo boat "M/N Virgen de Monserrate"	Longline	16 sharks

Tourism in Galapagos: a strong growth trend[1]

María Eugenia Proaño[a,b] & Bruce Epler[a]

[a]CDF Consultant, [b] Consultant, GEF Invasive Species Control Project

The Galapagos Islands have experienced accelerated development driven by rapid growth in tourism and population. This rapid growth is increasingly putting a variety of strains on local resources and municipalities. The increased likelihood of introducing new invasive species, a result of population growth, has long-term implications for both conservation and human health. Key indicators for population and tourism in Galapagos confirm the rapid rate of growth (Table 1).

Tourism is closely related to population growth, creating higher demand for services and products, which in turn increases the risk of introducing invasive species.

Table 1. Key growth indicators for population and tourism in Galapagos.

Average annual population growth rate (1990-1998)	6.4 %
Average annual increase in visitors (1981-2005)	9 %
Average annual increase in hotel beds (1991-2005)	4.8 %
Average annual increase in vessel berths (1991-2005)	72 %
Average annual rate of growth in tourism (1990-2005)	14 %

Source: Epler, 2007[1]

Note:

* Number of vessel berths equals the total number of legal berths as defined in tourism permits issued by the Galapagos National Park.

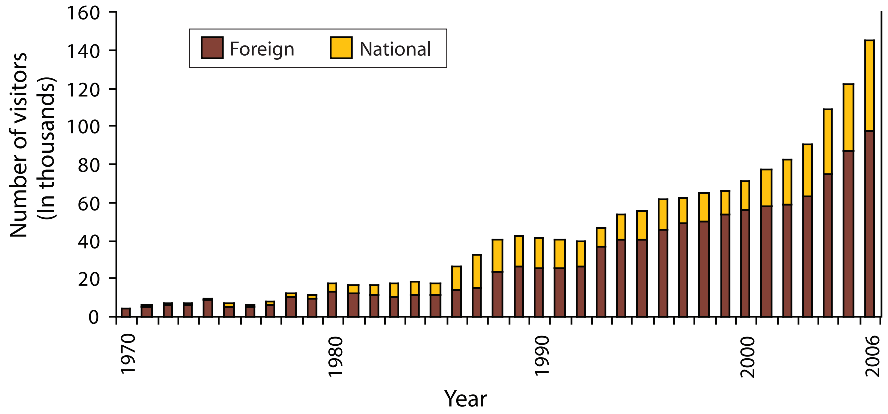
One of the highest growth rates in South America

From 2005 to 2006, Galapagos experienced a 13.1% growth in the number of international visitors. This is much higher than the average for South America (3.0%) and is in striking contrast to the decline in the number of international visitors to the country of Ecuador (-2.2%)[2]. The only countries in the Americas with a higher percent increase in international visitors than the Galapagos National Park were Panama (20.1%), El Salvador (17.4%), Guatemala (14.2%), and Jamaica (13.5%).[2]

How many tourists arrive each year?

The annual number of tourists visiting Galapagos has risen from approximately 18,000 in 1985, to 41,000 in 1990, to nearly 72,000 in 2000, to almost double that in 2006 (Fig. 1). The annual growth rate in the number of tourists from 2000 to 2006 was 14%[3]. If that rate continues, there will be more than 500,000 tourists visiting Galapagos ten years from now.

Figure 1. Number of visitors to the Galapagos National Park, 1970-2006



Source: Galapagos National Park database

Santa Cruz: the center of development

Between 1974 and 1980, tourism began to expand in earnest. The industry was clearly the driving force behind an emerging economy and its growth began to dictate the rate and types of change that occurred in Galapagos. Santa Cruz quickly blossomed into the industry hub due to its geographic location near the center of the archipelago, its proximity to the airport on Baltra, and the presence of the Charles Darwin Research Station and the headquarters of the Galapagos National Park.

The "floating hotel" model of tourism advocated by conservationists prevailed. Tourists were housed on vessels and were allowed relatively brief visits to designated sites within the National Park, accompanied by knowledgeable, trained guides; a practice that continues today. Commercial flights to Galapagos began in 1963, and for many years there were no more than two flights per week. Today there are as many as seven flights per day.

Astute entrepreneurs began to offer a wider range of services catering to more diverse income groups. Greater emphasis was placed on expanding land-based facilities rather than on the more expensive and ecologically sensitive "floating hotel" model of tourism. New tourist-related activities, such as bay and snorkeling tours, kayaking, land-based diving, visits to the highlands, camping, and horseback riding, were developed based on market demand, with little or no planning. Revenues from tourism finally began to fill the pockets of resident entrepreneurs. This transition triggered the economic boom that many residents had long sought and others had feared.

The annual growth rate in the number of tourists from 2000 to 2006 was 14%. If that rate continues, there will be more than 500,000 tourists visiting Galapagos ten years from now.

Tourism on San Cristóbal

Prior to tourism, San Cristóbal, the provincial capital, boasted 49% of the archipelago's inhabitants. Government and fisheries were the main economic activities. In the 1970s, when Santa Cruz emerged as the center of tourism, its population surpassed that of San Cristóbal. With the construction of the airport near the port town of Puerto Baquerizo Moreno in 1986, funds started to flow into building new hotels, tourist shops, restaurants, a museum, and better infrastructure. Within a few years of the opening of the airport, tourism replaced government as the largest employer. Fearing that land would be bought up and developed by outsiders, the municipality and townspeople called for tourism with a local base. However, by the late 1990s, the growth rate of San Cristóbal's economy began to fizzle, while Santa Cruz continued to thrive.

Tourism on Isabela and Floreana

Isabela and Floreana have the smallest populations and, until recently, had little involvement with tourism. Isabela's population was mainly involved in fishing and farming. There were no significant attempts to develop tourism there until the 1990s. Since then tourism infrastructure projects have been undertaken and local residents have begun to receive training for work in tourism. A third airport capable of handling small planes that fly between the islands was inaugurated on Isabela in 1996. Its impact on local tourism was minimal. However, life on the island may change when the recently renovated airport finally meets all of the technical requirements for commercial flights from the continent. Details and dates are as yet unclear, but it is expected that small 50-70-passenger airplanes will begin scheduled flights between the mainland and Isabela, perhaps as soon as 2008.

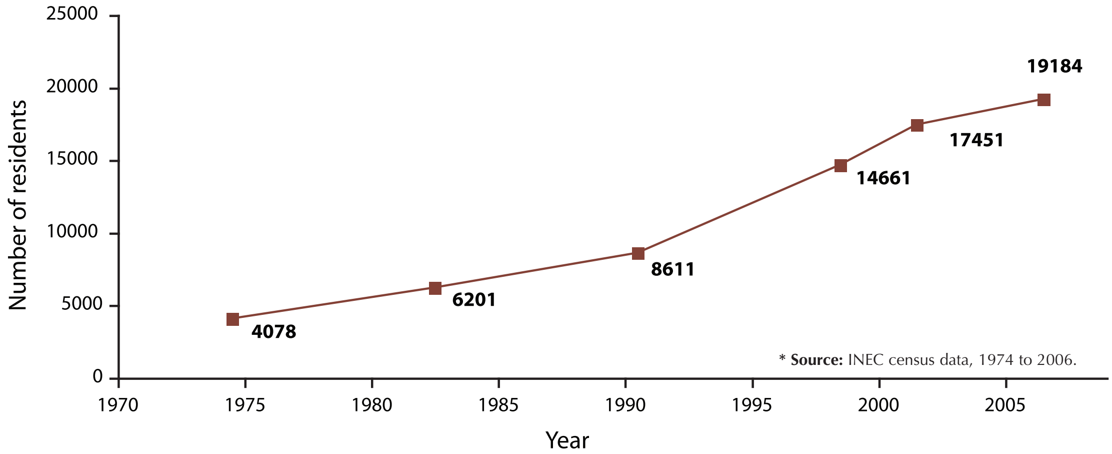
Isabela has the richest natural endowment of any of the inhabited islands and therefore the greatest potential for land-based tourism. There is speculation and concern that the island will become a major tourism hub.

The economy of Floreana is still reliant on small-scale agriculture, but some residents are linking development to tourism. It seems highly unlikely that the island will escape the trends occurring elsewhere, even if the citizenry prefers to limit growth.

A constantly growing population

Rapid and sustained population growth in Galapagos, beginning in the 1970s, was primarily driven by the inflow of tourism dollars that attracted Ecuadorian immigrants. However, extenuating circumstances, such as a meltdown of the national economy and political turmoil during the 1980s and 1990s, also motivated the influx of Ecuadorians from the mainland. According to the National Institute of Statistics and Censuses (INEC), the resident population of Galapagos has quadrupled over the last 30 years, from 4078 in 1974 to 19,184 in 2006. From 1990 to 1998, the average rate of population growth in the Galapagos was an alarming 6.4% per year, three times greater than in mainland Ecuador, where the growth rate was 2.1%. If temporary and clandestine workers from the continent that also reside in the islands are included, the overall annual rate of population growth would approach or exceed 8%. If a growth rate of 6.4% or more continues, the population will double at least every 11 years (Fig. 2).

Figure 2. Population growth in Galapagos, 1974-2006*



*** Source:** INEC census data, 1974 to 2006.

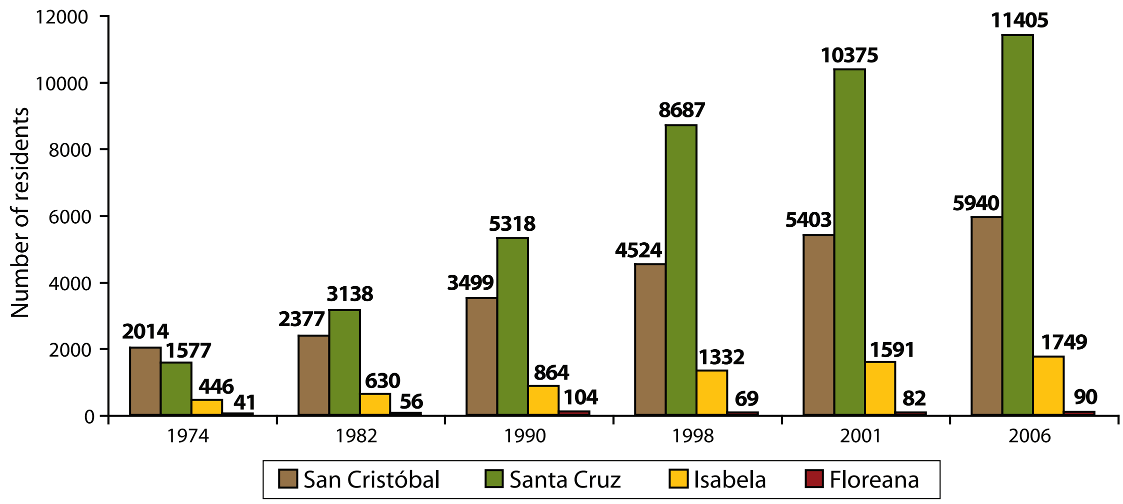
Note:

The official census data from INEC up to 2006 reflect only the resident population of Galapagos. The nature of the population censuses of Galapagos has varied over the years; this should be carefully considered in any analysis.

Each of the four inhabited islands has fared differently. Their economies, population growth rates (Fig. 3), and standards of living are directly correlated with the number of tourists that visit them.

From 1990 to 1998, the number of Galapagos residents grew by an alarming 6.4% per year. At this growth rate, the population will double every 11 years.

Figure 3. Comparative population growth on the populated islands of Galapagos, 1974-2006



Source: INEC census data, 1974 to 2006.

Is there an end to growth?

Due to the fame earned by Galapagos as an ecotourism and diving destination, tourism in the islands continues to grow. In 1980, despite official guidelines recommending that the number of tourists be restricted to 12,000 per year, 18,000 entered the Park. A government commission evaluated the situation and concluded that the limit should be raised to 25,000. Despite some years of decreased tourism due to an unfavorable national or international environment, the overall trend has continued to increase and attempts to set an annual limit on the number of tourists have been abandoned.

Growth in tourism generates more sources of employment and prosperity, and this boom attracts more immigrants and produces a greater demand for food and other supplies, which swells the volume of cargo arriving in Galapagos. Increasing the number of residents and tourists and the amount of cargo increases the risk of introduction of exotic species, with the potential to cause major problems for both human health and the biodiversity of the archipelago.

The challenge

Over the last three decades, Galapagos has become one of the world's most famous ecotourism destinations. Improved means of transportation, communication, infrastructure, and healthcare, as well as socioeconomic conditions, are directly due to the tourism industry and all benefit local residents. Since it was created, the Galapagos National Park has provided over 1.5 million visitors the singular experience of enjoying the natural wonders that only Galapagos can provide.

For more than four decades, managers, scientists, and officials in Galapagos have worked hard to balance opposing mandates in one of the most important ecosystems on Earth. There has been a long series of successful initiatives that have improved the management of the National Park and Marine Reserve, protected the unique biodiversity of the archipelago, and enhanced the socioeconomic well-being of Ecuadorians living on the islands and mainland. This has helped Galapagos to maintain more than 95% of its biodiversity intact. However, the methods used to date will not be sufficient to maintain that diversity in the future.

Ecotourism as defined by the World Conservation Union (IUCN, 1997) is "environmentally responsible travel and visitation to natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features, both past and present), that promote conservation, have a low visitor impact, and provide for beneficially active socioeconomic involvement of local people." If one looks solely at the direct impact of visitors on visitor sites in Galapagos, one would be hard pressed to find other areas where the objectives of ecotourism have been so successfully achieved. However, the widening impacts of tourism on population growth, development, the resulting increase in introduced species, and nearly all aspects of life in the Galapagos Islands are growing concerns.

Tourism and population are intertwined. The annual growth rate in the number of tourists from 2000 to 2006 was 14%. If that rate continues, there will be more than 500,000 tourists visiting Galapagos ten years from now. The municipalities must be forward-looking. Unlike the Park Service, they have not yet considered establishing limits to growth despite their burgeoning populations. If the 6.4% per year increase in population continues, by 2030, the population in Galapagos will reach 118,000. The population density in settled areas will be 500 inhabitants/km^2 and many times that in the coastal towns. These numbers will lead to greater, more intense issues and conflicts.

These are the challenges facing Galapagos. A major management issue for the new millennium and one that complicates conservation worldwide is how to balance the trade-offs between environmental protection and socioeconomic development that will in turn enhance the well-being of citizens. Better planning is key to achieving such a balance. The archipelago must be managed in its entirety, not on a component basis made up of the National Park, the Marine Reserve, and the four inhabited islands. Each component is inter-connected. Biological and socioeconomic factors must be incorporated into a comprehensive management plan that will ensure the sustainability of the unique biodiversity and the local communities.

The future challenge is to find a formula to control tourism and population growth that will ensure sustainable and equitable development and conservation of the biodiversity of Galapagos.

How many tourists can Galapagos accomodate?[1]

Bruce Epler[a] & María Eugenia Proaño[a]

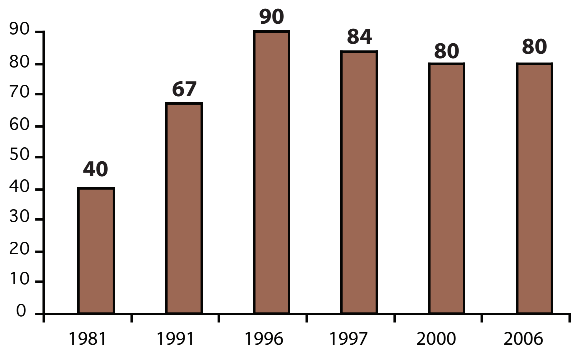
[a]Consultants, Charles Darwin Foundation

Development of tourism in the Galapagos Islands began in earnest in the 1970s, when a few boats offered cruises through the islands and construction of hotels began on land. Since then, a fleet of vessels and hotel infrastructure were developed to provide services for tourists with a range of requirements and budgets.

The Tourist Fleet

By 1981, the tourist fleet had grown to 40 vessels capable of accommodating approximately 600 passengers (Fig. 1). The fleet increased to 67 vessels by 1991, then peaked in 1996 at 90 vessels, and subsequently decreased to 80 vessels and has remained relatively stable in recent years. While the number of vessels doubled between 1981 and 2006, passenger capacity more than tripled, from 597 to 1,805 (Fig. 2).

Figure 1. Number of tourist vessels, 1981-2006*

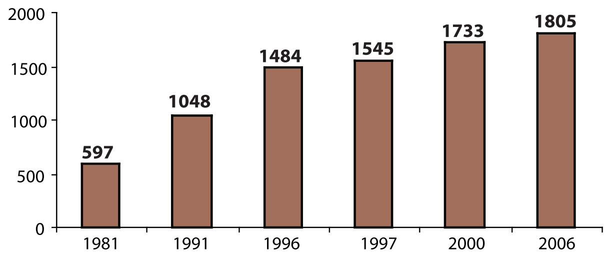


Source: Epler 1993[2], GNP database.

Note:

* The number of boats in 2006 is updated to May of that year, according to GNP records delivered to the author at that time.

Figure 2. Total on-board capacity, 1981-2006



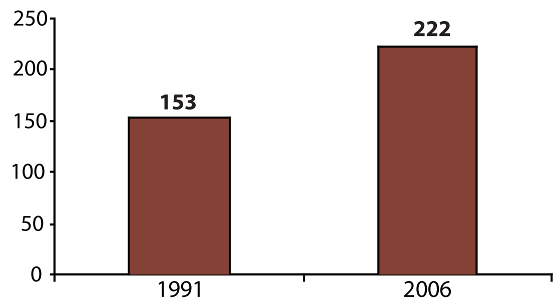
Source: Epler 1993[2], GNP database.

The greater increase in passenger capacity is explained by the fact that the capacity/vessel increased by 50% between 1981 and 2006, from an average of 14.9 passengers per vessel to an average of 22.5.

While vessel capacity increased 3-fold from 1981 to 2006, a result of the increase in average capacity per vessel and the number of vessels, the number of recorded visitors increased 8.5-fold, from 16,265 to 140,000. Profit-minded tour operators achieved this growth by: 1) increasing the number of cruises per year and thus the number of days that their vessels spent at sea; 2) increasing the occupancy rate/cruise, and 3) converting vessels that offered 1-day tours ("day boats") to those that offer live-aboard, multiple-day and week-long tours. Currently, boats operate more days per year, averaging 69 days more at sea than in 1991 (Fig. 3)[1].

A consequence of this increase in the number of days at sea is the 150% increase in the total annual number of passenger-nights, from 145,408 in 1991 to 363,226 in 2006[1] (Table 1).

Figure 3. Average number of days at sea per vessel, 1991 and 2006



Source: Epler 1993[2], GNP database.

> Over the past 15 years, passenger capacity has increased by 76% and the number of days at sea by 66%, while the average number of days at sea per vessel increased by 45%.

Table 1. Changes in fleet structure and performance, 1991 to 2006.

	1991	2006	% change
Number of vessels	67	80*	19
Total passenger capacity	1,026	1,805	76
Total days at sea	10,710	17,750	66
Average number of days at sea/vessel/year	153	222	45
Total passenger-nights per year**	145,408	363,226	150
Total number of visitors	40,746	140,000	201

Source: Epler 1993[2], GNP database and data from the Puerto Ayora Authority.

Notes:

* The number of vessels in 2006 is updated to May of that year according to GNP records delivered to the author at that time. The eight largest craft include 3 with 100-passenger capacity, 1 with 90, 1 with 80, 1 with 48, and 2 with 40.
** Total passenger-nights is the average number of days per passenger times the total number of passengers in a given year.

Vessel licenses and owners

To conduct tourism activities in the archipelago, boat owners must be licensed by the Galapagos National Park Service (GNPS). The license consists of a quota that the GNPS grants an individual, family, or company, allowing a designated number of passengers per cruise. With continued growth in Galapagos tourism, the GNPS granted new licenses to satisfy demand.

As of May 2006, 8 of the 80 vessels in the Galapagos tourist fleet were large 40- to 100-passenger vessels, which operate more efficiently than the smaller vessels (Table 2). Their average potential capacity is 76 passengers per night. The 72 remaining vessels have capacities ranging from 10 to 20, with most having 16, and an overall average of 17 passengers per night.

Although the larger vessels account for only 34% of the total passenger capacity, they spend a little over 50% more days at sea and have higher rates of occupancy per cruise. Consequently, the larger vessels account for approximately 46% of all annual vessel-occupancy-days.

As of May 2006, the 8 largest of the 80 tourist vessels account for 34% of total onboard capacity, but through higher occupancy rates and more days at sea, they account for approximately 46% of the annual total number of passenger-days.

Table 2. Fleet operation summary by vessel class (June 2005 to May 2006).

	Large Vessels	Other Vessels	Total
Number of vessels	8*	72*	**80**
Passenger capacity	606	1,199	**1,805**
Average capacity per vessel	76	17	**22,6**
Percent of total capacity	34%	66%	**100%**
Percent of foreigners on board	93.6%	90%	**91.8%**
Percent of Ecuadorians on board	6.4%	10%	**8.2%**
Average number of days at sea per vessel per year	321	211	**222****
Average occupancy per vessel	87%	78%	**81%****
Percent of total passenger-nights **	45.6%	54.4%	**100%**

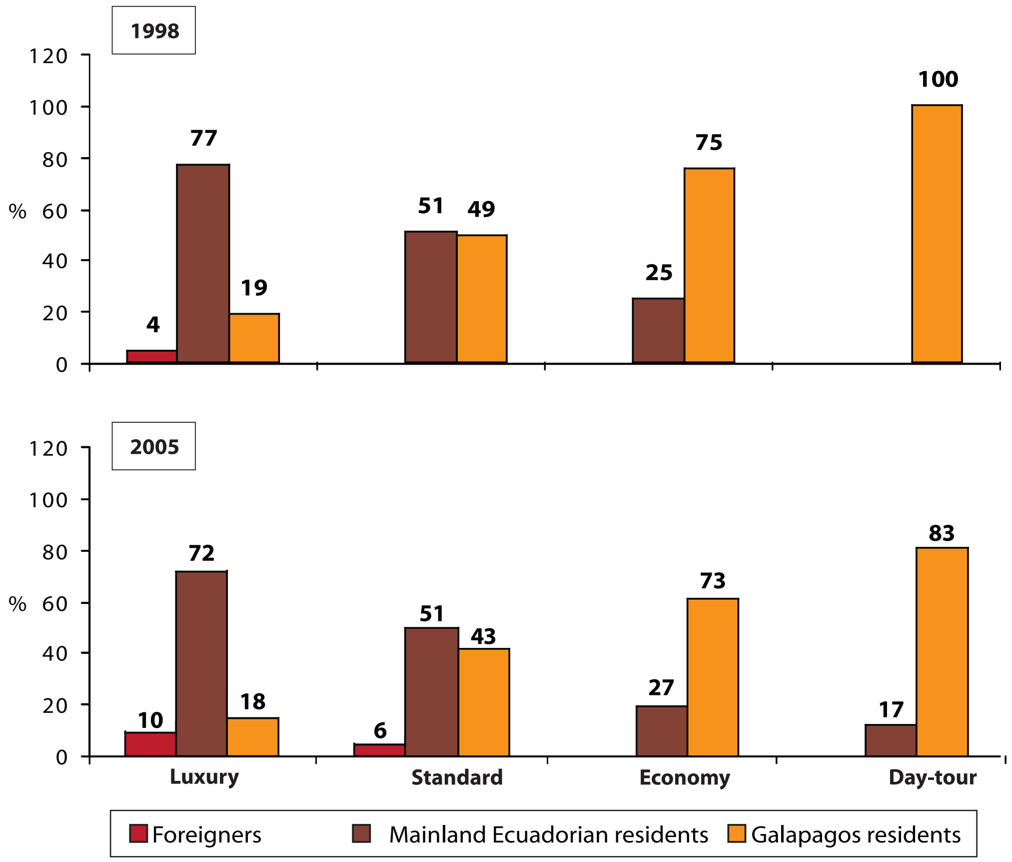
Source: Epler 1993[2], GNP database and data from the Puerto Ayora Authority.

Notes:

* The number of boats in 2006 is updated to May of that year. The 8 largest vessels include 3 with 100-passenger capacity, 1 with 90, 1 with 80, 1 with 48, and 2 with 40.
**Estimates are weighted to reflect the fact that 10% are high-capacity vessels and 90% are smaller vessels.

As of May 2006, 45 individuals, companies, or families owned the 80 tour vessels operating in Galapagos, including luxury, standard, economy, and day-tour vessels (Fig. 4). Between 1998 and 2005, the percentage of the fleet owned by both mainland and local residents decreased slightly, while foreign ownership increased from 2.1% to 6.5% (Fig. 4). Also, the luxury and standard vessels owned by foreign investors tend to be large. If the number of legal berths is used as a measure, foreign ownership grew significantly more than identified above. This is contrary to the 1998 Special Law, which stipulates that new vessels be owned by island residents. At present, local operators represent 39% of licensed tourist vessels in Galapagos, but they are losing ground to international and mainland operators who are better equipped to access the competitive production chains of tourism.[3]

Figure 4. Ownership of tourism vessels by class and resident category in Galapagos in 1998 and 2005



Source: Taylor et al. 2006[3]

As of May 2006, 25 owners (57% of the total) possessed one vessel each and cumulatively controlled 33% of fleet capacity (Table 3). Ten possessed two vessels each and 25% of licensed capacity. Seven owners possessed three vessels each and 28% of all berths. Fourteen vessels and 15% of all berths are held by three companies, one of which owns six vessels (7% of total capacity).

Local operators represent 39% of licensed vessels in Galapagos.

Table 3. Distribution of ownership of tour vessels and overall capacity.*

	Own 1 vessel	Own 2 vessels	Own 3 vessels	Own 4 vessels	Own 6 vessels	TOTAL
Number of owners	25	10	7	2	1	**46**
Number of vessels	25	20	21	8	6	**80**
Percent of all owners	56%	22%	16%	4%	2%	**100%**
Number of berths	596	450	504	137	118	**1,805**
Percent of all berths	32%	25%	28%	8%	7%	**100**

Source: GNPS database, Epler 1993 and Epler 2007.

Hotel-based tourism

Hotel-based tourism infrastructure has grown as rapidly as the tourism fleet. In the last 15 years, the number of hotels and their capacity has doubled from 26 to 65 hotels and from 880 to 1668 beds[1]. The services provided by hotels and thus their clientele are more restricted than they are for vessels because they are unable to provide access to most visitor sites (both dive and land sites). Consequently, hotels provide services to a market segment with lower buying capacity, including backpackers and budget-conscious travelers.

Their growth has spawned the appearance of a number of diverse land-based operators that offer day tours to various parts of the island, bay tours, kayaking, day diving trips, etc. For example, during the span of time mentioned above, the number of restaurants and bars increased from 31 to 114[1]. Also, hotel owners are improving their accommodations and services to cater to higher income groups and linking stays in their hotel as add-on options to conventional seagoing cruises.

There is no evidence of horizontal integration of the hotel sector. Each hotel appears to belong to a separate owner. There is some vertical integration however, with at least five hotel owners also owning tourism boats.

The development of hotels and their success have differed on the four inhabited islands. Hotels on Santa Cruz have been much more successful than on the other islands. Prior to organized tourism, Puerto Ayora had only two or three hotels, the largest of which was the Hotel Galapagos. As tourism increased, Santa Cruz emerged as the economic and tourism hub of the archipelago. By 2006, its guest capacity was twice that of San Cristóbal (Table 4 and Fig. 5). However, San

Table 4. Land-based tourism infrastructure: 1982, 1991, and 2006.

	Tourist Infrastructure	1982	1991	2006
Santa Cruz	Number of hotels	12	16	28
	Hotel capacity	86	492	990
	Number of restaurants and bars*	8	16	61
San Cristóbal	Number of hotels	4	6	23
	Hotel capacity	82	315	449
	Number of restaurants and bars	9	9	35
Floreana	Number of hotels	1	1	1
	Hotel capacity	24	21	36
	Number of restaurants and bars	1	3	0
Isabela	Number of hotels	1	3	13
	Hotel capacity	22	52	193
	Number of restaurants and bars	2	2	18
TOTAL	Number of hotels	**18**	**26**	**65**
	Hotel capacity	**214**	**880**	**1668**
	Number of restaurants and bars	**20**	**31**	**114**

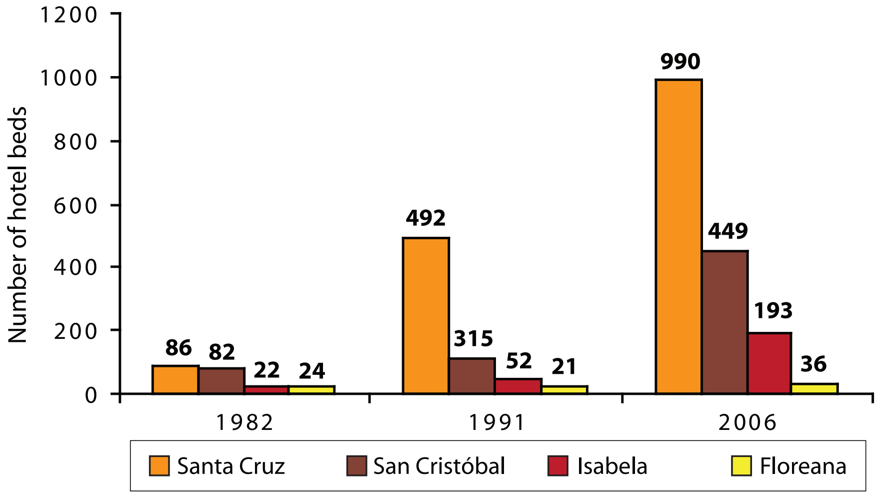
* This number does not include restaurants in hotels.

Source: CAPTURGAL, GNPS database, Epler 1993 and Epler 2007.

Note:

[1]The bed count in hotels assumes one guest per bed.

Figure 5. Hotel infrastructure by island: 1982, 1991, and 2006



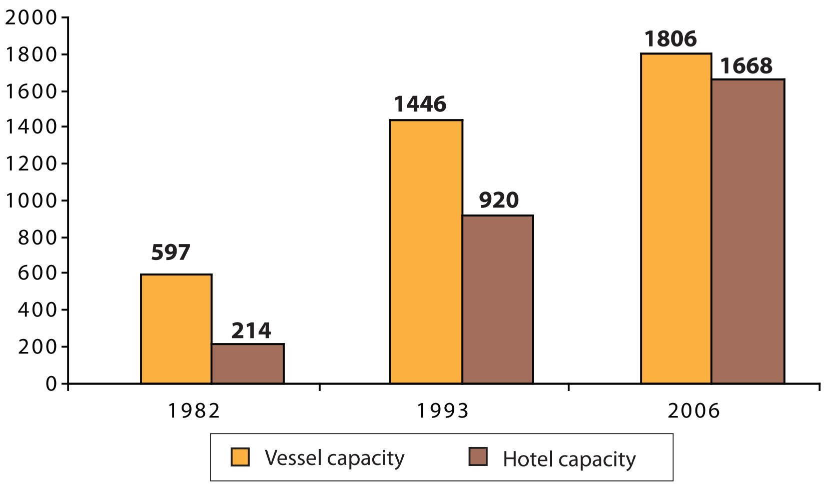
Source: GNPS database, Epler 1993 and Epler 2007.

Cristóbal and Isabela have also seen significant tourism growth in recent years, as reflected in the number of hotels and beds. Growth of the hotel infrastructure on Isabela has been striking: 1 hotel in 1982 compared to 13 hotels in 2006. One factor influencing this growth was the opening of a small airport in 1996, large enough for inter-island flights. New hotels have recently been constructed in anticipation of the renovation of the airstrip and the construction of an expanded air terminal with the capacity for commercial flights from the continent.

Total capacity: boats and hotels

Both vessel and hotel capacities have continually increased since the 1970s, when an emerging tourism industry spurred the initial development of the sector. In 1982, the combined capacity of hotels and vessels was 811, with 26% in hotels and 74% on vessels (Fig. 6). Capacity continued to expand on vessels and in hotels into the early 1990s, but the rate of growth in hotel capacity began to exceed that of vessels. Total guest capacity reached 2,366 per night in 1991, with

Figure 6. Tourist capacity of vessels and hotels: 1982, 1993, and 2006



Source: GNPS database, Epler 1993 and Epler 2007.

39% in hotels. From 1991 to 2006, the number of hotel beds increased by 90%, from 880 to 1,668, while there was only a 76% increase in the number of vessel berths (Tables 1 and 4).

The trend continues. As of 2006, Galapagos hotels and tour vessels could accommodate 3,479 persons per night, with hotels accounting for 49% of the total. The total number of hotel beds is expected to soon exceed the number of berths.

Conclusions

The tourism infrastructure in Galapagos is constantly expanding and diversifying. As tourist operators adapt to growing and changing demands, this trend will continue. Ownership and operating licenses have also shifted, with an increase in the number of vessels and hotels owned by non-Galapagos-resident Ecuadorians who now live in the islands and by the number of standard and luxury vessels owned by foreigners. Higher guest capacity in both hotels and vessels and a more diverse clientele have led to new trends and more alternatives, such as day tours, for those tourists on a tighter budget. Moreover, each island presents its own growth rate, infrastructure, level of involvement with tourism, and development path. Future planning for development in Galapagos must consider and evaluate the growth trends of the tourism sector in order to ensure a more coordinated and sustainable future for the archipelago.

From 1991 to 2006, the hotel capacity grew by approximately 4.8% per year. The total number of hotels in Galapagos increased by 150% and total guest capacity by 90%.

Tourism and the Galapagos economy[1]

Bruce Epler[a], Graham Watkins[b] & Susana Cárdenas[b]

[a]Consultant CDF, [b]Charles Darwin Foundation

Tourism is the main economic activity in Galapagos and contributes directly and indirectly to business development and population growth in the islands. It also triggers the largest, most complex distribution network for revenues generated in the archipelago. This article summarizes the main indicators and estimates of financial flows from tourism in Galapagos. These findings result from a broad-based study of the tourism economy in the islands, information available in prior economic studies, and field research conducted in 2006 (surveys with 960 visitors, interviews with tourism operators and institutions, archives, databases, and information from various sources related to Galapagos tourism).

Key growth indicators

Due to continued and growing interest in visiting the Galapagos, reflected in more visitors each year, the tourism infrastructure and services, including hotels, vessels, travel agencies, and associated services, have grown significantly in the last 15 years[1]. Total revenues from tourism have increased at a rate of 13% per year over the same period[2], directly driving the growth of the overall economy of Galapagos. Key indicators confirm the rapid rate of growth (Table 1).

> The economic growth rate for tourism in Galapagos during the last 15 years was 14% per year.

Table 1. Growth indicators for Galapagos tourism.

Average annual increase in visitors (1981-2005)	9%
Average annual increase in hotel beds (1991-2005)	4.8%
Percent increase in onboard capacity (1991-2005)	72%
Average annual increase in vessel revenues (including travel agency fees) (1991-2005)	14%
Average annual increase in hotel revenues (1991-2005)	14%
Average annual increase in total revenues from tourism (1991-2005/06)*	13%
Average annual population growth (1990-1998)	6.4%

Note:

*Based on Taylor et al., 2006[2]

Source: Epler 2007.

Estimated revenues from tourism

Vessels

From June 2005 through May 2006, Galapagos tourist vessels generated US$ 120.5 million in revenues, excluding travel agency fees (Table 2). The eight largest vessels brought in nearly $59.3 million or 49% of total revenue.

[1]For more details about increasing tourism supply and demand, see the articles on "How many tourists can Galapagos accommodate?" and "Tourism in the Galapagos: a strong growth trend" in this Report.

Table 2. Estimated prices and total revenues (US$) of Galapagos tourist vessels, June 2005 to May 2006.[1]

	Large vessels*	Other vessels	All vessels
Number of passenger-nights*	165,671	197,555	363,226
Average price per night*	$358**	$310**	$333**
Total revenues	$59,310,218	$61,242,050	$120,552,268
Percent of total revenues	49%	51%	100%

Notes:

Source: GNPS database & calculations in Epler 2007

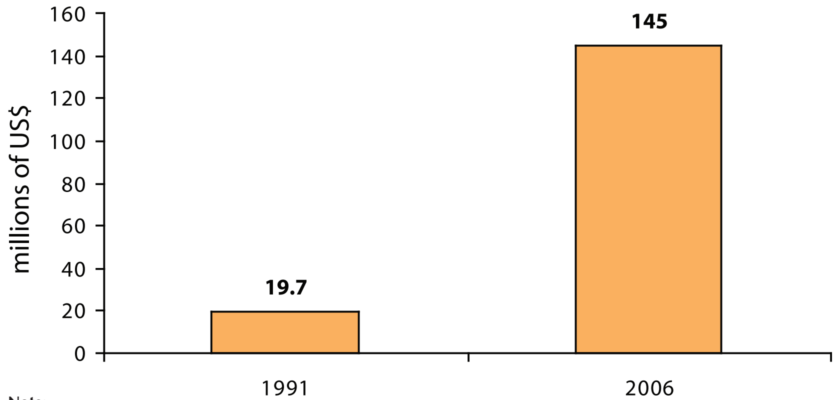
* The eight largest craft include 3 with 100-passenger capacity, 1 with 90, 1 with 80, 1 with 48, and 2 with 40.
** Average price excludes travel agency fees, estimated at 16.7% for this study.
\+ Total passenger-nights is the total number of nights in Galapagos for all visitors during a given period.

During the last 15 years, the average price per night for a cruise increased by over 190%, from US$135 to US$400 per night from 1991 to 2006.

Revenues received by the Galapagos tourist fleet, including travel agency fees, have multiplied nearly eight-fold over that period, from US$19.7 million in 1991 to US$145.5 million in 2006 (Fig. 1). Of the total revenues in 2006, travel agencies retained approximately $25 million, with $20 million going to overseas travel agencies and $5 million to Ecuadorian companies.

The economic growth rate for tourism in Galapagos during the last 15 years was 14% per year.

Figure 1. Increase in yearly revenues from tourist vessels, 1991 to 2006*



Note:

Source: Epler 2007.

*Revenue figures include travel agency fees.

Land-based tourism

The transition from the original model of cruise ships or “floating hotels” to more land-based tourism began in the late 1970s, when the port towns established themselves as tourist destinations. Since then, hotel capacity has grown significantly, at an average annual rate of **4.8%** from 1991 to 2006. This growth is reflected in increasing revenues for this sector.

Overall, Galapagos hotels had gross revenues of roughly US$10.7 million in 2006 (Table 3). This is significantly higher than the US$1.2 million estimated for this economic sector in 1991[3] (Fig. 2). From 1999 to 2006, the annual compounded growth in revenue of the hotel sector was slightly over 14%, similar to that of tourist vessels.

Table 3. Hotel room occupancy and revenues (US$) by island, 2006.

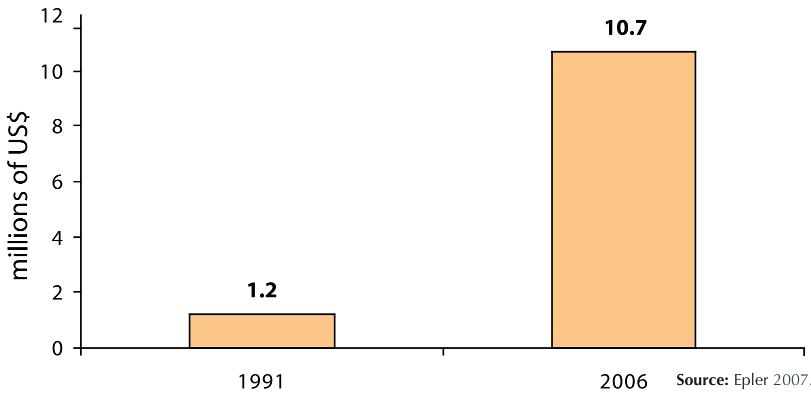
	Santa Cruz	San Cristóbal	Isabela & Floreana	TOTAL (weighted)
Number of rooms	431	217	109	757
Maximum possible occupancy (nights/year*)	57,315	79,205	39,785	276,305
Occupancy rate	70%	14%	31%	48%
Actual occupancy (nights/year)	110,120	11,089	12,333	131,958
Average weighted price per night**	$89.18	$43.62	$34.20	$68.25
Total estimated revenues	$9,820,501	$483,702	$421,789	$10,725,992

Source: Epler 2007.

Notes:

* The number of rooms multiplied by 365 days.
** The average weighted prices assume two people per room and reflect differences in prices paid by foreigners and Ecuadorians.

Figure 2. Increase in gross yearly revenues for hotels, 1991 and 2006

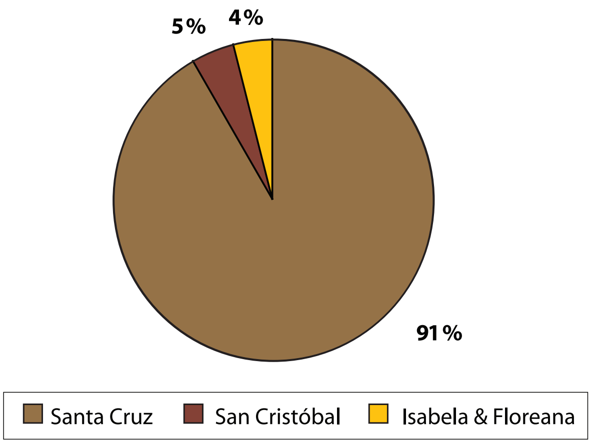


Source: Epler 2007.

The highest percentage of revenues generated by hotels in Galapagos is concentrated in Santa Cruz (91.6%) (Fig. 3). Santa Cruz is frequented by more visitors and has a greater number of hotel beds than the other islands. A comparison between San Cristóbal and Isabela Islands shows that Isabela has a higher rate of occupancy and length of stay even though it has half the number of beds. However, prices on Isabela are below those charged on San Cristóbal so the island's hotel revenues are lower.

Total annual hotel revenues in Galapagos have increased from US$1.2 million to US$10.7 million over the last 15 years.

Figure 3. Distribution of hotel revenues by island, 2006



Source: Epler 2007.

Although hotels have almost the same tourist capacity as vessels, their revenues equal about 10% of vessel revenues[1]. While hotels, in part, cater to budget-minded foreign backpackers, students, and Ecuadorians, this difference in revenues can also be attributed to the fact that vessels provide additional services, including interisland transport, meals, guides, etc.

Other on-island expenditures

In addition to expenditures on vessels and hotels, tourists spend significant amounts on meals, dive tours, recreation, souvenirs, gratuities, and other items and services.

Estimating expenditures for such products and services involved an analysis of the different categories of tourists and their share in this type of spending. When each category of tourist was weighted to reflect their importance in terms of percentage of all tourists, the average expenditure per tourist was US$ 114.65. Therefore, the total expenditures on the items identified above, based on a total of 105,000 tourists per year[11], would be approximately US$ 12.1 million per year. This amount represents revenues received by island-based operators and residents for land-based tourism services and related businesses, excluding hotels and vessels.

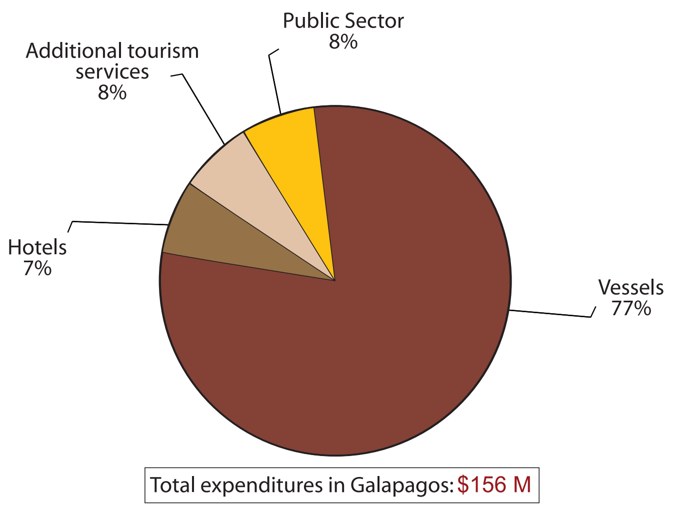
Summary of financial flows from tourism

Direct expenditures in Galapagos

According to this study, tourists' expenditures in Galapagos in 2006 were estimated at US$156 million. This total includes revenues from vessels (US$120.6 million, excluding travel agency fees), revenues from hotels (US$10.7 million), estimated additional expenditures by tourists on land (US$12.1), and estimated revenues received from tourism in the public sector (US$12.1 million, including the GNP entrance fee and other tourism-related fees for permits and licenses). The public sector revenues include those received by several local institutions (GNP, INGALA, municipalities, Provincial Council), which then trickle down to various secondary beneficiaries and the community at large, especially through employment.

A breakdown of tourism revenues in Galapagos by recipient is presented in Figure 4. Vessels receive the largest portion (77%) of tourism-generated income.

Figure 4. Galapagos tourism revenues by recipient



Note:

* Includes direct income from GNP entrance fees and tourism operation fees such as municipal permits, licenses and other fees.

[11] The number of tourists in this calculation comes from the estimate by Epler (2007) based on the National Park entrance cards, excluding an estimated percentage of 'non-tourists,' from June 2005 to May 2006.

Indirect benefits in the Galapagos Islands

In addition to the above-mentioned direct revenues, tourism provides the local populations with secondary benefits, including revenue flows generated through employment in various tourism-related activities and services[3]. Taylor *et al*. (2006) used a social accounts matrix model to calculate direct and indirect effects of tourism on the local economy. This model estimated revenues of approximately US$62.9 million per year from tourism-related activities including trade, transport, banks, agriculture, construction, and public and social services (Fig. 6).

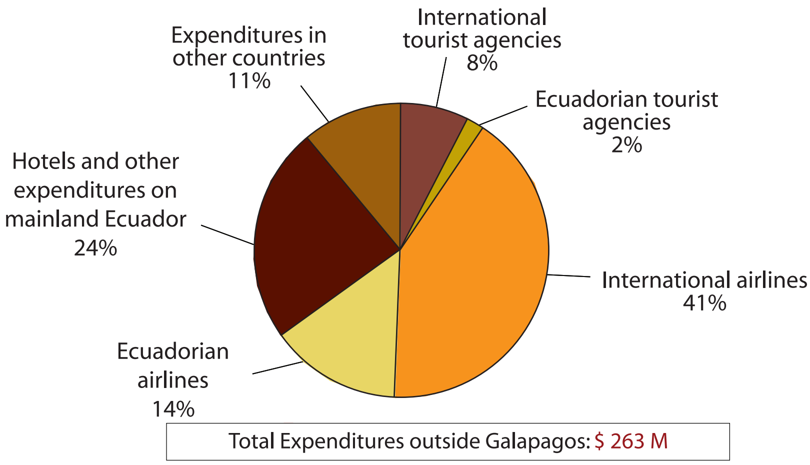
Indirect tourism-generated benefits for the local economy primarily include revenue flows generated through employment and other tourism-related services.

Economic impacts of Galapagos tourism outside the archipelago

Tourists' expenditures related to travel to the Galapagos Islands also involve benefits outside the archipelago. Beneficiaries include Ecuadorian and international tourism operators and agencies, hotels on Ecuador's mainland and in other countries, as well as other small service providers.

The total direct expenditures on tourism involving travel to the Galapagos Islands are approximately US$419 million[1]. Excluding direct benefits to the Galapagos economy (US$156 million, Fig. 4), estimated expenditures outside Galapagos are approximately US$263 million per year (Fig. 5).

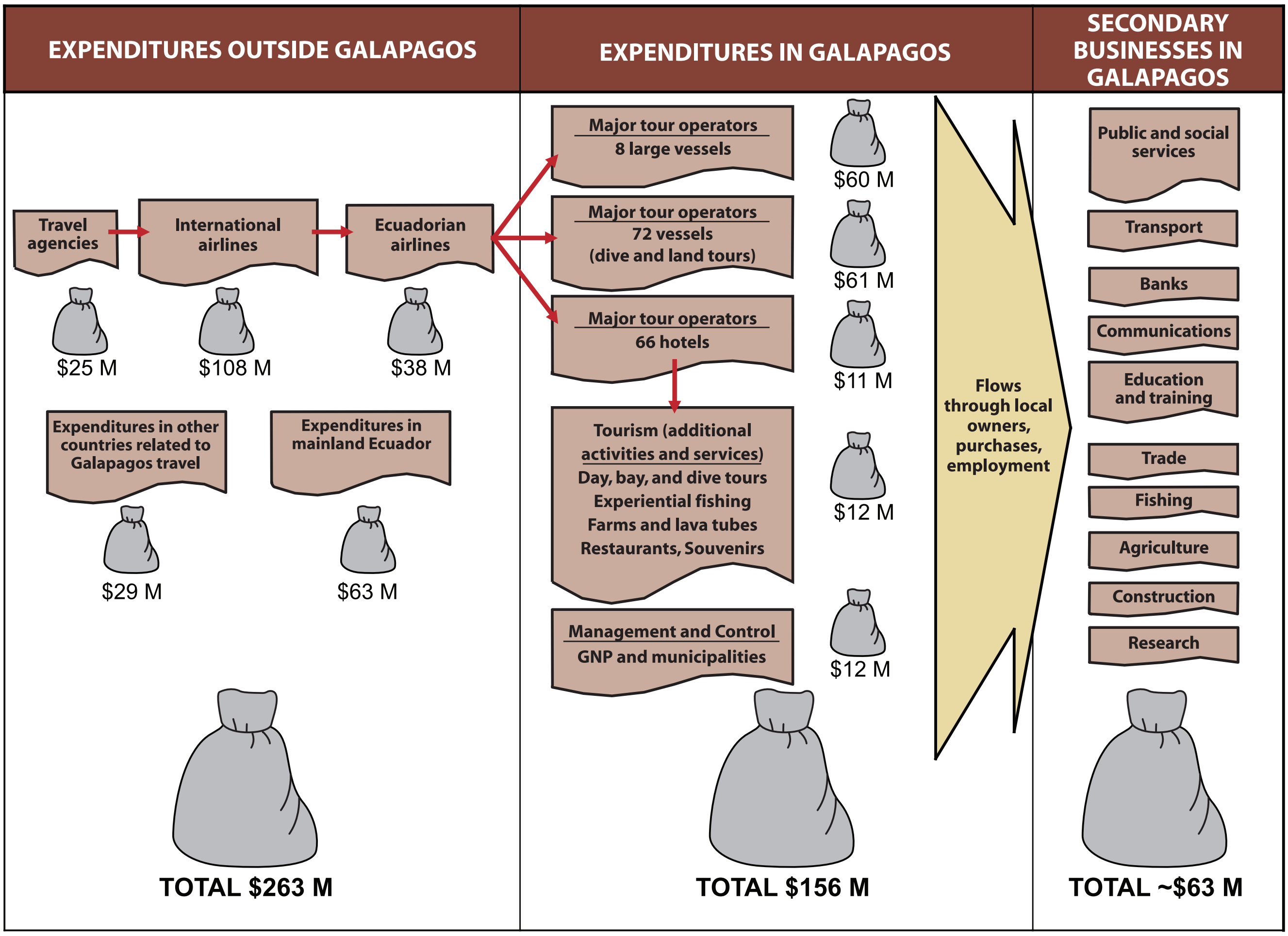
Figure 5. Distribution of tourists' expenditures outside Galapagos



Where do financial flows from tourism end up?

Expenditures on Galapagos tourism reach a variety of direct beneficiaries, both in the islands and elsewhere. Direct beneficiaries in the islands then generate a secondary distribution of revenues among the local population, especially through employment[3]. This complex distribution network of tourism revenues is summarized in Figure 6. There has been an on-going discussion about how economic flows from tourism are distributed and, above all, how much of this benefit reaches residents of the Galapagos. Although expenditures at the tourist destination (i.e., the Galapagos Islands) total US$156 million, many owners of the main sources of income (vessels) are not residents of Galapagos. At present, local operators own 40% of all

Figure 6. Distribution of tourists' expenditures related to travel to the Galapagos Islands (estimates for 2006)



Source: Epler 2007[1] and Taylor et al. 2006[3]

vessels with concessions to operate in the archipelago. The nature of these highly competitive and changing tourism markets leaves minority operators at a disadvantage vis-à-vis international and mainland Ecuadorian operators who are better equipped to access larger-scale production chains.[3] Nevertheless, local revenues and ownership of licensed vessels have increased since the 1980s, although not as rapidly as revenues of international and mainland Ecuadorian operators.

Conclusion

There has been a major transformation in the distribution of financial benefits and the structure of tourism in Galapagos. These changes have influenced the distribution of benefits at the local level, especially because of expanding facilities on land and the secondary service network that supports tourism activities. Several studies have shown that tourism is the mainstay of the Galapagos economy and that the primary revenue flow is through the generation of employment and secondary activities[3]. Current economic flows from tourism form the basis of the economy in Puerto Ayora and of the small and medium companies providing services or trade in Galapagos.

Economic flows from tourism involve and benefit a variety of stakeholders in Galapagos and elsewhere. Estimates from the most recent studies on this subject suggest that approximately 15.5% of total tourism revenues remain in the archipelago. More in-depth studies on this topic are required, with greater participation of the private sector, in order to develop a business model for tourism in Galapagos that will be better suited to the special nature of Galapagos and the islands' local population.

Air traffic to Galapagos is increasing[1]

David Cruz & Charlotte Causton

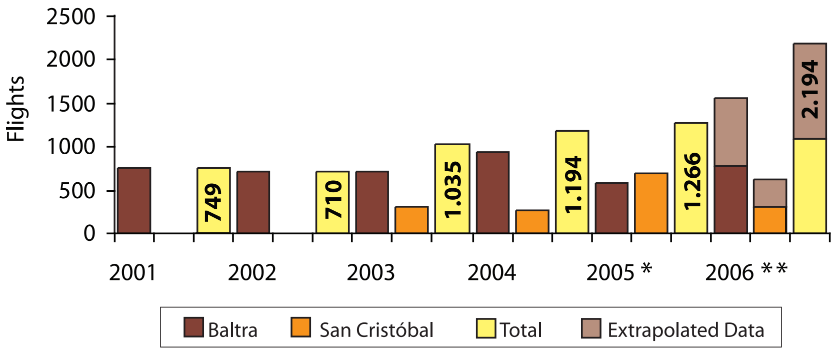
Charles Darwin Foundation

Flights to the Galapagos Islands began with the military air and naval base created on South Seymour (Baltra) in 1942. Then, in 1963, commercial flights began[1]. Compiling and analyzing data on air traffic indicates that commercial and private flights to and among the islands have increased alarmingly over the last few years, resulting in an increase in the volume of passengers, luggage, and cargo. These are all proven means of introducing invasive species into the Galapagos Islands.

Regular commercial flights to the Galapagos Islands

From 2001 to 2006, the number of commercial flights to Galapagos increased by **193%**. From January to June 2006, there were **1097** commercial flights (Fig. 1). At the time this analysis was completed, there were no data available for the second half of 2006, but if the number of flights continued similarly to the first half of the year, there would be an increase of 73% in commercial flights from 2005 to 2006.

Figure 1: Commercial flights to the Galapagos Islands from 2001 to 2006



Source: Civil Aviation Authority (DAC).

Note

* In 2005, the Baltra airport was closed for five months.
** Data from the first half of 2006 were doubled to extrapolate data for the second half.

Commercial flights by the domestic companies, TAME and AEROGAL, are the primary means of transport for the local community and for visitors to the islands. These flights, in addition to transporting passengers, carry both organic (of plant and animal origin) and inorganic cargo.

In 2006, there were a minimum of **136** flights per month, with a maximum of **170** flights per month during high tourism season. In 2006, TAME operated 2 flights per day to Baltra, Monday through Saturday, 3 on Sundays, and 2 flights per week to San Cristóbal. This gives a total of **17** regular flights per week and **68** flights per month, and a total of **78** flights per month during the high season.

In 2006, AEROGAL operated 7-9 flights per week (36 per month) to Baltra, plus 4 weekly flights to San Cristóbal (16 per month), for a total of **52** flights per month. ICARO began flying to the Galapagos Islands in December 2005, on the route Manta-Guayaquil-San Cristóbal. In 2006, ICARO only operated charter flights to Galapagos.

> From 2001 to 2006, the number of commercial flights to Galapagos increased by 193%.

Private flights

From 2001 to 2006, a minimum of 343 private aircraft landed in Galapagos (Table 1 and Fig. 2). The information supplied by the Civil Aviation Authority (DAC) does not identify the port of origin for each flight nor its route prior to arrival in Galapagos; it only indicates the airplane's last port of departure. Nevertheless, the data show that at least 10 aircraft traveled directly to Galapagos from other countries (United States, Panama, Peru, Costa Rica, Curacao, Easter Island, and Mexico).

During that period, **69.4%** (240) of private aircraft entering the Galapagos Islands from mainland Ecuador were registered in the United States, **13%** (45) in Ecuador, and the remainder in countries of Latin America, the Caribbean, Europe, and Australia. This suggests that the majority of private aircraft heading to Galapagos come from other countries, but fly first to mainland Ecuador.

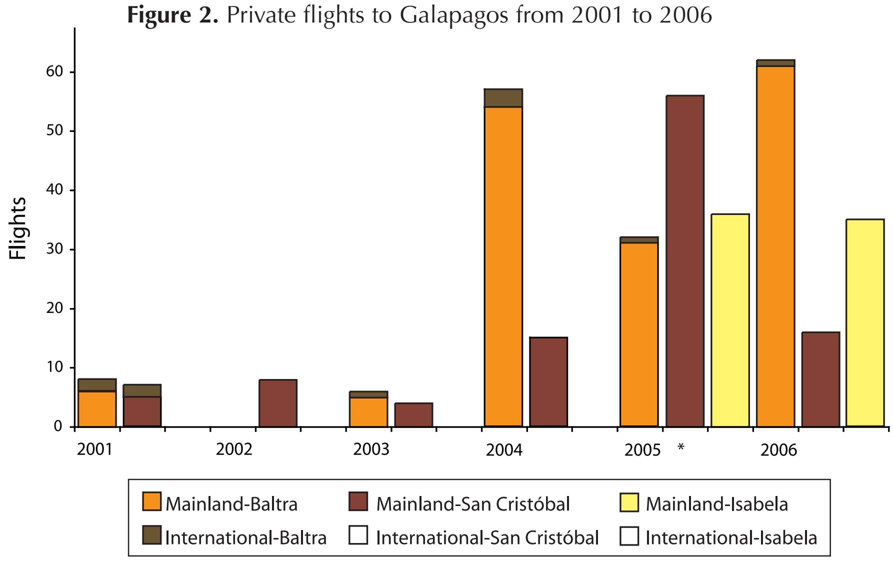
A minimum of **343** private flights arrived in the Galapagos Islands from 2001 to 2006, with at least **10** of them arriving directly to the islands from other countries.

Table 1. Last airport prior to arrival in the Galapagos Islands, private aircraft, 2001 to 2006.

	Port of origin	No	%	
NATIONAL	Guayaquil	238	69.4	
	Manta	71	20.7	
	Quito	19	5.5	
	Salinas	4	1.2	96.8%
INTERNATIONAL	Panama	2	0.6	
	Easter Island	2	0.6	
	Mexico	2	0.6	
	United States	1	0.3	
	Costa Rica	1	0.3	
	Antilles	1	0.3	
	Peru	1	0.3	2.9 %
	Undetermined	1	0.3	0.3 %
Total		**343**	**100**	**100 %**

Source: Civil Aviation Authority (DAC).

Figure 2. Private flights to Galapagos from 2001 to 2006



Source: Civil Aviation Authority (DAC).

Note

* In 2005, the Baltra airport was closed for five months.

The data indicate that most private aircraft from Ecuador and other countries arrived first at the Baltra airport, except for five months in 2005 when that airport was closed for maintenance (Fig. 2). There are no data on flights arriving in Isabela for 2001, 2002, and 2004; DAC had no staff assigned to Isabela during those years. However, a substantial number of aircraft arrived there in 2005 and 2006. Records indicate that they came from mainland Ecuador.

Military flights

The Air Force of Ecuador (FAE) operates logistical flights to supply its personnel working in the Galapagos Islands. In the year 2000, the FAE normally flew to the Galapagos Islands every two weeks, via Quito, Guayaquil, San Cristóbal, Isabela, and Baltra. Currently, regular flights occur with the same frequency only to Isabela; there are no regular flights to Baltra or San Cristóbal. There are also logistical flights to transport personnel and cargo (including organic cargo) for the Navy, usually arriving twice a month at San Cristóbal.

The highest number of military flights was observed in 2002, with a total of **383** flights and with San Cristóbal as the most frequent destination. Since 2002, the frequency of military flights has decreased significantly. In 2006, the total was estimated at **60** flights.

Inter-island flights

Inter-island air service is provided by the EMETEBE Company's air taxis. Generally, this service transports passengers and, to a lesser degree, cargo (mainly inter-island airmail). The EMETEBE Company runs flights Monday through Saturday on the route: San Cristóbal – Baltra – Isabela – Baltra – San Cristóbal. The established schedule includes flights following this route once each day; sometimes there is more than one flight per day in response to demand. This company also makes charter flights on Sundays when required.

In addition to inter-island flights via the air taxi service, there are occasional inter-island flights by other private airplanes or charter flights that come to Galapagos, and by the Galapagos National Park Service and other national and international authorities.

Increased flights to and among the Galapagos Islands during 2001-2006

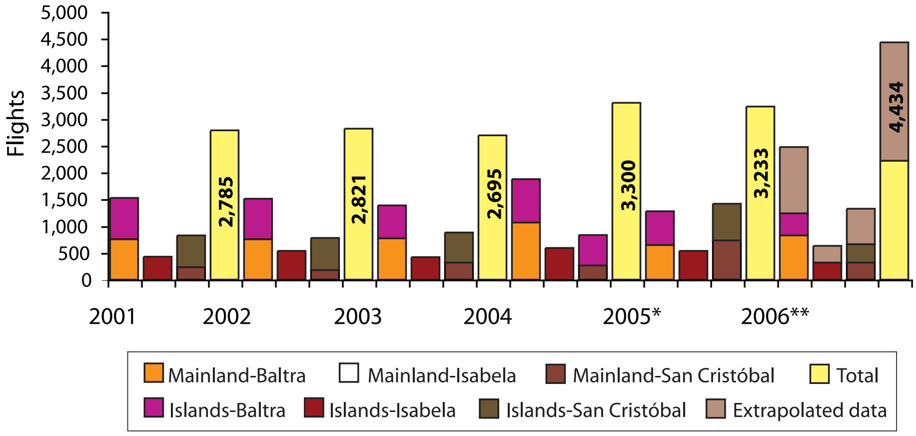
DAC data can be analyzed in terms of regular commercial domestic traffic (regular flights with fixed schedules and itineraries) and non-regular air traffic (no fixed schedules or itineraries) (Fig. 3). These data indicate that flights to and among the Galapagos Islands have increased by **59.2%** since 2001. In the first six months of 2006, the **2,217** flights to Galapagos were already equal to **67.8%** of the flights during 2004 and 2005. Assuming that the second half of 2006 had about the same number of flights, regular and non-regular domestic traffic to and within the islands would have risen by **37%** over 2005 figures. The Baltra airport had the most movement, except for five months in 2005, when it was closed for repair of its landing strip.

Passenger transport

The number of people transported on regular commercial flights to the Galapagos Islands from mainland Ecuador rose by **100%** from 2001 to 2006. In the first six months of 2006, **91,220** passengers arrived, **61%** of the figure for 2005 **(149,635)**. Assuming that the same number of passengers traveled to the Galapagos Islands in the second half of 2006, the total number of passengers transported on those flights from the mainland would have increased by **22%** from 2005 to 2006.

Between 2001 and 2006, total air traffic (regular flights and others) increased by **59.2%** in number of flights, **58.5%** in number of passengers, and **94%** in air freight.

Figure 3. Regular and non-regular domestic flights to and among the Galapagos Islands, 2001-2006



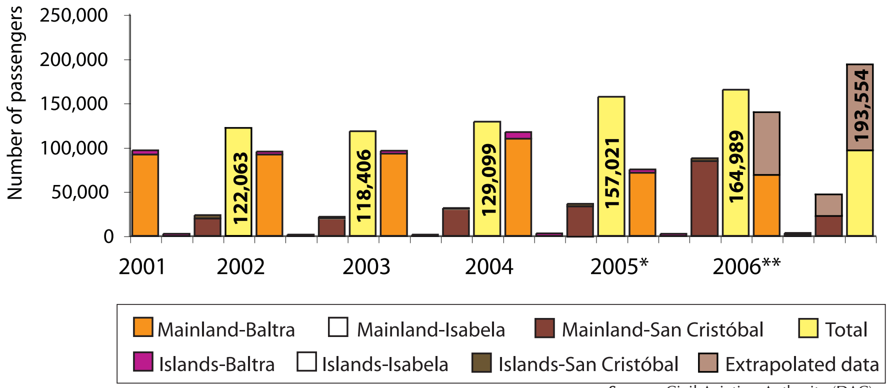
Source: Civil Aviation Authority (DAC).

Notes

* In 2005, the Baltra airport was closed for five months.
** Data from the first half of 2006 were doubled to extrapolate data for the second half.

If you sum the number of passengers arriving by non-regular flights and those on regular flights, the total increased by **58.5%**, from 122,063 to 193,554, from 2001 to 2005 (Fig. 4).

Figure 4. Passengers on regular and non-regular domestic flights to and among the Galapagos Islands, 2001-2006



Source: Civil Aviation Authority (DAC).

Notes

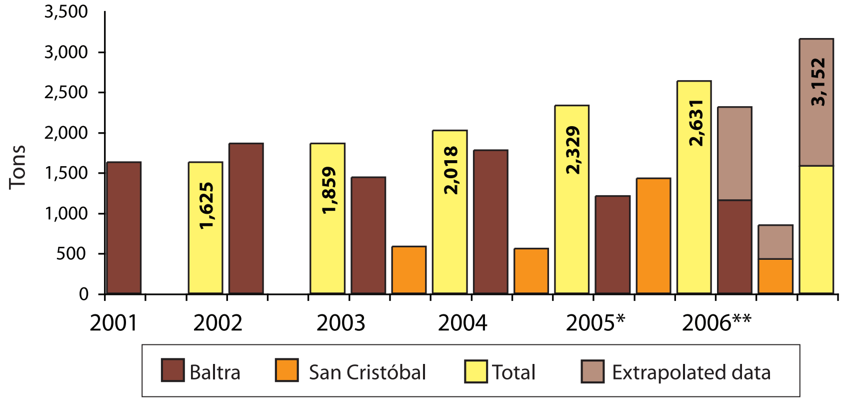
* In 2005, the Baltra airport was closed for five months.
** Data from the first half of 2006 were doubled to extrapolate data for the second half.

Information is lacking on the number of passengers transported on all flights registered by DAC. Data are particularly scarce on private aircraft, military flights, and inter-island flights. Private airplane records show a broad range in their size and capacity. For example, in 2002 four airplanes left Baltra for Easter Island with an average of **76** passengers and a maximum of **96** passengers per airplane. Historically, local residents have used military flights to travel to and from the Galapagos Islands. In the case of small airplanes that do inter-island flights, we estimate that approximately 42 passengers are transported per day, or over **1,000** per month, given that EMETEBE has two airplanes with a mid-range capacity of 9 to 12 passengers and that these light planes normally fly 4 times per day.

Cargo transport

Cargo transported from mainland Ecuador to the Galapagos Islands has increased steadily over the last six years, with a total increase of **94%** (Fig. 5). Although records for 2006 cover only January through June, the **1,576** MT of cargo transported by air during that time was already over half (60%) of what had been transported during 2005. If this trend continued during the second half of the year, cargo transport would have increased nearly 20% from 2005 to 2006. Most cargo arrives from Guayaquil, Quito, Cuenca, and Esmeraldas.

Figure 5. Cargo transported on regular commercial flights to the Galapagos Islands, 2001-2006



Source: Civil Aviation Authority (DAC).

Notes

* In 2005, the Baltra airport was closed for five months.
** Data from the first half of 2006 were doubled to extrapolate data for the second half.

The Baltra airport, followed by the San Cristóbal airport, received the majority of air cargo, except in 2005 when it was closed for five months. Approximately 20% of the air cargo to Baltra was organic products, with most of that pertaining to tourism companies. In 2005, over 570 tons of agricultural products entered by air.

Enforcement of SICGAL legislation and protocols

A legal framework exists to ensure the isolation of the Galapagos Islands and the enforcement of the Quarantine Inspection System of Galapagos (SICGAL) including the Special Law for Galapagos, Regulations for Total Control of Introduced Species, and several resolutions by the Agricultural Health Committee and SICGAL. One important resolution, No. 43, establishes the protocol for insect extermination on aircraft. Another, No. 60, requires airports with flights to and from the Galapagos to have suitable health facilities and an adequate number of inspectors and inspection infrastructure. Table 2 summarizes the current status of compliance with this law and these protocols.

Due to the lack of airport inspectors, it is not possible to confirm that all airplanes have been fumigated nor to evaluate the effectiveness of fumigations.

Table 2. Compliance with current law and protocols on air activities.

Type of air transport	Current Situation
Commercial/ regular	TAME began fumigating its airplanes in November 2005, applying Permethrine at 2% for a 60-day period.[2]
	AEROGAL began fumigations in January 2006.[3]
	Commercial airlines do not give notification of their private or charter flights, schedule changes, or additional flights, making it difficult to coordinate proper inspection.
	It is impossible to confirm compliance with fumigation requirements or assess quality due to the lack of inspectors. However, live insects have been found,[1] demonstrating that the processes are not working properly.
Private	Private aircraft are not inspected in Guayaquil or Quito due to SICGAL's lack of resources, and the lack of coordination with and support from authorities and companies. Moreover, in Manta and Salinas, the port of origin of 20.5% of the aircraft, SESA-SICGAL has no offices.
	52% of flights arrived outside inspectors' work hours. Supervisory institutions (SESA, GNPS, INGALA) were not notified in advance or in a timely fashion about the arrival of these flights.[4,5]
	At least 10 flights arrived directly from other countries.
Logistics/ military	Military flights are not inspected on the mainland or in the Galapagos Islands. SESA-SICGAL has no authorization to enter military facilities.
Inter-island	Only the luggage that passengers carry with them is inspected. The protocol for fumigations has not been implemented and the airplanes are not inspected.

Source: Cruz JD & Causton C (2007) [1]

New proposed routes

The airlines are interested in opening up new commercial routes between the mainland and Galapagos. These would include flights from Cuenca and/or Manta to Baltra and San Cristóbal and from Quito and Guayaquil to Isabela. It is important to ascertain whether any environmental impact studies have been conducted, as required by the Special Law for Galapagos, in order to analyze the risks that such flights may pose for Galapagos ecosystems.

Current infrastructure would allow for the authorization of commercial airlines to make night flights to the Baltra airport; its landing strip was equipped with lighting in 2006. However, at this time, SESA-SICGAL does not have sufficient staff to perform night inspections. INGALA and the GNPS are also short-handed to oversee or inspect passengers and aircraft at origin or destination airports.

A new airport terminal in Isabela was recently completed and could provide a new entry point into the Galapagos Islands from the Ecuadorian mainland.

So far, the existing landing strip has been used only for local flights (light airplanes), FAE military planes or emergency flights for logistical purposes, and charter and private flights. According to the risk analysis (see the article on *"Risks associated with current and proposed air routes to the Galapagos Islands"* in this report), opening up direct commercial flights to Isabela wouldtd significantly increase the risk of introducing species and therefore the rate of ecological degradation on that island.

Opening new commercial routes, night flights, and direct flights to Isabela involve significant risks of introducing species if there is no appropriate impact assessment or sufficient response capacity from SICGAL.

Overall conclusions and recommendations

Research results indicate that commercial and private flights to and among the islands have increased alarmingly in recent years, bringing an increased volume of passengers, luggage, and cargo. These are all proven means of introducing invasive species into the Galapagos Islands.

Occasional arrival in the Galapagos Islands of private flights directly from other countries and non-inspection of charter or private flights from mainland Ecuador increase the risk of transporting invasive species and diseases from other countries, which are not yet found in mainland Ecuador, e.g. the mosquito carrying West Nile virus.

In order to decrease the risk of introducing species into the Galapagos, it is recommended that SESA-SICGAL be strengthened and an improved insect extermination system for aircraft be implemented. Taking into account that no quarantine inspection system can be 100% effective, other prevention mechanisms are also needed, including minimizing routes and prohibiting direct flights from other countries to the Galapagos Islands.

> Minimizing routes and prohibiting direct flights from other countries to the Galapagos Islands must be implemented since no quarantine inspection system can be 100% effective.

Risks associated with current and proposed air routes to the Galapagos Islands[1]

Charlotte Causton

Charles Darwin Foundation

There is ample evidence demonstrating that animal and plant species can be transported by aircraft in both cargo and personal luggage of passengers and crew, as well as elsewhere inside the aircraft. If they successfully colonize the islands, some of these exotic species will pose a danger to humans and to the biodiversity of Galapagos, due to their potential for disease transmission or aggressive invasiveness. Beyond the potential danger for human health and negative impacts on both the environment and the local economy, exotic species require extremely expensive eradication or long-term control programs if eradication proves impossible.

There are numerous records of species entering the Galapagos Islands in luggage and cargo. In 2006, data from the Quarantine Inspection System for Galapagos (SICGAL) show that **1022** infested products were confiscated at the airports, as well as other products that are not allowed entry into Galapagos. Moreover, an assessment of inspection effectiveness[2] shows that current control activities do not prevent entry of species from outside Galapagos. The actual rate of interception by inspectors is **1** interception for every **8230** entries of individual plants and invertebrates.

Although cargo and luggage have been shown to be significant means of introducing exotic species into Galapagos, the extent to which airplanes themselves are potential vehicles for carrying new species to the islands has not been thoroughly evaluated. The goal of this analysis was to determine the potential of aircraft as vectors for exotic species that pose a high risk to Galapagos. Results of Phase 1, the assessment of the increase in air traffic over the last few years, are outlined in the previous article, *"Air traffic to Galapagos is Increasing."*

Risks associated with current commercial flights

Invertebrate monitoring at the airports has demonstrated that despite the initiation of an insect fumigation system for commercial airlines in November 2005, an average of 0.71 invertebrates per inspected airplane

> The introduction of harmful exotic species can endanger human health, have negative impacts on biodiversity, and result in very expensive eradication or long-term control programs when eradication proves impossible.

arrived during the first half of 2006. It is estimated that at least **779** invertebrates entered by aircraft during that period (Table 1). A total of **30** live invertebrates were collected in commercial airplanes between July and December 2006, 22 at the Baltra airport and 20 in San Cristóbal. An additional **2** insects were collected from the military's logistical airplane in Isabela. In Baltra, **72%** of inspected airplanes had insects present. The 19 live invertebrates encountered included spiders, crickets, flies, and 3 mosquitoes, 1 of which was full of blood. In San Cristóbal, invertebrates were found on 35% of the commercial airplanes; none were found on the 3 charter flights that were inspected. The 11 live insects collected included ants, cockroaches, flies, and 2 mosquitoes. All of the insects collected were found in the holds of the aircrafts, except for one mosquito found in the cabin. The logistical airplane inspected in Isabela had a cockroach and a moth[3].

The risk of introducing live invertebrates into Galapagos is expected to increase during the rainy season, when invertebrates are typically more abundant. However, the SESA-SICGAL inspections reported here were conducted during the cool season when insect activity is lower. The risk of transporting invertebrates to the Galapagos is also predicted to increase whenever any species increases its population on the mainland. For example, in January 2007, there was an outbreak of crickets around the Guayaquil airport resulting in many stowaways on airplanes to Baltra[4].

> In Baltra, 72% of inspected airplanes had insects present.

Table 1. Live invertebrates found in airplanes checked in Baltra, San Cristóbal, and Isabela.

Airport	Airline	No. of airplanes inspected (No. with invertebrates)	Live invertebrates	
			Number	Order: common name
Baltra	TAME	11 (6)	5	Arachnidae: spider (1) Diptera: mosquito (1) Orthoptera: cricket (3)
	AEROGAL	11 (10)	14	Arachnidae: spider (3) Diptera: fly (7) Diptera: mosquito (2) Hymenoptera: wasp (1) Orthoptera: cricket (1)
San Cristóbal	TAME	10 (3)	4	Diptera: fly (2) Hymenoptera: ant (2)
	AEROGAL	10 (4)	7	Blattaria: cockroach (1) Coleoptera: beetle (1) Diptera: mosquito (2) Hymenoptera: ant (2) Orthoptera: cricket (1)
	Charter flights (2 by ICARO)	3 (0)	0	
Isabela	Military Logistical	1 (1)	2	Blattaria: cockroach (1) Lepidoptera: moth (1)

Source: Cruz JD & Causton C (2007)[1]

Risks associated with current and new routes of private flights to the Galapagos

The principal risk associated with permitting flights from international airports or Ecuadorian airports other than those with SICGAL infrastructure is that they connect Galapagos to places with species that have not yet been reported in the archipelago. This increases the probability of new invasive species reaching the islands. Private or charter flights that arrive directly from other countries[1] create new and dangerous routes for the introduction of invasive species that are not yet present in mainland Ecuador and therefore not a risk from domestic commercial flights or cargo ships. The map in Figure 1, showing current and proposed routes to the Galapagos Islands and the distribution of some high risk species, demonstrates the ease of transporting species to Galapagos that are alien to mainland Ecuador and the archipelago.

Further, opening new airports in the Galapagos will connect islands that have had no direct link to mainland Ecuador or other countries, facilitating the arrival and establishment of introduced species. The construction of an airport on Isabela for airplanes arriving directly from the mainland increases the risk of introduction and range of dispersal of new exotic species. As the largest of the Galapagos Islands (>50% of the total land area), Isabela has the largest proportion of endemic species and, therefore, the potential consequences of the introduction and establishment of invasive species are significant. Isabela is also located close to the most pristine island, Fernandina, and could provide a steppingstone for invasive species to reach that island. Presently, it is less likely that introduced species will become established on these islands because they must disperse from San Cristóbal or Baltra.

Flights directly from other countries and opening new airports in the islands will create new, dangerous routes for the arrival of invasive species, which could influence the unique evolutionary processes of the Galapagos biota.

Risks associated with initiating night flights to Galapagos

We know of no environmental assessments of the impacts of landing strip lights or air activity on biodiversity in Baltra or the nearby islands[1]. Increasing flight schedules to include night flights is expected to increase the diversity of invasive species potentially transported to Galapagos, such as species of mosquitoes and moths. Moreover, lighting of airports and aircraft will attract more insects, increasing the probability of accidentally introducing them into airplanes and transporting them to the Galapagos. Night flights will also increase vehicle traffic between Puerto Ayora and the Itabaca Canal, with the associated risk of increasing the probability of negative impacts on night birds, which are often affected by lights[5].

Other risks

In addition to the risk of introducing highly aggressive invasive species, flights may interfere with evolutionary processes in Galapagos. The interesting, unique island species have often resulted from slow evolutionary processes related to genetic isolation and adaptive radiation. Introduction of a mainland species with phylogenetic affinities to endemic Galapagos species could influence the speciation process and the uniqueness of the Galapagos biota.

Organisms posing a high risk for the Galapagos

Some examples are given below of high-risk species that could reach the Galapagos via aircraft. These species could cause significant impacts on the natural ecosystems and potentially damage sustainable development in the archipelago.

Disease vector insects

There is a risk of disease vectors entering and affecting human beings and the biodiversity of Galapagos. So far, the Galapagos remain free of these kinds of diseases, with the sole exception of dengue fever, transmitted by the *Aedes aegypti* mosquito, introduced in 2001. The route of introduction has not been determined. An international workshop in 2000 on threats to Galapagos birds identified **11** serious diseases that have not yet reached the Archipelago[6].

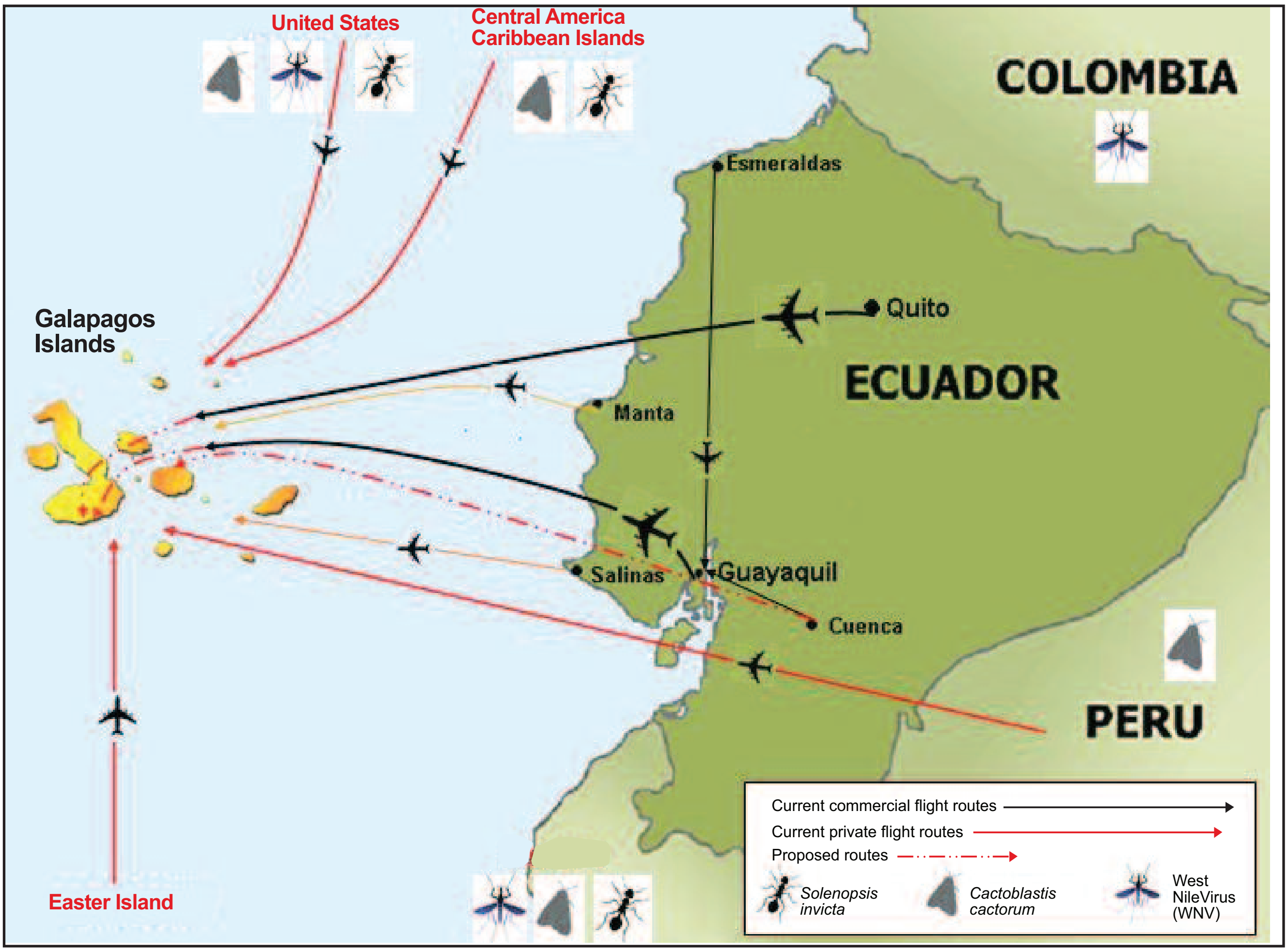
Introduction of the West Nile Virus (WNV) into Galapagos is of special concern because it would affect both the biodiversity (birds and reptiles) and human beings. A risk analysis by a team of experts examining potential methods of transport of WNV to Galapagos determined that aircraft is the method that poses the greatest risk[7]. There is currently the risk for WNV to enter the islands via private flights from countries with the disease (Fig. 1). At this time, WNV has not been reported in Ecuador, but its presence is documented in Colombia[8].

Other invertebrates

According to Rogg,[9] there are at least 53 high-risk species for the Galapagos that could still enter the islands on aircraft from mainland Ecuador. The number of invasive species that could be introduced from other countries is much higher.

> The West Nile Virus (WNV) is one of the most alarming diseases that have not yet reached Galapagos; however, aircraft represent the method of transport of greatest risk.

Figure 1. Current and proposed flight routes to Galapagos and distribution of some invasive species posing a high risk for the Galapagos



Source: Cruz JD & Causton C (2007) [1]

In addition to the risk from domestic commercial flights, international routes[1] provide entryways for other species known to be invasive in other parts of the world, which could have the same or even greater impacts in Galapagos. For example, species such as the fire ant, *Solenopsis invicta*, identified as one of the world's 100 most invasive organisms[10], has a high probability of being transported in international airplanes (Fig. 1). This ant could affect human health and alter native invertebrate and vertebrate communities, either as a predator or simply by killing other species with its sting.

Another species of great concern for Galapagos is the cactus-boring worm, *Cactoblastis cactorum* (Lepidoptera). This species could be introduced into the Galapagos via its adult phase, a night moth attracted by lights. The ecological consequences of introducing *C. cactorum* into the islands could be very serious. This species could quickly destroy the populations of *Opuntia* cactus, one of the signature plants of Galapagos.

At least 53 high-risk species could enter the islands on aircraft from mainland Ecuador; the number is much higher from other countries.

Vertebrates

Animals stowing away on aircraft are not limited to invertebrates, but can also include reptiles, amphibians, and other vertebrates[11]. One example is the spread of the invasive brown tree snake from Guam Island. This snake can wrap itself around plane wheels or get into holds, and has been reported to have been introduced via airplanes flying to Hawaii and other islands of the Pacific, Singapore, Taiwan, and Australia. This snake has not only affected biodiversity as a predator of birds, but has also affected local economies. The annual losses resulting from damage to electrical systems in Guam are estimated at some US$ 4 million[12].

Conclusions and recommendations

There are many invasive species, such as snakes, insects, and viruses, that have not yet reached the Galapagos Islands and could be introduced via aircraft.

Despite the insect fumigation system being applied, invertebrates are still reaching Galapagos via airplanes. Records of organisms detected in cargo and luggage indicate that commercial flights and their cargo are already vectors for introduced species. The risk of introducing new species will increase with the increase in the number of commercial flights to Galapagos and the incorporation of proposed new routes and schedules, including night flights.

Both the occasional arrival in the Galapagos Islands of private flights directly from other countries and non-inspection of charter or private flights from mainland Ecuador bring the risk of transporting invasive species and diseases from other countries, which are not yet found in mainland Ecuador.

Based on the high risk of introducing invasive species to Galapagos with an expansion of flights, it is considered critical to minimize routes to the archipelago. It is also important to consider a substantial increase in the resources required to strengthen SICGAL and ensure a stable legal framework for its effective operation.

Evaluation of the Quarantine and Inspection System for Galapagos (SICGAL) after Seven Years[1]

Carlos E. Zapata

Director of FUNDAR Galapagos, Consultant

The Quarantine Inspection System for Galapagos (SICGAL) began as a pilot project in May 1999 and was formally established in June 2000. Since August 2001, SICGAL has operated as a semi-autonomous program of the Ecuadorian Agricultural Health Service for Galapagos (SESA). SICGAL's principal source of funding is a 5% earmark from the entrance fees to the Galapagos National Park (GNP). It also receives some funding from the national SESA office.

From 2002 to 2007, SESA-SICGAL has received technical assistance and supplies from two major projects: *The Environmental Management Program for the Galapagos Islands* (funded by the Inter-American Development Bank and national counterpart funding) and the UNDP-GEF/ECU/00/G31 project, *Control of Invasive Species in the Galapagos Archipelago* (funded by the United Nations Development Program through the Global Environment Facility).

SICGAL has been in operation for seven years. Considering the support it has received via international cooperation, SICGAL is expected to have improved its capacity to reduce the number of exogenous species entering Galapagos.

An assessment to determine SICGAL's technical and operational efficiency, conducted from June 2006 to January 2007[1], was comprised of:

a. An institutional evaluation, which considered the legal, financial, administrative, operational, and technical effectiveness of SICGAL in terms of fulfilling its objectives.

b. A practical evaluation of SICGAL's effectiveness to intercept products and organisms harmful to Galapagos during quarantine inspections.

c. An evaluation of the knowledge of inspectors.

Results and trends

During the evaluation of SICGAL, a central problem became evident: *SICGAL cannot significantly reduce the number of introduced species and its effectiveness is progressively declining.*

Three main causes were identified:

- SICGAL is under-funded and under-staffed, and therefore unable to cope with the increase in demand for its services resulting from growth in tourism and the resident population of Galapagos.
- The system is technically ineffective and inefficient.
- Local governance in Galapagos is unnecessarily complex, offering no clear direction in public policy and decision making.

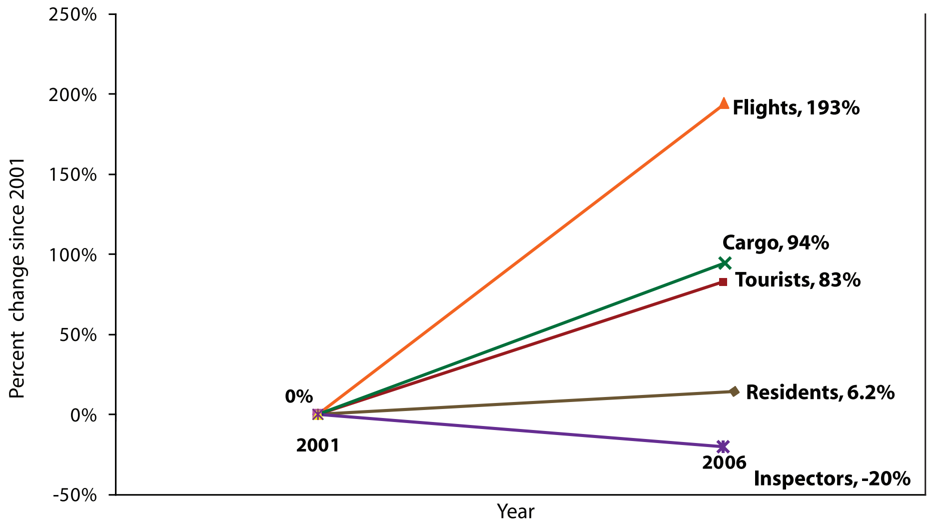
Annex 1 defines the principle factors that influence SICGAL's effectiveness.

Insufficient resources to respond to service demands

The scenario in which SICGAL was created seven years ago is no longer the same. Since SICGAL began operations, its staff has been cut by 20%, while the resident population and the number of tourists in Galapagos continue to increase. The population doubled over the last ten years, with an annual growth rate over 6%[2] (Fig. 1). The number of tourists visiting the Galapagos each year has also doubled, with an average annual increase of 12%[2], and the number of passengers traveling to Galapagos has increased by 100%[3].

> SICGAL does not have sufficient resources to respond to the increase in demand for its services resulting from growth in tourism and the resident population of Galapagos.

Figure 1. Percent change in key indicators related to SICGAL, 2001 to 2006



Source: Zapata (2007)

The increase in the number of people entering Galapagos has resulted in an increase in demand for goods and services, most of which must be imported from mainland Ecuador. Food is imported via maritime transport (about 75%) and by air (about 25%). The volume of foodstuffs imported to Galapagos from 1998 to 2006 increased by 50% (maritime freight) and 94% (air freight)[3,4].

Commercial flights increased by 193% from 2001 to 2006, with an average growth rate of 27% per year[3]. New commercial routes were added, e.g., Manta-Galapagos (ICARO airline). Private flights also land in Galapagos, with a minimum of 343 reported from 2001 to 2006, including flights from international airports[3] (see the article in this Report on '*Air traffic to Galapagos is increasing*').

Although the number of cargo vessels has not increased significantly, there has been an increase in the amount of cargo per ship. In 2005, cargo ships were carrying cargo not only in their holds but elsewhere as well[4]. In 2006, there were as many as five ships, each making 24 trips per year to Galapagos[5].

Vessels from abroad periodically enter the Galapagos Islands. Moreover, in 2006, vessels with a capacity for over 500 passengers visited the islands. Two cruise ships with this capacity are currently arriving every year. The number of vessels of this size is expected to increase to as many as 12 per year.

The system is technically ineffective and inefficient

Insufficient number of inspectors

There is no direct proportional relationship between the number of SESA-SICGAL inspectors and the increasing number of flights, cargo ships, and passengers and cargo (inspection units) entering Galapagos. The ratio of inspectors to inspection units is very low (Table 1). Further, under-staffing makes it impossible to inspect airplanes and ships at both their origin and destination to ensure enforcement of fumigation certificates.

> From 2001 to 2006, the number of inspectors was cut by 20%, compared to a 100% increase in the number of inspection units.

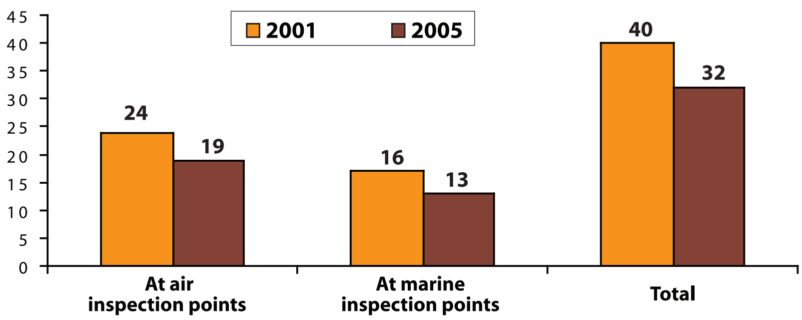
Table 1 shows how SICGAL's response capacity has been reduced. In Year 1 of operation, **40** inspectors, considered the minimum required to operate the system, were contracted. The system currently operates with approximately 32 inspectors (20% less than in 2001). On the other hand, from 2001 to 2005, the number of passengers, suitcases, and cargo per inspector has grown significantly: **103%**, **105%**, and **143%**, respectively.

Table 1. Inspectors and inspection units at points of origin and destination in 2001 and 2005[3].

		2001 (Nº/shift)	2005 (Nº/shift)	% change
INSPECTORS				
Nº of inspectors		40	32	- 20%
Nº of inspectors at air inspection points	San Cristóbal	4 (3)	3 (2)	- 25%
	Baltra	5 (4)	4 (3)	- 20%
	Isabela	2	1	- 20%
	Quito	8 (5)	6 (3)	- 25%
	Guayaquil	5 (3)	5 (3)	—
Nº of inspectors at marine inspection points	Guayaquil	6 (4)	4 (2)	- 33%
	San Cristóbal	4 (3)	3 (2)	- 25%
	Santa Cruz	5 (3)	4 (2)	- 20%
	Isabela	2	2	—
INSPECTION UNITS				
Commercial flights /year		749	1,266	69%
Passengers on commercial flights /year		90,910	149,635	65%
Passengers/inspector/week		350	710	103%
Suitcases on commercial flights /year		69,091	113,722	65%
Suitcases/inspector/week		266	546	105%
Cargo on commercial flights/year (MT)		1,625	2,631	62%
Cargo/inspector/week (MT)		10.4	25.3	143%
Cargo ships		4	4	—
Trips by cargo ships per year		96	96	—

Source: Cruz, J. D. and Causton, C (2007)

Figure 2. Decrease in the number of SICGAL inspectors at inspection points from 2001 to 2005



Source: Cruz, J. D. and Causton, C (2007)

Figure 3. Increase in inspection units per inspector per week from 2001 to 2005

Source: Cruz, J. D. and Causton, C (2007)

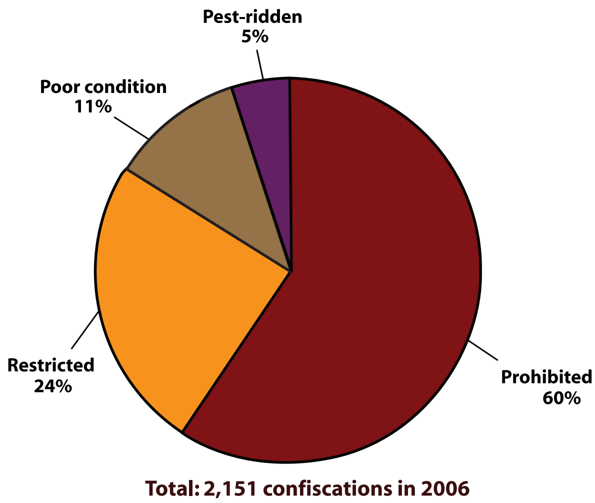
Lack of technical staff

In addition to the lack of trained inspectors working effectively, there are no technical specialists on staff to support fieldwork of the inspectors or to monitor technicians (Annex).

Technical-operational effectiveness

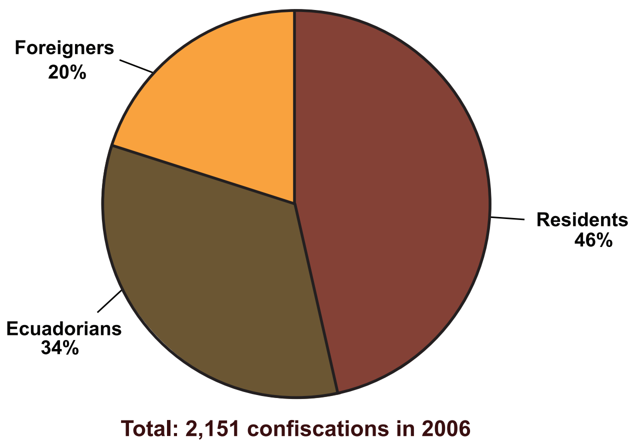
During 2006 there were **2151** confiscations (Figures 4 and 5). The primary reason for most confiscations was that they were prohibited or restricted products (**85%**). Products with pests (confiscated because they contained organisms) represented **5%** of total confiscations. This leads to the conclusion that inspectors focus on identifying larger products rather than searching for small organisms, such as invertebrates, plant seeds, etc. Nearly half of the confiscations (46%) were from Galapagos residents.

Figure 4. Confiscations by SESA-SICGAL inspectors in 2006 by primary reason



Source: SESA-SICGAL database

Figure 5. Confiscations by SESA-SICGAL inspectors in 2006 by passenger's origin



Source: SESA-SICGAL database

It appears that most products are either confiscated from passengers who are unaware of regulations (and do not intentionally hide products) or from passengers who voluntarily admit to carrying organic products; they are not due to the effectiveness of the inspectors in intercepting introduced organisms. During an evaluation in 2006, in which volunteer passengers intentionally carried organic products and attempted to avoid detection, the interception rate was **0%**. It appears that when someone wants to transport restricted products to Galapagos there is little or no likelihood of an inspector detecting them.

The effectiveness of SESA-SICGAL inspectors in detecting and confiscating smaller exotic species entering the islands is very low. The evaluation of effectiveness at intercepting organisms at the Baltra airport revealed that inspectors intercepted only **1** out of **8230** organisms entering Galapagos[1].

According to SESA-SICGAL data for 2001–2006, the total number of confiscations per year has declined (Table 3). It is likely that this failure of current control procedures is affected by the reduced response capacity of SICGAL (number of inspectors) and the increase in the number of inspection units.

Table 3. Total confiscations and year-to-year trends, 2001-2006.

Year	Total No. of confiscations	Percent change per year
2001	2,518	
2002	1,827	-27%
2003	937	-49%
2004	2,460	163%
2005	2,308	-6%
2006	2,151	-7%

Source: SESA-SICGAL database

The actual rate of interception by inspectors is 1 out of 8230 individual plants and invertebrates entering Galapagos.

Technical competence of inspectors

The level of technical competence of inspectors regarding SICGAL, evaluated in 2005 and 2006, averaged **66%**[1]. The most knowledgeable inspectors are located in Santa Cruz and Quito, with the least knowledgeable in Isabela and San Cristóbal. Of the **18** inspectors in Galapagos, only **2** have a university degree related to SICGAL's activities (agriculture, veterinary medicine, biology, environmental sciences, etc.). In Quito and Guayaquil, all inspectors are university-trained professionals. However, an inspector's performance is not directly related to their education. Specific training and experience can, at times, compensate for professional qualifications.

The greatest priority in terms of filling gaps in knowledge involves inspection procedures, a key component that directly influences inspection efficiency.

Legal regulations and procedures are inadequate, insufficient, or not applied

Legal regulations and procedures are the basis for the system's uniformity and consistency. Current legal regulations that support the work of SICGAL have major gaps and discrepancies[6]. Among other problems, there are no penalties for infractions[6].

Administrative framework: lack of clear public policy and authority

SESA-SICGAL lacks the necessary level of technical and administrative staff, in terms of experience and knowledge, to effectively implement inspection and control policies or to manage the quarantine and inspection system. SESA-SICGAL has also not been able to operate with sufficient autonomy because of legal constraints and its own shortcomings and poor leadership.

The deficiencies of SESA-SICGAL have prevented it from obtaining adequate funding. At present it receives only 5% of the tourist entrance fee to the GNP and additional transfers from the national SESA office.

The political framework for decision-making is complex and often redundant. There is little coordination among the numerous institutions and committees. Staff within these institutions often fill multiple roles within and among committees, working groups, and various inter-agency delegations. This complex tangle of organizations and committees was designed to ensure participation, but in practice it has proven confusing and ineffective.

Conclusions and recommendations

SICGAL's inability to avert new introduced species arriving in Galapagos cannot be addressed solely by improving staff and institutional competency. Rapid growth in the different means of transport and the number of people and products entering Galapagos has resulted in ever-increasing demands for services, which SICGAL, under the most favorable conditions, is unable to meet.

Until a clear policy is set to limit growth in and access to Galapagos, any improvement to SICGAL will have a limited impact.

The following recommendations resulted from the 2006-07 assessment:

1. Implement a training and professional education program for inspectors, based on performance evaluations and the SICGAL Inspector Training Manual.
2. Reform the legal framework of SICGAL, based on the legal assessment conducted under the GEF project, *Control of Invasive Species in the Galapagos Archipelago*, and include penalties to discourage infractions.
3. Contract as a SESA-SICGAL employee an attorney or someone specifically responsible for advancing necessary legal reforms.
4. Restructure the institution, developing a new organizational structure and creating key positions for SICGAL's operations.
5. Ensure adequate funding for SICGAL to operate properly.

> SICGAL's action capacity is mainly limited by a lack of qualified personnel, adequate leadership, and an appropriate legal framework.

Annex. Assessment of the principal factors influencing the effectiveness of SICGAL[1].

The system is technically ineffective and inefficient				Administrative framework: lack of clear public policy and authority			SICGAL lacks response capacity
SICGAL staff is unable to achieve effectiveness	**Legal norms and procedures are inadequate, insufficient or not applied**	**Little or no infrastructure, equipment or materials**	**External clients do not support SICGAL activities**	**Organizational structure of SESA Galapagos does not permit effective response**	**Participation is weak and poorly coordinated**	**Funding is insufficient to meet growing responsibilities**	**Increased food, persons, and means of transport entering Galapagos**
Inadequate number of inspectors and monitoring technicians	Technical procedures are not applied properly or evaluated regularly	Suitable inspection filters and equipment at airports or ports do not exist	The public is not well informed about SICGAL regulations	SESA-Galapagos is dependent administratively on the national SESA head office	Weak coordination of activities among institutions comprising SICGAL	People who generate health risks and problems do not cover costs of control or prevention	Population growth (natural and due to migration) over 6% pear year
Job instability and staff turnover	Legal framework doesn't include penalties for infractions	Inspection areas at ports have no zones to keep unauthorized persons out	The public has a bad impression of SICGAL	The position of "SESA-SICGAL Coordinator" is unstable and low-prestige	The SICGAL Committee has little political capacity	No awareness of cost-benefits of prevention	More tourists every year
Low professional level of inspectors	No legal department to enforce penalties or provide follow-up	The assessment system of SESA- Galapagos is weak	Some means of transport and passengers do not fully comply with regulations	SESA-SICGAL has no solid administrative or technical staff	No adequate mechanisms for participation	Lack of adequate financing for SICGAL to operate fully	Per capita consumption is rising: consumerism
No technical staff on the payroll	The Special Law for Galapagos, Regulations for Total Control of Introduced Species and other norms are out of date	Maritime transport provides no health security		Disparity in capacity among different SESA-SICGAL offices	CIMEI committees are uninvolved with SICGAL health policy		Galapagos does not produce enough food
Lack of knowledge about legal procedures and norms		Inspection materials and equipment are insufficient or not in constant supply			The INGALA Council has no health policy (which should be consistent with SICGAL health policy)		Lack of coherent policies, including the problem of introduced species
Low inspector commitment and responsibility		Insufficient equipment to inspect vessels from abroad			Weak organization of commercial and agriculture sectors		Increased number of airports with flights to Galapagos
No formal monitoring of staff performance		No facilities for quarantine treatment or isolation					Insufficient community awareness regarding the threat posed by invasive species

Source: Zapata, C (2007).

Energy subsidies in Galapagos

Carlos Jácome

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In the last few years, the geographical isolation of Galapagos and the resulting policy of Ecuador's government to maintain subsidies to its energy sector have resulted in substantial contributions of government resources to this province. Moreover, the isolated location of the archipelago has given rise to many insular activities being managed as isolated systems, separate from mainland Ecuador. For instance, the electrical system is independent, not only in the archipelago but even on each island. The electrical system in Galapagos is Ecuador's second largest unconnected system, after that of Sucumbíos in northeast Ecuador. The electricity sector is not the only one operating in isolation in Galapagos. This is also the case for fuels used for terrestrial and maritime transport.

Fuel consumption

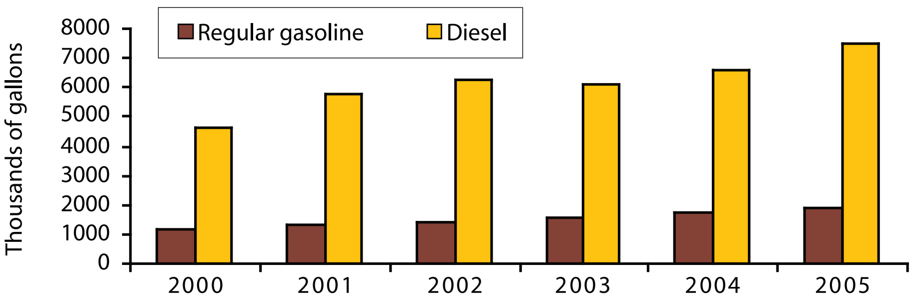
Liquid fuels used in the archipelago include regular gasoline and diesel fuel; premium gasoline is not sold in Galapagos.

> The State contributes significantly to the operation of the electrical system and supply of fossil fuels in Galapagos.

Figure 1 shows fuel demand in Galapagos for 2000-05: gasoline consumption rose by 63% and diesel by 64%.

Figure 2 shows the breakdown of different types of fuel used in the archipelago in 2005, and Figure 3 shows diesel consumption by sector during that year. The greatest consumer of diesel is the maritime fleet, mainly tourism vessels, accounting for 61% of total demand. Generation of electricity is the second-greatest consumer, at 25% of total demand. A comparison of these data with those published in the last *Galapagos Report (2001-2002)* show that diesel consumption by sector has not changed from 2001 to 2005.

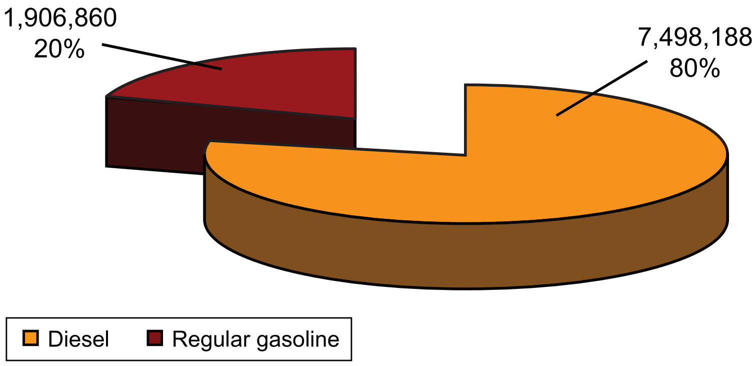
Figure 1. Fuel consumption in Galapagos, 2000-2005



Source: Petrocomercial database

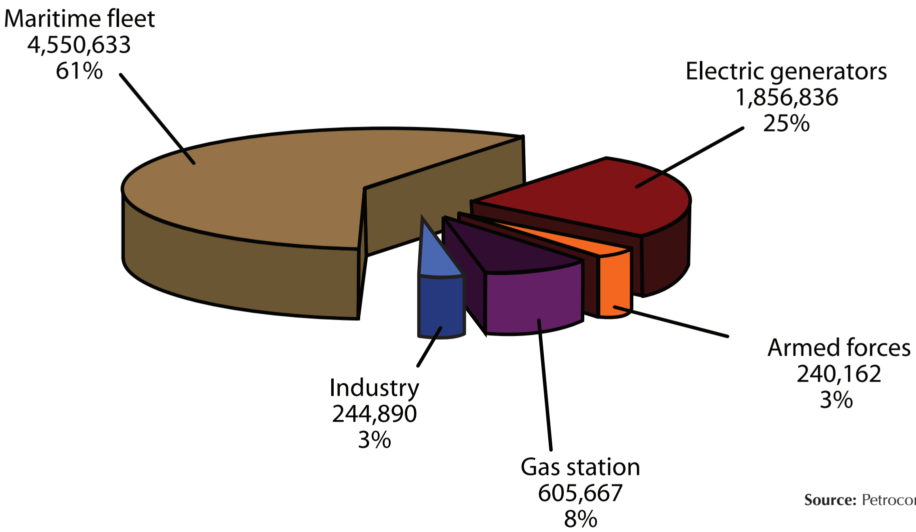
> The greatest consumer of diesel is the maritime fleet, primarily tourist vessels, which account for 61% of total demand.

Figure 2. Liquid fuel consumption (in gallons) in Galapagos, 2005



Source: Petrocomercial, 2006

Figure 3. Diesel consumption (in gallons) in Galapagos by sector, 2005



Source: Petrocomercial, 2006

Energy Prices

Fuel prices in the archipelago are the same as on the mainland. However, prior to Executive Decree 338 in 2005, ELECGALAPAGOS paid a reduced price for diesel used for thermoelectric generation, the same as the Sucumbíos Electric Company, as both were considered isolated systems. With the signing of Executive Decree 338, this incentive was extended to all other electric companies in Ecuador.

Generation of electricity using thermoelectric plants in Galapagos is more expensive than hydroelectric plants used in the national interconnected system. However, electricity prices on the islands, listed on the rate schedule of the National Electricity Council (CONELEC), do not differ substantially from electricity prices in mainland Ecuador.

> Energy prices (fossil fuels and electricity) do not cover the real costs of generating and distributing them in the islands.

Subsidies in Galapagos

The real cost of petroleum derivatives in the islands

To quantify the subsidy for petroleum derivatives in Galapagos, it is first necessary to determine the cost of diesel and regular gasoline on each island. The *Opportunity Cost,* the price of the petroleum derivative as an imported product (price at the terminal), is indicated in Table 1. These costs are then added to maritime shipping costs from the mainland to the islands and land transportation costs from the dock to the fuel storage site, plus the value added tax (VAT) and marketing expenses. For example, fuel for Santa Cruz is brought from the mainland to Baltra, where it is stored at the Clean Product Terminal. Fuels are subsequently dispatched from the terminal and transported by barge across Itabaca Canal to northern Santa Cruz, and then overland in tank trucks to the Petrocomercial Service Station or the power plant of ELECGALAPAGOS, both located in Puerto Ayora (southern Santa Cruz). Table 2 shows the average subsidy at the insular level. However, real costs vary among islands due to different transportation and storage costs.

Table 1. Real costs of regular gasoline and diesel in Galapagos (US$/gallon), 2005.

Fuel	Price at the terminal (a)	Maritime transport (b)	Overland transport (c)	Subtotal	VAT	Marketing profit (d)	Real cost
Diesel	1.94	0.204	0.060	2.202	0.264	0.049	2.515
Gasoline	1.93	0.204	0.060	2.190	0.263	0.049	2.501

Source: PETROCOMERCIAL and author's calculations.

Notes:

Average prices in the Archipelago
(a) Ministry of Energy and Mining.
(b) Resolution No. 230/03 by the Directorate General of Merchant Marine and the Coast.
(c) Agreement 123 Published in the Official Register of December 4, 2004.
(d) 2% profit.

The subsidy for fossil fuels in Galapagos

The fuel subsidy is equivalent to the difference between the cost of derivatives on the islands and their sale price (US$ 0.92/gallon for diesel used for electric generation, US$ 1.01/gallon for diesel used for transport, and US$ 1.48/gallon for regular gasoline).

Table 2. Fuel subsidy estimates for gasoline and diesel, 2005.

Derivative	Subsidy/gal [US$/year]	Demand [gal/year]	Total subsidy [US$/year]
Regular gasoline	1.021	1,906,860	1,947,560
Diesel, electric sector[1]	1.595	1,856,836	2,962,358
Diesel, other sectors[2]	1.505	5,641,352	8,492,375
		9,405,048	**13,402,294**

Source: PETROCOMERCIAL and author's calculations.

Notes:

[1] The category of "Diesel, other sectors" includes diesel for maritime and terrestrial transportation and industry.

[2] The subsidy for diesel used for the electricity sector is not the only component of the subsidy for energy consumed. Total electricity sector subsidy, taking into account all other components, is calculated separately.

In 2005, the subsidy for diesel and gasoline consumption by "other sectors" (maritime and terrestrial transportation and industry), based on opportunity cost, was US$ **10.44** million (Table 2).

The cost of producing electricity in the Galapagos Islands

The production cost has been calculated for two scenarios, with and without the subsidy for diesel. Table 3 breaks down production costs for each kilowatt-hour of energy per island. The cost of generating electricity incorporates the cost of diesel fuel used for thermo-electric generation. The first scenario (the current situation) uses the subsidized price of diesel, US$ 0.92/gal. Table 4 breaks down costs per island, considering the real cost of diesel, which varies by island. The island with the lowest cost per kWh is Santa Cruz, whereas the highest cost is on Floreana, which confirms that electrical production is an activity based on economies of scale.

Table 3. Cost of producing electricity by island (US$/ kWh), 2005.
(Reference scenario: Current Situation with *subsidized diesel*)

Sector	San Cristóbal	Santa Cruz	Isabela	Floreana
Generation	0.135	0.101	0.187	0.889
Distribution	0.025	0.010	0.029	0.102
Marketing	0.020	0.005	0.030	0.060
Administration	0.036	0.015	0.048	0.099
TOTAL	0.216	0.131	0.295	1.149

Source: Financial reports from ELECGALÁPAGOS, 2005.

Table 4. Cost of producing electricity by island (US$/ kWh), 2005.
(Reference scenario: Current Situation with *Diesel at real cost*)

Sector	San Cristóbal	Santa Cruz	Isabela	Floreana
Generation	0.263	0.229	0.339	1.126
Distribution	0.025	0.010	0.029	0.102
Marketing	0.020	0.005	0.030	0.060
Administration	0.036	0.015	0.048	0.099
TOTAL	0.344	0.259	0.446	1.386

Source: Financial reports from ELECGALÁPAGOS, 2005.

The subsidy for electricity

The sale price of electricity for the province of Galapagos is set by CONELEC. For both scenarios, the cost of producing electricity is higher than the sale price set by CONELEC (Tables 3 and 4). The average sale price used to calculate the subsidy per island is 8.9 cents per kWh. At present, the Galapagos Provincial Electric Company covers the operating and maintenance deficits via an allocation from the Rural and Urban Marginal Electrification Fund (FERUM).

For 2005, the total subsidy for fossil fuels and generation of electricity in Galapagos is estimated at US$ 15.3 million.

Table 5. Subsidy for electricity (US$/year) for 2005.

Island	US$/kWh	Electricity kWh/year	Subsidy US$/year
San Cristóbal	25.539	6,546,056	1,671,776
Santa Cruz	16.963	14,603,200	2,477,191
Isabela	35.735	1,655,270	591,517
Floreana	129.707	53,917	69,934
TOTAL		**22,858,443**	**4,810,418**

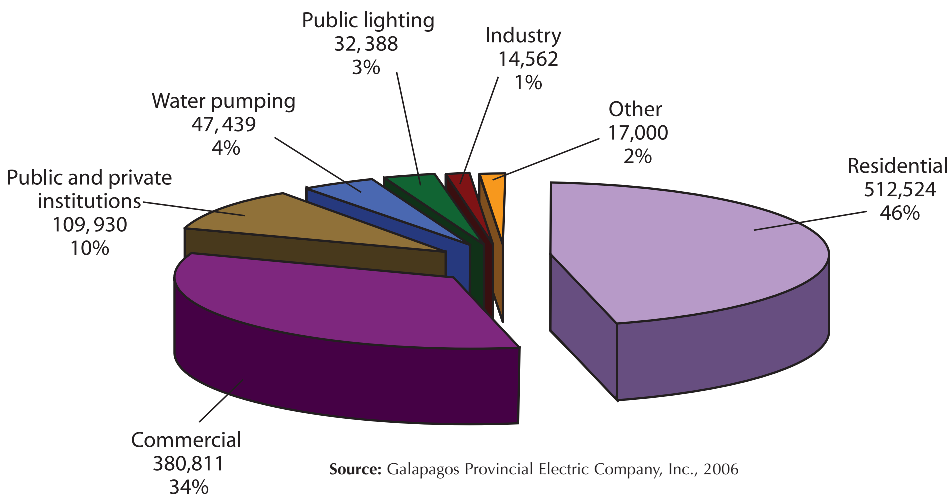
Table 5 indicates the real subsidy for electricity, incorporating the real cost of diesel used to generate electricity. The annual subsidy for the electricity sector is US$ 4.81 million.

Analysis of subsidy allocation in the electricity sector

The demand structure of the electricity sector is made up of residential, commercial, public and private institutions and organizations, public lighting, water pumping, industrial, and other sub-sectors that include social welfare, public benefit, and sports facilities.

Figure 4 shows energy demand by sector. The residential sector generates the greatest demand and has the largest number of users. The commercial sector is second in energy demand, which is expected given that Galapagos' main activities involve tourism and commerce. Public and private institutions and organizations, including those that supervise and oversee science and natural resource management in Galapagos, also account for a significant portion of demand for electricity. Energy demand by the industrial sector, which is restricted to artisan industries, is quite low compared to mainland Ecuador.

Figure 4. Energy demand in Santa Cruz by sector (kWh/month)



Source: Galapagos Provincial Electric Company, Inc., 2006

To categorize distribution of subsidies in Galapagos according to different economic strata, the average monthly energy consumption (in kWh) was classified by sector. A total of five different energy consumption ranges (kWh/month) were defined (Table 6). Consumption rates less than 100 kWh per month corresponded to families with low energy demands compared to the national average of 117 kWh/month.

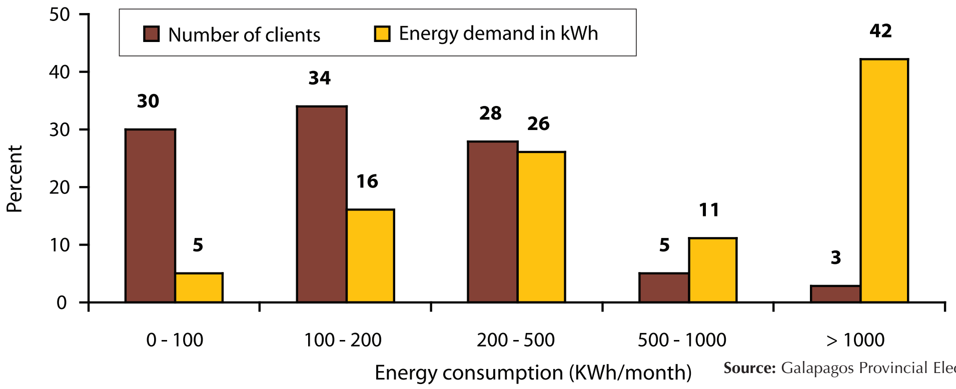
Customers from different sectors consuming 0–200 kWh/month represent 64% of all clients (Table 6 and Fig. 5). However, they account for only 20.5% of energy demand. A more detailed analysis by sector shows that the residential and commercial sectors with consumption over 500 kWh/month represent only 7% of all clients, but 36% of energy demand.

Table 6. Distribution of clients and total energy demand in kWh by range of consumption in Santa Cruz.

Sector	0 - 100	100 - 200	200 -500	500 - 1000	>1000	Total
Residential	873	1,079	786	82	18	2,838
Commercial	110	86	143	84	73	496
Public and private institutions	8	6	8	9	16	47
Water pumping	0	0	1	0	5	6
Public lighting	0	0	0	0	1	1
Industry	28	21	16	2	3	70
Other	21	10	14	2	2	49
Total (no. of clients)	**1,040**	**1,202**	**968**	**179**	**118**	**3,507**
Total (demand in kWh)	**52,716**	**176,283**	**290,178**	**123,833**	**471,644**	**1,114,654**

Source: Galapagos Provincial Electric Company, Inc., 2006

Figure 5. Distribution of clients and total energy demand in kWh by range of consumption in Santa Cruz



Source: Galapagos Provincial Electric Company, Inc., 2006

The future: renewable energy as an economical and environmental solution

Substantial resources are allocated to cover the subsidy in different energy sectors in Galapagos. In 2005, subsidies in Galapagos for liquid fuels used for transportation equaled approximately US$10.48 million and those for electricity approximately US$4.8 million.

> Renewable energy projects will help reduce fossil fuel consumption and, therefore, associated environmental risks.

Given the importance of preserving this World Heritage Site and balancing energy and production activities in the islands, it is essential to promote renewable energy projects in the archipelago.

The project, *Renewable Energies for Galapagos* (ERGAL), is designed to reduce diesel consumption by using alternative sources to generate electricity (e.g., wind, photovoltaic, and biofuels), and thus reduce environmental problems resulting from use of fossil fuels. Once renewable energy projects are implemented, it is expected that the Government of Ecuador will experience substantial savings in fuel consumption, which are estimated in Table 7.

Table 7. Expected savings compared to 2005 costs when renewable energy projects are implemented.

Item	San Cristóbal	Santa Cruz	Isabela	Floreana	Total
Extent of renewable energy system	50%	40%	70%	40%	45.4%
Reduction in diesel consumption (gal/year)	270,944	463,201	110,116	3,517	844,260
Real cost of diesel in the electric sector (US$)	2.478	2.532	2.518	2.525	2.50
Total savings (US$/year)	**671,447**	**1,173,028**	**277,226**	**8,878**	**2,121,701**

Source: ERGAL Project, UNDP and MEM

Vehicles in Galapagos[1]

Ángel Villa, engineer

INGALA Planning Department

Eight years after the Special Law for Conservation and Sustainable Development in Galapagos was enacted, a law which included language to limit the introduction of vehicles to the Archipelago, indicators of regulation and control of entry of vehicles do not reflect the intended outcomes. Since 1998, the vehicle fleet in Galapagos has increased significantly, especially on the islands of Santa Cruz and San Cristóbal, with the greatest increase occurring in 2001 and 2002.

This rapid growth is an effect of the unplanned and sometimes erratic process of development in Galapagos. The different characteristics of the inhabited islands have resulted in differences in the increase in vehicles. However, all communities show a trend of increasing vehicle numbers in the short term, an increase in fuel demand, and collateral effects related to traffic and air and noise pollution. These effects are especially evident during rush hour in urban areas such as Puerto Ayora on the island of Santa Cruz. Other problems generated by the increase in the number of vehicles are pollution from wastes, spare parts that are not recycled, and increased demand for road maintenance, which in turn requires more intensive quarrying on each island.

INGALA is conducting studies to define indicators to measure vehicle fleet growth trends in the province of Galapagos. This article examines the most significant initial indicators from INGALA's databases, with data collected since 1999, as well as findings from the vehicle census on Isabela (September 2005, updated to November 2006). It also estimates the vehicle population in Galapagos and reviews growth trends both before and after the Special Law was enacted. This information comes from the study entitled *"Situational Analysis of the Growing Vehicle Fleet in Galapagos"*[1], submitted to the INGALA Council in late 2006.

Legal Framework

The Special Law for Galapagos, enacted on 18 March 1998, required that the entry of vehicles to Galapagos be regulated. The Ministry of the Environment, which at that time served as chair of the INGALA Council, was given the responsibility of establishing enforcement measures. Subsequent constitutional reforms named the Governor of Galapagos chair of the INGALA Council, at which time the Governor assumed responsibility for control regulations and procedures.

At present, vehicle entry is subject to the *"Special Regulations to Control Motor Vehicle and Machinery Entry into the Province of Galapagos"*, approved by INGALA Council Resolution No. CI-18-I-2005 and published in Official Register No. 09 of 3 May 2005. These regulations established a five-year moratorium on additional permits for public service cooperatives, and on the creation of new land transport cooperatives. This resolution also created the Technical Oversight Committee for Entry of Automotive Vehicles, whose members include the Governor's Office (chair), a representative of the Galapagos National Park Service (GNPS), a representative of the transportation sector, the mayor of each canton, the general manager of INGALA, and a representative of the National Merchant Marine and Directorate for the Coast (DIGMER), the institution responsible for authorizing maritime transport of automotive vehicles to Galapagos.

In 2006 it was estimated that there were 2,051 vehicles in Galapagos, including motorcycles and scooters, 59% of which entered in the last eight years.

Estimate of the vehicle fleet as of 2006

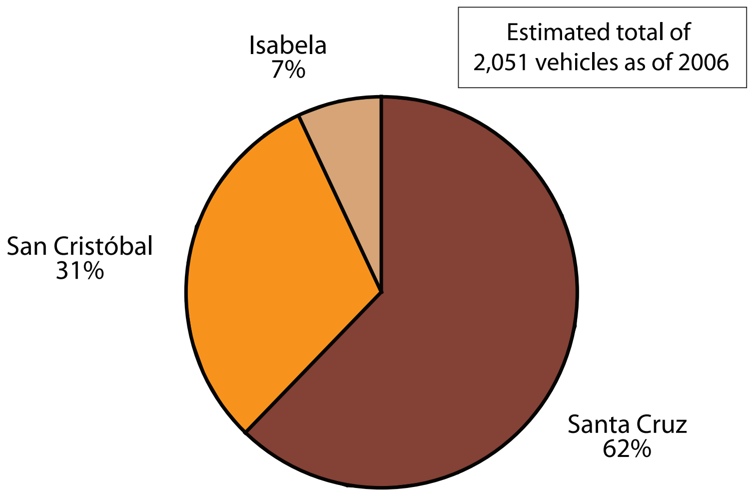
A minimum of 2,051 vehicles were estimated to be in circulation in Galapagos as of 2006 (Table 1). This figure includes pickup trucks, jeeps, buses, vans, motorcycles, scooters, four-wheelers, and large machinery for public projects. According to these estimates, Santa Cruz has 1,276 vehicles (62% of the total), San Cristóbal has 633 (31%), and Isabela 142 (7%) (Fig. 1).

Table 1. Estimated number of vehicle entries into Galapagos, up to and after 1998.

	Up to 1998			After 1998			Total in 2006
Canton	4-wheeled vehicles	Motorcycles	Total	4-wheeled vehicles	Motorcycles	Total	
Santa Cruz	470	134	604	271	401	672	**1,276**
San Cristóbal	140	54	194	272	167	439	**633**
Isabela	39	3	42	78	22	100	**142**
Total	**649**	**191**	**840**	**621**	**590**	**1,211**	**2,051**

Sources: INGALA databases, estimates by Cárdenas S. 2002[2], Provincial Transit Authority, Municipal tax rosters, information from the vehicle census on Isabela.

Figure 1. Distribution of the number of vehicles in Galapagos by island, as of 2006



Sources: INGALA databases, estimates by Cárdenas S. 2002[2], Provincial Transit Authority, Municipal tax rosters, information from the vehicle census on Isabela.

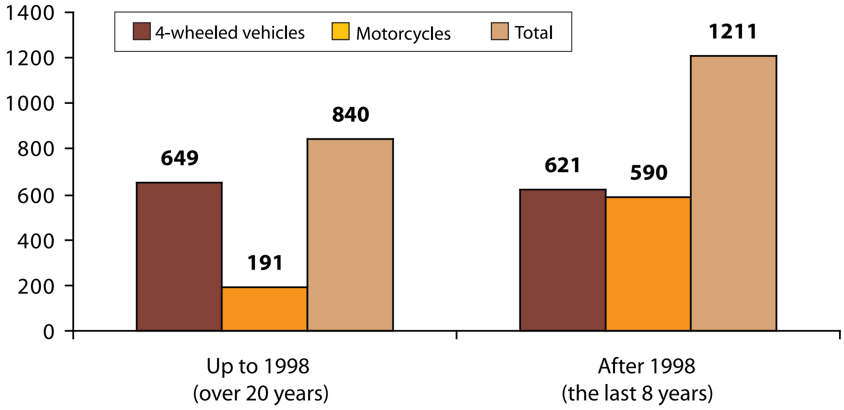
If we analyze the estimated total number of vehicles in Galapagos by vehicle type, there are approximately 1,270 4-wheeled vehicles (62%) and 781 motorcycles and scooters (38%) (Table 1).

62% of estimated vehicles in Galapagos are in Santa Cruz; 58% of those are four-wheeled.

Growth trends in the vehicle fleet

To assess the effectiveness of control measures, it is important to analyze the number of vehicles that entered Galapagos after 1998, when formal control of vehicle entry began. Data prior to 1999 are incomplete. Also, it is probable that some vehicles entering Galapagos were not registered during the first few years of control implementation. For this study, it was estimated that before the Special Law went into effect, Galapagos had a total of 840 vehicles. According to INGALA databases, 1,211 vehicles have entered between 1998 and November 2006. Therefore, 59% of the vehicles in Galapagos in 2006 entered during the last eight years (Table 1, Fig. 2).

Figure 2. The Galapagos vehicle fleet up to 1998 and vehicle entries to Galapagos after 1998



Sources: INGALA databases, estimates by Cárdenas S. 2002[2], Provincial Transit Authority, Municipal tax rosters, information from the automotive census on Isabela.

There has been a sharp rise in the number of vehicles on Santa Cruz, San Cristóbal, and Isabela over the last eight years (Table 2 and Fig. 3). In 2006, Santa Cruz recorded 236 entries authorized by the Vehicle Entry Committee, of which 152 were motorcycles and scooters, 50 were vehicles (pickups, buses, vans, and boats) and 35 were replacement vehicles (see attachment). However, these figures also show a clear decrease in the annual rate of increase in vehicles, from 86% in 2004-05 to 21% in 2005-06, primarily a result of more effective enforcement of regulations.

Table 2. Yearly increase in the number of vehicles in Galapagos, according to entries authorized by INGALA since 1999*.

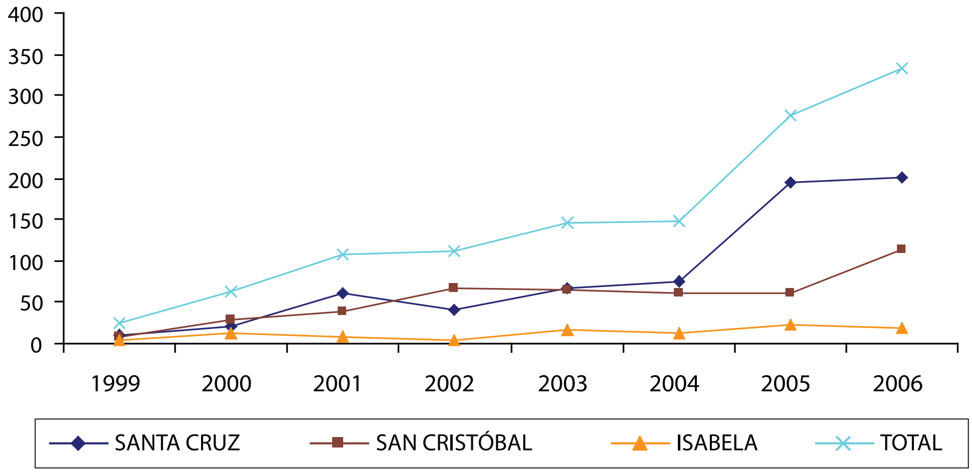
Canton	1999	2000	2001	2002	2003	2004	2005	2006	Total
Santa Cruz	11	21	61	40	66	76	195	202	672
San Cristóbal	9	28	38	66	64	61	60	113	439
Isabela	5	13	8	5	16	12	22	19	100
Total	25	62	107	111	146	149	277	334	1,211

Source: INGALA databases

Note:

* Includes only new vehicle entries, not authorized replacements.

Figure 3. Annual increase in the number of vehicles by canton, 1999-2006



Source: INGALA databases

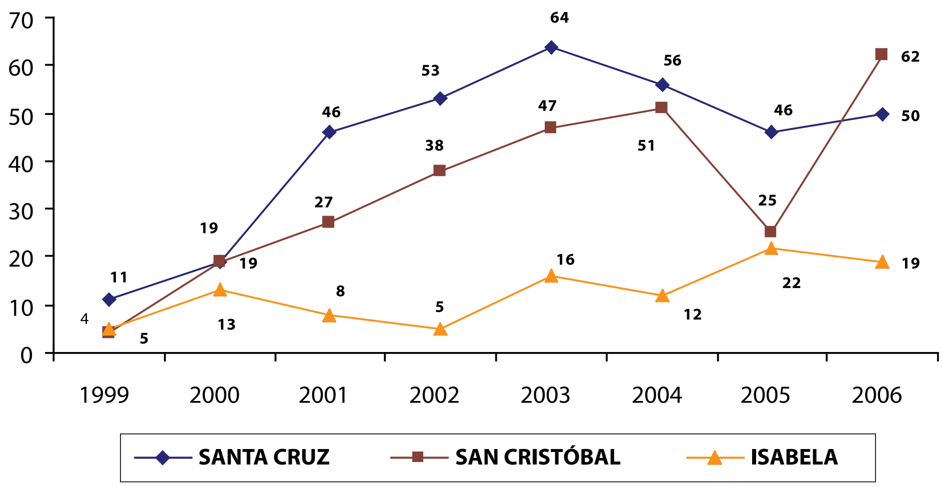
Note:

* Includes only new vehicle entries, not authorized replacements.

Resolution No. 008-CI-24-III, approved on 24 March 2004, established a five-year moratorium on the entry of vehicles for public transportation and on the creation of new overland transport companies or cooperatives. This moratorium was ratified in 2005 with approval of the *Special Regulations to Control Entry of Four-Wheeled Motor Vehicles and Machinery into the Province of Galapagos*. Enforcement of these regulations has resulted in a significant decrease in vehicle entries since 2004, with the exception of San Cristóbal, where the entry of 46 large machines and vehicles for public projects was recorded in 2006. These will be returned to the mainland when the projects (wind power generation infrastructure, airport landing strip, etc.) are completed (Fig. 4).

Motorcycles represented less than 5% of all vehicle entries in 2000, whereas in 2006 their percentage increased to 75%.

Figure 4. Yearly growth in 4-wheeled vehicles and machinery by canton, 1999-2006



Source: INGALA databases

One cause of the excessive increase in vehicles in Santa Cruz in relation to the other islands was the sale in San Cristóbal and Isabela of approximately 20 used vehicles in poor condition that were taken to Santa Cruz, primarily from 2001 to 2003. These used vehicles were then replaced with new ones, which signified replaced vehicles within the province of Galapagos, but an actual increase in the number of vehicles on Santa Cruz.

From 1998 to 2000, motorcycles and scooters represented less than 5% of yearly vehicle entries, whereas from 2001 to 2006, their percentage increased from 10% to 75% (annex).

Case study: vehicle census on Isabela, 2005-2006

In September 2005, a vehicle population census was conducted on the island of Isabela to highlight potential socioeconomic and environmental impacts related to vehicle fleet growth. Because of the relatively small size of the fleet, it was possible to survey 100% of vehicle owners as well as public officials and public transport and production sector representatives. This data provides an excellent baseline to assess the number of vehicles on Isabela before and after enactment of the Special Law. This census was later updated through November 2006 using information from INGALA databases.

The 2006 update identified 117 4-wheeled vehicles in Isabela. These are heavy- and light-duty vehicles and machinery for public projects (Table 3). An estimated 39 4-wheeled vehicles entered Isabela before 1998 (33% of the current fleet), while 78 (67% of the current fleet) entered from 1999 to November 2006. The census did not include motorcycles; however the number of motorcycles and scooters on Isabela is estimated at 25. The census reports a total of 142 vehicles on Isabela in 2006.

67% of all 4-wheeled vehicles on Isabela have entered since 1999, i.e. 78 vehicles.

Table 3. Overall description of vehicles by activity and date of entry into Isabela.

Type of activity of vehicles	Description of vehicles in the canton of Isabela by economic activity	Vehicle fleet census on Isabela		
		Up to 1998	After 1998	Total on Isabela
Public transportation	"Sierra Negra" Cooperative	8	19	36
	Pre-coop."Piquero Azul"	1	3	
	"Cotranscartin" bus company	2	3	
Productive activities	Agriculture	1	20	50
	Small-scale fishing	1	7	
	Tourism	0	12	
	Commerce	1	2	
	Other	6	0	
Official use (public institutions)	Public institutions (light, heavy-duty and road-making machinery)	39	12	31
Total		**39**	**78**	**117**

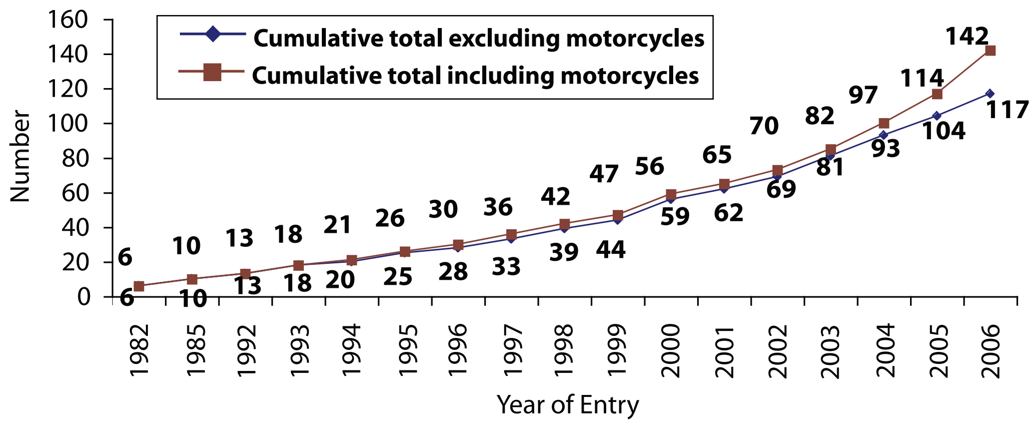
Note:

Does not include motorcycles or scooters.

Source: Vehicle census on Isabela, 2005-2006

Figure 5 shows the cumulative vehicle increase on Isabela. Interestingly, before 1998 the annual growth rate in vehicles (excluding motorcycles and scooters) was 2 vehicles per year. Following the enactment of the Special Law, this number increased to 10 vehicles per year.

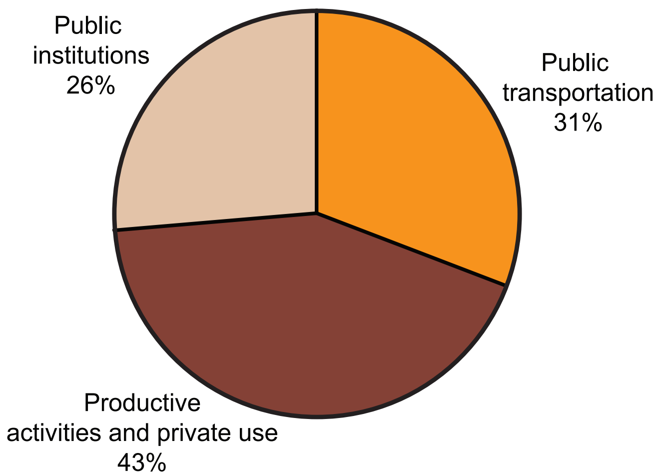
Figure 5. Cumulative vehicle increase by year of entry into Isabela



Source: Vehicle census on Isabela, 2005-2006

An analysis of the vehicle fleet on Isabela by activity shows that 31% of the vehicles provide public transportation, 43% are for productive and private use, and 26% for public institutions (Table 3 and Fig. 6). The public transport sector, comprising two cooperatives that use pick-up trucks and one bus company, registered a total of 36 vehicle entries by 2006. Using the entry authorization census (INGALA databases) for comparison, of the 25 vehicles used for public transport that entered since 1998, only 13 were authorized for such service. That means that 12 of the vehicles registered with cooperatives for public transport service entered Galapagos under authorizations for other economic activities.

Figure 6. Distribution of vehicles on Isabela by activity



Source: Vehicle census on Isabela, 2005-2006

Discussion

It is estimated that there are a total of 2,051 vehicles in Galapagos, with 59% having entered in the last eight years. The majority of all vehicles (62%) are in Santa Cruz. Enforcement of regulations since 2004 has significantly reduced the entry of new 4-wheeled vehicles, especially pickup trucks for public transportation. Consequently, average annual vehicle entry growth rates have dropped for all islands. At the same time, more motorcycles and scooters have entered.

In 2007, public transportation capacity for both passengers and cargo is generally greater than demand. Therefore, it would be useful to analyze future trends in what motivates vehicle entries into the islands.

Based on findings of the vehicle census on Isabela and an analysis of cargo and passengers, the INGALA Council recommended in December 2006 to extend the moratorium on the entry of public transportation vehicles to the island of Isabela and to extend the application of this measure to the entire province of Galapagos. This measure must be applied until suitable socioeconomic and environmental indicators are defined to improve implementation of vehicle entry regulations. It is important to continue with specialized studies to provide a stronger technical foundation for decision-making and to upgrade and evaluate information in relevant databases.

Norms enforced since 2004 have resulted in fewer entries of new 4-wheeled vehicles into Galapagos.

The INGALA Technical Secretariat requires support from the INGALA Council to strengthen its work in the area of vehicle control and to provide more effective technical and legal support to the Vehicle Control Committee. In the short term, a study is planned to provide data on vehicle supply and demand by economic activity. This study will contribute to a comprehensive transportation study for Galapagos that will result in recommendations for public and private transport policies.

The current vehicle entry regulations are too weak. They do not reflect the spirit of the Special Law nor do they provide sound socioeconomic and environmental management for the Province of Galapagos. The current *Regulations to Control Motor Vehicle and Machinery Entry into the Province of Galapagos* must be revised on the basis of sound data and experience. In the short term, it appears that the public service vehicle fleet is the only group that must be increased (with obsolete vehicles replaced as needed), until a real increase in demand for transportation of cargo and passengers is identified and quantified.

Annex. Authorizations for entry of vehicles and machinery into Galapagos, 1999-2006.

SUMMARY: SANTA CRUZ

2006

TOTAL AUTHORIZED ENTRIES	236
REPLACEMENTS	35
MOTORCYCLES	152
4-WHEELED VEHICLES	50
NEW ENTRIES	202

2005

TOTAL AUTHORIZED ENTRIES	269
REPLACEMENTS	43
MACHINERY	31
MOTORCYCLES	149
4-WHEELED VEHICLES	46
NEW ENTRIES	195

2004

TOTAL AUTHORIZED ENTRIES	128
REPLACEMENTS	52
MOTORCYCLES	20
4-WHEELED VEHICLES	56
NEW ENTRIES	76

2003

TOTAL AUTHORIZED ENTRIES	122
REPLACEMENTS	56
MOTORCYCLES	2
4-WHEELED VEHICLES	64
NEW ENTRIES	66

2002

TOTAL AUTHORIZED ENTRIES	84
REPLACEMENTS	44
MOTORCYCLES	2
4-WHEELED VEHICLES	38
NEW ENTRIES	40

2001

TOTAL AUTHORIZED ENTRIES	109
REPLACEMENTS	48
MOTORCYCLES	15
4-WHEELED VEHICLES	46
NEW ENTRIES	61

2000

TOTAL AUTHORIZED ENTRIES	53
REPLACEMENTS	33
MOTORCYCLES	2
4-WHEELED VEHICLES	19
NEW ENTRIES	21

1999

TOTAL AUTHORIZED ENTRIES	33
REPLACEMENTS	22
MOTORCYCLES	0
4-WHEELED VEHICLES	11
NEW ENTRIES	11

SUMMARY: SAN CRISTÓBAL

2006

TOTAL AUTHORIZED ENTRIES	125
REPLACEMENTS	12
MOTORCYCLES	51
4-WHEELED VEHICLES	62
NEW ENTRIES	113

2005

TOTAL AUTHORIZED ENTRIES	74
REPLACEMENTS	14
MOTORCYCLES	35
4-WHEELED VEHICLES	25
NEW ENTRIES	60

2004

TOTAL AUTHORIZED ENTRIES	74
REPLACEMENTS	13
MOTORCYCLES	10
4-WHEELED VEHICLES	51
NEW ENTRIES	61

2003

TOTAL AUTHORIZED ENTRIES	77
REPLACEMENTS	13
MACHINERY	9
MOTORCYCLES	8
4-WHEELED VEHICLES	47
NEW ENTRIES	64

2002

TOTAL AUTHORIZED ENTRIES	75
REPLACEMENTS	9
MOTORCYCLES	13
4-WHEELED VEHICLES	53
NEW ENTRIES	66

2001

TOTAL AUTHORIZED ENTRIES	44
REPLACEMENTS	6
MOTORCYCLES	11
4-WHEELED VEHICLES	27
NEW ENTRIES	38

2000

TOTAL AUTHORIZED ENTRIES	41
REPLACEMENTS	13
MOTORCYCLES	9
4-WHEELED VEHICLES	19
NEW ENTRIES	28

1999

TOTAL AUTHORIZED ENTRIES	13
REPLACEMENTS	4
MOTORCYCLES	5
4-WHEELED VEHICLES	4
NEW ENTRIES	9

SUMMARY: ISABELA

2006

TOTAL AUTHORIZED ENTRIES	19
REPLACEMENTS	0
MOTORCYCLES	12
4-WHEELED VEHICLES	7
NEW ENTRIES	19

2005

TOTAL AUTHORIZED ENTRIES	24
REPLACEMENTS	2
MOTORCYCLES	6
4-WHEELED VEHICLES	16
NEW ENTRIES	22

2004

TOTAL AUTHORIZED ENTRIES	12
REPLACEMENTS	0
MOTORCYCLES	0
4-WHEELED VEHICLES	12
NEW ENTRIES	12

2003

TOTAL AUTHORIZED ENTRIES	16
REPLACEMENTS	0
MOTORCYCLES	0
4-WHEELED VEHICLES	16
NEW ENTRIES	16

2002

TOTAL AUTHORIZED ENTRIES	7
REPLACEMENTS	2
MOTORCYCLES	0
4-WHEELED VEHICLES	5
NEW ENTRIES	5

2001

TOTAL AUTHORIZED ENTRIES	8
REPLACEMENTS	0
MOTORCYCLES	0
4-WHEELED VEHICLES	8
NEW ENTRIES	8

2000

TOTAL AUTHORIZED ENTRIES	31
REPLACEMENTS	0
MOTORCYCLES	0
4-WHEELED VEHICLES	13
NEW ENTRIES	13

1999

TOTAL AUTHORIZED ENTRIES	6
REPLACEMENTS	1
MOTORCYCLES	0
4-WHEELED VEHICLES	5
NEW ENTRIES	5

Source: INGALA databases

Note:

Motorcycles include motorcycles and scooters.

Integrated solid waste management in Santa Cruz

Dr. Ulf Tosten Hardter[a,b] & Marcos Sánchez Rivera[a]

[a]Environmental Management Unit, Municipal Government of Santa Cruz, [b]World Wildlife Fund

Human settlements in Santa Cruz are recent, with the first colonists arriving in the 20th century. However, in the last few years, the human population of Santa Cruz has grown substantially. The census of 2006, by the National Institute of Statistics and Censuses (INEC), indicates a total of 11,262 residents in Santa Cruz. In addition, there are more than 100,000 tourists entering Galapagos each year and Santa Cruz is the tourism hub, both as a base of operations and as a prominent attraction.

The growth in both the resident population and tourism has major implications for the local government due to an increasing demand for basic services, including drinking water, sewage systems, garbage collection, health, and education. The Municipality of Santa Cruz has increased its efforts to address public health issues by establishing regulatory frameworks, increasing technical staff, providing more equipment and vehicles for public programs, and raising funds and implementing waste management projects, which include collection, recycling, and treating solid and liquid wastes, and sewage treatment.

Evolution of waste management in Santa Cruz

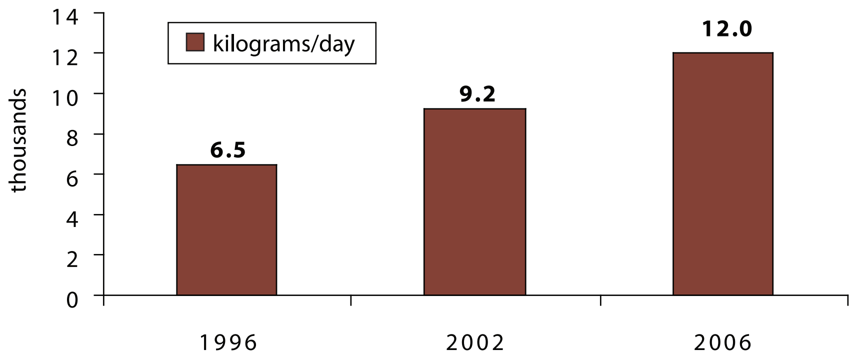
Decades ago, when the human population on Santa Cruz was small, garbage collection and port cleanup were not critical issues. At that time, the garbage collection program of the Municipality consisted of a cart pulled by a donkey. Later, dump trucks were used to collect garbage and transport it to the compacting vehicle, which deposited the compacted materials four kilometers inland from the town. The Municipality has now initiated an **Integrated Solid Waste Management System**. The new system includes selective collection, treatment, and disposal of wastes and residues, with sorting of garbage at the source for regular domestic waste. The system also includes hazardous and hospital waste collection programs, and separate collection of bulky waste, such as weeds, scrap metal, and used tires.

Evolution of solid waste production in Santa Cruz

Growth trends in the total amount of solid waste production on Santa Cruz are significant (Fig. 1). In the last ten years, total solid waste production has increased by 84%. It is estimated that in 2006, approximately 5500 kg more per day were produced than in 1996. The estimated total is based on the last comprehensive study of solid waste in 2001 and 2002[1]. At present, the canton of Santa Cruz produces about 12 tons of solid waste per day.

> In the last ten years, total solid waste production in Santa Cruz increased by 84%. In 2006, approximately 5500 kg more per day were produced than in 1996.

Figure 1. Total production of solid waste in Santa Cruz, 1996–2006



Source: Fundación Natura (1997)[2], Honkisch (2001)[1]

Categorization of garbage in Santa Cruz[1]

Prior to the implementation of a new waste collection system, a study on the composition of waste deposited at the sanitary landfill at km 27 was conducted in 2001[1] (Table 1). The resulting data were the basis for estimating total waste production for 2006 and for the design of current projects to selectively collect other materials (both recyclable and non-recyclable), such as weeds, scrap metal, used tires, and used batteries.

Table 1. Estimated total waste per person per year in 2002, in the canton of Santa Cruz.

Weeds and recyclables collected separately

Waste collection

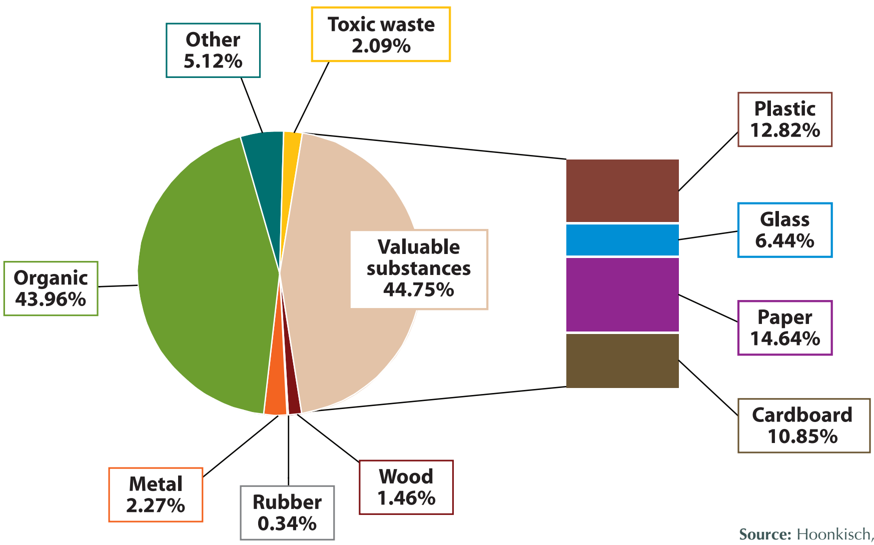
Total annual amount of wastes per person, 2002, Santa Cruz canton										
						Number of people		Annual amount		
Site	Zone	Weeds [kg/day]	Recyclables [kg/day]	Waste [kg/day]	Total [kg/day]	Residents	Tourists /year	Amount (tons/yr)	Amount (kg/person/yr)	Amount (kg/person/day)
Bellavista/St. Rosa				427.10	427.10	1138		155.9	136.98	0.38
Puerto Ayora	Residential	400.00		1380.08	1780.08	3410		649.7	190.53	0.52
Puerto Ayora	Commercial	400.00	246.70	5373.67	6165.73	5903	193	2250.5	369.19	1.01
	GNP			80.0						
	CDF			65.36						
Tourist vessels			101.42	753.26	854.68		1046	312.0	298.35	0.82
Estimates		**800.00**	**348.12**	**8079.47**	**9227.59**	**10451**	**1239**	**3368.1**	**288.13**	**0.79**

Estimates

Source: Hoonkisch, 2001

Valuable wastes that are easier to market account for 45% of the total, followed by organic materials (44%), metals (2%), wood (1%), and finally wastes that cannot be reused (8%) (Fig. 2). An estimated 92% of materials can be treated or recycled. Materials that cannot be reused (8%) include primarily toxic waste (2%), used batteries, computing wastes, and hospital waste. Santa Cruz also has a large amount of scrap metal (some 200 tons per year) and weeds, branches, and plant cuttings (averaging 30-40 m³ per day).

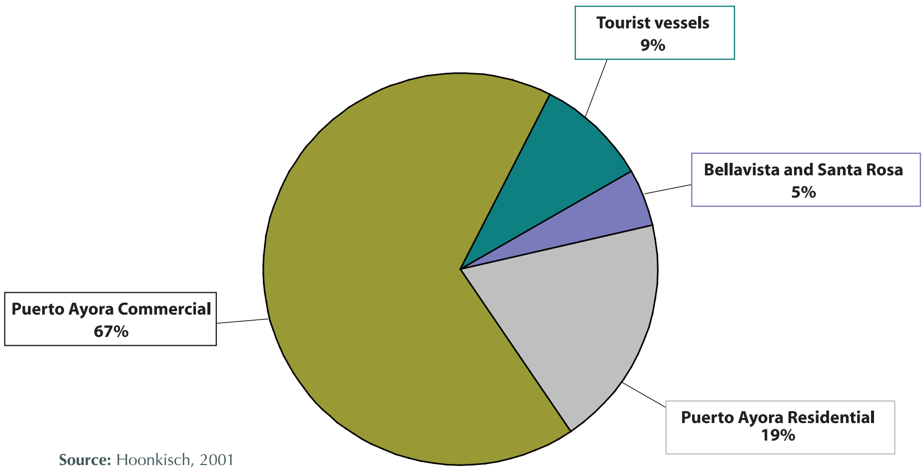
Figure 2. Composition of solid waste produced in Santa Cruz by type



Source: Hoonkisch, 2001

The waste management model for Santa Cruz must coincide with the socioenvironmental reality of the canton. For this reason, solid wastes were analyzed by sector (Fig. 3). The majority of waste is produced by the commercial sector (67%).

Figure 3. Distribution of waste on Santa Cruz by sector



Source: Hoonkisch, 2001

Integrated Solid Waste Management System

In April 2006, the Municipality of Santa Cruz initiated an Integrated Solid Waste Management System (Fig. 4). Total estimated waste and composition by type and sector have been used to determine the stages of the system summarized below.

The Separation System

The new system requires separation of waste at the source. To facilitate separation at the source, a set of three colored containers were distributed to each home, business, hotel, and restaurant: green (organic wastes), blue (recyclable wastes), and black (un-recyclable wastes). To separate hospital wastes, a red container was given to all hospitals, laboratories, doctor's offices, and pharmacies. The micro-enterprise RELUGAL (Collection of Used Lubricants in Galapagos) manages the collection and storage of used oils. The company ships the oil in barrels to Guayaquil and sells it to a company that refines and reuses it in products such as industrial greases or lubricants.

The Collection System

A variety of vehicles are used in waste collection. Two municipal compacting vehicles collect organic waste and non-recyclable waste on alternate days. Two private micro-enterprises contract their trucks to the Municipality for the collection of recyclable waste. The Municipality also handles collection of hospital wastes, using a pickup truck pulling a sealed trailer. Scrap, weeds, branches, and other cuttings are collected by a truck contracted from a private micro-enterprise.

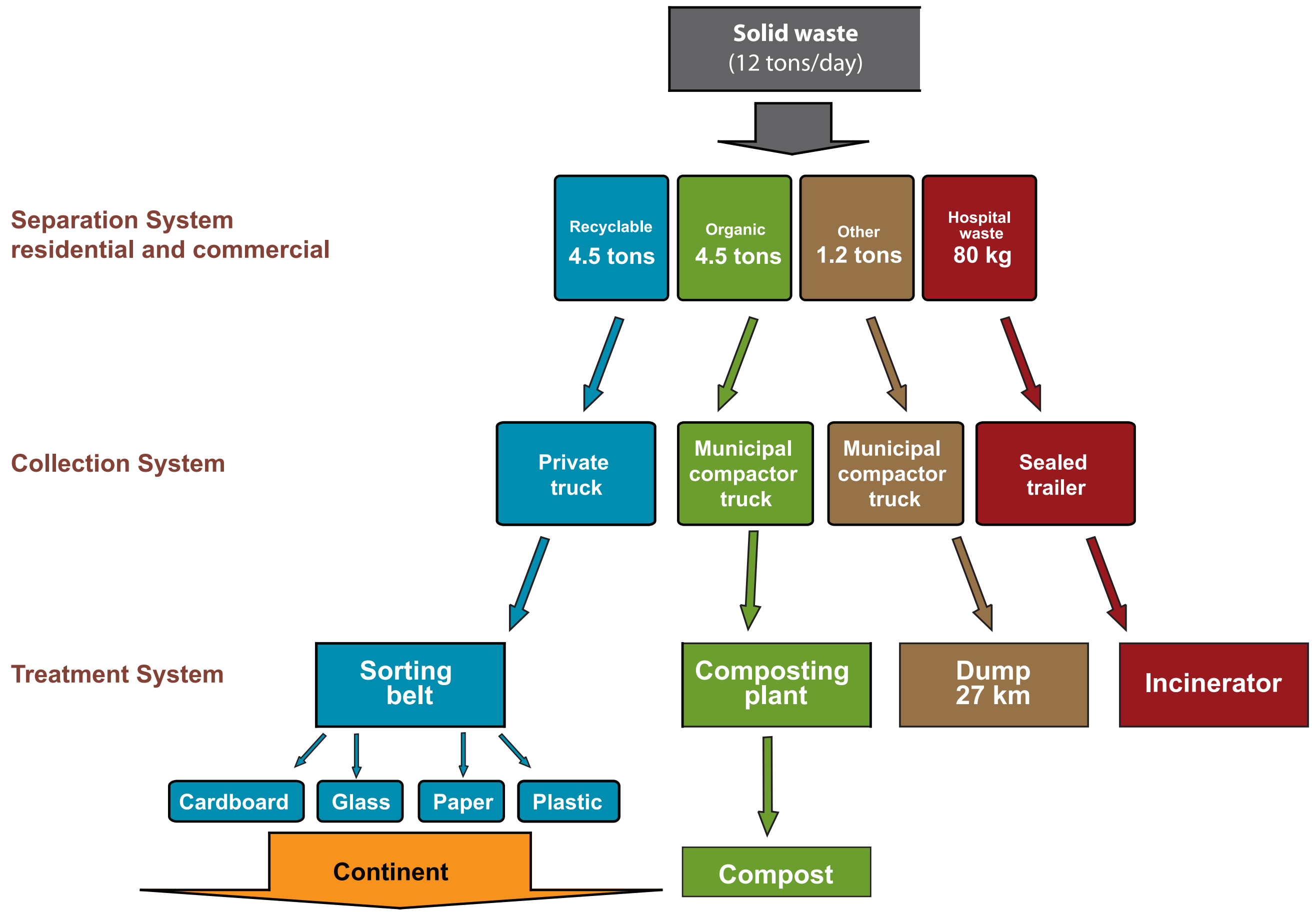
92% of waste produced in Santa Cruz, including plastic, paper, glass, metals, wood, and cardboard, can be recycled or treated.

The Treatment System: *The Fabricio Valverde Environmental Park*

The various types of waste have different destinations for treatment, recycling, reuse, or disposal. With the expansion of the Garbage Depot, the Fabricio Valverde Environmental Park was created. The Environmental Park has four main sections: the Depot, the Composting Plant, the Hospital Waste Incinerator, and the Interpretation Center for Solid Wastes. The *Inter-institutional Cooperative Agreement for the Integrated Waste Management System of the Canton of Santa Cruz* signed by the Municipal Government of Santa Cruz, the Galapagos National Park Service (GNPS), and the Fundación Galápagos Ecuador, forms the basis for the administration and management of the Fabricio Valverde Environmental Park.

The Fabricio Valverde Environmental Park has a staff of seven. Five employees usually work at the Depot and two at the Composting Plant. Recyclable waste enters the Depot. A new sorting belt makes it easier to separate the materials: cardboard, paper, plastic, and glass. In general, these materials are treated (paper, cardboard, batteries) or crushed (glass and plastic), stored, and then shipped for sale to companies in Guayaquil. After being crushed, the glass is used locally in the production of ornamental paving tiles. Organic wastes, such as weeds, branches, and cuttings, are dumped at the Composting Plant. The compost is used in school plant nurseries and municipal parks. Hospital wastes are burned in the modern incinerator of the Fabricio Valverde Depot. Non-recyclable wastes are deposited in the dump at kilometer 27 (Fig. 4).

Figure 4. Sorting and Recycling System of the Municipal Government of Santa Cruz



Outcomes achieved: increased recycling rate

The implementation of the Integrated Solid Waste Management System in Santa Cruz has had significant results (Table 2 and Fig. 5).

Plastic

The most sizable reduction in the amount of material collected is in plastic. This is due primarily to the enforcement, since September 2003, of Article 40 of the Regulation for Integrated Solid Waste Management for Galapagos of the Special Law, which prohibits the entry and selling of beer and soft drinks in disposable containers. Currently, the downward trend continues. In comparison with 2002, the amount of plastic containers collected has decreased by approximately 50%.

> Once norms were enforced in 2003, the amount of disposable material (plastic and glass) decreased by 50%.

Glass

Glass wastes show similar results. They increased significantly in late 2002; however, they then decreased to almost 50% in 2003 and continued to show a downward trend in subsequent years.

Cardboard

Collection of cardboard, an important packing material, has increased. This was expected once Regulations 41 and 42, prohibiting entry of wooden crates, were put into effect.

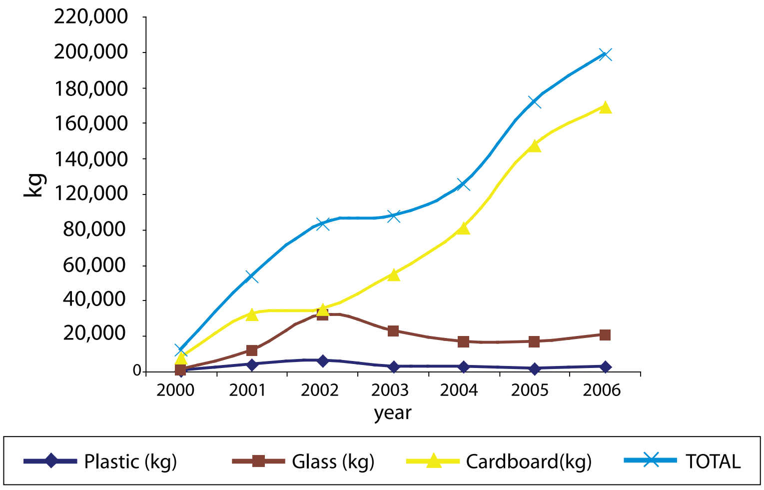
Batteries

The number of batteries collected continues to increase. In the future, a targeted campaign will be developed to initiate a strategy of collecting batteries along with recyclable materials.

Table 2. Annual amount of recyclable material (kg) that has left the Depot, 2000-2006.

MATERIAL	2000	2001	2002	2003	2004	2005	2006	TOTAL (kg)
PLASTIC	339	4,080.00	5,895.78	2,709.15	2,833.82	1,829.48	2,676.31	20,363.54
GLASS	921	11,777.00	31,761.14	22,995.18	16,887.42	16,858.64	20,400.29	121600.67
CARDBOARD	7,876.00	32,603.00	34,918.58	55,026.73	80,829.69	127,552.73	148,929.00	487,735.73
PAPER	1,259.00	2,957.00	8,853.06	5,010.14	3,149.09	3,981.48	4,726.95	29,936.72
TOTAL (Kg.)	10,395.00	51,418.00	81,428.56	85,744.20	103,700.0	150,222.33	176,732.55	659,636.66

Figure 5. Trends in the amount of recyclable material collected in Santa Cruz, 2000 to 2006



In conclusion, disposable materials entering Galapagos, such as glass and plastic, have decreased by 50% since 2003, primarily through enforcement of regulations. The Regulation for Integrated Solid Waste Management for Galapagos of the Special Law prohibit the entry and selling of beer and soft drinks in disposable containers. This environmental measure also benefits the Galapagos community in economic terms, by creating a savings of some 25% of the value of these products.

Before launching the new system in 2005, the average monthly collection of recyclable material was about 13 tons. In the first five months of 2006, this indicator has increased significantly to an average of 17 tons per month, increasing by almost 25% within the first two months. Recovery of recyclable material (plastic, paper, glass, and cardboard), from January to May 2006, showed an increase of 106%, with the greatest increase for glass and paper (200%).

Total efficiency in sorting and treating solid wastes ranges from 30% to 40%, and should reach 70% by 2007.

Currently, efficiency in sorting and treating solid waste ranges from 30% to 40%. With current public outreach and education programs, the efficiency rate is expected to increase to 70% by the end of 2007.

The data are encouraging. The continued effective implementation of this program will provide a model waste management system for use in other insular locations, especially tourist destinations similar to Galapagos and its different cantons.

Public acceptance of environmental restrictions[1]

Hugo Barber[a] & Pablo Ospina Peralta[b]

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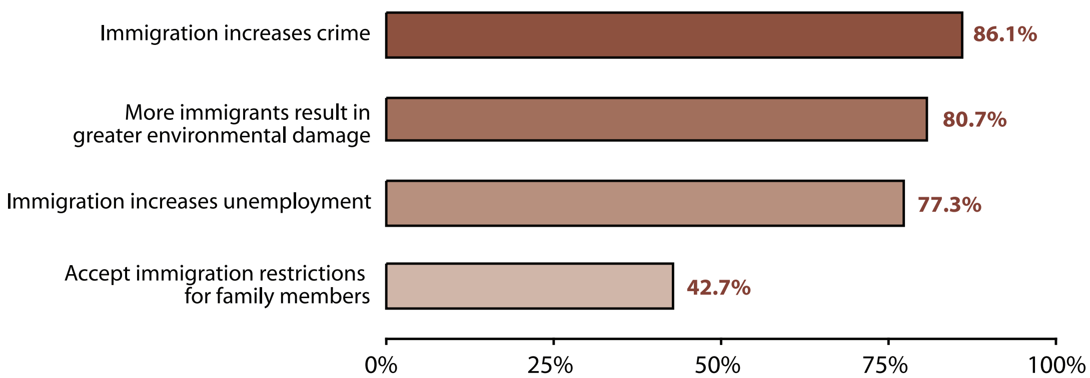
To what point are Galapagos residents willing to accept certain restrictions to preserve the natural environment of the islands? This article analyzes public attitudes toward human migration, resource utilization, and special legislation for the province based on the results of an Opinion Poll conducted in June 2006 on Isabela, San Cristóbal, and Santa Cruz islands.

Immigration

There is significant resistance to immigration, with a widespread view that newcomers increase crime and unemployment, as well as damage the environment (Fig. 1). However, when immigration restrictions personally affect family members, the level of acceptance declines.

Figure 1. Attitudes toward immigration

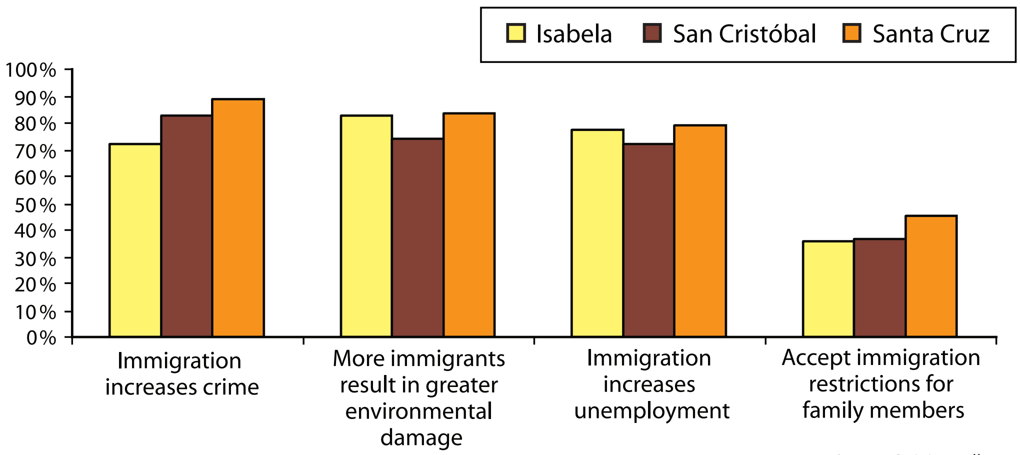


Source: Opinion poll 2006

The greatest level of concern about immigration is among residents of Santa Cruz Island. Residents on Isabela indicate that immigration affects the environment and increases unemployment, whereas on San Cristóbal the main concern focuses on an increase in crime resulting from immigration (Fig. 2).

Although Galapagos residents acknowledge that immigration results in environmental damage, their acceptance of immigration restrictions affecting their own family members is not very high.

Figure 2. Attitudes toward immigration by island



Source: Opinion poll 2006

Concern about immigration is higher among women, residents who are native or have lived in Galapagos longer, and those who have studied outside Galapagos or visited other islands (Tables 1-a and 1-b).

Table 1-a. Attitudes toward immigration by gender, time in Galapagos, and age group.

	Gender		Time in Galapagos			Age			
	Male	Female	Less*	More*	Born in Gal.	18-24 years	25-34 years	35-49 years	50 and older
Immigration increases crime	83.9 %	87.9 %	81.3%	87.1%	89.8%	86.6%	84.4%	87.8%	86.6%
More immigrants result in greater environmental damage	74.8 %	85.8 %	74.8%	83.7%	82.1%	82.1%	79.0%	81.2%	82.7%
Immigration increases unemployment	76.2 %	78.3 %	77.7%	79.7%	73.3%	72.4%	75.2%	79.0%	84.5%
Accept immigration restrictions for family members	43.1 %	42.4 %	35.5%	47.0%	44.6%	44.8%	37.2%	47.3%	45.2%
AVERAGE	69.5%	73.6%	67.3%	74.4%	72.5%	71.5 %	69.0 %	73.8%	74.8%

Source: Opinion poll 2006

Notes

* "Less" indicates someone who has lived in Galapagos less than one third of their current age;
"More" indicates someone who has lived in Galapagos more than one third of their current age.

Table 1-b. Attitudes toward immigration by education and visits to other islands.

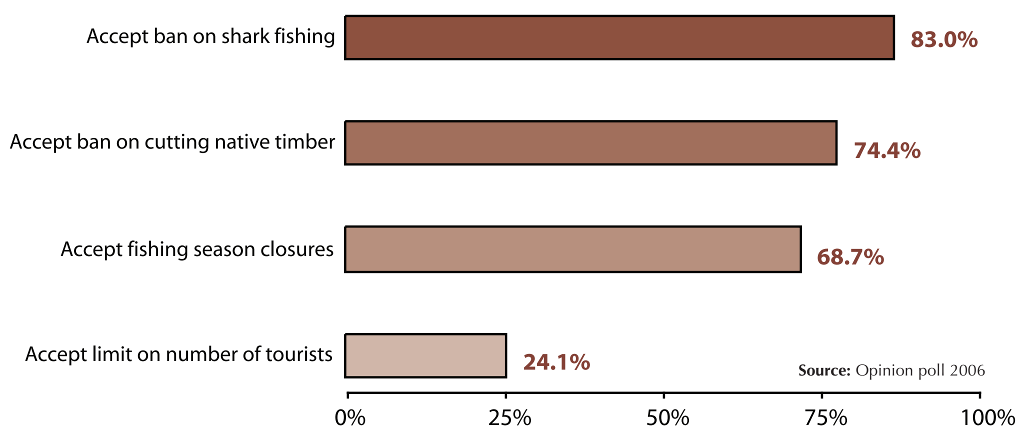
	Education		Visited other islands	
	Yes	No	Yes	No
Immigration increases crime	87.0%	84.1%	89.7%	83.1%
More immigrants result in greater environmental damage	80.5%	80.4%	81.4%	79.7%
Immigration increases unemployment	83.4%	68.3%	79.2%	75.3%
Accept immigration restrictions for family members	48.4%	34.7%	44.5%	40.1%
AVERAGE	74.8%	66.9%	73.7%	69.6%

Source: Opinion poll 2006

Resource utilization

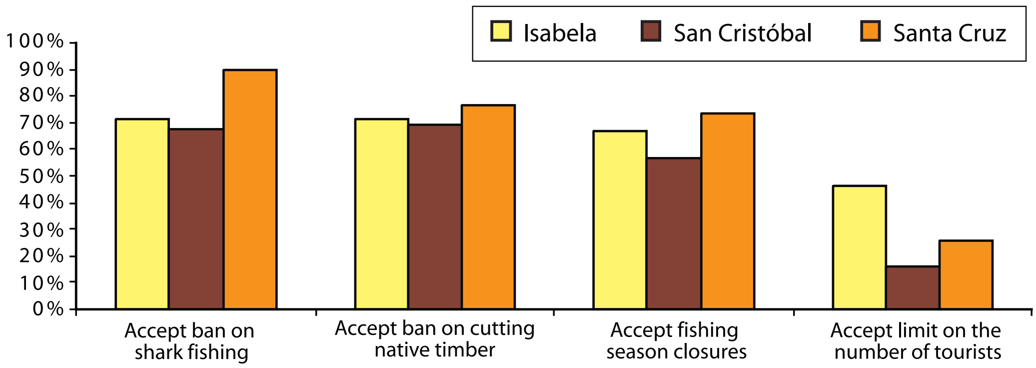
Regarding use of natural resources, residents of all three islands strongly agree with the ban on shark fishing (Fig. 3). Agreement is also significant, although to a lesser degree, with the ban on cutting native timber in the islands, and fishing season closures in general. However, the idea of restricting the number of tourists has much lower acceptance.

Figure 3. Attitudes toward resource utilization



Limits on resource utilization have a greater acceptance in Santa Cruz, except for limits on tourism, possibly because tourism contributes so significantly to that island's economy. The same hypothesis would tend to explain the greater acceptance for limits on tourism in Isabela, since a decrease in tourism would not seriously affect its economy. The population of San Cristóbal is the least likely to accept these types of restrictions (Fig. 4).

Figure 4. Attitudes toward resource utilization by island



Source: Opinion poll 2006

Agreement with limits on resource extraction is highest among young adults, those who have studied outside Galapagos, and those who have visited other islands (Tables 2-a and 2-b).

Santa Cruz has the highest acceptance levels for environmental restrictions except when limiting the number of tourists.

Table 2-a. Attitudes toward resource utilization by gender, time in Galapagos, and age group.

	Gender		Time in Galapagos			Age			
	Male	Female	Less*	More*	Born in Gal.	18 - 24 years	25 - 34 years	35 - 49 years	50 and older
Accept ban on shark fishing	78.8%	86.5%	80.3%	85.8%	80.8%	89.0%	82.7%	80.7%	79.3%
Accept ban on cutting native timber	76.5%	72.8%	71.6%	76.7%	74.5%	78.5%	73.7%	72.8%	75.8%
Accept fishing season closures	70.9%	66.7%	67.1%	70.4%	68.8%	70.6%	64.9%	68.6%	72.0%
Accept limit on the number of tourists	28.6%	20.2%	22.6%	20.0%	31.8%	32.8%	23.5%	21.3%	20.2%
AVERAGE	63.7%	61.6%	60.4%	63.2%	64.0%	67.7%	61.2%	60.9%	61.9%

Source: Opinion poll 2006

Notes

* "Less" indicates someone who has lived in Galapagos less than one third of their current age;
* "More" indicates someone who has lived in Galapagos more than one third of their current age.

Table 2-b Attitudes toward resource utilization by education and visits to other islands.

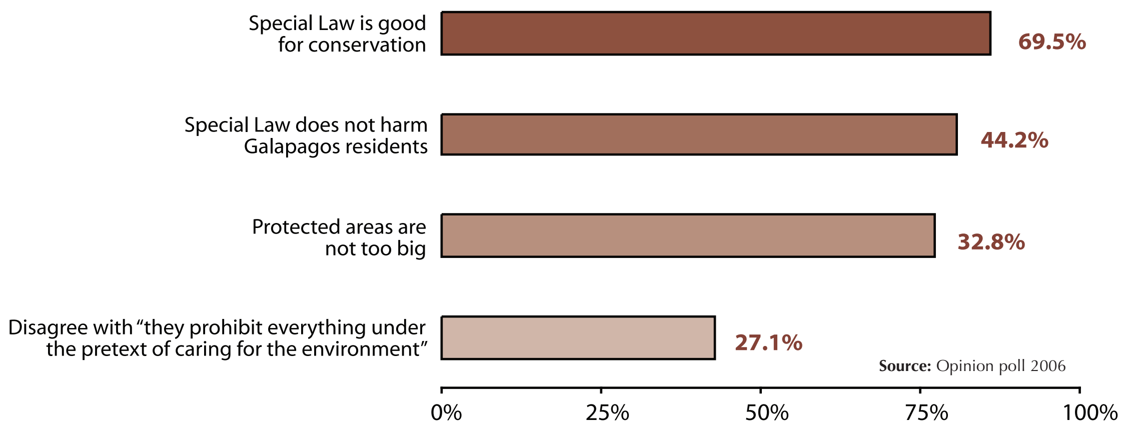
	Education		Visited other island	
	Yes	No	Yes	No
Accept ban on shark fishing	86.4%	78.3%	89.0%	77.6%
Accept ban on cutting native timber	77.1%	69.7%	76.2%	72.9%
Accept fishing season closures	72.5%	63.2%	76.7%	61.3%
Accept limit on the number of tourists	27.3%	19.8%	30.2%	18.9%
AVERAGE	65.8%	57.8%	68.0%	57.7%

Source: Opinion poll 2006

Restrictive legislation

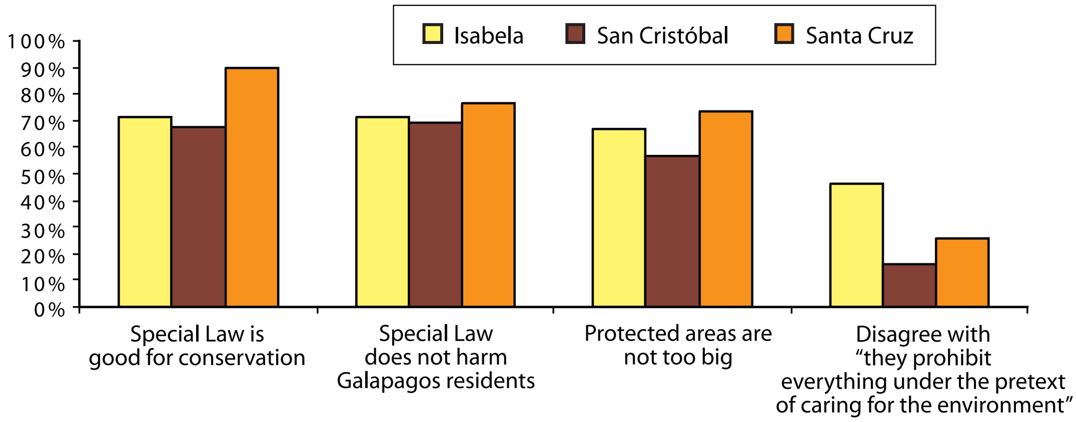
The Special Law for Galapagos is only somewhat accepted: 70% of those polled believe that this law is good for conservation and 44% do not believe that it harms the resident population (Fig. 5). Another example of the low acceptance of these norms is that the majority of those polled believe that the protected areas are too big and agree that, in Galapagos, "everything is forbidden under the pretext of caring for the environment".

Figure 5. Attitudes toward restrictive legislation



In Santa Cruz there is greater willingness to accept the Special Law for Galapagos and, to a lesser degree, the size of the protected areas (Fig. 6). There was also greater disagreement with the opinion that "everything is forbidden under the pretext of caring for the environment," although in general, this phrase was widely accepted on all three islands. Restrictive legislation received greater approval among younger residents and those who have visited other islands (Tables 3-a and 3-b).

Figure 6. Attitudes toward restrictive legislation by island



Source: Opinion poll 2006

Table 3-a. Attitudes toward restrictive legislation by gender, time in Galapagos, and age group.

	Gender		Time in Galapagos			Age			
	Male	Female	Less	More	Born in Gal.	18 - 24 years	25 - 34 years	35 - 49 years	50 and older
The Special Law is good for conservation	64.9%	73.5%	75.2%	69.3%	66.0%	79.3%	74.4%	61.7%	61.3%
The Special Law does not harm native or resident population	47.1%	41.7%	43.7%	41.3%	50.8%	44.8%	45.6%	46.8%	38.1%
Protected areas are not too big	34.5%	31.3%	37.1%	27.9%	35.8%	38.9%	31.9%	33.7%	26.1%
Disagree with "they prohibit everthing under the pretext of caring for the environment"	28.9%	25.6%	28.2%	23.4%	31.4%	34.1%	23.8%	26.8%	25.6%
AVERAGE	43.9%	43.1%	46.0%	40.5%	46.0%	49.3%	43.9%	42.3%	37.8%

Notes

Source: Opinion poll 2006

* "Less" indicates someone who has lived in Galapagos less than one third of their current age;
* "More" indicates someone who has lived in Galapagos more than one third of their current age.

Tabla 3-b. Attitudes toward restrictive legislation by education and visits to other islands.

	Education		Visited other islands	
	Yes	No	Yes	No
The Special Law is good for conservation	71.5%	65.8%	75.7%	65.2%
The Special Law does not harm native or resident population	45.7%	40.4%	54.4%	34.4%
Protected areas are not too big	34.7%	29.3%	36.6%	28.0%
Disagree with "they prohibit everthing under the pretext of caring for the environment"	24.7%	29.4%	31.1%	23.3%
AVERAGE	44.2%	41.2%	49.5%	37.7%

Source: Opinion poll 2006

Trends

Public acceptance of environmental restrictions have fluctuated between 1997 and 2006. Acceptance of the ban on shark fishing is high. In 2000 it dropped, but the acceptance level began to rise again in 2001, reaching its highest level in 2006 (83%). In general, the highest levels of acceptance during the period involve bans on removing sand from beaches and fishing season closures. However, this acceptance shows a declining trend over the years, with the most recent poll (2006) showing the lowest acceptance rates for fishing season closures (Table 4 and Fig. 7).

There is also low acceptance of immigration restrictions for family members and limits on the number of tourists, although the former shows a rising trend, whereas acceptance of limits on the number of tourists is falling (Fig. 7).

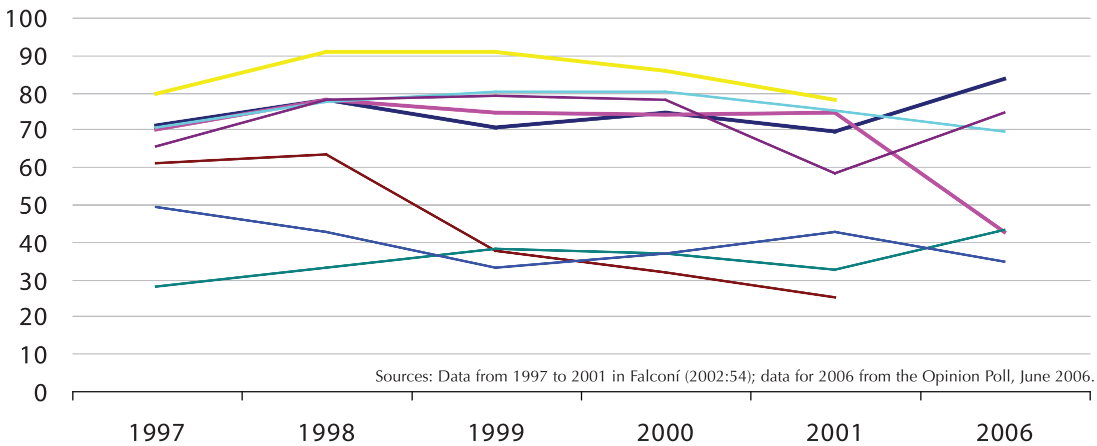
The trend seen in the average acceptance percentages seems to indicate that increases or decreases in public acceptance of environmental restrictions is more related to the specific situation affecting each variable than it is to changes in public attitudes or a general commitment by the resident population to the environment (Table 4).

There is high acceptance of the ban on shark fishing and, to a lesser degree, fishing season closures in general. However, the idea of restricting the number of tourists has much lower acceptance levels.

Table 4. Acceptance of environmental restrictions, 1997-2006 (% of respondents).

	1997	1998	1999	2000	2001	2006
Accept ban on shark fishing	70.6	77.6	70.5	74.0	69.1	83.0
Accept quarantine measures	69.9	77.3	74.2	73.7	74.3	42.0
Accept ban on removing sand from beaches	79.1	90.4	90.4	85.5	77.3	Nd
Accept fishing season closures	70.1	76.7	79.6	79.9	74.9	69.0
Accept ban on cutting native timber	64.9	77.6	78.5	77.8	57.9	74.4
Accept ban on sea cucumber fishing	60.4	62.8	37.3	31.5	24.9	Nd
Accept immigration restrictions for family members	27.4	32.7	37.5	36.4	32.3	42.7
Accept limits on the number of tourists	48.9	42.4	32.6	36.5	42.3	24.0

Figure 7. Acceptance of environmental restrictions (1997-2006)



Sources: Data from 1997 to 2001 in Falconí (2002:54); data for 2006 from the Opinion Poll, June 2006.

Note:

Data weighted according to each island's population.
Quarantine data are not comparable because the question was changed in 2006. Previous *Galapagos Reports* asked whether the respondent agreed or not with the phrase: "I would let them search my luggage for quarantine", whereas in 2006 the phrase was: "They should let them bring all kinds of fruits and vegetables to the islands because they are cheaper."

Public opinion of institutional performance in Galapagos[1]

Hugo Barber[a] & Pablo Ospina Peralta[b]

[a]DATANALISIS Consultant, [b]Universidad Andina Simón Bolívar

Throughout Ecuador, there is a lack of confidence in public and private organizations. The province of Galapagos is no exception. Perhaps that is why more than 25% of survey respondents during the study on *"Identities, social values, and nature conservation in Galapagos"* do not consider any of the institutions identified in the survey - the provincial government, the Charles Darwin Foundation (CDF), the National Institute of Galapagos (INGALA), the municipalities, the Galapagos National Park Service (SPNG), or the Ecuadorian Navy – to be trustworthy. About 20% of those polled indicated that none of these institutions uses its resources properly or has credibility.

Image of institutions

Among the organizations examined, the CDF has the best image, in terms of credibility, fulfillment of its functions, use of resources, and honesty. The CDF has the highest positive scores and lowest negative scores for all these attributes, except for "resource utilization," where the negative score of CDF is similar to that of the Ecuadorian Navy (Table 1). However, even in categories in which the CDF has the best image among all the institutions, its score is still negative.

Municipal institutions received a significant positive score in "concern for the community." Municipalities also stood out, though less strongly, in involving citizen participation in decision-making.

The GNPS is seen as having considerable economic resources, significantly more than the other institutions.

Among the institutions examined, INGALA and the Provincial Government have the poorest image.

In breaking down the institutional image by island, respondents scored institutions, especially municipalities, highest on Isabela (Table 2). By contrast, San Cristóbal residents gave the lowest scores overall, except for the Provincial Government, which scored even lower in Santa Cruz.

In general, institutions in Galapagos score low on trustworthiness. INGALA and the Provincial Government have the poorest images overall.

Table 1. Institutional Image (%*).

	Provincial Government	CDF	INGALA	Municipalities	GNPS	Ecuadorian Navy	None
Credible	19.1	39.2	15.8	29.6	25.0	29.2	18.1
Not credible	40.7	29.3	45.3	35.0	35.4	34.4	5.9
Does its work well	15.0	32.8	13.3	24.6	23.0	24.8	17.1
Does its work poorly	31.5	24.4	42.9	35.3	31.2	28.5	4.8
Honest	9.0	25.4	8.6	11.1	14.3	18.8	28.2
Dishonest	38.3	35.4	41.9	40.1	36.9	36.2	3.6
Concerned about the community	29.9	17.4	20.8	50.5	19.1	15.1	14.4
Not concerned about the community	24.9	31.4	31.3	21.7	34.6	32.1	5.2
Has significant economic capacity	18.2	37,1	22.4	24.4	55.0	16.4	1.8
Has limited economic capacity	15.8	12.2	23.6	26.9	8.9	20.0	3.7
Efficient uses of resources	14.7	28.0	10.1	19.6	21.4	16.2	20.4
Poor use of resources	28.7	24.8	33.2	33.5	29.3	24.3	3.8
Involves citizens in decision-making	22.1	15.1	15.7	37.8	18.8	11.8	16.1
Does not involve citizens in decision-making	23.0	29.0	32.1	22.5	31.5	35.3	4.4

Source: Opinion Poll, June 2006.

Notes

* Data weighted according to the population of each island.

Table 2. Institutional image index by island (%), 2006.

	Provincial Government	CDF	INGALA	Municipalities	GNPS
Total	18.3	26.3	14.1	28.9	20.3
Isabela	25.5	24.8	20.6	43.3	32.4
San Cristóbal	23.0	19.0	12.9	28.9	15.3
Santa Cruz	15.9	29.3	14.0	27.7	21.2

Source: Opinion Poll, June 2006.

Notes

- The index is constructed as a simple average of favorable opinions regarding credibility, proper use of resources, honesty, concern about the community, proper performance of functions, and acceptance of citizen involvement in decision-making.
- Data weighted according to the population of each island.
- The index does not include the variable on economic capacity because it is value-neutral.

Positioning

Positioning is understood as the array of attributes (positive or negative) characterizing each institution. Although the concept of "positioning" is related to the concept of "image," a correlation between the two is not necessarily automatic. For example, an institution's positioning can be very closely associated with a specific attribute, without having the best image with regards to that attribute.

The relationships among institutions and attributes are demonstrated in Figure 1. The distance between the position of an institution and a specific attribute indicates the strength of the relationship, with an institution having the strongest relationship to the closest attribute. However, the fact that an institution is closer to an attribute or characteristic does not necessarily mean that it has a better image regarding that attribute.

The CDF has a unique positioning in that it does not share its niche with any other institution. It is characterized as honest, credible, doing a satisfactory job, and as using its resources well.

The GNPS is characterized as an honest institution with significant economic capacity. It is the institution with the closest positioning to the CDF.

The municipalities are positioned in the lower right quadrant, associated with characteristics such as "accepting citizen participation" and "concern for the community."

INGALA (located in the upper right quadrant) has a negative positioning, associated with a perception of "low credibility" and "doing a poor job."

The Ecuadorian Navy is situated in the upper left quadrant, associated with "little concern for the community" and "no acceptance of citizen involvement in its decisions."

On the other hand, the Provincial Government is mainly associated with misuse of resources.

Trends

To analyze trends in institutional image, an index was developed using a simple average of all positive scores of every institution for the different variables. This index was compared with similar indices in the "Galapagos Report" from previous years.

Overall, the image of institutions improved up to 1999, and then declined by 2001. In 2006, improved scores were registered for the CDF and the GNPS, whereas scores for the other institutions declined.

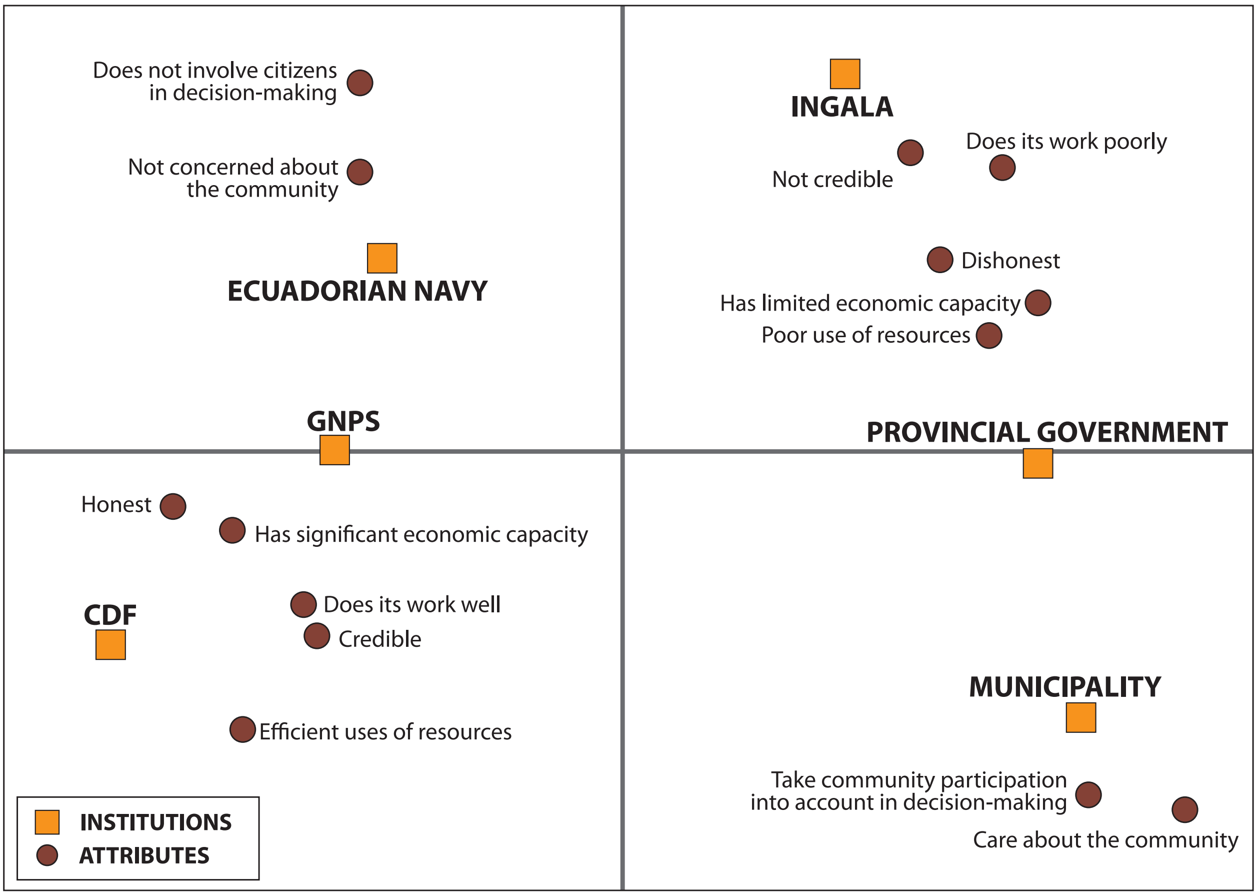
The image of the municipalities shows a different fluctuation. Their image remained stable from 1997 to 1999, showed an upward trend in 2000, and then a gradual decline in 2001 and 2006.

Until 1999, the GNPS had the highest indices of all institutions studied. In 2000 and 2001, municipalities scored the highest. In 2006, the CDF received the highest score (Fig. 2).

Significant changes in institutional image occurred during the study period, though the reasons for those changes are unclear. A comprehensive historical analysis could help reveal the causes underlying the changes in perception.

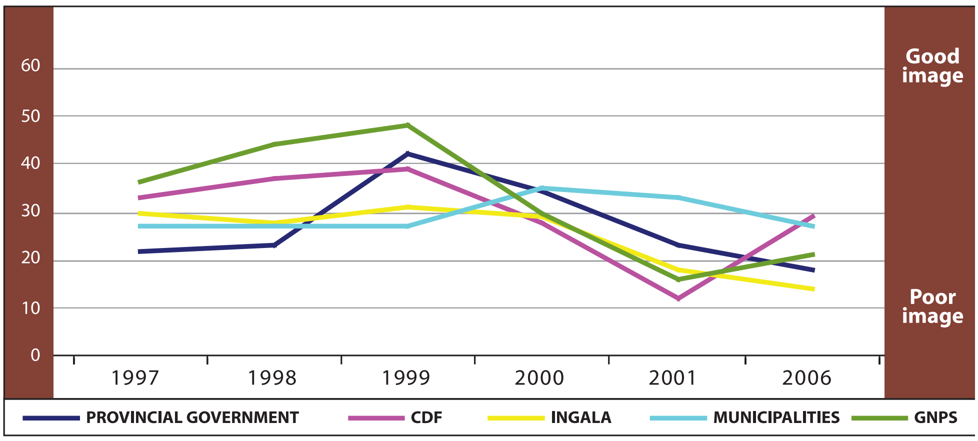
In 2006, positive appraisals of the Charles Darwin Foundation and Galapagos National Park increased, but the scores for other institutions declined.

Figure 1. Relationships among institutions and attributes



Source: Opinion Poll, June 2006.

Figure 2. Institutional image index, 1998 - 2006 (%)

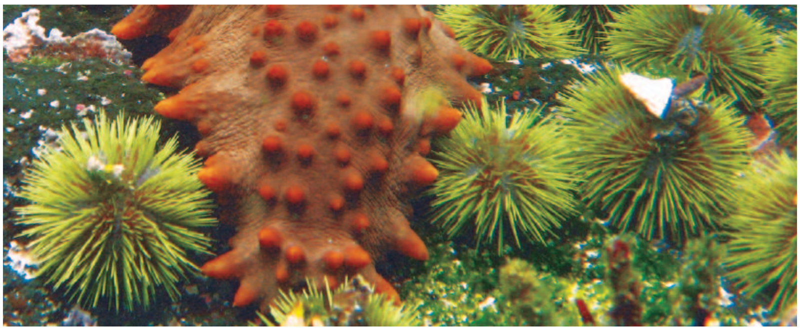


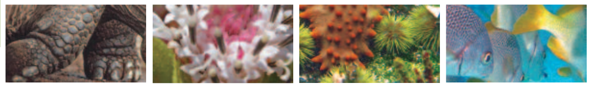
Sources: For 1997–2001, Fundación Natura (2002)[2]; for 2006, Opinion Poll, June 2006.

Notes

- The index is constructed as a simple average of favorable opinions regarding credibility, proper use of resources, honesty, concern about the community, proper performance of duties, and acceptance of citizen involvement in decision-making.
- Data weighted according to the population size of each island.
- To make the indices comparable, the average for 2006 does not include the additional variable on acceptance of citizen participation in decisions.
- The index does not include the variable on economic capacity because it is value-neutral.

BIODIVERSITY AND BIOPHYSICAL RESOURCES





The status of the endemic flora of Galapagos: the number of threatened species is increasing

Alan Tye

Charles Darwin Foundation

The endemic species of Galapagos are of the greatest conservation interest because their future depends entirely on their continued existence in the islands. A complete evaluation of the threat status of the endemic vascular plants (flowering plants and ferns) of Galapagos was published in the last *Galapagos Report*[1]. A re-evaluation of their threat status at full species level was carried out during 2006, as a contribution to the Ecuadorian national plant Red Data Book[2]. The present report summarises the results of this re-evaluation and assesses changes since 2002. As in the last report[1], all species have been evaluated under the IUCN criteria[3], using the same methods as by Tye[4,5]. These threat evaluations are carried out under the auspices of the Galapagos Plant Specialist Group of IUCN, and become the official evaluations of the IUCN Red List.

The status of many endemic plant species has deteriorated since 2002: 60% of the 168 species evaluated are threatened.

Results

The new evaluations cover 180 species, compared with 175 in 2002, eight of which were Not Evaluated (IUCN category NE)[1]. Of the 180 evaluated in 2006, nine species were placed in the IUCN category Data Deficient (DD) owing to uncertainties regarding the limits of the taxon and therefore its distribution. For the 171 species that were fully evaluated, Table 1 summarizes the results of the latest re-evaluation and the previous full evaluation in 2002[1]. No species were classified as EW (Extinct in the Wild). Table 1 gives the numbers and percentages of species in each category, and reveals that 100 of the 168 extant species that were evaluated (excluding the three extinct and the nine DD species) are threatened (60%).

The Appendix includes all the species evaluated and compares their present status with the one in 2002. It also shows that 33 species have moved up in category (become more threatened), while 14 have moved down, a net movement of 19 becoming more threatened.

Table 1. Numbers and percentages of taxa in each threat category. Data from 2002 are from Tye (2002).

				IUCN Threat Category				
		No. taxa fully evaluated	**EX**	**CR**	**EN**	**VU**	**NT**	**LC**
2002[1]	Species	167	3	13	21	61	15	54
	All taxa[2]	220	3	19	32	87	16	63
2006	Species	171	3	20	26	54	13	55
	Percent		2%	12%	15%	32%	8%	32%

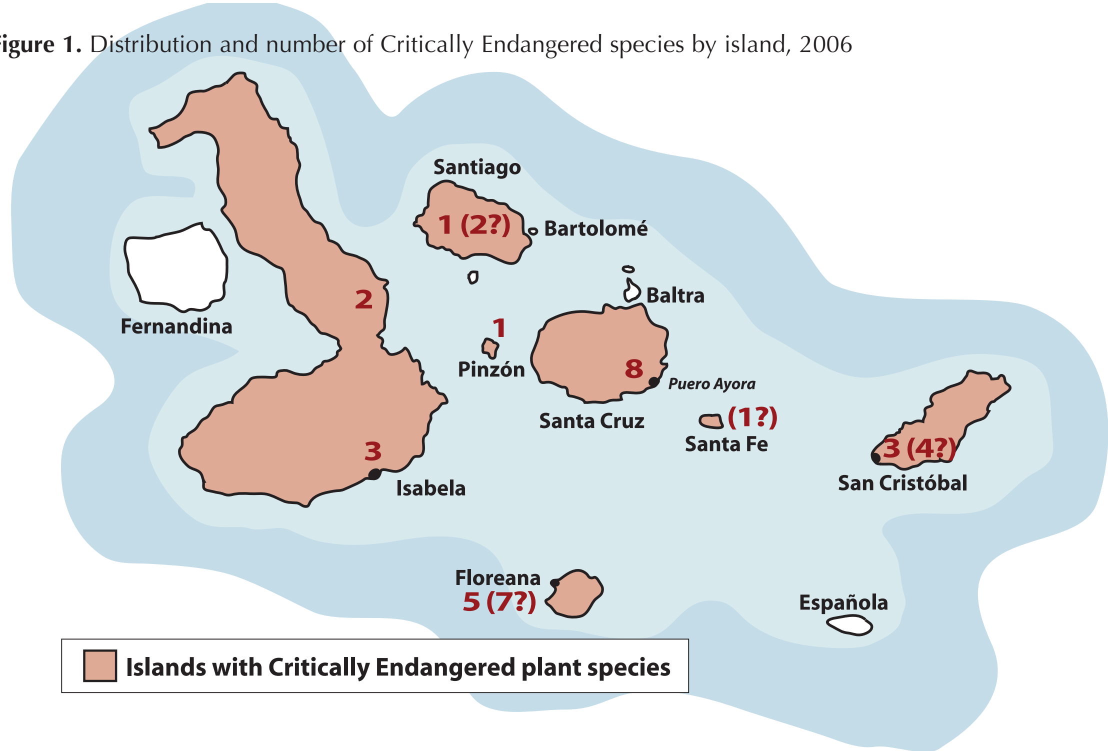
Notes

Source: CDF databases.

EX = Extinct, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near-threatened, **LC** = Least Concern
[1]The data for 2002 are taken from Tye (2002).
[2]Includes accepted subspecies and varieties.

Distribution by island of the 20 Critically Endangered species is shown in Table 2. All except four are restricted to the inhabited islands of Floreana, San Cristóbal, and Santa Cruz, or to the inhabited section of Isabela. Two of the four exceptions are restricted to northern Isabela (Alcedo Volcano). The single Critically Endangered species with known presence on uninhabited islands is *Lithophila subscaposa* (found on Pinzón and Santiago as well as Floreana), which may be better classed as Endangered although it technically falls into Critically Endangered. *Borreria perpusilla* is an enigmatic species only confirmed from Santa Cruz but possibly present on three other islands; further survey and taxonomic investigation of the genus *Borreria* in Galapagos are required to better determine its distribution. Of the three Extinct species, one occurred on Santiago and two on Floreana.

Figure 1. Distribution and number of Critically Endangered species by island, 2006



Source: CDF databases.

Table 2. Distribution of Critically Endangered species by island.

SPECIES	Floreana	Southern Isabela	Isabela Alcedo	Pinzón	San Cristóbal	Santa Cruz	Santa Fe	Santiago
Lithophila subscaposa	●			●				●
Darwiniothamnus alternifolius		●						
Lecocarpus leptolobus					●			
Lecocarpus pinnatifidus	●							
Scalesia gordilloi					●			
Scalesia retroflexa						●		
Opuntia saxicola		●						
Drymaria monticola						●		
Sicyocaulis pentagonus			●			●		
Cyperus grandifolius	?				?	●		
Acalypha wigginsii						●		
Euphorbia equisetiformis		●						
Hyptis gymnocaulos			●					
Linum cratericola	●							
Cyclopogon werffii						●		
Calandrinia galapagosa					●			
Borreria perpusilla	?					●	?	?
Borreria rotundifolia						●		
Psychotria angustata	●							
Lippia salicifolia	●							
TOTALS	**5 (7?)**	**3**	**2**	**1**	**3 (4?)**	**8**	**(1?)**	**1 (2?)**

● Presence confirmed
? Unconfirmed early record

Source: CDF databases.

Data quality

Of the 180 Galapagos endemic vascular plant species, only nine have been classed as Data Deficient. However, this does not imply that we have good and sufficient data to plan plant conservation, because the IUCN system encourages classification based on incomplete data, rather than leaving a taxon as Not Evaluated or Data Deficient. The maps of endemic species records reveal how poor the available data are, with data for many species depending on records that are many years old and that pre-date the drastic changes that have taken place in Galapagos over the last 30 years. Survey coverage on the ground is still very patchy, with some islands hardly surveyed at all, and records from others concentrated in a few well-known localities. Field research to fill the gaps in our knowledge of the rarest plants of Galapagos is still a high priority.

Changes in threat category since 2002

60% of the 168 extant endemic vascular plant species that have been evaluated (excluding the three extinct and the nine DD species) are currently regarded as threatened, compared with 58% of the 164 species evaluated in 2002.

Compared with 2002, the number of Critically Endangered and Endangered species is higher, and the number of Vulnerable and Near-threatened species is lower, indicating a net movement of species from lower to higher threat categories. These changes in category are primarily caused by improved knowledge of both the threatened species and of the degree of impact of the threats that are affecting them.

The crucial role of the inhabited islands for Galapagos plant conservation

The movement towards higher threat categories described above has occurred despite a drop in category of several species restricted to Santiago, Pinta, and northern Isabela, a result of the recent eradication of their main threat (feral goats and donkeys). Following these successful eradications, most of the Critically Endangered species are now species that are restricted to the inhabited islands, and the number of species on these islands that are Critically Endangered appears to be increasing. The inhabited islands are undergoing severe ecological change, resulting in continuing declines of many Galapagos endemics.

On San Cristóbal, most of the Critically Endangered species are arid zone plants, threatened mainly by introduced herbivores such as goats. The main threat to the Critically Endangered species on Santa Cruz is invasions by introduced plants in the humid highlands, although habitat clearance has affected some (such as *Acalypha wigginsii, Sicyocaulis pentagonus*, and the orchid *Cyclopogon werffii*), while *Scalesia retroflexa* is mainly threatened by feral goats and donkeys. On Floreana, perhaps the most altered island in Galapagos, and on southern Isabela, all these factors are important.

Threatened species and conservation planning

Of the 171 species classified in Table 1, 60% are regarded as threatened. This relatively high figure is caused partly by the large number classed as Vulnerable (32% of the total evaluated and 54% of the threatened species). Many island taxa automatically fall into this category because of their naturally small ranges. Classifying them as Vulnerable is valid, since they are naturally susceptible to rapid environmental changes, such as the introduction of a new disease or insect pest which could affect them. However, this is only part of the reason, since the high number of species falling into the categories Critically Endangered (20 species) and Endangered (26) together make up 27% of the total evaluated, and 46% of the species classed as threatened. In addition, several of the nine species classified as Data Deficient may also fall into these categories as more data about them are gathered, while many of the Vulnerable species are genuinely declining.

All these species are declining as a result of human impact, of which introduced herbivores and invasive plants are the major factors. To reverse the current trend of increasing numbers of species becoming more gravely threatened, decisive action must be taken over the next few years to reduce the pressure caused by such threats, thus reducing the number of threatened species and moving highly threatened species into lower categories.

> The situation of the endemic plants in the inhabited islands is serious. Almost all of the Critically Endangered species are restricted to these islands, all of which are undergoing a dramatic process of ecological change.

The Critically Endangered species face a high risk of imminent extinction and their future depends absolutely on conservation action now, mainly on the inhabited islands. Galapagos has seen only three endemic plant species go extinct in historical time. The results of the evaluation carried out in 2006 reveal that many more species are on the brink of extinction. We must concentrate our efforts and resources to deal with the threats that they face.

Having identified the most threatened species and populations, we can now design a strategy for their conservation. The next step is to obtain funding for the large amount of applied field research and practical conservation action that will be required in the coming years in order to save these most threatened species from extinction.

To reverse the current trend of increasing numbers of species becoming more gravely threatened, decisive action on the inhabited islands must be taken over the next few years.

Annex. Species Evaluated.

Family	Species	Threat status 2006	2002	Movement
Pteridophyta ((ferns and allies)				
Cyatheaceae	*Cyathea weatherbyana* (C.V. Morton) C.V. Morton	EN	EN	=
Dryopteridaceae	*Megalastrum pleiosoros* (Hook. f.) A.R. Sm. & R.C. Moran	VU	NT	↑
Lycopodiaceae	*Huperzia galapagensis* (O. Hamann) Holub	VU	NE	
Polypodiaceae	*Polypodium insularum* (C.V. Morton) de la Sota	NT	LC	↑
Polypodiaceae	*Polypodium tridens* Kunze	LC	LC	=
Pteridaceae	*Notholaena galapagensis* Weath. & Svenson	NT	LC	↑
Magnoliophyta (flowering plants)				
Acanthaceae	*Justicia galapagana* Lindau	NT	NT	=
Aizoaceae	*Sesuvium edmondstonii* Hook. f.	LC	LC	=
Amaranthaceae	*Alternanthera filifolia* (Hook. f.) Howell	LC	LC	=
Amaranthaceae	*Alternanthera flavicoma* (Andersson) Howell	VU	VU	=
Amaranthaceae	*Alternanthera galapagensis* (A. Stewart) Howell	VU	VU	=
Amaranthaceae	*Alternanthera helleri* (B.L. Rob.) Howell	VU	VU	=
Amaranthaceae	*Alternanthera nesiotes* Johnst.	EN	EN	=
Amaranthaceae	*Alternanthera snodgrassii* (B.L. Rob.) Howell	VU	VU	=
Amaranthaceae	*Amaranthus anderssonii* Howell	LC	LC	=
Amaranthaceae	*Amaranthus furcatus* Howell	VU	VU	=
Amaranthaceae	*Amaranthus sclerantoides* (Andersson) Andersson	LC	LC	=
Amaranthaceae	*Blutaparon rigidum* (B.L. Rob. & Greenm.) Mears	EX	EX	=
Amaranthaceae	*Froelichia juncea* B.L. Rob. & Greenm.	EN	VU	↑
Amaranthaceae	*Froelichia nudicaulis* Hook. f.	VU	LC	↑
Amaranthaceae	*Lithophila radicata* (Hook. f.) Standl.	EN	VU	↑
Amaranthaceae	*Lithophila subscaposa* (Hook. f.) Standl.	CR	CR	=
Amaranthaceae	*Pleuropetalum darwinii* Hook. f.	VU	EN	↓
Apiaceae	*Hydrocotyle galapagensis* B.L. Rob.	VU	VU	=
Asclepiadaceae	*Sarcostemma angustissimum* (Andersson) R.W. Holm	LC	LC	=
Asteraceae	*Acmella darwinii (D.M. Porter) R.K. Jansen*	VU	VU	=
Asteraceae	*Baccharis steetzii Andersson*	EN	EN	=
Asteraceae	*Chrysanthellum fagerlindii Eliasson*	DD	DD	=
Asteraceae	*Chrysanthellum pusillum Hook. f.*	LC	LC	=
Asteraceae	*Darwiniothamnus alternifolius Lawesson & Adsersen*	CR	EN	↑
Asteraceae	*Darwiniothamnus lancifolius* (Hook. f.) Harling	VU	NT	↑
Asteraceae	*Darwiniothamnus tenuifolius* (Hook. f.) Harling	NT	NT	=
Asteraceae	*Delilia inelegans (Hook. f.) Kuntze*	EX	EX	=
Asteraceae	*Delilia repens* (Hook. f.) Kuntze	VU	NT	↑
Asteraceae	*Encelia hispida Andersson*	EN	EN	=
Asteraceae	*Jaegeria gracilis* Hook. f.	LC	LC	=
Asteraceae	*Lecocarpus darwinii* Adsersen	EN	EN	=
Asteraceae	*Lecocarpus lecocarpoides* (B.L. Rob. & Greenm.) Cronquist & Stuessy	EN	VU	↑
Asteraceae	*Lecocarpus leptolobus* (S.F. Blake) Cronquist & Stuessy	CR	NE	
Asteraceae	*Lecocarpus pinnatifidus* Decne.	CR	EN	↑
Asteraceae	*Macraea laricifolia* Hook. f.	LC	LC	=
Asteraceae	*Pectis subsquarrosa* (Hook. f.) Sch. Bip.	LC	LC	=
Asteraceae	*Pectis tenuifolia* (DC.) Sch. Bip.	LC	LC	=
Asteraceae	*Scalesia affinis* Hook. f.	VU	LC	↑
Asteraceae	*Scalesia aspera* Andersson	VU	VU	=
Asteraceae	*Scalesia atractyloides* Arn.	EN	CR	↓
Asteraceae	*Scalesia bauri* B.L. Rob. & Greenm.	VU	VU	=
Asteraceae	*Scalesia cordata* A. Stewart	EN	EN	=
Asteraceae	*Scalesia crockeri* Howell	VU	VU	=
Asteraceae	*Scalesia divisa* Andersson	EN	CR	↓
Asteraceae	*Scalesia gordilloi* O. Hamann & Wium-And.	CR	VU	↑
Asteraceae	*Scalesia helleri* B.L. Rob.	EN	VU	↑
Asteraceae	*Scalesia incisa* Hook. f.	EN	VU	↑
Asteraceae	*Scalesia microcephala* B.L. Rob.	VU	EN	↓
Asteraceae	*Scalesia pedunculata* Hook. f.	EN	EN	=
Asteraceae	*Scalesia retroflexa* Hemsl.	CR	CR	=
Asteraceae	*Scalesia stewartii* Riley	VU	EN	↓
Asteraceae	*Scalesia villosa* A. Stewart	VU	VU	=
Boraginaceae	*Cordia anderssonii* (Kuntze) Gürke	DD	DD	=

Source: CDF databases.

		Threat status		
Family	**Species**	**2006**	**2002**	**Movement**
Boraginaceae	*Cordia leucophlyctis* Hook. f.	DD	DD	=
Boraginaceae	*Cordia revoluta* Hook. f.	NT	VU	↓
Boraginaceae	*Cordia scouleri* Hook. f.	DD	VU	
Boraginaceae	*Heliotropium anderssonii* B.L. Rob.	VU	VU	=
Boraginaceae	*Tiquilia darwinii* (Hook. f.) A.T. Richardson	LC	LC	=
Boraginaceae	*Tiquilia fusca* (Hook. f.) A.T. Richardson	LC	LC	=
Boraginaceae	*Tiquilia galapagoa* (Howell) A.T. Richardson	LC	LC	=
Boraginaceae	*Tiquilia nesiotica* (Howell) A.T. Richardson	VU	VU	=
Boraginaceae	*Tournefortia pubescens* Hook. f.	LC	LC	=
Boraginaceae	*Tournefortia rufo-sericea* Hook. f.	VU	VU	=
Bromeliaceae	*Racinaea insularis* (Mez) M.A. Spencer & L.B. Sm.	LC	LC	=
Burseraceae	*Bursera malacophylla* B.L. Rob.	VU	VU	=
Cactaceae	*Brachycereus nesioticus* (K. Schum.) Backeb.	LC	NT	↓
Cactaceae	*Jasminocereus thouarsii* (F.A.C. Weber) Backeb.	LC	NT	↓
Cactaceae	*Opuntia echios* Howell	LC	VU	↓
Cactaceae	*Opuntia galapageia* Hemsl.	VU	EN	↓
Cactaceae	*Opuntia helleri* K. Schum.	VU	VU	=
Cactaceae	*Opuntia insularis* A. Stewart	VU	EN	↓
Cactaceae	*Opuntia megasperma* Howell	EN	VU	↑
Cactaceae	*Opuntia saxicola* Howell	CR	CR	=
Caryophyllaceae	*Drymaria monticola* Howell	CR	VU	↑
Convolvulaceae	*Ipomoea habeliana* Oliv.	LC	LC	=
Convolvulaceae	*Ipomoea linearifolia* Hook. f.	LC	LC	=
Convolvulaceae	*Ipomoea tubiflora* Hook. f.	VU	VU	=
Cucurbitaceae	*Sicyocaulis pentagonus* Wiggins	CR	CR	=
Cucurbitaceae	*Sicyos villosus Hook. f.*	EX	EX	=
Cuscutaceae	*Cuscuta acuta* Engelm.	LC	NE	
Cuscutaceae	*Cuscuta gymnocarpa* Engelm.	LC	LC	=
Cyperaceae	*Cyperus anderssonii* Boeck.	LC	LC	=
Cyperaceae	*Cyperus grandifolius* Andersson	CR	EN	↑
Ericaceae	*Pernettya howellii* Sleumer	EN	EN	=
Euphorbiaceae	*Acalypha abingdonii* Seberg	VU	VU	=
Euphorbiaceae	*Acalypha baurii* B.L. Rob. & Greenm.	VU	VU	=
Euphorbiaceae	*Acalypha parvula* Hook. f.	LC	LC	=
Euphorbiaceae	*Acalypha wigginsii* G.L. Webster	CR	VU	↑
Euphorbiaceae	*Chamaesyce abdita* D.G. Burch	VU	VU	=
Euphorbiaceae	*Chamaesyce amplexicaulis* (Hook. f.) D.G. Burch	LC	LC	=
Euphorbiaceae	*Chamaesyce galapageia* (B.L. Rob. & Greenm.) D.G. Burch	DD	DD	=
Euphorbiaceae	*Chamaesyce nummularia* (Hook. f.) D.G. Burch	LC	VU	↓
Euphorbiaceae	*Chamaesyce punctulata* (Andersson) D.G. Burch	LC	LC	=
Euphorbiaceae	*Chamaesyce recurva* (Hook. f.) D.G. Burch	LC	LC	=
Euphorbiaceae	*Chamaesyce viminea* (Hook. f.) D.G. Burch	LC	LC	=
Euphorbiaceae	*Croton scouleri* Hook. f.	LC	LC	=
Euphorbiaceae	*Euphorbia equisetiformis* A. Stewart	CR	CR	=
Fabaceae	*Dalea tenuicaulis* Hook. f.	NT	NT	=
Fabaceae	*Phaseolus mollis* Hook. f.	NT	LC	↑
Iridaceae	*Sisyrinchium galapagense* Ravenna	EN	VU	↑
Lamiaceae	*Hyptis gymnocaulos* Epling	CR	CR	=
Lamiaceae	*Salvia prostrata* Hook. f.	EN	VU	↑
Lamiaceae	*Salvia pseudoserotina* Epling	EN	VU	↑
Linaceae	*Linum cratericola* Eliasson	CR	CR	=
Linaceae	*Linum harlingii Eliasson*	VU	VU	=
Malvaceae	*Abutilon depauperatum* (Hook. f.) Andersson ex B.L. Rob.	LC	LC	=
Malvaceae	*Fuertesimalva insularis* (Kearney) Fryxell	EN	VU	↑
Malvaceae	*Gossypium darwinii* G. Watt	LC	LC	=
Malvaceae	*Gossypium klotzschianum* Andersson	NT	VU	↓
Melastomataceae	*Miconia robinsoniana* Cogn.	EN	EN	=
Mimosaceae	*Acacia rorudiana* Christoph.	VU	VU	=
Molluginaceae	*Mollugo crockeri* Howell	VU	VU	=
Molluginaceae	*Mollugo flavescens* Andersson	LC	LC	=
Molluginaceae	*Mollugo floriana* (B.L. Rob.) Howell	VU	NT	↑
Molluginaceae	*Mollugo snodgrassii* B.L. Rob.	VU	NT	↑
Myrtaceae	*Psidium galapageium* Hook. f.	VU	VU	=

Source: CDF databases.

Family	Species	Threat status 2006	2002	Movement
Nolanaceae	*Nolana galapagensis* (Christoph.) Johnst.	VU	NT	↑
Nyctaginaceae	*Pisonia floribunda* Hook. f.	LC	LC	=
Orchidaceae	*Cranichis lichenophila* D. Weber	EN	VU	↑
Orchidaceae	*Cranichis werffii* Garay	VU	DD	
Orchidaceae	*Cyclopogon werffii* Dodson	CR	CR	=
Orchidaceae	*Epidendrum spicatum* Hook. f.	VU	VU	=
Passifloraceae	*Passiflora colinvauxii* Wiggins	VU	VU	=
Passifloraceae	*Passiflora tridactylites* Hook. f.	VU	NE	
Piperaceae	*Peperomia galapagensis* Hook. f. ex Miq.	LC	LC	=
Piperaceae	*Peperomia obtusilimba* C. DC.	LC	LC	=
Piperaceae	*Peperomia petiolata Hook. f.*	LC	LC	=
Plantaginaceae	*Plantago galapagensis* Rahn	VU	VU	=
Poaceae	*Aristida divulsa* Andersson	NT	NT	=
Poaceae	*Aristida repens* Trin.	LC	LC	=
Poaceae	*Aristida subspicata* Trin. & Rupr.	LC	LC	=
Poaceae	*Aristida villosa* B.L. Rob. & Greenm.	NT	NT	=
Poaceae	*Cenchrus platyacanthus* Andersson	LC	LC	=
Poaceae	*Paspalum galapageium* Chase	LC	LC	=
Poaceae	*Paspalum redundans* Chase	VU	VU	=
Poaceae	*Pennisetum pauperum* Nees ex Steud.	VU	NT	↑
Poaceae	*Trichoneura lindleyana* (Kunth) Ekman	LC	LC	=
Poaceae	*Trisetum howellii* Hitchc.	EN	VU	↑
Poaceae	*Urochloa multiculma* (Andersson) Morrone & Zuloaga	LC	LC	=
Polygalaceae	*Polygala anderssonii* B.L. Rob.	NT	VU	↑
Polygalaceae	*Polygala galapageia* Hook. f.	LC	LC	=
Polygalaceae	*Polygala sancti-georgii* Riley	VU	VU	=
Polygonaceae	*Polygonum galapagense* Caruel	VU	VU	=
Portulacaceae	*Calandrinia galapagosa* H. St. John	CR	CR	=
Portulacaceae	*Portulaca howellii* (D. Legrand) Eliasson	LC	LC	=
Rubiaceae	*Borreria dispersa* Hook. f.	VU	VU	=
Rubiaceae	*Borreria ericaefolia* Hook. f.	DD	VU	
Rubiaceae	*Borreria linearifolia* Hook. f.	VU	VU	=
Rubiaceae	*Borreria perpusilla* Hook. f.	CR	VU	↑
Rubiaceae	*Borreria rotundifolia* Andersson	CR	DD	
Rubiaceae	*Borreria suberecta* Hook. f.	DD	NT	
Rubiaceae	*Galium galapagoense* Wiggins	EN	EN	=
Rubiaceae	*Psychotria angustata* Andersson	CR	CR	=
Rubiaceae	*Psychotria rufipes* Hook. f.	VU	VU	=
Sapindaceae	*Cardiospermum galapageium* B.L. Rob. & Greenm.	VU	VU	=
Scrophulariaceae	*Galvezia leucantha* Wiggins	EN	EN	=
Simaroubaceae	*Castela galapageia* Hook. f.	LC	NE	
Solanaceae	*Capsicum galapagoense* Hunz.	EN	EN	=
Solanaceae	*Exodeconus miersii* (Hook. f.) D'Arcy	LC	LC	=
Solanaceae	*Iochroma ellipticum* (Hook. f.) Hunz.	VU	VU	=
Solanaceae	*Jaltomata werffii* D'Arcy	VU	VU	=
Solanaceae	*Lycium minimum* C.L. Hitchc.	LC	LC	=
Solanaceae	*Physalis galapagoensis* Waterf.	LC	LC	=
Solanaceae	*Solanum cheesmaniae* (Riley) Fosberg	NT	LC	↑
Solanaceae	*Solanum galapagense* S.C. Darwin & Peralta	LC	NE	
Urticaceae	*Pilea baurii* B.L. Rob.	LC	LC	=
Verbenaceae	*Lantana peduncularis* Andersson	LC	LC	=
Verbenaceae	*Lippia rosmarinifolia* Andersson	NT	VU	↓
Verbenaceae	*Lippia salicifolia* Andersson	CR	CR	=
Verbenaceae	*Verbena grisea* B.L. Rob. & Greenm.	VU	VU	=
Verbenaceae	*Verbena sedula* Moldenke	DD	DD	=
Verbenaceae	*Verbena townsendii* Svenss.	DD	DD	=
Viscaceae	*Phoradendron henslovii* (Hook. f.) B.L. Rob.	LC	LC	=
Zygophyllaceae	*Kallstroemia adscendens* (Andersson) B.L. Rob.	LC	LC	=

Source: CDF databases.

Galapagos vertebrates: endangered status and conservation actions

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Categorization of species on the Red List is useful for conservationists and managers to prioritize their efforts and actions regarding species and ecosystems that are endangered with extinction[1].

In Galapagos, **109** endemic and native vertebrate species have been recorded, of which **13** are considered Extinct. Seven of the extinct species are known from records of live specimens, while the remaining six are only known from the fossil record[2] (Table 1). The only species Extinct in the Wild (EW) is the giant land tortoise of Pinta, *Geochelone abingdoni*, whose sole survivor is known as Lonesome George.

Table 1. Extinct vertebrate species.

Order	Common name	Scientific Name	Island	Record	
				Fossil	Living
Reptile	Rábida gecko	*Phyllodactylus sp*	Rábida	x	
	Fernandina giant tortoise	*Geochelone phantastica*	Fernandina		x
	Floreana giant tortoise	*Geochelone elephantopus*	Floreana	x	x
	Rábida giant tortoise	*Geochelone wallacei*	Rábida	x	x
	Santa Fe giant tortoise	*Geochelone sp.*	Santa Fe		x
Mammal	Rábida rice rat	*Nesoryzomys sp* 1	Rábida	x	
	Isabela rice rat	*Nesoryzomys sp* 2	Isabela	x	
	Isabela rice rat	*Nesoryzomys sp* 3	Isabela	x	
	Santa Cruz giant rat	*Megaoryzomys curioi*	Santa Cruz	x	
	Isabela giant rat	*Megaoryzomys sp*	Isabela	x	
	Galapagos rice rat	*Oryzomys galapagoensis*	San Cristóbal	x	x
	Santa Cruz rice rat	*Nesoryzomys indefessus*	Santa Cruz - Baltra	x	x
	Santa Cruz rice rat	*Nesoryzomys darwini*	Santa Cruz	x	x

Source: Steadman *et al* (1991)

The number of species in an endangered category may change over time for a variety of reasons, such as a change in taxonomic classification, a change in status or origin, discovery of new species or fossils, and new assessments (Table 2, Fig. 1, Annex).

The principal causes for extinction of species on the Red List are:

- habitat loss and/or fragmentation;
- arrival of introduced species that are predators or disease vectors, or that compete for habitat or food;
- introduction of agents of infection, via air or sea, that pose a major risk factor that could lead to extinction of species, as occurred in Hawaii with the introduction of avian malaria;
- hunting, still occurring on Isabela, which can affect both reptiles and birds;
- increased tourism (without precautionary measures), population growth and political-economic pressure;
- global warming and its large-scale impacts on natural processes, with potentially serious consequences for existing populations.

The findings of the latest assessment are alarming, both because of the number of species now on the Red List and their threat category, and because of the problems they face. Among endangered fauna, birds have the greatest potential for extinction[3].

> Of the 109 endemic and native species of vertebrates, six became extinct prior to the arrival of humans in the Galapagos and seven became extinct after humans arrived.

Table 2. Number of vertebrate species per threat category (1999-2007).

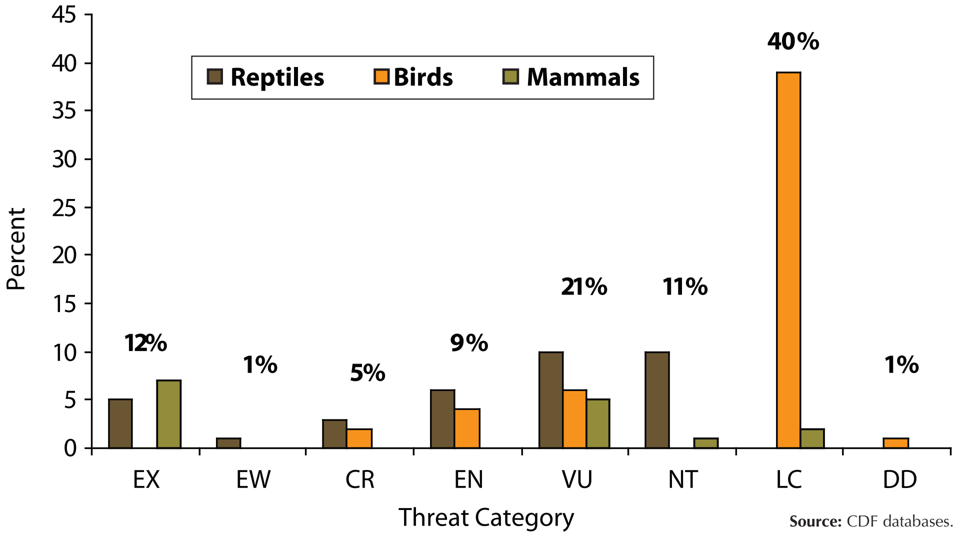
Year	Order	No. taxa of species evaluated	IUCN Threat Category							
			EX	EW	CR	EN	VU	NT	LC	DD
1999*	All Vertebrates	112	10	1	4	12	38	5	42	
2007**	Reptiles	37	5	1	3	6	11	11	0	0
	Birds	56	0	0	2	4	7	0	42	1
	Mammals	16	8	0	0	0	5	1	2	0
	All Vertebrates	**109**	**13**	**1**	**5**	**10**	**23**	**12**	**44**	**1**

Source: *Data taken from Snell *et al* (1999). ** Includes species and endemic and native subspecies accepted by the CDF.

Notes

Symbols Legend: **EX** = Extinct, **EW** = Extinct in the Wild, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern, **DD** = Data Deficient.

Figure 1. Percent of endemic and native vertebrate species by threat category, 2007



Source: CDF databases.

Note

Symbols Legend: **EX** = Extinct, **EW** = Extinct in the Wild, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern, **DD** = Data Deficient.

REPTILES

In 1965, the CDF initiated the program for captive rearing of **giant tortoises** (*Geochelone* spp.) on Santa Cruz Island. In 1968, with the establishment of the Galapagos National Park Service (GNPS), it became a collaborative program between the two organizations. The first tortoise populations in the program were from the islands of Pinzón, Española, and Santiago. The program grew to include other populations, including those from Wolf, Cerro Azul, and Sierra Negra volcanoes on Isabela; and the islands of San Cristóbal and Santa Cruz. To date, **4,049** land tortoises have been repatriated to these eight populations. The success of the program has resulted in the recovery of some populations (Santiago and Española) to the extent that they were moved from Critically Endangered to Endangered. The populations on San Cristóbal, Santa Cruz, and Cerro Azul Volcano are currently catalogued as Vulnerable. However, two tortoise populations remain Critically Endangered due to the threat from black rats (*Rattus rattus* – Pinzón Island) and humans (Sierra Negra Volcano on southern Isabela).

Raising and repatriating tortoises and land iguanas in captivity has resulted in certain species moving to less threatened categories.

The **land iguana** (*Conolophus subcristatus*) is in the Vulnerable category[4]. Its main threats are introduced species, primarily dogs (*Canis familiaris*), wild cats (*Felis catus*), and humans. In 1931 and 1932, Captain Allan Hancock and zoologist Cy Perkins transferred approximately 70 iguanas from Baltra to North Seymour, which saved the population as the resident population on Baltra became extinct sometime between 1938 and 1958, when Baltra was used as a US military base. In 1975, the CDF and the GNPS established an iguana rearing center in Santa Cruz. Adult iguanas from Santa Cruz (Cerro Dragón, Cerro Montura, and Conway Bay) and Isabela (Cartago Bay) were taken to the center for subsequent reproduction, and rearing and repatriation of juvenile iguanas to their places of origin. In 1979, the first pair of adult iguanas from North Seymour was transferred to the center and the first 35 juvenile iguanas were repatriated to Baltra in June 1991. Repatriations to Cartago Bay began in 1982, with the release of the first 39 juveniles. The first 53 juveniles were released at Cerro Dragón on Santa Cruz in 1987. The CDF and the GNPS also initiated a semi-captive program for land iguanas on the Venecia islets (close to Cerro Dragón) by transferring adult iguanas to these islets. With successful reproduction, the juvenile iguanas were then captured and repatriated to their places of origin. The first 11 juveniles were transferred from Venecia to Conway Bay on Santa Cruz in 1985. To date, 1,136 iguanas have been repatriated to their places of origin.

BIRDS

The **Galapagos penguin**, *Spheniscus mendiculus*, is distributed along the coasts of Fernandina and Isabela and the northern coast of Floreana. The **flightless cormorant**, *Phalacrocorax harrisi*, is found on the coasts of Fernandina and Isabela. Both species are catalogued on the IUCN's Red List as Endangered[1]. The threats include introduced species, such as dogs, cats, and rats (*Rattus* spp)[5]; global warming, which can worsen the effects of the El Niño phenomenon and affect their reproductive rate[6]; uncontrolled fishing with nets[1]; oil and fuel spills, and plastic garbage. As part of the conservation for these species, the CDF and the GNPS conduct annual censuses of both populations. Both species have stable populations, with a rising trend since 1999, although the Galapagos penguin population is still below the population high recorded in the 1970s.

The **Galapagos albatross**, *Phoebastria irrorata*, is listed as Vulnerable by the IUCN[1], and there is pressure to move it to Critically Endangered*. In 2002, the population was about 35,000[7]. Albatross nest on Española. From January to March they roam the Pacific Ocean off the coasts of southern Ecuador and northern Peru. They are threatened by global warming, since the El Niño phenomenon affects reproduction due to the resulting food shortage[8], by fishing in waters near the mainland[9,10], and by oil pollution from fishing boats[1]. At present, there is contact with the Ministries of the Environment and Foreign Affairs of Ecuador to ensure the protection of this species in the territorial waters of Peru.

Among all the endangered fauna, birds have the greatest potential for extinction. Both the number of species on the Red List and the problems they face are alarming.

* In 2007 the status of the Galapagos albatross was changed to CR, Critically Endangered. This change is not reflected in the tables and figures of this article.

The **mangrove finch**, *Camarhynchus heliobates*, is in the Critically Endangered category. The population, with an estimated 50 breeding pairs, is currently restricted to two patches of mangroves on western Isabela[11]. The main threats include introduced species such as wasps (*Polistes versicolor*), rats, cats, ants (*Solenopsis* spp.)[1], and the parasitic fly, *Philornis downsi*, whose larvae suck blood from baby birds. There are also avian diseases that may affect this species. Anthropogenic threats include climate change and potential impacts from tourism. The two sites have been visitor sites for decades, although they are seldom visited. The mangrove finch project began in 2006. Its goals and objectives include determining the status of the population, threats, reproductive success, capture-recapture, and captive rearing and reintroduction. The numbers confirm that the population status is critical.

The **Floreana mockingbird**, *Nesomimus trifasciatus*, is in the Endangered category. It became extinct on Floreana Island in 1880. Its extinction is attributable to predation by dogs and feral cats, nest predation by black rats, and the disappearance of the cactus, *Opuntia megasperma*, caused by goats (*Capra hircus*)[1]. The Floreana mockingbird is now only found on two islets near Floreana, Gardner-by-Floreana and Champion[1]. The introduced species that affected them on Floreana have not yet arrived on either islet. Since 2003, annual monitoring of this species and surveys to detect introduced species have been conducted. Monitoring is very important, even more so when there is a declining trend in the number of individuals.

The **Galapagos flamingo**, *Phoenicopterus ruber*, also lives in the Bahamas, Greater Antilles, Yucatán, and northwestern Colombia. In Galapagos, there are approximately 320–550 individuals. This is the world's smallest population and is listed as Endangered on the Red List for birds in Ecuador[1]. It is threatened by introduced animals, such as cats, pigs (*Sus scrofa*), goats, rats, and the frog, *Scinax quinquefasciatus*, which reduce the critical habitat for reproduction, transmit disease, and destroy nests, eggs, and hatchlings. The El Niño phenomenon affects food resources, causes flooding of their habitat, and results in decreased reproduction. Humans also affect the flamingo lagoons by depositing garbage and rubble or by landfill. The GNPS and the CDF have conducted an annual census of the population since 1967. This population is stable.

MAMMALS

The **Galapagos sea lion**, *Zalophus wollebaeki*, is found throughout the archipelago. Since 1997, twelve breeding colonies have been monitored. The number of pups recorded during breeding seasons shows a recovery in terms of reproductive success, following the 50% population decrease[12] during the El Niño phenomenon of 1997-1998. In the last few years, new problems have arisen for this species, such as diseases that mainly affect their offspring. An eye parasite, *Phylopthalmus zalophi*, related to a high incidence of conjunctivitis and eye secretions in sea lion breeding colonies, primarily during the hot season of the year, was discovered in 2002.

> Of the 12 endemic rodent species recorded in Galapagos, only four currently exist.

Of the 12 **endemic rodent** species recorded in the Galapagos, only four currently exist (Annex). The recently extinct species (*Nesoryzomys* spp. and *Oryzomys galapagoensis*) may have been impacted by introduced species such as rats (due to competition for habitat and food, predation, and introduction of infectious agents), and cats (due to predation). The causes for the extinction of endemic rats prior to the arrival of humans are unknown, but they are assumed to have been natural. The four species of rodents still present are threatened by introduced rats, primarily on Santiago. Although no *Rattus rattus* or other exotic species have been registered in the zones where the other three endemic rat species live, they may eventually arrive. For this reason, the GNPS and the CDF monitor rat presence/absence on these islands.

Annex. List of endemic and native vertebrate species by their Threat Category.

Class	Common name	Scientific Name	Threat Category
REPTILES	Giant land tortoise of Floreana	*Geochelone elephantopus*	EX[c]
	Giant land tortoise of Fernandina	*Geochelone phantastica*	EX[c]
	Giant land tortoise of Santa Fe	*Geochelone sp*	EX[c]
	Giant land tortoise of Rábida	*Geochelone wallacei*	EX[c]
	Rábida gecko	*Phyllodactylus sp.*	EX[c]
	Giant land tortoise of Pinta	*Geochelone abingdoni*	EW[b]
	Galapagos snake	*Antillophis slevini*	CR[b]
	Giant land tortoise of Pinzón	*Geochelone ephippium*	CR[b]
	Giant land tortoise of Sierra Negra Volcano	*Geochelone guntheri*	CR[b]
	Galapagos snake	*Alsophis biserialis*	EN[b]
	Galapagos snake	*Antillophis steindachneri*	EN[b]
	Giant land tortoise of Santiago	*Geochelone darwini*	EN[b]
	Giant land tortoise of Española	*Geochelone hoodensis*	EN[b]
	Giant land tortoise of Darwin Volcano	*Geochelone microphyes*	EN[b]
	Giant land tortoise of Cerro Azul volcano	*Geochelone vicina*	EN[b]
	Marine iguana	*Amblyrhynchus cristatus*	VU[b]
	Land iguana	*Conolophus pallidus*	VU[b]
	Land iguana	*Conolophus subcristatus*	VU[b]
	Giant land tortoise of Wolf Volcano	*Geochelone becki*	VU[b]
	Giant land tortoise of San Cristóbal	*Geochelone chathamensis*	VU[b]
	Giant land tortoise of Santa Cruz	*Geochelone nigrita*	VU[b]
	Giant land tortoise of Alcedo Volcano	*Geochelone vandenburghi*	VU[b]
	Lava lizard	*Microlophus bivittatus*	VU[b]
	Lava lizard	*Microlophus duncanensis*	VU[b]
	Lava lizard	*Microlophus grayii*	VU[b]
	Galapagos snake	*Philodryas hoodensis*	VU[b]
	Marine turtle	*Chelonia mydas*	NT[b]
	Lava lizard	*Microlophus albemarlensis*	NT[b]
	Lava lizard	*Microlophus delanonis*	NT[b]
	Lava lizard	*Microlophus habelii*	NT[b]
	Lava lizard	*Microlophus pacificus*	NT[b]
	Native gecko	*Phyllodactylus barringtonensis*	NT[b]
	Native gecko	*Phyllodactylus baurii*	NT[b]
	Darwin gecko	*Phyllodactylus darwini*	NT[b]
	Galapagos gecko	*Phyllodactylus galapagensis*	NT[b]
	Native gecko	*Phyllodactylus gilberti*	NT[b]
	Native gecko	*Phyllodactylus leei*	NT[b]
BIRDS	Mangrove finch	*Camarhynchus heliobates*	CR[a]
	Galapagos petrel	*Pterodroma phaeopygia*	CR[a]
	San Cristóbal mockingbird	*Nesomimus melanotis*	EN[a]
	Floreana mockingbird	*Nesomimus trifasciatus*	EN[a]
	Flightless cormorant	*Phalacrocorax harrisi*	EN[a]
	Galapagos penguin	*spheniscus mendiculus*	EN[a]
	Galapagos hawk	*Buteo galapagoensis*	VU[b]
	Medium tree finch	*Camarhynchus pauper*	VU[b]

Class	Common name	Scientific Name	Threat Category
BIRDS	Lava gull	*Larus fuliginosus*	VU [a]
	Galapagos rail	*Laterallus spilonotus*	VU [a]
	Española mockingbird	*Nesomimus macdonaldi*	VU [a]
	Galapagos albatross*	*Phoebastria irrorata*	VU [a]
	Galapagos martin	*Progne modesta*	VU [a]
	Galapagos pintail duck	*Anas bahamensis galapagoensis*	LC [a]
	Brown noddy	*Anous stolidus galapagensis*	LC [a]
	Great blue heron	*Ardea herodias cognata*	LC [a]
	Short-eared owl	*Asio flammeus galapagoensis*	LC [a]
	Striated heron	*Butorides striata sundevalli*	LC [a]
	Woodpecker finch	*Camarhynchus pallidus*	LC [a]
	Small tree finch	*Camarhynchus parvulus*	LC [a]
	Large tree finch	*Camarhynchus psittacula*	LC [a]
	Warbler finch	*Certhidea olivacea*	LC [a]
	Dark-billed cuckoo	*Coccyzus melacoryphus*	LC [a]
	Swallow-tailed gull	*Creagrus furcatus*	LC [a]
	Yellow warbler	*Dendroica petechia aureolla*	LC [a]
	Magnificent frigate bird	*Fregata magnificens magnificens*	LC [a]
	Great frigate bird	*Fregata minor*	LC [a]
	Common moorhen	*Gallinula chloropus*	LC [a]
	Large cactus finch	*Geospiza conirostris*	LC [a]
	Sharp-beaked ground finch	*Geospiza difficilis*	LC [a]
	Medium ground finch	*Geospiza fortis*	LC [a]
	Small ground finch	*Geospiza fuliginosa*	LC [a]
	Large ground finch	*Geospiza magnirostris*	LC [a]
	Cactus finch	*Geospiza scandens*	LC [a]
	Oyster-catcher	*Haematopus palliatus galapagoensis*	LC [a]
	Black-necked stilt	*Himantopus mexicanus*	LC [a]
	Galapagos flycatcher	*Myiarchus magnirostris*	LC [a]
	Paint-billed crake	*Neocrex erythrops*	LC [a]
	Galapagos mockingbird	*Nesomimus parvulus*	LC [a]
	Yellow-crowned night heron	*Nyctanassa violacea pauper*	LC [a]
	Madeiran storm petrel	*Oceanodroma castro*	LC [a]
	Galapagos storm petrel	*Oceanodroma tethys tethys*	LC [a]
	Brown pelican	*Pelecanus occidentalis urinator*	LC [a]
	Red-billed tropicbird	*Phaethon aethereus*	LC [a]
	Flamingo	*Phoenicopterus ruber*	LC [a]
	Vegetarian finch	*Platyspiza crassirostris*	LC [a]
	Galapagos shearwater	*Puffinus subalaris*	LC [a]
	Vermilion flycatcher	*Pyrocephalus rubinus*	LC [a]
	Sooty tern	*Sterna fuscata*	LC [a]
	Nazca booby	*Sula granti*	LC [a]
	Blue-footed booby	*Sula nebouxii excisa*	LC [a]
	Red-footed booby	*Sula sula*	LC [a]
	Common barn owl	*Tyto alba punctatissima*	LC [a]

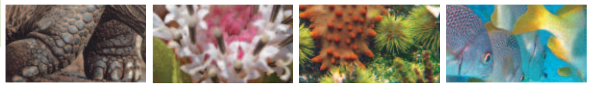
* In 2007 the status of the Galapagos albatross was changed to CR, Critically Endangered. This change is not reflected in the tables and figures of this article.

Class	Common name	Scientific Name	Threat Category
BIRDS	Galapagos dove	*Zenaida galapagoensis*	LC [a]
	Great egret	*Ardea alba*	LC [d]
	Elliot's storm petrel	*Oceanites gracilis galapagoensis*	DD [a]
MAMMALS	Santa Cruz rice rat	*Nesoryzomys darwini*	EX [a]
	Santa Cruz giant rice rat	*Megaoryzomys curioi*	EX [c]
	Isabela giant rice rat	*Megaoryzomys sp.*	EX [c]
	Santa Cruz rice rat	*Nesoryzomys indefessus*	EX [c]
	Rábida rice rat	*Nesoryzomys sp.1*	EX [c]
	Isabela rice rat	*Nesoryzomys sp.2*	EX [c]
	Isabela rice rat	*Nesoryzomys sp.3*	EX [c]
	Galapagos rice rat	*Oryzomys galapagoensis*	EX [c]
	Fernandina rice rat	*Nesoryzomys fernandinae*	VU [a]
	Santiago rice rat	*Nesoryzomys swarthi*	VU [a]
	Santa Fe rice rat	*Oryzomys bauri*	VU [a]
	Galapagos sea lion	*Zalophus wollebaeki*	VU [a]
	Galapagos fur seal	*Arctocephalus galapagoensis*	VU [a]
	Fernandina rice rat	*Nesoryzomys narboroughi*	NT [a]
	Galapagos red bat	*Lasiurus borealis brachyotis*	LC [a]
	Hoary bat	*Lasiurus cinereus*	LC [a]

Source: [a] IUCN 2007. [b] Red Book for Ecuador. [c] Steadman *et al*. (1991). [d] CDF 2007.

Notes

Symbols Legend: **EX** = Extinct, **EW** = Extinct in the Wild, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern, **DD** = Data Deficient



Evaluating land invertebrate species: prioritizing endangered species

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Invertebrates dominate terrestrial ecosystems in Galapagos, far outnumbering all other animal species. They play a key role in insular ecosystems as fundamental components of the mechanisms for pollination of plants, decomposition of organic matter, and soil building. They are present in nearly all habitats and form part of the food chain for many bird and reptile species.

The land invertebrate fauna in Galapagos is rich in endemic species but poor in diversity when compared to the South American mainland. Nearly 3,000 species of land invertebrates have been reported in Galapagos, 51.7% of them endemic. The most sizable group is insects, with 1,555 species, followed by arachnids and nematodes (Annex 1). Some groups, such as acarids and nematodes, have been little studied as yet or have a complex taxonomy, requiring more in-depth studies to identify all species.

It is vital to determine the conservation status of endemic species for the development of management strategies. To ensure that ecosystems function properly, it is necessary to restore communities with key species, such as invertebrates. In the last few years, one of the priorities of the Charles Darwin Foundation (CDF) has been to evaluate the conservation status of endemic species of land invertebrates according to World Conservation Union (IUCN) criteria. As of 2006, land snail species of the *Bulimulus* genus and species of the Lepidoptera order (moths and butterflies) have been assessed.

Threat status of groups of land invertebrates as of 2006

The final findings of the assessment of 103 species indicate that 2 are already Extinct, 26 are Critically Endangered, 9 are Endangered, 26 are Vulnerable, and 40 are apparently in no immediate danger of extinction (Table 1).

> Out of 103 species of endemic land invertebrates evaluated as of 2006, two are extinct and 61 are under a Threatened Category

Table 1. Number and percent of taxa in each Threat Category as of 2006.

			IUCN Threat Category					
Year	**Group**	**No. Taxa Evaluated**	**EX**	**CR**	**EN**	**VU**	**NT**	**LC**
2006	Total Taxa	103	2	26	9	26	–	40
	Percent		2	25	9	25	–	39
	Lepidoptera	53	–	–	2	11	–	40
	Percent		–	–	4	21	–	75
	Bulimulus	50	2	26	7	15	–	–
	Percent		4	52	14	30	–	–

Source: CDF databases.

Notes

Symbols Legend: **EX** = Extinct, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern.

Lepidoptera

Moths and butterflies belong to one of the most diverse orders (Lepidoptera) in the class Insecta and are the second most diverse taxonomic group in Galapagos. This order comprises over 340 species in the archipelago. At this time, approximately 200 native species have been recorded, of which some 100 species are endemic[1].

Most representatives of this group have nocturnal habits. Nearly all larvae of these species are herbivorous, but there are some exceptions. Some genera, such as *Galagete*, have many species adapted to live in diverse habitats and to feed on a wide variety of resources, ranging from decomposing plant leaves to giant tortoise droppings[2]. On the other hand, adults in most species simply feed on the nectar of flowers. For these reasons, Lepidoptera play a key role in ecosystem processes. Many birds and some insects eat their larvae. Bats, birds, and spiders eat adult butterflies and moths, whereas some flies and wasps are parasites of their larvae.

Assessments of 53 species in this group indicate that 2 species are Endangered, 11 are Vulnerable, and 40 are apparently not in any danger of extinction (Table 1, Annex 2).

Bulimulus land snails

Among land invertebrates, the mollusk fauna of Galapagos occupies a significant position, dominated by the Bulimulidae, a genus of endemic land snails that comprises about 90% of land snail species in the archipelago.

> Of the 33 species of land snails recorded in Santa Cruz, 25 still lived there prior to 1973, but only 7 have been found live in recent monitoring efforts.

All *Bulimulus* land snails in Galapagos are endemic. They have undergone a spectacular process of speciation, resulting in 65 described species, with several subspecies and a total of 93 taxa[3]. The morphological diversity observed in the Galapagos *Bulimulus* is surprising, including variation in the shape of the shell, the opening, and the navel, as well as the sculpture, color, and size of the shell surface.

Bulimulus snails have adapted to a broad range of climatic conditions and habitats. Some species live in semi-desert situations and others are found only in moist forests with more temperate climates. The distribution of some *Bulimulus* species is restricted to very limited areas, such as a valley in the highlands or on an isolated hill, characterized by a particular microclimate or a special type of vegetation. *Bulimulus* land snails are often very sensitive to microclimatic changes; therefore, they could be used as ecological indicators of the state of habitats in order to assess ecological changes in Galapagos[3].

Of the 93 taxa in this genus described for Galapagos, only two species are officially considered Extinct (*B. kublerensis* and *B. steamani*) and known only by fossil records. However, there are many other species that have not been sighted in the last 30 years, especially on Santa Cruz. Out of the 33 species known for that island, 25 still lived there prior to 1973[3], but only seven have been found live in recent monitoring efforts[4]. More intensive searches are required to determine whether the species not recorded recently are extinct or whether there are still populations in areas not yet studied.

Assessments of this group indicate that a total of 26 species are Critically Endangered, 7 are Endangered, and 15 are Vulnerable (Table 1, Annex 2).

Principal threats to the groups evaluated

Habitat destruction

Destruction and loss of habitat is the main threat to these species. Many of them are especially sensitive to habitat alteration, such as conversion of natural forest to pasture for grazing of introduced species and urban expansion. In the last few years, there has been acceleration in the alteration of natural habitats on the four populated islands.

Table 2 shows the distribution of the two groups evaluated (Lepidoptera and *Bulimulus* land snails) by island and threat category. Most threatened species are on the populated islands such as Santa Cruz, and the only known extinctions have occurred on those islands (Fig. 1).

Table 2. Distribution of threatened species of land invertebrates evaluated as of 2006.

	IUCN Threat Category			
ISLAND	**CR**	**EN**	**VU**	**Total**
Santa Cruz	16	1	13	30
Santiago	3	3	8	14
Floreana	1	6	5	12
Isabela		2	10	12
San Cristóbal	5	4	2	11
Fernandina			10	10
Pinta		1	3	4
Española	1	1	1	3
Rábida			2	2
Pinzón	1			1
Santa Fe		1		1

Source: CDF databases.

Note

CR: Critically Endangered, EN: Endangered; VU: Vulnerable

Figure 1. Distribution of threatened species of endemic land invertebrates evaluated as of 2006 by island

Source: CDF databases.

Most threatened species are on the populated islands and the only known extinctions have occurred on those islands.

The process of land snail extinction is recent and may be directly related to human settlement of the different islands of the archipelago[3]. Transformation of their natural habitat for farming and ranching has significantly influenced the distribution of species on Floreana and San Cristóbal since 1847 and on Santa Cruz since 1920. This modification of the natural habitat in colonized zones has seriously harmed many land snail species and other species of land invertebrates whose natural habitats were the moist *Scalesia* forests and transitional woodlands[3].

As for Lepidoptera, 15 of the species listed as threatened are mainly jeopardized by loss of habitat, especially because of their limited distribution. The drastic reduction of the *Scalesia pedunculata* forest on Santa Cruz affects many species, especially those that feed on plants found only in this zone[5].

Introduced species

Introduced species are the second greatest threat to endemic invertebrates, whether from direct predation or by habitat destruction and the destruction of their vegetative food resources.

Introduced predators, such as black rats (*Rattus rattus*) and little fire ants (*Wasmania auropunctata*), have a direct negative impact on land snail populations through predation or by destroying their eggs and limiting their reproduction[3]. Curiously, two potential competitors of endemic snails that were introduced accidentally (the small pan-tropical snail, *Subulina octona*, and a small black slug, *Deroceras laeve*[3]) have apparently not suffered serious consequences from these same threats. Another mollusk present on the archipelago is the well-known slug, *Vaginulus (Sarasinula) plebeius* (Veronicellidae), probably introduced into Galapagos in 1984. This species has become successfully established and is currently found in all settled areas, where it seems to have contributed to eliminating some endemic land snail species[3].

Host plant destruction is the second most important threat to the 13 endangered species of Lepidoptera. The larvae of many endemic moths are specific to one or a few species of plants that have been severely disturbed by introduced species. Roque-Albelo (2003)[6] reported a decrease in the populations of three endemic species of Lepidoptera specifically associated with shrubs of the genus *Darwiniothamnus*; this decline was caused by the introduction of the cottony cushion scale, *Icerya purchasi*, into Galapagos. There are no known cases of introduced parasitic species of Hymenoptera or Diptera insects that directly attack endemic butterfly or moth species in Galapagos, although a more intensive study of this issue is needed[5]. Similarly, fire ants (*Solenopsis geminata* and *W. auropunctata*), which eat Lepidoptera eggs and larvae, are also affecting many endemic species of moths and butterflies.

Conclusions

The land invertebrate fauna of Galapagos is endangered. The only two groups for which the conservation status has been assessed show a large number of species that are seriously threatened. The factors most influencing the conservation status of these species are habitat destruction and alteration resulting from human activities and the effect of introduced species such as fire ants, goats, and rats. For the 35 species with a high degree of threat (Critically Endangered or Endangered), it is urgent to take conservation action to prevent their probable extinction. However, the main limiting factor to designing restoration programs is the lack of knowledge about the biology and distribution of these species. Therefore, it is an immediate priority to study these issues.

> Introduced species are the second greatest threat to endemic invertebrates, mainly black rats and fire ants (direct predation), and goats (habitat destruction).

Annex 1. Diversity of land invertebrate species in Galapagos.

		Native species	Endemic species	Notes
Phylum Arthropoda				
Subphylum Chelicerata				
Class Arachnida	Arachnids (spiders, scorpions, acarids, etc.)	207	184	1, 2, 3, 4, 5, Unpublished information
Subphylum Myriapoda				
Class Chilopoda	Centipedes	2	6	6, 7
Class Diplopoda	Millipedes	0	1	6, 7
Class Symphila	Centipede-like animals	0	0	7
Subphylum Crustaceae	Crustaceans	24	7	8
Subphylum Hexapoda				
Class Elliplura	Collembola	22	10	9
Class Diplura	Springtails	1	0	9
Class Insecta	Insects	823+	735+	9, Unpublished information
PhylumTardigrada	Water bears	14	2	10, 11
Phylum Mollusca	Land snails	3	80	12
Phylum Nematoda	Nematodes	100+	5	13

Source: CDF database.

Annex 2. Species of Land invertebrates Evaluated as of 2006.

Common name	Scientific Name	Class: Order	Threat Category	Islands
Land snail	*Bulimulus achatellinus*	Gastropoda: Stylommatophora	CR	San Cristóbal, Española
Land snail	*Bulimulus adelphus*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus adserseni*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus chemitzioides*	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	*Bulimulus curtus*	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	*Bulimulus deridderi*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus duncanus*	Gastropoda: Stylommatophora	CR	Pinzón
Land snail	*Bulimulus eos*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus eschariferus*	Gastrópoda: Stylommatophora	CR	San Cristóbal
Land snail	*Bulimulus galapaganus*	Gastrópoda: Stylommatophora	CR	Floreana
Land snail	*Bulimulus habeli*	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	*Bulimulus hirsutus*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	Bulimulus indefatigabilis	Gastropoda: Stylommatophora	CR	Santiago
Land snail	*Bulimulus jacobi*	Gastropoda: Stylommatophora	CR	Santiago
Land snail	*Bulimulus lycodus*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus ochsneri*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus reibischi*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus saeronius*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus sculpturatus*	Gastropoda: Stylommatophora	CR	Santiago
Land snail	*Bulimulus sp. nov. josevillani*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus sp. nov. krameri*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus sp. nov. nilsondhneri*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus sp. nov. tuideroyi*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus sp. nov. vanmoli*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus tanneri*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus wolfi*	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	*Bulimulus cinerarius*	Gastropoda: Stylommatophora	EN	Floreana, Santiago, Isabela
Land snail	*Bulimulus cucullinus*	Gastropoda: Stylommatophora	EN	Española, Floreana, Santa Fe
Land snail	*Bulimulus nux*	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	*Bulimulus olla*	Gastropoda: Stylommatophora	EN	Santiago
Land snail	*Bulimulus perspectivus*	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	Bulimulus planospira	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	*Bulimulus rugulosus*	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana, Pinta
Nocturnal butterfly	*Macaria cruciata cruciata*	Insecta: Lepidoptera	EN	Santa Cruz, Santiago
Nocturnal butterfly	*Macaria cruciata isabelae*	Insecta: Lepidoptera	EN	Isabela
Land snail	*Bulimulus akamatus*	Gastropoda: Stylommatophora	VU	Santa Cruz
Land snail	*Bulimulus alethorhytidus*	Gastropoda: Stylommatophora	VU	Santa Cruz

Common name	Scientific Name	Class: Order	Threat Category	Islands
Land snail	*Bulimulus amastroides*	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	*Bulimulus blombergi*	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	*Bulimulus calvus*	Gastrópoda: Stylommatophora	VU	Santa Cruz, Floreana
Land snail	*Bulimulus cavagnaroi*	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	*Bulimulus darwini*	Gastrópoda: Stylommatophora	VU	Santiago
Land snail	*Bulimulus hoodensis*	Gastrópoda: Stylommatophora	VU	Española
Land snail	*Bulimulus jervisensis*	Gastrópoda: Stylommatophora	VU	Rábida
Land snail	*Bulimulus nesioticus*	Gastrópoda: Stylommatophora	VU	Santiago
Land snail	*Bulimulus perrus*	Gastrópoda: Stylommatophora	VU	Fernandina
Land snail	*Bulimulus rabidensis*	Gastrópoda: Stylommatophora	VU	Rábida
Land snail	*Bulimulus tortuganus*	Gastrópoda: Stylommatophora	VU	Isabela
Land snail	*Bulimulus unifasciatus*	Gastrópoda: Stylommatophora	VU	Floreana
Land snail	*Bulimulus ustulatus*	Gastrópoda: Stylommatophora	VU	Floreana
Nocturnal butterfly	*Epiplema becki*	Insecta: Lepidóptera	VU	Isabela, Fernandina
Nocturnal butterfly	*Eupithecia galapagosata*	Insecta: Lepidóptera	VU	Isabela, San Cristóbal, Santiago
Nocturnal butterfly	*Eupithecia perryvriesi*	Insecta: Lepidóptera	VU	Fernandina, Floreana, Isabela, Santa Cruz, Santiago
Nocturnal butterfly	*Platyptilia vilema*	Insecta: Lepidóptera	VU	Fernandina, Isabela, Pinta
Nocturnal butterfly	*Semiothisa cerussata*	Insecta: Lepidóptera	VU	Isabela, Santa Cruz, San Cristóbal
Nocturnal butterfly	*Tebenna galapagoensis*	Insecta: Lepidóptera	VU	Fernandina, Isabela, Pinta, Santa Cruz, Santiago
Nocturnal butterfly	*Trachea cavagnaroi*	Insecta: Lepidóptera	VU	Isabela, Santa Cruz
Nocturnal butterfly	*Tyrintheina umbrosa*	Insecta: Lepidóptera	VU	Fernandina, Floreana, Isabela, Santa Cruz, Santiago
Nocturnal butterfly	*Utetheisa devriesi*	Insecta: Lepidóptera	VU	Pinta, Isabela, Fernandina, Santiago
Nocturnal butterfly	*Utetheisa perryi*	Insecta: Lepidóptera	VU	Isabela, Santa Cruz, Santiago
Nocturnal butterfly	*Xylophanes norfolki*	Insecta: Lepidóptera	VU	Fernandina, Isabela, Santa Cruz
Land snail	*Bulimulus albermalensis*	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	*Bulimulus elaeodes*	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	*Bulimulus hemaerodes*	Gastrópoda: Stylommatophora	DD	Isabela, Fernandina
Land snail	*Bulimulus nucula*	Gastrópoda: Stylommatophora	DD	San Cristóbal, Floreana
Land snail	*Bulimulus pallidus*	Gastrópoda: Stylommatophora	DD	Isabela, Pinta
Land snail	*Bulimulus rugatinus*	Gastrópoda: Stylommatophora	DD	San Cristóbal, Isabela
Land snail	*Bulimulus rugiferus*	Gastrópoda: Stylommatophora	DD	Santa Cruz, Santiago
Land snail	*Bulimulus simrothi*	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	*Bulimulus trogonius*	Gastrópoda: Stylommatophora	DD	Isabela

Source: CDF databases.

Notes

Symbols Legend: **EX** = Extinct, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern.

Status of marine species and habitats

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The driving questions for research in marine conservation remain: How has and will the human presence in Galapagos change natural ecosystem processes? And how do we achieve a sustainable multi-use Marine Reserve that maintains biodiversity and endemism and hence its unique status as a natural resource, while at the same time permit responsible use of these resources for fisheries, tourism, science, and education? Marine Reserve managers worldwide face these same questions, yet few places of comparable size harbor such a unique confluence of marine species of differing biogeographic affinities, such rich and inspiring natural seascapes, a hugely dynamic biophysical environment, and at the same time have undergone such rapid development of human activities.

Even after decades of exploration, the Galapagos Marine Reserve (GMR) continues to reveal new mysteries. Now, with novel satellite and sensor technology, we are beginning to understand how to follow and predict how marine ecosystems change under strong climatic pressures such as El Niño. With climate change a global issue, Galapagos may experience more frequent El Niño/Southern Oscillation (ENSO) effects. New species previously hidden in deep waters and others believed to be extinct can now be revealed by remote deep water exploration vehicles. Monitoring frameworks for marine species and the subtidal marine ecosystem provide us with a wealth of new information regarding the composition of Galapagos coastal communities, yet much work remains to ensure a timely flow of information to an effective participatory decision-making forum. Complex interactions arising from the juxtaposition of cold and warm current systems, extractive fisheries, and non extractive tourism activities emphasize the importance of making informed management decisions based upon the best and most recent scientific advice available.

IUCN evaluation of marine groups

Early red listing by the IUCN focused on charismatic groups and those obviously impacted by human activity on a global scale, such as whales, pinnipeds, and more recently marine reptiles and sharks (Fig. 1, Table 1). Despite their importance, little attention was given to the many important subtidal habitat-forming species such as corals and macroalgae. These species are heavily impacted by ENSO events and their subsequent recovery most likely compromised by rapid human development in the coastal zone. A red listing process was initiated in 2006 for these groups, and a further fish evaluation is planned for 2007.

A review of Galapagos marine groups includes 25 species not yet accepted on the IUCN Red List (Table 1, Fig. 2). Of these 25, 80% have already been reviewed by experts for inclusion in 2007. Of the 57 species already incorporated into the Red List, 41% are categorized as threatened: Vulnerable (VU), Endangered (EN), or Critically Endangered (CR).

> According to the IUCN Red List, 40% of the marine species evaluated to date are threatened.

Table 1. Number of marine species listed in IUCN threat categories by marine group.

Marine group	No. species on Red List as of 2006	No. species submitted for inclusion
Marine Birds	5	
Cetaceans	15	
Fish	6	2
Molluscs	2	
Pinnipeds	2	
Rays	5	
Marine reptiles	5	
Sharks	17	
Echinoderms		2
Corals		4
Macroalgae		16
Crustaceans		1
Total	**57**	**25**

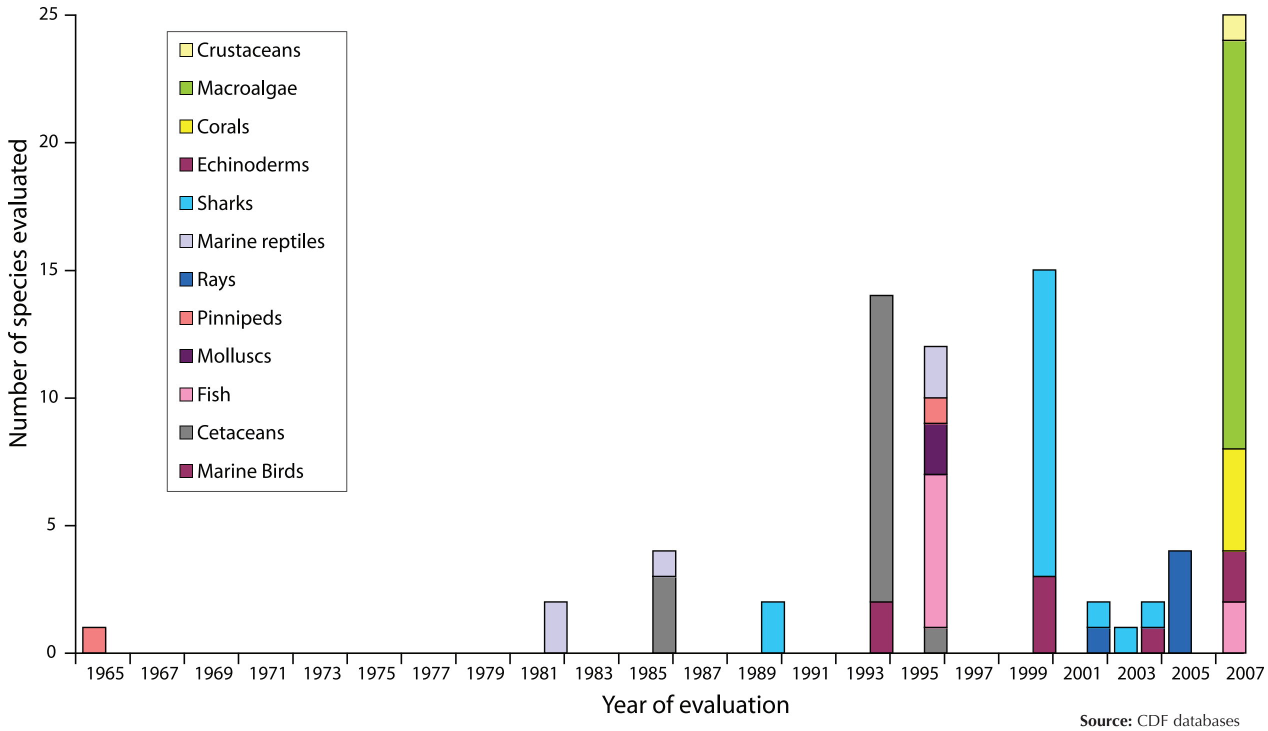
Source: CDF databases

Table 2. Marine species in IUCN Red List by threat category.

		Species listed	Threat Category: EX	CR	EN	VU	NT	LC	DD
2006	Species	57	—	3	6	14	5	17	12
	Percent		—	5%	11%	25%	9%	30%	21%
		Species submitted for inclusion	**EX**	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**
2006	Species	25	—	13	3	9	—	—	—

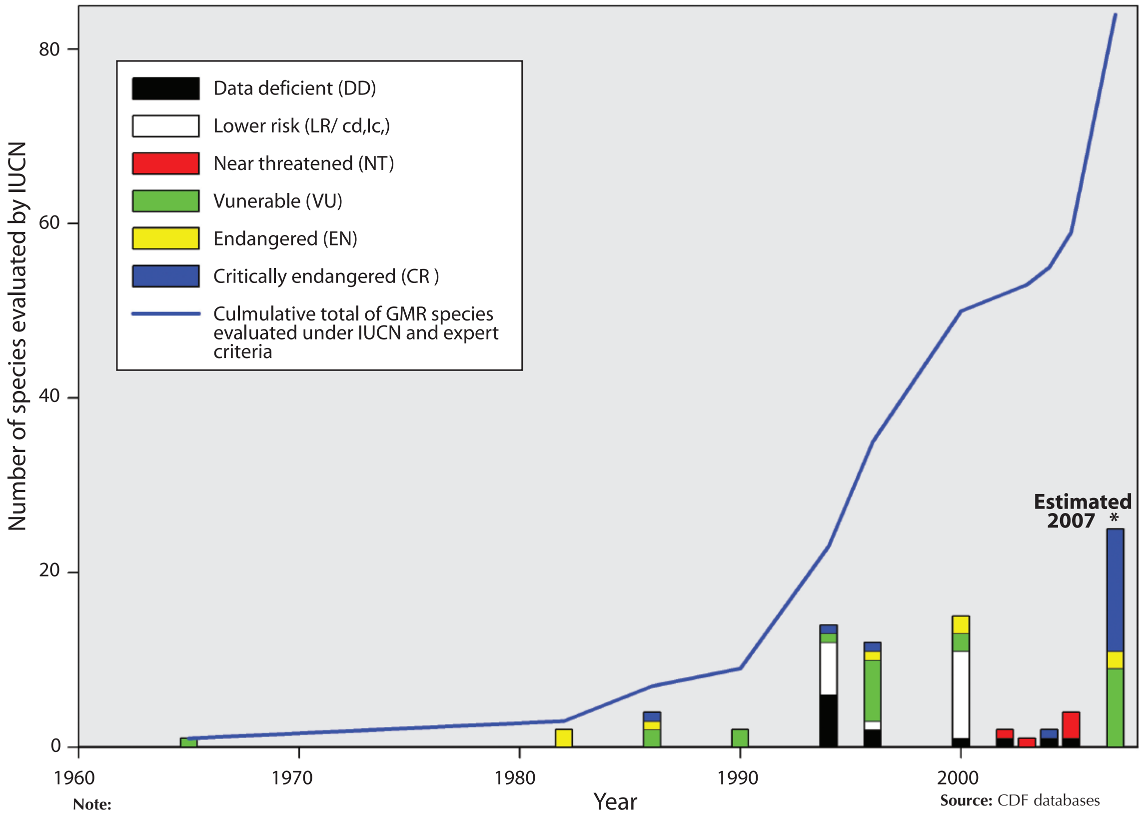
Source: CDF databases

Figure 1. Marine groups evaluated in recent years (data for 2007 were recently submitted)



Source: CDF databases

Figure 2. Marine species of the GMR evaluated by IUCN threat categories



Note:

Source: CDF databases

Figure includes threatened species reviewed in 2006 for Red List inclusion in 2007.

Threatened marine species

The marine species listed in Annex 1 are the most threatened coastal marine species in the GMR. These species are particularly sensitive to stress due to climatic events and human activities. Endangered species that visit the GMR but are seldom observed (such as the great white shark) are not included. The data cover marine birds and some other vertebrates that form colonies on land but spend the majority of their life in the marine environment. Annex 2 includes all species evaluated as Data Deficient and for which further research and monitoring are required.

Population data for threatened species and reasons for their decline

All species listed in Table 2 have experienced severe declines or have very restricted distributions. El Niño events have strongly affected the majority of resident marine species, particularly the coral and macroalgae communities, both of which include important habitat-forming species upon which many other species depend.

Bleaching of reef corals and strong swells led to a >97% reduction in abundance, although the colonies that remain are still relatively widespread and show signs of recovery in some areas. Certainly thermal and physical wave stress on large intertidal algae has driven several species collected from the early 1930s and later, such as *Bifurcia galapagensis,* to Critically Endangered status and possibly to Extinction. Reconstruction of past climate suggests that strong climatic events have altered marine subtidal and intertidal habitats in Galapagos for hundreds if not thousands of years. In contrast, the greatly increased human activity in the coastal zone over the last 40 years is unprecedented in the islands evolutionary history.

Overfishing of key predators, such as bacalao and lobster, has likely impacted the top-down control of habitat engineers such as urchins, which today form extensive barrens encrusted with coralline algae

Corals and macroalgae are important habitat-forming species that have been severely impacted by El Niño; the evaluation of their threat status began in recent years.

throughout the archipelago, compromising the natural recovery of other species while breaking down the foundation of old corals. The magnificent scallop, *Nodipecten magnificus*, is now only found in parts of western Isabela and Fernandina, having been fished as incidental catch after being already heavily affected during strong El Niño events. Threatened solitary corals, such as *Tubastrea taguensis*, that were formerly widespread are now only found in small pockets of cold water. Many migratory species, such as marine turtles and pelagic sharks, are still threatened by industrial fishing activities outside of the GMR and illegal fishing activities within the Reserve.

As global warming scenarios predict more frequent and stronger El Niños, an increase in sea level, acidification of the world's oceans, and possible changes in current patterns, the only thing that is certain is that change will occur. How we respond and adapt in the face of that change over the coming decades will likely determine the extinction or survival of many threatened and endemic species.

Marine turtles and pelagic sharks continue to be highly threatened species primarily due to illegal fishing activities in the GMR.

Key habitats

More than 80% of the near coastal subtidal and intertidal habitat is rocky reef, fringed by soft bottom sediments that host distinct species assemblages that change with the often dramatic bathymetry and oceanographic environment. In the open waters, strong currents scour the islands, forming productive fronts, eddies, and submarine channels that affect species' distribution and recruitment patterns. Few areas of similar size harbor such a rich diversity of habitat where productive coastal waters and the fringes interact with open and deep water systems, volcanic submarine hotspots, mangrove-fringed bays, fragmented coral reefs, sand flats, and thick algal beds (Table 3).

Some dark, deep-water habitats below 30 m appear as calm as protected coastal mangroves or lagoons and harbor species previously believed to be extinct. Others are dominated by localized upwelling, which encourages endemism of cold-water species and provides a constant influx of nutrients into the coastal fringe. Strong currents tearing past vertical walls produce some of the greatest biological turnover of filter feeders in any system, while attracting large pelagic visitors, such as sharks and consequently tourists. The habitats reflect the unique placement of the islands on the equator and the currents that surround them - particularly those associated with cold water upwelling and hydrothermally active hot spots. This great diversity of near-shore and off-shore habitats in a relatively confined area generates an astounding biological panorama.

Although all habitats in Galapagos are influenced by the interplay between El Niño events and human use, highly productive habitats that are of particular importance have been damaged since the El Niño of 1982/83. Macroalgae beds forming important nursery habitat for many species and coral reef communities were prevalent across the archipelago 40 years ago, whereas today they are greatly reduced (to <5% of their historical range) and restricted to localities in the far north and west of the archipelago and a few fragments elsewhere. Today the prevalent habitat across subtidal rocky reefs is urchin barrens, with biogenic sediments from deteriorated coral reefs, which change the physical and biotic environment. These areas, as well as habitats for which little information exists (such as sea mounts and soft bottom sediments), have been targeted as a priority for conservation measures. With the development of subtidal monitoring over the last seven years, the species inventory for the GMR is greatly improved and now includes those rare and newly discovered species and the habitats that they depend upon to survive (Table 4).

Macroalgae beds, abundant in the GMR 40 years ago, are perhaps the marine habitat that is most threatened. Today, the remaining 5% of the original beds are restricted to a few sites.

Table 3. Habitat types within the Galapagos Marine Reserve.

Type of habitat or community	Area covered (estimated area or percent of coastline)	Status
Rocky intertidal	>80%	Stable
Rocky subtidal reef	> 80%	Stable
Soft bottom sediments	< 20%	Stable
Vertical walls	> 50 significant walls	Stable
Coral communities	< 500 m extensions in Wolf and Darwin, elsewhere fragmented	Fragmented, low
Macroalgae beds	<15% of the coast	Predominant in the west coasts of Isabela and Fernandina Low – medium
Mangroves	Approximately 5800 ha	Stable
Sandy beaches	Approximately 460 ha	Stable
Coastal lagoons	Approximately 285 ha	Unknown
Open water pelagic	Approximately 127,000 km^2	Stable
Seamounts	Approximately 1,400 km^2	Stable
Hydrothermal vents	Baseline data not available	Unknown
Abyssal plain (> 3000 m depth)	Approximately 26,000 km^2	Stable
Galapagos shelf and platform (>100 - 3000 m)	Approximately 17,000 km^2	Stable

Source: CDF databases

Table 4. New and rediscovered marine species in the Galapagos Marine Reserve.

Year	Group	Species	Island registered
2004	Anemone	*Anthopleura mariscali*	Pinzón, Santa Cruz, South Plaza, Sin Nombre
2004	Bivalve	*Nodipecten magnificus*	Fernandina, Isabela, Genovesa
2006	Coral	*Leptoseris sp.*	Darwin
2006	Coral	*Pavona duerdeni.*	Santa Cruz
2004	Damselfish	*Nexilosus latifrons*	Fernandina, Isabela
2006	Fish	*Kathetostoma averruncus*	Santa Cruz
2005	Gorgonia	*Heterogorgia hickmani*	Floreana
2005	Gorgonia	*Pacifigorgia symbiotica*	Darwin
2004	Gorgonia	*Pacifigorgia damperi*	Darwin , Wolf
2004	Gorgonia	*Pacifigorgia rubripunctata*	Central archipelago
2004	Hermatypic coral	*Leptoseris scabra*	Wolf, Darwin
2003	Hermatypic coral	*Gardineroseris planulata*	Wolf, Darwin
2006	Hydroid	*Nemalecium lighti*	Wolf
2004	Macroalgae (kelp)	*Eisenia galapagensis*	Isabela, Fernandina
2007	Macroalgae (kelp)	*Desmeretia ligulata*	Isabela
2006	Octacoral (sea pen)	*Ptilosarcus sp.*	Wolf
2006	Octacoral (sea pen)	*Virgularia galapagensis*	Santiago
2006	Octacoral (sea pen)	*Cavernulina cf. darwini*	Santiago
2004	Pinniped	*Mirounga leonina*	Isabela
2004	Ray	*Raya veléis*	Isabela
2004	Ray	*Torpedo tremens*	Isabela
2002	Sea star	*Heliaster cumingii*	Isabela, Santa Cruz
2004	Sea star	*Pauli ahorrida*	Isabela, Santa Cruz
2004	Sea star	*Coronoaster marchenus*	Fernandina
2002	Sea star	*Acanthaster planki*	Darwin
2005	Shark	*Bythaelurus sp.*	Isabela
2002	Slipper lobster	*Parribacus scarlatinus.*	Wolf, Darwin, Pinzón, Isabela, Genovesa
2004	Solitary coral	*Tubastraea taguensis*	Isabela
2004	Solitary coral	*Tubastraea faulkneri*	Isabela
2004	Solitary coral	*Tubastraea floreana*	Floreana
2000	Solitary coral	*Rhizopsammia wellingtoni*	Santa Cruz
2003	Solitary coral	*Astrangia brownii*	Floreana, Isabela

Source: CDF databases

Annex 1. Threatened marine species on the Red List or submitted in 2006 for evaluation, by category.

Species	Scientific Name	GLPS Expert Advice Status	Year of evaluation	Principal threat
Galapagos petrel	*Pterodroma phaeopygia*	CR	1994	Fisheries and predation by introduced species
Hawksbill turtle	*Eretmochelys imbricata*	CR	1996	Fisheries bycatch
Leatherback turtle	*Dermochelys coriacea*	CR	1986	Fisheries bycatch
Black-spotted damselfish	*Azurina eupalama*	CR*	2007	El Niño
Twenty-four-rayed sun star	*Heliaster solaris*	CR*	2007	El Niño
Elongate heart urchin	*Clypeaster elongatus*	CR*	2007	Unknown process
Wellington's coral	*Rhizopsammia Wellington*	CR*	2007	El Niño
Floreana coral	*Tubastraea floreana*	CR*	2007	El Niño
Tagus cup coral	*Tubastraea taguensis*	CR*	2007	El Niño
Galapagos stringweed	*Bifurcaria galapagensis*	CR*	2007	Overgrazing
Tropical acidweed	*Desmarestia tropica*	CR*	2007	El Niño, climate change, overgrazing
Brown alga	*Glossophora galapagensis*	CR*	2007	El Niño, climate change, overgrazing
Brown alga	*Spatoglossum schmittii*	CR*	2007	El Niño, climate change, overgrazing
Red alga	*Gracilaria skottsbergii*	CR*	2007	El Niño, climate change, overgrazing
Red alga	*Galaxaura barbata*	CR*	2007	El Niño, climate change, overgrazing
Red alga	*Phycodrina elegans*	CR*	2007	El Niño, climate change, overgrazing
Blue whale	*Balaenoptera musculus*	EN	1986	International fisheries
Galapagos penguin	*Spheniscus mendiculus*	EN	2000	El Niño and predation by introduced species
Flightless cormorant	*Phalacrocorax harrisi*	EN	2000	El Niño and predation by introduced species
Green turtle	*Chelonia mydas*	EN	1982	Fisheries and predation by introduced species
Olive ridley turtle	*Lepidochelys olivacea*	EN	1982	Fisheries bycatch
Magnificent scallop	*Nodipecten magnificus*	EN	1996	Fisheries and El Niño, climate change
String sargassum	*Sargassum setifolium*	EN*	2007	Overgrazing
Brown alga	*Dictyota major*	EN*	2007	Overgrazing
Galapagos kelp	*Eisenia galapagensis*	EN*	2007	El Niño, climate change, overgrazing
Galapagos sea lion	*Zalophus wollebaeki*	VU	1996	El Niño, overfishing of food source, disease,
Galapagos fur seal	*Arctocephalus galapagoensis*	VU	1965	El Niño, overfishing of food source, disease
Sperm whale	*Physeter macrocephalus*	VU	1996	Fisheries
Humpback whale	*Megaptera novaeangliae*	VU	1986	Fisheries
Lava gull	*Larus fuliginosus*	VU	1994	Unknown
Waved albatross	*Phoebastria irrorata*	VU	2000	Fisheries
Marine iguana	*Amblyrhynchus cristatus*	VU	1996	El Niño and predation by introduced species
Whale shark	*Rhincodon typus*	VU	1990	Fisheries
Oceanic whitetip shark	*Carcharhinus longimanus*	VU	2000	Fisheries
Bacalao or sailfin grouper	*Mycteroperca olfax*	VU	1996	Fisheries
Bigeye tuna	*Thunnus obesus*	VU	1996	Fisheries
Seahorse	*Hippocampus ingens Pacific*	VU	1996	Fisheries
Mystery goby	*Chriolepis tagusi*	VU*	2007	Unknown process
Cartago crab	*Hexapanopeus cartagoensis*	VU*	2007	Unknown process
Isabela coral	*Polycyathus isabelae*	VU*	2007	El Niño
Galapagos rocksnail	*Neorapana grandis*	VU*	1996	El Niño
Red alga	*Galaxaura intermedia*	VU*	2007	El Niño, climate change, overgrazing
Red alga	*Laurencia oppositoclada*	VU*	2007	Overgrazing
Red alga	*Myriogramme kylinii*	VU*	2007	Overgrazing
Red alga	*Pseudolaingia hancockii*	VU*	2007	Overgrazing
Red alga	*Acrosorium papenfussii*	VU*	2007	El Niño, climate change, overgrazing
Red alga	*Schizymenia ecuadoreana*	VU*	2007	El Niño, climate change, overgrazing

Symbols Legend: **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable.

Source: CDF databases

Note: * Species submitted for the IUCN Red List inclusion in 2007 according to scientific criteria from Galapagos experts.

Annex 2. Species on the IUCN Red Listed evaluated as being Data Deficient.

Marine Group	Year added to the Red List	Year Evaluated	Common Name	Scientific Name
Cetaceans	1994	1994	Pygmy killer whale	*Feresa attenuata*
Cetaceans	1994	1994	Fraser's dolphin	*Lagenodelphis hosei*
Cetaceans	1994	1994	Blainville's beaked whale	*Mesoplodon densirostris*
Cetaceans	1994	1994	Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*
Cetaceans	1994	1994	Rough toothed dolphin	*Steno bredanensis*
Cetaceans	1994	1994	Cuvier's beaked whale	*Ziphius cavirostris*
Fish	1994	1996	Albacore tuna	*Thunnus alalunga*
Fish	1994	1996	Swordfish	*Xiphias gladius*
Rays	2001	2005	Longtail stingray	*Dasyatis longa*
Sharks	2001	2002	Thresher shark	*Alopias vulpinus*
Sharks	2001	2004	Longnose catshark	*Apristurus kampae*
Sharks	1994	2000	Great hammerhead	*Sphyrna mokarran*

Source: CDF databases

Coastal fishery resources in the Marine Reserve are declining

Alex Hearn[a] & Juan Carlos Murillo[b]

[a]Charles Darwin Foundation, [b]Galapagos National Park

Coastal fisheries in Galapagos

Fishing in Galapagos has focused historically on coastal species. Over the last decade, the most lucrative resources have been the spiny lobster (*Panulirus penicillatus* and *P. gracilis*) and the sea cucumber (*Isostichopus fuscus*), although the fishery for the endemic grouper "bacalao" has also been of great importance to many fishers, especially those operating out of San Cristóbal. Although sea cucumbers were harvested in an unregulated fashion since the early 1990s, beginning with the arrival of Asian merchants and then the official opening of the sea cucumber fishery in 1999, the fishery has caused accelerated growth in the fishing sector.

From 2002 to 2006, fishing activities were managed by a Five-Year Fishing Calendar (FYC), approved by the Inter-institutional Management Authority (IMA). It includes the timing of each fishing season as well as specific biological indicators for each resource, with reference points and emergency measures. In general, the indicators can be summarized as follows:

- Catch (the amount of resource extracted, in weight or number of individuals, per fishing season)
- CPUE or Catch per Unit Effort (the amount of resource extracted by one fisher over a given period of time, usually one hour or one day)
- Density (the number of individuals of a given resource in a specific area)
- Mean size of individuals caught

The values for these indicators are obtained by means of participatory monitoring programs.

> Despite the efforts of authorities to generate a sustainable framework for fisheries, the reality is very different - both spiny lobster and sea cucumber resources are showing significant declines in their populations.

Fisheries monitoring

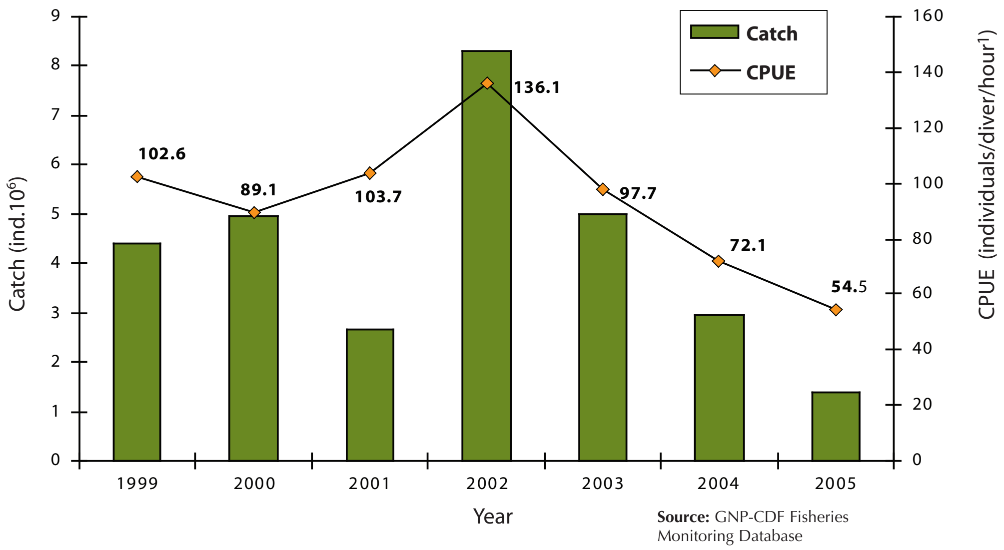
Fisheries monitoring consists of a series of steps to register information regarding fishing activity. This process includes a program of onboard observers who take measurements *in situ*; monitoring at landing sites by staff of the Galapagos National Park Service (GNPS) who certify the catch, and finally, product inspection by GNPS staff prior to leaving the islands for the continent, at which time the merchant receives a transport permit, thus completing the chain of custody for the resource.

Population surveys are mainly carried out for the sea cucumber resource. To obtain information on size structure and densities of populations before and after each fishing season, participatory sampling, using circular transects of 100 m^2, is carried out at different sites around the archipelago.

Does the sea cucumber fishery have a future?

Since the official opening of the sea cucumber fishery in 1999, the maximum number of landings was registered in the 2002 season, when no quota was imposed. On the other hand, only around 3 million individuals were caught the year before, even though densities were higher. This was mainly due to the imposition of a catch quota per individual fisher by the Inter-institutional Management Authority (IMA). Of the over 8 million individuals caught in 2002, almost half were juveniles (smaller than the minimum legal landing size of 20 cm). After 2002 there was a steady decline in catch. By the 2004 and 2005 seasons, overall quotas were not reached (Fig. 1). At the same time, CPUE showed a decline, from 136 individuals caught per diver-hour in 2002, to 54 individuals per diver-hour in 2005. This resulted in an alarming decline in the cost-effectiveness of the fishery. For this reason, the authorities closed the fishery in 2006.

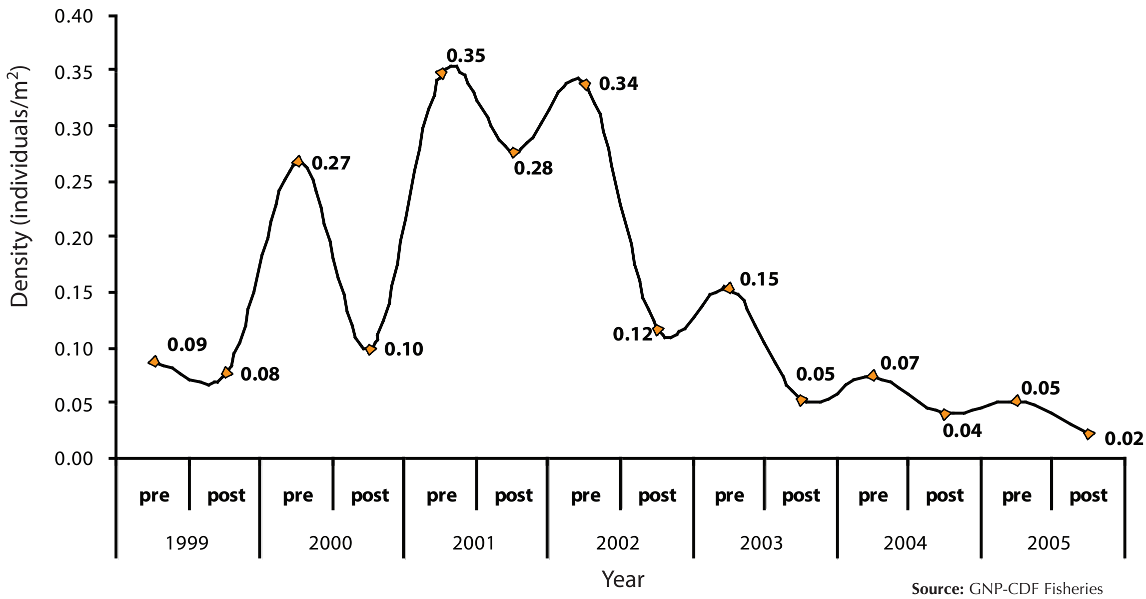
Figure 1. Catch and CPUE of sea cucumber during the 1999 to 2005 fishing seasons in the Galapagos Marine Reserve



Source: GNP-CDF Fisheries Monitoring Database

Sea cucumber densities registered during population surveys have declined notably since the 2002 fishing season (Fig. 2). Since 2002, clear signs of overfishing have been detected during the post-fishery survey and populations have failed to recover during the no-take season. Sea cucumber density has followed a similar pattern to that of catch and CPUE. After 2004 the mean population density has been so low that no real changes in population have been detected.

Figure 2. Sea cucumber (*Isostichopus fuscus*) density before and after each fishing season, 1999 to 2005



Source: GNP-CDF Fisheries Monitoring Database

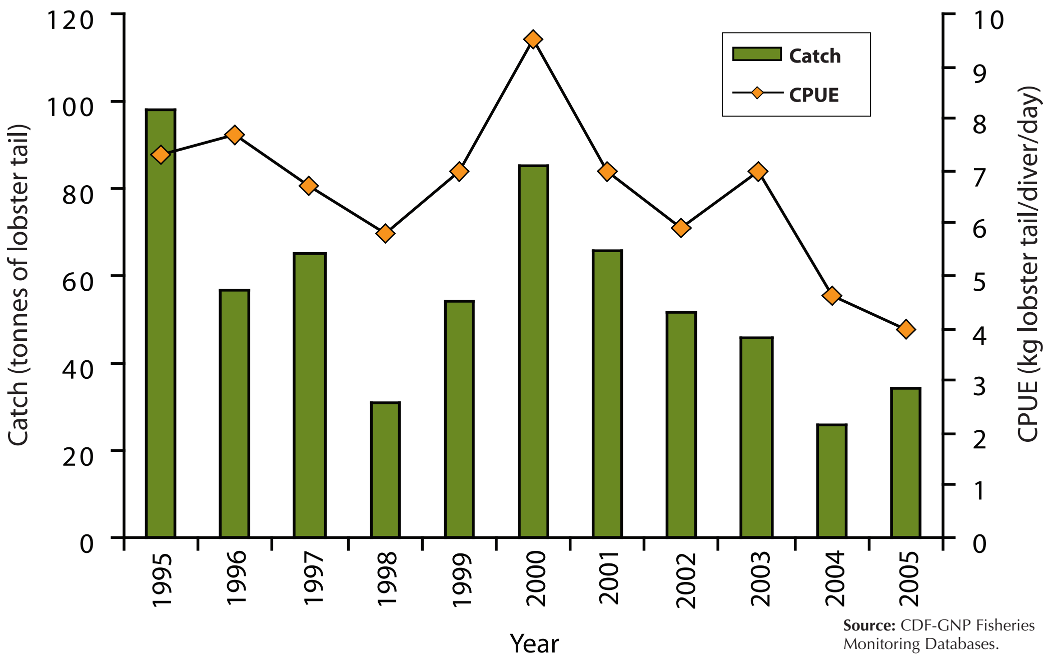
Factors such as the excessive capture of under-sized lobsters and sea cucumbers, of egg-bearing lobsters, and fishing during no-take seasons, have impeded the recovery of these populations.

The lobster fishery is also in decline

Spiny lobster catches have declined steadily since 2000 (Fig. 3). The CPUE showed the same trend in 2004 and 2005, dropping below the threshold level of 5.8 kg of lobster tail per diver per day, registered during the 1998 El Niño event and subsequently adopted as a limit reference point. In 2004, the sea cucumber and lobster fisheries overlapped for six weeks, resulting in a lower lobster catch than expected because fishers were focused on the more lucrative sea cucumber.

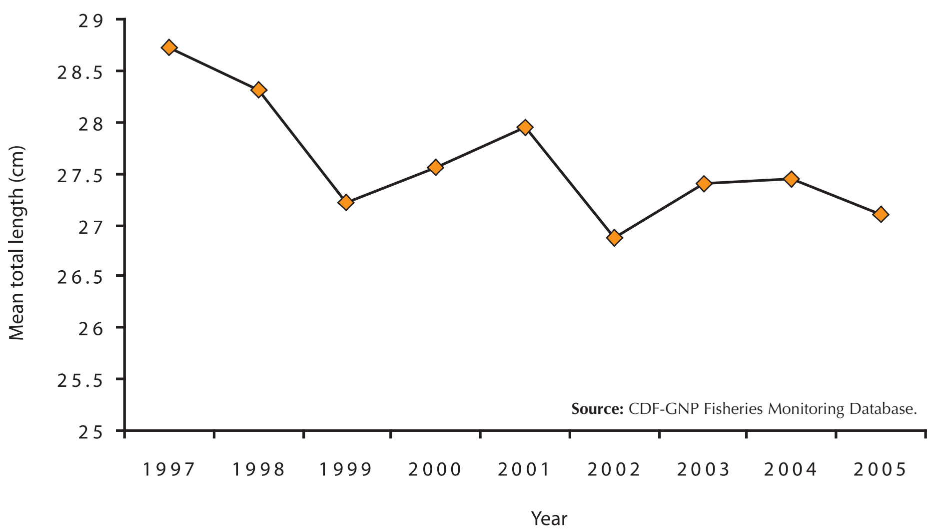
The mean size of red spiny lobsters decreased steadily from 1997 to 2005, from 28.7 cm to 27.1 cm, a reduction of 1.6 cm in only 8 years (Fig. 4).

Figure 3. Capture and CPUE for spiny lobsters – the red lobster (*Panulirus penicillatus*) and the green lobster (*P. gracilis*) – during fishing seasons, 1995 to 2005



Source: CDF-GNP Fisheries Monitoring Databases.

Figure 4. Mean total length of red spiny lobsters (*Panulirus penicillatus*) captured during the fishing season, 1997 to 2005



Source: CDF-GNP Fisheries Monitoring Database.

Why have the fisheries become uneconomical?

The indicators presented for both fishery resources show a significant decline in the populations despite the efforts of authorities to manage them within a sustainable framework. Factors, such as the excessive capture of undersized lobsters and sea cucumbers, of egg-bearing lobsters, and fishing during no-take seasons, have impeded the recovery of these populations, which are also affected by climatic events such as El Niño.

For example, lobster catches and CPUE increased in 1999 and 2000 (post El Niño). During the El Niño event of 1998, over 50% of females in the catch were egg-bearing, suggesting that it may have been beneficial to the fishery, as it may provide optimal oceanographic conditions for reproductive activity, larval survival, and post larval recruitment. This requires further study in future El Niño events in order to fully understand its effects on lobster recruitment in Galapagos.

To attain a truly sustainable fishery, using the precautionary principle and adaptive management, it is paramount to have mechanisms that identify "target reference points," which provide an important foundation for sound management decisions and subsequent action.

Despite the development of the 2002-2006 Fishing Calendar during a period when little information was available on the species in question, management measures were considered to ensure response to "critical reference points"– values for biological and fishery indicators which are undesirable. Negative trends for these indicators were also taken into account. In the case of the sea cucumber, density and CPUE indicators were incorporated, and in the case of lobster, CPUE. Additionally, emergency measures such as closures of areas, reduction of fishing effort, and quotas were established in case critical reference points were reached.

Although data collection efforts have been carried out in recent years through onboard observer programs, population surveys, and other studies, decisions have been based primarily on sociopolitical pressures rather than on technical information, making it impossible to slow down resource deterioration. As the resources have become less profitable, the economic situation of the fishing sector has worsened, with the fishers becoming even less inclined to adopt corrective measures. A vicious circle has been generated, resulting in the collapse of the sea cucumber fishery and the near-collapse of the lobster fishery.

For both resources, a recovery plan is urgently needed to return to an economically viable fishery. However, any corrective measure requires harvesting less, either by reducing effort, imposing quotas and size limits, or closing areas. In a participatory system such as the GMR, it will not be possible to carry out the necessary measures without the participation of the fishing sector and its understanding of the realities associated with these overexploited resources.

Any corrective measure requires harvesting less, either by reducing effort, imposing quotas and size limits, or closing areas.

Subtidal ecological monitoring of the coastal management subzones: 2004 to 2006

Stuart Banks

Charles Darwin Foundation

In April 2000, the location, limits, and characteristics of the three coastal management subzones in Zone 2 (Limited Use) of the Galapagos Marine Reserve (GMR) were approved, based on a proposal created by stakeholders through consensus agreement. The subzones are: 2.1 – Comparison and Protection; 2.2 – Tourism (non-extractive) and Conservation; 2.3 – Fisheries (extractive and non-extractive uses) and Conservation; and 2.4 – Special Management Use areas, established in multiple use zones, such as populated ports, military outposts, and other.

Zoning, and in particular creating subzones, is an adaptive management tool to help decision makers and planners respond to evolving challenges in the GMR. Originally designed to adapt to the changing natural state and human use of the coastal waters, they provide a framework for management of the principal biogeographic regions of the GMR. The use of subzones helps to protect important tourism areas and sites that are critical to the functioning of marine ecosystems and the conservation of vulnerable species. They also contribute to the sustainability of Galapagos fisheries by providing potential areas from which stocks can recover, at the same time assuring that the artisanal fishers have access to the majority of richest fishing sites.

The preliminary results of the subtidal ecological monitoring of the coastal management subzones, carried out from 2004 to 2006, will be used in the development of the next GMR management plan. The two-year data set includes information compiled from 66 sites and forms part of the CDF's planned evaluation of GMR coastal resources under the different management subzones in 2007.

Relative species abundance in protected and artisanal fishing areas throughout the GMR were compared at 66 sites selected by the Participatory Management Board (Figs. 1-3). Although tentative, the patterns are encouraging - especially given the problems of effective patrolling and stakeholder respect for these zones.

As an ecosystem-level analysis, the study emphasizes the role and interactions of species as functional components within the marine subtidal ecosystem.

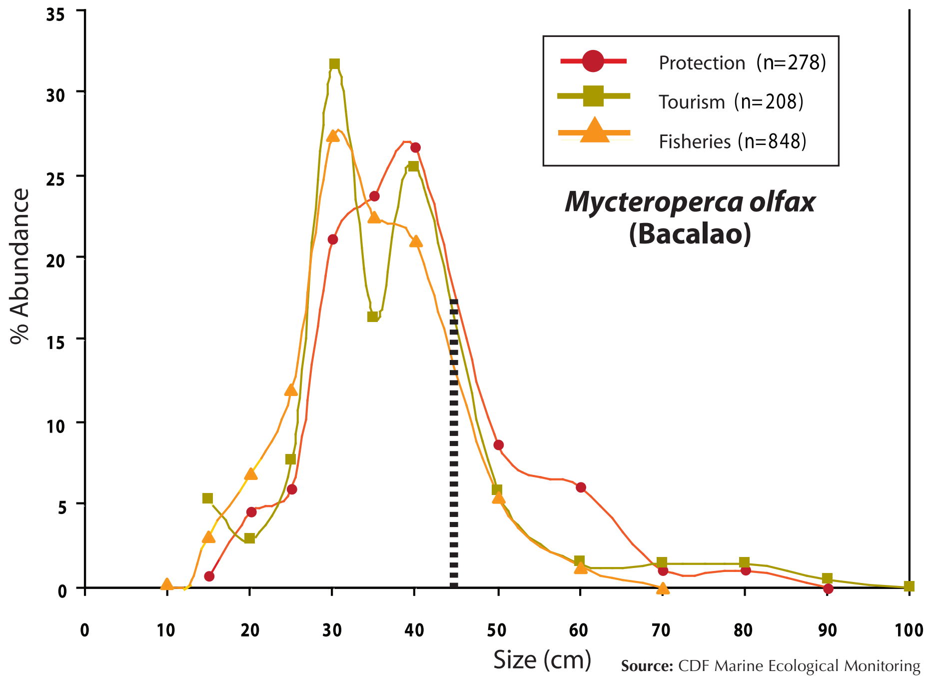
Despite a general lack of awareness and compliance with no-take areas in the coastal zone, the data suggest partial benefits associated with the few areas that have had some degree of patrolling (mostly sites near Park outposts or areas frequented by tourism).

Improved understanding of the associated benefits, respect, and strengthened patrolling of the different zones will permit an increase in the positive effects of the no-take zones within the GMR.

Case: the endemic bacalao

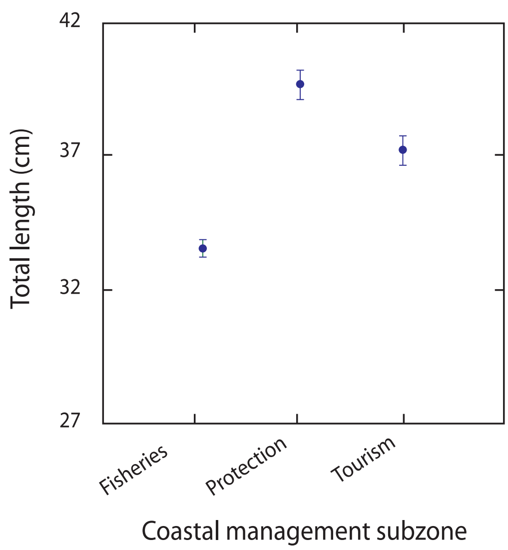
Monitoring shows shifts in size distribution for the endemic grouper bacalao (*Mycteroperca olfax*) between populations within extractive zones and those in zones that have had some degree of protection. This species is hermaphroditic, first reaching sexual maturity as a female at 45.5 cm, then converting to a male upon reaching 83.1 cm. A greater proportion of female adults over the median reproductive age (45.5 cm) are found within no-take zones and significantly larger individuals are found within areas demarcated as exclusively protected areas (17% over 50 cm in protected areas compared to 11% in tourism areas and 7% in fisheries zones). Notably, the few large males that play a crucial role in fertilization (over 80 cm and estimated to be ~12 years old) form less than 2% of the population and were only found in no-take zones. Although these zones have only been recently physically demarcated, these data suggest that the overall effect of these zones is potentially positive and the trends are likely to improve if the zones are respected. Already red listed as vulnerable by IUCN, the existing zoning scheme is one of the few protective measures that exists for this over-fished species.

Figure 1a. Relative abundance of bacalao (endemic grouper) by size and coastal management subzone. The dotted line indicates estimated size at reproductive age



Source: CDF Marine Ecological Monitoring Database

Figure 1b. Mean total length of bacaloa (endemic grouper) by coastal management subzone



Source: CDF Marine Ecological Monitoring Database

Note:

(ANOVA df=2/1331, F=26.2, P=0).

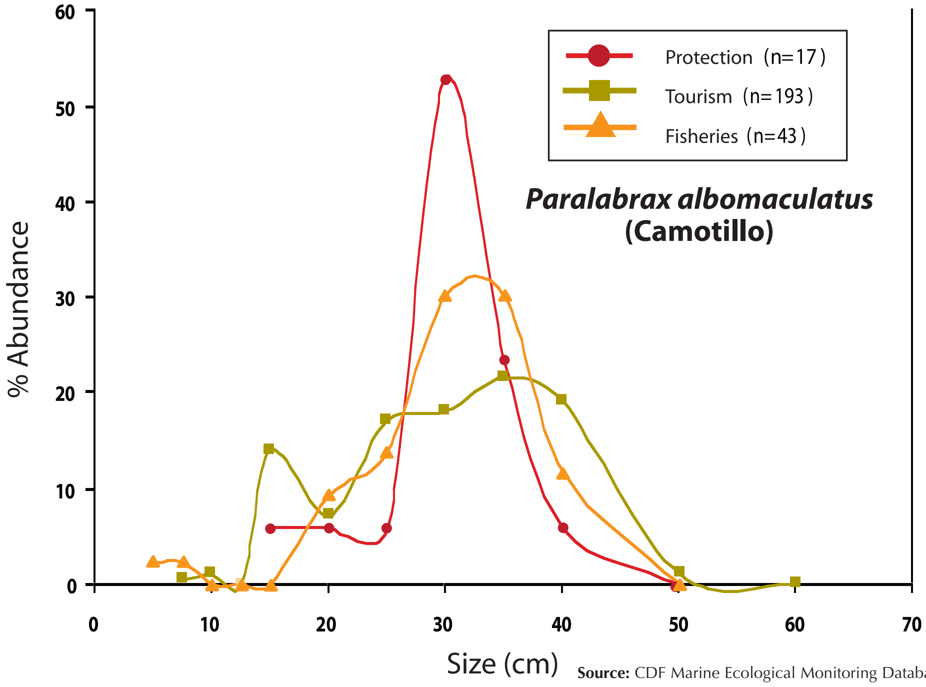
Bacalao, commonly fished in the coastal zone, is less abundant in current harvests than in previous years (Fig. 1a). The proportion of individuals of reproductive age is significantly higher in protected areas compared to areas designated for fishing and tourism. Significant differences in the mean total length between zones are clearly evident in Figure 1b.

Case: the endemic camotillo

Camotillo (*Paralabrax albomaculatus*), an endemic sea bass, is a deep water fish species and an important endemic predator that prefers colder waters. It was also prevalent in the tourism areas sampled, with more individuals of reproductive age within those zones than in fishing or protected zones (Fig. 2). Again, these tend to be sites, such as Tagus Cove in western Isabela, that are close to GNP patrol outposts and that provide a suitably cold water habitat. Two factors contribute to this: 1) these sites were probably chosen for tourism because of the abundance of species, and 2) frequent tourism traffic results in a reduced number of fishing infractions. For species such as camotillo, these sites may now be important refuge, nursery, and reproduction areas.

> The proportion of larger individuals of bacalao, camotillo, and the Galapagos grunt is significantly higher in the protected zones than in the Extractive Use zones.

Figure 2. Relative abundance of camotillo (endemic sea bass) by size and management subzone

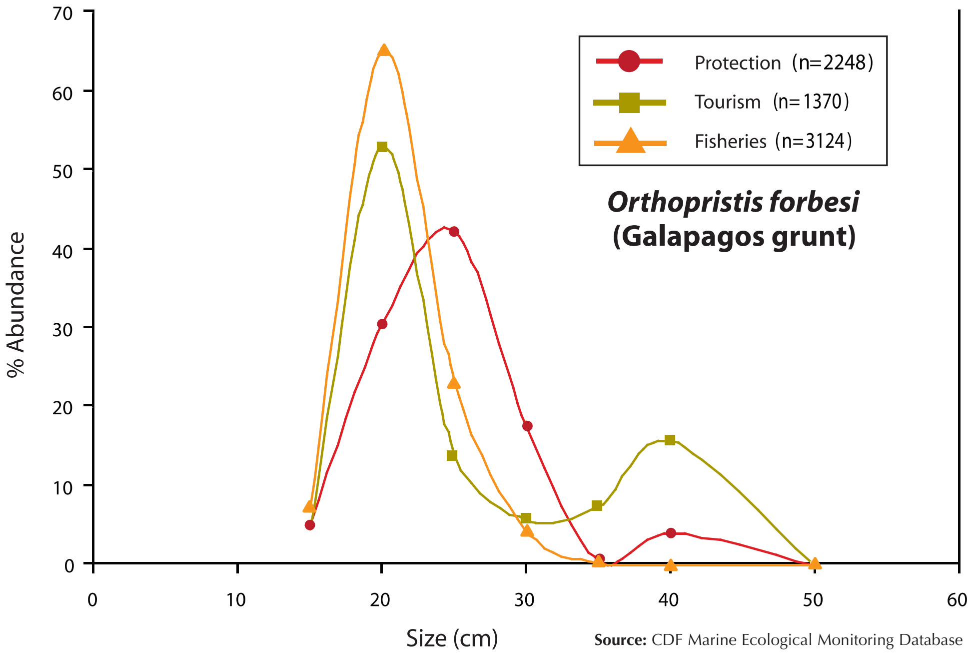


Source: CDF Marine Ecological Monitoring Database

Case: the Galapagos grunt

The Galapagos grunt, *Orthoprostis forbesi*, is an omnivore that is found across the archipelago. As in the previous examples, there are two peaks in protected and non-extractive tourism areas with respect to size distribution, with intermediate-sized individuals found in greater numbers in protected zones (Fig. 3). While not actively fished, the greater abundance of this species in protected areas suggests possible indirect benefits for non-target species due to the management of these sites.

Figure 3. Relative abundance of the Galapagos grunt by size and management subzone



Source: CDF Marine Ecological Monitoring Database

Case: Composition of the sea floor

The composition of the sea floor (benthic environment) over all 66 sample sites is shown in Figure 4. In terms of functional group composition or role within the ecosystem, there is not a major difference between management subzones. The relative proportion of functional groups is similar even though species composition and biodiversity within each area may differ. Anecdotal observations from before the strong 1982-83 El Niño suggest that there has been a unilateral shift in benthic habitat across the Reserve yet to be validated by recent data.

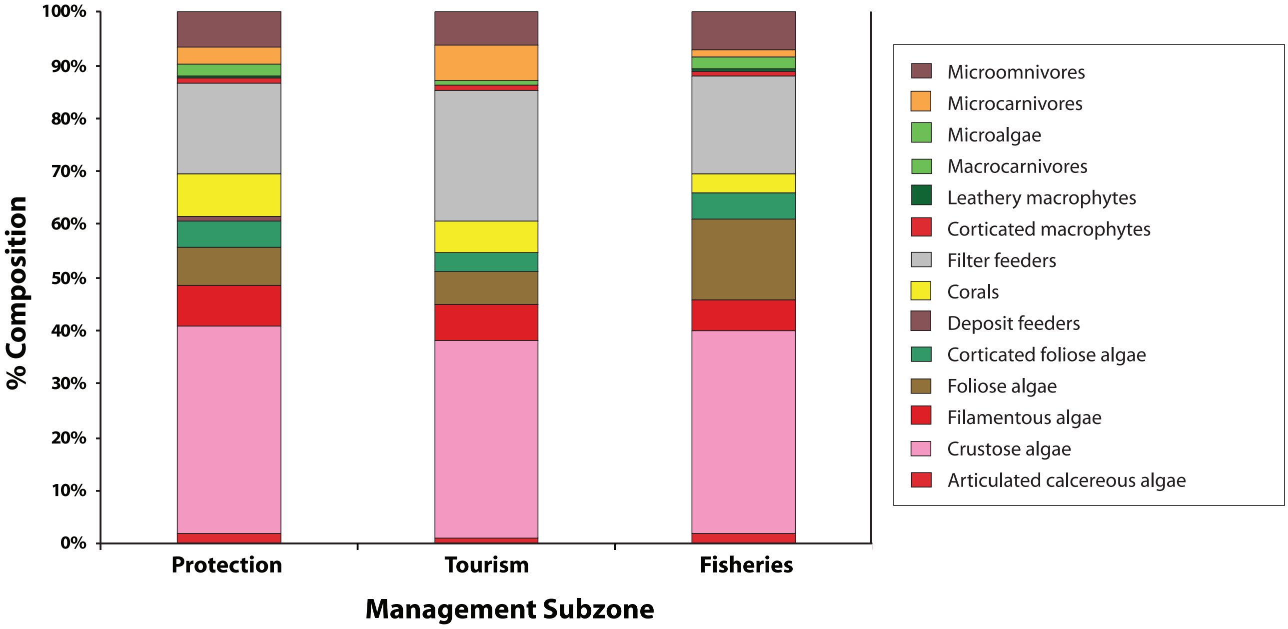
Across the Reserve there is a predominance of encrusting, calcareous, and filamentous algae, indicative of urchin barrens - subtidal areas where the population growth of sea urchins has gone unchecked resulting in overgrazing. In contrast, the macroalgal and coral components, both important habitat-forming species, are very small. The CDF will examine the historical data to determine how the composition has changed over the last 40 years and expects to see a changing equilibrium between habitat-forming species and natural reef predators (sharks, lobsters, and reef fish).

Intensive Extractive Use zones demonstrate the absence of natural predators, such as lobsters, indicating a trophic disequilibrium in the ecosystem now dominated by urchins (particularly the pencil urchin *Eucidaris galapagensis*).

The absence of these predators is an indicator of trophic disequilibrium in the ecosystem causing unchecked urchin (herbivore) population explosions, overgrazing, and compromised recovery of corals and macroalgae.

Another interesting feature is the greater abundance and diversity of filter feeders and microcarnivores at tourism sites, which again reflects that these sites are usually chosen for their aesthetic value and for being in high-current environments that favor pelagic species valued in dive tourism. The coral population is low and fragmented and its recovery to pre 1982 conditions is still far in the future. However, coral abundance is still greatest in protected areas in comparison with fisheries areas and tourism zones.

Figure 4. The composition of the sea floor (benthic environment) over all 66 sample sites



Conclusions and recommendations

Although a comprehensive analysis of the information collected in 2004 to 2006 is not yet completed, some general observations can be made. Key among them is that certain sites are of great importance to associated threatened species particularly sensitive to natural and human disturbance (Table 1.).

In the areas that have had a greater level of protection for more than six years (such as at the GNP outpost in western Isabela) or sites with high levels of tourism (such as Sullivan Bay), there is a greater abundance and diversity of species, including top-level predators such as the grouper bacalao and the yellow-tailed snapper. On the other hand, there is evidence of dominance by urchins and reduced benthic diversity in areas with similar habitats and comparable environmental conditions, but which have been fished intensively. These trends will be analyzed in greater detail through a study that compares levels of extraction with the level of adherence to the established zoning.

It appears that seasonality affects the composition of marine communities—especially during sustained periods of climatic stress such as El Niño. Small patches of water that depend upon the upwelling of nutrient-rich cold waters to provide refuge for some highly threatened species exist, primarily to the west of Isabela and Fernandina (Tagus Cove, Cape Douglas, Cape Hammond, Black Turtle Beach, and Iguana Cove, etc.). Management recommendations for timely intervention in these areas during El Niño events should be incorporated into contingency plans.

The trend toward greater biodiversity and abundance of marine life at tourist dive sites reflects not only the effects of no-take zones, but also the fact that these sites were originally selected for their high value to divers. An observed increase in the use of sites such as Darwin, Española, and Genovesa may affect the behavior of animals as well as the security and enjoyment of the divers in the water. Further study of resource use in these zones (including a review of the threat from invasive marine species upon hulls) is required.

Cape Douglas (Fernandina), the Marielas (Elizabeth Bay), and Cape Iguana (southern Isabela) should be included as fixed monitoring sites in the future given that they show high levels of endemism and represent the last habitats for the macroalgal and endemic kelp beds that were common in the GMR prior to 1981.

Table 1. Important sites for associated threatened species that are particularly sensitive to natural and human disturbance[1].

Site / Island	Species of conservation importance that are sensitive to disturbance	No. Threatened Taxa
West coast , Fernandina	Habitat for the Endangered kelp *Eisenia galapagensis*	6
Cousins Islet, Santiago	A site with two Critically Endangered corals (*Tubastraea floreana* and *Rhizopsammia wellingtoni*) that are both known from only one other site	7
Iguana Cove, Isabela	The only known site for the Vulnerable alga *Myriogramme kylinii*, other threatened large *Eisenia* kelps	8
Punta Moreno, Isabela	The only known site for the Vulnerable alga *Laurencia oppositocladia*	7
Punta Essex, Isabela, and León Dormido	The only known sites for the Vulnerable gastropod *Neorapana grandis*	6
Wreck Bay, San Cristóbal	The only known site for the Vulnerable alga *Pseudolaingia hancocki*	4
Gordon Rocks, Santa Cruz	One of two known sites for the Critically Endangered coral *Rhizopsammia wellingtoni*	7
Gardner-by-Floreana, Floreana	One of two known sites for the Critically Endangered coral *Tubastraea floreana*	4

Source: Edgar *et al* in prep[1].

Although seven years have passed since the development of the last Management Plan for the GMR, sustainability in the marine environment of Galapagos has not yet been achieved. However, the most recent results of coastal zoning, described in this report, indicate that change is possible, although it can be a long and slow process. The increasing use of the coastal zones for fisheries leading to greatly reduced populations of key species and the increase in tourism impacts in the coastal communities have together created an urgent need for the development of new management practices that are supported by all stakeholders and that will catalyze positive changes in the short- to mid-term.

Increase in the number of introduced plant species in Galapagos

Alan Tye[a], Rachel Atkinson[a] & Víctor Carrión[b]

[a]Charles Darwin Foundation , [b]Galapagos National Park

Mauchamp[1] charted the rise in the number of introduced vascular plant species (flowering plants and ferns) in the Galapagos Islands up to 1997. Since that time the number of introduced plants has continued to rise[2]. However, a more comprehensive analysis[3] indicates that the rise in number of identified introduced plant species since the 1980s is not only due to recent introductions but also, in large part, due to an increase in interest in invasive plants and their impact on natural ecosystems, and thus the recent identification of species that were introduced in the past. The present report summarizes the previous data and brings the total number of introduced plant species known in Galapagos up to date. It also briefly examines the distribution of invasive plants on different islands.

Data from Tye[3] and the more recent records in the Database of the Galapagos Flora of the Charles Darwin Foundation (CDF) are presented in Table 1 and Figure 1. The recent records are largely a result of exhaustive surveys of the towns and agricultural areas of the four inhabited islands, which attempted to record all introduced plants on every parcel of land.

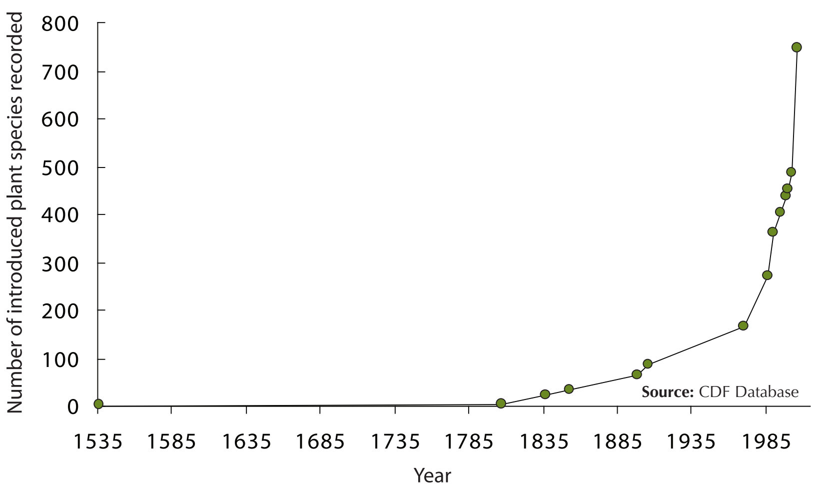
Table 1. Reports of introduced plant species in Galapagos.

Year	Cumulative number of introduced species[1]	Reference
1535	0	
1807	2	Porter 1822[4]
1837	23	Hooker 1847[5]
1853	35	Andersson 1858[6]
1899	65	Robinson 1902[7]
1906	85	Stewart 1911[8]
1970	166	Wiggins & Porter 1971[9]
1986	271	Lawesson *et al*. 1987[10]
1990	364	Mauchamp 1997[1]
1995	404	Mauchamp 1997[1]
1999	437	CDF database: records to end of 1999
2000	453	CDF database: records to end of 2000
2003	486	CDF database: records to end of 2003
2006	748	CDF database: records to end of 2006

Note

[1]Excludes doubtfully native species[3]. The figures in this column sometimes differ from those quoted by the author cited (and from those cited in Tye[2]), owing to reclassification or re-identification of some species, and to the addition of species reported by prior authors, some of which were overlooked by later authors.

Figure 1. The cumulative number of introduced vascular plant species registered in Galapagos



The apparent rate of increase is obviously affected by increased scientific interest in recent years in the introduction process, as well as increased sampling effort. Although the earliest botanists included cultivated species[4,5,8], Wiggins & Porter[9] did not. They only included naturalized species (introduced species that have become successfully established in the wild). Thus, the jump in numbers presented by Lawesson *et al.*[10] was partly due to the re-inclusion of cultivated species. All major studies since Lawesson *et al.*[10] have included both cultivated and naturalized species.

The increases reported since 1987 were primarily due to surveys that were carried out specifically to record introduced plants. The large increase in 2001[2] was due to initial inaccurate estimates of an exhaustive survey of the agricultural zone of Santa Cruz. The figures are corrected in Table 1 and Fig. 1. The recent large increase up to 2006 resulted from the inclusion of the more complete analysis of this survey and from surveys of Puerto Ayora and of the towns and agricultural areas on Floreana and Isabela (Fig. 2). The field survey on San Cristóbal is complete but the results have not yet been fully analysed; new species from this survey have not been included in Table 1 and Fig. 1. After including the results from San Cristóbal, we expect the total list of introduced vascular plants in Galapagos to be between 800 and 900 species, nearly twice that of the native flora (500 species).

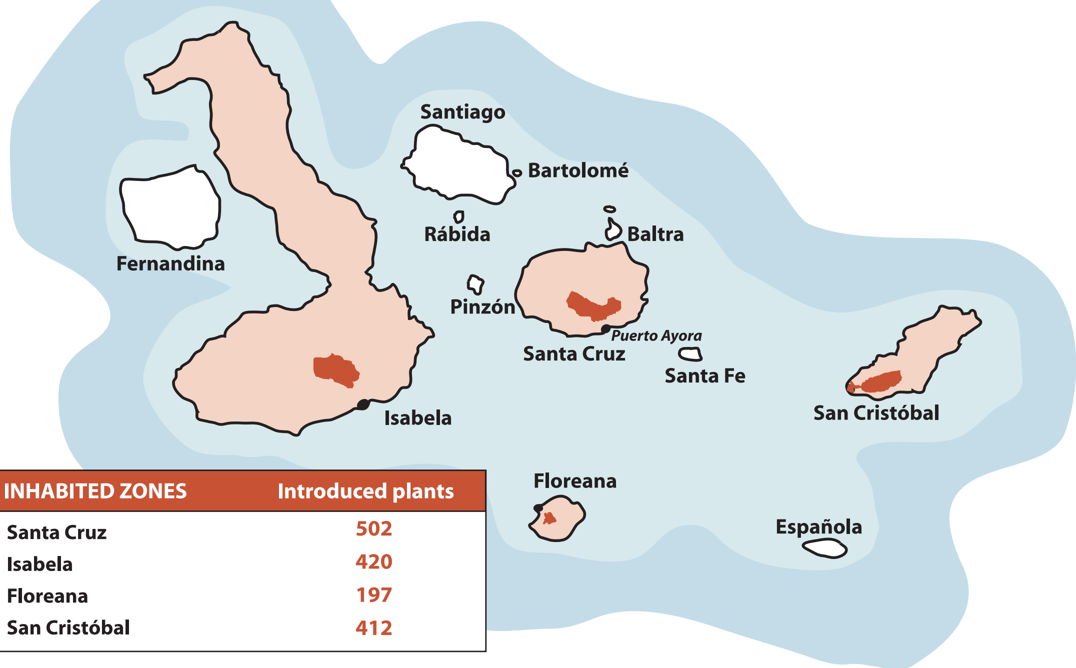
> The list of introduced vascular plant species recorded in Galapagos has reached 748, many more than the 500 species of native flora.

The true rate of introduction-naturalization in Galapagos has been linear, although the graph may show exponential growth[3]. And despite the implementation of quarantine controls in 1998, the rate is not yet declining. The number of cultivated species appears to have increased exponentially in recent years, but this is not necessarily due to an increase in introduction rate. Property owners interviewed as part of the study indicated that many of the recently registered species were brought to the islands many years ago but only recently recorded by botanists.

The most aggressive invasive plant species are concentrated in the inhabited islands (Table 2) and have not been introduced to the majority of the uninhabited islands. However, Santiago is an uninhabited island with several highly-invasive plant species. Following goat and pig eradication on Santiago, several invasive species, including Hill Blackberry (*Rubus niveus*), are spreading and there is an intensive effort by the Galapagos National Park and the CDF to eradicate them.

A few of the most invasive species are still only found in small numbers in some of the inhabited islands. Two examples are the Curse of India (*Lantana camara*) in Isabela and Hemp Agave (*Furcraea hexapetala*) in Floreana. Eradication programs have recently been initiated to eliminate these species before they become a serious problem as they have on other islands in the archipelago.

Figure 2. Map of the recent introduced plant surveys of the inhabited zones of Galapagos*



INHABITED ZONES	Introduced plants
Santa Cruz	502
Isabela	420
Floreana	197
San Cristóbal	412

Note:
*Numbers in this figure are provisional.

Source: CDF Database

Table 2. Distribution of some of the most aggressive invasive plants in Galapagos.

SPECIES	SCIENTIFIC NAME	Floreana	Isabela	San Cristóbal	Santa Cruz	Santiago	Other islands
Guava	*Psidium guajava*	P	P	P	P		
Hill Blackberry	*Rubus niveus*	C	C	P	P	EP	
Quinine	*Cinchona pubescens*		P				
Hemp Agave	*Furcraea hexapetala*	C	C	P	P		
Avocado	*Persea americana*	P	P	P	P	EP	
Cuban Cedar	*Cedrela odorata*	P	P	P	P		
Angels' Trumpets	*Datura y Brugmansia spp.*	P	P	P	P		
Castor Oil	*Ricinus communis*	P	P	P	P		
Mother of Thousands	*Bryophyllum pinnatum*	P	P	P	P		
Laurel	*Cordia alliodora*	P	P	P	P		
Leucaena	*Leucaena leucocephala*	C	P	P	P		
Lime	*Citrus limon*	P	P	P	EP		
Passionfruit	*Passiflora edulis*	P	P	P	P		
Blackberry	*Rubus glaucus*	P	EP				
Blackberry	*Rubus adenotrichos*	C	E				
Male sauco	*Citharexylum gentryi*		EP				
Pará Grass	*Urochloa spp.*	P	P	P	P		
Elephant Grass	*Pennisetum purpureum*	P	P	P	P		
Poleo	*Hyptis pectinata*	P	P	P	P	P	
Rose-apple	*Syzygium jambos*	C	P	P	P		
Sauco	*Cestrum auriculatum*	P	P	P			
Curse of India	*Lantana camara*	P	EP	P	P		
Dutchman's Pipe	*Aristolochia odoratissima*				EP		

Source: CDF & GNP Database

Note

Key: **An empty cell** = not present; **P** = present; **C** = control in progress; **EP** = eradication in progress; **E** = eradicated.

Other species, such as the Guava (*Psidium guayava*) and the Quinine plant (*Cinchona pubescens*) in Santa Cruz are so widespread that their complete eradication would be extremely difficult and expensive. The control of these and other species is underway in priority conservation areas, such as Media Luna and Los Gemelos. Meanwhile, options for biological control and complete eradication are being considered.

Eradication programs have been initiated for some species and biological control methods are being considered for others.

Status of introduced vertebrates in Galapagos

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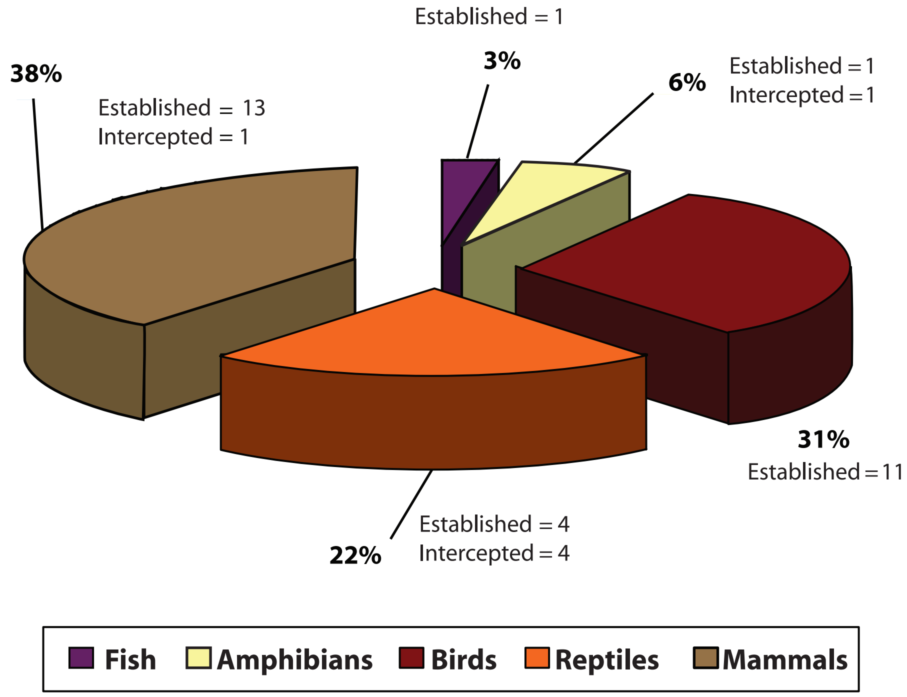
[a]Charles Darwin Foundation, [b]Galapagos National Park

As of May 2007, 36 species of introduced vertebrates have been recorded in Galapagos, 30 of which are now established: 1 fish, 2 amphibians, 4 reptiles, 10 birds, and 13 mammals (Fig. 1).

The six remaining species were intercepted upon arrival in Galapagos: 1 toad (*Bufo sp.*) on San Cristóbal in 1995; 4 reptiles, including 1 small terrapin (*Podocnemis unifilis*) on San Cristóbal, 1 Florida turtle (*Trachemys scripta*), 2 green iguanas (*Iguana iguana*) on San Cristóbal and Santa Cruz, and 1 five-banded lizard (*Eumeces inexpectatus*) ready to lay eggs; and 1 mammal, a cotton-head monkey (*Saguinus Oedipus*) on San Cristóbal, a pet on a private boat (2005-06).

Figure 1. Introduced vertebrate species recorded in Galapagos as of May 2007

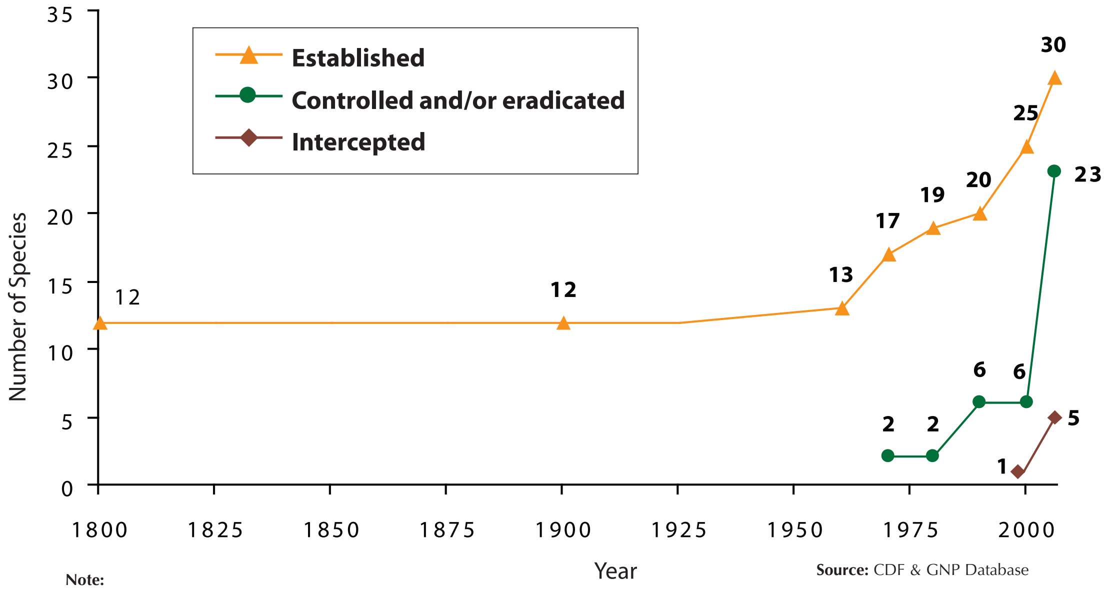


Source: CDF & GNP Database

The increase in introduced and established vertebrate species on one or more islands of the archipelago has occurred since human settlers arrived, approximately 150 years ago. However, the conservation and management institutions in Galapagos have achieved considerable success at managing and controlling invasive species at local and regional levels. Control and eradication of large vertebrate species on some islands and islets of the archipelago, as well as the interception upon arrival of six new species in recent years, are examples of achievements in prevention and management (Figs. 2 and 3).

Of the 36 species of introduced vertebrates recorded in Galapagos to date, 30 have become established and cause serious damage to the insular ecosystems.

Figure 2. Number of introduced vertebrate species recorded in Galapagos, by status (established, under control and/or eradicated, and intercepted)

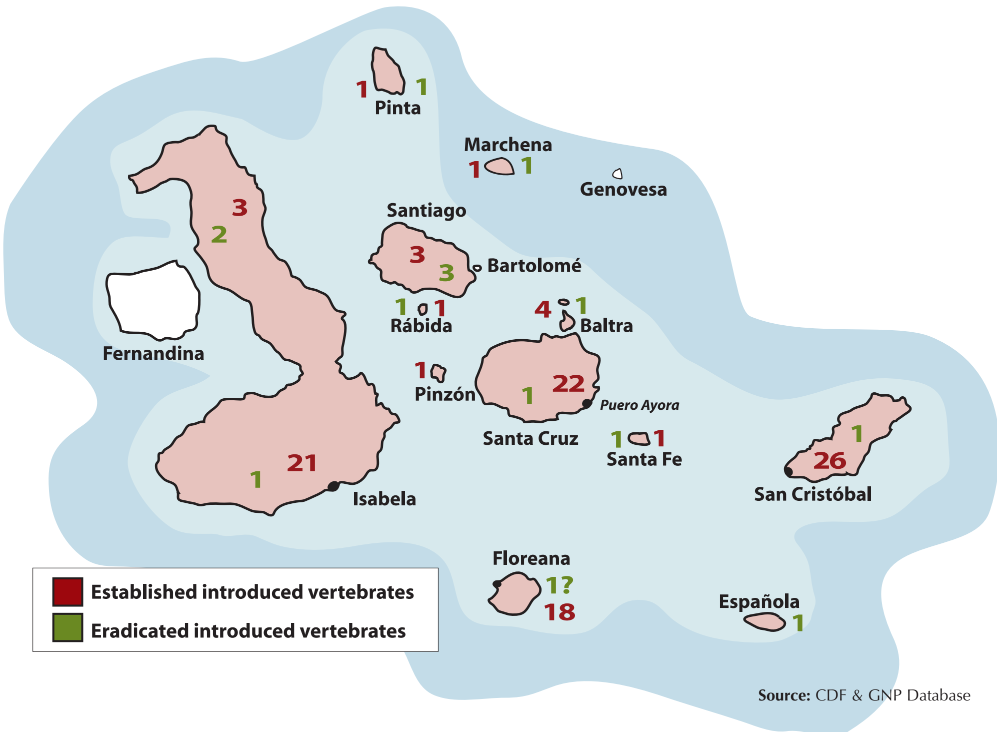


Source: CDF & GNP Database

Note:

*Species controlled and/or eradicated on one or more islands or islets, not Archipelago-wide.

Figure 3. Distribution of introduced vertebrate species (established and eradicated) in the main islands of Galapagos



Source: CDF & GNP Database

Note:

The number of established species does not include those observed or possibly observed in the indicated islands.

Established introduced species

Exotic species have been introduced by humans, accidentally or intentionally, since 1535. Once established, they cause serious, in some cases irreparable, damage to the natural ecosystems.[1] Therefore, managing, controlling and eradicating introduced species are top-priority goals. Beginning in 1968, the Galapagos National Park focused on eradicating goats (*Capra hircus*), pigs (*Sus scrofa*), and dogs (*Canis familiaris*)[1]. With advisory and technical support from the Charles Darwin Foundation, control and/or eradication techniques have been applied in specific sites or islands where these species are found.

Details on the presence and status of all 36 species of introduced vertebrates, as well as management actions taken on the main islands, are presented in Annex 1. The historical details on arrival and current status on the different islands or islets of Galapagos are presented below.

Fish

Tilapia (*Oreochromis niloticus*) was detected in El Junco lagoon on San Cristóbal Island in 2006[2]. An invasive species, it is now regularly monitored and a suitable eradication method is being sought. This species has not been recorded in the other lakes.

Frogs

The **tree frog** (*Scinax quinquefasciatus*) from the coastal zone of mainland Ecuador was recorded for the first time in Galapagos in 1998[1]. This species has spread through the lagoons of southern Isabela and has been recorded on Santa Cruz. As of 2002, it had not been recorded on San Cristóbal or Floreana[3]. Despite attempts at developing an eradication method, no satisfactory method has been found.

Reptiles

The first record of **introduced geckos** was *Gonatodes caudiscutatus* in 1892 and *Phyllodactylus tuberculosus* in 1906[4,5], followed by *Lepidodactylus lugubris*[6], all in San Cristóbal. On Santa Cruz, *P. reissi* appeared in 1975[6], and later *L. lugubris*[7]. *L. Lugubris* was also found on Isabela[6]. These species compete with endemic species for habitat. So far their management has been limited to research on their distribution and level of competition with endemic species.

Birds

The **smooth-billed** ani, *Crotophaga ani*, was introduced on Isabela in 1962 and first recorded on Santa Cruz in 1966 and on Santiago in 1967[8]. It has been recorded on Champion, Gardner-by-Floreana, South Plaza, Marchena, Genovesa, Fernandina (where it is not established but does appear sporadically), Daphne[1], and Pinta[3]. The results of eradication efforts on Marchena are not yet clear. When there is plenty of rainfall, the population increases, as occurred during El Niño in 1997–1998[1].

The **pigeon**, *Columba livia*, was introduced into Galapagos in 1972-73[12] and has been recorded in and around populated areas of San Cristóbal, Santa Cruz, and Isabela. It was successfully eradicated from these areas in 2004.

The **cattle egret**, *Bubulcus ibis*, was recorded in 1964 on Santa Cruz, but may have arrived in 1960[9]. Its nesting was not recorded until 1986[10]. It is distributed on the four populated islands (Santa Cruz, San Cristóbal, Isabela, and Floreana), mainly in cattle-ranching areas, although it has also been sighted on other islands[8]. While it may have arrived by natural migration (there is no available information), it has established itself on the islands because humans have altered the land for ranching and other uses.

The **Guayaquil red-masked parakeet**, *Aratinga erythrogenys*, was recorded in 1996 on San Cristóbal[11] as a pet, not an established population[8].

Domestic birds, including chickens (*Gallus gallus*), ducks (*Anas sp.*), Guinea hens (*Numida meleagris*), turkeys (*Meleagridis gallipavo*), and peacocks (*Pavo muticus*), were brought to Galapagos by settlers. The quail (*Coturnix sp.*) was first recorded in 2001[13]. All are found in urban and rural areas. There are also populations of feral chickens.

Tilapia and frogs are both introduced species that were detected in recent years and for which effective eradication methods are still being sought.

Mammals

The **goat**, *Capra hircus*, had been reported in Galapagos since 1685[14]. Goats were one of the first introduced species recorded on most islands, and were also the first eradicated from many of them. Goats were recorded on Santiago in 1813[15] and 1900[16] and on Floreana in 1832.[17] Both islands are now monitored to confirm recent eradications. Goats were detected on southern Isabela in 1897, and on northern Isabela in 1968[18], where they were eradicated in 2006. The first record of goats on Baltra dates back to 1900[17] and a few feral individuals remain. Goats were detected on Santa Fe and Española in 1905[19] and were eradicated in 1971 and 1978, respectively[15]. On San Cristóbal and Santa Cruz, goats were detected in 1847 and 1925[17]; some feral goats remain despite subsistence hunting by Galapagos residents. Goats were first detected on Pinta in 1959[20] and then eradicated in 2000[21]. The first record of goats on Marchena was in 1967[16] and they were initially eradicated in 1979[17], and again in 1983[3] following an intentional re-introduction. On Rábida, goats were detected in 1971 and eradicated that same year[17] and again in 1975[3]. Their date of introduction to South Plaza is unknown, but they were eradicated in 1961[15]. Domestic goats are currently found on the four populated islands, with some feral and "Judas" goats on Isabela and Santiago.

> Goats were one of the first introduced species to become established in Galapagos and one of the most invasive. The successful eradication of goats from Santiago and northern Isabela was the largest eradication project in the world.

Cattle, *Bos taurus*, were introduced to Floreana in 1832,[22] Isabela about 1850, Santa Cruz in 1923, and San Cristóbal in 1841[17]. Domestic cattle are currently found on the populated islands. Feral cattle still remain on Isabela and Floreana. The current goal is to eradicate feral cattle from the National Park.

Horses, *Equus caballus*, and **donkeys**, *E. asinus*, were introduced to Floreana in 1832[15] and 1934[23], San Cristóbal in 1847, and southern Isabela in 1897[15]. Records of donkeys on Santiago date back to 1875; they were eradicated in 2004[23]. At present, donkeys and horses remain in the populated areas (Santa Cruz, San Cristóbal, Isabela, and Florena). There are feral populations on San Cristóbal and Santa Cruz.

The date of introduction of **sheep**, *Ovis ariens*, on Santa Cruz, San Cristóbal, and Isabela is unknown, but the first record was in 1984[17]. No wild sheep have been recorded. In 2002, Patry[3] did not record sheep on the main islands, and the species is now considered gone.

Guinea pigs, *Cavia porcellus*, were recorded before 1984 in the farming area of Santa Cruz, San Cristóbal, and Isabela. No wild guinea pigs have been recorded[17]. In 2002, Patry[3] noted them as disappeared from San Cristóbal, and on Santa Cruz their current status is unknown.

Rabbits, *Oryctolagus cuniculus*, were recorded in the farming areas of Santa Cruz before 1989 but no wild rabbits have been recorded[15].

Pigs, *Sus scrofa*, were introduced on Floreana in 1832 and then eventually to the other inhabited islands. Pigs were first recorded on San Cristóbal in 1835[15] and again in 1847[17]. On Santiago there were reports of pigs in 1875 and again in 1878[15]; they were eradicated from Santiago in 2004[24]. The first record on southern Isabela was in 1897 and on Santa Cruz about 1920[17]. At present there are both domestic and feral pigs on the four populated islands (Santa Cruz, San Cristóbal, Isabela, and Floreana).

The first **cat**, *Felis catus*, was recorded on Floreana in 1832. They arrived on Santa Cruz and San Cristóbal with early human settlers[15], and were recorded on Isabela in 1869[25]. Both feral and domestic cats remain on these islands. They were introduced to Baltra, possibly during World War II, but were eradicated from the island in 2004.

The first record of **dogs**, *Canis familiaris*, was on Santiago in 1685[14], and later on Floreana in 1832, San Cristóbal in 1842 and 1847[17], Isabela in 1835[26] or 1868[17], and Santa Cruz in 1868[17]. Feral dogs were eradicated from Floreana and San Cristóbal in 1970[26]. Domestic dogs are currently found on Santa Cruz, San Cristóbal, Isabela, and Floreana. There are still sporadic reports of feral dogs on Santa Cruz and San Cristóbal.

> The majority of introduced mammals are also as domestic animals on the four populated islands of the archipelago.

Rodents, including the black rat (*Rattus rattus*), the Norwegian rat (*R. norvegicus*), and the house mouse (*Mus musculus*), arrived in Galapagos with humans, possibly when the islands were first discovered[15]. Charles Darwin reported the black rat on Santiago in 1835. On Pinzón, it was recorded in 1890. Norwegian rats were recorded on Santa Cruz and San Cristóbal in 1982. As of 2002, black rats were on the five populated islands (Santa Cruz, San Cristóbal, Isabela, Floreana, and Baltra), Bartolomé, Marielas, Pinzón, and Santiago; Norwegian rats were on the five populated islands and Rábida, and house mice on the five populated islands, Santiago, and South Plaza[3]. Research and control programs are being conducted in the National Park, as well as rural and urban areas.

Eradication efforts have resulted in some islands and islets being free of cats, goats, pigeons, donkeys and pigs.

Changes in the status of introduced vertebrate species, 1999-2006

Significant efforts to eradicate introduced vertebrate species from Galapagos have occurred in recent years, resulting in the successful elimination of several species from some of the major islands and islets. Changes in the status of introduced vertebrate species during the period from 1999 to 2006 are indicated in Table 2. Five species have been eradicated from a zone, island, or several islands in the archipelago: **cats** from Baltra; **goats** from northern Isabela, Santiago, and Pinta; **pigeons** from southern Isabela, Santa Cruz, and San Cristóbal; **donkeys** from northern Isabela and Santiago; and **pigs** from Santiago.

Table 2. Changes in the status of introduced vertebrate species on the main islands of Galapagos.

			STATUS BY YEAR			
ISLAND	Common Name	Scientific Name	1999	2001	2004	2006
Baltra	Cat	*Felis catus*	Present	Present	Eradicated	Eradicated
Floreana	Quail	*Coturnix sp.*	Absent	Absent	Present	Present
Genovesa	Smooth-billed ani	*Crotophaga ani*	Present	Disappeared	Present	Present
Northern Isabela	Goat	*Capra hircus*	Present	Present	Present	Eradicated
Northern Isabela	Donkey	*Equus asinus*	Present	Present	Present	Eradicated
Southern Isabela	Dog	*Canis familiaris*	Present	Present	Domestic	Domestic
Southern Isabela	Pigeon	*Columbia livia*	Present	Present	Eradicated	Eradicated
Southern Isabela	Quail	*Coturnix sp.*	Absent	Absent	Present	Present
Southern Isabela	Donkey	*Equus asinus*	Present	Present	Present	Domestic
Marchena	Goat	*Capra hircus*	Eradicated	Present	Present	Present
Pinta	Goat	*Capra hircus*	Present	Eradicated	Eradicated	Eradicated
San Cristóbal	Pigeon	*Columbia livia*	Present	Present	Eradicated	Eradicated
San Cristóbal	Quail	*Coturnix sp.*	Absent	Absent	Present	Present
Santa Cruz	Pigeon	*Columbia livia*	Present	Present	Eradicated	Eradicated
Santa Cruz	Quail	*Coturnix sp.*	Absent	Absent	Present	Present
Santiago	Goat	*Capra hircus*	Present	Present	Present	Eradicated
Santiago	Donkey	*Equus asinus*	Present	Present	Eradicated	Eradicated
Santiago	Pig	*Sus scrofa*	Present	Eradicated	Eradicated	Eradicated

Source: CDF & GNP Database

Annex 1. Introduced vertebrates in the Galapagos: status, distribution on the main islands, and management actions.

Class	Common Name	Scientific Name	Island (or zone)																	
			Isabela (North)	Isabela (South)	Floreana	Santa Cruz	San Cristóbal	Santiago	Fernandina	Genovesa	Rábida	Española	Pinzón	Baltra	Pinta	Santa Fe	Marchena	Others (Control)	Others (Eradication)	Others (Present)
Amphibians	Tree frog	*Scinax quinquefasciatus*		M		O	O													
Amphibians	Toad	*Bufo sp.*					I													
Birds	Guayaquil red-cheeked parakeet	*Aratinga erithrogenys*					D													
Birds	Quail	*Coturnix sp.*		D?	D?	D	D?													
Birds	Guinea hen	*Numida meleagris*		D?	D?	D	D													
Birds	Chicken	*Gallus gallus*		D	D	D	D							D						
Birds	Goose	*Anser anser*					D													
Birds	Smooth-billed ani	*Crotophaga ani*	P	P	P	P	P	P	O	O					P		O			
Birds	Cattle egret	*Bubulcus ibis*		P	P	P	P													
Birds	Pigeon	*Columba livia*		E		E	E													
Birds	Duck	*Anas platyrhynchos*		D	D?	D	D?													
Birds	Turkey	*Meleagris gallopavo*		D?	D?	D	D?													
Birds	Peacock	*Pavo muticus*					D?													
Mammals	Donkey	*Equus asinus*	E	C	UE	C	C	E												
Mammals	Horse	*Equus caballus*		C	D	D	D													
Mammals	Goat	*Capra hircus*	E	C	UE	C	C	E			E	E		E	E	E	E		3	
Mammals	Pig	*Sus scrofa*		C	UE	C	C	E												
Mammals	Rabbit	*Oryctolagus cuniculus*				D?	D?													
Mammals	Guinea pig	*Cavia porcellus*		D?	D?	D?	D?													
Mammals	Cattle	*Bos taurus*		C	BE	D	D													
Mammals	Cat	*Felis catus*	M	M	M	M	M							E					1	
Mammals	Sheep	*Ovis aries*		H			H													
Mammals	Dog	*Canis familiaris*		C	C	C	C													
Mammals	Black rat	*Rattus rattus*	M	M	M	M	M	P					M	M			O?	11		16
Mammals	Norwegian rat	*Rattus norvegicus*		P?	P?	M	P?				P			P?						1
Mammals	House mouse	*Mus musculus*		P	P	M	M	P						M						9
Mammals	Cotton-headed tamarin	*Saguinus oedipus*					I													
Fish	Tilapia	*Oreochromis niloticus*					BE													
Reptiles	Gecko	*Gonatodes caudiscutatus*					P							P						
Reptiles	Gecko	*Lepidodactylus lugubris*		P		P	P													
Reptiles	Gecko	*Phyllodactylus reissii*				P														
Reptiles	Gecko	*Phyllodactylus tuberculosus*					H													
Reptiles	Green iguana	*Iguana iguana*				I	I													
Reptiles	Five-banded lizard	*Eumeces inexpectatus*					I													
Reptiles	Terrapin	*Podocnemis unifilis*					I													
Reptiles	Fresh-water turtle	*Trachemys scripta?*				I														

Legend:
E Eradicated, **UE** Under eradication, **C** Controlled, **D** Domesticated, **O** Observed, **I** Intercepted, **H** Historical record, **P** Present without action, **M** Mitigation

Source: CDF & GNP Database

Latest records of introduced invertebrates in Galapagos and measures to control them

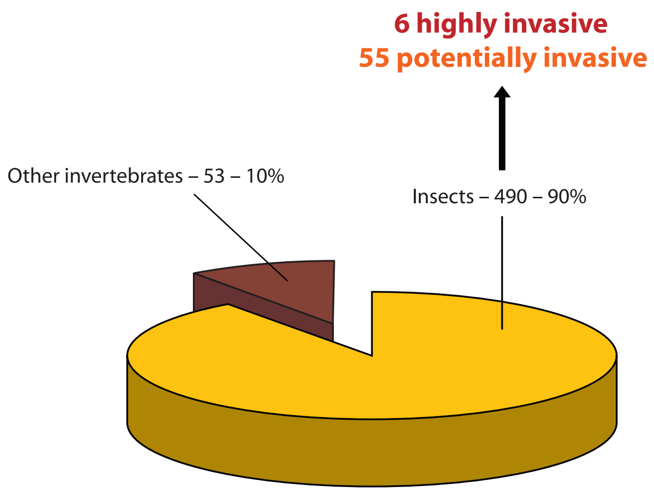
Charlotte Causton[a] & Cristian Sevilla[b]

[a]Charles Darwin Foundation, [b]Galapagos National Park

Records up to late 2006 show **490** species of insects and **53** species of other invertebrates (e.g., spiders, snails, and slugs) introduced into Galapagos. Out of these species, six are known to be invasive species with significant impacts on Galapagos ecosystems: fire ants (*Wasmannia auropunctata* and *Solenopsis geminata*), wasps (*Brachygastra lecheguana* and *Polistes versicolor*), cottony cushion scale, (*Icerya purchasi*), and a bird ectoparasite (*Philornis downsi*). A risk analysis has highlighted another 55 species of insects considered to have the potential to cause serious impacts in Galapagos.

During 2005 and 2006, at least **26** species of introduced invertebrates were recorded for the first time in Galapagos: 2 beetles (Coleoptera), 7 flies (Diptera), 3 scale insects (Homoptera), 8 ants and 1 wasp (Hymenoptera), 1 moth (Lepidoptera), 2 booklice (Psocoptera), and 2 thrips (Thysanoptera). These species were probably introduced in lumber, fruits and vegetables, and decomposing organic matter. Figure 2 clearly shows the increase in the number of species recorded in the last few years. However, some of the species reported during 2005 and 2006 arrived in Galapagos at an earlier date; 69% of the new species recorded were collected in Galapagos from 1960 to 2004, but were first identified in 2005 and 2006. This was mainly due to difficulties in identifying species or because many specimens were kept unclassified for years in the Terrestrial Invertebrates Reference Collection of the Charles Darwin Foundation (CDF). It is also possible that some other species reached Galapagos before 2005 but were not recorded because they were in places where no intensive invertebrate collections had been carried out until recently, e.g., in urban areas. As a consequence, the interval between the collection date and the first record makes it difficult to compare invertebrate introductions over the years.

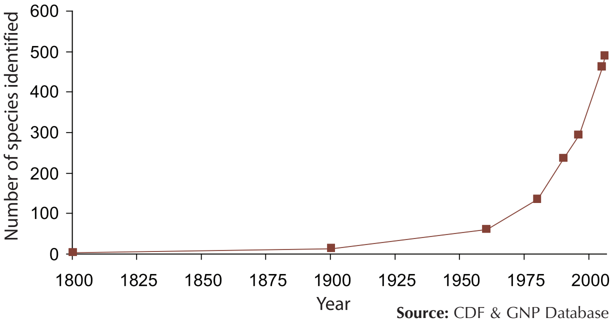
Figure 1. Introduced invertebrate species recorded in Galapagos up to 2006



Source: CDF & GNP Database

To date, **490** species of introduced insects and **53** species of other introduced invertebrates have been registered in Galapagos.

Figure 2. The cumulative number of introduced invertebrate species recorded in Galapagos



Source: CDF & GNP Database

Notes

Many were introduced from a few years to decades prior to their identification.

Newly recorded species posing the greatest risk for Galapagos

Of the new introduced species recorded in Galapagos, 16 have the potential to cause a major impact on the economy and biodiversity of Galapagos (3 are very high risk species and 13 are high risk species). Of these, the three species of scale insects (Hemiptera), *Coccus longulus* (collected on an ornamental plant in Santa Cruz), *Nipaecoccus nipae* (collected on a guava plant in Isabela), and *Inglisia vitrea* (found on a chirimoya plant in San Cristóbal), deserve special attention because they are well known as pests in other parts of the world, and they eat a wide variety of plants, which could jeopardize both cultivated and endemic vegetation. The 8 species of ants (Hymenoptera: Formicidae), the thrips, *Neohydatothrips portoricensis* (Thysanoptera: Thripidae), and the wasp *Sceliphron caementarium* (Hymenoptera: Vespidae) are predators of other insects. The moth, *Phyllocnistis citrella* (Lepidoptera: Gracillaridae), specializes on citrus, affecting tree growth by mining the leaves.

> Out of the introduced insects recorded, **55** have the potential to cause a serious impact on the economy and biodiversity of Galapagos.

The Annex includes new reports of introduced invertebrate species in Galapagos for the 2005-2006 period and identifies their threat level.

Control and eradication of invasive invertebrates to date

The most invasive or potentially invasive species of introduced invertebrates, their distribution, and the management actions implemented are shown in Table 1.

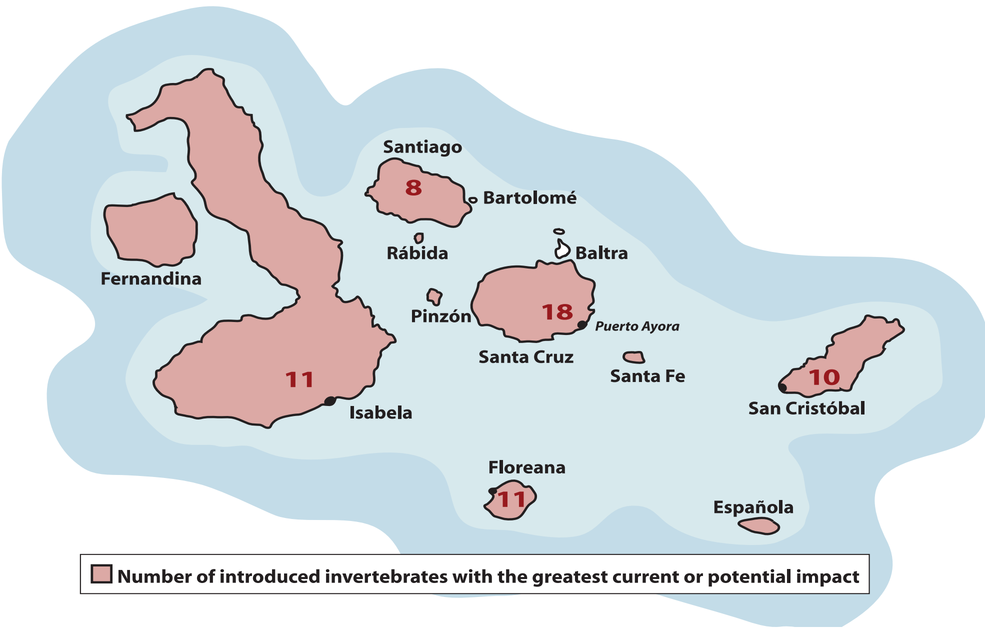
Since most of the species recorded in 2005 and 2006 arrived previously, no action has yet been taken for any of them. However, studies are recommended to determine if Galapagos ecosystems are being affected. Early in 2006, CDF and staff of the Quarantine Inspection System for Galapagos (SICGAL) responded quickly when a large number of thrips (*Gynaikothrips uzeli*) were discovered attacking ornamental plants of the *Ficus* genus. However, when it was later confirmed that this species of thrips specializes on *Ficus* (an introduced, potentially invasive plant), it was concluded that Galapagos plants would not be affected. The mud dauber wasp, *Sceliphron caementarium*, is currently being monitored to see if it has become established.

> Eradication or control efforts focus on high-impact species, such as the little fire ant, *Wasmannia auropunctata*, and the tropical fire ant, *Solenopsis geminata*.

Current emphasis is on eradicating or controlling high-impact species such as the little fire ant, *Wasmannia auropunctata*, and the tropical fire ant, *Solenopsis geminata*. These ants give a painful sting and affect juvenile reptiles and birds, as well as impact human activities. They are also predators of other invertebrates. Currently, the distribution of these two ants is being researched and priority areas for control actions identified. Sites with threatened plant species and islands with new infestations are top priority. The Galapagos National Park, with technical assistance provided by CDF, is now pursuing eradication programs for the little fire ant on Marchena (an area of 21 ha), San Pedro on Isabela (an area of 28 ha), and Mao islet (1.2 ha). They are also carrying out eradication programs for tropical fire ants on Bainbridge Rocks (10 ha), Las Marielas (1.2 ha), and Champion (2 colonies). Fire ants are also being controlled on Black Turtle Beach on Isabela, the last refuge of the critically endangered Mangrove Finch.

Another invasive species being controlled is the cottony cushion scale, *Icerya purchasi*. Since 2002, its primary natural enemy, the Australian ladybug (*Rodolia cardinalis*), has been released on 11 islands of the archipelago. This is the first time that biological control has been applied in Galapagos and the program is being evaluated with the help of the community. The results so far indicate that the ladybug has been established on most islands and has also spread naturally to Baltra.

Figure 3. Distribution of introduced invertebrate species with the greatest current or potential impact in 2006



Source: CDF & GNP Database

Table 1. Introduced invertebrate species with the greatest current or potential impact and their distribution on the larger islands of Galapagos.

Common Name	Scientific Name	Santa Cruz	San Cristóbal	Isabela	Floreana	Santiago	Fernandina	Santa Fe	Marchena	Other Islands[1]
Little fire ant[2]	*Wasmannia auropunctata*	P	P	P/E? (28ha)	P	P		E (3ha)	E? (21ha)	P
Tropical fire ant[3]	*Solenopsis geminata*	P	P	P/C (3ha)	P	P	P	P		P
Cottony cushion scale	*Icerya purchasi*	BC	BC	BC	BC	BC	BC	BC	BC	BC
Paper wasp	*Polistes versicolor*	P	P	P	P	P				P
Black paper wasp	*Brachygastra lecheguana*	P	P							
Ectoparasitic fly	*Philornis downsi*	P	P	P	P					
Lesser snow scale	*Pinnaspis strachani*	P	P	P	P	P			P	P
Tiger beetle	*Cicindela trifasciata*	P								
Mealybug	*Paracoccus solani*	P		P		P				P
Southern house mosquito	*Culex quinquefasciatus*	P	P	P	P					
Singapore ant	*Monomorium destructor*				P					P
Bicolored trailing ant	*Monomorium floricola*	P			P					P
Wooly white fly	*Aleurothrixus floccosus*	P		P		P				
Lantana lace bug	*Leptobyrsa decora*	P	P		P					
Southern green stink bug	*Nezara viridula*	P	P	P	P					P
Cow pea aphid	*Aphis craccivora*	P		P		P	P			
Coconut mealybug	*Nipaecoccus nipae*	P		P					P	
Green peach aphid	*Myzus persicae*	P					P			
Yellow Fever mosquito	*Aedes aegypti*	P								

Source: CDF & GNP Database

Key to abbreviations: **P** = Present, **C** = Control under way, **BC** = Biological control, **E** = Eradicated, **E?** = Eradication to be confirmed.

Notes

1 'Other Islands' includes: Rábida, Genovesa, Española, Daphne, Pinta, Seymour Norte, Pinzón, Baltra
2 Found in many places on Isabela and being eradicated in the San Pedro area.
3 Found in many places on Isabela and being controlled on Black Turtle Beach.

Top-priority actions.

- Strengthen SICGAL, both in control and inspection activities as well as detection, monitoring, and rapid response.
- Determine the distribution and impact of species identified as potentially very invasive in Galapagos.
- Prioritize areas that require control of fire ants and develop control methods for inhabited areas.

Annex. New records of introduced invertebrate species in 2005-2006

ORDER	SPECIES	ISLAND	TYPE OF ARRIVAL	THREAT	ACTION TAKEN	ESTABLISHED
Choleoptera (beetles)	*Trigonodera lineata*	Santa Cruz	A- in wood	Low	NA	Yes
Choleoptera (beetles)	*Ancholaemus acuminatus*	Santa Cruz	A- in wood	Low	NA	Yes
Diptera (flies)	*Bradysia ocellaris*	Floreana	A- in organic material	Low	NA	Yes
Diptera (flies)	*Bradysia radicum*	Floreana	A- in organic material	Low	NA	Yes
Diptera (flies)	*Calycomyza lantanae*	Santa Cruz Floreana	A-in plants	High	NA	Yes
Diptera (flies)	*Eugnoriste planiforceps*	Santa Cruz Floreana	A- in organic material	Low	NA	Yes
Diptera (flies)	*Lonchaea n. sp.*	San Cristóbal	A-in plants	High	NA	Yes
Diptera (flies)	*Megaselia seticauda*	San Cristóbal	A- in organic material	Low	NA	Yes
Diptera (flies)	*Zaprionus? sp.*	Santa Cruz	A- in fruits or vegetables	Low	NA	Yes
Hemiptera (scale insects)	*Coccus longulus*	Santa Cruz	A-in fruits	Very High	NA	Yes
Hemiptera (scale insects)	*Inglisia vitrea*	San Cristóbal	A-in fruits or plants	High	NA	Yes
Hemiptera (scale insects)	*Nipaecoccus nipae*	Isabela agricultural zone	A-in fruits	Very High	NA	Yes
Hymenoptera (ants/wasps)	*Adelomyrmex myops*	Isabela	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Brachymyrmex heeri*	Santa Cruz	A	High	NA	Yes
Hymenoptera (ants/wasps)	Crematogaster sp	Baltra	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Cyphomyrmex rimosus*	Santa Cruz	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Hypoponera punctatissima*	Santa Cruz	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Pyramica membranifera*	Isabela (Alcedo)	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Rogeria curvipubens*	Santa Cruz	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Sceliphron caementarium*	Santa Cruz	A	High	NA	Yes
Hymenoptera (ants/wasps)	*Solenopsis (near) tenuis*	Floreana, Isabela, Santa Cruz	A	Very High	NA	Yes
Lepidoptera (moths)	*Phyllocnistis citrella*	Santa Cruz San Cristóbal	A-in citrus	High	NA	Yes
Psocoptera (booklice)	*Pseudocaecilius citricola*	Isabela (agricultural zone)	A	Low	NA	Unknown
Psocoptera (booklice)	*Soa flaviterminata*	San Cristóbal (agricultural zone)	A	Low	NA	Unknown
Thysanoptera (thrips)	*Gynaikothrips uzeli*	Santa Cruz San Cristóbal	A-in plants	None	CO	Yes
Thysanoptera (thrips)	*Neohydatothrips portoricensis*	Isabela (agricultural zone)	A- in plants or vegetables	High	NA	Yes

Source: CDF & GNP Database

Key to Abbreviations:
Type of Arrival: Accidental (A), Intentional (I)
Action Taken: Control Method Developed (CO), No Action (NA)
Established: Yes, No

Fresh water: the reality of a critical resource

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Although fresh water is not very visible in Galapagos, it is found in several places (underground, crevices, and streambeds) and is indispensable for all forms of life. Historically, Galapagos residents barely survived, having to search for water (rainwater, brackish water, and springs). Now they are part of a water supply system and pay for their water. However, when they don't know where the resource comes from, they don't take responsibility for preserving it.

Currently, water resource users do not know where the water comes from nor do they take responsibility for preserving it.

Table 1. Definition of terms related to water resources.

FRESH WATER: Water in a natural state that is part of the water cycle: rain, lakes, streams, underground water.

Water Resource: The **amount** of fresh water that can be sustainably used for human consumption and use.

Domestic water supply: Water used for all household chores (bathing, cooking, etc.)

Potable Water: Water suited for human consumption according to health standards.

Irrigation water: Water used by the agricultural sector to water crops and livestock.

Sewage water: The "black water" returning to the environment after having been used for human consumption and use. There are various forms of treatment and disposal of sewage water.

POLLUTION / CONTAMINATION: The process affecting water **quality** with contaminants such as salt water, pesticides, oils, and fecal coliform (human feces). It is not always possible to remedy the problem.

Contaminated water: Natural fresh water, whether for human consumption or other uses, that is altered from its natural state and poses risks for health or the environment.

User: Person who pays for a service such as water from a tank truck or from a water supply system.

Survival / subsistence: State in which one's foremost concern is to satisfy one's basic needs to live.

Hydrological conditions in Galapagos

The **water entering the hydrological cycle** varies from year to year. The availability of water is particularly important for the agricultural sector. Water resources include rain and "garúa" (a thick mist that dominates the highlands during the cool season). The abundance of water varies greatly from exceptionally rainy years (El Niño) to years of severe drought (La Niña).

The **outlets from the hydrological cycle** are:

(i) Evaporation, which is quite high in winter and low in the garúa season in the highland areas;

(ii) Infiltration, which occurs rapidly because the soils are highly permeable;

(iii) Springs, both non-perennial springs fed by exceptionally heavy rainfall and permanent springs fed by underground water sources.

Fresh water in Galapagos is found in the following forms (Table 2):

- **Coastal lagoons and ocean inlets:**
This water is less useful as a resource because the lagoons and inlets are vulnerable and readily affected by changes in watersheds.

- **Underground water in aquifers:**
This is the fresh water that "floats" in equilibrium above sea water and is found beneath the surface of an island where the sea water has penetrated. An aquifer exists on all the islands. In the case of Santa Cruz, it is known that it is not very thick. This is a very fragile resource because it can quickly be contaminated by substances entering through the crevices in the Earth's surface.

- **Ponds, lakes, and wetlands (perennial or temporary):**
These ecosystems are very important from a hydrological standpoint because of their role in water collection and storage for both the flora and fauna. Located in the more humid areas of the islands, they could be the optimal areas for infiltration.

- **Springs and streams:**
Except for San Cristóbal, where there is a permanent surface spring that has been studied continually during 2006, the islands have little surface water. Springs have very low flow rates and streams run sporadically. Nevertheless, they are an important resource. However, because they flow on the surface, they are exposed to a high risk of direct contamination. They also depend on climatic conditions and underground storage.

- **Underground water in the highlands:**
The lack of current data on underground water in the highlands makes it difficult to make the proper management decisions. While this type of resource might exist on other islands, only San Cristóbal is identified as having underground water resources. Their protection requires the protection of springs and streams.

> Inhabited areas in Galapagos were settled and have grown significantly with little thought to integrated water management.

Table 2. Parameters and characteristics of the forms of water present in Galapagos and an appraisal.

FORM OF THE WATER RESOURCE	CHARACTERISTICS				
	Importance for utilization	Sensitivity to changes	Abundance	Risk of contamination	Requires protection and monitoring
Coastal lagoons and ocean inlets	-	+++	++	++	+++
Underground water in aquifers	++++	++	++	++++	++++
Ponds, lakes and wetlands	-	+++	+	++	+++
Springs and streams	+++	+++	+	+++	+++
Underground water in the highlands	?	+	?	+	+++

Note

The symbols indicate the strength and direction of the relationship between each water resource and the stated characteristic. The plus symbol (+) indicates a positive relationship and the minus symbol (-) a negative relationship. The strength of the relationship is expressed by the quantity of symbols.

Water resource issues in Galapagos

Fresh water is a dynamic resource. Inhabited areas in Galapagos were established and have grown significantly with little thought to integrated water management. Rainfall, runoff, brackish water, contamination, pollution, the agricultural zone, and the National Park are components of the same water cycle, yet the interrelationships are not fully understood. Water resources and scarcity are critical issues on the different islands (Table 3). Prices of water in 2006 can be used as a guide for future monitoring (Table 4).

Table 3. The critical situation of fresh water sources on the inhabited islands, 2006.

USE	Santa Cruz	San Cristóbal	Isabela	Floreana
Domestic in urban zones	Municipal system – water from crevices and deep wells (not contaminated)	Municipal system - water from a stream (not El Junco Lake)	Municipal system – water from wells	Rainwater, spring
	Contaminated source (salt and fecal coliform)	Contamination beginning; leakage causes scarcity	Brackish, contaminated	Drought – lack of rain, the spring dries up
Domestic in rural zones	Rainwater	Rainwater, streams	Rainwater	Spring, rainwater
	Drought	Some streambeds are affected by drought	Drought	Drought
Potable Water	Private desalination plants; rainwater	Private desalination plants; rainwater	Imported drinking water; rainwater	Imported drinking water; rainwater
Water for agriculture	Rainwater, tank trucks – salty, contaminated water	Rainwater, streams	Rainwater, tank trucks – brackish, contaminated water	Rainwater - drought

Table 4. Prices of water resources in Santa Cruz.

Type of water	Unit price
Contaminated water from the Municipal system, domestic use	\$3.00 per month
Contaminated water from the Municipal system, commercial use	\$8.00 per month
Water from the deep well supplied to Bellavista with meters	\$1.21 per m^3
Contaminated water supplied by tank trucks, highlands	\$10 - \$30 per m^3
Desalinated water	\$100 (in jugs) per m^3 \$25 (from a hose) per m^3

For domestic use, the most serious problems are <u>contamination</u>, which affects water **quality** (Santa Cruz), and <u>losses due to leakage,</u> which results in **scarcity** of water (San Cristóbal).

The major problem for the agricultural sector, except on San Cristóbal, is the <u>lack of fresh water</u> and the <u>need to purchase brackish water.</u>

In summary:

- **Santa Cruz** has very poor underground water quality on its coast due to contamination. Irrigation water is in short supply for farmers and there is a lack of sufficient knowledge of the aquifer to manage it on a sustainable basis. It is necessary to seek alternatives.
- **San Cristóbal** has abundant water in the highlands but it does not reach the population. The distribution system is complex and requires better management. A simple treatment system for stream water is needed. It is also essential to establish a flow-rate monitoring system to provide information to decision-makers in the event of a drought.
- **Isabela** has problems with contamination of coastal sources due to an increase of salt and fecal coliform. It also lacks water in the highlands.
- **Floreana** has depleted its springs and there is a total lack of water for its population.

Research results and recommendations

JICA-GNPS Program – water quality monitoring in Santa Cruz[1]

Monthly monitoring of 11 land sites and 9 marine sites has been conducted to track contamination. The monitoring includes assessment of several parameters to determine water quality, such as oils and greases, fecal coliform, detergents, mercury, lead, and hydrogen potential (alkalinity), among others. These values are then compared with the maximum allowable limits.

In the case of water resources distributed to the human population, the level of fecal coliform is particularly important. Monitoring results in 2005 indicate very high levels of coliform bacteria in the crevices of Puerto Ayora: 100 to over 10,000 nmp/ml, depending on the month and site. The maximum allowable limit for total coliform bacteria is 600 nmp/ml. In all sites sampled, the highest levels of fecal coliform were recorded in November and December. It is extremely important to continue this monitoring because contamination levels affect water quality and cause health problems. This contamination could be reduced with the support and participation of Galapagos residents.

Recommendation: Monitor all water sites used for human consumption and in zones of the Park (because of the effect on ecosystems) and monitor water that is desalinated by small private companies that use contaminated brackish water for conversion to potable water.

Hydrological-hydrogeological project of Galapagos[a] - University of Paris-6 in collaboration with the GNP, CDF, INGALA and Municipalities[2]

The goal of this project is to understand how the hydrological cycle works in Santa Cruz and San Cristóbal.

Santa Cruz: Four pressure probes measure hourly variation in the water level in the deep well of three crevices, two of which are used for water supply and one which is not.

Data show that tidal variations influence water levels for a period of time that can range from a few hours (in the crevices closest to the ocean) to 42 hours in the case of the deep well. These variations also affect the electrical conductivity of the water at these sites. It is important to monitor increases in electrical conductivity in the deep well because a continued increase could be attributed to saline intrusion, which could affect water quality. The probe in El Chato Lake revealed that the lake level dropped gradually from late March 2005 until it dried up that October. The lake's water level has not yet recovered. Non-perennial springs are being monitored in relation to rainfall. The study also delimited the watersheds.

Recommendation: The concept of managing by watersheds is used more and more extensively worldwide and should be applied in Galapagos. For example, the watershed encompassing Cerro Crocker and Puerto Ayora includes the nesting zone of endemic species in the Park, two urban areas, and one agricultural area. It is also a region where concentrations of rainfall during El Niño periods can cause serious damage. Watershed management should involve all the authorities who have responsibilities over these zones.

San Cristóbal: The very dry climatic conditions in 2005 and early 2006 have reduced the level of El Junco Lake and river flow rates on this island (both monitored under the project). The level of El Junco Lake fluctuates according to climatic variations. However, it **is not** a source of water for the human population.

Recommendation: It is important to protect the lake's perimeter to ensure maximum recharging during both the garúa and the rainy seasons. The decrease in stream flow affects some tributaries, which become permanently dry. However, the fact that the four rivers leading to the sea continue carrying water to the ocean during drought periods means that they are fed not only by rainfall, but also by underground reserves.

> Each island has its own water needs and priorities, but the most serious problems are the same on all islands: pollution, waste, and scarcity of fresh water.

[a] The hydroclimatic data compiled and analyzed under the project will appear in the doctoral thesis of Noémi d'Ozouville and in scientific publications.

The concept of managing by watersheds is used more and more extensively worldwide and should be applied in Galapagos.

Seeking an overall solution

The year 2006 has been marked by several events that affirm national and international support for changing the current situation in Galapagos and seeking comprehensive and integrated solutions. To address water issues in Galapagos it is important to work simultaneously on:

(1) Technical and scientific information. A project, begun in 2003, is focused on understanding how the hydrological cycle works, determining the resources available, and evaluating the dynamics among them. This collaborative project was developed by Pierre and Marie Curie University in France, the GNP, the CDF, INGALA, and the Municipalities[3]. In 2006, this project mounted a geophysical study of Santa Cruz and San Cristóbal by helicopter to investigate the presence of underground resources.

(2) Citizen participation. In May 2006, a local NGO (FUNDAR),[4] in conjunction with Paris 6 University, held a panel discussion entitled "Fresh Water in Galapagos: A resource to rediscover." Presentations on international and national experiences were followed by a debate on "how much water costs" and a participatory forum broadcast live on television.

(3) Political advocacy. In 2006, INGALA and CAMAREN held a provincial working group on water resources involving the various institutions that play a major role in water management to encourage policy reflection on this issue. This working group was fundamental in promoting the search for feasible solutions.

During the August 2006 Colloquium of Social Science for Galapagos, a literature review was presented[5] on past initiatives and a detailed presentation was made about the "social issues" of water in Galapagos. Implementation of a new Potable Water Project on the four inhabited islands is set to begin in 2007 and should be operational by 2008. The purpose of this project is to provide potable water through new systems in the four port towns. Desalination plants will be used on all islands except in Puerto Baquerizo Moreno in San Cristóbal where the water comes from streams in the highlands. Potentially, this project could solve the water supply problem in ports but **will not** solve problems related to: i) contamination of water sources; ii) supply for the agricultural sector (the cost will be too high to buy and transport desalinated water for agricultural use); iii) lack of social responsibility and a culture of water conservation; and iv) pollution from sewage. It is important to note that the current price of water does not represent its real cost for production, distribution, and treatment.

Without an integrated fresh water management plan for both urban and rural areas that addresses potable water contamination and treatment, and unless users assume their social responsibility, the situation will only get worse. Until now, the gap in knowledge about hydrological systems in Galapagos has been an obstacle to integrated management of ecosystems and implementation of adequate water systems. To fill this gap, it is necessary to carefully consider the relationships among fresh water, water resources, potable water, sewage water, and environmental pollution.

An integrated fresh water management plan is needed. It must involve urban and rural sectors, issues of contamination and treatment of potable water, and, above all, citizen responsibility.

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