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GALAPAGOS REPORT 2009-2010

Parque Nacional GALÁPAGOS Ecuador

PUNTO VERDE AREAS PROTEGIDAS POR TI.

Ministerio del Ambiente

CONSEJO DE GOBIERNO DEL RÉGIMEN ESPECIAL DE GALÁPAGOS

fundación Charles Darwin foundation

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PUNTO VERDE AREAS PROTEGIDAS POR TI.

Galapagos Report 2009-2010

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FOREWARD

The Governing Council of Galapagos, the Galapagos National Park Service, and the Charles Darwin Foundation are pleased to present Galapagos Report 2009-2010--a compilation of social, economic, political, and biological analyses that will assist decision-makers and help deepen our understanding of the many diverse and complex challenges facing the archipelago.

Galapagos is one of the best conserved archipelagos in the world, but the long-term protection of its unique biodiversity and ecosystems requires effective policies and actions to ensure both sustainable development and long-term conservation. These measures must be based on sound information and analysis.

Galapagos Report 2009-2010 addresses a wide range of issues related to the natural world, the inhabited areas of Galapagos, and the impacts of social and economic activities of humans in Galapagos ecosystems. Understanding the interactions between the natural world and humans, as well as the connections between Galapagos and the rest of the world, is essential to developing sound policy and a shared vision for the future.

Our three institutions remain committed to working with all Galapagos stakeholders to build a shared vision for Galapagos and to ensure the long-term sustainability of one of the world's most important natural treasures.

Ing. Fabián Zapata
President
Governing Council of Galapagos

Biól. Edwin Naula
Director
Galapagos National Park

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The report was improved by photographic contributions from Celso Montalvo, Claudio Crespo, Elizabeth Knight, George Hillman, Jacintha Casthora Photography, Johnny Vásquez, Juan Carlos Guzmán, Mandy Trueman, Marco Rodríguez, Mary Witoshynsky, Mónica Calvopina, Sharon Deem, Susana Chamorro, Verónica Toral, Emmanuel Cléder, Christophe Grenier, and Etienne Ouvrard.

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Photo: Jacintha Castora Photography

CONSEJO DE GOBIERNO
DEL RÉGIMEN ESPECIAL DE
GALÁPAGOS

Institutional Presentation

Governing Council of the Special Region of Galapagos

On the 10th of April 2007, following an analysis of the status of conservation and development in the Galapagos Islands, the Ecuadorian Government's Presidential Decree Nº 270 declared that the Galapagos Archipelago is at risk and its conservation and environmental management are a national priority.

Article 258 of the 2008 Constitution of the Republic of Ecuador states: "The Galapagos province will have a special governance structure. Planning and development will be conducted in strict adherence to the principles of conservation of the Nation's natural heritage in accordance to law." Under presidential decree Nº 1880 (August 5, 2009), the two main governing institutions in Galapagos, the National Institute of Galapagos (INGALA) and the Provincial Government of Galapagos, were combined into a single institution.

The process of combining the two institutions began on October 20, 2009, with the formation of the Governing Council of the Special Region of Galapagos. All active and passive assets, employees, and responsibilities of INGALA and the Provincial Government were transferred to the Governing Council.

The Governing Council is the entity responsible for planning and coordination in the Galapagos province. It is committed to open dialogue and consensus among decision-makers and local communities and ensuring a balance between humans and nature that is essential to sustainable human development.

The authority given to this new institution has allowed for the continuity and implementation of a series of strategic programs and projects: immigration control, implementation of information and communication technologies for development, the strengthening of local governments, planning for territorial zoning, education and human resource capacity building, and management of the natural resources of Galapagos, with special emphasis on the control of invasive species.

The new mission, vision, and values of the Governing Council of Galapagos are focused on successfully implementing these strategic lines of action.

Mission:
The Governing Council of Galapagos is a governance structure created by constitutional mandate with authority to administer the Province. Through its planning activities it permits sustainable human development while ensuring the conservation of Ecuador's natural heritage. Managing resources with transparency, responsibility, the best available technology, and a commitment to service, we guarantee a high quality of life in Galapagos.

Vision:
The Governing Council of Galapagos is a model government in its administration of the Galapagos Province, ensuring human development and protection of the environment.

Values:
The Governing Council of Galapagos is ethical, respectful, transparent, and balanced in its work.

Photo Page 8 : M. Verónica Toral Granda

Photo: Jacintha Castora Photography

INTRODUCTION

Sustainability in Galapagos: the need for a shared vision and collaborative work for the good of the ecosystems and the human population

Washington Tapia[1], J. Gabriel López[2] and Fabián Zapata[3]

[1]Galapagos National Park
[2]Charles Darwin Foundation
[3]Governing Council of Galapagos

Galapagos is recognized as a model of conservation. It is in fact a natural laboratory where evolutionary processes can be observed and where unique ecosystems have largely been preserved.

However, it is also true that for more than a century, since the first permanent human population was established, Galapagos has undergone continued, exponential growth and has become a social laboratory, with a human population with many different origins, and as one would expect, many distinct interests. The problem arises with the recognition that Galapagos is a geographically isolated oceanic archipelago with few business opportunities that are both profitable and environmentally-friendly.

There are those who believe that this is not a problem given that there are many natural resources in Galapagos that can be exploited. But what many do not realize is that these resources include both biotic and abiotic elements of unique ecosystems, which in the case of Galapagos are fragile and have developed in complete isolation. Moreover they are resources needed for our survival and for the survival of future generations.

Photo: Daniela Chalén

In the last 15 years, the archipelago has undergone uncontrolled economic and population growth resulting from continually increasing tourism, with corresponding increases in the generation of waste and demands for water and energy. This process has also been accompanied by a significant increase in the number of motorized vehicles and cargo ships, and the rapid expansion of a consumer lifestyle that is in direct conflict with the ecological reality of this fragile archipelago.

Humans have destroyed many of the geographic barriers described by Darwin to help explain the evolution of the Galapagos biota. The results are clear: increasing numbers of invasive species, new threats to the endemic flora and fauna, severe tension related to the provision of basic services, the arrival of pandemic viruses, and increasing social problems commonly found in rapidly changing societies throughout the world.

There is a simple lesson that should be learned from this. Galapagos is not a paradise separate from the rest of the world. It is a constellation of very fragile ecosystems that now requires special care and attention to ensure that the forces of globalization do not overcome its capacity to assimilate, adapt, and recuperate from natural and human-made disturbances.

At this critical juncture, we must ask ourselves important questions. How do we best share the message regarding the limits to growth that exist in such a fragile and emblematic ecosystem? Are there alternatives to the scenarios of growth that have ultimately led to environmental degradation and the impoverishment of the populations in other fragile ecosystems around the world?

We ask ourselves these questions because Galapagos is at a crossroads with a narrow window of opportunity to act in a decisive manner to put the archipelago on a path to sustainability.

The development of a shared vision for the future of Galapagos is urgently needed. Arriving at this vision requires reflection on a number of questions that are both simple and complex. Can natural resources be exploited in Galapagos as they are in other parts of the world? What will happen to the human population if Galapagos loses the species and landscapes that attract visitors? Is it possible to develop profitable businesses that can guarantee the welfare of the local population? Is it possible to achieve human development without the conservation of nature and vice versa? There are many questions but only one response: a healthy and sustainable population and economy and a high quality of life for the population of Galapagos require healthy and resilient natural ecosystems.

In this sense it is clear that while urgent measures are needed to increase the resiliency of ecosystems confronted by human activity and the erosion of geographic isolation, it is equally essential to understand and accept that the Galapagos social system requires a profound transformation in terms of its structure, without which policies and management models will be ineffective over the long term (Tapia *et al.*, 2009).

This transformation depends upon those who live in Galapagos, as well as those in continental Ecuador and throughout the world, who have an interest in conserving the archipelago and improving the quality of life of its human population. We must begin by recognizing that the only reason that Galapagos is at risk is that it continues to be an archipelago in an excellent state of conservation. The islands still have nearly all of the species and ecosystems that developed thousands or millions of years ago, before humans even knew the islands existed. It is critical that we learn to live in balance with the natural systems in Galapagos, even if this means that we must modify our way of life.

The Galapagos ecosystem is extremely fragile and complex with strong links and interconnections among ecological, social, and economic components. It is time to plan and implement whatever actions are needed to protect this system, however simple they may seem. We must all understand that resiliency is not an absolute and fixed property. On the contrary, resiliency is variable over time and dependent in a large part upon the actions of humans. The ancient Heraclitus stated, "There is nothing permanent except change." This statement gains greater validity in an increasingly globalized world when speaking of sustainability. The transformation of complex systems such as Galapagos is inevitable, especially when Ecuador and the entire region are undergoing a process of transformation and adaptation to change.

The biodiversity and ecosystems of Galapagos—properly managed—are capable of sustaining a quality life for local residents. However the economic model in Galapagos and lifestyle of the local population will determine whether or not this balance between humans and nature is met. Twelve years ago, the Special Law for Galapagos called for conservation and sustainable development in the province. Achieving these goals will require consideration of both the natural and socioeconomic systems in Galapagos at all levels of decision-making.

A new integrated vision of a sustainable and equitable society that lives in harmony with the natural resources of Galapagos could be the solution for the islands and at the same time serve as a model for the world. But this vision must be built among all stakeholders, with a focus on both the short and long term. This is still possible in Galapagos. Galapagos residents understand the need for change. The current process to develop the new Special Law for Galapagos is forcing us to evaluate the situation and make decisions that will lead us to a better, more sustainable future. But time is short. Clear, direct, and well-founded decisions and actions are required.

The current situation in the islands requires the cooperation and goodwill of all institutions and individuals concerned about Galapagos and interested in building a future that will ensure both the long-term conservation of the unique ecosystems of the archipelago and the welfare of its inhabitants. The challenge is huge and time is short. The responsibility is ours. Future generations will judge whether or not we met the challenge.

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TRANSPORTATION

Photo Title Page Transportation Section: Jacintha Castora Photography

Photo: Jacintha Castora Photography

Optimizing marine transport of food products to Galapagos: advances in the implementation plan

Fabián Zapata Erazo and Marcelo Martinetti Granja

Governing Council of Galapagos

Maritime transport has been the principal means of supplying the Galapagos population with a wide range of products. Since the very first humans inhabited Galapagos, cargo ships have transported provisions and other products unavailable in Galapagos in shipments that increased in size and frequency with the growth of the population. Today, 86.7% of cargo destined for Galapagos is transported by sea, since maritime transport is the most inexpensive means of delivering goods to the archipelago (Table 1). However, maritime transport presents greater probability of food safety problems because of the poor quality of docks, ships, and the latent risk of transporting and introducing invasive pests to Galapagos. It is estimated that more than 75% of the food products that arrive in Galapagos enter via maritime routes (Zapata, 2007). Guayaquil is the primary port from which cargo is shipped to Galapagos.

Table 1. Quantity of cargo transported from continental Ecuador by air and maritime routes (2009).

Month	Air				Maritime		TOTA L	
	Quito		Guayaquil		Guayaquil		Packages	Kg
	Packages	Kg	Packages	Kg	Packages	Kg		
January	19 450	82 088	2 944	7 053	19 491	203 849	41 885	292 990
February	3 730	75 344	3 558	38 735	60 113	400 345	67 401	514 424
March	4 400	80 039	3 387	35 382	72 321	523 417	80 108	638 838
April	4 800	92 212	2 971	34 374	79 435	615 846	87 206	742 429
May	5 058	91 269	3 877	40 089	87 533	629 872	96 468	761 230
June	4 799	87 696	3 677	37 960	90 019	640 981	98 495	766 637
Total	42 237	508 648	20 414	193 593	408 912	3 014 310	471 563	3 716 551
%	9 %	13.7%	4.3 %	5.2%	86.7%	81.1%	100%	100%

Economic development has generated a continual increase in the demand for agricultural products among inhabitants of the islands and the thousands of tourists who visit Galapagos annually. Food products are transported to Galapagos from different parts of Ecuador under climatologically adverse conditions. Physical damage is common, caused by improper handling, pests, temperature changes, and prolonged storage.

Optimizing maritime cargo transport

On January 21, 2008, the INGALA Council approved a project and implementation plan entitled "A System to Optimize Maritime Transport," with a key goal being the optimization of maritime transport of food products. In this same year, a phytosanitary emergency was declared in Galapagos because of the introduction of the fruit fly.

The National Institute of Galapagos (INGALA), the Ecuadorian Agency for Quality Assurance in Agriculture (AGROCALIDAD), and representatives of the commercial sector of the islands established a list of appropriate packing materials according to the characteristics of the product to be transported. This list was approved in December 2008 by the Agricultural Health Committee, the entity responsible for planning and ensuring compliance with health and phytosanitary measures in Galapagos.

This article documents problems associated with the traditional maritime transport system, advances in the implementation of the new system, and improvements planned for the coming years.

Traditional system of transporting cargo to Galapagos

During the last 10 years the number of cargo ships serving Galapagos has fluctuated between four and five, with ships averaging between 30 and 40 years old. Ships deliver food products to the three principal islands in the archipelago: San Cristóbal, Santa Cruz, and Isabela. On average, each ship completes its delivery route (Guayaquil-Galapagos-Guayaquil) in three weeks. The capacity of the ships ranges from 300 to 1100 tons (Zapata, 2005). Food products (animal and vegetable) represent 7% of the total maritime cargo. This low percentage has resulted in food shortages and price speculation in local stores.

The new plan addresses the many problems identified in the current maritime transport system (Table 2; Figures 1-4).

Table 2. Problems and potential solutions associated with the current maritime transport system.

Traditional Transport System	Problems Identified	Potential Solutions
Cargo is loaded on the city of Guayaquil dock	• Lack of port infrastructure for proper loading and quarantine control • Physical damage to cargo especially food products due to poor handling	• Implement the use of containers and mechanized loading techniques
Port facilities	• An ideal location has not been identified in Guayaquil for the construction of an improved port facility with quarantine facilities • The docks of Guayaquil and Galapagos do not have restricted areas for personnel, climate-controlled storage areas, or cold storage for products arriving from other regions • The docks of Galapagos are made from reinforced concrete	• Conduct design studies for port facilities on the islands of San Cristóbal, Santa Cruz, and Isabela • Acquire a location in Guayaquil for the construction of a port authority for cargo and quarantine control • Construct port facilities on the islands of San Cristóbal, Santa Cruz, Isabela, and the city of Guayaquil

Port facilities	and do not have adequate space for proper port facilities, including quarantine control for food products that arrive in Galapagos • The docks in Galapagos do not have mechanical cranes to optimize loading and unloading operations (it is currently done by manual labor) • The docks in Galapagos are used for multiple purposes (fishing, fueling, and local inter-island transport)	
Pest control and fumigation	• Pest control/fumigation systems on docks, ships, or in cargo facilities do not exist • Procedures do not exist to certify fumigation services or to verify compliance with fumigations controls	• Initiate pest control and fumigation procedures and quarantine of food products, merchandise, docks, and ships in the city of Guayaquil
Quarantine measures	• There are no approved quarantine procedures for cargo and food products in Galapagos or in Guayaquil • Current quarantine measures include random visual inspections; 60% of the cargo entering Galapagos via maritime transport is inspected in this manner	• Develop a procedures manual for each type of food and restricted product • Inspect 95% of the food products that are shipped from the city of Guayaquil
Ships without infrastructure to transport food products	• The majority of ships do not have storage holds that can ensure proper refrigeration of perishable products • The walls of the holds are oxidized and in bad condition and can contribute to the deterioration of cargo—especially food products • Ships regularly overload cargo holds • Shipping containers are not used	• Implement the use of cold chambers • Update older ships in the maritime cargo fleet

Traditional Transport System	Problems Identified	Potential Solutions
Storage onboard ships	• Essential goods, food, non-organic cargo, and inflammable goods, such as construction supplies, household supplies, and cooking gas, are stored in the same locations within ships; specialized holds do not exist for storing different kinds of items, and cross contamination occurs • Food cargo and general cargo are loaded without any kind of planning or procedures	• Train dock hands, port personnel, and maritime transport personal
Unloading in Galapagos	• Unloading is done manually and in an unorganized fashion, resulting in mishandling and damage to cargo especially food products • Food and perishable products are damaged during stowage because of inadequate or inappropriate packing materials • The smaller boats and barges used to transfer cargo from anchored ships to the docks are not regularly cleaned, disinfected, or fumigated • These boats are obsolete and are inadequate for transporting perishable food and general merchandise	• Train the dock handlers in the islands • Renovate the barges used to transfer cargo especially food and perishable items from the boats to the docks in the islands
Commercialization of essential goods and food	• Due to scarcity of food products, many inhabitants of the islands are obliged to buy products in bad condition and possibly contaminated with bacteria, parasites, toxins, etc., which could cause gastrointestinal problems especially among young people	• Train the commercial sector in best practices in handling, storage, and commercialization

Figure 1. Ship transporting cargo over capacity and in unsanitary conditions.

Figure 2. There is no evidence of application of physical methods to control pests on the deck of the cargo ships.

Figure 3. Storage of organic consumer products alongside sacks of cement in the hold of the ship.

Figure 4. Caraguay Dock in the city of Guayaquil, where cargo ships destined for Galapagos are loaded. There are no mechanical cranes, no areas for pest control, receipt/handling of cargo, or road access to protect food cargo.

As a result of current handling practices and inadequate infrastructure, food products—especially fruit, vegetables, legumes, grains, and meat and dairy products—often arrive in Galapagos in bad condition. Between 2000 and 2008, 60% of the food products that were confiscated were prohibited products (PP), 30% were restricted products (RP), 8% were in poor condition (PC), and 2% were infested with pests (IP) (Table 3). The current system allows for the possible introduction of pests, including insects, rodents, mammals, and reptiles, which could have negative effects on the unique ecosystems of Galapagos. Eradication and control of invasive species is expensive and not always possible. The cost associated with introduced species affects everyone in Galapagos—especially farmers and the institutions in charge of eradicating and controlling introduced species in the Galapagos National Park.

Table 3. Units of food cargo confiscated in Guayaquil, Quito, and Galapagos between 2000 and 2008 (PP=Prohibited Products; RP=Restricted Products; PC=Poor Condition; IP=Infested Products).

Year	PP	RP	PC	IP	Total
2000	197	57	37	17	308
2001	475	114	349	63	1001
2002	566	161	347	44	1118
2003	504	66	295	72	937
2004	1303	783	229	145	2460
2005	1342	587	260	119	2308
2006	1277	525	244	105	2151
2007	1414	696	94	112	2316
2008	1654	814	232	55	2755
Total	**5664**	**2293**	**1761**	**565**	**15 354**

Implementation of system to optimize the transport of maritime cargo

The implementation plan includes the production of a guide geared to suppliers, transportation companies, and merchants that explains the use of appropriate packaging materials and techniques for different kinds of food products (Figure 5). For example, the use of plastic bins, appropriately sized cardboard boxes, and sacks for less delicate items makes cargo more uniform and optimizes the space in the holds of ships (Figure 6). It also facilitates phytosanitary controls and the loading and unloading of products. The guides were handed out at events held by INGALA and other organizations in Galapagos and the information was also disseminated via local radio and television.

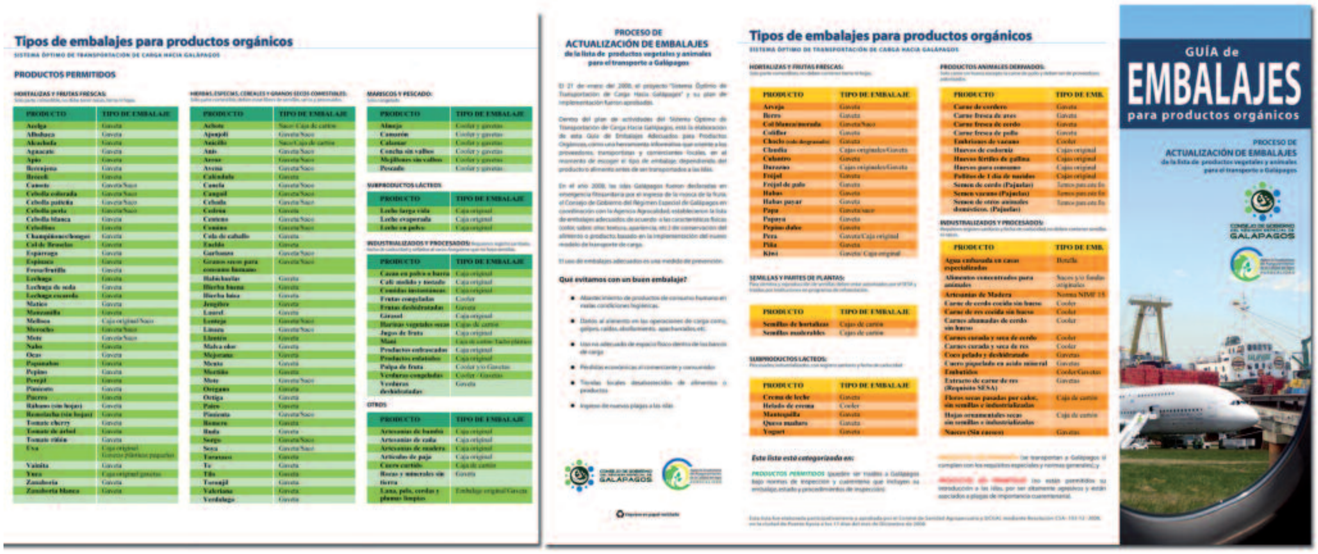

Figure 5 . Packaging guide for food products, designed to educate the commercial sector about selecting packing materials according to the characteristics of different products.

Figure 6. Implementation of the measures outlined in the Packaging Guide, with packaging selected according to the type of produce.

Labeling cargo—especially food items—is essential. To assist in this, INGALA designed and distributed a guide of symbols used for the handling and storage of cargo. Packaging of items destined for Galapagos should include the following information: name of the consignee, island of destination, storage requirements (for food products), and symbols that orient handlers about how to handle the product. Beginning in 2010 colored tapes are used to identify the island of destination. This has helped to reduce confusion and economic losses.

INGALA and AGROCALIDAD signed an agreement to design a campaign to certify Galapagos merchants selling food products, in order to facilitate the collection of information by food quality inspectors. The campaign was carried out in August 2009, during which time 264, 93, and 29 merchants were registered on Santa Cruz, San Cristóbal, and Isabela, respectively. Merchants provided basic information about their products (origin, destination, areas free of pests, list of pests, etc.). This process also provided an opportunity to identify individuals with irregular immigration status who were involved in the commercialization of basic goods.

INGALA will use the information obtained through this process to create a phytosanitary monitoring system to prevent the introduction of pests and to provide up-to-date, relevant information to planners and decision-makers. The implementation of this system involves educational activities for merchants, consumers, and inspectors on best practices for handling food items, food safety, and quarantine procedures. A guide has been designed on best practices related to preventative sanitary practices to reduce the risk of contamination of food products and the introduction of pests, which will help to guarantee the health of consumers and Galapagos ecosystems (Figure 7).

Figure 7. Guide of best practices - developed to prevent physical, chemical, and microbiological contamination of food products throughout the transportation chain and in local stores.

During three participatory meetings, representatives of the five maritime transport companies serving Galapagos and four representatives from the institutions responsible for pest control, quality of food products, and maritime safety (Galapagos National Park, AGROCALIDAD, INGALA, and the Directorate of Insular Water Areas) established requirements for ships carrying food products to Galapagos. The most important requirement is the separation of general cargo from food products. The regulations stipulate that fruits, vegetables, and legumes must be transported in holds with cold storage capacity. Shellfish, fish, and processed meats must be kept frozen. Food products that do not need to be refrigerated must be transported in sealed holds. General cargo and dangerous items must be kept in holds that are hermetically separated from items for human consumption (Figure 8).

Figure 8. Climate controlled storage containers onboard cargo ships help to preserve products during the three-day voyage from Guayaquil to Galapagos.

Another requirement is that boats must be fumigated before departing the mainland with cargo. Since September 2009, maritime authorities have prohibited the departure of three ships that did not comply with this requirement. INGALA and AGROCALIDAD have developed and disseminated a list of certified fumigation companies that can be used by ships traveling to Galapagos (Table 4).

Table 4. Fumigation companies certified by AGROCALIDAD.

Name of the company	Legal representative	Province	Mode of transport they can fumigate	Products used
Rizobacter Ecuatoriana	Tomas Cantore Mugica	Guayas	Air and maritime	SIPERTRIN beta cipermetrina 5% concentrated suspension MAXFORCE CUCARACHAS (Fipronil 0.01%) MAXFORCE HORMIGA (Hydramethyl non 1.0%) KLERAT BLOQUE PARAFINADO (Brodifacuom 0.05 g/kg of product)
Balin Fumigaciones	Mauricio Peralta Hidalgo	Pichincha	Air and maritime	SIPERTRIN beta cipermetrina 5% concentrated suspension MAXFORCE CUCARACHAS (Fipronil 0.01%) MAXFORCE HORMIGA (Hydramethyl non 1.0%) KLERAT BLOQUE PARAFINADO (Brodifacuom 0.05 g/kg of product)
Desinpalet	Juan del Pozo	Pichincha	Palette	Bromuro de metilo
Galápagos Radiante	Grace Vascones	Galápagos	Air and maritime	SIPERTRIN beta cipermetrina 5% concentrated suspension MAXFORCE CUCARACHAS (Fipronil 0.01%) MAXFORCE HORMIGA (Hydramethyl non 1.0%) KLERAT BLOQUE PARAFINADO (Brodifacuom 0.05 g/kg of product)
SEGMAR	Gerardo Vargas	Guayas and Galápagos	Air and maritime	SIPERTRIN beta cipermetrina 5% concentrated suspension MAXFORCE CUCARACHAS (Fipronil 0.01%) MAXFORCE HORMIGA (Hydramethyl non 1.0%) KLERAT BLOQUE PARAFINADO (Brodifacuom 0.05 g/kg of product)

In 2008, the Government of Ecuador facilitated the entry of two new ships (Angelina I and Galapagos) to the maritime transport fleet in order to ensure an adequate supply of food items for Galapagos (Figure 9). Both ships are equipped for proper transport of organic materials.

INGALA is working with the Provincial Government, the Sub-secretary of Ports and Transportation, and the Consortium of Galapagos Municipalities on the design of new port facilities for Galapagos, which will include piers equipped for loading and unloading and quarantine areas. INGALA provided $50,000 to the local governments of Santa Cruz and Isabela for studies and designs associated with new port facilities. In the case of San Cristóbal, INGALA will invest $50,000 to contract consultants to carry out similar studies and designs. INGALA has invested $25,000 in a study to identify sites for dedi-

Figure 9. New cargo ships for Galapagos, the Angelina I (top) and the Galapagos (bottom). According to the new shipping regulations, only vessels with proper loading equipment and cold storage can enter the fleet.

cated port and quarantine facilities on the mainland. Once a location has been identified, design services will be contracted.

During the first 20 months following the implementation of the Plan, INGALA invested a total of US$128,730 and implemented 39% of the project. The implementation plan, to be completed in 2012, has three components: (i) optimization of cargo (quarantine controls, fumigations/pest control); (ii) optimization of ship infrastructure, and (iii) optimization of port facilities.

Photo: Emmanuel Cléder

Taxis in Santa Cruz: Uncontrolled mobilization

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Introduction

Since the 1980s, the lifestyle of the resident population of Galapagos has changed rapidly, appearing more and more like the lifestyle of continental Ecuador. This process of continentalization (Grenier, 2007) has accelerated in the last decade and is characterized by increased use of motorized terrestrial transportation. These changes are taking place primarily in Puerto Ayora, Santa Cruz, the economic center of Galapagos and home to approximately two thirds of the insular population (INEC, 2006). The increase in the use of motorized vehicles – especially taxis – transforms both the inhabited space of Santa Cruz and the relation of its inhabitants to their surroundings, which is referred to in this article as the "geographic milieu" of the insular population. The objectives of this article are: (i) to better understand the socioeconomic aspect of the taxi system; and (ii) to show that the increasing use of taxis contributes to a transformation of the geographic milieu of Santa Cruz, creating challenges for decision-makers who seek to maintain an insular lifestyle and to protect the environment.

Methods

Study area

This study was completed between February and April 2009 in Santa Cruz. Santa Cruz was chosen because terrestrial transport is more developed on the island, making it easier to observe the role of taxis in transforming living space and the geographic milieu.

Data collection

At the time of this study, a complete census of vehicles in Santa Cruz had not been completed (INGALA completed one in 2009, which is reported in this volume). The only database available was the municipal vehicle registry initiated in 1999. However, this source did not clearly indicate whether or not a vehicle was used as a taxi. Therefore it was necessary to cross-reference these data with information obtained from the three taxi cooperatives and two taxi companies on Santa Cruz, each of which has documentation for the permits issued by the Provincial Council of Transit and Transportation (now the Provincial Commission of Transportation, Transit, and Road Safety). However, knowing the number of taxis *sensu strictu* is not sufficient to explain how these vehicles and their use contribute to the organization and transformation of the landscape and the relationship of the population with its environment.

For this reason, the study observed the operation of taxis on the roads of Santa Cruz. Vehicles were counted at seven representative locations in Puerto Ayora. Circulating vehicles were counted every day of the week at the same times (7h-8h, 11h30-12h30, 17h-18h). This process was conducted twice at each location. Vehicles were classified by type: construction machinery and cargo transport, taxi, private non-professional vehicle, bus and minibus, motorcycle, and institutional and private business vehicles. In the case of taxis, it was also noted whether or not the vehicle carried passengers.

To determine the relationship between the data collected and the impacts of taxis, the study took into account the organization and evolution of the physical space of Santa Cruz (Sánchez, 2007). However, the 119 surveys of taxi drivers and 63 of taxi owners provided the best information regarding the space used by taxis in Santa Cruz. The surveys provided a deeper understanding of the role of taxis in the evolution of the geographic milieu of Santa Cruz inhabitants, in part because the relationship between society and its environment includes a subjective dimension that cannot be analyzed solely through traditional statistical data. The surveys had the advantage of providing insights based on perceptions, as well as qualitative and quantitative data related to the financial dimensions of the taxi sector that are unavailable through information provided by public institutions or taxi cooperatives and companies. For example, only those people directly involved in the sector could provide information on costs and benefits and the sharing of costs and income between taxi drivers and owners.

Results

The total number of vehicles and taxis: unlimited growth?

According to the vehicle census completed by INGALA in 2009, there were 1962 vehicles registered in Galapagos, of which 1074 are located in Santa Cruz. In Santa Cruz, 205 of these vehicles were taxis (Oviedo *et al.*, this volume). This number is lower than INGALA's 2006 estimate, which indicated "at least 2051 vehicles in Galapagos" and 1276 vehicles in Santa Cruz (Villa, 2007; pp 74). However, even the casual observer will note that the number of vehicles has not declined. In fact, 93% of 120 inhabitants surveyed in 2008 indicated that traffic has increased in recent years (Grenier, 2008).

The current study is based on 260 taxis in Santa Cruz, which is the number of taxis registered by Santa Cruz taxi cooperatives and companies with the Provincial Commission of Transportation, Transit, and Road Safety. The INGALA census of 2009 shows 55 fewer taxis than the registry, highlighting a problem in data keeping, perhaps related to the sensitive nature of this topic.

It is clear that taxis play an increasingly important role in the life of the population of Santa Cruz. In 1990 there was only one taxi for every 350 inhabitants (15 taxis in the island), while in 2006 (the last population census) there was one taxi for every 50 inhabitants. In 2008, it was estimated that 64% of the population of Santa Cruz used taxis at least a few times each week (Grenier, 2008).

The evolution of mobility in Santa Cruz is reflected by the increase in the number of taxis as well as the number of vehicles in general (Figure 1), which reveals a growing dependence on the use of motorized vehicles. The sale of fuel destined for terrestrial transport is also a good indicator of this evolution. Using survey results and data from Petroecuador, it is estimated that each taxi consumes an average of eight gallons per day, which translates into fuel consumption by the taxi fleet in Santa Cruz of approximately 1800 gallons per day. This represents US$2500 in average daily sales for Petroecuador or 55% of all fuel destined for terrestrial transport in Santa Cruz.

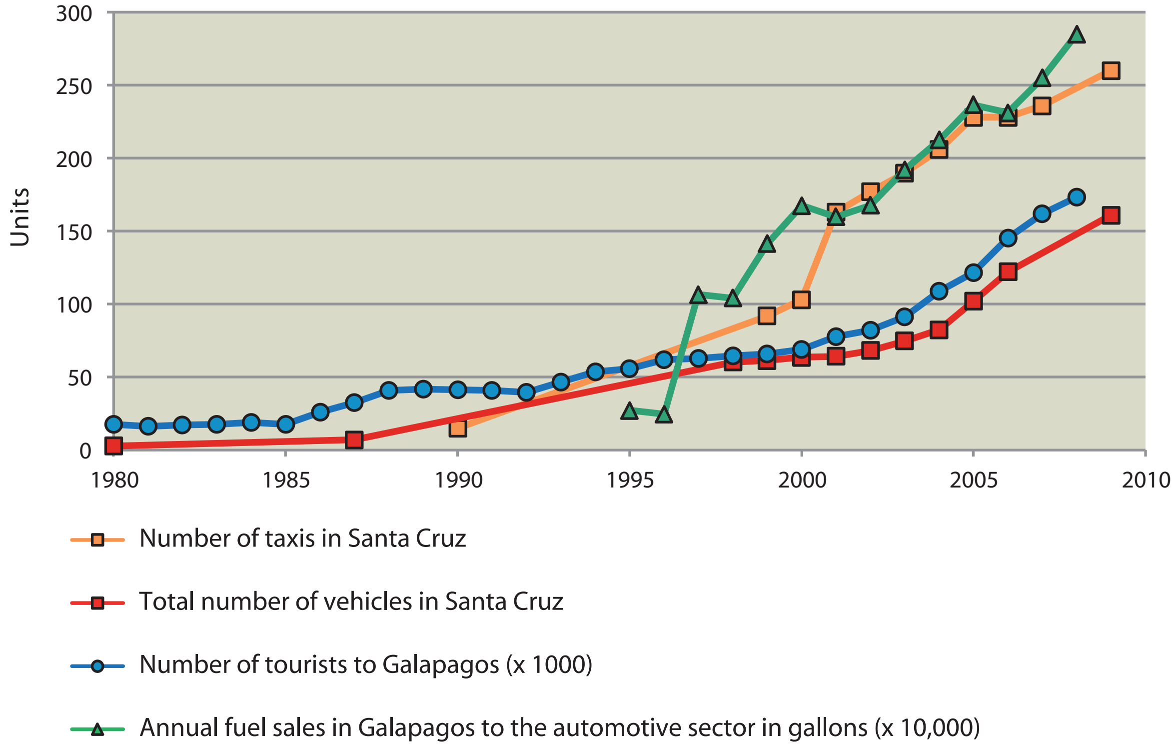


Figure 1. The growth in the number of taxis is part of a general tendency of unsustainable growth in the total number of vehicles, the annual number of tourists, and the annual fuel consumption. Sources: Taxi cooperatives and companies, 2009; Municipal records of Santa Cruz, 2008; Petroecuador, 2008; GNPS, 2008; Grenier, 2007.

Pervasiveness of taxis in Santa Cruz

The vehicle counts in this study show that taxis represent 62% of the vehicles that circulate in Puerto Ayora and almost 80% if we exclude two-wheeled vehicles (Figure 3; Map 1). The highest densities of taxis are found on Baltra Avenue (Figure 2) and Charles Darwin Avenue, which are the areas of busiest economic activity. The area near the dock, where the two principal routes cross, forms the circulation hub of taxis in Santa Cruz. Traffic jams are most frequent at the foot of Baltra Avenue. Significantly fewer taxis circulate in the residential neighborhoods in the northern part of the city, although a large portion of the population lives there.

Figure 2. Traffic on Baltra Avenue at 5 PM, Puerto Ayora, February 2010. Photo: Emmanual Cléder.

Photo: Etienne Ouvrard

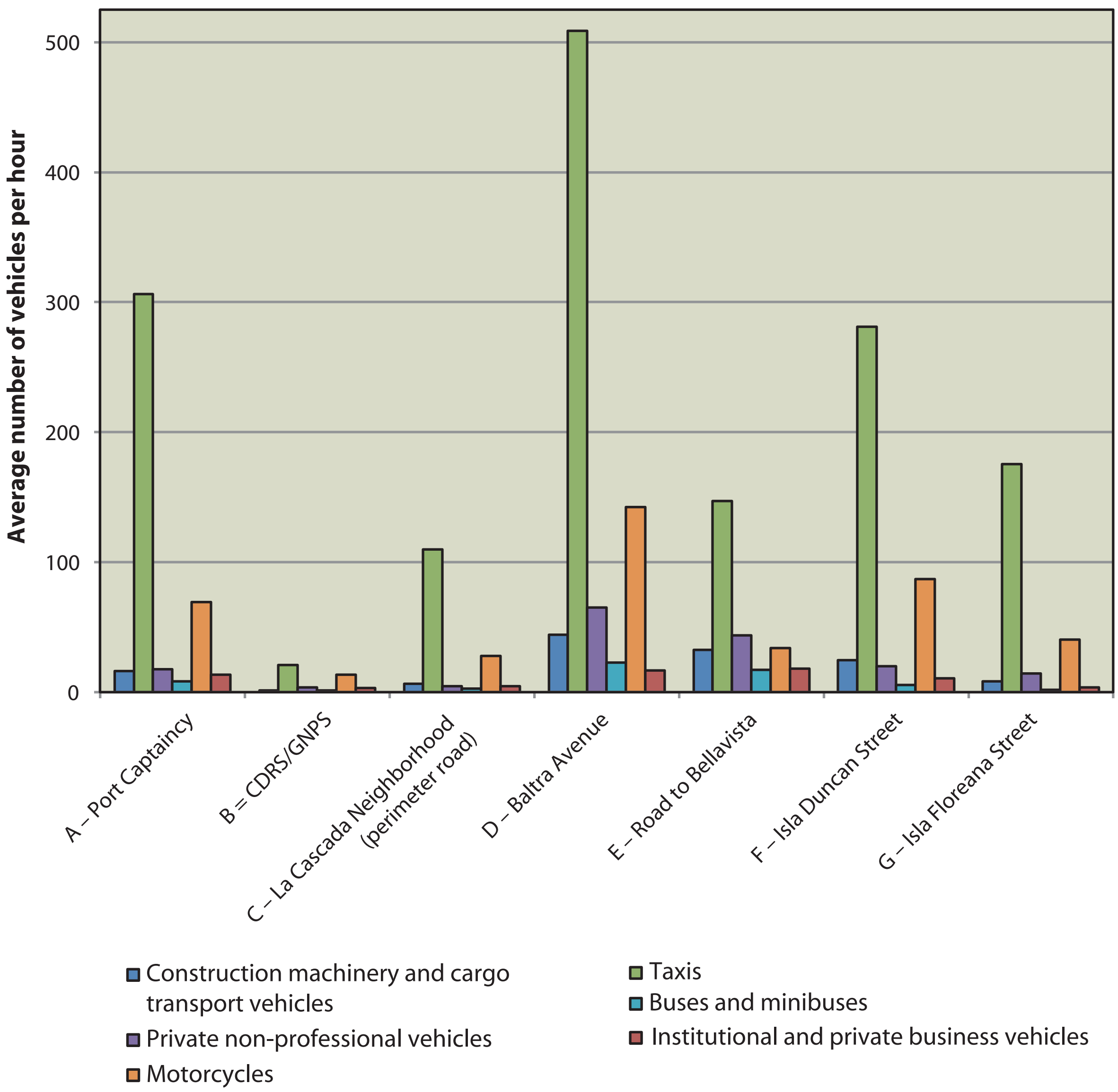
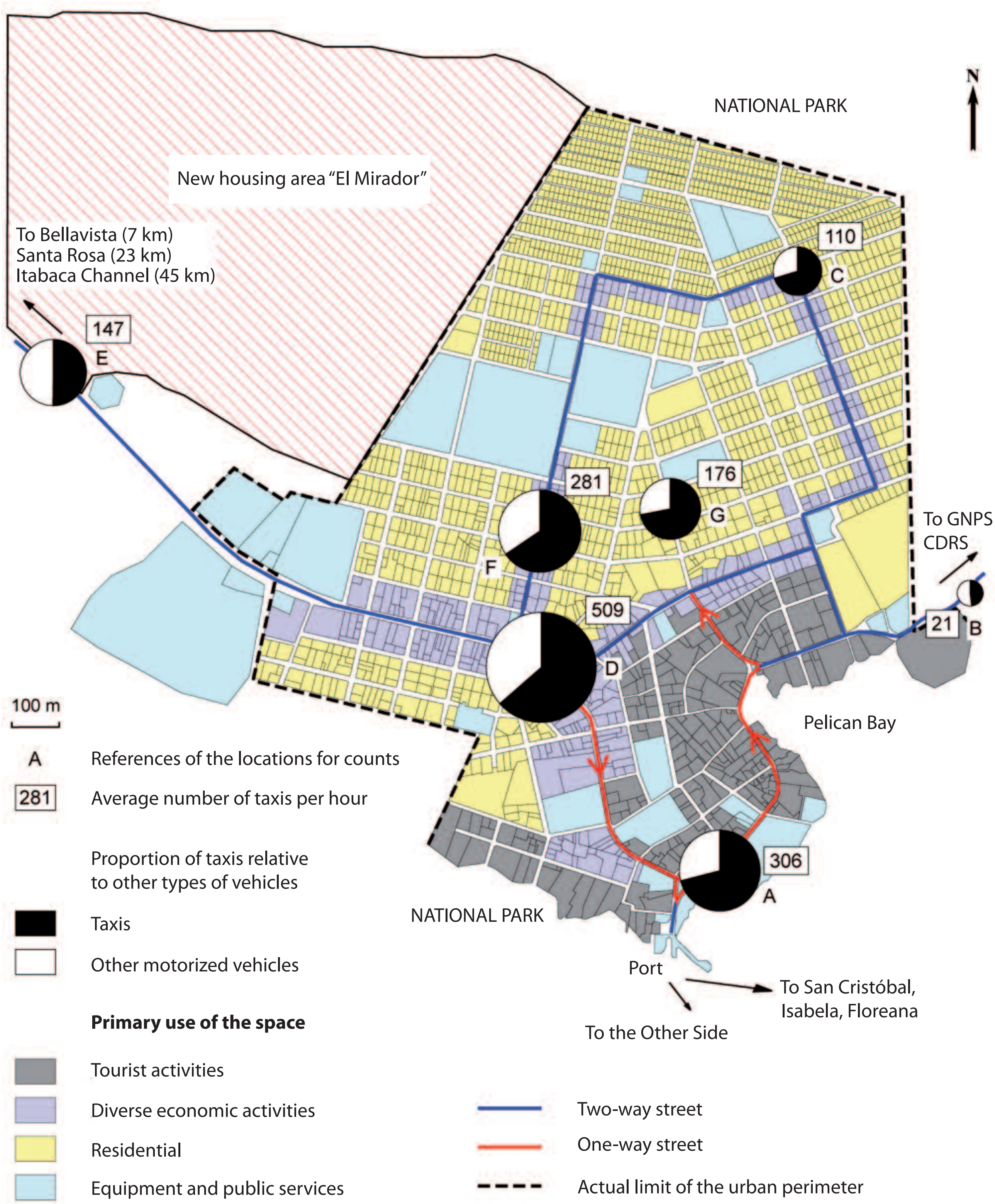


Figure 3. Classification of vehicles in circulation in Puerto Ayora indicating the average number observed per hour by location. The letters (A-G) reference the sites where the counts were made – see map.



Note: CDRS: Charles Darwin Research Station, GNPS: Galapagos National Park Service
Sources: Personal counts, INGALA, Municipality of Santa Cruz (land ownership map of 2007)

Map 1. Circulation of taxis in Puerto Ayora. Map design: Emmanuel Cléder

The observed densities of taxis do not truly reveal the use of taxis by the population. Since there are no specified taxi stands, taxis often circulate empty (Figure 4). A high degree of competition and no coordination of schedules among taxi drivers result in constant circulation, whether carrying passengers or not. The number of circulating unoccupied taxis varies by location. Baltra Avenue and Charles Darwin Avenue in front of the Port Captaincy represent extreme examples of inefficiency in the use of taxis in Santa Cruz, with almost two thirds of the vehicles circulating empty. The current method of searching for passengers by constantly circulating Puerto Ayora creates traffic jams, increased noise and air pollution, and greater danger for pedestrians and cyclists than would occur if taxis circulated only when carrying passengers.

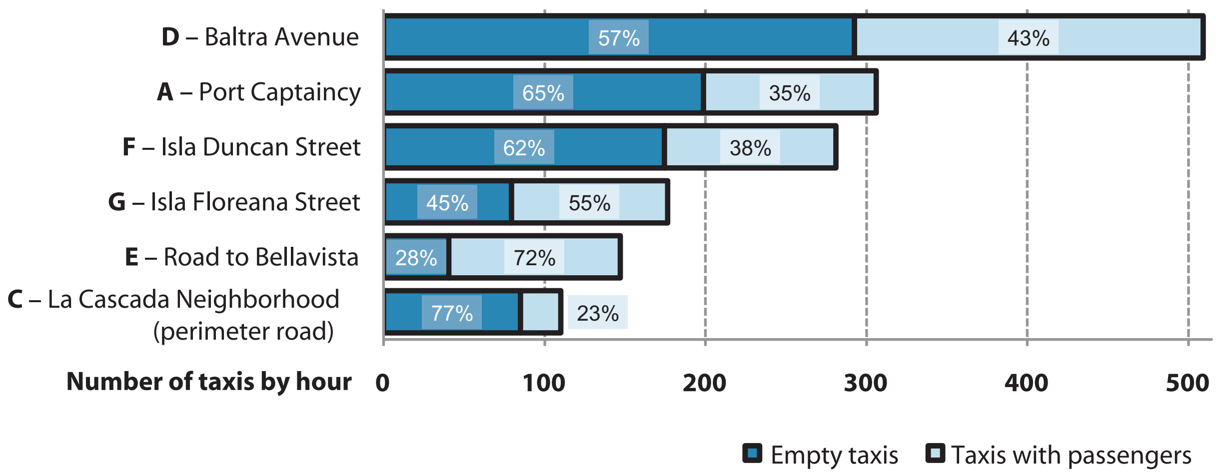


Figure 4. Number of taxis observed by hour and rate of occupation (%), by location. Note: data from the road to the CDRS and the GNPS are not included as few taxis use that route.

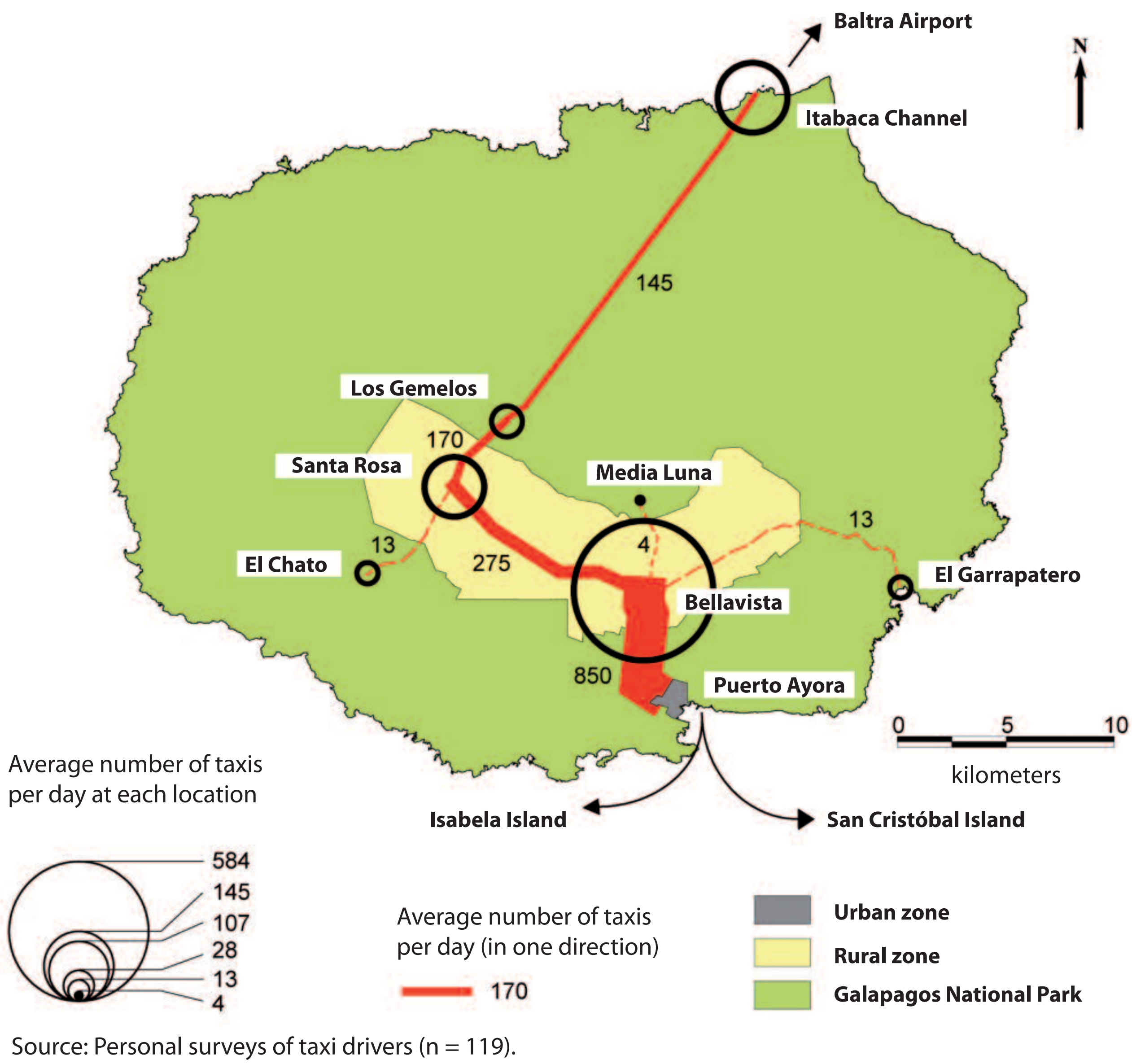
The increase in motorized transport and circulation of taxis is directly related to the expansion of the urban zones of Puerto Ayora. The road between Puerto Ayora and the Itabaca Channel, the backbone of terrestrial transport in Santa Cruz, concentrates the majority of the circulating taxis (Map 2). However, most taxi fares occur between Puerto Ayora and Bellavista, which has become a suburb of Puerto Ayora, in part due to the growing number of taxis. Today many people live in the highlands and work in Puerto Ayora. The increased population living in the highlands results in greater dependence on the use of personal cars or motorcycles, taxis, and buses.

Impacts of taxis on the geographic milieu of Santa Cruz inhabitants

The increase in circulation and use of taxis has measurable environmental impacts in Santa Cruz, such as animals, especially birds, struck by vehicles (Jiménez-Uzcátegui and Betancourt, 2008). The high fuel consumption by taxis (taxis average 240 km/day) results in carbon dioxide emissions of nearly 12 tons per day [1]. In addition, the high fuel consumption creates an increased demand for tanker ships to Galapagos, which in turn increases the risk of fuel spills. Additional impacts that are more difficult to measure must also be considered, such as increased noise, the degradation of island vistas, and increased stress among inhabitants due to the danger generated by the vehicular traffic.

The geographic milieu of the inhabitants of Santa Cruz has been even more impacted. The use of taxis makes everything closer. People become more and more accustomed to using motorized vehicles, even for short distances--sometimes less than two blocks, according to taxi drivers surveyed. Urban space appears to become larger for a population that "no longer wants to walk," as many of the taxi drivers indicated. These attitudes reflect a significant evolution in lifestyle. As the population attempts to gain economic benefit from the geographical opening of the island,

[1] According to the website of Toyota, a taxi such as those that circulate in Santa Cruz emits an average of 220 g of CO2 per kilometer (www.toyota.com).



Map 2. The circulation of taxis in Santa Cruz Island. Map design: Emmanuel Cléder

everything becomes faster than before and more like continental Ecuador. One could hypothesize that an individual does not have the same relation to his or her environment when they walk, ride a bicycle, or circulate in taxi (or in other motorized vehicles), and that their mode of transport will affect their perceptions of their environment and their views towards the conservation of Galapagos. This theme must be investigated further (see Grenier, 2008).

Why is the number of taxis in Santa Cruz increasing so rapidly?

The increase in taxis in Santa Cruz is driven by the income generated by this sector (an average of US$380,000/month is generated by taxi fares in Santa Cruz). To understand how this economic sector is organized and why it attracts so many investors, it is necessary to examine three categories of participants: (i) owners who lease their taxi to a driver; (ii) taxi drivers who own their vehicle; and (iii) taxi drivers who are employees and do not own their own vehicle.

Today in Santa Cruz, there are 204 owners of 260 registered taxis; 84% own a single vehicle and 12% own two taxis, while seven owners have three or four vehicles and the two major owners have six and eight taxis, respectively (Santa Cruz Municipality, vehicle registry, 2008). Of the 204 owners, about 43% drive their own vehicle, while 57% contract one or more drivers, depending on the number of vehicles they own. In other words, of the 260 taxis in Santa Cruz, 67% are driven by employees and 33% by their owners. Income levels vary significantly among these groups. (Figure 4).

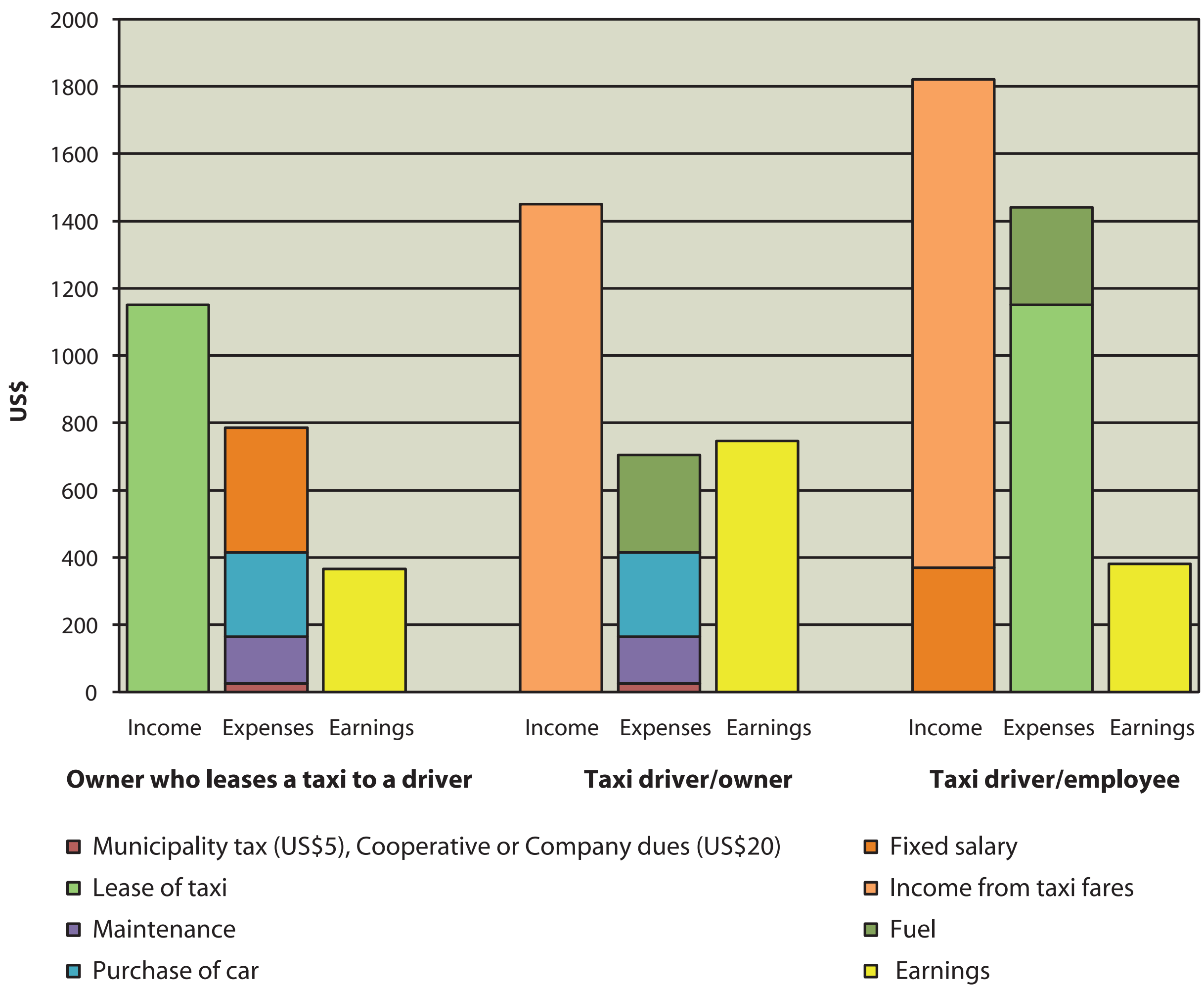


Figure 5. Monthly average economic situation (in US$) of each person involved in the taxi sector. Source: personal surveys - taxi drivers (n = 120) and owners (n = 60).

For owners who contract a driver (117), the purchase of a taxi represents a sound investment, generating approximately US$365 per month (net) for each taxi. This amount alone explains why so many people have purchased taxis in recent years. The initial cost of purchasing a taxi and the time required to recuperate this cost is the most significant barrier to investment. A taxi costs an average of US$20,000 and it must be exchanged for a new taxi every five years according to the law. If the taxi is resold for around US$5000, the investment represents a cost of US$250 per month.

Taxi owners pay a fixed salary to contracted drivers, averaging US$370/month. However, the driver must pay a daily amount back to the taxi owner (between $40-$50/day) to help cover maintenance costs and various permits. This payment or "leasing fee", which is not related to the fares collected, provides the owner approximately US$1150/month. The other expenses for the owner include cooperative or company dues (average of US$20/month), municipal taxes (average of US$50/year), and maintenance (approximately US$140/month).

Taxi owners who drive their own vehicles earn the most (average of US$745/month; Figure 5), since they do not pay a driver's salary; however they must work at the same intensity of other drivers. Owner/drivers must also pay for their fuel. This is the most important expense, averaging US$290/month. However this cost is subsidized by the Ecuadorian government, and has been for more than 20 years. In fact, the national fuel subsidy, plus an additional subsidy to cover the cost of transporting fuel to the archipelago, reduces the price of gasoline by approximately US$1/gallon and the price of diesel by approximately US$1.56/gallon (Jácome, 2007). In this sense, the Ecuadorian government expends more than US$10 per day for every taxi circulating in Santa Cruz.

Finally, contracted taxi drivers earn around US$380 per month. Although the average daily fares collected total around US$50, most of this is paid back to the owner. In general, fares are not sufficient to cover the cost of "leasing" the vehicle and buying the gasoline (the 119 taxi driver employees surveyed indicated that they pay for the gas). Although driver-employees earn only a bit more than the owner who doesn't have to do the driving, taxi driving is highly attractive to young men from continental Ecuador who could not earn as much in their town of origin (of the taxi drivers who are not galapagueño, more than 60% came to Galapagos for work). The surveys reveal that only 10% of taxi drivers were born in Galapagos, and that more than half of the immigrant taxi drivers arrived in the archipelago after 2000.

While taxis generate benefits, those benefits are distributed unequally among owners, owner/drivers, and driver/employees. Taxis remain an attractive investment to those with sufficient resources, because owners can find drivers willing to work for little money.

Taxis in Santa Cruz – organized disorder

While economic incentives explain the increase in the number of taxis in Santa Cruz, the traffic jams and disorder created by taxis constantly circulating in Puerto Ayora is better understood through the "organization" of this economic sector.

To use a vehicle as a taxi, an owner must be a member of one of three taxi cooperatives or two taxi companies of Santa Cruz and obtain a permit from the Provincial Commission of Transportation, Transit, and Road Safety. Beyond this, each taxi owner manages their business as they see fit, with limited controls or regulations (owners decide who to hire, how much to pay, when to operate, etc.). In reality, the "taxi system" is a conglomeration of 204 independent businesses. Taxi cooperatives and companies are little more than associations of private interests. Members will defend a common objective only when personal interests appear to be threatened, for example when the municipality proposed to establish taxi stands to reduce traffic. The contractual relationship between driver/employees and the owners they work for may explain the competition among taxis for passengers (which translates into speeding and constant circulation), since drivers only begin to earn money after they cover the daily lease fees. Also, since the fare is independent of the time required for a given trip, taxi drivers gain the most advantage when they deliver their passengers as rapidly as possible.

The lack of regulation can also help to explain the sense of competition that exists within the taxi sector. However, there are a number of laws that limit the importation of vehicles, including new taxis. Five different regulations[2] have been established since 1997, when it was decreed that "importation of automobiles is authorized only for activities of conservation, agriculture, and to renovate public and private transportation." The regulations of 1999 and 2005 established moratoria on the importation of vehicles to Galapagos. Even so the number of vehicles and taxis in Santa Cruz continues to increase.

The difficulty of regulating this sector was demonstrated when the project to establish taxi stands, proposed by the municipality of Santa Cruz, failed. Taxis continue to circulate continuously searching for passengers, resulting in air and noise pollution, increased traffic, and even traffic jams on some streets. The situation is compounded by the lack of signage, which makes it dangerous to walk or to travel by bicycle in Santa Cruz, as demonstrated by recent accidents involving taxis (see for example, the local newspaper *El Colono*, April 2009 and May 2009).

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[2] 1997: Segundo Suplemento, Official Register No. 55, Wednesday 30 April 1997.
1998: Ley Orgánica de Régimen Especial para la Conservación y el Desarrollo Sustentable de le Provincia de Galápagos, approved by the National Congress, Official Register No. 278, 18 March 1998.
1999: Normas para la autorización y control del ingreso de vehículos motorizados y maquinaria al Archipiélago de Colón, approved by the INGALA Council via Resolution No. 002-CI-IV-99.
2005: Reglamento especial de control del ingreso de vehículos motorizados y maquinaria a la provincia de Galápagos, approved by the INGALA Council via Resolution No. 02-18-CI-2005, January 2005.
2009: El reglamento substitutivo de control de ingreso de vehículos motorizados y maquinaria a la provincia de Galápagos, approved by the INGALA Council via Resolution No. CI-11/ 12-II-2009.

Photo: Emmanuel Cléder

Discussion

In just a few years, taxis in Santa Cruz have become omnipresent in the lives of the population. It has become common to use a taxi to travel relatively short distances and the number of taxis continues to increase. The high density of taxis in Santa Cruz can be explained by the structure of the "taxi system." Incentives in that system explain the competition between taxi drivers, which results in a race for clients and higher velocities.

After months of study, surveys, and interviews, we asked ourselves if public authorities are capable of regulating this sector, which appears to hold a great deal of power. Nevertheless, increased levels of traffic, noise, and danger to pedestrians and cyclists have deteriorated the quality of life in Puerto Ayora, and this must be reversed. With this in mind, we propose a series of recommendations:

- Reduce the constant circulation of empty taxis by creating taxi stands in the principal areas of use and/or develop a radio system similar to that of San Cristóbal.

- Accompany these measures by rotations in work hours of the taxi drivers to better match supply and demand, thus avoiding the excessive number of taxis on the roads of Santa Cruz. This measure could improve working conditions of the taxi drivers without reducing their income; if taxis only circulate with passengers, the number of taxis in circulation could be nearly halved without decreasing the service to the population.

- Develop other means of transport, including buses and minibuses, to reduce both emissions and traffic. While a taxi usually has no more than three or four passengers (when they are not empty), a bus can transport up to 45.

- Improve the conditions for bicyclists and pedestrians, by creating pedestrian walkways and sidewalks and extending the network of bike lanes and paths, thus providing greater incentive to use these modes of transport.

Conclusion

Decision-making requires political will and strong grassroots support. As the principal means of transportation in Santa Cruz, the taxi fleet represents a public service. At the same time, however, this sector is transforming the inhabited areas of the island. The extension of asphalt and the ever-increasing number of vehicles is contributing to a lifestyle that is incompatible with the fragile Galapagos environment. Citizens should be able to find a better balance between mobility and protection of their quality of life. To do this, there must be greater transparency regarding the economic benefits of the taxi cooperatives and companies, and a commitment by these groups to improve the organization of the sector. At the provincial level, the recently created Vehicles Committee must justify the importation of every new taxi.

It is disingenuous to present Galapagos as a "natural paradise" if the current transportation situation in Santa Cruz continues. Sustainable, locally-based tourism that is attractive to visitors who are tired of traffic and noise in their cities of origin requires a reduction in the number of taxis, the elimination of costly gasoline subsidies, and the development of a transportation system and culture that is better adapted to the island environment.

Photo: Jacintha Castora Photography

Transporting passengers by launches in Galapagos

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Introduction

Inter-island movement of people within Galapagos has greatly increased in recent years, due to a doubling of the population, increased tourism, and the associated transformation of the insular lifestyle. Although the biological consequences of increased boat traffic within the archipelago has been studied (Roque-Albelo *et al.*, 2008; Causton *et al.*, 2008), little is known about the socioeconomic aspects of maritime transportation. Our objective was to describe and evaluate current human movement among the populated islands of the archipelago via a fleet of speedboats, locally called launches.

This system of maritime transportation has evolved rapidly. Until 2004, trips between islands were available weekly aboard two public boats and a few launches (Zapata, 2005). Today, transportation options have increased significantly in number and quality, as the boats have been replaced by much faster launches. The analysis of this popular means of transportation contributes to an understanding of the kind of development that is occurring in Galapagos and its consequences for the conservation of the archipelago. This article presents the results of a study completed between February and May of 2009 as part of the Geographical Index Project carried out by the Charles Darwin Foundation.

Methods

To better understand the organization of the fleet of inter-island launches, 23 captains and/or owners of launches were asked to complete a questionnaire. Additionally, interviews were conducted with the Port Captains of Santa Cruz, Isabela, and San Cristóbal, the commander of the Second Naval Zone, and personnel of the

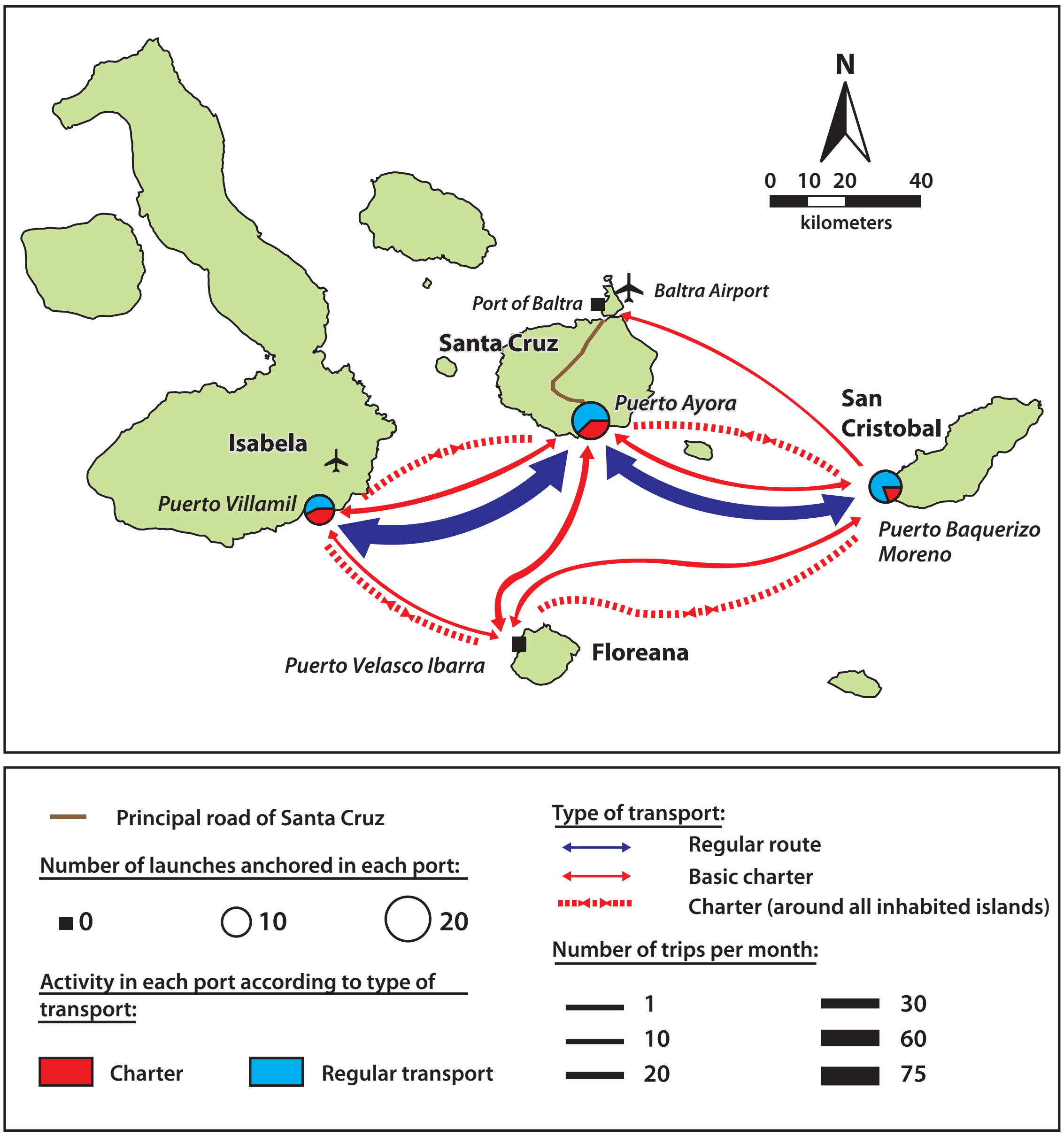
National Institute of Galapagos (INGALA) and the Inspection and Quarantine System for Galapagos (SICGAL). Finally, interviews were conducted with 166 residents of Galapagos (77 in Santa Cruz, 49 in San Cristóbal, and 40 in Isabela) and 41 tourists to study their movements within the archipelago, their use of launches, and their opinions regarding this type of transport. To complement these quantitative methods, we also observed launch operations in the ports of the four inhabited islands and traveled in launches.

Results

Organization of interisland transport

According to the Ecuadorian Navy, 35 launches offered regular passenger transportation in Galapagos in May 2009, with seven additional launches making sporadic trips. However, the Navy's lists are not up to date; of 50 registered boats, 13 were listed as "inoperative" although they continue to function. Comparing this information with observations we made in each port, we estimate that the maximum number of launches providing inter-island transportation is 44 (20 in Puerto Ayora, Santa Cruz; 14 in Puerto Baquerizo Moreno, San Cristóbal; and 10 in Puerto Villamil, Isabela). There are three associations of launch owners, one in each of the main ports. Only 20% of the owners operate their own vessels; the others employ a captain and crewman, who are generally paid daily for one round trip.

There are various routes and types of inter-island transport. The most common type is the regularly scheduled trips connecting the ports of the three



Map 1. Organization of the interisland transport of passengers among the inhabited islands. Sources: Questionnaires with captains (N = 23).

county seats of Galapagos. Launches leave Puerto Ayora every day in the early afternoon for Puerto Baquerizo Moreno and Puerto Villamil, and return to Santa Cruz the next morning (Map 1). This system provides daily connections, via Santa Cruz, between Isabela (where no national flights arrive) and Baltra, the principal airport in the archipelago.

The second type of transport by launch consists of charters contracted by residents, institutions, or tourism agencies or hotels for their clients. These trips might be "port to port," or might cover the four inhabited islands with the passengers spending the night on each island (Map 1).

The type of transport and the frequency of trips differ among the islands. Santa Cruz is the hub of the launch network. It is from this port that the majority of passengers travel to both Isabela and San Cristóbal using regularly scheduled service. In terms of charters, Floreana is the most common destination. The schedules and routes of the launch system appear to be directly related to the infrastructure (airports) on each island and scheduled flights to the continent.

Evolution of transportation by launches

Although transport by launch developed during the last decade, it is nearly impossible to document its evolution. The only register that we were able to obtain from the Port Captaincy of Puerto Ayora indicated that there were seven launches in Santa Cruz in 2004 and today the number is 20 (two of which began operation during the months of this study).

The fleet of launches is growing not only in terms of number but also the size of engines used. Today launch engines average 450 horsepower. Boats are able to make the trip between the major ports of the archipelago in approximately two hours, when only a few years ago it took at least five hours to travel from Puerto Ayora to Puerto Villamil aboard Isabela's municipal boat, the Estrella del Mar. The length of the trip may be shortened even more given that 40% of launch owners have indicated that they want to increase the size of their engines. It should be noted that during the last two years, 55% of the launch owners purchased more powerful engines.

Launches have an average authorized capacity of 20 passengers. They generally travel full when contracted as charters, but this is not always the case for the regularly scheduled trips. For example, the 30 launches in which we conducted head counts carried an average of 15 passengers. However, of the five launches we traveled on during the study, three traveled over capacity. The excess of passengers is due to a lack of coordination and last minute ticket sales. Since the Navy rarely monitors the launches and more passengers result in more income, owners often do not respect the legal passenger limits. If Navy personnel do observe a launch with too many passengers, the owner is supposed to pay a fine. In reality, fines are often not levied by the Navy (which provides permits to the launches) because of arrangements with boat owners, such as allowing Navy personnel to travel for free.

Users

Interviewing tourists proved difficult. Many declined to participate because they did not have time or were too tired from their trip. However, from those interviewed it was possible to determine that their perceptions of this means of transportation are different than those who live in Galapagos (Table 1).

The research was carried out in March-April when the seas are most calm. Transport by launch is considered more comfortable by residents than by tourists.

Table 1. Comparison in the perception of their trip by launch between tourists and residents.

Question	Residents (N=166)			Tourists (N= 41)		
	Yes (%)	No (%)	NR (%)	Yes (%)	No (%)	NR (%)
Is the trip by launch comfortable?	81	12	7	44	27	29
In the launch, is the noise a problem?	52	42	6	46	30	24
In the launch, do you travel relaxed?	59	33	8	85	12	3
In the launch, are you able to observe views and wildlife?	70	22	8	44	47	9
Would you have liked to have seen more marine animals?	82	8	10	74	23	3
Are you satisfied with this type of trip between islands?	75	18	7	65	35	0
*Is this a better service than the old boats?**	57	36	7	-	-	-

Photo: Etienne Ouvrard

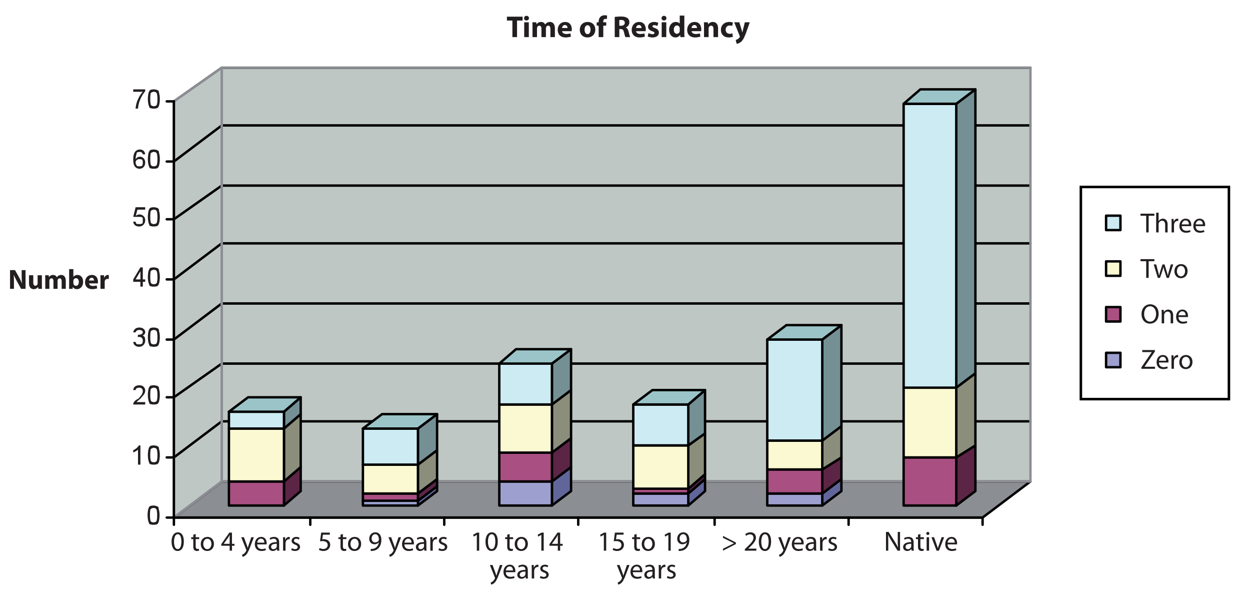
Tourists appear to expect certain comforts that residents do not require. The opposite is true when asking about safety. For some local residents the trips by sea seemed to be a kind of "test" – they were simply happy to arrive safely (28% of residents spontaneously reported being seasick, compared to only 5% of tourists).

Interviews reveal that residents appeared more attentive to the marine environment while traveling on launches than tourists, who generally come to Galapagos to view wildlife. Some of the tourists interviewed explained that they were less concerned about viewing wildlife aboard the launch because they had the opportunity to do so in the national park. However, the Park's last management plan highlighted the fact that conservation problems can arise when the public thinks differently about areas dedicated to tourism, where certain activities are restricted or prohibited, than they do about areas open for general public use (such as the maritime routes between the inhabited islands), where there are few restrictions on human activity. According to the launch captains, in order to offer increased comfort, boats are becoming more and more enclosed, making it more difficult to observe birds, marine mammals, or even the surrounding ocean. In the absence of regulations, they are also continuing to increase the speed of their vessels to better compete with the small planes that transport passengers between islands (Table 2).

Table 2. Type of transport preferentially used by residents.

Type of transport	%	Reasons mentioned
Launch	60	Cheapest form of transport (71%)
Small plane	22	Speed (77%); Comfort (16%)
No preference	6	Choose based on urgency and schedules
Work boat	2	Profession (fisher, seaman, etc.)
No answer / never	10	-

The number of islands visited by a Galapagos resident tends to increase with income and numbers of years living in the island (Figure 1). However, there are notable exceptions: some residents interviewed have never traveled to other islands of the archipelago although they have lived in Galapagos for more than 15 years.



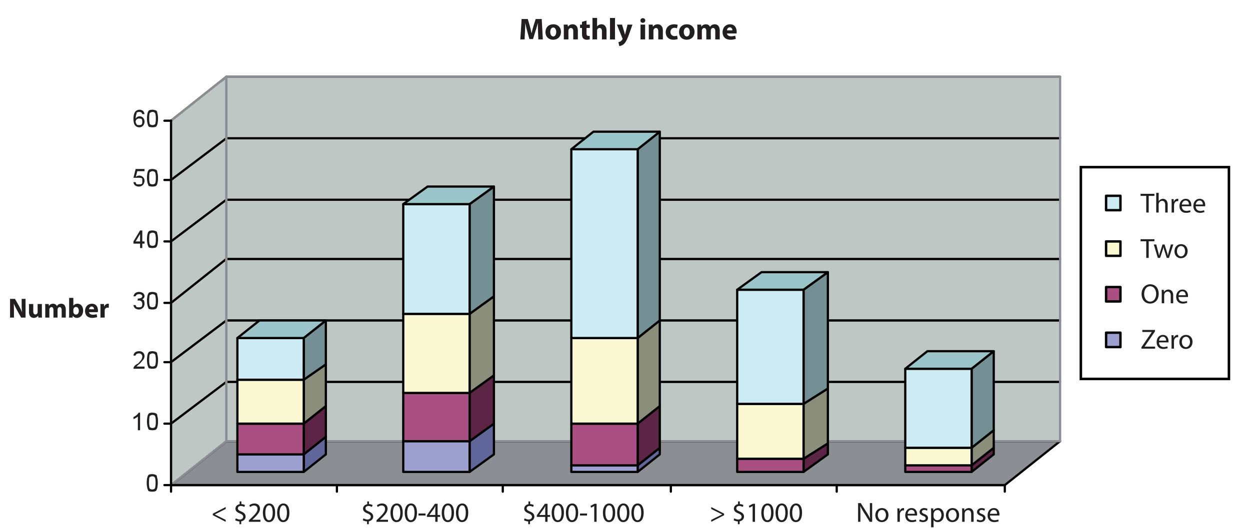
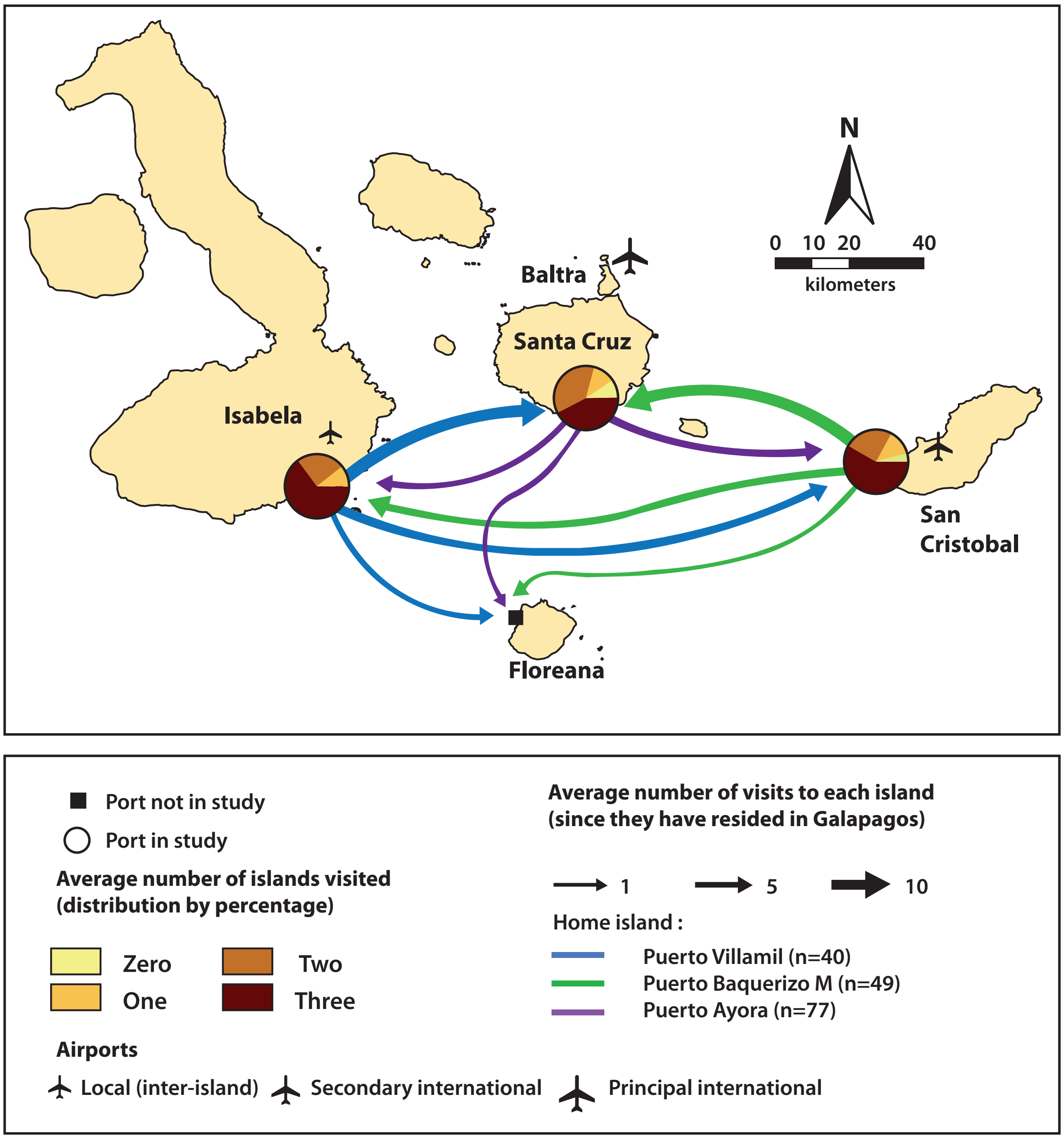


Figure 1. Number of islands visited by years of residency in Galapagos (above) and income (below). Source: Interviews of residents (N=166).

Galapagos residents tend to travel infrequently to other islands in the archipelago. However, inhabitants of Isabela and Floreana must travel to either Santa Cruz or San Cristóbal before continuing to the continent (Map 2). Also, residents of Santa Cruz, Isabela, and Floreana must make occasional trips to Puerto Baquerizo Moreno, the capital of the archipelago, for various administrative matters. Even so, Puerto Ayora is the port most visited by residents of Galapagos.



Map 2. Movement of residents among the inhabited islands of Galapagos.
Source: Interviews with residents (N=166).

Effectiveness of the quarantine system

Launches carrying passengers and cargo among the islands create a potential network for dispersing invasive species--one of the greatest threats to the conservation of Galapagos. In the four inhabited ports of the archipelago, the personnel of the Inspection and Quarantine System for Galapagos (SICGAL) inspect launches in an attempt to limit the spread of invasive species. Zapata (2007) showed that due to budget reductions that resulted in a decrease in the number of inspectors, SICGAL has been unable to effectively reduce the entrance of introduced species to Galapagos. This situation continues to worsen as the number of passenger and cargo trips increases.

Residents and tourists traveling on launches were asked about the effectiveness of the quarantine system (Table 3). Approximately two thirds of residents responded that SICGAL was effective at achieving its goal of avoiding the introduction of invasive species. Tourists believed that the partial inspection of their bags was insufficient. While 25% of tourists reported that their luggage had not been examined, only 13% of residents did.

It is common to observe launches departing port without having been inspected by SICGAL. Inspectors working in SICGAL are aware of this situation and explain that it is due to a lack of personnel. Another factor is that with the exception of Puerto Ayora, SICGAL offices are located away from the docks, making it

Table 3. Effectiveness of the quarantine system (SICGAL) according to passengers on launches.

Question	Answer	Residents (%)	Tourists (%)
Before embarking on the launch, was your luggage inspected by SICGAL? Do you think that the inspection was effective?	*Yes*	65	38
	No	31	59
	No answer	4	3
	Total	**100**	**100**
Have you ever transported something to another island without SICGAL seeing it?	*Yes*	9	18
	No	83	82
	No answer	8	0
	Total	**100**	**100**

more difficult for personnel to observe the movement of boats, cargo, and passengers.

Discussion

Currently inter-island transport using launches is unregulated, except for limited Navy and SICGAL supervision. There are serious safety issues associated with launch transport in Galapagos: insufficient life vests, boats traveling at excess capacity and excessive speeds that are dangerous in rough seas, the absence of a life raft onboard, etc. The frequency of incidents (one of the authors was stranded aboard a launch that had run out of fuel) points to the dangers inherent in this form of transportation. The Navy, the National Park Service, the municipalities, and INGALA are all entities that could play a role in ensuring the safety of launch passengers. Will it be necessary for a serious accident to occur before implementing oversight and basic safety measures?

One could argue that the demand to connect Galapagos with the mainland, rather than internal activity within the islands, drives the growth and organization of this form of transportation. Launch schedules are based on flight schedules to and from the continent. For example, it is impossible to leave Isabela on a launch later than 7 AM (the time it is necessary to leave Isabela for a flight to the mainland). Puerto Ayora serves as a hub for launch transportation, and is the source of the largest number of boats and passengers. And although Puerto Baquerizo Moreno plays an important role in this system, the launch owners of Villamil obtain greater benefit by using their launches for charters and tourism activities.

Additional studies of other marine transportation to Galapagos (cargo ships, etc.) are needed to complement this analysis and to provide a broader understanding of the threats to the national park (such as invasive species) and the lifestyle of the insular population.

Conclusions

A number of indicators from this study provide a baseline to understand future trends and the impact of launches on Galapagos. These indicators have been integrated into the Geographic Index of Galapagos Project of the Charles Darwin Foundation.

Table 4. Indicators to measure the evolution in the impacts generated by launches in Galapagos.

Variable	Value in 2009
Number of launches in Galapagos	42
Number of regular monthly trips between Santa Cruz and San Cristóbal	60
Number of regular monthly trips between Santa Cruz and Isabela	75
Total number of monthly charters in Galapagos	110
Fuel consumption per trip between Santa Cruz and Isabela (in gallons)	60
Average horsepower of the launches (in horsepower)	450

Photo: Emmanuel Cléder

Galapagos institutions should actively regulate this form of transportation and review its organization and operation. Safety issues must be dealt with as soon as possible, including:

- Insufficient number of life vests,
- Overloaded launches, and
- High speeds that could result in boats sinking in high seas.

In addition to fuel consumption and associated air and water pollution, launches pose other potential direct impacts for insular ecosystems, such as the transportation of uninspected cargo that could contain invasive species, collisions with sea turtles, etc., and indirect impacts, such as changes in the relationship of Galapagos residents to the natural world in which they live.

Finally, re-instituting a municipal transportation system between the inhabited islands could offer an attractive alternative for tourists (allowing better observation of marine species, vistas, etc.) and provide Galapagos residents with a low-cost option to the launches. A municipal maritime transportation system could also help to reduce pollution, increase marine safety, and generally reduce the impacts that launches have on the geographic space and environment of Galapagos. A public system for inter-island transport could also generate additional income for the government, which could in turn be invested in the conservation of the Galapagos National Park.

Photo: Jacintha Castora Photography

The first complete motorized vehicle census in Galapagos

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Introduction

The Galapagos Islands are one of the most complex and unique oceanic archipelagos in the world, considered a natural laboratory of evolution with worldwide importance for science, education, and nature tourism. The increase in the human population and economic activities has provoked an increase in the size of the vehicular fleet, which is affecting the local population and the environment and biodiversity of Galapagos.

The Special Law for Galapagos of 1998 (LOREG) established that the entry of vehicles into Galapagos must be regulated and controlled. Since then, there have been many efforts on the part of the National Institute of Galapagos (INGALA) to meet this requirement. In 2005 a pilot census of vehicles on Isabela identified a total of 117 vehicles and analyzed the socioeconomic and environmental impacts related to the increase in vehicles. In June 2008, INGALA carried out a study of the environmental impact of the vehicular fleet in the three most populated islands (San Cristóbal, Santa Cruz, and Isabela) to ensure adequate regulation.

Based on the recommendations of the 2008 study, a census of terrestrial vehicles was carried out in February-March 2009 for the entire province. This study provided updated data on the number and characteristics of vehicles and provided information needed to develop a database for better control.

Regulation of vehicles in Galapagos

Between 2005 and March of 2009, the entry of vehicles into Galapagos was governed by a regulation approved by the INGALA Council in May 2005[1]. This regulation established a five-year moratorium on the number of permits in the public service cooperatives, as well as a moratorium on the creation of new terrestrial transportation cooperatives. This initial regulation was replaced in March 2009[2]. The 2009 regulation established that the entry of motorized vehicles and machines into Galapagos was further restricted and promoted the use of vehicles that use alternative energy or hybrids. These decisions complemented the Government of Ecuador's vision for the elimination of the use of fossil fuels in Galapagos.

Vehicle census of 2009

A vehicle census was carried out between February and March 2009 in all of the populated islands: San Cristóbal, Santa Cruz, Isabela, Floreana, and Baltra. Information was recorded on the technical characteristics of each vehicle, the reason for entry of the vehicle, the owner's name, and if it was owned by an individual or business. All of the data associated with this study can be found in a database accessible via the website of the Governing Council of Galapagos (Consejo de Gobierno de Galápagos). The information related to the rationale for entry of the vehicles will be particularly important for anticipating future demand for vehicles generated by the business sectors of the province.

Between February and March 2009, the census identified a total of 1962 terrestrial vehicles in the five populated islands (Figure 1; Table 1). The study showed that the largest number of vehicles is on Santa Cruz (1074), followed by San Cristóbal (699), Isabela (154), Baltra (24), and Floreana (11).

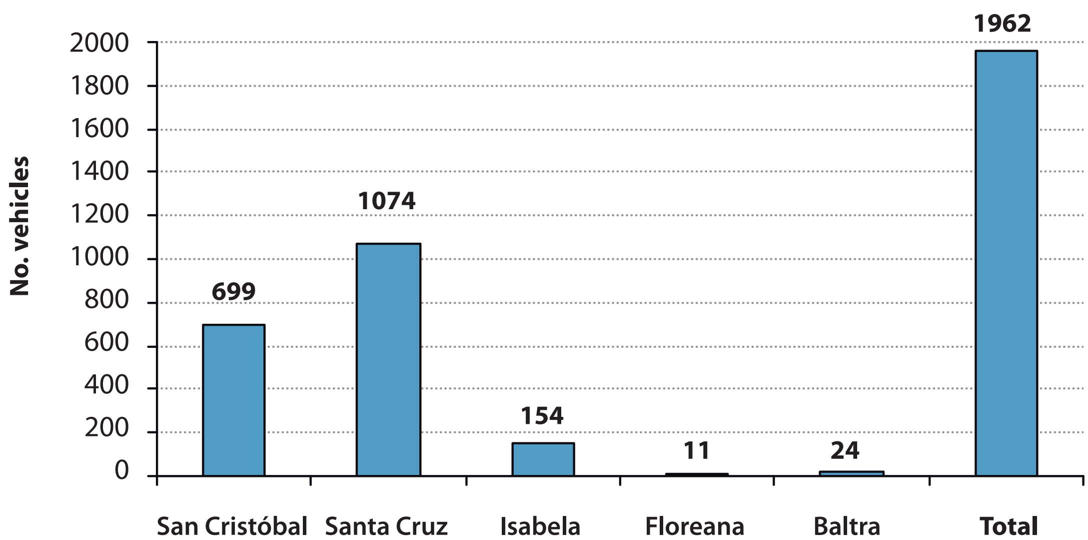

Figure 1. Number of vehicles in the inhabited islands of the Galapagos Province in February-March 2009.

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[1] Special Regulation for the Control of the Entry of Motorized Vehicles and Machinery in the Province of Galapagos; resolution No. CI-18-I-2005 published in the Official Register No. 09 of 3 May 2005.

[2] Substitute Regulation for the Control of the Entry of Motorized Vehicles and Machinery in the Province of Galapagos; resolution No. CI-11/12-II-2009, published in the Official Register No. 555 of 24 March 2009.

Table 1. Number of vehicles in Galapagos by type and sector, 2009.*

Class	Sector											
	Public	Private: individual-owned					Private: business-owned				Personal use	Total
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	4	13	44	28	3	2	314	23	34	62	117	644
Automobile	0	3	3	13	0	4	0	0	1	0	12	36
Jeep	1	0	12	5	3	0	0	0	2	14	44	81
Motorcycle	0	1	0	2	0	0	0	0	0	30	902	935
4 Wheeler	0	0	0	0	0	0	0	0	0	0	16	16
Truck	0	2	6	24	8	0	0	18	1	11	18	88
Van	1	0	0	0	0	0	0	0	6	8	7	22
Small bus	1	0	0	0	0	0	0	0	7	3	5	16
Large bus	20	0	0	0	0	0	1	0	14	2	10	47
Road equipment	0	0	0	0	0	0	0	0	0	51	9	60
Tanker	0	0	4	1	0	0	0	1	1	6	4	17
Total	27	19	69	73	14	6	315	42	66	187	1144	1962

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

Most vehicles were designated for personal use (1144), followed by commercially owned (610), for personal use in business (181), and for public transport (27) (Table 1). The most common types of vehicles were motorcycles and scooters (935), followed by pick-up trucks (644) and trucks (88). There were also 315 taxis and 187 institutional vehicles.

A total of 699 terrestrial vehicles were censused in San Cristobal (Table 3). Most public transport vehicles are taxis (110). Of the 438 vehicles identified for personal use, 380 are motorcycles. The remaining 151 vehicles are used for a variety of economic activities, such as agriculture, fishing, cargo transport, construction, and artisan activities.

Table 2. Vehicles registered in San Cristóbal in 2009.*

Class	Sector											
	Public	Private: individual-owned					Private: business-owned				Personal use	Total
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	0	10	12	14	1	1	110	0	8	23	36	215
Automobile	0	3	3	10	0	4	0	0	1	0	6	27
Jeep	0	0	5	4	0	0	0	0	1	9	9	28
Motorcycle	0	0	0	1	0	0	0	0	0	7	380	388
4 Wheeler	0	0	0	0	0	0	0	0	0	0	3	3
Truck	0	0	0	1	0	0	0	3	1	3	3	11
Van	0	0	0	0	0	0	0	0	1	2	0	3
Small bus	0	0	0	0	0	0	0	0	5	0	0	5
Large bus	0	0	0	0	0	0	0	0	5	1	0	6
Road equipment	0	0	0	0	0	0	0	0	0	10	0	10
Tanker	0	0	0	0	0	0	0	0	0	2	1	3
Total	0	13	20	30	1	5	110	3	22	57	438	699

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

In Santa Cruz, 1074 terrestrial vehicles were censused (Table 3). The majority (627) were categorized for personal use. Of these vehicles, 470 were motorcycles. There were 351 pick-up trucks, most of which pertain to the taxi sector (204).

Table 3. Vehicles registered in Santa Cruz in 2009.*

Class	Sector										Personal use	Total
	Public	Private: individual-owned					Private: business-owned					
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	0	1	22	14	2	1	204	0	15	23	69	351
Automobile	0	0	0	2	0	0	0	0	0	0	6	8
Jeep	0	0	5	1	1	0	0	0	1	5	32	45
Motorcycle	0	0	0	0	0	0	0	0	0	16	470	486
4 Wheeler	0	0	0	0	0	0	0	0	0	0	9	9
Truck	0	2	5	22	6	0	0	9	0	6	15	65
Van	1	0	0	0	0	0	0	0	3	2	6	12
Small bus	1	0	0	0	0	0	0	0	1	1	4	7
Large bus	20	0	0	0	0	0	1	0	7	0	4	32
Road equipment	0	0	0	0	0	0	0	0	0	38	9	47
Tanker	0	0	4	1	0	0	0	1	1	2	3	12
Total	22	3	36	40	9	1	205	10	28	93	627	1 074

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

In Isabela 154 vehicles were censused (Table 4). Nearly half of them were pick-up trucks (68), of which 23 were used for cargo transport, 11 by the tourism sector, 10 by the agricultural sector, 9 by institutions, 9 for personal use, and the remainder by fisheries and other.

Table 4. Vehicles registered in Isabela in 2009.*

Class	Sector										Personal use	Total
	Public	Private: individual-owned					Private: business-owned					
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	4	2	10	0	0	0	0	23	11	9	9	68
Automobile	0	0	0	1	0	0	0	0	0	0	0	1
Jeep	1	0	2	0	2	0	0	0	0	0	0	5
Motorcycle	0	1	0	1	0	0	0	0	0	6	50	58
4 Wheeler	0	0	0	0	0	0	0	0	0	0	3	3
Truck	0	0	1	1	2	0	0	3	0	1	0	8
Van	0	0	0	0	0	0	0	0	2	1	0	3
Small bus	0	0	0	0	0	0	0	0	1	1	0	2
Large bus	0	0	0	0	0	0	0	0	2	0	0	2
Road equipment	0	0	0	0	0	0	0	0	0	3	0	3
Tanker	0	0	0	0	0	0	0	0	0	1	0	1
Total	5	3	13	3	4	0	0	26	16	22	62	154

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

Eleven vehicles were censused in Floreana, seven belonging to individuals and four to institutions (Table 5).

Table 5. Vehicles registered in Floreana in 2009.*

Class	Sector											
	Public	Private: individual-owned					Private: business-owned				Personal use	Total
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	0	0	0	0	0	0	0	0	0	1	2	3
Automobile	0	0	0	0	0	0	0	0	0	0	0	0
Jeep	0	0	0	0	0	0	0	0	0	0	3	3
Motorcycle	0	0	0	0	0	0	0	0	0	1	1	2
4 Wheeler	0	0	0	0	0	0	0	0	0	0	0	0
Truck	0	0	0	0	0	0	0	0	0	0	0	0
Van	0	0	0	0	0	0	0	0	0	0	0	0
Small bus	0	0	0	0	0	0	0	0	0	1	1	2
Large bus	0	0	0	0	0	0	0	0	0	1	0	1
Road equipment	0	0	0	0	0	0	0	0	0	0	0	0
Tanker	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	4	7	11

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

Twenty-four vehicles were censused in Baltra: twelve institutional, nine private, and three for cargo transport (Table 6). Of those belonging to individuals, six were large, 45-passenger buses for passengers and tourists.

Table 6. Vehicles registered in Baltra in 2009.*

Class	Sector											
	Public	Private: individual-owned					Private: business-owned				Personal use	Total
	Heavy Equipment	Fishing	Agriculture	Commercial	Construction	Artisanal	Taxi	Cargo	Tourism	Institutional		
Pick -up truck	0	0	0	0	0	0	0	0	0	6	1	7
Automobile	0	0	0	0	0	0	0	0	0	0	0	0
Jeep	0	0	0	0	0	0	0	0	0	0	0	0
Motorcycle	0	0	0	0	0	0	0	0	0	0	1	1
4 Wheeler	0	0	0	0	0	0	0	0	0	1	0	1
Truck	0	0	0	0	0	0	0	3	0	1	0	4
Van	0	0	0	0	0	0	0	0	0	3	1	4
Small bus	0	0	0	0	0	0	0	0	0	0	0	0
Large bus	0	0	0	0	0	0	0	0	0	0	6	6
Road equipment	0	0	0	0	0	0	0	0	0	0	0	0
Tanker	0	0	0	0	0	0	0	0	0	1	0	1
Total	0	0	0	0	0	0	0	3	0	12	9	24

* Classifications used were those established by the Organic Law for Terrestrial Transportation, Transit, and Road Safety.

Conclusions

The vehicle census of 2009 indicates that between 1999 and 2004, a period when no structured regulations to control the entry of vehicles to Galapagos existed, there was a considerable increase in the number of vehicles in the archipelago. From 2005 forward, with the new regulations in place, there was a reduction in the entry of new vehicles, particularly pick-up trucks used for taxis (public transport), due to the five-year moratorium on permits for new taxis and new terrestrial transport cooperatives.

The 2005 regulation allowed for the unrestricted entry of motorcycles for personal use and resulted in a considerable increase in the number of motorcycles up to March 2009, when the regulation was modified. The new regulation required justification for importing a motorcycle based on its proposed use. If the justification was approved, based on technical and legal reports, it was turned over to the Vehicle Committee for consideration.

The principal economic activity of the population is tourism. However, the census does not reflect an increase in the number of vehicles used in this sector. This is probably due in large part to the fact that the majority of tourists remain onboard tourist boats and those who stay in the towns overnight generally use taxis. Even so, it could be argued that the increase in the number of vehicles is directly related to population growth and increasing tourism.

Recommendations

- A system for controlling the entry of vehicles into Galapagos is in place and functioning. There is ongoing coordination between INGALA (now part of the Governing Council of Galapagos) and the Provincial Commission for Terrestrial Transportation, Transit, and Road Safety. It is important that this coordination is maintained and that the two institutions play their respective roles in keeping vehicle registration and control up to date.

- The software program for the vehicle database should be continually updated and improved to allow more information to be captured and to ensure easy access for end users.

- The use of vehicles using alternative energy should be encouraged, to replace those that use fossil fuels. Incentives should be established to make such vehicles accessible.

- It is important to continue the process of vehicle control; a study of the supply and demand of vehicles circulating in Galapagos is planned.

MARINE MANAGEMENT

fauna flora

galápagos

development community

Photo Title Page Marine Management Section: Celso Montalvo

Photo: Elizabeth Knight

Identification of rearing areas for blacktip sharks *Carcharhinus limbatus* in the mangrove stands of coastal San Cristóbal Island

Yasmania Llerena, Juan Carlos Murillo and Eduardo Espinoza

Galapagos National Park

Sharks fill a vital ecological role within marine ecosystems as a top predator (Stevens *et al.*, 2000). They help eliminate dead and weak animals from the water, impeding the spread of disease and strengthening the genetic structure of populations (Galván *et al.*, 1989).

The current status of shark populations in the Galapagos Marine Reserve (GMR) is unknown. However, they are under strong pressure from illegal fishing in spite of the prohibition of shark fishing (Reyes and Murillo, 2007). In Galapagos sharks are a symbol of the marine biodiversity and at least five shark species (reef whitetip shark *Triaenodon obesus*, whale shark *Rhincodon typus*, hammerhead shark *Sphyrna lewini*, Galapagos shark *Carcharhinus galapagensis*, and the silky shark *Carcharhinus falciformis*) represent an important tourism resource in the GMR, especially for dive trips (Reyes and Morillo, 2007). Knowledge of shark biology and ecology in the coastal zones is critical for effective management and conservation.

This study examines the different species of juvenile shark that use certain coastal zones of San Cristóbal Island for rearing. These data will help to establish a baseline for these areas and to promote similar studies in the rest of the archipelago to improve management in all coastal areas of the GMR.

Shark rearing areas

Gravid females of many shark species travel to specific rearing areas to give birth to their young or deposit eggs on the sea floor.

The young spend the first part of their lives where they are born, making these areas critically important to shark populations (Springer, 1967; Castro, 1993). Rearing areas can be relatively closed or open to the sea, but are usually located in the shallow, highly-productive coastal zones, where the newborn can find abundant food and protection from larger sharks (Simpfendorfer and Milward, 1993; Bonfil, 1997; Carlson, 1999). These areas can be identified through observations of gravid females, neonates, and young-of-the-year (Bonfil, 1997). This study focused on evaluating five sites in San Cristóbal to determine if they are rearing areas for sharks.

Critical habitats for the protection of sharks

Shark populations can be limited by the number of rearing areas with adequate habitat (Springer, 1967). Knowing the location of the rearing areas is important to ensure adequate protection for these species and to evaluate possible human impacts in these areas (Skomal, 2007).

A variety of factors, such as increased fishing effort, inadequate fishing regulations, and the degradation of important rearing areas in coastal habitats, estuaries, and fresh water, has resulted in a decline in shark populations in various regions of the world (Camhi *et al.*, 1998). Ecosystems such as mangroves are both ecologically and biologically important, given that they stabilize coasts, protect the inland terrain, and provide habitat for many bioaquatic species (Reserva Nacional de Investigación Estuarina Bahía de Jogos, online). These ecosystems have high biodiversity with very high primary productivity, maintaining a complex trophic network that includes nesting areas for birds, and feeding, rearing, and protective zones for reptiles, fish, crustaceans, and mollusks (MacNae, 1968).

Management and conservation of critical habitats for reproduction and rearing in the waters off San Cristóbal through fishing closures and/or the establishment of protected zones is vital to ongoing reproductive processes (Anislado and Robinson, 2001). These sites have similar habitat characteristics and are surrounded by mangroves (Figure 1a), primarily the red mangrove (*Rhizophora mangle*). The roots of the mangroves provide a refuge from predators for juvenile sharks and young of other fish species (Figure 1b).

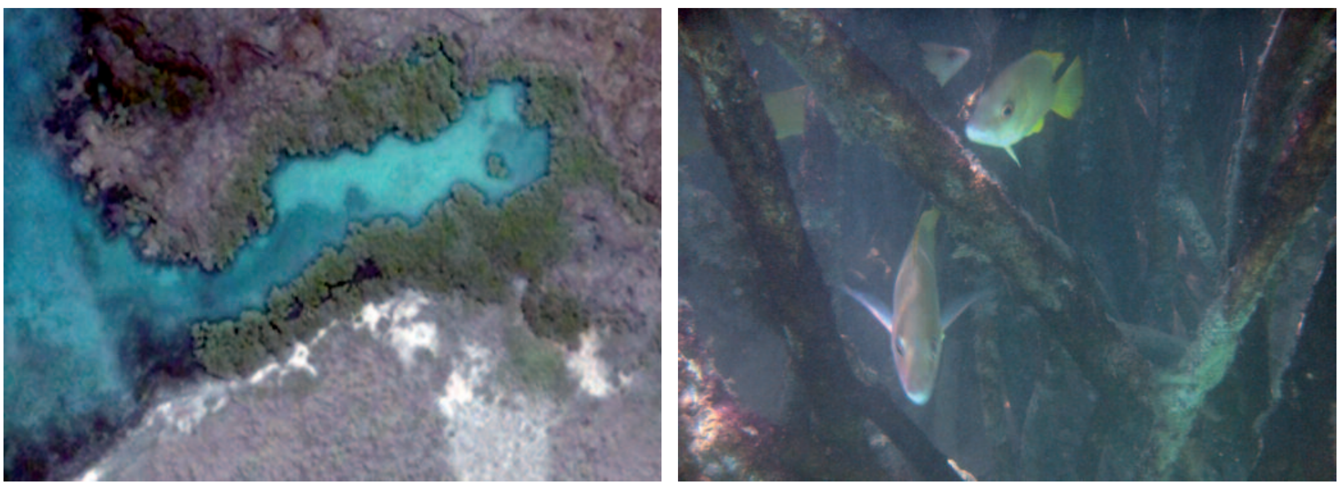

Figure 1. (a) Aerial view of the Tortuga study area surrounded by red mangrove (*Rhizophora mangle*); (b) Juvenile fish among the roots of the mangroves.

Study areas

This study was completed in five mangrove areas in the coastal zone of San Cristóbal: Tortuga, Cerro Brujo (the mangrove area), Puerto Grande, Manglecito, and Bahía Rosa Blanca (Figure 2). At all sites, sharks were fished using gill nets, locally known as "trasmallo lisero" and generally used in Galapagos for fishing mullets. The number of neonate and one-year-old sharks captured was recorded.

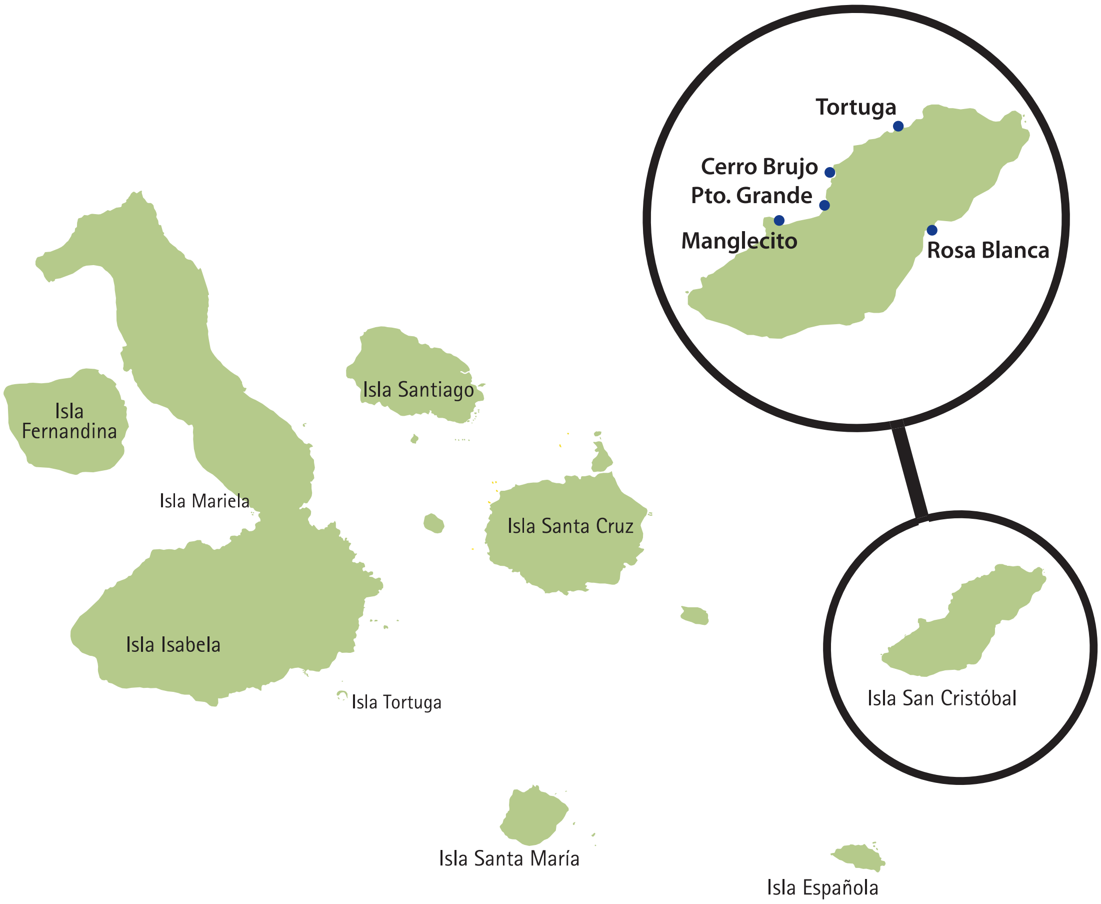

Figure 2. The Galapagos Islands with details of San Cristóbal Island and the five coastal study areas: Tortuga, Cerro Brujo (mangrove area), Puerto Grande, Manglecito and Bahía Rosa Blanca.

Methods

From May to December 2008, direct observations were made via snorkeling to detect and count sharks in the five study areas. In January, February, and April of 2009, six additional field trips were conducted to capture juvenile sharks using a gill net with 3-inch holes measuring 100 m x 3.5 m. The net was located at the entrance of each study area during one hour.

The captured sharks were immediately freed from the net and brought onboard where weight, measurements (total length, furcal length, and standard length), sex, and species were recorded. The state of the umbilical scar was also noted as either open or partially closed, to determine the shark's stage of development (Figure 3).

Figure 3. (a) Blacktip shark with an open umbilical scar (neonate); (b) Blacktip shark with a partially closed umbilical scar (young-of-the-year).

Results

Nineteen blacktip sharks were observed at Tortuga and Bahía Rosa Blanca and 23 reef whitetip sharks (both juveniles and adults) were spotted in the mangrove areas of Manglecito, Bahía Rosa Blanca, and Cerro Brujo (Table 1). Using the gill net, 52 neonates and one-year-old juvenile blacktip sharks were captured at Tortuga, Puerto Grande, and Manglecito; one neonate hammerhead shark was caught in Puerto Grande. This indicates that this fishing method is more efficient for studying these two species, especially the blacktip shark.

Table 1. Number of the three species of shark observed and captured in each study area in San Cristóbal.

Methodology	Species	Study Area					
		Tortuga	Cerro Brujo	Puerto Grande	Manglecito	Rosa Blanca	Total
Observed	Blacktip shark	9	0	0	0	10	**19**
	Reef whitetip shark	0	17	0	2	4	**23**
	Hammerhead shark	0	0	0	0	0	**0**
Captured	Blacktip shark	9	0	29	14	0	**52**
	Reef whitetip shark	0	0	0	0	0	**0**
	Hammerhead shark	0	0	1	0	0	**1**
	Total	18	17	30	16	14	**95**

In terms of neonates and one-year-olds, the species most often caught was the blacktip shark, which was observed in three of the study areas (Table 2). In January, the number of neonates was greater than the number of one-year-olds in both Puerto Grande and Manglecito, but not at Tortuga. In February, on the other hand, the number was nearly the same and they were present in Puerto Grande, Manglecito, and also Tortuga. In April, there were no neonates caught in any of the study areas, while the most one-year-olds were captured in Puerto Grande.

Table 2. Number of blacktip shark neonates and young-of-the-year captured at three of the study areas between January and April 2009.

Study Area	Month	Neonates	Young-of-the-year
Tortuga	January	0	0
	February	5	2
	April	0	2
Puerto Grande	January	6	1
	February	2	0
	April	0	20
Manglecito	January	5	0
	February	2	6
	April	0	1
TOTAL		20	32

The results suggest that blacktip sharks probably give birth in the first months of the year. For example, at Tortuga in February, young with a total length (TL) of 65 cm and a portion of their umbilical cord attached were captured (Figure 5), indicating that they had been born only a few days earlier. More frequent sampling is needed throughout the year to confirm this finding.

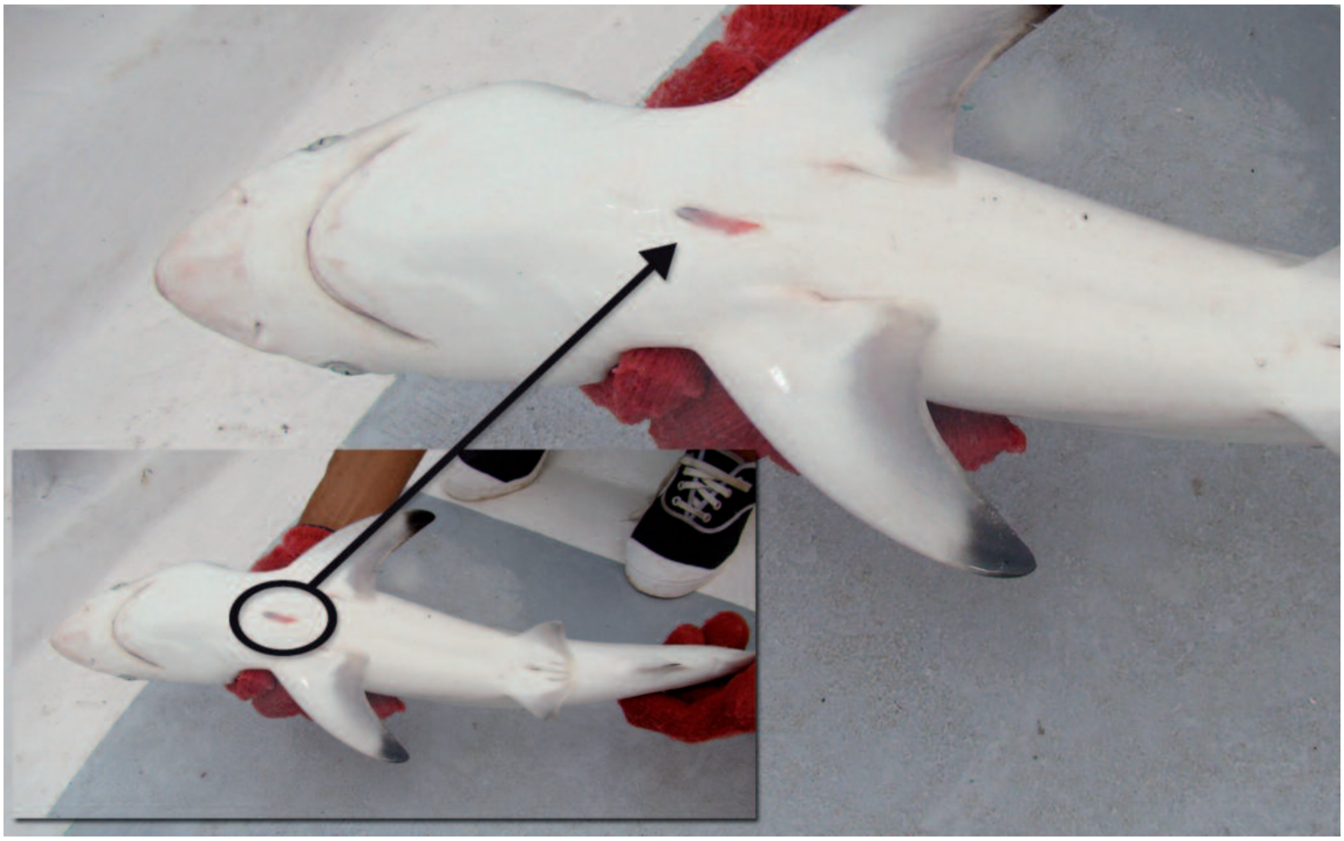

Figure 5. Blacktip shark neonate of 65 cm total length (TL), captured at Tortuga, showing in the circle the umbilical cord, indicating that it was born a few days before.

Other fauna in the five study areas

The number and species of fish observed using both methods confirm that the five mangrove areas possess a high abundance and diversity of species typically found in coastal bays (Allen *et al.*, 1995; Grove and Lavenberg, 1997; Humann and Deloach, 2003; Molina *et al.*, 2005), such as black-tailed mullet (*Xenomugil thoburni*), yellowfin mojarra (*Gerres cinereus*), golden-eye grunt (*Haemulon scudderii*), and blackspot porgy (*Archosargus pourtalesii*). The majority of these species remain in these areas during their juvenile stage.

Species of rays and fish were observed in all five study areas, with the greatest diversity of species at Tortuga and Manglecito, followed by Bahía Rosa Blanca, Puerto Grande, and finally Cerro Brujo (Table 3).

Conclusions and recommendations

The mangrove areas of Tortuga, Puerto Grande, and Manglecito of San Cristóbal are rearing areas for blacktip shark, with 98% of captured sharks being blacktip neonates and young-of-the-year. The remaining 2% were hammerhead sharks. Gill nets were more effective for collecting data on recently born sharks than direct observation.

It is evident that juvenile blacktip sharks prefer mangrove areas. The lack of observations of adult sharks suggests that they do not frequent these zones.

Additional studies are needed throughout the year to determine other characteristics of the population dynamics of blacktip sharks and other species, including movement patterns and growth rates. It is also necessary to determine if juvenile sharks use other types of habitats in the coastal zone of the GMR.

Table 3. Diversity of accompanying wildlife species in the five study areas of San Cristóbal, by presence/absence.

Species		Study Area				
Common Name	**Scientific Name**	**Tortuga**	**Cerro Brujo (Mangroves)**	**Puerto Grande**	**Manglecito**	**Rosa Blanca**
Blackspot porgy	*Archosargus pourtalesii*			X		
Yellowtail surgeonfish	*Prionurus laticlavius*	X		X		X
Yellow-tailed damselfish	*Stegastes arcifrons*	X	X	X	X	X
Milkfish	*Chanos chanos*				X	
Marbled goby	*Eleotrica cableae*	X	X	X	X	X
Bigeye jack	*Caranx sexfasciatus*	X			X	
Black-tailed mullet	*Mugil galapagensis*				X	
Thoburn's mullet	*Xenomugil thoburni*	X	X	X	X	X
Yellowfin mojara	*Gerres cinereus*	X			X	X
White salima	*Xenichthys agassizi*	X				
Brown-striped snapper	*Xenocys jessiae*	X				
Yellow-tailed snapper	*Lutjanus argentiventris*	X				X
Pacific dog snapper	*Lutjanus novemfasciatus*	X				X
Panamic sergeant major	*Abudefduf troschelii*	X	X	X	X	X
Spotted eagle ray	*Aetobatus narinari*				X	
Stingray	*Dasyatis brevis*	X	X	X	X	X
Grunt	*Orthopristis spp.*				X	
Golden-eye grunt	*Haemulon scudderii*	X	X			
Galapagos thread herring	*Opisthonema berlangai*			X	X	
Bullseye puffer	*Sphoeroides annulatus*	X	X	X	X	X
Yellow-tailed grunt	*Anisotremus interruptus*				X	
TOTAL		**14**	**7**	**9**	**14**	**10**

The gill net was effective for capturing both neonate and juvenile sharks that live in mangrove areas. The five study areas are all designated as fishing zones within the GMR zoning system and are regularly used by fishermen. This suggests that a continued incidence of capture of juvenile sharks and other protected species (i.e., rays) in nets may be occurring (Figure 6).

Based on the results of this research, we recommend that additional studies be carried out in San Cristóbal and other islands to determine the fishing methods and regulations that will help to protect shark rearing areas. The gill net used in this study resulted in a high incidence of capture of neonate and juvenile sharks. Its use by fishermen over the long-term could cause unintentional deterioration of these ecosystems. We recommend the reevaluation of the current zoning of important rearing areas and the establishment of protected zones in mangrove stands. The creation of protected zones for shark rearing would improve the management of these habitats, and also protect and conserve juvenile sharks and other species.

Figure 6. Eagle ray (*Aetobatus narinari*) captured incidentally in the gill net in Manglecito.

Figura 1. Impressive marine vista dominated by a group of hammerhead sharks

Photo: Alex Hearn

Hammerhead sharks of Galapagos: their behavior and migratory patterns

César Peñaherrera[1], James Ketchum[2], Eduardo Espinoza[3], Alex Hearn[2] and Peter Klimley[2]

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Hammerhead sharks (*Sphyrna lewini*) are unique among sharks in many ways, most notably in the shape of their head. Their gregarious behavior has always fascinated people, so much so that many tourists spend large amounts of money to travel around the world to observe them. In the Galapagos Islands, hammerhead sharks, along with whale sharks (*Rhincodon typus*), Galapagos sharks (*Carcharhinus galapagensis*), and reef whitetip sharks (*Triaenodon obesus*), constitute an important attraction for dive tourism (Espinoza and Figueroa, 2001), generating substantial income for the local economy. This is due to the fact that the archipelago remains one of the few locations in the world where these animals can still be seen in large groups (Figure 1). This article presents a review of a series of studies carried out under a hammerhead shark tagging and monitoring program in the Galapagos Marine Reserve (GMR) .[1]

Hammerhead sharks are at risk primarily due to overfishing. Strong economic pressure for the commercialization of shark fins worldwide has provoked an increase in the capture of sharks and their fins along the entire western coast of South America (WildAid, 2005). An estimated 1.7 million tons of sharks are captured worldwide annually (Clarke *et al.*, 2006). In the GMR, sharks are protected by law (AIM, Resolution No.011-2000), but unfortunately illegal

[1]The complete analysis of telemetry data of the hammerhead shark will be presented in the doctoral thesis of James Ketchum and in scientific publications currently being prepared by the research team.

fishing continues to threaten their survival. In the last ten years, up to 20,500 fins have been confiscated (GNP, 2009).

Why should we conserve these animals? In addition to their high value as a resource for non-extractive activities such as tourism (WildAid, 2001), sharks play a very important role in marine environments. Most are top-level predators, meaning they feed on many animals but almost no other animal feeds on them. They help to maintain population stability of their prey, preventing disproportionate increases in their numbers and any resulting negative impacts on other marine organisms. However, sharks are very sensitive to any deterioration in their population. Their life history characteristics (low reproductive rate, long-lived, and late sexual maturity) prevent rapid population recuperation following significant reductions in their numbers (Compagno *et al.*, 2005). Examples of direct negative impacts (in shark populations) and indirect impacts (in marine environments as a result of the removal of sharks) are currently reported frequently in the scientific literature (for example: Stewart and Wilson, 2005; Myers and Worm, 2005; Heithaus *et al.*, 2007; Myers *et al.*, 2007).

For these reasons, the authorities of the Galapagos National Park (GNP) implemented a complete ban on the capturing of any sharks within the GMR. Still, protection of sharks requires a better understanding of their distribution, abundance, behavior, and interactions with the marine environment. Baseline information is needed to detect trends in their population status over time. Without this information, conservation efforts will not have a solid scientific foundation. To address these information needs, the Research and Conservation of Sharks Project began over three years ago, as a multi institutional effort of the Charles Darwin Foundation, the GNP, and the University of California-Davis.

The shark tagging project

Since its beginning in 2006, the project has primarily focused on studying the movements of hammerhead sharks, at both macro and micro levels. To date, more than 130 sharks have been tagged and monitored in the northern zone of the archipelago, specifically around Darwin and Wolf Islands, using acoustic and satellite telemetry. Three types of equipment were used: (i) ultrasonic tags for continuous monitoring of individual sharks; (ii) ultrasonic tags for long-term monitoring using monitoring stations, and (iii) satellite tags to permit remote monitoring at a macro scale (Figure 2). Continuous monitoring was done for more than 48 hours at a time around Wolf Island. Monitoring stations were installed in strategic locations throughout the archipelago to be able to detect the acoustic tags, with the greatest density around Darwin and Wolf Islands (Figure 3; for greater detail on the methodology, see Hearn *et al.*, 2008).

Daily behavior

Much as human beings follow daily routines, the seven hammerhead sharks monitored continuously showed interesting movement patterns (Figure 4). During the day the sharks remained very passive in

Figure 2. Left: Free diving method for attaching ultrasonic tags on the posterior portion of the dorsal fin of the shark (Photo: Eduardo Espinoza). Right: Attaching a satellite tag onboard the Sierra Negra of the GNP. The tag is attached to the dorsal fin of the shark while a constant stream of seawater is poured over the shark to allow respiration (Photo: Peter Oxford).

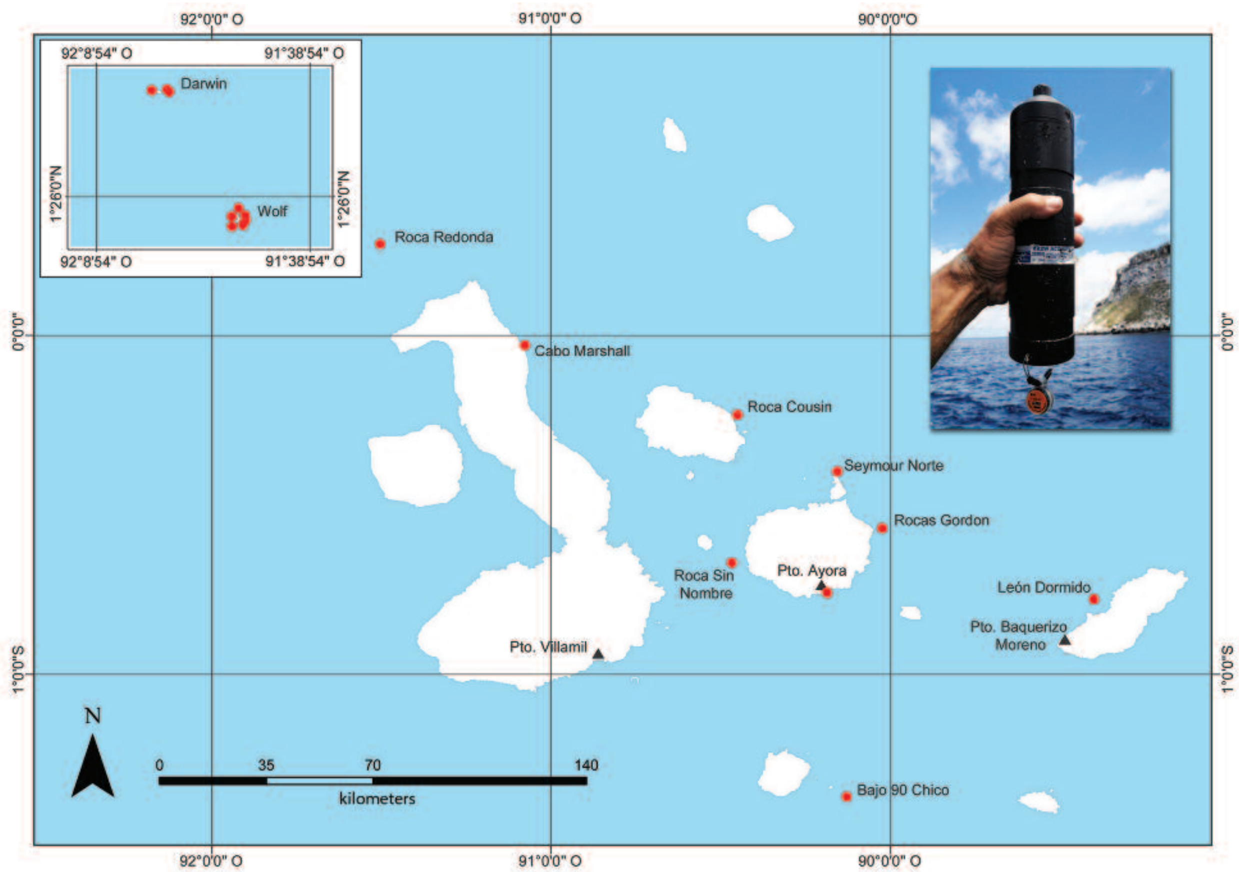

Figure 3. Location of the monitoring stations in the GMR. Upper right hand corner: photo of one of the monitors. Photo: Peter Oxford

zones surrounding the island and then became very active during the night with frequent trips to the open sea.

Three principal types of movement were detected (Ketchum *et al.*, in prep.)[1]:

(i) *Resting* - navigating at low velocity in areas close to the island. Resting occurred primarily during the day, when the sharks stayed close to the rocky areas and coral reefs in the southern, eastern, and northeastern areas of the island. Although hammerhead sharks generally swim in schools or groups, it is unknown whether the monitored sharks stayed in groups or traveled alone.

(ii) *Directional* - when sharks head toward open water or return to the island. Directional navigation was described for this species in Baja California (Klimley *et al.*, 1993), but it was not known if the sharks of Galapagos followed the same movement pattern. The longest directional navigation recorded by this study was more than 40 km, a direct route returning to the island. But how do the sharks find a path and maintain their route? Klimley (1993) suggests that hammerhead sharks use geomagnetism of the sea floor to orient themselves, and that in open water, deep dives allow them to re-orient themselves (one tagged shark descended to 936 m). Hammerhead sharks use electro-receptor organs located at the extremes of their heads to sense the electrical differential in their surrounding environment, including the electric field of other animals (Bennet and Clusin, 1978). This ability is certainly one of the evolutionary reasons responsible for the strange form of their heads, which in addition to geomagnetic-location allows them to better detect and capture their prey.

(iii) *Non-directional or erratic* - primarily in zones away from the shore. Non-directional movements occur during the night. The movements are agile but without direction, with the shark accelerating rapidly for a short time and then moving slowly. Given that the diet of hammerhead sharks is composed almost 90% of squid (Castañeda-Suárez and Sandoval-Londoño, 2007), it is assumed that these movements are a product of feeding behavior. Hammerhead sharks take advantage of the nightly vertical migrations of squid when they move to open waters to feed.

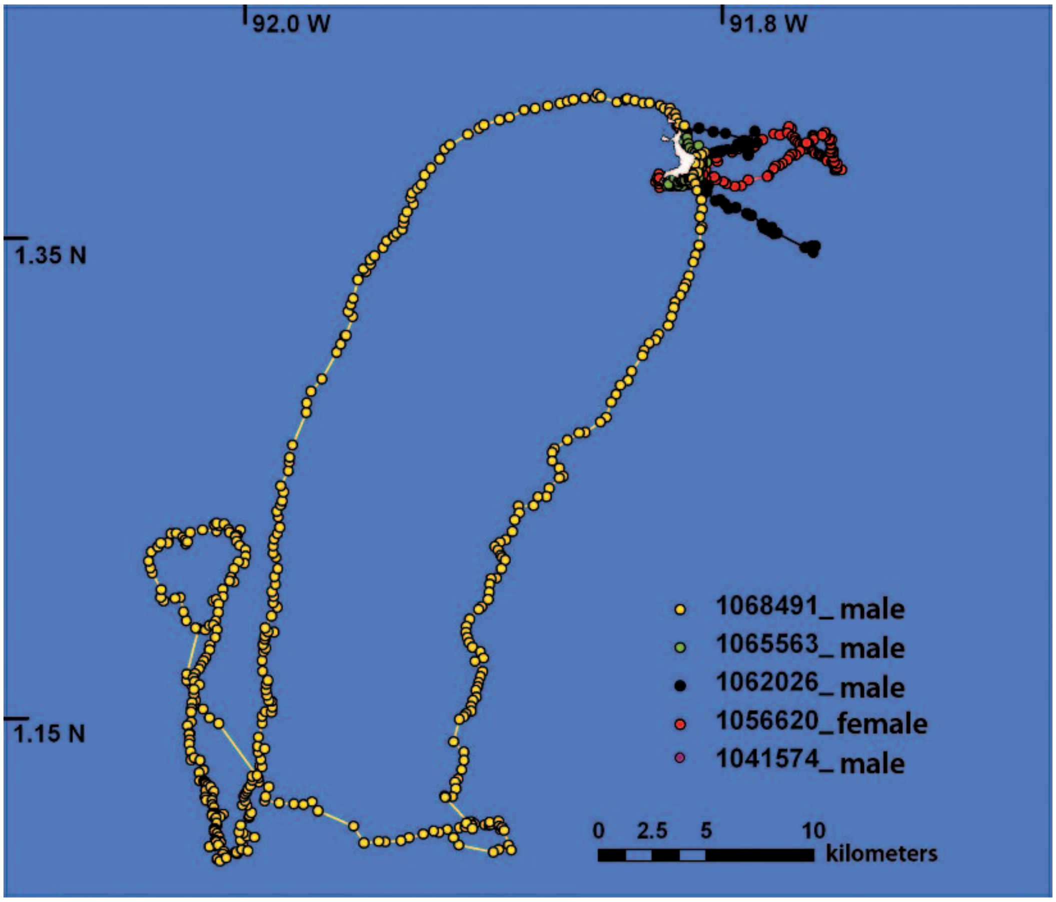

Figure 4. Navigation routes of hammerhead sharks followed continuously for 48 to 72 hours around Wolf Island. (Source: Ketchum *et al.*, in prep.).

Hammerhead sharks were also observed to have high site fidelity. One hundred percent of the monitored sharks used the southeastern and northeastern faces of Wolf Island exclusively during the daytime. This preferential behavior was confirmed by information obtained from the monitoring stations around Wolf Island, where the majority of ultrasonic tag detections were on the eastern side of the island (Figure 5). Visual censuses of sharks carried out on both sides of the island suggest that the behavior of schools of sharks differ on the two sides of the island. On the western side, their movements are rapid and directed, while on the eastern side sharks move about slowly and cover the same areas over and over. Hearn *et al.* (in prep.) suggest that this behavior could result from a variety of interacting factors. The southeastern side of the island is constantly bathed by currents that import nutrients, creating a large concentration of organisms in a protected area where sharks can feed without moving great distances. Hammerhead sharks also take advantage of these areas in the center of their range for resting and for the "cleaning services" provided by the local fauna. Important cleaning zones have been recorded in this area, with angel fish (*Holocanthus passer*) and blacknosed butterflyfish (*Johnrandallia nigrirostris*) the most important species filling this role (Ketchum *et al.*, in prep.).

Connectivity and migratory behavior

Large-scale movements observed were surprising. Monitoring station data indicate that the connectivity within the archipelago is limited to the islands of Darwin, Wolf, and Roca Redonda, while outside the GMR hammerhead sharks have been recorded in areas of the Pacific far from where they were tagged. Three hammerhead sharks tagged at Darwin and Wolf Islands were detected at Cocos Island (Costa Rica), a distance of nearly 500 km. One, tagged at Malpelo Island (Colombia), resided in the northern part of Galapagos for nearly one year (this shark made its first stop at Cocos Island before heading on to Galapagos). Satellite monitoring of seven sharks also shows an intensive use of the areas around Darwin and Wolf Islands as well as open waters outside of the GMR (Figure 6; for more details, see Ketchum *et al.*, 2009).

These results confirm that the hammerhead shark is a highly migratory species and that there exists connectivity between the northern waters of the GMR and

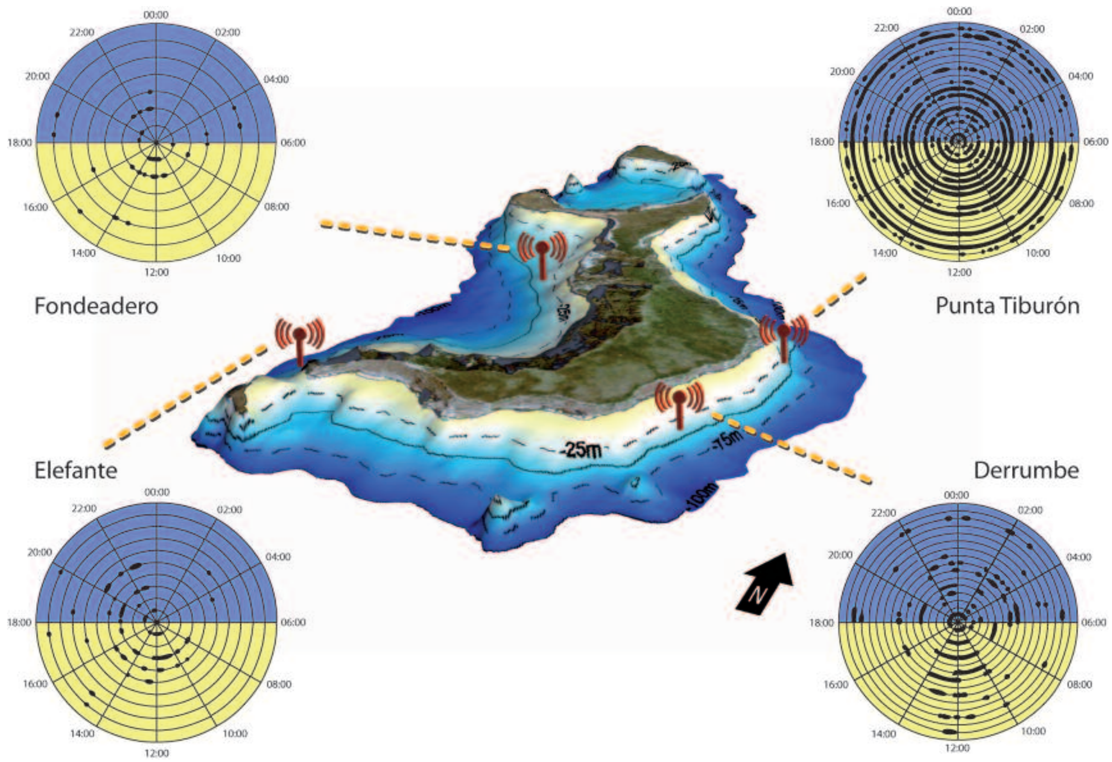

Figure 5. Differences in the number of recorded detections of sharks by the four monitoring stations in Wolf Island in August 2007 indicate the preference of different areas by hammerhead sharks. The circular graphs indicate the nighttime detections (blue) and the daytime detections (cream); the concentric circles correspond to the number of tags recorded by the monitoring stations.

other protected areas of the Eastern Pacific. However, a major question remains: Why were no individuals detected in the central-southern regions of the GMR? Satellite tracking of seven sharks showed that only one individual traveled to the center of the archipelago. Historical data provided by divers with a long history in the GMR indicate that more than 20 years ago large schools of hammerhead sharks were observed in the central part of the islands, at sites such as North Seymour (Fernando Ortiz, pers. comm.). Today only small schools of hammerhead sharks are observed at North Seymour and other sites where they were frequently observed in the past (such as Gordon Rocks, Devil's Crown, and Kicker Rock).

The historical presence and importance of hammerhead sharks in the south-central portion of the archipelago is indisputable. However, the absence of connectivity between this region and the north generates many questions. To explain the current situation, two hypotheses are currently being discussed. The first explains the lack of connectivity by the migratory response of hammerhead sharks as they become adults. The southern zones are probably used as birthing and rearing areas, while the northern zones are used as feeding grounds for adults. Evidence for this hypothesis is based on observations and recording of the presence of neonate and juvenile hammerhead sharks in the mangrove areas and bays of the southern and central archipelago, such as San Cristóbal (Llerena, 2010). In the northern zones only adults and subadults more than 1.5 m long are sighted. The second hypothesis presents the possibility that there has been a considerable decline in the population in the south resulting from over-fishing. In any case, more studies are required before the true reasons for this difference in abundance of hammerhead sharks throughout the GMR can be determined.

Conclusions and recommendations

Based on the results of this study, it is evident that the hammerhead shark is a resident species of Galapagos but at the same time highly migratory. Its site and habitat preferences at both macro and micro scales are beginning to be revealed but there are still many questions that need answers. What are the environmental conditions that make hammerhead sharks prefer specific sites? What drives the major migrations to other areas of the Pacific? Why has no connection been detected between the northern and southern areas of the GMR? What is the abundance of hammerhead sharks in the different regions of the GMR? Where are the rearing areas for this species? Given these questions, additional

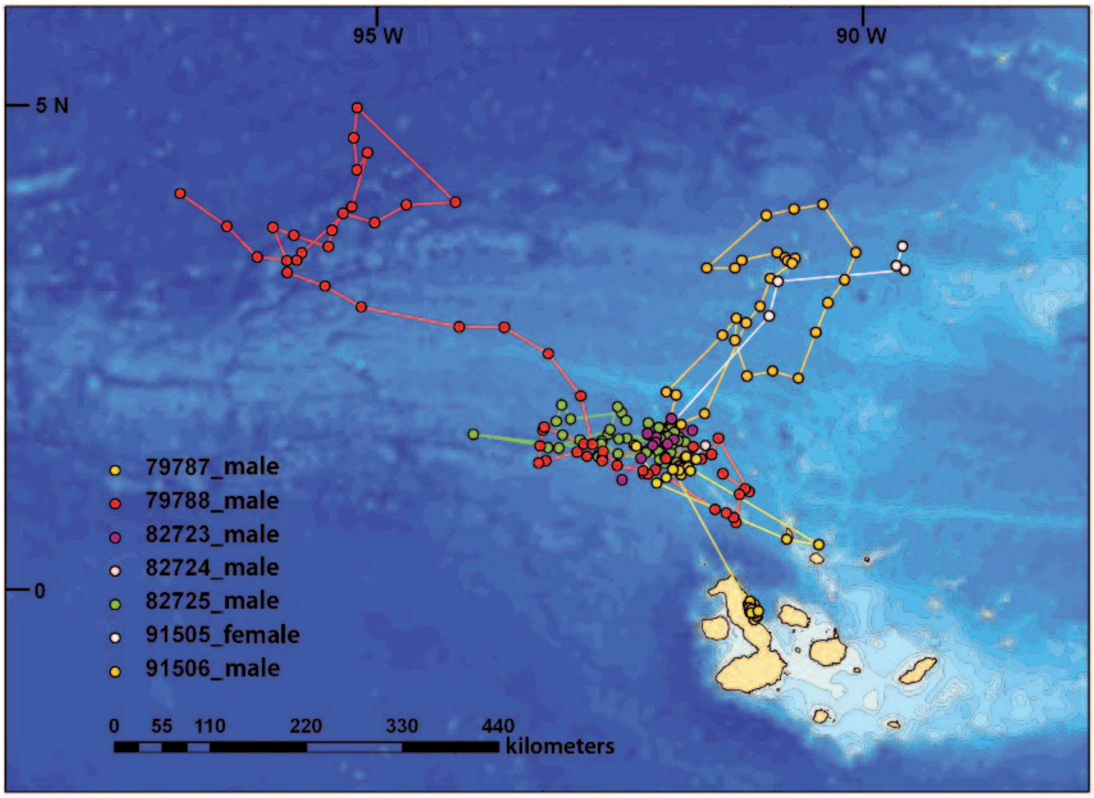

Figure 6. Navigation routes of seven hammerhead sharks tagged with satellite devices in Darwin and Wolf Islands from November 2007 to May 2009. Source: Ketchum *et al.*, in prep).

population, oceanographic, and geologic data, and environmental modeling is needed to increase our understanding of the conditions and environmental forces that mold the behavior of this species.

Studies of this type for hammerhead and other sharks, such as whale sharks, Galapagos sharks, and reef whitetip sharks, are very important for understanding their behavior and use of the various zones of the GMR. In terms of management, identifying the areas of greatest use can result in improved and more effective control and patrolling to combat illegal fishing. Research will also determine rearing and resting patterns in the coastal zones, which would help the authorities to evaluate current zoning of the GMR and incorporate measures for greater protection in critical areas. The protection of sharks will result in greater protection of some of the less charismatic species that are of great ecological value for marine environments. Finally, understanding migratory patterns for these species helps to identify priority conservation zones in open water, which could serve as a basis for the possible zoning of the open waters of the GMR. Cooperation with other countries, such as Costa Rica and Columbia, is essential for adopting management measures that will protect hammerhead sharks in international waters. These efforts are advancing and scientists in the Eastern Pacific are cooperating in the production of regional information critical to achieving this goal *(for more information on international cooperation visit the webpage: www.migramar.org*).

This project was made possible thanks to the support of: Conservation International, WWF-Galapagos, Linblad Expeditions, Galapagos Conservation Trust, and Swiss Friends of Galapagos.

Photo: Susana Chamorro

Population ecology of two species of chitons, *Chiton goodallii* and *Chiton sulcatus,* in the rocky coastline of San Cristóbal Island, Galapagos

Juan Carlos Murillo Posada

Galapagos National Park

Introduction

Chitons (Mollusca: Polyplacophora) include approximately 600 marine species. They live primarily in rocky, intertidal habitats, although some have been found at depths up to 7000 m (Campbell and Fautin, 2001). These organisms are relatively sedentary and are generally more abundant on exposed rocks, living in crevices or adhering to the underside of rocks using pressure they exert on their ventral foot and belt. They prefer living among algae in intertidal and submarine zones (Cruz and Sotela, 1984; Piercy, 1987; Randall and Martine, 1987).

Thirteen coastal species of chitons have been recorded in Galapagos (Finet, 1994), six of which are endemic. Two of the endemic species, *Chiton goodalli* (Broderip, 1832) and *C. sulcatus* (Wood, 1815), are harvested by artisanal fishermen due to their larger size and abundance. *C. goodalli* is known locally as "smooth *canchalagua*" and *C. sulcatus* as "sculpted *canchalagua*." Collection of these mollusks is carried out at low tide under full moon when these organisms are most accessible (Herrera and Bustamante, 1996; Herrera *et al.*, 2003)(Figures 1 and 2). To dislodge them, fishermen hit them with rocks until they detach themselves. Shells left along the length of the shores of Santa Cruz and San Cristóbal provide evidence of their extraction and indicate a preference for *C. goodalli* over *C. sulcatus*, due to its larger size (Herrera and Bustamante, 1996; Murillo, 2008).

Commercial fishing of chitons in Galapagos is primarily carried out by groups of fishermen who are not on the Fishing Register of the Galapagos National Park (GNP). They have been carrying out this activity for many years and generally approach the fishing grounds via land. To date, these fishermen have not been included in the formal fishery management system of Galapagos. Some of the artisanal fishermen registered with the GNP also harvest chitons, but usually only to feed themselves during longer fishing trips to islands such as Española, Santa Fe, and islands in the north. The chiton fishery is not included in fishery management plans in Galapagos.

The objective of this study was to determine growth rates, recruitment, and mortality of two species of chiton, *C. goodalli* and *C. sulcatus*, in San Cristóbal, with the goal of providing recommendations for future studies and for the management and conservation of these species.

Figure 1. Measuring a chiton during nighttime sampling.

Figure 2. Chitons grazing at night on a rock surface in the intertidal.

Methods

The study was carried out in the rocky intertidal zone of San Cristóbal. Four study areas were selected: two in the intertidal zone of the town (designated "near town") and two located approximately 9 km from Puerto Baquerizo Moreno (designated "far from town")(Figure 3). Eight sampling periods were completed at each site between September 2005 and April 2006, covering the two climatic seasons. Both day and night sampling was conducted during full and waning moons. At night, the larger chitons move out to eat and become more visible and vulnerable to fishermen (Figure 4). Chitons recorded during night

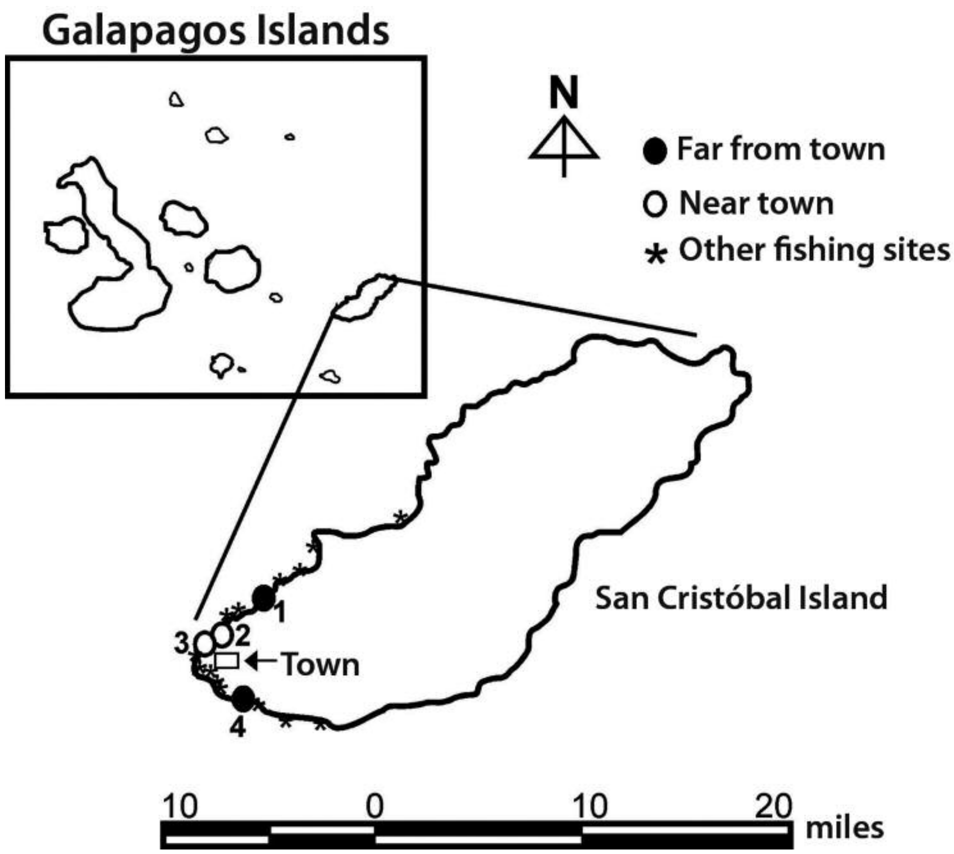

Figure 3. Chiton fishing sites in San Cristóbal selected as study areas. The sites near town are: Site 2 – La Predial and Site 3 – Playa de los Marinos. The sites far from town are: Site 1 - Cerro Mundo and Site 4 – Las Negritas.

sampling periods were designated as "population vulnerable to harvesting." Sites sampled during the night were also sampled during the day in order to obtain a more representative range in size of individuals in order to better estimate growth parameters. The daytime searches were conducted in crevices and under rocks (Herrera *et al.*, 2003).

The study considered two types of recruitment. The first was biological recruitment, which is the establishment of juveniles in a given area (Beverton and Holt, 1957; Royce, 1996). Juvenile chitons are not vulnerable to fishing; their use of cryptic habitat during the day and night allows them to remain camouflaged. The second type of recruitment is adding individuals to the adult stock (Pitcher and Hart, 1982). These chitons are vulnerable to fishing as they include

Figure 4. Specimens observed during nighttime sampling.

the larger, older individuals that forage at night on the surface of rocks, where they are more visible. This is considered as recruitment to the art of fishing (Beverton and Holt, 1957; Sparre and Venema, 1992; Tresierra-Aguilar and Culquichicón-Malpica, 1993).

Results

While chitons were measured at all four study sites, growth estimate data for *C. goodallii* was possible only from Las Negritas and for *C. sulcatus* from Playa de los Marinos, as insufficient numbers of chitons were observed in the other two areas.

Larger chitons were observed during the nighttime sampling at sites both far from and near town (Figure 5). The size of *C. sulcatus* observed both during day and night sampling was larger in the two study areas far from town. The average size observed at night was 2.9 cm (± 0.06 standard error) in sites far from town and 2.6 cm (± 0.02) in sites near town, compared to daytime average sizes of 1.6 cm (± 0.04) and 1.1 cm (± 0.02) in these same locations. Sampling of *C. goodallii* showed the same pattern: at night the average size was 3.5 cm (± 0.03) far from town and 2.6 cm (± 0.08) near town, while daytime sampling at these sites resulted in average sizes of 1.4 cm (± 0.03) and 1.2 cm (± 0.06).

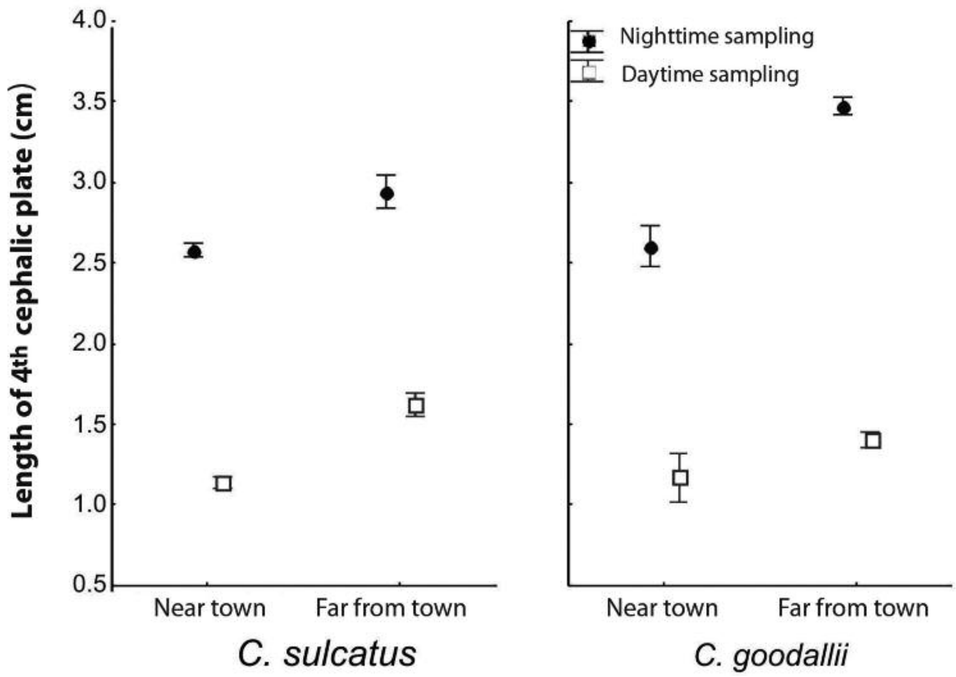

Figure 5. Comparison of average sizes of *C. sulcatus* and *C. goodalii* by study area located near and far from town and type of sampling (daytime and nighttime).

At all of the fishing sites, growth of modal groups was observed throughout the sampling periods (Figure 6). A new cohort of juveniles appeared in February 2006 at Playa de los Marinos and in December 2005 at Las Negritas. These events coincided with the seasonal change in climate that begins in Galapagos in December. The average size of these juveniles when they began to appear in the fishing areas was estimated at 0.87 cm in Playa de los Marinos for *C. sulcatus* and 0.79 cm at Las Negritas for *C. goodallii*.

Growth parameters of the two species suggest that *C. sulcatus* grows more rapidly and reaches its full size at six years of age but is significantly smaller than *C. goodallii*, which reaches its full size at ten years. These differences in size produce a much stronger preference for *C. goodallii* by chiton fishermen, given that it is larger and therefore has greater volume and weight of meat per individual (Figure 7).

Conclusions and recommendations

The characteristics of Playa de los Marinos, which include low levels of wave action and the predominance of a highly heterogeneous substrate, could favor attachment and recruitment of *C. sulcatus* in

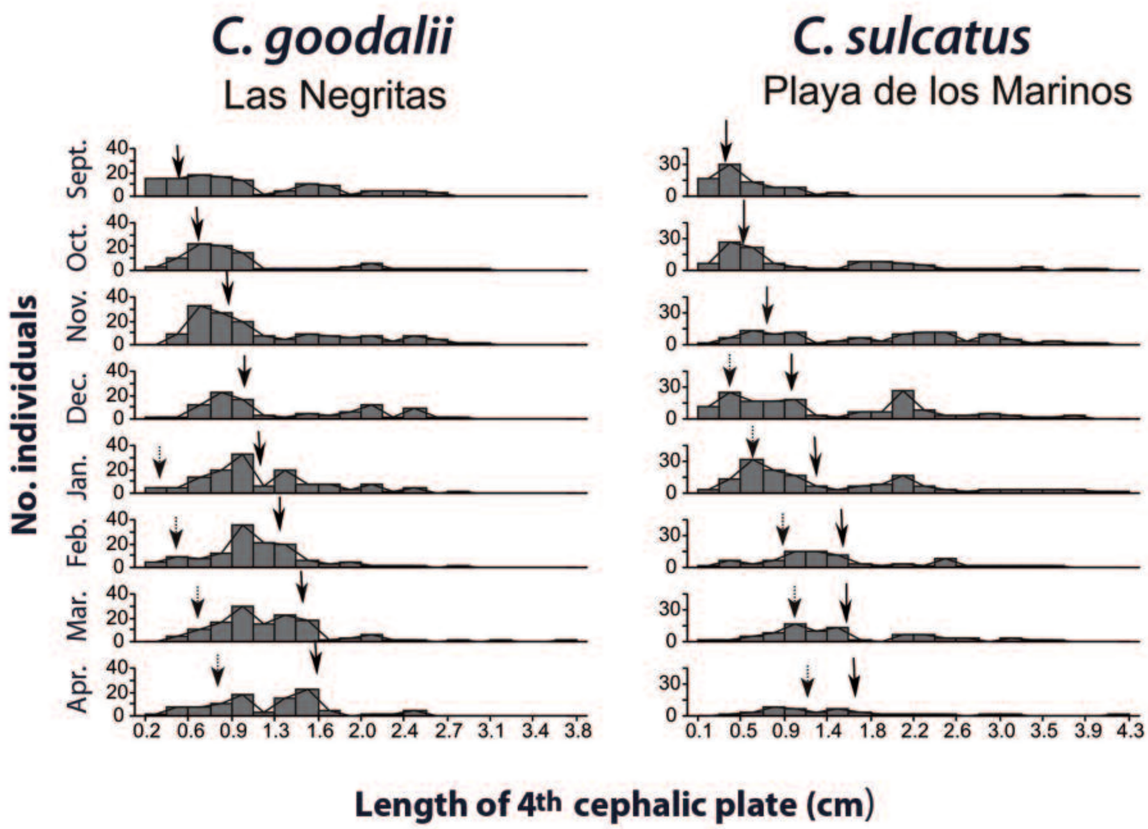

Figure 6. Monthly change in the size of the fourth cephalic plate for modal groups of *C. goodallii* at Las Negritas and *C. sulcatus* in Playa de los Marinos. The arrows follow the growth of individuals of first and second cohorts, with the second cohort appearing at Las Negritas in January and at Playa de los Marinos in December.

the area. This could explain the constant, high abundance of chitons that were observed during all sampling months, even though it is known that this zone is traditionally harvested by members of the local community.

The minimum size of individuals found in the fishing zone was 0.67 cm for *C. sulcatus* and 0.79 cm for *C. goodallii*, which indicates an age of three to four months. In Playa de los Marinos at least two recruitment events were observed during the study (September and December), which would also influence the high abundance of chitons found during nighttime sampling. For *C. sulcatus*, recruitment events seen at Playa de los Marinos could be closely related to the spawning season of the parental stock that lives in the zone. The Playa de los Marinos area is protected from wave action and the fact that chitons have short larval stages suggests that the larvae produced by the parental stock in this zone settles in the same area. This does not occur with *C. goodallii* in Las Negritas, due to the greater wave action and strong currents in this site, which disperse any larva far from the zone in which they are produced.

Recruitment size corresponds to the stage at which chitons can attach to rocks and forage. At this stage they are significantly larger than those initially recruited to fishing zones. The sizes for the two species were 2.6 cm for *C. sulcatus* and 2.9 cm for *C. goodallii*.

Given that there are as yet no specific management measures for this fishery, the following is recommended:

1. Present this study to the direct users of the resource and the natural resource managers of the GNP to initiate a discussion about this fishery and potential management methodologies.

2. Identify the fishermen involved in this activity who harvest chiton for their own consumption and those who depend economically on this fishery during at least part of the year.

3. Establish a chiton monitoring system to include other inhabited islands and expand the

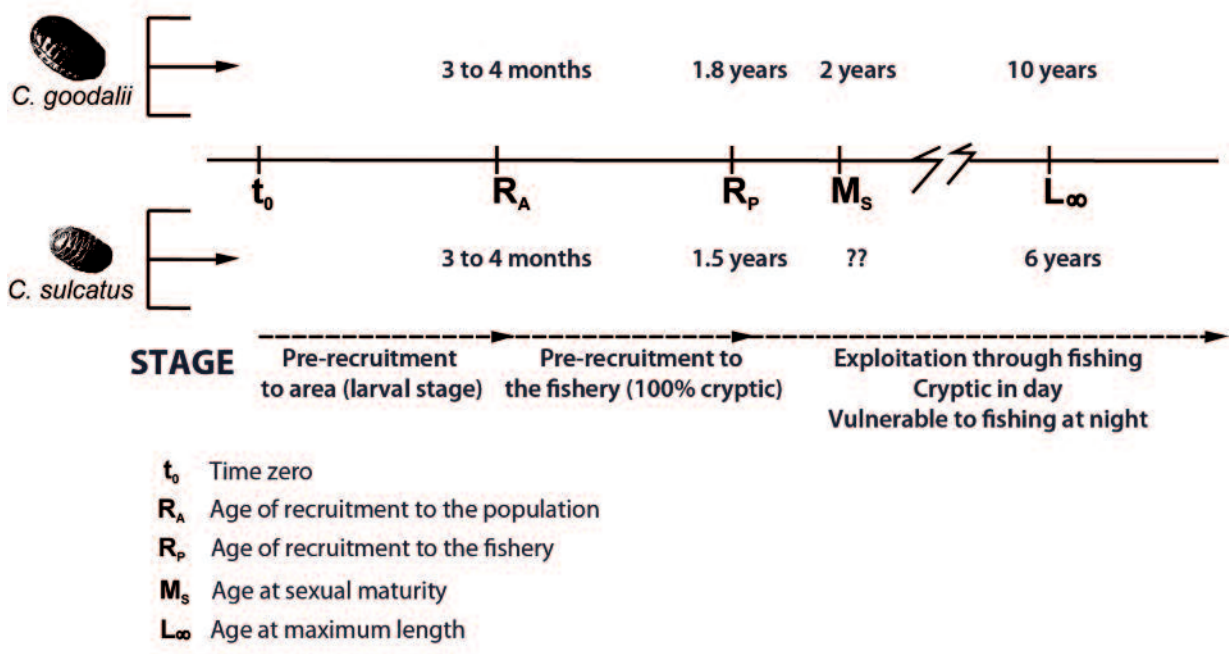

Figure 7. Critical stages and relative ages for *C. goodallii* and *C. sulcatus*, based on growth parameters calculated in this study.

research through surveys of fishermen in an attempt to determine sustainable levels for this fishery.

4. Carry out parallel studies of the reproductive biology and growth parameters of chiton, using marked individuals, in order to adapt management methodologies to the biological capacity of the species.

5. Include management methodologies for this fishery (beginning with issuing licenses specific to this fishery) in the overall Fisheries Management Plan.

Photo: Diego Ruiz

A revised strategy for the monitoring and management of the Galapagos sea cucumber

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[1]Charles Darwin Foundation (CDF), [2]World Wildlife Fund (WWF)

Introduction

The Galapagos sea cucumber fishery began in the early 1990s with catches increasing annually until a peak period from 1999 to 2005. During this peak period nearly 30 million sea cucumbers were harvested legally within the Galapagos Marine Reserve (GMR), corresponding to a total fresh weight of over 8000 tons (CDF/GNP Fisheries Reports). Catches peaked in the year 2002, with over 8.3 million individuals harvested (Figure 1). Following 2002, the harvest continued to decrease as a result of permanent overfishing due to factors such as overcapacity of the fishing fleet, a "race for fish" situation - a worldwide phenomena caused by a total allowable catch for all fishermen versus individual quotas for each fishermen making them fish as much as they can in as little time as possible - and a reactive instead of proactive fisheries management system. In addition, the determination of an annual quota was not based on a scientific study; rather it was negotiated with the fishermen and was therefore largely based on their demands.

In 2008, for the first time, a limit reference point (LRP) of 11 individuals/100 m^2 in the principal fishing zone west of Isabela Island was established - as derived from the pre-fishery monitoring - to determine if the fishing season would be opened or not. The use of this LRP caused two problems. First, instead of using stock size as the basis for the LRP, mean densities based on pre-fishery monitoring in the principal fishing zone (western Isabela) were used as the condition for opening the fishery. This motivated fishermen, who participated in the monitoring, to focus on areas where densities had traditionally always been high. The results unfortunately did not represent the overall mean density in all fishing areas. The second problem was that once the fishery was opened, fishermen harvested all sea cucumbers above the minimum landing size (20 cm total length) within their quota (when applied) and economic limits. This led to the post-fishery stock being extremely small without the potential to rebuild prior to the next year's fishing season. When sea cucumber densities are too small, fertilization is not possible and the stock cannot recover.

This study evaluated the monitoring and management strategy of the sea cucumber fishery during the past 10 years and aimed to estimate the stock size

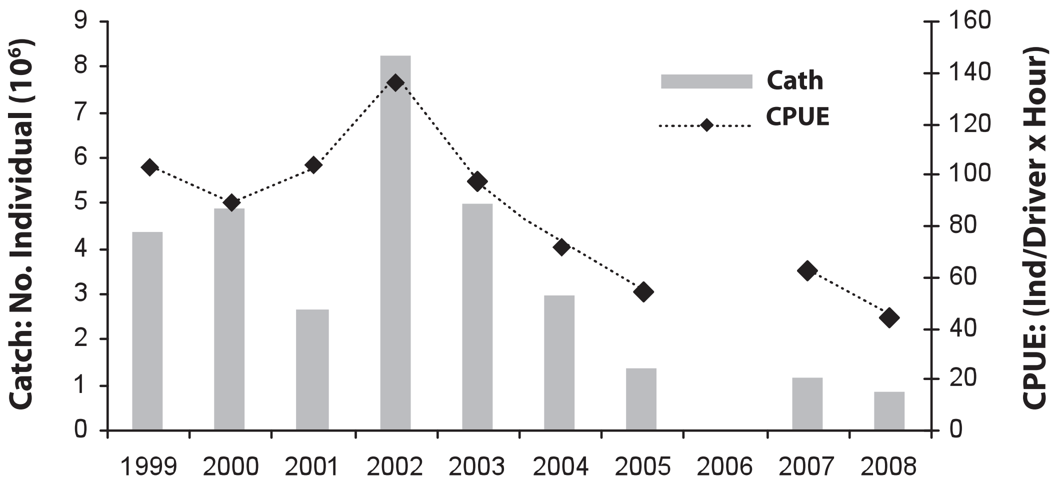


Figure 1. Annual catch in number of individuals and Catch per Unit of Effort (ind/diver*hour) from 1999-2008 (2006 season was closed). Source: CDF Fisheries Reports.

and to optimize the way in which the annual harvest quota is determined. In recent years, fishermen have argued that sea cucumbers may be more abundant in deeper, less fished waters, thus providing the needed stock reserves to counteract heavy fishing in the shallower waters. Therefore, we compared mean densities in shallow areas (< 15 m) with those in deeper waters (> 15 m). The results of the 2009 monitoring season were compared with those from the past ten years in order to demonstrate density and size structure trends, specifically the proportion of specimens smaller than 20 cm in the population. This trend in size structure should be indicative of recruitment strength in previous years.

Methods

Area estimates, transect numbers, and density estimates

Macrozones were defined based on historical and current major fishing areas, identified through onboard fisheries observations from 1999 to 2008, gathered by the Galapagos National Park (GNP) and the Charles Darwin Foundation (CDF). The zones were then delimited based on bathymetric data compiled by Chadwick (1994), which were interpolated using ArcGIS. The outer boundary was set at the -30 m isobath, based on historical data indicating that it is the maximum depth at which diving for sea cucumbers is carried out (CDF Fisheries Reports). With the isobath line as the outer and the coastline as the inner boundary, the area of each macrozone (km^2) was mapped. Of the total macrozone area, the suitable habitat for sea cucumbers and therefore the effective fishing area was estimated at approximately 50%, given that approximately 30% has unsuitable sandy bottoms and another 20% is either intertidal waters that are too shallow (< 5 m) or uninhabitable steep slopes.

To calculate the number of transects required to represent each macrozone, we reviewed means and standard deviations of stock densities from previous surveys. Based on this, the minimum number of replicates (transects) needed to achieve a precision of ±25% was estimated using the following formula:

$$n = \left(t_{(n-1)} * \frac{SD}{0.25 * Av}\right)^2$$

where n = minimum number of replicates required to achieve a precision of ±25% around our estimate of mean density; t = value of the t distribution (student's t-test) for $p < 0.05$; Av = annual average sea cucumber density per macrozone, and SD its standard deviation.

The number of replicates required for the different macrozones varied depending upon differences in spatial distribution and stock density, with more replicates needed in areas with greater patchiness and fewer in zones where the population appears more evenly distributed.

A circular transect (radius of 5.6 m, area of 100 m^2), proven to be effective in previous studies, was used. Transects were evenly distributed over the two depth strata (<15 m and >15 m). The mean number of sea cucumbers per m^2 within each macrozone was extrapolated for the entire macrozone and then the stock sizes of all macrozones were summed to determine the stock size of the entire effective fishing area.

Since the density values of each macrozone were not normally distributed, a bootstrap resampling routine (Efron, 1981) was applied. This consisted of a random resampling (1000x) of the data matrix for each macrozone. This yielded 1000 normally distributed mean density values and allowed for the computation of the standard deviation and coefficient of variation around the mean. To test for depth differences in sea cucumber densities, all measurements taken in each depth stratum (5-15 m and 15-25 m, respectively) were considered for the calculation of overall means per depth strata. The resulting mean densities were bootstrapped for each stratum and compared using a t-test of means. For comparative purposes we also applied a non-parametric Mann-Whitney U test for the medians.

Calculating the catch quota

Under conditions of sustainable exploitation, annual stock production is balanced by the sum of Fisheries Mortality (F) and Natural Mortality (M), called Total Mortality (Z). Cadima (in Troadec, 1977) proposed the following formula to attain maximum sustainable yield from an already fished resource:

Maximum Sustainable Yield (Quota) = $0.5 * Z * B$

where B = current stock biomass.

This formula was shown not to be applicable if $F > M$; however, and even in cases when $F = M$ (at an exploitation rate of 50%; $E = F/Z = 0.5$), a stock may be overfished as was shown by Garcia and LeReste (1980). Following this reasoning, we chose a more precautionary rate of 30% or $E = 0.3$, when applying the above formula. With our value for the Natural Mortality at 17% ($M = 0.17$) based on Hearn *et al.* (2005), the Fishery Mortality was calculated as follows: $F = 0.073$. By inserting the resulting Total Mortality value ($Z = F + M = 0.243$) in Cadima's formula we arrived at a quota estimate of:

Quota = $0.5 * 0.243 * B = 0.122 * B$

Therefore, the annual quota or total allowable catch (TAC) proposed is 12.2% of the standing stock.

Results

Estimates of macrozone areas and number of transects per macrozone

The distribution of sea cucumber fishing activities in the archipelago from 1999 to 2008 was determined from data collected by onboard fisheries observers (Figure 2). These data were used to define the

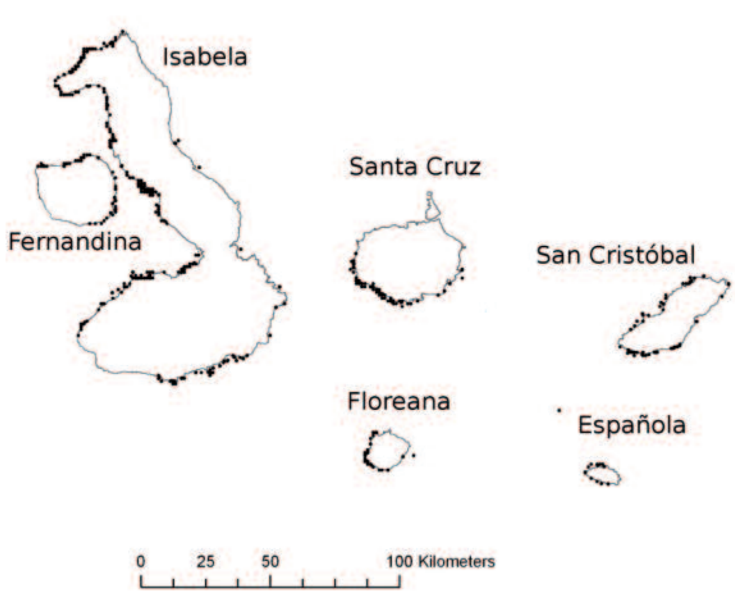
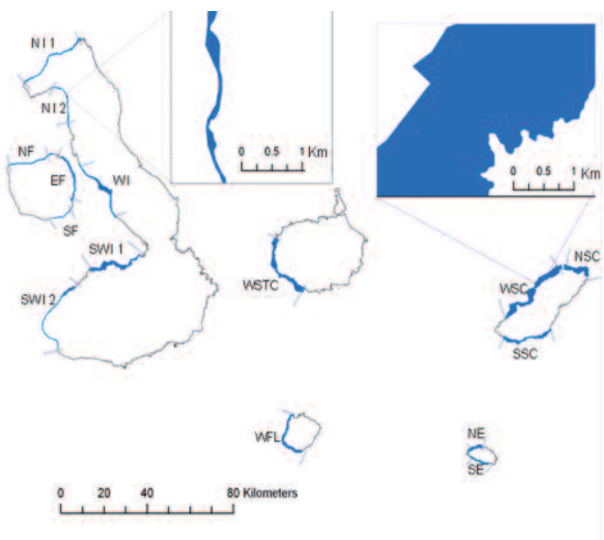


Figure 2. Sea cucumber fishing sites in Galapagos assembled from geographical referenced data from onboard and landing site monitoring (CDF and GNP data bases, 1999-2008).

macrozones (Figure 3). To adequately represent each of these macrozones, the number of transects required to fulfill a 25% precision limit was calculated for each one.

The estimated size of the effective fishing area, which represents 50% of all of the macrozones, is 125 km^2 (Figure 3). San Cristóbal has the largest fishing area (52 km^2), followed by Isabela (33 km^2) and Santa Cruz (20 km^2). Floreana, Española, and Fernandina combined represent 20 km^2. It is interesting to see that replicate numbers vary greatly between zones, with Española requiring the highest number per area (49/5 km^2), while Santa Cruz requires only 31 transects in 20 km^2 (Table 1).



Code	Macrozone	Effective fishing area (km^2)*
NI 1	North Isabela 1	3.6
NI 2	North Isabela 2	1.6
WI	West Isabela	10.3
SWI 1	Southwest Isabela 1	13.3
SWI 2	Southwest Isabela 2	4.0
NF	North Fernandina	1.5
EF	East Fernandina	4.5
SF	South Fernandina	8.5
WSTC	West Santa Cruz	20.4
WFL	West Floreana	0.3
WSC	West San Cristóbal	31.8
NSC	North San Cristóbal	10.5
SSC	South San Cristóbal	9.3
NE	North Española	3.0
SE	South Española	2.1
	Total	125

*50% of the total macrozone area

Figure 3. Macrozones identified based on the major fishing sites and their effective fishing area (50% of total macrozone area) in km^2.

Table 1. Mean and maximum density values (ind/100 m^2) of all macrozones and islands with the number of transects planned and carried out, standard deviation (SD), and coefficient of variation (CV).

Island	Macrozone (code)	No. transects planned	No. transects completed	Mean density	Maximum density	SD	CV (%)
Isabela	NI1	25	10	2.8	7	0.7	25.00
	NI2	19	21	3.6	19	0.9	25.00
	WI	55	40	3.7	27	0.8	21.62
	SWI1	57	24	3.6	17	0.9	25.00
	SWI2	23	30	2.2	14	0.6	27.27
	combined	**179**	**125**	**3.3**	**27**	**0.4**	**11.59**
Fernandina	NF	10	11	1.0	8	0.7	70.00
	EF	31	20	3.5	16	0.9	25.71
	SF	8	4	1.6	6	1.3	81.25
	combined	**49**	**35**	**2.5**	**16**	**0.6**	**24.90**
Santa Cruz	**WSTC**	**31**	**25**	**4.8**	**23**	**1.1**	**22.82**
Floreana	**WFL**	**32**	**26**	**2.7**	**13**	**0.6**	**22.14**
San Cristóbal	NSC	14	5	2.4	8	1.4	58.33
	WSC	47	56	4.8	42	0.9	18.75
	SSC	58	36	6.1	38	1.2	19.67
	combined	**119**	**97**	**5.1**	**42**	**0.7**	**13.26**
Española	NE	28	12	4.7	11	0.9	19.15
	SE	21	27	4.9	11	0.6	12.24
	combined	**49**	**39**	**4.9**	**11**	**0.5**	**9.67**
All Islands	**combined**	**459**	**347**	**3.9**	**42**	**0.3**	**6.81**

The population monitoring was carried out in the last two weeks of May 2009 by fishermen, and GNP and CDF staff. The work was coordinated and financed primarily by the GNP and WWF. Due to insufficient funds, fewer transects were carried out than originally planned.

Densities and catch quota for 2009

Mean density of sea cucumbers for western Isabela (3.28 ± 0.38 ind/100 m^2) was far below the critical value established for opening the fishery (11/100 m^2). Based on these results it was recommended not to open the fishery for the year 2009, which was later accepted by the co-management body, the Interinstitutional Management Authority (IMA).

Following our new approach, the fishing quota or total allowable catch (TAC) for the entire archipelago for the 2009 fishing season would have been 598,938 individuals, based on the stock size (4.9 million individuals) derived from the overall mean density (3.9 ind/100 m^2) and our combined area estimate (125 km^2).

Based on the pre-fishery monitoring data from 1999-2009 for each island, the mean densities and the proportion of small (< 20 cm) sea cucumbers in the samples show general trends over the past 10 years (Figure 4). In general, sea cucumber densities in Galapagos have decreased since 2002. Floreana, Isabela, and Fernandina show a steady decrease in density over recent years, while Santa Cruz has remained relatively constant. It is interesting to note that the density value for San Cristóbal in 2009 was the second highest density value recorded there since 1999. The proportion of juveniles (recruits) in the stock has steadily decreased for the western islands, Isabela and Fernandina, and in 2009 was the lowest ever recorded in Española and Floreana. Santa Cruz and San Cristóbal reveal a slight increase in recruits over the last three years.

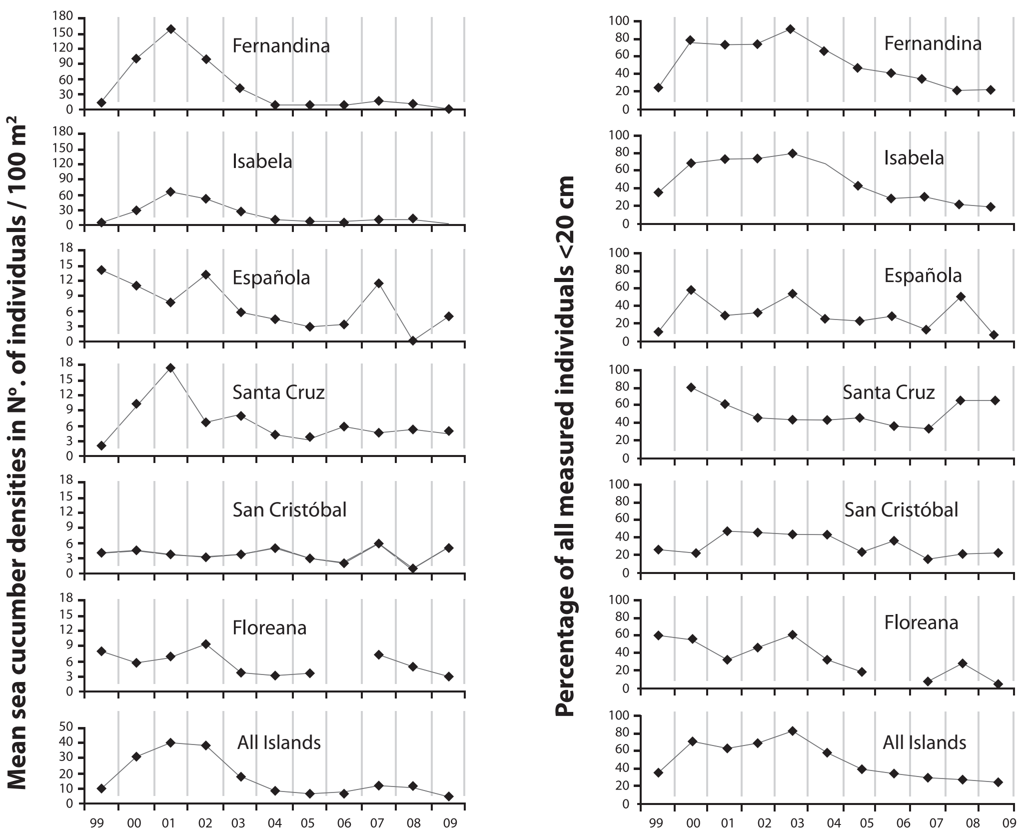


Figure 4. Left: pre-fishery monitoring mean densities (ind/100 m^2) from 1999-2009, by island. Right: percentage of measured individuals that are smaller than 20 cm in total length, by island (1999-2009).

Mean density values of our 2009 monitoring for the two depth strata were 4.5 and 3.2 ind/100 m^2, for 0-15 m and 15-30 m, respectively (Figure 5). The non-parametric Mann-Whitney U test of the median density values confirmed the significant difference found for the mean values using the bootstrapping routine (t-test; $p<0.05$). Accordingly, a higher sea cucumber density in deeper waters, suggested by the fishermen, could not be verified. Instead, higher densities were observed in the shallow stratum.

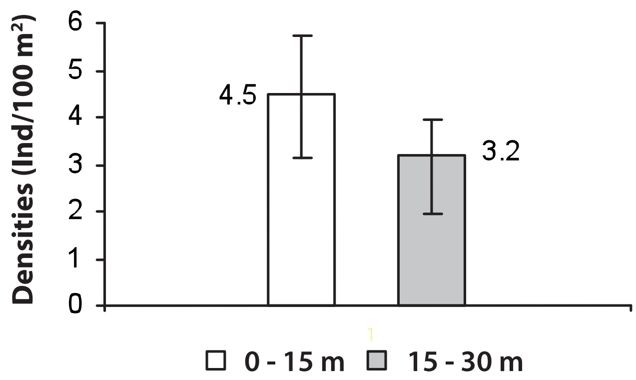


Figure 5. Mean densities (ind/100 m^2) shown with standard deviation for the two depth strata, after using a re-sampling bootstrap method.

Discussion

Estimating the fishing area was difficult due to substantial variability in topography and slope of the seafloor between macrozones. Polygon mapping to determine the area (m^2) between the coastline and the -30 m isobath using ArcGIS could not always be done without a certain margin of error. However we consider our area estimation a good and necessary starting point to calculate a fishing quota. The fishing season was not opened in 2009, as the sea cucumber density was calculated at a value substantially below the set limit reference point (11 ind/100 m^2 in western Isabela). Although the quota calculation of nearly 600,000 sea cucumbers for 2009 was only a virtual quota because the season remained closed, it provides a reference point for the future.

Using the new approach, we calculated a hypothetical quota for each of the past years and then compared them with the annual sea cucumber catches (Figure 6). The newly calculated quotas based on sea cucumber densities from pre-fishery population monitoring were lower than the actual catches during most of the years, except for 1999, 2001, 2007, and 2008, when the quota was slightly higher than the catch.

The rather low sea cucumber catch in 2001 was a result of an individual quota system applied for the first and only time, where each registered fisherman was assigned a quota of 3174 sea cucumbers, which they could use or sell. Many vessel owners bought quotas from other fishermen. However, they miscalculated the economical limit of their fishing activities, which resulted in a total catch of only 60% of the overall quota (2001 CDF-GNP Fishing Report). The virtual quota of 2007 and 2008 is rather high based on the high pre-fishery density estimates, which we believe is based on biased population monitoring and therefore cannot be trusted in the same way as the 2009 estimate.

Of the 459 planned transects, only 383 (83%) were carried out during the 2009 pre-fishery monitoring due to financial constraints. This was the largest

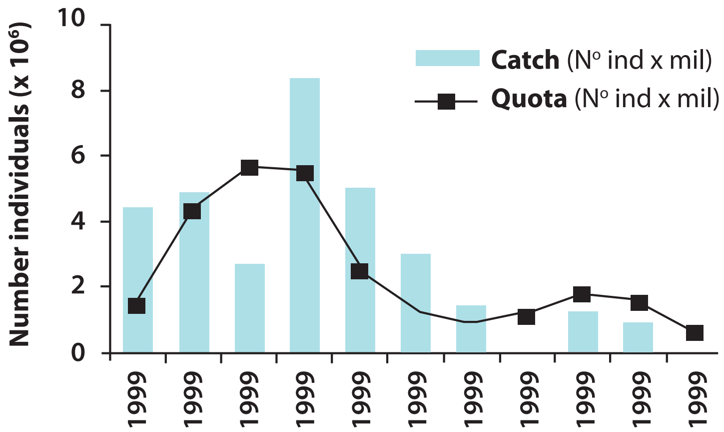


Figure 6. Annual sea cucumber catches and the calculated quota based on this study in millions of individuals from 1999-2009 (2006 season was closed).

number of circular transects ever completed in the Galapagos sea cucumber fishing areas during a pre-fishery monitoring. The precision around the mean densities differs between macrozones, with a coefficient of variation (CV) ranging from 12.2% for eastern Española to 81.2% for southern Fernandina (Table 1). These differences can be attributed to the number of transects and the degree of patchiness of the sea cucumbers in each zone. When the transect data are integrated for each island, the respective density estimate is greatly improved, with CVs always <25%. The two islands that had the highest transect numbers (Isabela with 125 and San Cristóbal with 97) had the lowest CV around the mean density estimate (11.6% and 13.3%, respectively). The density estimate for all transects combined (3.93 ± 0.26; CV = 6.8%) can be considered of very high precision.

Of all macrozones sampled, none reached the limit reference point of 11 ind/100 m^2 to open the fishery, which points to a very critical state of the stock. Several factors may explain this situation. Since the last strong El Niño in 1997/98, which apparently resulted in improved recruitment of sea cucumbers observed during 2000-2002, the past ten years were dominated by cold waters (Sea Surface Temperature database of CDF) and no further recruitment boom has been observed. This lack of recent recruitment and the problem of a too small spawning stock remaining after each fishing season may have combined to reduce overall spawning activity as well as larval and pre-recruit survival, thus not allowing the sea cucumber stock the chance to recover. Furthermore the catch quotas determined during the co-management process were often too high or not present at all as in 1999 and 2002, leaving behind a stock too small to recover prior to the next season. The general problem was that the quota was set with no available estimate of the absolute stock size.

The belief that sea cucumber densities may be higher in deeper waters, giving the stock a strength in reserve if fishing pressure in shallower waters is high, was shown to be incorrect. This is an important finding since it removes the basis for the argument that a large portion of the stock is out there in deeper waters where it cannot be caught.

We believe that the monitoring and management strategy of the Galapagos sea cucumber stock presented here is an important step towards a sustainable sea cucumber fishery. It is the first time that an attempt has been made to estimate the size of the entire fishing area and of the fishable stock. Moreover, the monitoring was adapted to specific conditions - primarily size and sea cucumber patchiness of each macrozone. The suggested quota was set as a fraction of the stock size (12.2%), which makes it adaptive to natural inter-annual stock fluctuations. If environmental conditions are not too adverse in the coming years, the proposed strategy should allow for sustainable harvests while the sea cucumber stock rebuilds. This strategy also seems economically viable for the management authority since it only considers one annual, pre-fishery monitoring instead of two monitoring surveys as in previous years.

Acknowledgements

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Changes in land use and vegetative cover in the rural areas of Santa Cruz and San Cristóbal

Ángel Villa C and Pool Segarra

Governing Council of Galapagos

Introduction

Land ownership and use in Galapagos began in 1832 when the first colonists initiated agricultural activities for their self-sustenance. This represented the first economic activity in the islands. Over the years, areas with urban and rural human settlements have undergone important changes in land use and vegetative cover. In these areas, the propagation of invasive plant species represents a threat with significant socioeconomic and environmental consequences.

In 1974 the Ecuadorian government designated the boundaries of the Galapagos National Park (GNP) and areas for urban and rural human settlements. Land ownership was formalized by the Ecuadorian Institute for Agricultural Reform and Colonization (known by the Spanish acronym IERAC). In the ensuing years, the resident population grew and caused greater changes in land use and vegetative cover. As a result, propagation of invasive species on Santa Cruz and San Cristóbal, the two islands with the greatest human population, increased significantly.

This analysis of changes in land use and vegetative cover was based on the following studies:

1. Maps of Vegetation Formations and Current Land Use developed as part of the study entitled "Cartographic Inventory of Natural, Geomorphic, Vegetative, Hydrological, Ecological and Biophysical Resources of the Islands of Santa Cruz and San Cristóbal," (scale of 1:100.000) carried out by the National Institute of Galapagos (INGALA-PRONAREG-ORSTOM) in 1987.

2. Study of Topographic and Thematic Cartography of the Galapagos Islands, carried out in 2006 by The Nature Conservancy (TNC) in cooperation with the Center for Integrated Surveys of Natural Resources through Remote Sensors (CLIRSEN), with the collaboration of the GNP-Ministry of the Environment and the Charles Darwin Foundation (CDF).

The current analysis was possible only for San Cristóbal and Santa Cruz because the 1987 INGALA study did not cover Isabela and Floreana.

This and similar studies by INGALA (now a part of the Governing Council of Galapagos) will contribute to regional planning and public policy for the integrated management of resources such as water, soil, and vegetative cover. These resources are directly related to the conservation of watersheds and the characteristics of the hydrologic cycle, and are important for improving storage capacity and/or production of water, especially in San Cristóbal where there are important natural sources of fresh surface water.

Methods

This study was conducted by superimposing maps created in 1987 and 2006 in the urban and rural areas of Santa Cruz (8352.8 ha) and San Cristóbal (14,841.3 ha). The changes in vegetative cover and land use were compared and analyzed for the period 1987-2006, using the following steps:

- The 1987 maps were transferred to digital format using a scanner, geo-referencing, and digitalization. These maps describe five main categories and sub-categories of vegetation formations and land use.

- The 2006 maps describe 14 categories of vegetation formations, which were combined into five groups to permit the superimposition of the maps and the comparison of similar categories from 1987.

- The maps were superimposed using a digital format (Arc-GIS version 9.2 software) to generate new maps that demonstrate the changes in land use between 1987 and 2006.

Results

The superimposed maps show major changes in the vegetation formations and land use in both San Cristóbal and Santa Cruz between 1987 and 2006, primarily due to the significant increase in the propagation of invasive species. In addition there are other local socioeconomic factors that contributed to the changes in the areas of human settlement in the two islands.

Vegetation formations and land use are defined in categories and sub-categories as follows:

1. Natural vegetation and pastures dominated by native and endemic species (a total of 6884.7 ha between the two islands in 1987).

2. Agricultural use with three sub-categories:

   2.1. Artificial pastures, associated with long-cycle cultivated plants (13,049.4 ha; the sub-category with the largest area of land in both islands in 1987).

   2.2. Short-cycle and long-cycle cultivated plants (498.8 ha in 1987).

   2.3. Coffee dominated (1151.5 ha for both islands in 1987, with a greater predominance in San Cristóbal).

3. Invasive species. In 1987 guava (*Psidium guajava*) forests occupied 1310.7 ha on the two islands and rose apple (*Syzygium jambos*) occupied 62.1 ha. Other invasive species were not recorded, probably because of lower incidence in 1987.

4. Populated centers. Because of the nature of this category (primarily buildings and roads), the maps do not show any change in vegetative cover. However, they do show changes related to land occupancy in the urban areas. In 1987, San Cristóbal had a larger urban area than Santa Cruz, while today the opposite is true. Unfortunately, the 2006 maps did not document this type of information, so determining the magnitude of the changes of land occupancy is impossible.

San Cristóbal

The greatest changes in vegetation over the 19-year period are principally due to the propagation of invasive species in all of the categories of vegetation formations and land use, with the greatest changes in three of the categories (Table 1; Maps 1 and 2). Of the total agricultural area in 1987 (8352.9 ha), 71% had converted to invasive species by 2006, while only 21% remained unchanged.

Natural vegetation: Of the 2936 ha in 1987, 77% (2251.3 ha) has changed to cropland and at the same time has been invaded by introduced species. In San Cristóbal one can observe agricultural production units that have been semi-abandoned, probably due to the low profit levels associated with this activity because of high production costs and lack of available labor.

Artificial pastures associated with long-cycle crops: Of the 2726 ha in 1987, 80% (2174.5 ha) showed changes in 2006, corresponding to crops and primarily to the presence of invasive species, especially rose apple, guava, and Hill raspberry (*Rubus niveus*).

Short-cycle crops (vegetables and grains) and **long-cycle crops** (banana, sugarcane, and fruits): Of the 498.8 ha in 1987, 86% (427.5 ha) was impacted principally by invasive species.

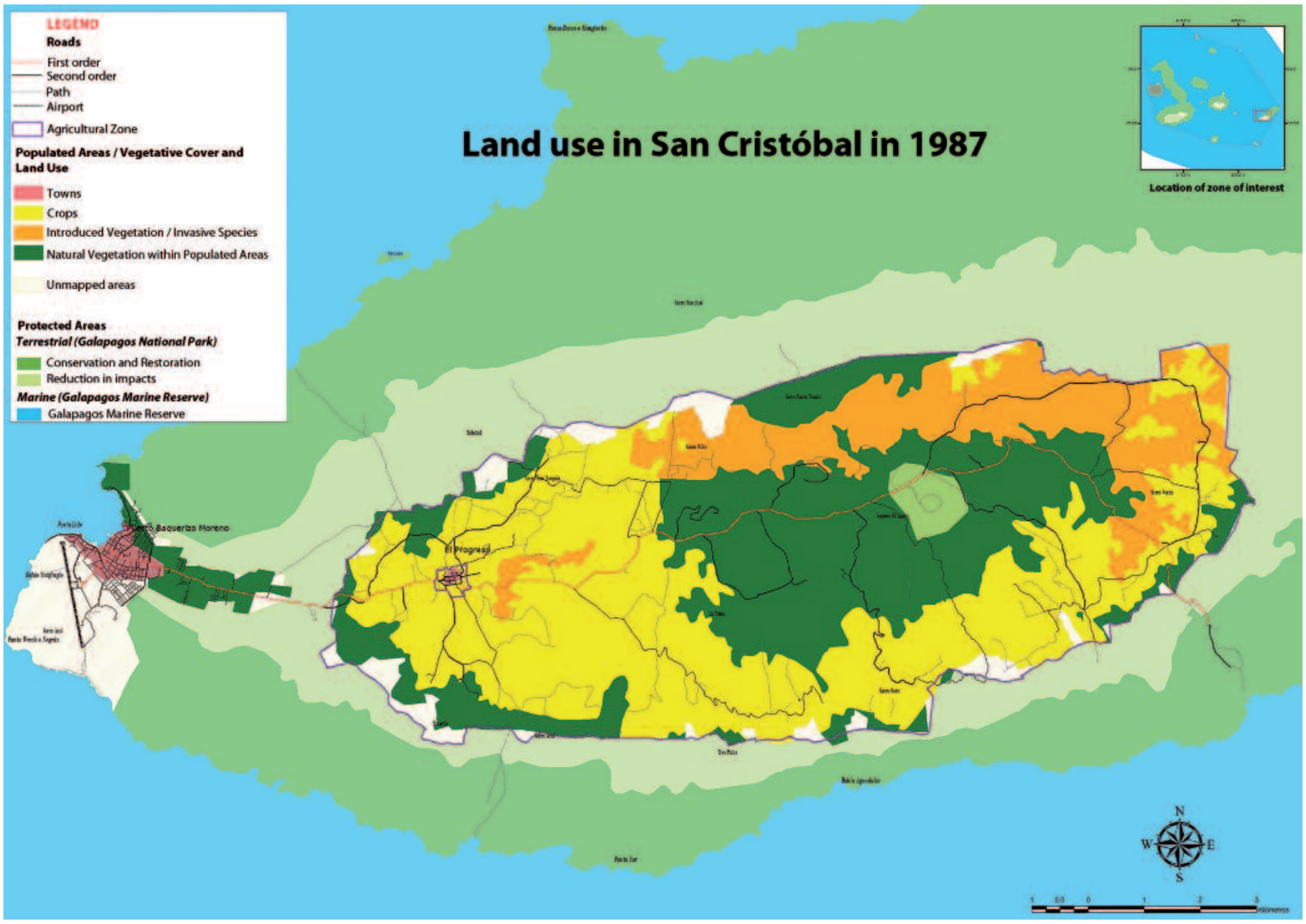
Invasive species: The areas in this category in 1987 now show some positive environmental and socioeconomical effects. For example, of the 1310.7 ha of guava forest identified in San Cristóbal in 1987, 61% (804.7 ha) has been converted primarily to crops and grazing land. But it must also be remembered that invasive species have been propagated transversally over the other categories (Table 1), with 68% (5643 ha) of the agricultural area affected by invasive species.

Populated centers: Since populated centers in the rural areas are relatively small, and this category was not included in the maps of 2006, no comparison in land occupancy was possible.

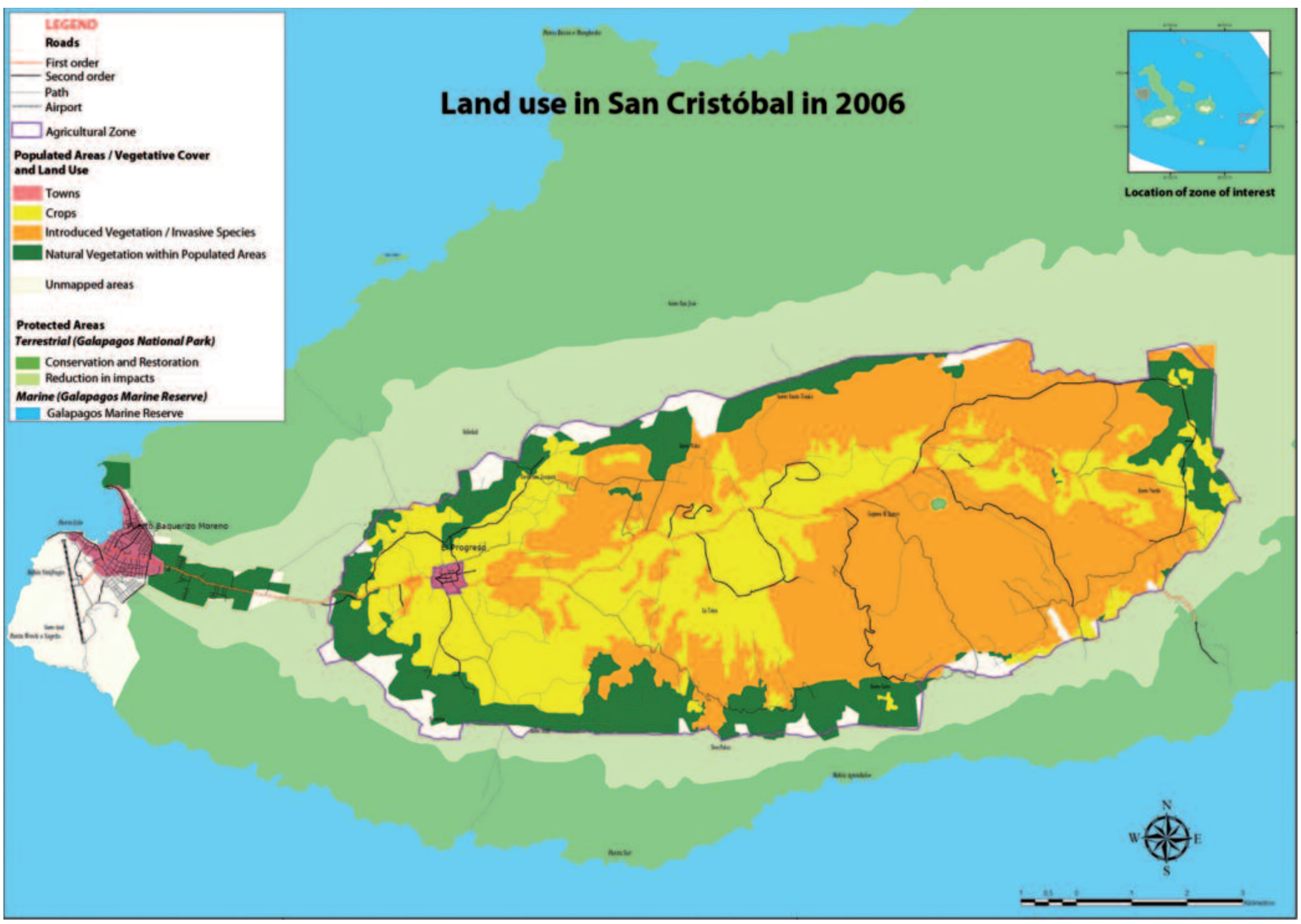
Table 1. Changes in vegetation and land use in San Cristóbal, between 1987 and 2006.

Vegetation Formations and Land Use in 1987		Changes in Vegetation Formations and Land Use between 1987-2006				
		No Change		With Changes		
		ha	%	ha	%	Description
Protected area of the GNP (zone around El Junco lagoon; 128.9 ha)		24.2	19	104.7	81	Invasive vegetation: primarily Hill raspberry, guava
Natural vegetation and pasture (2936.1 ha)		684.8	23	2251.3	77	Cultivated plants; invasive vegetation; urban structures
Agricultural Use	Artificial pastures associated with long-cycle crops (2726.2 ha)	551.7	20	2174.5	80	Cultivated plants and invasive vegetation (quinine tree, Spanish cedar, rose apple, guava, Hill raspberry); infrastructure
Agricultural Use	Short- and long-cycle crops (498.8 ha)	71.3	14	427.5	86	Invasive vegetation (guava, Hill raspberry, rose apple); grasses; infrastructure
Agricultural Use	Coffee dominant (595.0 ha)	456.8	77	138.2	23	Invasive vegetation (Spanish cedar, guava, Hill raspberry, rose apple); grasses; infrastructure
Invasive Species	Invasive vegetation: guava forests (1310.7 ha)	506.0	39	804.7	61	Crops and grazing areas; mixed invasive vegetation (Hill raspberry, guava, rose apple)
Invasive Species	Invasive vegetation: rose apple forests (62.1 ha)	41.2	66	20.9	34	Crops and pastures; invasive species (guava)
Populated centers in the rural areas (95.1 ha)		95.1	100	--	--	
TOTAL	8352.9 ha	2431.1	29.1	5921.8	70.9	

Source: Maps of Vegetation Formations and Current Land Use, INGALA-PRONAREG-ORSTOM, 1987; and Vegetative Cover, Topographic and Thematic Cartography of the Galapagos Islands by TNC, CLIRSEN, MAE, PNG, 2006.



Map 1. Vegetation formations and land use in San Cristóbal in 1987.



Map 2. Vegetation formations and land use in San Cristóbal in 2006.

Santa Cruz

As in San Cristóbal, important changes were observed in Santa Cruz (Table 2; Maps 3 and 4). Of the entire agricultural area (14,841.3 ha), 50% had no observable changes while 49% changed during the period 1987-2006.

Natural vegetation comprised of both native and endemic species: 86% (3415.3 ha) of the 3948.7 ha in 1987 changed to crops. This zone was affected by the propagation of invasive species due to the semi-abandonment of areas previously used for agricultural production.

Artificial pastures: This island had the most artificial pasture in 1987 (10,323.1 ha), of which 68% (7061 ha) remained in 2006.

Coffee dominant: Of the 556.5 ha recorded in 1987, 94% (522.0 ha) had been affected by invasive species during the period analyzed (1987-2006).

Short-cycle crops: Unlike San Cristóbal, there was no change in Santa Cruz, primarily because the majority of the land use is dedicated to extensive grazing and short-cycle agriculture, which has become more technical and more intensive in recent years. Although this category does not appear in the analysis, it likely exists in small areas at a scale too small to be measured on the maps.

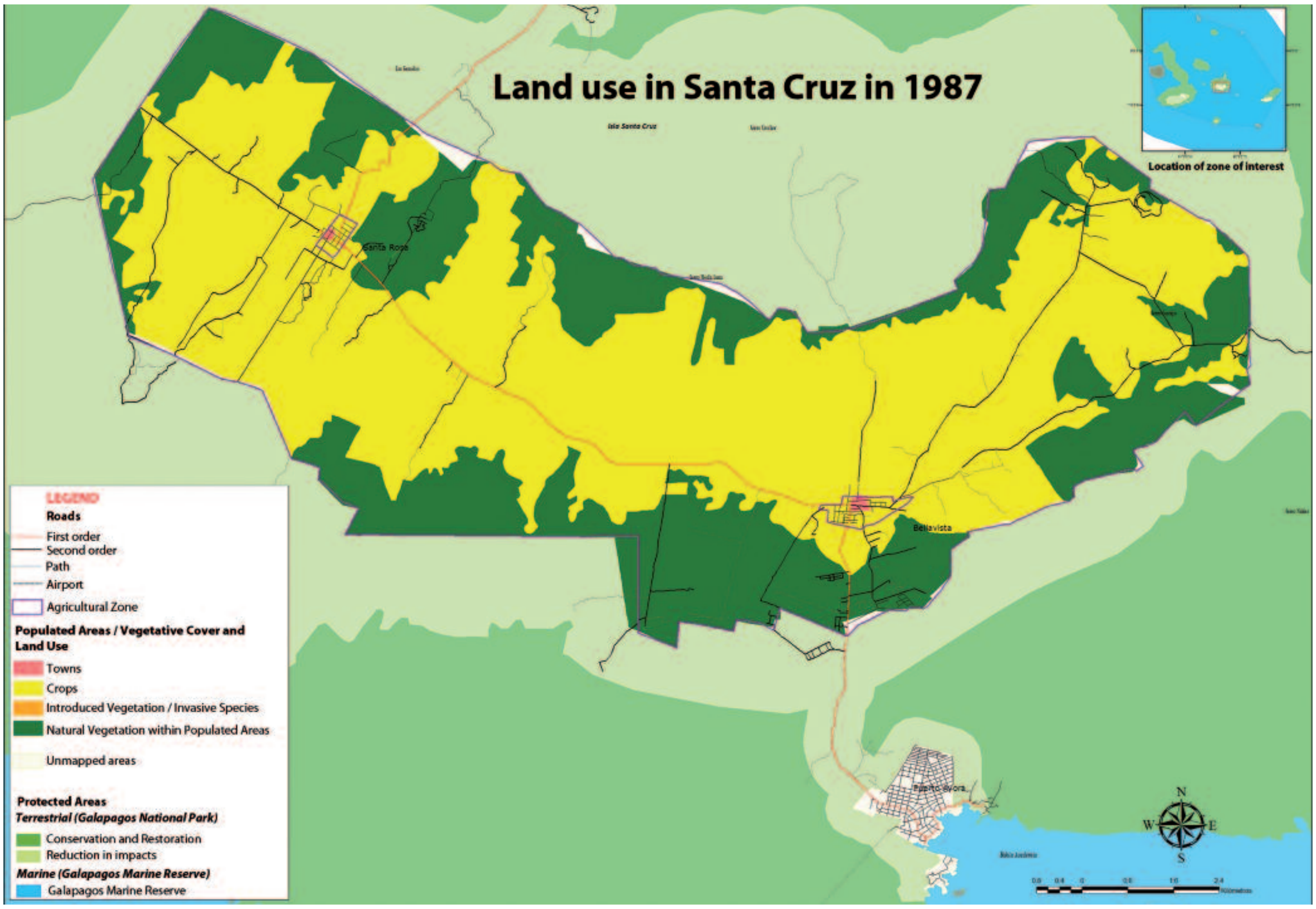
Invasive species: In 1987, invasive species were not recorded, probably due to their low incidence and the scale of the maps. Even so, in 2006 it was evident that invasive species had become propagated throughout all categories of vegetation formations, with approximately 50% (7199 ha) of the agricultural area affected.

Table 2. Changes in vegetation formations and land use in Santa Cruz, between 1987 and 2006.

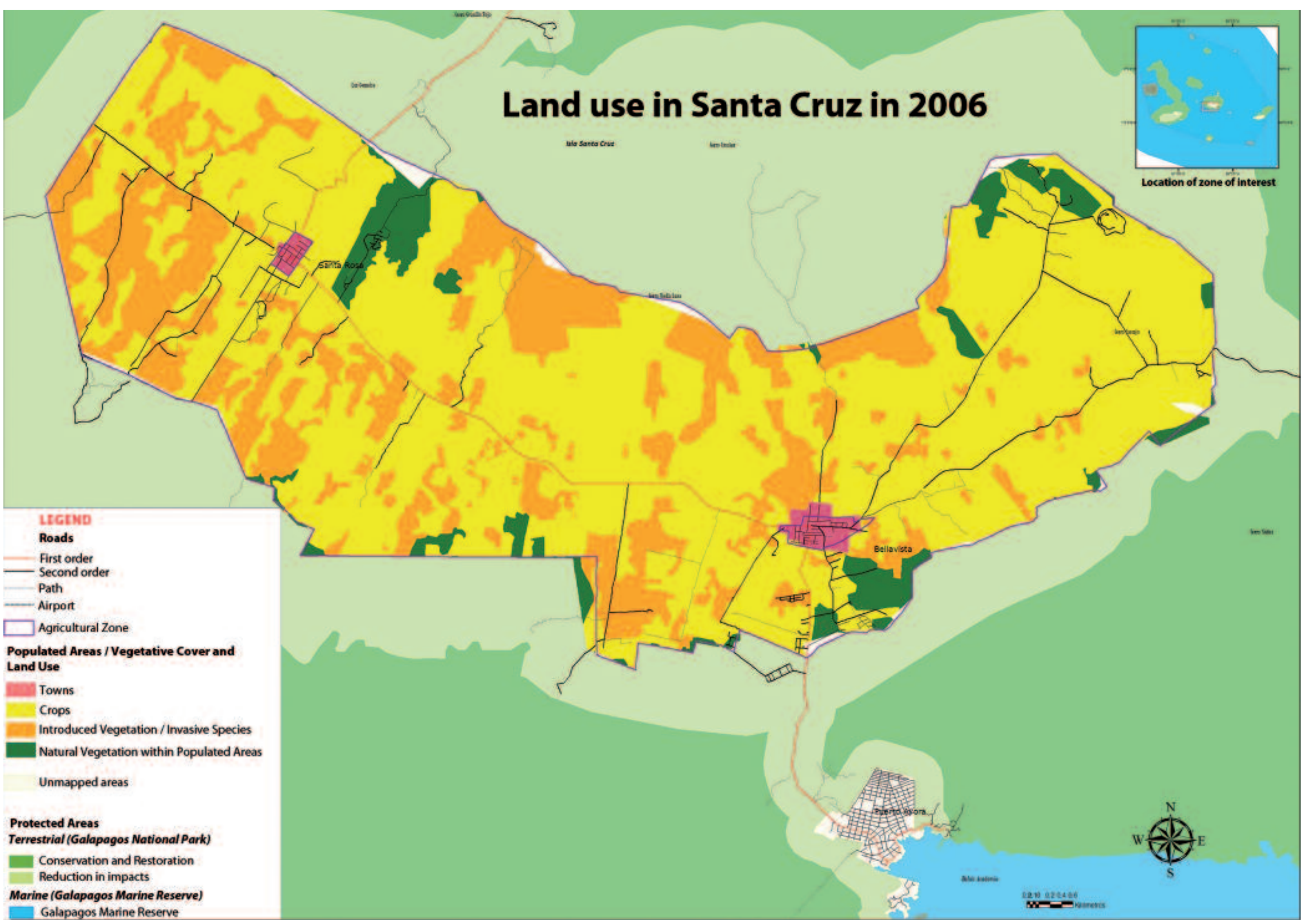
Vegetation Formations and Land Use in 1987		Changes in Vegetation Formations and Land Use between 1987-2006				
		No Change		With Changes		
		ha	%	ha	%	Description
Protected area of the GNP*		--	--	--	--	
Natural vegetation and pastures (3948.7 ha)		533.4	14	3415.3	86	Crops; invasive vegetation; infrastructure
Agricultural Use	Artificial pastures associated with long-cycle crops (10,323.1 ha)	7061.0	68	3262.1	32	Crops; woody vegetation according to elevation; invasive species (quinine tree, Spanish cedar, guava, Hill raspberry); infrastructure
Agricultural Use	Short-cycle and long-cycle crops (0.0 ha)	--	--	--	--	Invasive vegetation (guava, Hill raspberry); pasture; vegetation associated with each zone; infrastructure
Agricultural Use	Coffee dominant (556.5 ha)	34.5	6	522.0	94	Invasive vegetation (Spanish cedar, guava, Hill raspberry); trees associated with each elevation; pasture; infrastructure
Invasive Species	Guava forests, quinine tree, Hill raspberry (0.0 ha)	--	--	--	--	
Populated centers in the rural area (13.0 ha)		13.0	100	--	--	
TOTAL	14,841.3	7641.9	51.5	7199.4	48.5	

Source: Maps of Vegetation Formations and Current Land Use, INGALA-PRONAREG-ORSTOM, 1987; and Vegetative Cover, Topographic and Thematic Cartography of the Galapagos Islands by TNC, CLIRSEN, MAE, PNG, 2006.

* There is no protected area in the human settlement zones on Santa Cruz.



Map 3. Vegetation formations and land use in Santa Cruz in 1987.



Map 3. Vegetation formations and land use in Santa Cruz in 2006.

Conclusions and recommendations

1. The comparison and analysis of the 1987 and 2006 maps resulted in five major categories and three subcategories of vegetation formations and land use for the human settlement areas of San Cristóbal and Santa Cruz. Changes during that period were greatest in San Cristóbal where 71% of the area (8352.9 ha) was affected. In Santa Cruz, 49% of the area (14,841.3 ha) experienced significant changes.

2. Natural Vegetation areas, composed of both native and endemic species, showed significant changes toward greater cultivation, pastureland, and presence of invasive species. In San Cristóbal, only 23% (648.8 ha) of the 2936 ha of natural vegetation existing in 1987 remained. In Santa Cruz, only 14% (533.4 ha) of 3948.7 ha remained.

3. Pasture areas, a subcategory of cropland, showed significant changes during the study period. In San Cristóbal, 80% (2174.5 ha) of this subcategory was affected by invasive species and some of the area was converted to crops. In Santa Cruz, pastureland showed no significant changes.

4. The crop land of San Cristóbal underwent important changes (86% or 427.5 ha), due in large part to the propagation of invasive species caused by the semi-abandonment of agricultural production units. In Santa Cruz the area with coffee as the dominant species was greatly affected by the presence of invasive species, such as the quinine tree (*Cinchona succirubra*), guava and Hill raspberry, with 94% of the area impacted (522.0 ha).

5. Invasive species constitute the central major threat to the islands, especially in the agricultural areas where they are widespread across all land categories. In 1987 San Cristóbal had only 1310.7 ha of guava forest in the agricultural area, while in 2006 the forest was four times larger (5643 ha). In Santa Cruz in 1987, the presence of invasive species was not recorded in the maps, while in 2006, 49% (7199 ha) of the agricultural area was affected by invasive species.

6. In addition to affecting the natural environment and conservation of Galapagos, invasive species also impact the profitability of agricultural production. It is critical to support the public and private sectors in the development of environmentally-friendly production projects suited to the particular environment of the islands.

7. Guava is one of the invasive species that has been recognized by land owners as providing various economic benefits. In San Cristobal, this species plays an important role in the protection of the watersheds. Research on possible positive effects of some invasive species, such as guava, should be carried out.

8. Public policies on land use and vegetative cover should be established and implemented in order to preserve remaining natural areas, provide incentive for the recuperation of native and endemic vegetation and habitats impacted by invasive species, and to prohibit human activities that are not compatible with the environment.

Photo: Monica Calvopiña

Photo: Jacintha Castora Photography

SIMAVIS
System of Managing Visitors of the Galapagos National Park

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Galapagos tourism was conceived as nature-based tourism that is selective, educational, and designed for individuals whose primary interest was to enjoy the wildlife of the islands (Reck *et al.*, 2008). This focus was reiterated in the Special Law for Galapagos (LOREG), the Galapagos Regional Plan, and the Special Regulation for Tourism in Protected Natural Areas (RETANP). Everyone recognized the economic and social importance of tourism development and the need to minimize negative impacts and threats to the fragile insular biodiversity. The current Management Plan of the Galapagos National Park (PNG, 2005) reflects this same view.

The tourism management practices used in Galapagos have included the designation of specific visitor sites, the use of trails, tour boat itineraries, naturalist guides, and a permit and concession system. These practices have contributed to keeping ecological impacts in the visitor sites within acceptable and/or manageable levels. From the beginning, visitor management and interpretation have focused on providing travelers with the opportunity to experience nature close up. Interpretation techniques have sought to foster appreciation and understanding of Galapagos wildlife and landscapes.

Currently, an array of tourism management tools, such as Carrying Capacity (Cayot *et al.*, 1996), tourism monitoring (PNG, 2000), and the Network of Visitor Sites for Ecotourism (PNG, 2005), are being adapted and integrated based on current needs and realities.

The result of this process is the System of Managing Visitors (SIMAVIS) (Reck *et al.*, 2008).

SIMAVIS

SIMAVIS is an adaptive management tool that integrates and addresses five key elements: zoning, acceptable visitor load, itineraries, tourism monitoring, and visitor site management strategies (Figure 1). It draws on various methodologies and management tools that have been adapted to Galapagos realities, including Visitor Experience and Resource Protection (VERP; United States National Park Service, 1993), which was derived from the concept of Limits of Acceptable Change (LAC; Stankey *et al.*, 1985), and zoning principles based on visitor activities and expectations, originally proposed in the Recreational Opportunity Spectrum (ROS; Clark and Stankey, 1979).

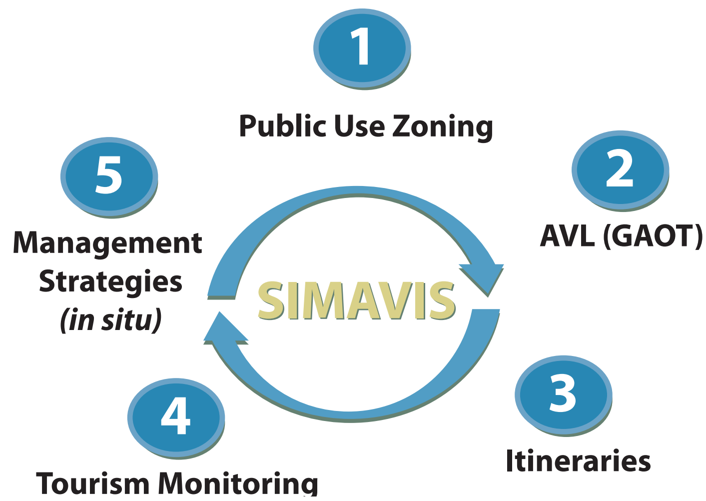

Figure 1. Principal components of SIMAVIS: Public Use Zoning (PUZ), Acceptable Visitor Load (AVL) measured as the number of Groups at any One Time (GAOT), regulation of itineraries, tourism monitoring, and management strategies to respond to negative impacts detected that result from tourism activities.

SIMAVIS establishes guidelines to optimize the management of visitor sites and the natural and social resources that attract visitors to Galapagos (Figure 2). SIMAVIS should not be seen as a tool that will solve the complex problems of tourism in the archipelago. Rather, it is a methodology designed to systematize and implement technical planning and management tools related to the public use areas of the park.

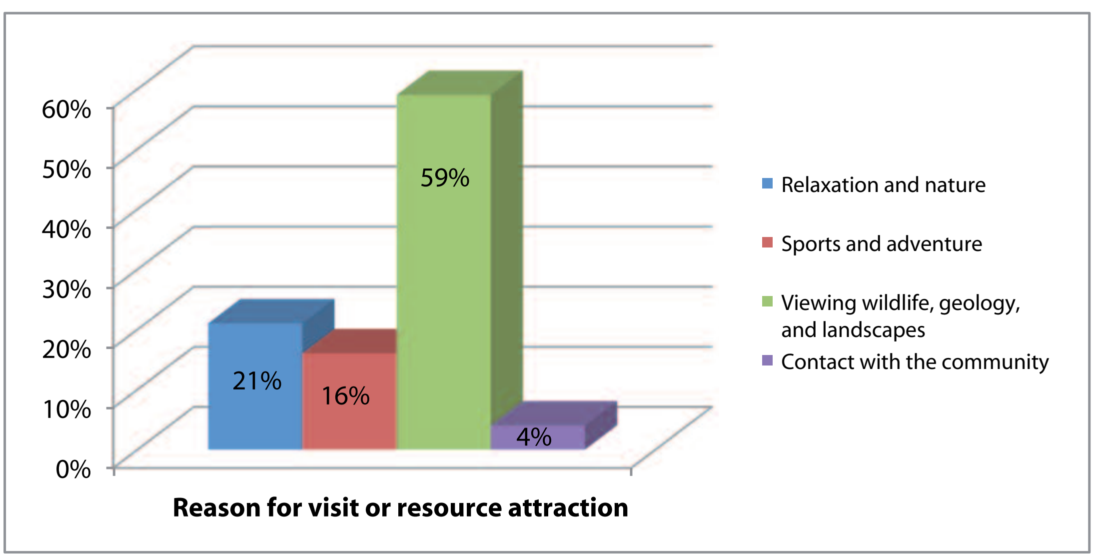

Figure 2. Results of the survey on GNP visitor satisfaction, "Motive for your visit to Galapagos," carried out in the following visitor sites: Punta Suárez, Punta Espinoza, Bartolomé, North Seymour, Punta Cormorant, El Barranco, Sombrero Chino and Cerro Dragón (GNP data).

Zoning: Public Use Zones within the Network of Ecotourism Visitor Sites of the GNP

The 2005 Management Plan of the GNP redefined categories within the visitor site zoning system, based on a study of biophysical, social, and management considerations in each terrestrial visitor site. This resulted in the designation of six Public Use Zones (PUZ) encompassing 70 GNP visitor sites (Table 1).

The new visitor site zoning system adapts the management approach defined in the GNP Management Plan (PNG, 2005) to the current reality of each visitor site, based on biophysical elements (natural state, uniqueness, fragility), social elements (number of visitors, frequency of visits), and management elements (current, necessary, and acceptable levels of direct management intervention and/or infrastructure).

Table 1. Comparison between the visitor site zoning in the Management Plan of 2005 and the proposed zoning according to SIMAVIS.

Public Use Categories in the Management Plan of 2005	Zoning SIMAVIS	Examples of Visitor Sites
Restricted	Restricted	Alcedo, Punta Tortuga Negra, Daphne Major
Intensive	Intensive - Natural	Punta Suárez, Gardner Bay, Punta Espinoza, Punta Moreno, Playa Espumilla, etc.
Did not exist	Intensive – Managed	Cerro Dragón, Bartolomé, North Seymour, Punta Pitt, Punta Cormorant, etc.
	Intensive – NearTown	Asilo de la Paz, Media Luna, Gemelos, El Junco, Sierra Negra, Tintoreras, etc.
Recreational	Recreational	Tortuga Bay, Garrapatero, Las Grietas, Carola, Lobería, Concha de Perla, etc.
Did not exist	Cultural - Educational	Interpretation Center and Breeding and Rearing Centers

The Restricted Zone, the area of greatest protection, includes those visitor sites whose biophysical elements are more intact, unique, fragile, and/or vulnerable. They are areas for specialized research, interpretation, and observation; visitors are required to justify their visit and must obtain authorization prior to visiting the site. Management guidelines restrict the number of groups and the number of individuals per group, and require visitors to pass through a quarantine process to avoid the introduction of species. In terms of management *in situ*, physical interventions are limited to the minimum needed to ensure the safety of visitors. This category includes Alcedo (Figure 3), Punta Tortuga Negra, and Daphne.

Figure 3. Volcán Alcedo, Isabela is designated as a Restricted visitor site due to its fragility. This site is undergoing recovery following the elimination of introduced species that caused major degradation of the environment. Photo: GNP, 2008.

Intensive - Natural visitor sites have highly attractive biophysical characteristics. They are not as fragile as Restricted sites and are generally not vulnerable to guided tourism activities (Figure 4). The social aspects of visits should be geared to nature tourism, creating a sense of isolation and solitude for visitors. Management interventions should seek only to ensure the safety of visitors and the delineation of trails with boundary markers.

Visitor sites in the **Intensive - Managed Zone** usually provide the same level of attraction and importance in terms of biophysical elements as those in the Intensive - Natural zone. The difference is that in these areas the current or potential accumulated impact of visitors (usually erosion) justifies more direct management interventions, such as wooden retention barriers, the relocation of rocks, construction of scenic viewing areas, handrails, etc. (Figure 5). The management of impacts allows for a broader profile of potential visitors, and decreases the need for specialized visits. Infrastructure for safety and orientation is acceptable.

Visitor sites in the **Intensive - Near Town Zone** are easily accessible to the local population and have natural and/or historical-cultural resources of significant interest (Figure 6). These sites and their biophysical resources can have a moderate to high level

Figure 4. Playa Espumilla, on Santiago was designated an Intensive – Natural site due to its conservation status, natural state, and relative fragility related to the high density of nesting sea turtles. Photo. GNP, 2008.

Figure 5. Cerro Dragón on Santa Cruz is an Intensive – Managed visitor site. The deterioration of the trail from trampling can be seen in the photo. This is an acceptable impact for this zone. Photo: GNP, 2008.

of alteration from tourism and local traditional use. The social expectations associated with the visit are generally lower, allowing for greater numbers and interaction of visitors, without losing the necessary conditions for observation, contemplation, and interpretation. A wider range of management interventions are allowed at these sites, including infrastructure to increase access and safety for a broader range of visitors (steps, hardened trail surfaces, gates, scenic viewing areas, etc.) and to protect and recover degraded resources.

Recreational visitor sites have the same level of accessibility as Intensive - Near Town sites and offer interesting opportunities for interpretation (Figure 7). However, these sites have conditions that are appropriate for the development of more varied recreational activities, provided they do not jeopardize the sites' biophysical resources. Given the different types of activities permitted, larger numbers of visitors are possible and more infrastructure is acceptable, as long as it makes use of local and/or environmentally friendly resources and blends in with the surrounding area.

Finally, the **Cultural - Educational Zone** includes visitor sites that are artificial or semi-natural, whose main function is to provide environmental education

Figure 6. El Junco, San Cristóbal, an Intensive – Near Town visitor site is easily accessed by the local population. It has infrastructure to minimize trampling and erosion and to facilitate a broader array of visitors. Photo: María Casafont, 2006.

Figure 5. Tortuga Bay, Santa Cruz is a Recreational visitor site that is accessible by foot from the local town. Photo: GNP, 2008.

for tourists and the local population (Figure 8). Accessibility, the absence of fragile resources, and the physical capacity of these sites make them appropriate for larger groups of tourists.

The definition of these six Public Use Zones provides a framework for the management of each visitor site and a starting point for using SIMAVIS to determine other necessary measures and actions.

Figure 8. The Interpretation Center of San Cristóbal is a Cultural - Educational visitor site, constructed specifically for educational activities. Photo: GNP, 2007.

Acceptable Visitor Load (AVL)

Beginning in 1996, Carrying Capacity (CC) was the method used to define the maximum number of visitors above which a visitor site's ecosystem would begin to degrade (Cayot *et al*, 1996). CC is estimated using a formula that has been proven to be unsuccessful at correctly estimating the optimum number of visitors for each visitor site:

1. CC of some visitor sites was overestimated (e.g., Sombrero Chino or Playa de las Bachas), while CC of others was underestimated (e.g., Puerto Grande or Punta Carola).

2. CC calculations did not consider acceptable social conditions during visits. Some sites that were not considered overused according to their calculated CC are subject to complaints from tourists regarding the excessive number of visitors (e.g., Sombrero Chino).

3. CC determines the maximum number of groups per day at each visitor site, without considering an optimum distribution of those groups throughout the day.

4. Degradation at sites cannot always be directly attributed to overuse. Some sites do suffer resource degradation that is not caused by excessive numbers of visitors (e.g., Punta Cormorant or Caleta Tagus).

SIMAVIS defines the Acceptable Visitor Load (AVL) at each visitor site, replacing the concept of CC. This management tool was introduced by Reck *et al.* (2008) and is being used by the GNP to determine itineraries beginning in 2010.

The parameter used to determine the AVL in each visitor site is Groups at Any One Time (GAOT). National parks in the United States use a similar parameter, known as PAOT (People at Any One Time). This new approach assumes that the quality of the visit and the environmental conditions at each visitor site do not depend on the total number of visitors in one day or the next, but rather on the number of people at the site at any one moment.

To estimate the AVL, a series of social and management factors are considered, including previously unanalyzed variables such as the quality of visit and the organization/management planning related to visits (Table 2).

When applying this concept, it is assumed that the goal is to achieve the fewest possible visitors in a site at any one time, in order to foster greater satisfaction among the visitors. Given the high levels of demand, this is not possible in many sites and park managers must look for the best options to reduce interference among groups.

Table 2. Sample evaluation matrix to determine the number of groups that can visit a site at the same time.

Biophysical Aspects	Social Aspects / Satisfaction	Management Aspects
Presence of vulnerable species	Minimum distance between groups based on visibility	Presence of infrastructure or acceptability of infrastructure to facilitate access
Level of conservation of the landscape and wildlife	Time of visit including interpretation stops	Nº of actual or potential activities with opportunity to disperse visitors
Erosion level of the substrate	Trail design (circular or dead-end)	Actual or potential level of control
Available usable area and/or length of trail	Actual or potential bottleneck points	Acceptability of management (management and desired use)

Tourism monitoring

Monitoring is an ongoing management tool aimed at detecting changes over the long term and making necessary decisions regarding actions needed to maintain and restore the desired conditions at each site.

SIMAVIS provides a systematic and ongoing monitoring protocol, using a group of quantifiable ecological, physical, social, and management-related indicators. It also establishes the desirable conditions and the limit for acceptable changes for each zone and site.

The new monitoring process was structured to integrate different management tools. Modifications have been made to the system for defining system elements, updating information, analyzing data, and making management and policy decisions.

Dynamic variables reflecting tourism-related changes occurring in each visitor site (impacts on the natural resources and the social quality of the visit) were used to define indicators (Table 3). Measurement units were established for each indicator, as was frequency of data collection, those responsible for data collection, and standards and limits of change associated with the zones and visitor sites.

Once problems are analyzed and causes of unacceptable situations are determined, all available management responses are discussed by the appropriate authorities. All possible alternatives for resolving a problem or conflict are considered, including the possibility of no intervention (acceptance of the impact).

Management strategies

Monitoring is the foundation for adaptive and participatory management of visitor sites and optimizing capacity for corrective response. This includes the identification of causes of impacts, which is fundamental in determining response alternatives.

Management alternatives can include both direct methods that regulate and control tourism activity *in situ* and indirect methods that influence the behavior of visitors. The level of direct intervention depends upon the zone to which a specific visitor site has been assigned.

A proposal for management interventions designed to improve the quality of visits and minimize the impacts of visitors was developed based on the evaluation of the sites and a search for diversified tourism activities in and around the sites. Examples of interventions already implemented include the conversion of dead-end trails to circular trails to avoid encounters between groups and to create more opportunities for interpretive activities on new trails, hardening the surface of some trails to limit erosion, and the construction of infrastructure to facilitate access and/or increase visitor safety. These kinds of changes have been made at a number of sites including Tintoreras (Figure 10), Cerro Dragón, Punta Espinoza, and Los Gemelos.

Itineraries

One of the most important uses of SIMAVIS is the optimization of visitor flows at visitor sites through the organization and coordination of itineraries. Currently, many tourist boats visit certain visitor sites at the same time, while other sites remain underutilized. The congestion of groups of tourists beyond the Acceptable Visitor Load at some sites reduces the quality of the visitor experience. An example of such overcrowding is found at Punta Suarez (Figure 11), one of the most emblematic visitor sites in Galapagos. All boats offering multi-day tours (69[1])

[1] As of 31 December 2009, 69 tourist boats offering multi-day tours were in operation.

Table 3. Summary of indicators for tourism management in the visitor sites.

Parameter	Indicator	Persons Responsible	Frequency
Erosion	% (Depth/width) or % (Trail width/length of the chain)	Field technicians, park rangers	6 months
Trail width	% (Increase/predefined width)	Field technicians, park rangers	6 months
Compaction: canals and cracks	Yes/No (Nº occurrences)	Field technicians, park rangers	6 months
Vegetative cover	Yes/No (Nº occurrences)	Field technicians, park rangers	6 months
Alternative trails	Yes/No (Nº occurrences, sp.)	Field technicians, park rangers, volunteers	6 months
Garbage	Yes/No (Nº occurrences)	Field technicians, park rangers, volunteers, guides	6 months weekly
Fires	Yes/No (Nº occurrences)	Field technicians, park rangers, volunteers	6 months weekly
Graffiti	Yes/No (Nº occurrences)	Field technicians, park rangers, volunteers	6 months weekly
Introduced species	Yes/No (Nº occurrences, sp.)	Field technicians, occasionally volunteers	6 months weekly
Diversity of biological attractions	N/C	Field technicians, occasionally volunteers, guides	6 months
Dynamics of the visit	Nº encounters	Guides, volunteers	Weekly
On-site behavior	Nº complaints	Guides, volunteers, field technicians	Weekly
Accidents	Nº complaints	Guides, volunteers, field technicians	Weekly
Visitor satisfaction	% satisfaction	Guides, park rangers, volunteers	-
State of the infrastructure	Qualitative, state of conservation	Field technicians, park rangers, volunteers, guides	6 months weekly

visit this site, and as many as 10 groups can be present at the same time.

Various alternative proposals for adjusting the itinerary system to current realities of Galapagos tourism are being developed. These proposals integrate all of the available management tools. Some of the new measures will be implemented starting in 2010.

Conclusions and recommendations

The GNP is currently in the final phase of implementing SIMAVIS. The participation of experts in tourism management, naturalist guides, and tourism operators is important at this stage. Tourism demand is what is creating pressure on visitor sites, and tourism operators are in a unique position to help modify demand and to adjust it to what the GNP offers. The GNP and tourism operators are both interested in ensuring the quality of the visitor experience and preserving the park's natural resources. Working together, they need to redefine tourism opportunities within the Network of Public Use Sites, and consider an array of adjustments such as changes in itineraries and visiting hours at tourist sites. Other alternatives include:

- Review and create micro-zones for ancillary tourism activities (snorkeling, panga rides, kayaking). Ancillary activities can help disperse groups at visitor sites. However, some activities (snorkeling and panga rides, for example) are incompatible if carried out in the same area and must be

Figure 10. Map of the Tintoreras visitor site, showing the new trail. Source: Google Earth, 2008.

Figure 11. Visitor congestion at the Punta Suarez visitor site. Photo: Roberto Plaza, 2008.

segregated (e.g., Bartolomé; Figure 12). Micro-zoning will allow guides to engage their visitors in ancillary activities based on the visitor saturation of the site at any given time, and time their visit on land to achieve the greatest level of exclusivity.

• Identify alternatives to the most congested sites to distribute tourist groups among sites that offer the same or similar attractions.

• Shift to 14-day itineraries, with the goal of reducing pressure on the most critical sites by 50%. In order to implement 14-day itineraries, it will be necessary to first identify additional alternative visitor sites.

• Open new trails within current visitor sites to reduce congestion and bottlenecks; open new visitor sites in cases where there is no potential for new trails.

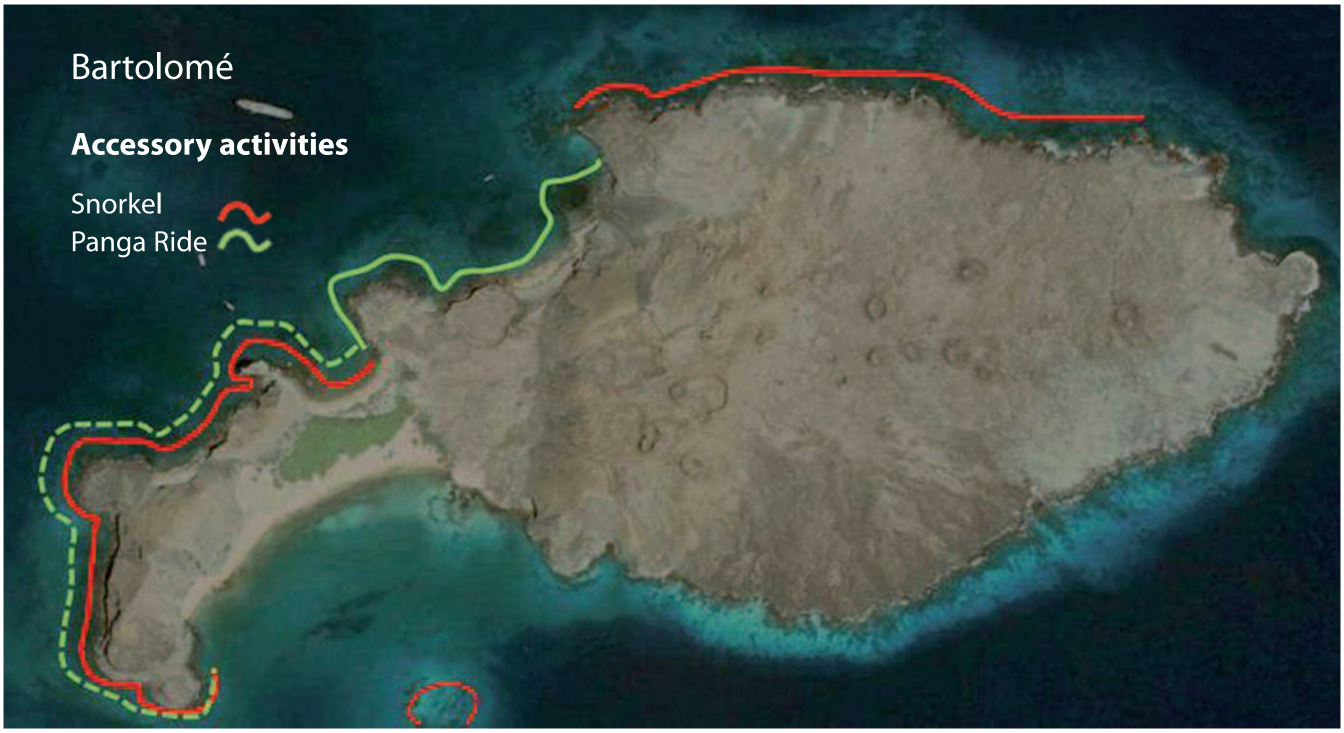

Figure 12. Micro-zoning of the accessory activities in Bartolomé.. Source: Google Earth

- Through the application of GAOT, establish a more effective system of rotating and timing visits, especially in the towns.

- Require boats carrying the largest number of visitors to function according to the continental time zone (visiting sites one hour earlier than others). Some boats already function in this manner.

- Optimize the distribution of arrivals and departures of tourists, utilizing both major airports and adjacent visitor sites for the first and last days of cruises.

All of these elements should be considered and discussed among the relevant stakeholders in order to reach consensus and achieve the management objective of SIMAVIS, which is to organize tourism activity within the protected areas of the archipelago.

This process is supported by the Management Plan of the GNP where it mentions that *"management of the protected areas of Galapagos should be governed by adaptive and precautionary principals, to achieve the objectives of protection and conservation, as well as ensure quality and safety."*

Photo: M. Verónica Toral Granda

Water quality monitoring system in Santa Cruz, San Cristóbal, and Isabela

Javier López and Danny Rueda

Galapagos National Park

Introduction

Economic development and population growth in Galapagos have generated a significant increase in the demand for goods and services. The consumption of these goods generates human waste, which is often dumped directly into the subsoil or the sea. This results in the contamination of surface seawater and the water table, affecting human health and the fragile ecosystems of the archipelago. Degradation of water can occur due to high concentrations of nutrients (eutrofization) and contamination by fecal coliform and heavy metals.

Water quality is an important factor for the wellbeing of the Galapagos human population and the native flora and fauna. Regular monitoring of water quality, both on land and in the sea, is important for detecting changes in quality and implementing measures to mitigate any contamination. This article presents the results of a 2008 analysis of water quality in eight sites on the three islands with the greatest human population. It concludes with recommendations for the local population and the institutions responsible for water management in the province.

Monthly water quality monitoring began in Santa Cruz in 2005, led by the Galapagos National Park (GNP) with the support of the Japan International Cooperation Agency (JICA). Water quality monitoring was extended to San Cristóbal and Isabela in 2007. Currently the GNP runs this program on all three islands.

A key objective of the program is to monitor the quality of the water used for human consumption and domestic use. A total of seven terrestrial sites were selected in areas where the local municipality extracts water for distribution to the population. An eighth site, the Ninfas Lagoon in Santa Cruz, was selected because it is an important recreational site for the residents of Puerto Ayora (Table 1). The four sites in Santa Cruz have been monitored since the project began in 2005.

Criteria for selecting sampling sites

Various criteria were taken into account to select both terrestrial and marine monitoring sites, including accessibility, representativeness, existing information and data from previous studies, needs of users, and level of contamination. Both terrestrial and marine sites were selected in Santa Cruz, while in San Cristóbal and Isabela two terrestrial sites with water for human consumption and domestic use were chosen (Table1).

Sampling characteristics

Sites: Santa Cruz, San Cristóbal, and Isabela

Sampling frequency: Monthly

Analysis: Conducted in the Water Quality Lab of the Galapagos National Park (GNP) and Environmental Chemistry Lab of the Central University of Ecuador

Maximum Permissible Limits (MPL): Norms established under the national environmental legislation TULAS (Texto Unificado de la Legislación Ambiental Secundaria, 31 March 2003)

Table 1. Water quality monitoring sites.

Santa Cruz	San Cristóbal	Isabela
Terrestrial	Terrestrial	Terrestrial
INGALA Crevice	Municipal Plant	Manzanillo
Deep Well	House in Puerto Baquerizo	House in Puerto Villamil
Colegio San Francisco Crevice		
Coastal		
Ninfas Lagoon		

Determination of the analyzed parameters

Norms established under TULAS were used to select the parameters to be included in this study. Due to financial limitations, it was not possible to monitor all of the recommended parameters. Therefore, a preliminary analysis was conducted to determine the parameters considered the most important for decision-making on water management for human and domestic use and for the conservation of flora and fauna (Table 2).

Table 2. Parameters analyzed in the water quality monitoring program in Santa Cruz, San Cristóbal, and Isabela.

Physical	Chemical	Biological
Temperature	Nitrate	Fecal coliform
Salinity	Nitrite	Total
pH	Total phosphorous	
Dissolved oxygen		
Turbidity		

Figure 1. Measuring dissolved oxygen and pH of the water in the Ninfas Lagoon, Santa Cruz.

Results

The results of the study show that with the notable exception of fecal coliform, the parameters monitored fall within the maximum allowable limits for water used for human consumption and domestic use (Table 3).

The monitoring stations in the highlands and those close to the sea measured lower levels of salinity, pH, and dissolved oxygen than water on the continent.

Table 3. Average annual values registered during 2008 for each parameter measured in the different sampling sites in Santa Cruz, San Cristóbal, and Isabela.

Parameter	Site							
	Colegio San Francisco Crevice	Deep Well	INGALA Crevice	Ninfas Lagoon	Municipal Plant	House in Puerto Baquerizo	Manzanillo	House in Puerto Villamil
Fecal coliform (nmp/100 ml)	1236	9	18	481.1	0	433	756	1011
Hydrogen potential (pH)	7.8	7.5	7.5	7.2	7.1	7.6	7.4	7.8
Dissolved oxygen (mg/l)	7.7	7.8	8	5.6	10.1	9.6	4.4	6
Salinity (mg/l)	2.3	1.1	1.6	20	*	*	1.2	1.5
Turbidity (NTU)	0.4	0.9	0.7	1.6	2.7	3.7	0.8	0.8
Temperature	24.5	24.7	24	24.3	22.8	25.5	24	23.1
Nitrite (mg/l)	0.003	0.006	0	0.007	0.011	0.003	0	0.05
Nitrate (mg/l)	0.15	0.1	0.1	0.12	0.05	0.04	0.2	0.06
Total phosphorous (mg/l)	0.57	0.57	1.1	0.22	1.62	1.22	0.9	0.99

* Fresh water.

Fecal coliform

In 2008 the average concentration of fecal coliform in the Colegio San Francisco Crevice in Santa Cruz was 1236 colonies per 100 ml of water, compared to the norm established by TULAS of 600 colonies per 100 ml (Table 3). The World Health Organization (WHO) recommends even more conservative levels of zero colonies per 100 ml for drinking water. Both standards confirm that the water from the Crevice is not suitable for human consumption.

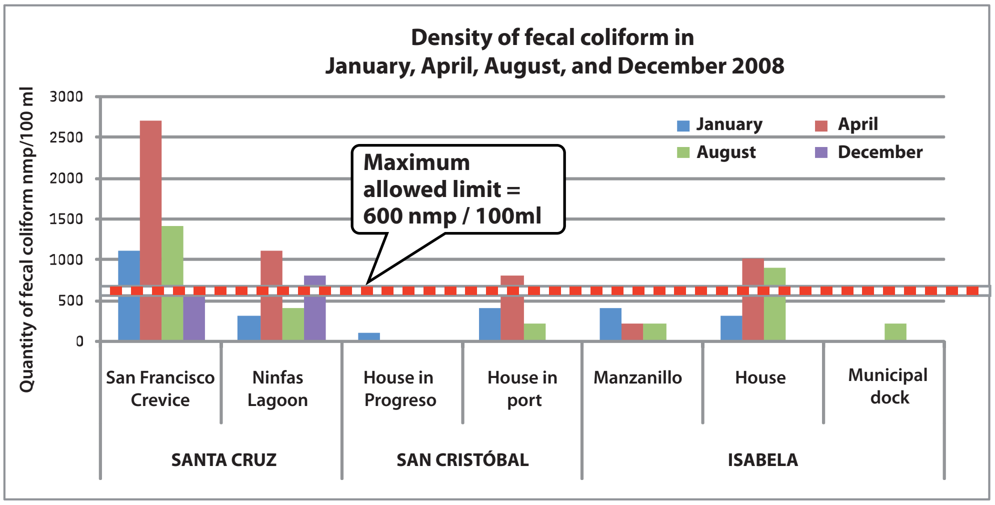

Figure 2. Fecal coliform density in January, April, August, and December of 2008 in Santa Cruz, San Cristóbal, and Isabela.

In the case of El Manzanillo in Isabela, the level of fecal coliform during 2008 averaged 756 colonies per 100 ml (Table 3). This indicates that although the level of contamination is approximately 40% less than at the Colegio San Francisco Crevice, the water is unsuitable for human consumption.

Another site showing high contamination by fecal coliform was the house selected at random in Puerto Villamil, where the results showed levels of 1011 colonies per 100 ml.

Houses monitored in Puerto Baquerizo Moreno registered an average of 433 colonies per 100 ml, and the Ninfas Lagoon in Santa Cruz had an average of 481.1 colonies per 100 ml (Table 3).

Only the Municipal Plant in San Cristóbal showed no presence of fecal coliform in 2007-2008, while the Deep Well and the INGALA Crevice, both in Santa Cruz, had annual averages in 2008 of nine colonies per 100 ml and 18 colonies per 100 ml, respectively. The levels at these two sites in Santa Cruz were much lower than the other sites monitored (Table 3).

The INGALA Crevice is the source of 70% of the water extracted by the municipality of Puerto Ayora for distribution to the local population. Only 27% of the water is taken from the Colegio San Francisco Crevice.

Table 4. Average annual values of fecal coliform recorded during the years 2005, 2007, and 2008, in the sampling sites on Santa Cruz, San Cristóbal, and Isabela.

PARAMETER	Year	SITE							
		Colegio San Francisco Crevice	Deep Well	INGALA Crevice	Ninfas Lagoon	Municipal Plant	House in Puerto Baquerizo	Manzanillo	House in Puerto Villamil
Fecal coliform (nmp/100ml)	2005	*	0	0	400	*	*	*	*
Fecal coliform (nmp/100ml)	2007	3148.9	16.6	8.3	1458.3	0	150	391.6	425
Fecal coliform (nmp/100ml)	2008	1236	9	18	481.1	0	433	755.5	1011.1

* No analysis was done.

Photo: Mary Witoshynsky

The levels of fecal coliform contamination exceed the limits set by TULAS in some sites (Table 4). However, following the completion of this study, considerably lower levels of fecal coliform were measured in Ninfas Lagoon and in the Colegio San Francisco Crevice (Santa Cruz). This reduction is probably the result of mitigation measures implemented after the study was presented to local authorities and the general public through meetings, workshops, and conferences.

Although results varied slightly from one site to the next, parameters other than fecal coliform fell within the limits for human consumption (Table 3). It appears that fecal coliform is the parameter of greatest concern and which requires most urgent attention.

Conclusions and recommendations

Based on the results of this study, the following conclusions and recommendations are presented:

- Direct comparison of water quality among the three islands is not possible, given that San Cristóbal uses fresh water from the highlands (precipitation) for human consumption and domestic use, while Isabela and Santa Cruz rely on brackish water, which is extracted from subterranean fissures.

- Due to the high levels of fecal coliform contamination detected in the Colegio San Francisco Crevice in Santa Cruz and in El Manzanillo in Isabela, these sites should be closed and no longer used for human consumption and domestic use.

- The high concentration of fecal coliform in the Ninfas Lagoon in Santa Cruz suggests that there is inadequate management of water run-off in the surrounding area. Mitigation measures should be coordinated by the appropriate institutions. Recreational use of the area for swimming and snorkeling should be avoided.

- It is critical for all institutions in Galapagos to become involved and work in a coordinated manner to conserve water resources, which are critical for a high quality of life for the local population.

- It is important to include biological parameters, such as phytoplankton, zooplankton, chlorophyll, and organic carbon in future analyses. This information would help to determine possible sources of contamination and necessary mitigation measures.

Photo: Jacintha Vanbeveren

Rapid, recent and irreversible habitat loss: Scalesia forest on the Galapagos Islands

André Mauchamp and Rachel Atkinson

Charles Darwin Foundation

Introduction

The Galapagos biota has suffered few extinctions, due mainly to the late colonization by humans and the high level of protection on most of the archipelago as an uninhabited national park. Thus, the same radiations of finches, mockingbirds, and giant tortoises that inspired Darwin in formulating his theory of evolution can still be observed today. However, land use change on the four inhabited islands (San Cristóbal, Santa Cruz, Floreana, and Isabela) has affected much of the natural vegetative cover in the highlands. It is estimated that on these islands 29,600 ha of the highlands (33% and 49% respectively of the humid and very humid vegetation zones) have been altered due to the combined presence of invasive plants and agriculture (Watson *et al.*, 2009).

In this paper we present all available spatial information on the Scalesia forest community to evaluate the impacts of human-induced changes on its distribution. In particular we reconstruct the historical range of the forest dominated by *S. pedunculata* and *S. cordata* (Lawesson *et al.*, 1987; Adsersen, 1990; Itow, 1995). Using available evidence we then document the current extent of these forests to estimate the proportion that remains and analyze reasons for the dramatic and rapid loss of this unique habitat type.

The genus Scalesia

Scalesia is one of the seven endemic plant genera of the Galapagos Islands. The genus includes 15 species, with 21 taxa distributed on all except four of the main islands (Eliasson, 1974). Some species are widely distributed whereas others are single island endemics. Most are shrubs found dispersed within the arid and transition zones, but three species, *S. pedunculata*, *S. cordata*, and *S. microcephala*, are trees that occur in dense forests as the dominant plant species. These forests are mainly found in the humid highlands and are structurally unique. Tree Scalesias have a very short life cycle. Seeds germinate in forest clearings, reaching 4-4.5 m in height in one year, and 10-15 m at maturity. They start to produce flowers and fruits at 1-2 years of age, and live for about 25 years (Itow, 1995). Cohort recruitment has been noted to be linked to El Niño events that affect the archipelago periodically. The increased rain appears to result in a massive dieback of adult plants and mass recruitment from the seedbank (Lawesson, 1988; Itow and Mueller-Dombois, 1988).

Scalesia forest

Scalesia pedunculata forests occur in the transitional and humid zones of Santa Cruz, San Cristóbal, Floreana, and Santiago, while *S. cordata* forests are restricted to Cerro Azul and Sierra Negra volcanoes on Isabela (Wiggins and Porter, 1971; Hamann, 1981). Santa Cruz, San Cristóbal, Floreana, and Sierra Negra volcano (Isabela) are the only inhabited regions of the archipelago (with the exception of military bases and an airport on Baltra), and the highlands of each have been severely affected by human presence due to agricultural activities and invasive species. While Cerro Azul volcano (Isabela) and Santiago Island are unpopulated, they have also been severely degraded by introduced herbivores and invasive plant species.

Scalesia forest distribution

Historical distribution (1915)

Information on the historical distribution of the Scalesia forest comes from observations of Stewart (1915) who described the vegetation as he walked along transects from the coast to the peaks of different islands. These surveys suggest that the upper slopes of San Cristóbal, Santa Cruz, Santiago, Floreana, and Isabela were all dominated by Scalesia forests. For example, on Santa Cruz, he reported that dense forests between 150 and 580 m were largely made up of *S. pedunculata*. This corresponds to an area of 9600 ha. Stewart also noted that above 80 m in elevation on Sierra Negra volcano (Isabela), the forest consisted mostly of *S. cordata* and *Sapindus saponaria*. He recorded that a considerable amount of *S. cordata* forest had already been cleared away on Sierra Negra, and estimated an original range of over 17,300 ha. On Santiago, Stewart (1915) estimated that the Scalesia forest covered at least 1000 ha of the island.

Distribution changes from 1960-1990

Ground surveys carried out between 1960 and 1980 indicate without exception the considerable decrease in area covered by Scalesia forest (Elliason, 1984; Hamann, 1984). Forest stands on the southern slopes of Santa Cruz have not existed since 1964, with the last trees cleared in the 1970s (Itow, 1995). In addition, studies in the 1980s (Adsersen, 1989) mention only one small area of humid Scalesia forest on the northern slope of the same island. By 1975 on Santiago, only a few trees remained due to intense grazing by introduced goats (van der Werff, 1978, 1979; Hamann, 1975). On San Cristóbal, the original *S. pedunculata* forest had been completely destroyed by 1986 with only a few trees on a steep and inaccessible cliff along a watercourse on the south side of the island remaining (Itow, 1995). The same study mentions that on Floreana there was still a good but small stand of *S. pedunculata* in 1991 (Itow, 1995). The first vegetation maps for the archipelago were compiled in 1987, using aerial photographs and field notes taken between 1980 and 1985 (INGALA *et al.*, 1989). For Santa Cruz, the area covered by *S. pedunculata* forest indicated on the maps can be estimated at 1852 ha or 19% of the original extent.

Current distribution (2009)

Recent information from field surveys and herbarium sample locations provide a current estimate of a maximum of 100 ha of Scalesia forest on Santa Cruz. This represents 1.1% of the original forest (Figure 1). In San Cristóbal, there is no Scalesia forest left (0% of the original distribution), while in Santiago the remaining area is restricted to within the five fenced areas that were constructed between 1974 and 1999 and covers a total of 1.1 ha (less than 0.1% of the original distribution). There may be a little more remaining on Floreana, but data collection there is not yet complete.

Studies of the distribution of *S. cordata* on southern Isabela carried out by Delgado (1997) and Shimizu

(1997) provide data on the location and size of current remnants on Sierra Negra volcano, which in total cover less than 10 ha, with only two of the forest remnants covering more than 2 ha. Moreover, Jaramillo *et al.* (2006) found that most of these remnants were heavily invaded by the introduced *Psidium guajava*. We estimate that there has been a loss of 99.9% of *S. cordata* forest on Sierra Negra (Figure 2).

Discussion

While extensive loss of forest in the highlands, due to habitat destruction, herbivory, and invasive plant species, is commonly recorded, this is the first time that the actual extent of habitat loss of *S. pedunculata* and *S. cordata* forest in Galapagos has been calculated. The results indicate an almost complete loss of an entire vegetation type on the inhabited islands of the archipelago.

The rapid reduction of Scalesia forest during the early 20th century occurred as a result of direct human destruction for wood and clearing of forests for agriculture on all the inhabited islands (Lundh, 2006). Water is a critical resource in Galapagos and the Scalesia forest zone occurs in the only zone of the islands with reliable water availability, due to garúa mists during the cold season. In addition, on southern Isabela, major fires in 1985 and 1995 led to the replacement of remaining fragments of *S. cordata* forest by the invasive *Psidium guajava* (Nowak *et al.*, 1990), due to the ability of the latter to resprout after fire (Delgado, 1997; Shimizu, 1997).

High densities of introduced goats were the main factor for the loss of the Scalesia forest zone on the uninhabited island of Santiago (de Vries and Calvopiña, 1977). Now that herbivores have been eradicated there (Cruz *et al*., 2005; Guo, 2006; Carrión *et al.*, 2007), the vegetation is recovering, even though invasive plants are beginning to become increasingly problematic (Atkinson *et al.*, 2008). However, since the eradication of goats in 2006, no regeneration of *S. pedunculata* has been observed outside the fenced areas despite the ability of Scalesia to reach maturity within one year of germination. However, it is hoped that in the future this species and the forests might regenerate.

On the inhabited islands, Scalesia forest has not returned to abandoned agricultural land due to the competitive ability of invasive plants. In Isabela many of these areas are now covered in dense *Psidium guajava* forests, while in Santa Cruz several farms are still dominated by introduced pasture 50 years after their abandonment. In addition, the small forest remnants that were never cleared are being invaded by introduced plant species, such as *Cedrela odorata*, *Cinchona pubescens*, and *Rubus niveus* (Rentería and Buddenhagen, 2006; Jaramillo *et al.*, 2006). While this review does not consider the *S. cordata* forest on Cerro Azul volcano as there is very little spatial information about this area, a recent field survey found a small forest of 18 ha on the flank of the volcano at an elevation of 200-300 m, surrounded by an extensive forest of *Psidium guajava* (Guezou, A. CDF, pers. obs.).

Active management to help restore these areas is complicated by the difficulties of controlling fast growing and competitive invasive plant species. This problem is compounded in the National Park areas of Cerro Azul and Sierra Negra, where ungulates continue to eat the bark and young of *S. cordata*, and disperse the seeds of the introduced *Psidium guajava*. Although weed control is carried out in priority sites, to date it has had little impact on forest regeneration due to the large and persistent seed banks of invasive species and their rapid growth rate (Gardener *et al.*, this volume). The invasion of these areas is made worse by the effect of El Niño events, which increase forest vulnerability to invasion by plants due to gap formation and heavy rainfall. It is likely that this threat will become more severe as these events increase in frequency and intensity as predicted under climate change models (Mitchell *et al.*, 2003).

Recommendations

A program of active and focused research as identified in Gardener *et al.* (this volume) needs to be initiated to inform and optimize the restoration of the remaining fragments of Scalesia forest, and to provide a sound methodology for the successful reestablishment of areas within the natural distribution.

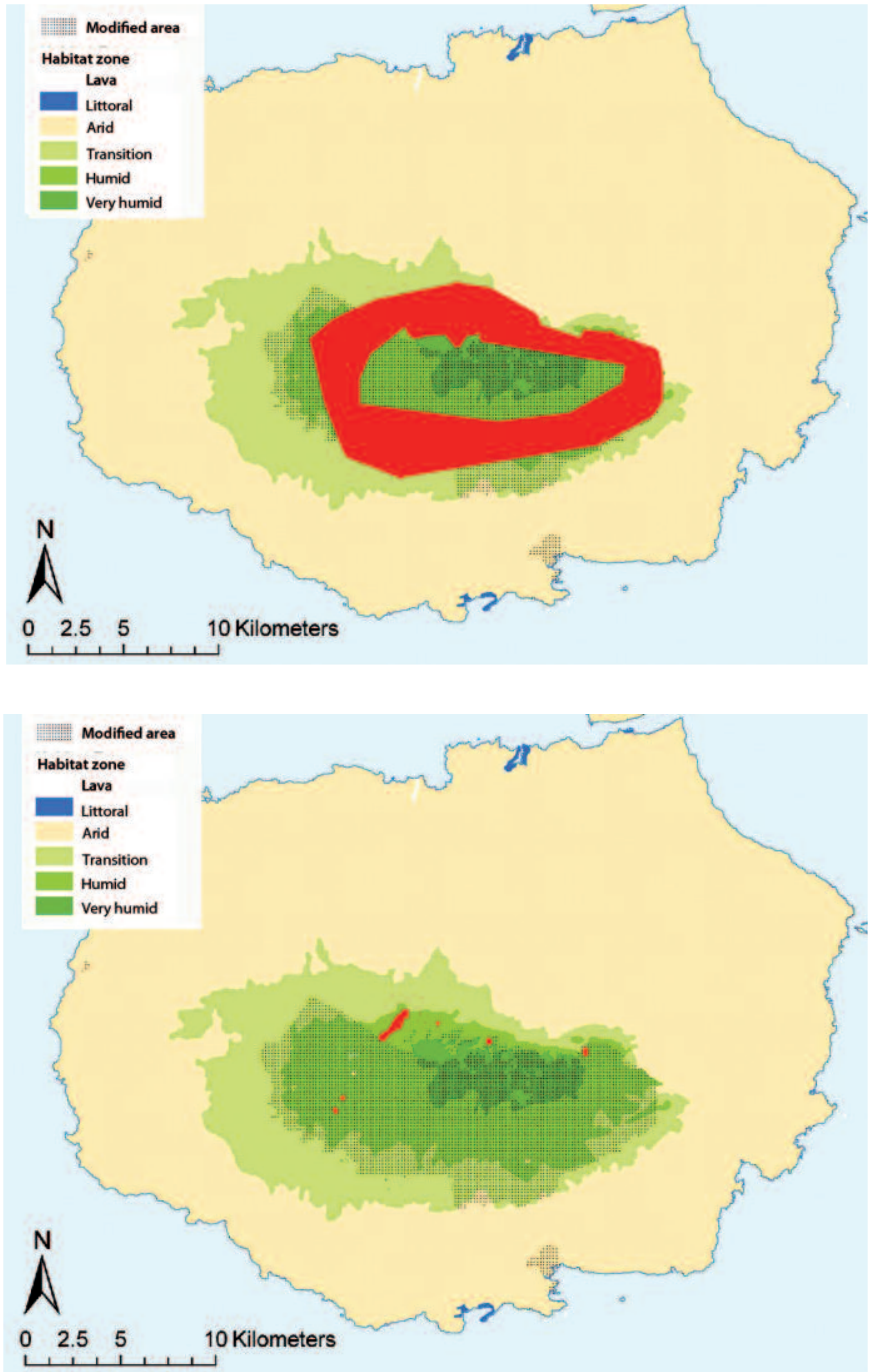

Figure 1. Maps of vegetation types showing the *Scalesia pedunculata* forest (in red) on Santa Cruz, with historical distribution above and current distribution below.

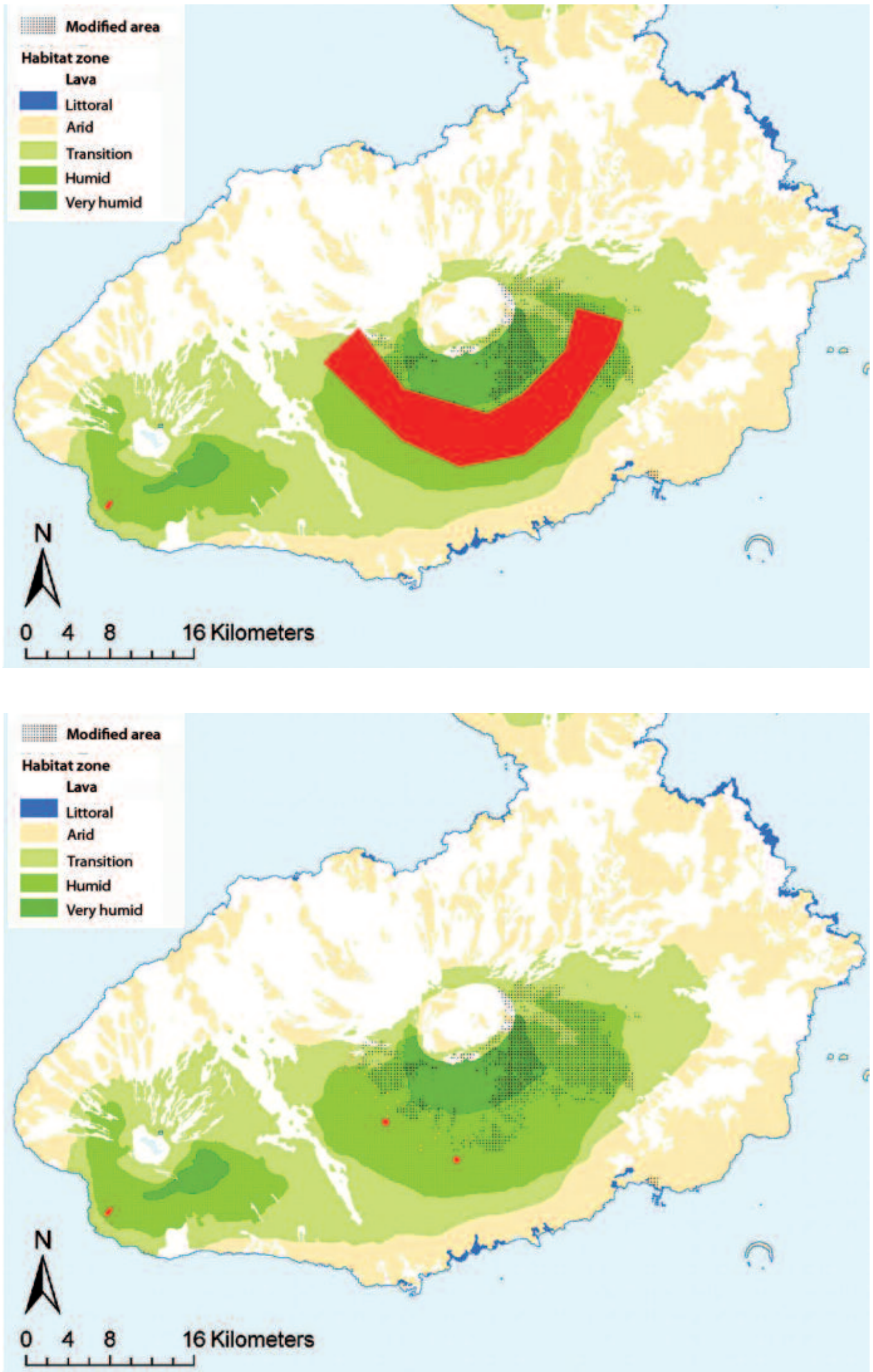

Figure 2. Maps of vegetation types showing the *Scalesia cordata* forest (in red) on southern Isabela, with historical distribution above and current distribution below. The largest red points represent remnants of forest of more than 2 ha. .

Photo: Emmanuel Cléder

The commercial sector of Puerto Ayora and its relation to the environment

Pamela Villarreal[1] and Christophe Grenier[2,3]

[1]Universidad Andina Simón Bolivar, [2]Charles Darwin Foundation, [3]University of Nantes

Tourism is the principal economic activity of Galapagos, particularly in Puerto Ayora, the largest city in the archipelago. Increasing economic flows into Galapagos have generated new demands among the local population. The local commercial sector has grown to respond to those demands and has significantly increased the number of available products. The principal streets of Puerto Ayora are lined with shops selling artisan goods, t-shirts, computers, household appliances, as well as internet cafes, restaurants, laundromats, and even supermarkets where one can find a wide variety of national and international products. This proliferation of shops is transforming the urban landscape of Galapagos into one similar to those found on the continent.

One of the keys to long-term conservation of Galapagos is the collaboration and commitment of the archipelago's residents. It is important to understand how the local population views and values their surroundings. Although various surveys and studies have measured public opinion of the local population regarding its relation to Galapagos ecosystems, little attention has been focused on specific social sectors. Among these, one of the largest and least studied is the commercial sector, which is comprised of merchants and small shop owners.

There is a clear division in the commercial sector of Puerto Ayora between businesses serving tourists and those serving the local population. The highest concentration of businesses is found on Charles Darwin Avenue, which runs along the shoreline, and Baltra Avenue (Figure 1), with businesses targeted to tourists primarily on Charles Darwin Avenue and some on the first few blocks of Baltra Avenue (Photo 1). Businesses located farther up Baltra

Avenue and dispersed throughout the secondary streets of Puerto Ayora primarily serve the local population. Many homes have small shops offering a few products primarily to their nearest neighbors. The commercial sector is quite dynamic. After the map for this study was completed, several businesses closed and others opened.

Figure 1. Map of the businesses in Puerto Ayora, October 2009.

This article is based on research carried out in October and November 2009 as part of the Geographic Footprint Project of the Charles Darwin Foundation. One hundred businesses in Puerto Ayora were surveyed to gain an understanding of the economics of this sector, the views of local merchants, their business practices and travel within and outside the archipelago, and their relation to their environment. The analysis of these surveys attempts to identify the principal concerns of the commercial sector and how its members value the natural and social environment in which they live.

Photo 1. Souvenir shops along Charles Darwin Avenue, Puerto Ayora. Photo: Lenin Dávila.

Characterization of the commercial sector

More than half (52%) of the merchants and shop owners in Puerto Ayora's commercial sector came from the Ecuadorian Andes, with the greatest percentage (23%) originally from the province of Tungurahua, while 32% came from coastal Ecuador and 4% from other countries. The remaining 14% was born in Galapagos. The majority of those surveyed arrived in the islands between 1991 and 2000 (Figure 2). Nearly a fifth (18%) of those surveyed indicated that they arrived in the islands after the enactment of the Special Law of Galapagos in 1998, despite immigration restrictions included in the law.

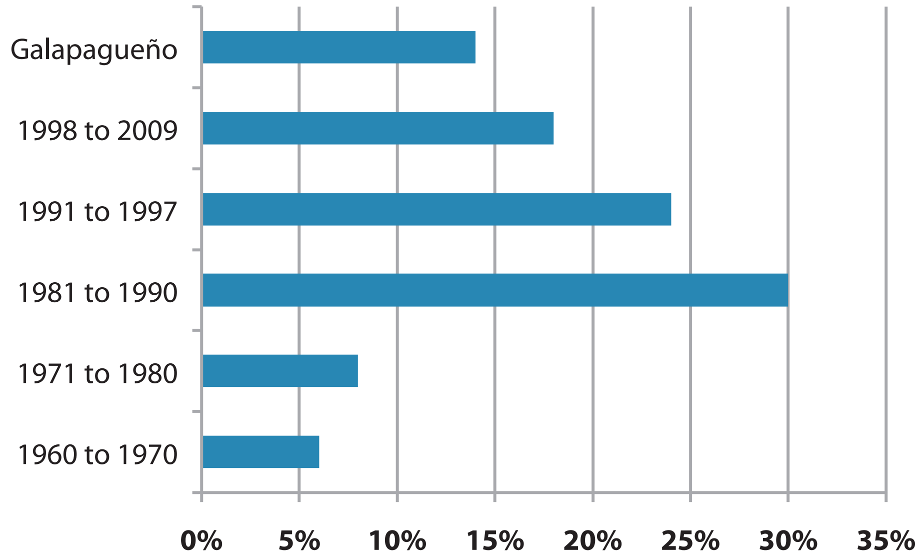

Figure 2. Year of arrival in Galapagos.

Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

Forty-seven percent of the businesses in the study were established during the last decade, 29% between 1991 and 2000, and only 7% between 1970 and 1990. The remaining 17% of the businesses were acquired as functioning establishments. The vast majority of the businesses surveyed (76%) began operations in the last 20 years, which corresponds to the period of rapid growth of Galapagos tourism, the local population, and an increase in income of the inhabitants of Puerto Ayora.

In terms of employment offered by these businesses, nearly half (47%) are run by the owners or family members and do not contract any employees (Figure 3). According to those surveyed, these businesses do not generate sufficient income to be able to contract additional employees. Approximately a third of the businesses (32%) contract one employee and 11% have two salaried employees.

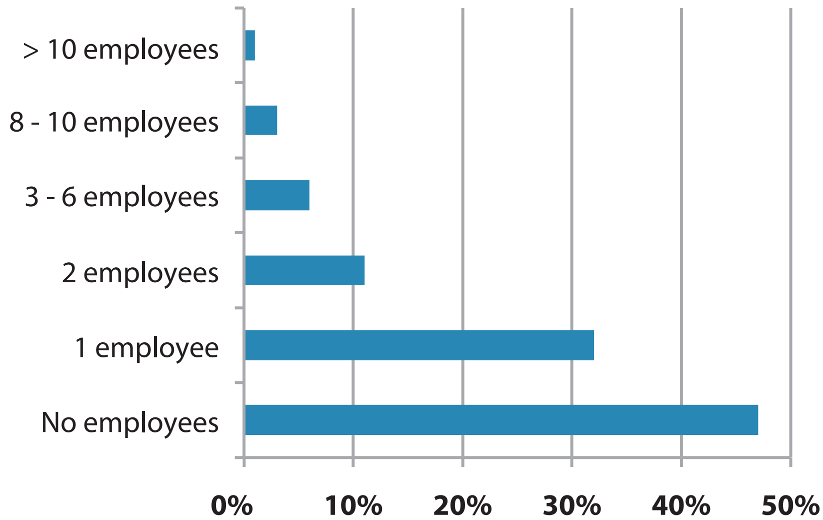

Figure 3. Number of salaried employees in the business.
Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

Still, 9% of those surveyed plan to contract an employee soon; 6% said they would prefer an employee from the continent because "local workers charge more and don't work well." Bringing an employee from the continent creates a situation of dependence on the part of the employee. It is easier for an employer to manage someone who comes to a place where they don't know anyone and when their only objective is to work.

A number of businesses, generally the larger ones, chose not to share information regarding income and salaries. Twenty percent of the owners indicated they earned between US$100 to US$500 per month, which is minimal considering the high cost of living in Galapagos. Twenty-two percent earned between US$501 to US$1000; this group included many of the souvenir shops that serve Ecuadorian tourists. Fourteen percent reported income between US$1001 and US$2000; these businesses offer a wide assortment of supplies and liquor. Those reporting income between US$2001 and US$5000 (11%) include businesses that cater to international tourists. Nine employees were also asked about their salaries; seven reported salaries between US$200-400, while two earn between US$600-700.

The survey revealed that income and salaries range from relatively high to barely sufficient to keep a business in operation. The most successful businesses are souvenir shops located close to the shore where visitors pass on their way from the municipal docks to the Charles Darwin Research Station.

Under current conditions, 73% of business owners do not invest in their shops beyond maintaining merchandise. Of the 27% planning to make additional investments, most intend to diversity their product line (10%) or enlarge the physical space of their shop (7%) (Figure 4).

While many businesses do not serve tourists as their principal clients, all of the merchants surveyed, even those that specifically target the local population, indicated that they depend on economic flows generated by tourism. Business activity is closely tied to the income of those who live in Puerto Ayora, and those incomes are very closely related to tourism.

Migration

Twenty-five percent of merchants surveyed had a favorable opinion of immigration, while 53% said that it was harmful and 22% responded that it had both

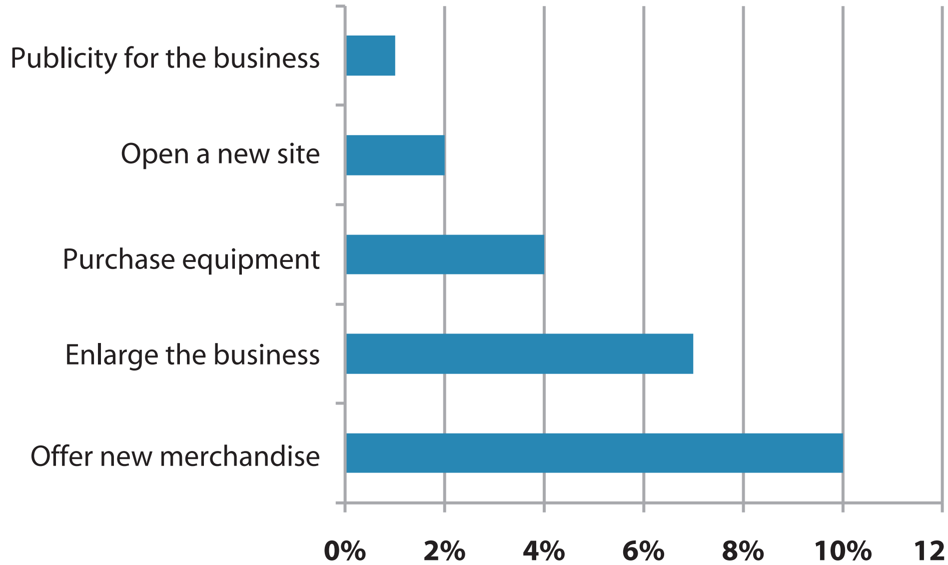

Figure 4. Areas in which the business owner plans to invest (73% of the respondents are not included as they had no plans for investment in their businesses).

Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

positive and negative aspects. Some of those who considered immigration harmful indicated that those arriving from the continent "take jobs from permanent residents" (30%; Figure 5). Those with a positive view towards immigration highlighted the fact that the migrants "work better and charge less" (18%). Twenty-three percent indicated that immigration brings with it problems including overpopulation and environmental degradation. It was generally agreed that newcomers to Galapagos do not understand conservation and consequently have a negative impact on the environment.

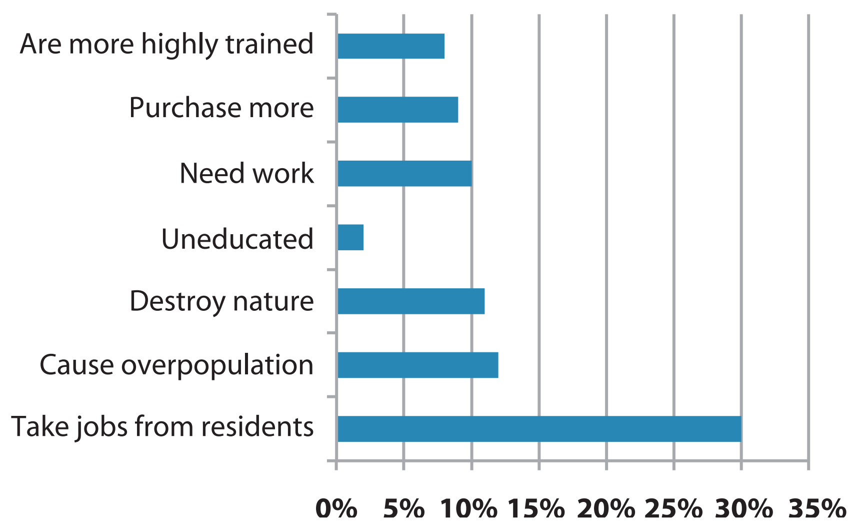

Figure 5. Opinions of merchants regarding immigrants to Galapagos.

Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

The results of this survey differed from one carried out among the general population in 2006 (Barber and Ospina, 2008), in which 81% of the population agreed with the phrase "the more people that live in the islands, the greater the environmental damage," and 86% agreed that "immigration increases crime." Some of the variation in these perceptions could be due to the fact that the principal concern of the commercial sector is the growth of competition, which means that the principal threat that immigration brings is the possibility that their business will fail. Still, approximately 10% showed their support for more immigrants, given that new residents will frequent their shops.

Mobility and travel

In terms of travel within Galapagos, 13% of those surveyed had never left Santa Cruz and 13% indicated that they know most or all of the inhabited and uninhabited islands of the archipelago (Figure 6). The remaining 74% know only Santa Cruz and one other island.

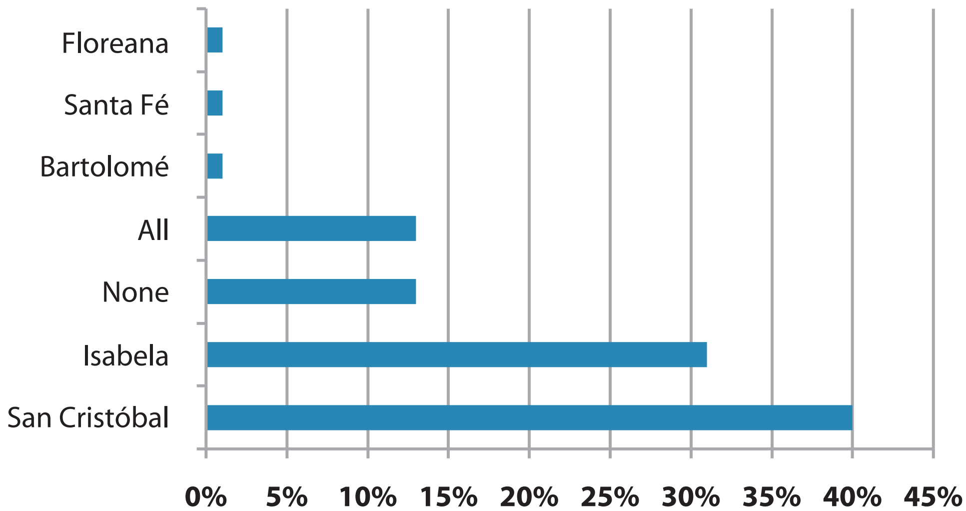

Figure 6. Islands visited by those surveyed; "all" was the response of those who had worked in tourism. Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

The island most frequently visited by members of the Santa Cruz commercial sector is San Cristóbal, with 40% of those surveyed reporting that they had been there: 75% traveled there for work and government-related business and 25% for personal reasons. Isabela had been visited by only 31% of the merchants surveyed, 58% for tourism (because of its tranquility and landscapes) and 42% for personal or business reasons. Those who visited Isabela agreed that it is a beautiful place but that they would not choose to live there because of its isolation, the lack of local activity, the small population, and the introverted behavior of its inhabitants. Those who indicated they had visited "all" of the islands had worked previously in the tourism sector.

In terms of transportation within Puerto Ayora, 38% indicated that they use bicycles, 33% prefer to walk, and 29% alternate between walking and motorized vehicles. In spite of the fact that nearly 70% indicated concern about the noise and pollution associated with the growth of the motorized fleet of Santa Cruz, 35% of those surveyed own a motorcycle, taxi, or truck.

Visits to the continent are common among the merchants of Puerto Ayora (77%): 35% make the trip once each year and 42% make trips two or more times per year. The most frequent destinations are Guayaquil (35%), Quito (30%), and Ambato (17%). The 23% that does not make planned annual trips tend to go to the continent when confronted with an emergency. When asked about their reasons for remaining in the islands, almost all agreed that they would like to go to the continent more frequently but could not due to the cost (about US$120 for a Galapagos-Guayaquil-Galapagos ticket at resident rate). Reasons for trips to the continent include family visits (32%), vacation (23%), and medical services (22%). Most of those surveyed agreed that they do not trust doctors working in Galapagos, and that "any illness more serious than a cold should be treated on the mainland." All agreed that health care in Galapagos is poor and more should be done to attract doctors and specialists to the islands.

When asked if they would be willing to move to the continent, 62% said no. They prefer to remain in the islands because they are accustomed to the lifestyle and have family ties. Also, they have work in the islands and are concerned about the level of crime that is common in big cities. Eighty-four percent of those surveyed indicated that tranquility—the security and peace offered by life in the islands—is one of the most important and valued aspects of Galapagos life.

One quarter of those surveyed, however, would like to return to their native city. Many miss family members left behind and the familiarity of their home

Photo: Christophe Grenier

town or city. Others are considering a return to the continent because "the situation in Galapagos is more and more difficult," "everything is more expensive," and "Galapagos isn't like it was when we arrived." Twelve percent of respondents are currently evaluating the possibility of returning to live on the continent permanently.

Leisure time

Forty-nine percent of those surveyed reported that they have little free time and that work demands their presence a minimum of six days a week. Any free time is dedicated to rest and taking care of the home. The other 51% divides their free time between taking walks, going out to eat, and visiting beaches or the highlands. The most well-known recreational site in Santa Cruz is Tortuga Bay (48%), followed by the Charles Darwin Research Station (10%), Garrapatero (9%), Las Grietas (6%), and the Playa de los Alemanes (6%). However, the area most visited by merchants is the highlands; more than 85% visit Bellavista at least one each month. Reasons for the visits include the opportunity to spend time with family, traditional food offered on Sundays, and the chance to play volleyball.

The ocean plays an important role in the lives of inhabitants of any island. Seventy-eight percent of the individuals surveyed in this study indicated that they like the ocean, while 22% responded that they prefer to stay away from the water or that they like to look at it but don't like to swim. In terms of encounters with marine life, 15% had never seen a marine iguana, sea lion, or sea turtle while swimming. Approximately 60% responded that if they encountered one of these animals they would do nothing, while 15% would get out of the water or move away from the animal. Sharks and rays cause the greatest fear among those surveyed, although nearly 30% had never seen one. All of the respondents emphasized the importance of not disturbing native fauna. In this sense it appears that conservation principals—at least in a theoretical sense—have been assimilated by those surveyed. Even so, many respondents have not had the opportunity to experience nature close up and to develop a deeper understanding of their surroundings.

Development

Opinions of this sector are divided regarding development in Galapagos. Twenty-five percent believe that development is good and that the construction of major public works should continue because it results in better services, an improved quality of life, and greater ease in obtaining certain products (Figure 7). However, 31% think that development is occurring too rapidly. Those who have lived the longest in Galapagos have positive memories of the days when there was no public lighting in Puerto Ayora, electricity was available only until 11 PM, and there was very little crime. Even so, it is difficult for them to imagine life in Galapagos without current amenities and comfort. There exists a clear tension between "conservation" and the search for comfort. Increasingly the continental lifestyle is the point of reference for Galapagos residents when imagining the most attractive lifestyle for Galapagos.

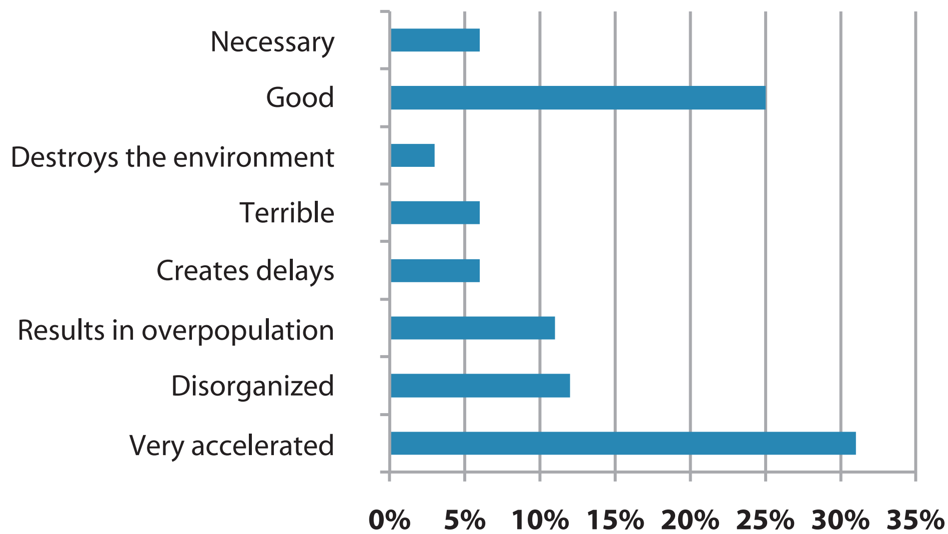

Figure 7. Opinions regarding development.
Source: Opinion Survey carried out in Puerto Ayora in October-November 2009 (N=100).

Conclusion

Responses from the survey questions posed by the authors revealed a growing economic sector in Galapagos with little connection to the unique environment of the archipelago. The commercial sector is a relatively new player in the Galapagos landscape, with most businesses having been established in the last twenty years. There appears to be no integration of the industry, its employees, and its economic trajectory into a long-term vision that values sustainable and island-appropriate development. While the tourism industry is flagged by respondents as a critical economic driver of the commercial sector (including tourists themselves and the growing local population that depends on tourism), the survey responses did not indicate that the businesses themselves take a proactive stance to protect the natural assets of Galapagos, which support and encourage tourism.

With this as background, and reflecting the upward trajectory of new and growing businesses evidenced in the data, there is a compelling rationale for working with local businesses to increase their appreciation and direct engagement in conservation management and sustainable practices. Business owners surveyed indicate that they are uncomfortable with the speed with which the sector is growing, but acknowledge that development provides an increasing level of comfort similar to that found on the continent. The surveys also indicate a deep dependence on the part of the merchants of Puerto Ayora on mainland services, in particular for public health and a workforce, dependencies that could be reduced if these resources were improved and more available in Galapagos. The challenge posed by this and other responses will be to establish a uniquely Galapagos lifestyle to which businesses and individuals can align their interests and behavior – a lifestyle that ensures the protection of the very assets on which their livelihoods depend. The path to a singular and adapted Galapagos lifestyle, including the commercial sector of Puerto Ayora, can be attained through the reduction in the geographic opening of the archipelago.

Photo: Christophe Grenier

The geographic opening of Galapagos

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Introduction

The "geographic opening" of a region describes the deep ecological and/or social transformations of that region caused by its full integration with the globalized world, through numerous transport and communications networks and subsequent flows. This concept was first created to analyze weaknesses in Galapagos conservation efforts (Grenier, 2007) and has since been more broadly used. For example, it is found in the second article of the draft for the new Special Law for Galapagos and was the theme of the international workshop on sustainability of islands hosted by the Charles Darwin Foundation in March 2010. The concept of geographic opening could be useful in advancing both the conservation and socioeconomic sustainability of the Galapagos.

This article begins with a discussion of the role of isolation in oceanic islands. It then describes the human history of Galapagos as a process of geographic opening that has been fostered, not limited, by conservation efforts. Next it analyzes how the geographic opening of Galapagos is manifested in the spatial organization of the archipelago, which has led to an ecological and socio-cultural process of "continentalization" of the islands. Finally, it concludes with a proposal for establishing a policy of sustainable conservation for Galapagos that will reduce the geographic opening of the archipelago without removing sources of income for the insular population.

Oceanic islands as natural and geographic regions

The adaptation of organisms to the geographic diversity of the Earth has resulted in the formation of biodiversity. During most of human history, societies have adapted to terrestrial diversity through cultural diversification and more precisely through geographic diversification processes. Each human society has had a lifestyle in accordance with its ideas, values, technology, and the natural resources of the area it inhabits. Consequently, each society has left footprints on the surface of the earth (or "geo-graphs") specific to their location and culture. The processes of biological and cultural diversification form natural regions ("eco-regions") and geographic regions. A region is an area of medium scale (from hundreds to thousands of km^2) that is distinguished by its natural features and/or geography from other spatial entities of similar dimensions.

Oceanic islands are natural regions characterized by long-term ecological isolation (hundreds of thousands to millions of years). The oceanic barrier that isolates islands from continents is not impermeable, but it functions as a filter. Before the arrival of humans, only representatives of a few species were able to colonize these islands, resulting in low biodiversity and disharmonic flora and fauna in relation to that of the nearby continent. Once these organisms established themselves on the islands, they were separated from their populations of origin by the ocean, allowing for divergent evolution and in some cases the eventual formation of endemic species, specifically adapted to these isolated, relatively small regions of low biodiversity.

Due to their isolation, some oceanic islands constitute the last places on Earth to have been populated by humans. Once humans arrived on an oceanic island, its ecological isolation depended upon the geographic isolation of the society that colonized it. In some cases when the first humans settled on islands, they formed geographic regions that were in large part isolated from the rest of the world during historical times. One example of insular isolation is Rapa Nui (Easter Island), which was inhabited by Polynesians for nearly a millennium with very few contacts with the rest of the world. In many oceanic islands, the geographic isolation was not complete. Certain island societies (in Melanesia for example) produced spatial networks that allowed them to maintain contact with other insular societies with travel strictly controlled by the leaders.

From the biological or cultural point of view, oceanic islands illustrate the adaptation of certain organisms or societies to ecological or geographical isolation, a limited area, scarcity of resources, and major differences between the insular environment and the environment from which they came. Oceanic islands give rise to biological and cultural speciation processes through which species or lifestyles adapt to insular isolation and other environmental limits. It is for this reason that many oceanic islands are considered conservatories of unique natural or cultural occurrences and are of great interest both to biologists as well as anthropologists. Oceanic islands also provide models for understanding the effects of ecological or geographic isolation in continental regions with similar characteristics (Whittaker and Fernandez-Palacios, 2007) and for analyzing current global ecological crises (Bahn and Flenley, 1992; Diamond, 2004).

Since the visit of Darwin and the development of his theory of evolution by natural selection, the Galapagos Islands represent an archetype for the study of biological evolution in conditions of ecological isolation. Galapagos is also unique among oceanic islands as it was the last archipelago in the tropical zone to have its ecological isolation disrupted. It was not until the beginning of the 19th century that the archipelago became a geographic region used and later populated by humans. This prolonged ecological isolation explains the interest that Galapagos generates in the fields of biology, conservation, and tourism. This archipelago allows for study of evolutionary processes in ecosystems that are still close to their natural, pre-human condition. There is no other place on earth where tourists can approach wild animals so closely. However, the recent human colonization of Galapagos has impeded the development of an island culture with a lifestyle adapted to the insular realities of the region, as has occurred in other oceanic archipelagos of the South Pacific.

The human history of Galapagos is the history of its geographic opening

The human history of Galapagos reveals a gradual geographic opening of this region to the rest of the world and coincides with the formation of the Modern World system. A world system connects various regions in different continents or oceans via transportation networks that permit a regular flow of materials (raw materials, products, etc.), people, money, organisms, and ideas. The Modern World system is closely related to the expansion of capitalism beginning in the early 15th century in Western Europe and spreading to the rest of the world. Globalization, an emerging property of the Modern World system, can be seen, in part, as a geographic opening of strategically important regions by powerful geographic actors, including nations, international organizations, and transnational corporations.

In the first centuries of human history in Galapagos, there was a very small geographic opening of the archipelago, although the islands were known to the world due to their presence on maps as early as 1570. The Spanish who discovered Galapagos in the 16th century did not settle in the islands. At the end of the 17th century and beginning of the 18th century, the islands were used as a base of operation by buccaneers who also did not leave permanent footprints, with the notable exception of the introduction of rats. The real disruption of the ecological isolation of Galapagos began in the 19th century, through the connection of the archipelago with Nantucket by whaling fleets of the United States, and then its integration into the national space of Ecuador through colonization and the subsequent introduction of domestic animals. From this point forward, the geographic opening of Galapagos was characterized by exploitation of resources for exportation (in the 19th century, primarily sperm whales, giant tortoises, fur seals, the orchilla lichen, etc.), which resulted in drastic reductions in the populations of some species.

The geographic opening of Galapagos grew throughout the 19th century. After 1870, the Ecuadorian colonization became permanent. The highlands of San Cristóbal and later Isabela were opened to cattle and agriculture (sugarcane and coffee plantations) and their raw materials were exported to the mainland. Western scientific expeditions collected large numbers of specimens of all types, putting even greater pressure on the survival of certain species (Thornton, 1971). This geographic opening did not translate into an improvement of conditions for the insular population. While Galapagos was open to private businesses of specific colonists (Valdizán, Cobos, and Gil, for example) and to foreign scientists, the archipelago became home to laborers from continental Ecuador who were held prisoner in the islands by powerful landowners (Silva, 1992).

In the first half of the 20th century, there was a relative pause in the geographic opening of Galapagos. The haciendas collapsed, giving rise to open but infrequent colonization, in part because the Ecuadorian State continued to have difficulty in connecting its insular territory to the continent. Even so, the process of opening continued. European colonists settled Floreana and Santa Cruz, tuna fishing fleets from California began to frequent the waters of the archipelago, western scientists continued their voyages around the islands, and a limited number of wealthy tourists identified Galapagos as a destination. It was during this short period of a reduced geographic opening that an island culture began to appear. It arose in a population of diverse origins, isolated from the rest of Ecuador and the world, which survived in large part through self subsistence. The galapagueño culture that arose thus reflected a lifestyle adapted to the isolation and the scarce resources of the archipelago.

After 1940, the geographic opening of Galapagos increased even more with the establishment of a US military base on Baltra during World War II. During the war, several thousand US troops passed through Baltra, a significant increase in human population in economic terms (the base also generated immigration of labor from the continent) and its impact on the environment (although there has been no research demonstrating introductions with negative impacts during this short period). The presence of the military base proved that the Galapagos Islands—even the more arid ones--could support a large population, if adequately supplied from the continent. In other words, geographic opening with high energy consumption could colonize any environment. The US military base provided a window to the actual current situation in Galapagos.

In the 1950s, the goal of the Ecuadorian government was to fully integrate its insular territory through colonization, according to the geopolitical doctrine of "living frontiers." At the beginning of this decade, the Ecuadorian Institute for Agrarian Reform and Colonization (IERAC) organized the colonization of the highlands of Santa Cruz. The relative failure of this effort showed that Galapagos could not be colonized through agriculture as had been accomplished in certain sectors of the Amazon.

During this period, western scientists, supported by UNESCO and the IUCN, stepped up their pressure to establish a natural reserve in Galapagos. In 1959, the Ecuadorian government designated 97% of the archipelago as the Galapagos National Park (GNP). The Charles Darwin Foundation, an international, scientific NGO, was established in the same year and through an official agreement with the government was to advise Ecuador on the conservation of Galapagos. However, the creation of a national park would ultimately result in Galapagos becoming a center for world tourism.

The conservation of Galapagos has accelerated the geographic opening of the archipelago

Paradoxically, the creation of the GNP accelerated the geographic opening of Galapagos. The international media drew attention to the park and the work of scientists. This, in turn, attracted tourism and generated economic development in the colonized areas of the archipelago and provided incentive for voluntary migration of Ecuadorians from the continent. This influx of Ecuadorians finally allowed a real national sovereignty on Galapagos, which until this time had been freely open to foreign actors (businessmen, scientists, tourists, etc.). The model of tourism designed in 1966-67, which used boats as hotels, began to function towards the end of the 1960s. At that time, permits were reserved for one large national company and Galapagos colonists. The Ecuadorian government granted Galapagos provincial status in 1973, despite the fact that the islands' population was only 4000. This move permitted the free immigration of Ecuadorian citizens to the archipelago. In 1979, the national government created the National Institute of Galapagos (INGALA) to oversee the development of the insular region. Since that time, the size of the insular population has followed the same ascending curve as the number of visitors to Galapagos: 6700 inhabitants and 17,000 tourists in 1982 and 10,000 residents with 40,000 visitors in 1990. These increases were accompanied by a significant growth in the number of boat permits and capital investments from outside Galapagos. In 1986 an airport was inaugurated in San Cristóbal, opening a second entry port for airplanes to the archipelago.

In the 1990s, the geographic opening of Galapagos grew even more, due in part to the boom in the sea cucumber fishery for export to Asia and a continual increase in the number of tourists traveling to Galapagos from Europe and North America. These activities brought more and more immigrants to the archipelago, where the population grew to 18,000 by 1998, with 60,000 tourists visiting Galapagos that same year. However, the socio-political disruptions related to the sea cucumber fishery led first to participatory management of the Galapagos Marine Reserve (GMR) and later in 1998 to the Special Law for Galapagos (LOREG). On the surface, these measures appear to reflect a policy aimed at reducing the geographic opening of the archipelago: the GMR was extended and its resources reserved for fishermen from Galapagos and the LOREG established the status of permanent resident and prevented new immigrants from staying in the province beyond the time stipulated by their work contracts. However, it appears that the primary objective of the LOREG was to resolve social conflict in the archipelago and organize a new distribution of the economic benefits of the geographic opening driven by tourism. For that reason, no thought was given to limiting tourism.

LOREG stipulates that 40% of the park entrance fee is to go to the municipalities, the Provincial Council, and INGALA. The GNP also receives 40%, while the remaining 20% is divided between the Navy, the Quarantine System, Management of the GMR, and the National System for Protected Areas. With such income streams, it is logical that these institutions would not be in favor of limiting tourism--their primary source of revenue. LOREG officially named the population centers of the archipelago and protected areas as tourism "destinations" in Galapagos (Article 45). This resulted in the "locally based" tourism sector undergoing a period of rapid growth during the next decade, surpassing the passenger capacity of the tour boat sector (Epler, 2007). Both sectors took advantage of the boom in tourism in Galapagos, which nearly tripled in ten years from 60,000 visitors in 1998 to 173,000 in 2008.

The insular population has continued to grow, reaching approximately 30,000 inhabitants in 2010. Galapagos now has an immigration system very similar to the developed countries of the world. Its economic wealth relative to the continent combined with its immigration restrictions increased its appeal and fostered illegal immigration, which is supported by businesses and residents who take advantage of cheaper and more manageable labor, for example in the commercial sector (see Villareal, this publication) and the construction sector (see Jimbo, this publication) of Puerto Ayora.

However, the human movement is not only in the direction of Galapagos. Eighty-two percent of 120 residents interviewed in 2008 in the ports and highlands of Santa Cruz, San Cristóbal, and Isabela had traveled one or more times to the continent during the previous year (Grenier, 2008). A similar proportion (77%) of shopkeepers in Puerto Ayora makes such trips (Villareal, this publication). A substantial portion of the insular population flies regularly to the continent for a variety of reasons, including health and education. These figures demonstrate a high level of dependence on and vulnerability to the external world. The insular population continues to push the geographic opening process in Galapagos, constantly demanding greater ease in "leaving" the islands.

The organization of space in Galapagos reflects the geographic opening of the archipelago

The geographic opening of Galapagos can be represented at local, regional, national, and global levels (Figure 1). The regional level is comprised of local spaces (populated islands and protected areas), which are integrated into both national and global space.

Different parts of the world are connected to Galapagos via various pathways, but always through continental Ecuador. The intensity of ecological and social transformations occurring in the archipelago depends upon the volume, intensity, and types of flows that circulate within these networks. An efficient policy to support conservation and social sustainability must act on the connections between Galapagos, continental Ecuador, and the rest of the world, to reduce the flows that enter and leave the archipelago. It is important to note that the local spaces in Galapagos are less related to each other than the archipelago is to the rest of the world. Because of this, Galapagos development patterns are oriented "to the outside" in ways that affect the organization of the regional space (Figure 2).

The "core" of the archipelago is formed by Santa Cruz-Baltra and the adjacent islands, where two thirds of the population and insular tourism activities occur (Figure 2). This situation arose in the 1970s because of the land/sea route between Baltra (the only airport in Galapagos at the time) and Puerto Ayora, the center of tourism operations and conservation in the archipelago. The road crossing Santa Cruz generated urban expansion and tourism activity in the highlands of the island. This core area of Galapagos has a greater level of connectivity with continental Ecuador than it does with the other islands of the archipelago. Baltra is by far the major airport in the archipelago and is the only fuel supply port, making it the most important hub of tourism operations in Galapagos. Puerto Ayora receives the greatest volume of material coming from the continent via cargo ships and is the only port connected by daily passenger boats with all of the other populated islands of the archipelago. The visitor sites located in the "core" of the archipelago are the most visited of the protected areas for obvious logistical reasons.

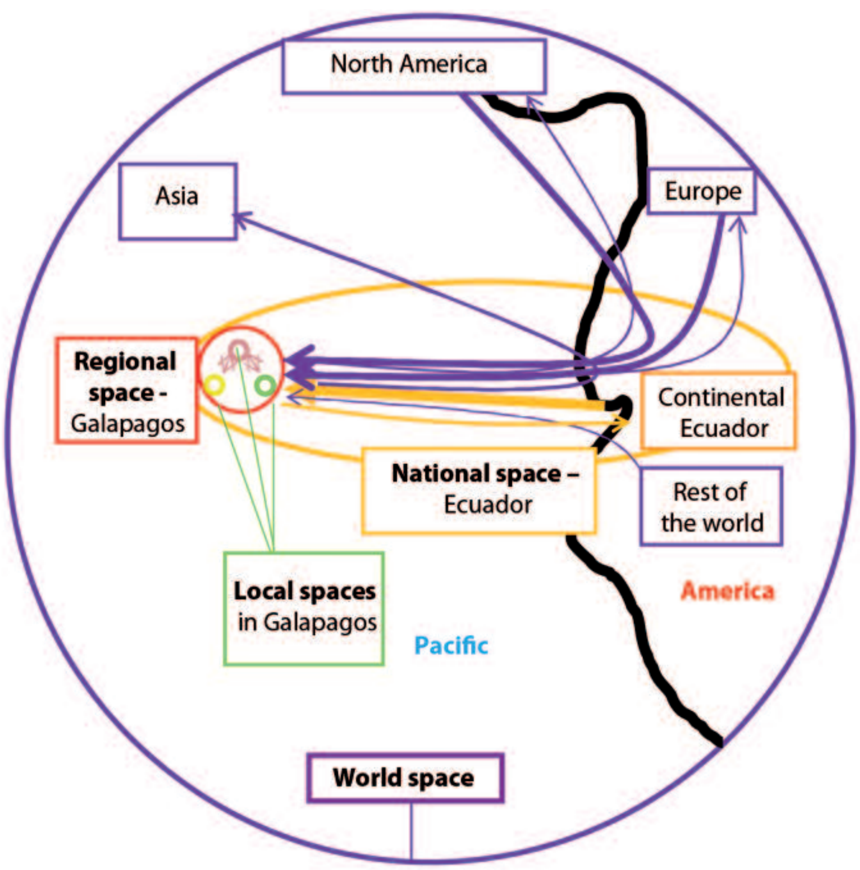

Figure 1. The spaces of Galapagos.

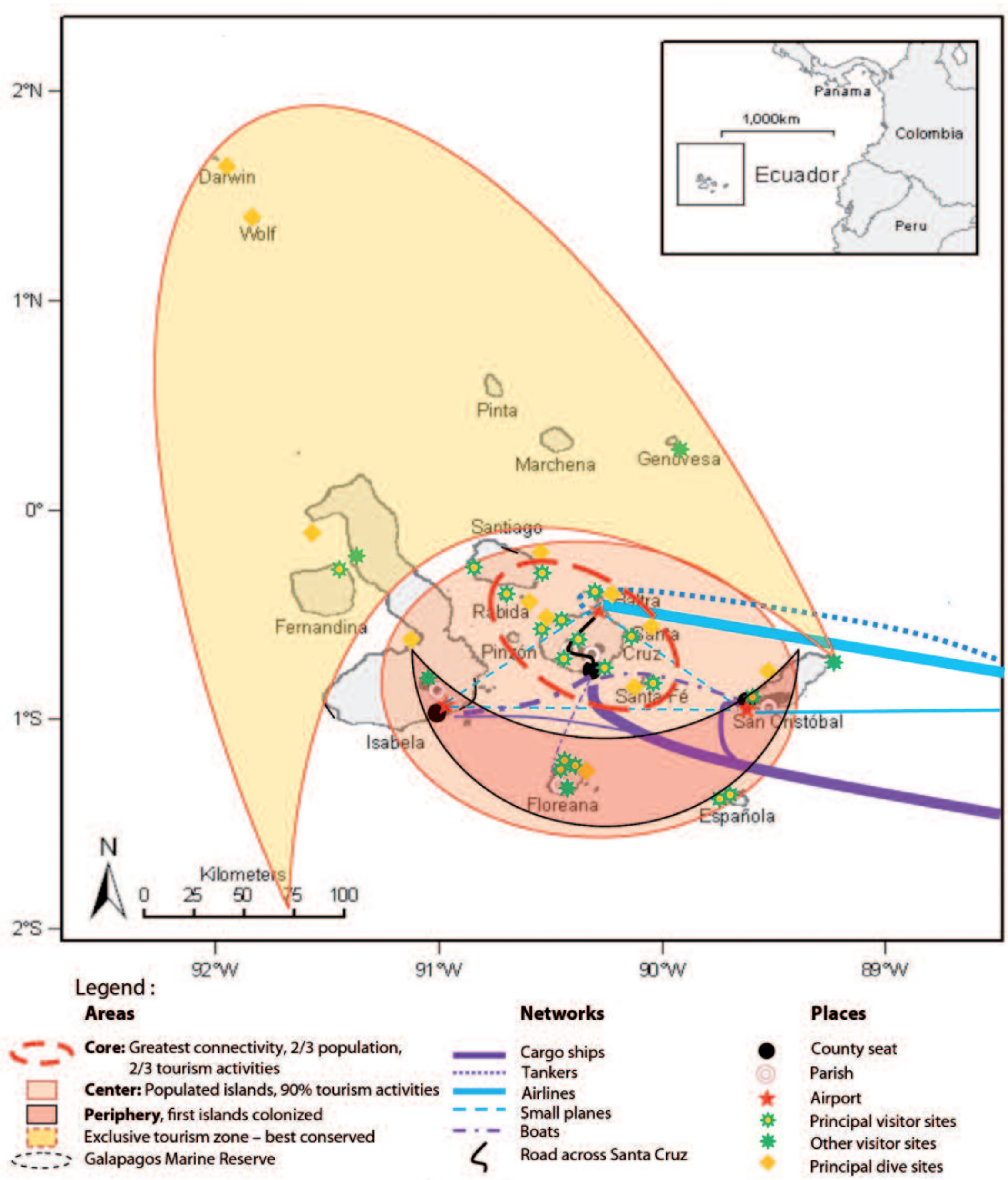

Figure 2. The organization of the regional space of Galapagos.

The central area of Galapagos, beyond the Santa Cruz-Baltra core, includes the three other populated islands. Floreana, the western portion of San Cristóbal, and the southern end of Isabela formed the historical colonized region of the archipelago prior to the development of tourism. The longer human occupation of these islands explains the extensive ecological degradation of their highlands. The fact that Puerto Baquerizo Moreno continues as the provincial capital is an inheritance from the past. The central area includes all of the population of Galapagos and 90% of its tourism activity (all of the most visited GNP sites are found there). Consequently, it is also the zone with the greatest conservation problems. The level of connectivity of the three less populated islands with the mainland and other islands in the archipelago is much lower than that of the "core area." The airport in San Cristóbal has only a fourth of the activity as Baltra, and San Cristóbal has no regular connection with its rural parish, Floreana. The airport on Isabela caters only to regional traffic and the island does not have a direct maritime connection to San Cristóbal.

Finally, the uninhabited islands and the uninhabited parts of the populated islands that are farthest from populated centers and the transportation hub form an area of exclusive tourism and the highest levels of conservation. This area includes much of the north and west of the archipelago (although Punta Pitt on the northeast end of San Cristóbal is also in this group). It is the area with the lowest geographic opening in Galapagos and is of the greatest scientific interest (for example, Fernandina and Wolf Volcano). It is also home to some of the most important recent conservation projects (Project Isabela and Project Pinta). Few tourist cruises visit these special sites.

Photo 1. In 2010, it is possible to view three commercial planes at the same time in Baltra, although up to six planes arrive per day. Fifteen years ago, six planes arrived each week. Photo: C. Grenier.

The continentalization of the insular ecosystems and lifestyles

The consequences of the geographic opening of the archipelago can be described by the concept of "continentalization." This term highlights the contradiction between the geographic opening process and ecological isolation of oceanic islands such as Galapagos. It also describes something we can all see: social habits and human landscapes that are very similar to those on the continent. The increase in the use of taxis (see Cléder, this publication) and the invasion of introduced plants in the highlands of the populated islands (see Gardner *et al.*, this publication) are visible examples of the continentalization of Galapagos. This geographic and ecological process has obvious negative consequences for ecosystems, society, and the tourism-based economy in Galapagos.

The introduction of species and their subsequent proliferation in the archipelago have been identified for well over a decade as the principal threat to the conservation of Galapagos (Charles Darwin Foundation and WWF, 2002) and are directly related to its geographic opening. In other words, the conservation of Galapagos becomes increasingly difficult due to the growing geographic opening of the islands, as the flows entering the archipelago greatly surpass the capacity of the quarantine systems designed to control them.

The continentalization of the archipelago also affects the insular population, though many residents gain benefits from the geographic opening. According to the majority of the inhabitants interviewed, the principal advantage to living in Galapagos is "tranquility." This is also the opinion of 84% of the shopkeepers in Puerto Ayora (Villarreal, this publication). But the same people complain that Galapagos is losing this tranquility due to "immigrants," who are considered responsible for the increase in crime. Also, xenophobia against certain ethnic groups (such as the Salasacas) is slowly developing in Galapagos. It is clear that some groups in Galapagos are reproducing socio-cultural communities similar to those on the continent through immigration and personal networks.

Continentalization also impedes the formation of an island culture. The lifestyle of the insular population does not differ much from its urban counterpart in continental Ecuador. For example, galapagueños are continually increasing their use of motorized vehicles and construct their houses with the same materials and with the same styles as their compatriots on the continent. Consequently, the urban landscapes of Galapagos are similar to those on the continent. Continentalization and the resulting relationship of the local population to their environment can also be seen in their leisure activities. For example, according to the local newspaper, El Colono, one of the most popular sports in Santa Cruz is cycling, which is done on the asphalted roads. At the same time, 40% of the 150 inhabitants interviewed in Puerto Ayora never or almost never go to the beach and 90% have never visited Media Luna in the highlands (Brouyere, research in progress).

Finally, the continentalization of Galapagos is also resulting in a loss of the tourism resource, especially in populated areas. Other national parks exist where tourists can see wild animals, even close-up. But it is the co-existence of humans with native animals in populated centers that make Galapagos a unique region of the world. The interaction of fishermen with pelicans and sea lions in Pelican Bay and the sea lion beaches in front of the sea-wall of San Cristóbal are the only tourism attractions in the two towns. For 85% of the 1020 international tourists interviewed, the presence of native flora and fauna in the towns of Galapagos is important (Bram, research in progress). Obviously, more traffic, noise, cement, and lights will mean fewer animals in the towns. For 71% of the 150 residents interviewed, this decrease in the number of native animals is notable (Brouyere, research in progress).

Conclusion

In recent years, the GNP and the CDF have viewed conservation and sustainable development of Galapagos within the concept of a social-ecological system (GNP, 2006; Watkins *et al.*, 2007; Tapia *et al.*, 2008) under which the ecological and the social components have the same importance and an equal level of dependence on one another.

In reality, the insular ecosystem is every day more affected by the geographical opening of Galapagos. It will require an increasing level of intervention on the part of humans to maintain the archipelago in a close to natural state. However, social actors in Galapagos depend less on the insular ecosystem for their lifestyle than they do on imports of all types from continental Ecuador and the flow of tourists and tourism income coming from northern countries. Tourism only makes use of the most emblematic aspects of the insular nature. For example, tourists who visit the highlands of Santa Cruz focus on the giant tortoises and not on the local ecosystem, which has been totally transformed by invasive plants. If natural ecosystems are to survive, greater human involvement is needed. The concept of social-ecological systems does not take into account the disequilibrium that exists between society and nature in Galapagos and many other regions of the world.

A potential path to conservation and sustainability would be to build a social-ecological system in which the insular society truly depends on the ecosystems of the archipelago for its energy and food. But such an approach does not reflect current reality. The concept of a social-ecological system does not appear to be adequate to evaluate and resolve the current situation in Galapagos. Every human being lives in a populated region of the Earth to which the inhabitants identify themselves to greater or lesser degrees. A regional approach seems more relevant in working toward conservation and sustainability.

Using a regional approach provides a means of dividing the surface of the earth by both space and ecosystems. A region is at the same time an ecosystem and a geographic space. A geographic space is a social product, a portion of the surface of the earth organized by distinct social actors who live in and use its resources. Geographic spaces have existed and still exist in Galapagos, each with its own distinct footprints on the natural ecosystems and human landscapes of the archipelago. A conservation policy is sustainable when the different stakeholders in a geographic region leave footprints that do not impact the natural processes of the eco-region. In oceanic islands such as Galapagos, ecological isolation is a fundamental component of those natural processes.

Consequently, the concept of geographic opening must be at the center of an effective sustainable conservation policy for Galapagos. The concept of "geographic region" must be adapted as much as possible, focusing on the types of footprints that humans leave in Galapagos through their activity and attitudes. The rapid growth of the insular economy has

Photo: Christophe Grenier

increased the geographic opening of the archipelago, but has not resulted in real progress for the insular population, which continues to experience basic problems related to health, education, potable water, sewage, etc. In other words, insular economic development has not only had a strong negative impact on the ecology of the archipelago, it has also failed to improve the lives of the insular population. The model of economic development through geographic opening must be changed to a model of sustainable ecology with social progress.

All geographic and natural regions are systems that are open to the rest of the world. This is even more so in regions with high levels of tourism such as Galapagos. Given these circumstances, how is it possible to reduce the geographic opening of the archipelago in a manner that is sustainable for the human population? The challenge is maintaining the necessary level of economic activity for the insular population while reducing the geographic opening of the archipelago. To achieve this, the focus must be on quality not quantity, which means doing more with less. It is also fundamental to start with a complete evaluation and reorganization of tourism, the primary driver in the current and rapidly growing geographic opening of Galapagos.

Photo: Christophe Grenier

The national tourist in Galapagos: Practices and perceptions of the environment

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Introduction

For many years Galapagos was an expensive destination for Ecuadorian tourists and few were able to visit. Consequently, many Ecuadorian tourists opted to visit other destinations such as Columbia or Peru. However, over the last ten years, more Ecuadorian tourists traveled to Galapagos because of low-cost travel packages. Between 1998 and 2009, the number of Ecuadorian visitors increased from 14,440 (22% of all visitors) to 56,766 (35%). According to the official data of the Galapagos National Park (GNP), national tourism has increased by an average of 17% per year. Although the data on national tourists can be misleading, since many Ecuadorians travel to Galapagos for reasons other than tourism, the increase in visits by Ecuadorians is indisputable.

The objectives of this study were to determine:

1) How the Galapagos product is sold to national tourists;

2) The profile of the Ecuadorian tourist in Galapagos, and

3) The behavior of national tourists and their perceptions of the Galapagos environment.

Methods

This study was based on different types of information collected during 2009:

1) Surveys of the tourist agencies in Quito on Amazonas, Naciones Unidas, 6 de Diciembre and Colón Avenues (N=34);

2) Surveys of national tourists in the Baltra Airport as they prepared to leave Galapagos, in April-May 2009 (N=314);

3) Surveys of tourists staying at five hotels in Puerto Ayora that serve large numbers of national tourists, in December 2009 (N=146);

4) Field observations at tourist visitor sites in and around Santa Cruz;

5) Surveys and interviews with naturalist guides (N=54);

6) Semi-structured interviews with individuals involved in tourism and local tourist operations, September-November 2009, and

7) Official data of the GNP for 2009.

This information was used to evaluate the dynamics of national tourism in Galapagos, including perceptions, behavior, and practices of the tourists.

Results

Commercialization network

The main concentration of national tourist agencies is found in Ecuador's three major cities: Quito (36%), Guayaquil (20%), and Cuenca (6%). The remaining 38% are distributed throughout the country. All of the agencies offer Galapagos as the principal destination within Ecuador. For the last 15 years, Galapagos has been the primary tourism destination that Ecuador sells to the world (Gylbert, 1995).

Currently five travel agencies/tour operators market Galapagos tours directly to Ecuadorian tourists as well as through intermediary travel agencies (Figure 1).

Of the 34 tourist travel agencies surveyed in Quito, four reported selling their own tourism packages primarily to foreign tourists, while national tourists average about 26% of their clientele. The remaining 30 travel agencies reported that national clients average 19% of their business, and that they focus on selling tourism packages from five major Galapagos operators: Islas de Fuego, Ninfa, Puerta al Sol, Promoviajes, and Sevitur.

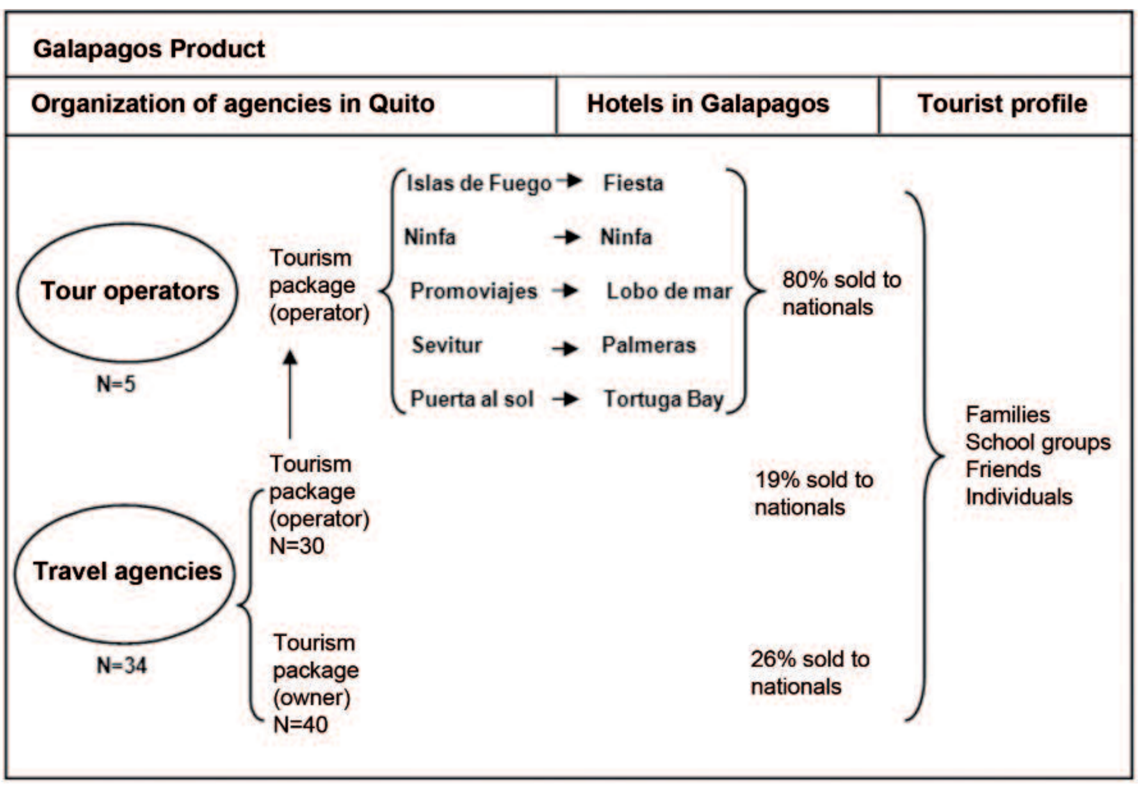

Figure 1. Marketing network for Galapagos tourism products at the national level, based on interviews (number indicated by "N").

These five tour operators capture 80% of the national market. They work directly with five hotels in Galapagos (Fiesta, Ninfa, Tortuga Bay, Lobo de Mar, and Palmeras), which are owned by the same family. Owners of tourism permits tend to maintain their business as an association within their own family so that the tourism activities, even on the continent, remain in the hands of galapagueños who now reside outside the archipelago or under the administration of some other relative. Based on the information obtained from these five hotels, two of the owners live in Galapagos and three in continental Ecuador. Two of them currently represent Galapagos in the national Congress.

National demand for Galapagos tourism packages is more focused on comfort and cost, rather than on itineraries. Some travel agencies prefer to sell packages offered by Islas de Fuego and Ninfa, due to the better services offered by these operators.

Profile and seasonality of the national tourist

The study identified two important segments within the national market: those who travel to Galapagos on family vacations and groups of school children, generally between the ages of 10-12 years old. The peak season for national tourists in Galapagos is August (almost 4000 visitors), while the lowest numbers arrive in November (2000 visitors; Figure 2). Throughout the rest of the year, the number of national visitors remains above 2000 per month. The largest number of school children visit between April and July, when schools of the Andes region organize end-of-year trips.

Surveys were used to develop a profile of adult national tourists who visit Galapagos and to compare that profile with foreign tourists (Table 1). The typical Ecuadorian tourist in Galapagos is young (21-29 years

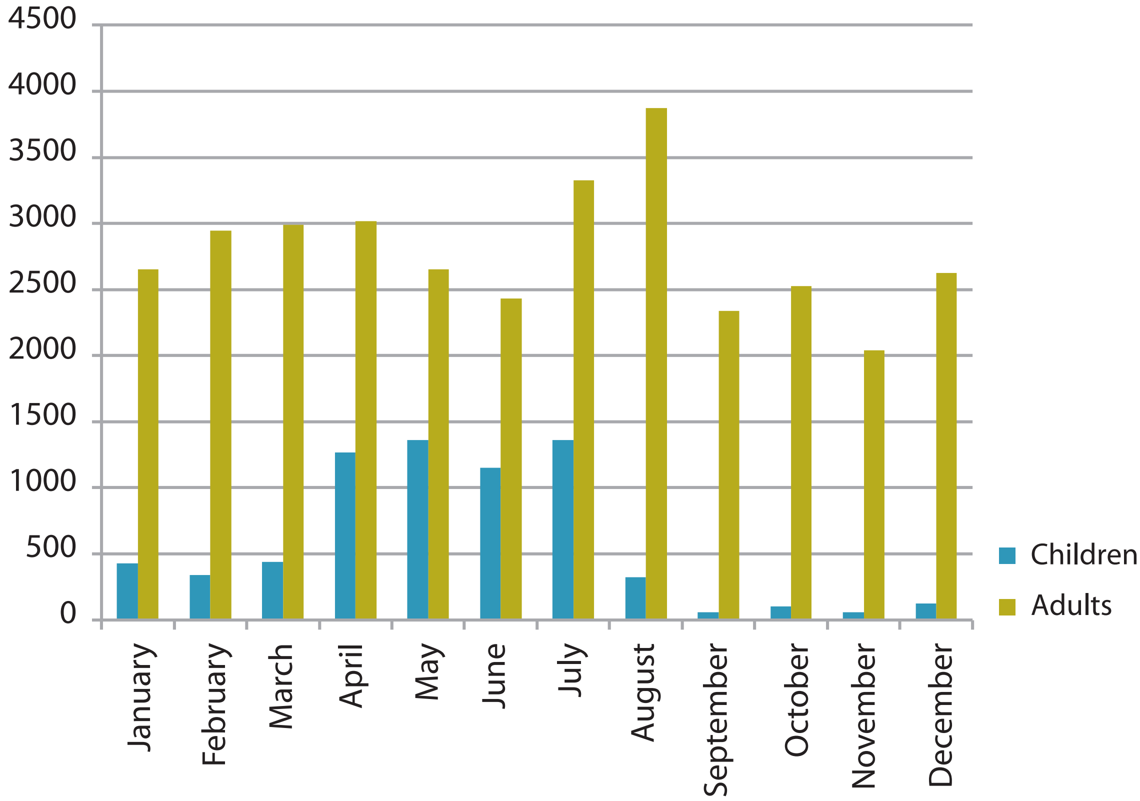

Figure 2. Arrival of national tourists in Galapagos during 2009: adults (over18 years old) and children between the ages of 10-12 years. Source: Official statistics of the Galapagos National Park, 2009.

of age) compared to foreign tourists, 25% of whom are over 60 years old. The monthly income of national tourists is much less than that of their foreign counterparts, which may explain the difference in time spent in the islands. Most national tourists stay on land (89%), while most foreign tourists travel aboard tour boats (72%). Of the national tourists who stay on land, 78% stay primarily in Santa Cruz. Only 66% of the foreign tourists who indicated they spent at least one night on land stay in Santa Cruz. Twenty-five percent of foreign visitors who spend nights on the inhabited islands have been to Isabela compared to only 15% of national tourists. San Cristóbal, although visited less often in general, attracts more foreign than national tourists. Also, foreign tourists in Galapagos participate in more international tourism, with 80% reporting that they had visited three or more foreign countries in the last three years, compared to 18% of Ecuadorian visitors.

Tour packages

The tour packages offered to Ecuadorian tourists by the five main operators are from three to four nights,

Table 1. General aspects of the profile of national and foreign tourists according to the most representative categories.

Profile of the tourist	National Tourist	Value (%)	Foreign Tourist	Value (%)
Most frequent age of respondents (mode)	21-30	29.6	Over 60 years	23.6
Most represented occupation	Professionals	17	Retired	17
Most frequent monthly salary (mode)	US$1000-2000	35	US$5001-10,000	21
Most frequent length of stay in the islands (mode)	Land	4 nights	Onboard tourist boat	6 nights
Most frequent type of lodging	Hotel	89	Onboard tourist boat	72
Most frequent number of nights on land (mode)	6 nights	92	4 nights	51
Island where the majority of the nights were spent	Santa Cruz 78%; San Cristóbal 4%; Isabela 15%; Floreana 3%		Santa Cruz 66%; San Cristóbal 5%; Isabela 25%; Floreana 3%	
Most frequently used internal transport	Taxi	21	Bus	33
Most frequent tourism outside Ecuador	Has visited 3 or more countries since 2007	18	Has visited 3 or more countries since 2007	80

Source: Geographic Footprint Project, interviews with tourists who were leaving the islands in the Baltra airport in April-May 2009 (national tourists, N=314; foreign tourists, N=598).

include visits to the same sites on Santa Cruz (Figure 3), and range from US$460 to US$750. Longer packages (more than five days) and packages that include other destinations (Isabela, Santa Fe, or Floreana, for example) are available, but they are generally too expensive for the majority of national tourists.

The common visitor sites for national tourists include several designated for "recreational use" (Las Grietas, Tortuga Bay, Garrapatero, etc.), private sites (El Chato and Primicias), and GNP visitor sites that are accessible by bus (Los Gemelos and the Charles Darwin Research Station). These sites are also frequented by international tourists and by the local population. In general national tourists do not visit the more pristine sites of Galapagos.

Locally-based tourism operations in Santa Cruz[1] make use of hotels, day tours, bay tours, restaurants, and discotheques, offering a product specifically targeted to Ecuadorian families and groups of school children.

[1] The hotels of Santa Cruz have been much more successful than those on other islands. Over time, Santa Cruz has become the economic and tourism center of the archipelago. Prior to organized tourism, Puerto Ayora had only two or three hotels of which Hotel Galapagos was the largest. In 1991, of the 26 hotels and 880 beds in the islands, 16 hotels and 492 beds (56% of the total capacity) were located in Santa Cruz. By 2006, the number of beds in Puerto Ayora had doubled to 990 (Epler, 2007).

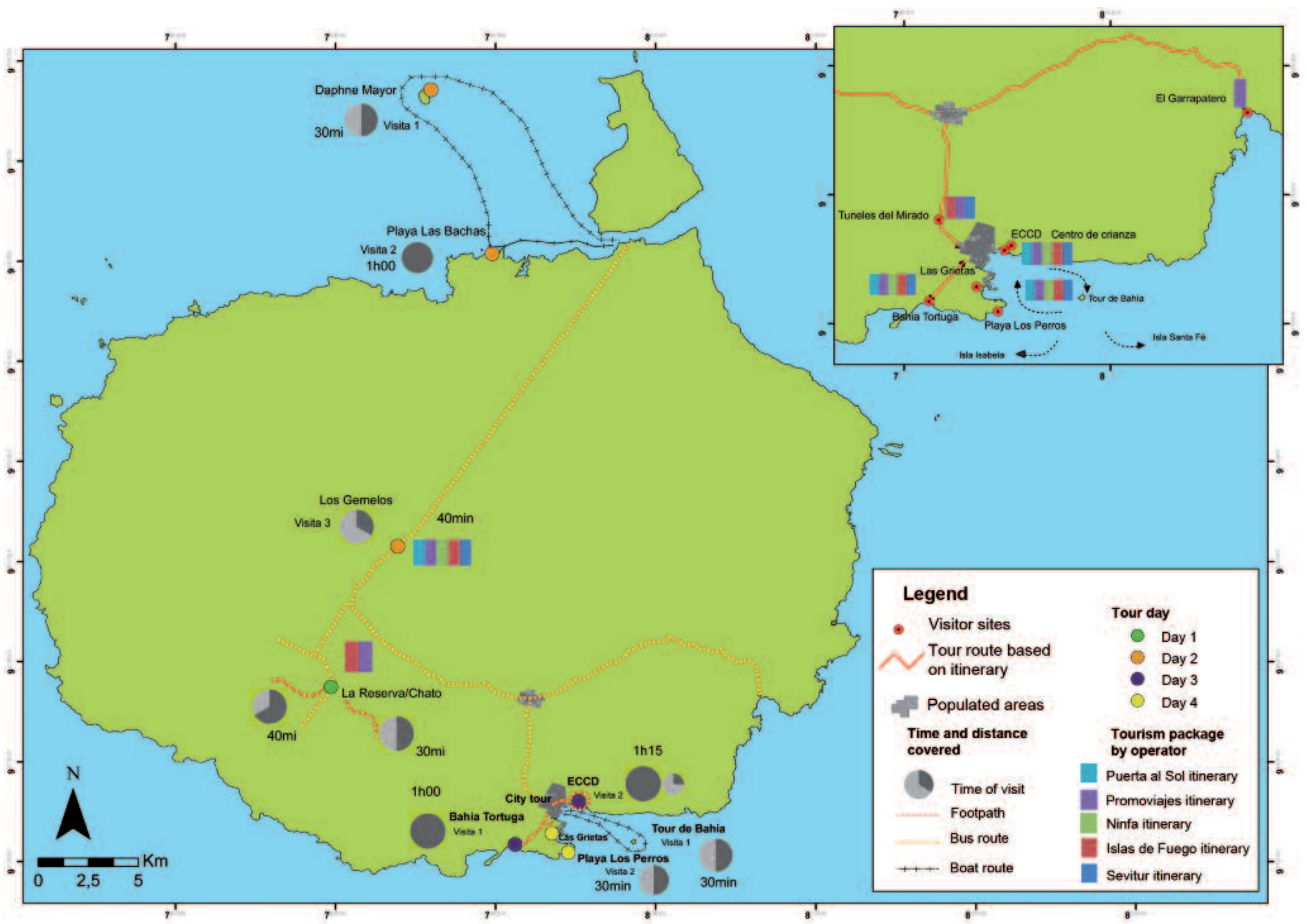

Figure 2. Visitor sites, itineraries, and length of tour in tour packages offered to national visitors in Santa Cruz.

The average income of national tourists visiting Galapagos is relatively high by Ecuadorian standards and tour operators have created a product that is suited to their economic profile. However, the relatively low cost of these packages limits the kind of activities and itineraries offered. Shorter itineraries make it difficult to observe the more natural and remote parts of Galapagos. This limited travel reduces their expectations and experiences in the islands and in part explains the consequences of this kind of tourism in the insular environment.

A responsible tourist?

The reasons tourists visit Galapagos determine their behavior in the islands and directly influence the way they interact with the environment. Asked about their principal reason for visiting Galapagos, 28% of national tourists responded "to experience the natural world of the archipelago," 25% indicated for "tourism and rest," and 17% "to know my country." This indicates that although 28% visit Galapagos to experience nature, most do not; national tourism in Galapagos tends to occur in a social environment among family and friends, predisposing the visitor to give less priority to learning about the natural history and conservation of the islands. Why, then, is Galapagos important to national tourists?

General behavior and reactions of national tourists were documented through direct observation at various visitor sites. Many demonstrated disinterest, lack of information about what they were experiencing, and made rapid visits to the site. During hikes, many paid more attention to taking photos with family members than photos of landscapes or animals, demonstrating greater interest recording social interactions than wildlife. However, their interactions with the environment do seem to have an impact. Some travelers commented, "Thanks to the guides I learned about recycling and am going to begin to adopt better conservation practices." It is possible that the visitors had not thought much about these practices prior to the visit, but in Galapagos they were required to follow them.

When national tourists were asked, "What are the most important criteria for tourism in Galapagos?" the

Photo 1. Group of national tourists walking to Las Grietas, Santa Cruz. Photo: C. Grenier.

most frequent responses were "low-impact tourism" and "a conservation conscience." They also indicated that comfort and international food were not important considerations. But these statements were contradicted by the observations of guides and other responses from the tourists, with 80% indicating that they preferred lodging with air conditioning and television. On a related note, Grenier (2008) indicated that the energy consumption of hotels increased 54% between 2006 and 2008.

When asked their opinions about various aspects of the towns of Galapagos, their perceptions of Puerto Ayora (where nearly 80% of Ecuadorians stay when in the islands) were generally positive. Safety within the city was the most appreciated factor, as it is for residents of Puerto Ayora, which reflects the importance, real or perceived, of violence and delinquency in day-to-day life on the mainland.

National tourists also have a positive opinion of the urban landscapes of Galapagos. However, national tourists, much like foreign tourists, don't really know Puerto Ayora beyond Charles Darwin Avenue (which runs along the coast) and adjacent streets, although they arrive in town via Baltra Avenue. The positive opinion that national tourists expressed for the urban landscape of Puerto Ayora could be interpreted as liking something that is familiar to them--their own urban landscapes on the continent.

Similarly, national tourists generally did not express negative opinions regarding human impacts at the visitor sites, such as pollution, noise, construction, or harassment of wildlife. The manner in which they visit Galapagos tends to keep them in an urban mindset, even when they are at a visitor site, with a large number of people (perhaps the only complaint of national tourists), cell phones with music playing during their walks, etc.

The image of the tourist

Tourism professionals in Galapagos were also surveyed to determine how they perceive national tourists. Fifty-four naturalist guides of the GNP participated in the survey (96% of respondents were Ecuadorian). Some of the questions focused on how national tourists perceive Galapagos. Nearly 40% responded "as a recreation site – sun and beach" (Table 2). According to these guides, the Ecuadorian tourist does not demonstrate much respect for nature or a conservationist culture, and few are interested in the scientific aspects of Galapagos.

When asked what activities most interest national tourists, the guides replied taking photos, swimming, and buying souvenirs, in that order. They also indicated that national visitors pay less attention to observing tortoises, birds, and marine species.

According to the guides, one of the important reasons for national tourists to visit Galapagos ("to know my country") helps to explain their behavior in the islands. One guide stated that "the sense of ownership results in specific behaviors in many national tourists. Since Galapagos is part of Ecuador, they feel that the islands belong to them and they can do as they please, including walking off designated paths and littering. There is a lack of respect for nature in the culture. They think that being Ecuadorian gives them the right to behave as they do in their city of origin."

According to guides interviewed, about 35% of national visitors are aware of the uniqueness of Galapagos as a destination but this awareness does not seem to influence their behavior. When asked if interests and reactions differed between national tourists and foreign tourists, 66% of the guides indicated that foreign visitors respect the National Park rules and are interested in conservation and scientific research; their level of knowledge about Galapagos is greater than national tourists and thus they have a great deal of interest in the nature of Galapagos. According to one local operator, "Ecuadorian tourists generally look for 'the good, the beautiful and the inexpensive.' They are demanding and complicated. They demand a lot and give little." Generally, operators fulfill the expectations of tourists with low cost products that have made Galapagos a popular destination for Ecuadorians rather than an exclusive one.

Table 2. Opinion of naturalist guides on how the national tourists perceive Galapagos.

How they perceive the Galapagos destination	%	No.
Scientific research laboratory	3.7	2
Unique place in the world	26.4	14
Place for recreation (sun and beach)	39.6	21
NA	30.2	17
Total	**100**	**54**

Conclusion

Recent growth in national tourism in Galapagos can be attributed to increased availability of all-inclusive tour packages designed specifically for the national market. While these products respond to the demands of this market, they provide limited opportunities to get to know the unique wildlife and landscapes of Galapagos.

The image national visitors develop about Galapagos during four nights and five days in Santa Cruz is skewed and incomplete. National tourists feel that tour operators meet their expectations, but this is because they do not have sufficient information about Galapagos prior to their trip.

The national tourist who comes to Galapagos does not demand much information from guides and does not appear to be particularly committed to the environment. They are motivated more by a desire to visit a special part of Ecuador, than to get to know the natural world of Galapagos.

The islands should be used as an instrument for environmental education for Ecuadorian nationals--especially considering that groups of Ecuadorian school children form one of the most important segments of the national market. Land-based tour packages should be designed in ways that foster learning and changes in the mindset among national visitors.

It is critical to better adapt this type of tourism to the insular environment. National tourists should know much more about Galapagos prior to their visit. This information should be taught in primary and secondary schools and shared through publications and advertisements that better reflect the archipelago's uniqueness.

A change in both vision and management is needed to improve national tourism in Galapagos. The product offered to nationals is low quality and does not promote environmental responsibility. Currently the product is not adequately regulated.

Photo: Jacintha Castora Photography

The construction sector of Puerto Ayora

Walter Jimbo[1] and Christophe Grenier[2,3]

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This is the first study to examine the construction sector of Puerto Ayora. It provides basic information about a cross-cutting activity that impacts the economy, immigration, and urban landscapes of Galapagos. The construction sector is one of the most economically dynamic sectors. It utilizes workers, who in many cases are illegal residents, and is rapidly transforming the urban landscape of Puerto Ayora, the largest city of Galapagos.

This article is based on research carried out between September and December 2009, as part of the Geographic Footprint Project of the Charles Darwin Foundation. The methodology included the creation of a map of the construction status of every lot or property in Puerto Ayora (based on the municipal property register), and 125 surveys with individuals involved in the construction sector (50 owners of houses under construction, 50 construction workers, and 25 owners of construction companies or individuals/companies contracted to supervise construction).

The map developed for the study shows a total of 2761 lots (Figure 1). The status of each lot was designated as: a) completed construction; b) construction in progress, or c) empty lot. Completed constructions include those with finished exterior and interior walls (plastered or painted), as well as those that still have unfinished walls but are inhabited and where no construction workers are present. Lots designated as "construction in progress" include those where construction workers and/or materials were observed on the lot. "Empty lots" include all those with no construction as well as some with evidence of abandoned construction.

This analysis focuses on:

1) The feasibility of promoting "ecological houses," and

2) The business aspects of the construction sector.

Ecological housing

Interviews asked residents what type of housing would have the least environmental impact in Galapagos and about the feasibility of promoting such construction. According to those surveyed, an "ecological" house is one that uses locally available materials and resources, renewable energy, and water recycling systems. In addition, ecological houses should have green areas with native flora.

Respondents generally believe that construction of this type of house would be more expensive than a traditional house in Galapagos. A person currently directing an ecological building project in the village of Bellavista responded that constructing a house with water recycling and solar power systems and material other than cinder blocks and cement costs at least 40% more than building a conventional home. Such costs would be beyond the means of many residents, especially those who build their

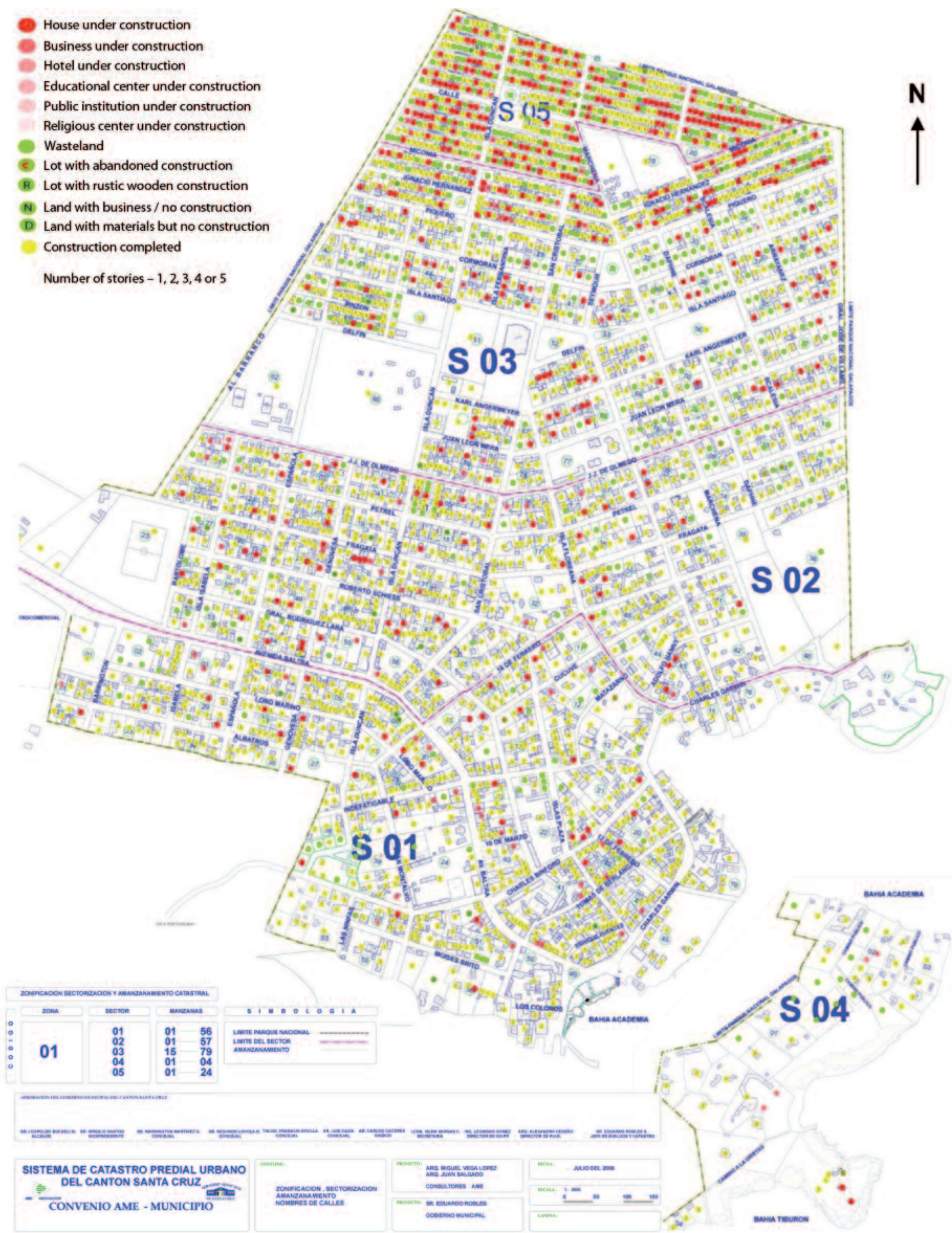

Figure 1. The construction situation in Puerto Ayora in October 2009, with 1871 properties with completed construction (yellow), 491 with construction underway (red), and 399 empty properties (green).

houses in stages determined by their own income flow. Another problem is that many landowners are building not only for themselves but also often for their relatives, or to have additional spaces to rent or establish a small business, all of which increases their basic costs.

For the most part, construction materials used in Galapagos are the same as those used on the continent: cinder blocks, iron rebar, cement, sand, and gravel. One variation in Galapagos is the use of volcanic rock extracted from the substrate at construction sites. This is often used to level the ground or to build small walls around the borders of a property. In some sites the use of illegally-harvested native wood was observed. In general, Galapagos construction does not reflect any particular consideration of environmental factors or the natural environment.

The study showed that most architectural designs used in Galapagos are not developed specifically for the insular environment. Building designs generally come from: a) generic plans offered by the municipality; b) styles associated with the owner's native city or town, or c) based on the family's income and cash flow (Table 1).

Table 1. How a customer selects their house plan.

Method	No.
Plan from the municipality	6
Model common in native town/city	6
In accordance with immediate needs	4
Architect's plan	4
Model from other country/place	2
In accordance with material of the site	1
In accordance with commercial activity	1
Unknown	2
Total	**26**

Source: Survey of property owners with current construction, September 2009.

Housing designs based on models from the continent require the use of similar building materials. In no case were Galapagos environmental considerations evident in the building plans. Plans offered by the municipality do not provide any options in terms of construction material, water storage, energy use, etc. A visit to "La Cascada" neighborhood of Puerto Ayora demonstrates the result of the broad use of plans offered by the municipality in early 2000, costing only $60 each (Photo 1).

The financial situation of a landowner's family plays an important role in influencing the construction process. Many of the newer neighborhoods in Galapagos appear similar to neighborhoods surrounding Quito or other cities on the continent, where houses are half built, walls have not been plastered, windows have not been fitted with glass or other materials, and construction projects have been abandoned. In these neighborhoods, landowners construct their houses in stages as they accumulate

Photo 1. La Cascada neighborhood in Puerto Ayora. Photo: W. Jimbo.

the money needed to continue. This makes it difficult to build "ecologically", which in addition to being more expensive requires pre-construction planning and investments.

The economic dynamics of the construction sector

The second part of the analysis focused on the business side of the construction sector, involving workers, contractors, and distributors of construction materials. The actual number of construction workers is not known, but of those surveyed 13 arrived in Galapagos during 2009, five of whom were under age

Of the 50 workers surveyed, only two are originally from Galapagos. The others are immigrants, mostly from the highlands of Ecuador (Table 3). It appears that construction is dominated by immigrants from continental Ecuador who arrive to fill jobs not taken by Galapagos residents.

Table 2. Year of arrival in Galapagos of construction workers.

Year	No.
Prior to 1990	3
1990 - 1998	7
1999 - 2008	25
2009	13
NA	2
Total	**50**

Source: Survey of construction workers, September 2009.

Table 3. Province of origin of construction workers.

Province	No.
Chimborazo	6
El Oro	2
Esmeraldas	1
Guayas	7
Imbabura	3
Loja	1
Manabí	1
Galápagos	2
Pichincha	1
Tungurahua	26
Total	**50**

Source: Survey of construction workers, September 2009.

The fact that the majority (28) of those surveyed are younger than 25 years old contributes further to the idea that construction contributes to immigration (Table 4). Prior to arriving in Galapagos, eleven of the construction workers surveyed were students (Table 5). Some suspended their studies to travel to Galapagos to work in construction. Others managed to stay and obtain their permanent residence in Galapagos and are continuing their studies in Santa Cruz.

Table 4. Age of construction workers.

Age (years)	No.
< 18	5
18 - 20	15
21- 30	15
31- 40	10
> 40	5
Total	**50**

Source: Survey of construction workers, September 2009.

Table 5. Previous occupation of the construction workers..

Occupation	No.
Student	11
Artisan, business	6
Construction	6
Boat crew	5
Occupations related to construction	4
Dressmaker, shoemaker	4
Restaurant, cooking	3
Agriculture, fish culture	3
None	1
NA	7
Total	**50**

Source: Survey of construction workers, September 2009.

To be legally contracted for work in Galapagos, a person must have permanent residence in the islands. However, any visitor may remain in Galapagos for up to three months and many individuals take advantage of this time to work illegally. This is fairly easy because employers generally care little about their employees' residency status (Table 6) and there is little risk for those who arrive as visitors and then work for three-months. Of the 13 recently-arrived construction workers, at least four plan to leave before the three month period is up; the others plan to stay as long as their irregular status is not discovered or as long as they have work.

Table 6. Requirements requested of construction workers by contractors.

Requirements	No.
Knowledge	6
References	1
Permanent residence and other (experience, police record, title, etc.)	6
Work with others known to the employer	1
None	3
NA	4
Total	**21**

Source: Survey of construction workers, September 2009.

A second group within the construction sector is comprised of contractors, architects, civil engineers, and construction supervisors who hire construction workers according to the number of projects they have. Only six of the 21 contractors surveyed indicated that they require workers to present proof of residency.

The 21 contractors surveyed accounted for an economic flow in Galapagos of US$2,663,200 in 2009 (three of the contractors accounted for 79% of this amount) and employed a total of 162 construction workers, in addition to plumbers, carpenters, and electricians. They reported that their profits varied between 10-15% of a given contract.

There are three large cement distributors involved in the construction sector. While it was very difficult to obtain data, two of the businesses are known to belong to the same owner. The distributors reported selling approximately 2000 quintals (each quintal contains 100 kg) per month. There are other businesses involved in construction, including one that sells paving stones produced in the island's quarry, located off the road to Baltra, where sand and gravel are extracted. These businesses are privately owned.

Conclusion

Santa Cruz is comprised of two clearly-delineated areas: the national park and the urban and rural inhabited zones. Adequate construction alternatives have not been developed to lessen the impact of increased levels of construction on the island's natural environment and landscapes (Photo 2).

Photo 2. Destruction of the natural landscape in the last preserved neighborhood of Puerto Ayora, "Barrio Estrada": construction of a house and a hotel. Photo: C. Grenier.

This study shows that the construction sector involves various actors with personal interests and needs, and complex social interactions among landowners, contractors, migrant workers, and related businesses. Improving the current situation requires strict legislation and mechanisms that will require landowners to construct more environmentally-friendly houses, using more appropriate materials and improved systems for water management and energy.

Little can be done in terms of the existing construction in Puerto Ayora. However, environmentally friendly alternatives should be used for future urbanization projects such as "El Mirador." This new residential area, which is comprised of 1000 lots (total area of 630,000 m^2) would benefit greatly from a more ecological approach towards housing.

Recommendations

Construction regulations are urgently needed in Galapagos and should be developed jointly by the GNP, local municipalities, and residents. Once regulations are in place, the government could require the use of alternative materials, such as lava rock or lumber from introduced tree species.

The construction of potable water and sewer systems are also urgently needed. The sewer system should not release waste water into the ocean, as this causes additional environmental problems.

Education campaigns are needed to create awareness among residents about the need for new architectural designs that could be considered "authentically galapagueño." Construction of housing that uses alternative energy should be promoted. In addition an evaluation of the possibility of creating a better system for collecting rainwater and for the reuse of waste water should be completed.

Construction workers should be required to form a local guild in order to better control the labor supply. The Chamber of Construction must work to regulate the sector and require designs and construction materials that have a lower impact on the environment.

Regulations and incentives should be extended beyond housing construction to avoid the construction of ecologically unfriendly buildings, such as the new bank and the five-story hotel on Baltra Avenue, both of which are completely inconsistent with the local environment.

Photo: Christophe Grenier

A geographic index to measure the carrying capacity for tourism in the populated centers of Galapagos

Christophe Grenier

Charles Darwin Foundation

Tourism is the driver of the Galapagos economy (Epler, 2007) and consequently of the constant increase in all kinds of flows between the archipelago and the rest of the world. This "geographic opening" of Galapagos (see Grenier, this publication) has negative consequences for the conservation and sustainable development of the archipelago. This article presents the principal results of the Geographic Footprint Index[1] (GFI), a technical tool designed to measure impacts of tourism in the populated areas of Galapagos (Grenier, 2008). Spatial, environmental, and "medial" impacts are discussed. Medial impacts describe the relationship between a society and its surroundings (space and nature).

Methods

An index provides a single number that characterizes a given situation, with the first calculation providing a baseline (reference time or place) that can be compared with future indices to evaluate trends over time. In this case, the GFI is constructed from 121 indicators of impact caused by various social actors connected to tourism at a given time (early 2008) and in a given place (rural and urban populated centers of Galapagos).

The data used to construct 114 of the 121 indicators were collected through surveys completed in December 2007 and January 2008 in all of the populated centers of Galapagos (except Floreana), in proportion to the population and the number of tourism businesses

[1] Geo-graphic is, literally, the science of the study of the footprints or tracks (« graphic ») that human activity leaves on the surface of the Earth (« Geo »).

in each area (Table 1). These 114 indicators or variables, numbered V1 to V114 are presented within five categories: (i) level and type of tourism; (ii) tourism area; (iii) energy and transportation; (iv) environmental impact; and (v) medial impact (Table 2).

Table 1. Number of surveys completed by group and location.

Site	General Population	Guides	Hotels	Tourist Shops	Travel Agencies	Tourists
Puerto Ayora	55	60	29	13	15	0
Rural Santa Cruz	12	0	3	1	0	0
Puerto Baquerizo	30	0	20	9	8	0
Rural San Cristóbal	4	0	2	0	0	0
Puerto Villamil	15	0	12	1	2	0
Rural Isabela	4	0	1	0	0	0
Baltra	0	0	0	5	0	1000
TOTAL	**120**	**60**	**67**	**29**	**25**	**1000**

The seven additional indicators, designated VA to VG, were constructed from available official statistics[2]. As with the numbered indicators, the lettered indicators are found under the appropriate category: VA under (i) level and type of tourism; VB to VE under (iii) energy and transportation, and VF and VG under (iv) environmental impact.

To construct the GFI, each indicator expresses human impacts using a numerical value (percentage, average, etc.). For example, the variable V1 is the average number of days a tourist spends in Galapagos, which is currently 6.6 days. Therefore the value of V1 is 6.6 (Table 1). The value of variable V2, which indicates that 60% of tourists surveyed spent nights only on boats, is thus 60, etc. In some cases, the average value is calculated with numbers between 1 and 5, when those surveyed were asked to classify their own responses from 1 (very important or positive) to 5 (not at all important or very negative). For example, when guides were asked their opinion regarding the interest of tourists in learning about nature (V11) using a number between 1 (high interest) and 5 (no interest), their responses averaged 2.6, which is then the value for V11.

Once the value is determined, each variable is given a grade that demonstrates the intensity of the impact, with 1 corresponding to the least impact and 5 the greatest. This grade is designated by the manager of the GFI and must be justified (for greater detail on the justification of the grades, see Grenier, 2008). For example, if it is desirable to increase the time spent in Galapagos, a grade of "4" is given to V1 because the average length of stay of 6.6 days is considered insufficient. In some cases, a grade between 1 and 5 is given directly by those surveyed, as it is the numerical value of the variable (as for V11).

To limit subjectivity in the construction of the GFI, each variable was given equal importance. The scale describes the depth of the geographic footprint for each variable, from 1 (least impact) to 5 (greatest impact). The sum of the 121 grades with values between 1 and 5 is the Geographical Footprint Index for tourism in the populated areas of Galapagos in January 2008 (Table 2). This value expresses the depth of the geographic footprint: the greater the value, the deeper the footprint and the greater the impact.

[2] GNPS, PETROCOMERCIAL, Empresa Eléctrica Galápagos, Unidad de Gestión Ambiental del Municipio de Santa Cruz, Galapagos Report 2006-2007.

Table 2. Geographic Footprint Index for tourism in the populated centers of Galapagos.

Groups of Indicators	Actors	Variable N°	Variable	Value	Grade
1) Level and type of tourism	Official statistic	A	% increase in tourism in Galapagos 2000-2006	51	5
	Tourists	1	Average number of nights in Galapagos	6.6	4
		2	% staying only on boats	60	4
		3	Average number nights spent only onboard	6.2	4
		4	Average number of nights spent only in a hotel	4	4
		5	Average number of nights spent in a hotel	3.7	4
		6	% who wished to stay additional days	64	2
		7	% with monthly earnings > US$10 000	28	3
	General population	8	% who want longer tourism visits	58	3
	Guides	9	% who prefer boats with < 16 passengers	47	3
		10	% who want longer tourism visits	68	2
		11	Opinion on tourists' interest in learning about nature	2.6	2.6
		12	Opinion on the change in the level of tourists' interest in learning about nature	2.9	2.9
		13	Opinion on tourists' interest in conservation	2.5	2.5
		14	Opinion on the change in the level of tourists' interest in learning about conservation	2.4	2.4
		15	Opinion on the interest of tourists in the towns	2.8	2.8
		16	Opinion on the change in the level of interest of tourists in the towns	2.4	2.4
		17	Opinion on tourists' need for comfort	2.7	2.7
		18	Opinion on the change in tourists' need for comfort	4.1	4.1
		19	Opinion on tourists' concern for safety	2.6	2.6
		20	Opinion on the change in tourists' concern for safety	4	4
	Hotels	21	Average number of beds	34	4
		22	Current average level of occupation (%)	45	4
		24	% with more clients than 3 years ago	54	3
		25	% with plans to increase capacity	60	5
		26	% with no knowledge of ecotourism	61	4
		27	% who want to limit the number of tourists	52	3
		28	% who want longer tourist visits	67	2
	Agencies and operators	29	% with more clients than 3 years ago	71	4
		30	% with no knowledge of ecotourism	40	3
		31	% who want to limit the number of tourists	37.5	4
		32	% who want longer tourist visits	66	2
	Tourism shops	33	% who want longer tourist visits	75	2
2) Tourism areas	Tourists	34	% of total nights in Galapagos spent in Puerto Ayora	68.7	4
		35	Opinion on pollution at visitor sites[3]	1.5	1.5
		36	Opinion on noise at visitor sites	1.4	1.4
		37	Opinion on construction at visitor sites	1.8	1.8
		38	Opinion on the number of people at visitor sites	1.9	1.9
		39	Opinion on the disturbance of wildlife at visitor sites	1.7	1.7

[3] Visitor sites mentioned here are those located close to the towns, designated for tourism-recreational use.

2) Tourism areas	General population	40	Opinion on pollution at recreational sites	2.2	2.2
		41	Opinion on noise at recreational sites	1.9	1.9
		42	Opinion on the number of residents at recreational sites	3.6	3.6
		43	Opinion on the number of tourists at recreational sites	2.9	2.9
3) Energy and mobility	Official statistic	B	% increase in gasoline consumption 2000-2007	45	5
		C	% increase in motorized vehicles 2001-2006	54	5
		D	% increase in flights to Galapagos 2001-2006	193	5
		E	% increase in electricity consumption 2000-2006	43	5
	Tourists	44	% who take the bus	79	2
		45	% who take a taxi	62	4
		46	Opinion on vehicle traffic in the towns	2.3	2.3
		47	Favor use of renewable energy	1.5	1.5
		48	Favor a reduction in traffic	2.2	2.2
	General population	49	% transport house-to-work by foot, bicycle, bus	56	3
		50	% who believe that traffic has increased	93	5
		51	% who own a car	15	3
		52	% who own a motorcycle	26	3
		53	% who use taxis several times per week	68	4
		54	% who travel to the continent 1 or more times per year	82	3
		55	% of monthly earnings spent on transportation	12	3
		56	Opinion on the amount of transportation continent-Galapagos	3.1	3.1
		57	% who use renewable energy	0	5
		58	% who use energy saving lights	68	2
		59	Average number of TVs per house	1.7	4
		60	% with domestic comforts: microwave, dryer, etc.	55	5
		61	Average number of air conditioners per house	0.1	1
		62	Opinion on traffic	4	4
	Hotels	63	% with a bus or pickup truck	22	3
		64	% who use energy saving lights	73	2
		65	Average number of TVs per hotel	7.5	5
		66	Average number of freezers per hotel	2	3
		67	Average number of air conditioners per hotel	7.3	5
		68	Average monthly costs for electricity ($)	320	3
		69	Average number of gas cylinders per months	11	3
		70	% increase in energy consumption in last 3 years	54	5
		71	% who do not use renewable energy	88	5
		72	% with no plans to invest in renewable energy	73	4
	Agencies and operators	73	% with bus or pickup truck	32	3
		74	% with speed launch	48	3
		75	% with boat	48	3
		76	Average horsepower of launch motors	224	5
		77	Average monthly fuel consumption (gallons)	1550	5
		78	% increase ave. energy consumption in last 3 years	63	5
	Tourism shops	79	% with no air conditioning	82	1

4) Environmental impact	Official statistic	F	% increase in waste in Santa Cruz 2000-2006	93	5
		G	% increase in introduced plants 2000-2006	39	5
	Tourists	80	Opinion on pollution in the towns	2.3	2.3
	General population	81	% who believe there is more pollution	91	5
		82	Opinion on whether tourism is responsible for pollution	3.1	3.1
		83	% who say they separate their garbage	74	2
		84	% who believe that their sewage pollutes	94	5
		85	% who use tanks to collect rainwater	21	4
		86	% who believe that the quality of tap water is inadequate	23	2
		87	Opinion on pollution in urban zones	4	4
	Hotels	88	% with no plans to invest in water conservation	71	4
		89	% who believe their sewage pollutes	70	4
		90	% who say they separate their garbage	74	2
		91	% who use fruits and vegetables from continent	96	5
5) Medial impact	Tourists	92	Opinion on urban landscapes	2.6	2.6
		93	Opinion on presence of native wildlife	2.3	2.3
		94	Opinion on tranquility	2.3	2.3
		95	Desire to limit urban growth	1.9	1.9
		96	Desire to improve urban zoning	1.9	1.9
		97	Favor use of lava rock in construction	2.2	2.2
		98	Want towns to favor native flora and fauna	1.3	1.3
	General population	99	Opinion on responsibility of tourism in more construction	2.9	3
		100	Opinion on tranquility	3.0	3.0
		101	Opinion on the number of people	3.9	3.9
		102	Opinion on landscaping	2.7	2.7
		103	Opinion on urban zoning	3.1	3.1
		104	% believe that the Galapagos lifestyle is like that on the continent	53	5
		105	% believe that it is good that Galapagos is like the continent	40	5
		106	% believe that nature makes Galapagos towns unique	86.5	1
		107	% who see fewer native animals in towns	69	4
	Hotels	108	Average size of structures (m^2)	576	3
		109	Average number of floors	2	3
		110	% that do not favor native/endemic plants	79	4
		111	% that do not use lava rock in construction	56	3
	Tourist shops	112	Average size of structures (m^2)	60.2	3
		113	Average number of floors	1	3
		114	% that do not use lava rock in construction	96	5
			GEOGRAPHIC FOOTPRINT JANUARY 2008		**394.6**
			Average value		3.29
			121 variables (114 V + 7 Official Statistics)		
			Theoretical maximum footprint (121 x 5)		605
			Theoretical minimum footprint (121 x 1)		121
			Average footprint		**363**
			Difference Geographic Footprint/ave. footprint		**+ 8.7 %**

Level and type of tourism

The results from this group of indicators confirm that tourism is undergoing sustained growth (VA, V24, and V29). Although the majority of tourists surveyed stayed only on boats (V2), there is ample evidence that land-based tourism is continuing to grow. Sixty percent of hotels plan to increase their capacity, which is surprising given that the average number of beds per hotel is high (V21) and the level of occupancy is less than 50% (V22).

The current tourism model in Galapagos is based on a rapid turnover of clients. The stays are short (V3, V4, and V5), which does not provide a firm foundation for the terrestrial tourism sector. For that reason, terrestrial tourism operators prefer tourists to stay longer, even though there may be fewer tourists (V28, V32, and V33). More than half of local residents (V8) and tourists (V6) surveyed would prefer longer stays. This shared desire could favor the implementation of ecotourism in Galapagos, although this term is little understood (V26 and V30). The lack of understanding of ecotourism, according to the guides, may result from today's tourists having less interest than previous tourists in learning about nature (V12) and greater concern for comfort (V18) and safety issues (V20)[4] .

Tourism areas

Sixty-nine percent of all tourist nights spent on land are concentrated in Puerto Ayora, the largest city of the archipelago with around 50% of the population. This high level limits opportunity for other towns and results in significant impacts in Puerto Ayora. However, the opinions of both tourists (V35-39) and residents (V40-43) concerning the visitor/recreational sites close to towns are generally positive, although there is a growing perception that these areas are going beyond their carrying capacity (V42).

Energy and mobility

In Galapagos, both tourism and the local lifestyle depend on a growing use of fuel (VB and VE; electricity is produced primarily by diesel generators). This is a result of the continual growth in tourism, but also due to the increased mobility of tourists and residents, as well as the speed of travel.

Increased mobility has an obvious environmental impact, but also consequences for the general milieu of Galapagos, as it modifies the relationship between tourists and residents with their surroundings. For example, the increase in the number of motorized vehicles (VC) and their increased use in the population (V50-V53) indicate a lifestyle that is more and more like that on the continent. Although tourists consider the traffic level acceptable (V46), probably because it is less congested than where they live, they also believe that it should be reduced (V48). Residents believe that the traffic situation is bad (V62) and that the growth in tourism is partially responsible for it.

The increase in traffic reflects the extension of the area used by residents on a daily basis, most notably in Santa Cruz where a growing portion of the population lives in the highlands but works in Puerto Ayora. This expansion of the populated area explains the growing expenditures of residents on transportation (V55).

The high mobility associated with tourism in Galapagos affects the entire insular society and contributes to greater "continentalization" and the desire of residents to leave the islands from time to time. A large majority of residents travels to the continent at least once each year (V54) and considers the number of available flights as "average" (V56).

This mobility, based on rapid transportation, can also be seen in ever-increasing horsepower of launches (Photo 1), the major method of inter-island transportation (V76), as well as the high monthly fuel consumption of tourism operators (V77) and the huge increase in energy use in recent years (V78). All of these factors result in negative environmental and medial impacts that degrade the tourism experience.

Indicators for energy use in the hotels (V66-V72) and by the population (V57-V61) are poor. For example, the use of renewable energy is 0% in the population and only 12% in hotels. It is also of concern that hotel owners have no plans to invest in renewable energy (V72), even when it is important to tourists that renewable energy be used in Galapagos (V47). At the same time, energy use by hotels has increased

[4] The grades given to these variables (V11 to V20) are based on interviews with guides. For example, when a guide states that the interest of tourists in learning about nature has diminished, the variable is given a low grade (more than 3) because it signifies that the medial impact (the relationship with the environment) is negative. The average grade for this group is 2.9.

dramatically in recent years (V70). The use of air conditioners in hotels (V67) is a good indicator of energy use. Even hotels considered "lower class" have invested in air conditioners as a symbol of achieving "international standards."

Photo 1. Ephemeral but harmful geographic footprint. Photo: C. Grenier.

Environmental impact

An increase of 93% in garbage (VF) and 39% in the number of introduced plants between 2000 and 2006 (VG) are of great concern for the sustainability of life in the islands as well as the conservation of the archipelago. An indicator of the relationship between tourism and introduced species is that 96% of hotels and restaurants in Galapagos import their organic food from the continent (V91).

The garbage problem is primarily due to the increase in the production of waste (VF) rather than a lack of effort by residents and businesses to recycle solid waste (V83 and V90). The general view of water pollution is very negative, both on the part of residents (V81 and V84) as well as hotel owners (V89), but there is little appreciation of the need to conserve the water resource (V85 and V88).

Medial impact

The dominant geographic milieu in Galapagos, that is the relationship between a society and its surroundings, is "continental" in nature, with a mix of habits and behaviors that originate in other parts of Ecuador and the world. An indicator of the loss of a Galapagos geographic milieu is the decrease in the number of native

Photo 2. The Miguel Cifuentes Center in Puerto Ayora, an example of architecture with lava rock. Photo: C. Grenier.

Photo 3. Visitors at the Tintoreras visitor site, Isabela. Photo: Christophe Grenier

animals in the towns, especially lava lizards, marine iguanas, and finches.

The continentalization of the insular milieu signifies less space and greater disturbances for the native wildlife, even though its presence in the towns is a great tourist attraction, according to tourists (V97) as well as residents (V106).

Tourists believe that it is important to limit urban growth, improve urban zoning, encourage the presence of native species in the towns, and use lava rock in construction to achieve a greater integration between landscaping and the environment (V95-98). Hotel owners, however, show no interest for the latter two measures (V110-111). The case of lava rock illustrates the lack of general awareness of the importance of the integration of landscaping for ecotourism, even though there are buildings in the islands that demonstrate that local materials can be successfully used with both modern and functional architecture. Key examples include the Miguel Cifuentes Center in Puerto Ayora (Photo 2), the tourist dock in Puerto Villamil, and the Interpretation Center in Puerto Baquerizo Moreno.

The majority of residents believe that the lifestyle in Galapagos is increasingly similar to that of the continent (V104). Of even more concern is that for many of these individuals, this is a good thing (V105). This continentalization undermines the conservation of the archipelago as well as the sustainability of an island society and its principal activity – tourism.

Conclusion

According to the GF indicators, the current geographical footprint of tourism in the populated areas of Galapagos is too deep, given that the index is 8.7% above the average. Even more worrying is that many of the indicators show that the trend in tourism in the populated areas is undergoing continual growth.

All tourism has impacts, but even more so in an ecosystem that was originally isolated from the rest of the world, as was Galapagos. This is especially true when you continue to increase the geographic opening of such an area through immigration, investment, biological invasion, and importation. The challenge is huge: it involves finding a tourism model that will leave the lightest footprint possible. This ecotourism model must be sold on the worldwide market and it must be the uniqueness of Galapagos that defines what is offered. This will result in a demand based on a light geographic footprint in the populated areas.

Photo: Jacintha Castora Photography

Economic dynamics and the workforce of Galapagos

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The conservation challenges in Galapagos are directly tied to human activity and the Galapagos economy. This article analyses the dynamics of the Galapagos workforce as an important component of the insular economy.

The various employment sectors can have both positive and negative impacts on the Galapagos environment. Tourism, with potential to be environmentally friendly, creates problems due to lack of regulation and its impact on immigration. Both fisheries and agriculture have, in the past, been considered two of the main sectors with a direct relationship to conservation in Galapagos. While fisheries has been generally considered to have a negative impact (due primarily to overfishing and illegal fishing), agriculture was seen as having a more positive impact (agriculture production decreases the need for imports from the continent and well-maintained farms reduce the expansion of invasive introduced species).

While it is generally understood that tourism is the primary driver in the Galapagos economy, this article will show that the public sector plays an important role as an employer and must be considered in long-term planning for Galapagos. A review of the last census (2006) indicates that employment in agriculture, fisheries, and construction has been underestimated (INEC, 2006).

This article is based on census reports, which due to differences among the census methodologies pose challenges when trying to determine trends over time. Not all of the censuses are available in digital form and the physical documents are difficult to access. The 2006 census was carried out only in Galapagos, making it impossible to make comparisons with national trends. Also, in the most recent

[1] Diana Hinojosa also collaborated in this work.

census, various changes in methodology were introduced, making it difficult to compare across censuses. Even so, the analysis of this data does reveal various trends in the Galapagos workforce.

Work in Galapagos

The 2006 census highlights the importance of the service sector, which represents 67% of total employment (Figure 1). In primary production, there are two main subsectors: agriculture, which is quite small, and fisheries, which employs a significant percentage of the population (6.7% of Galapagos residents versus 1.4% of Ecuadorians on the national level; Figure 2).

Analyzing the distribution of employment in Galapagos over time, we found that the service sector has grown considerably. In 1962, this sector represented less than 25% of employment (less than half of its current relative weight). The commercial sector has also undergone a major expansion from 2% of all employment in 1962 to 9% in 2006. During this same period, employment in the primary production sector appears to have declined. In 1962, fisheries and agriculture were combined in a single category, employing 58% of the population (Junta Nacional de Planificación, 1962). However, in the 2006 census, they represent less than 12%. In fact, the 2006 census shows 268 fewer fishermen than in 2001.

The invisible workforce

When comparing 2001 and 2006 data it is important to remember that the 2006 Census excluded individuals without resident status. This fact likely explains the 0.03% annual growth in workers between 2001 and 2006 (only 14 workers were apparently added to the workforce), compared to the 6% annual increase seen in the previous decade. It is likely that many workers with "irregular" residency status—a group that plays an important role in the archipelago's economy—participated in key sectors such as agriculture, fisheries, and construction, all of which showed declines in the 2006 Census. This suggests that the apparent decline in fishermen and other areas may in fact be untrue.

Tourism, transportation, international organizations, and the public sector

The tourism sector, an important part of the local economy, employed 4.9% of the workforce in 2001 and 6.8% in 2006—more than double the national average. Work in this sector has grown rapidly: 6% per year in the last five years and nearly 10% per year in the previous decade. These figures confirm that the tourism sector plays an important role in the human dynamics of Galapagos and suggests that its impacts on conservation require mitigation.

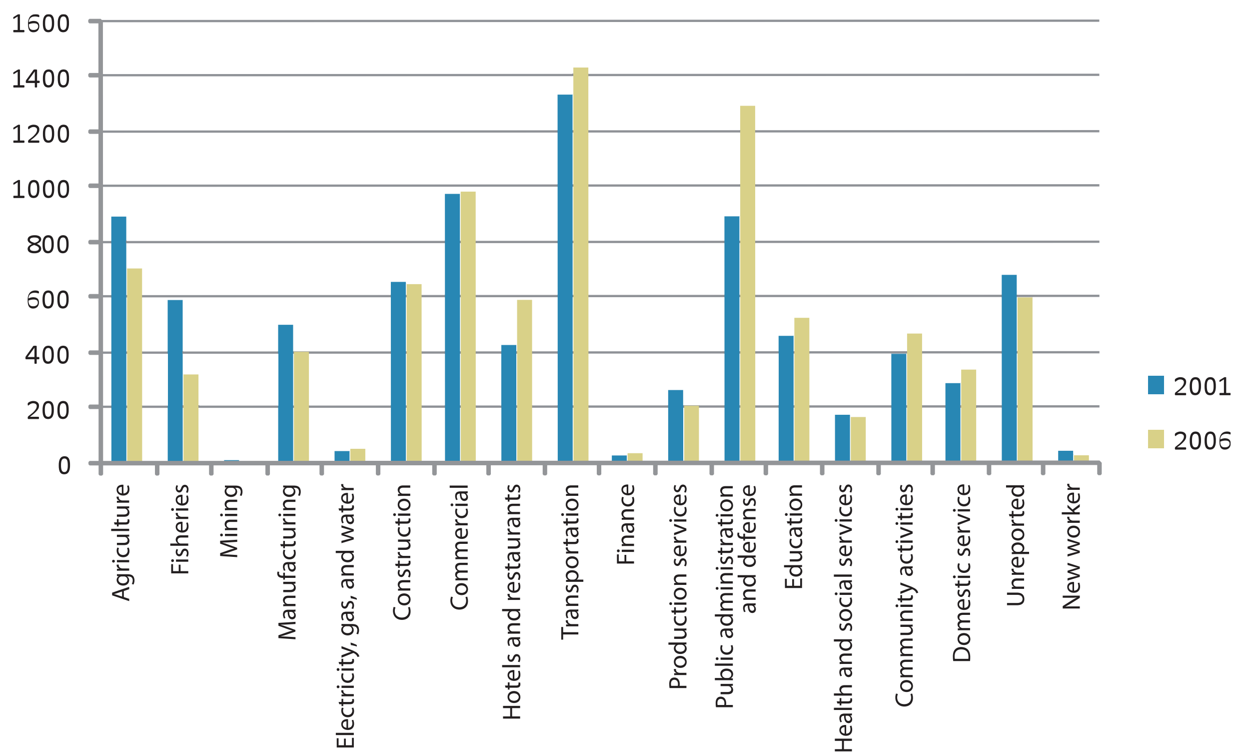


Figure 1. Change in the number of workers in each field in Galapagos from 2001 to 2006. Source: INEC, 2001 and 2006.

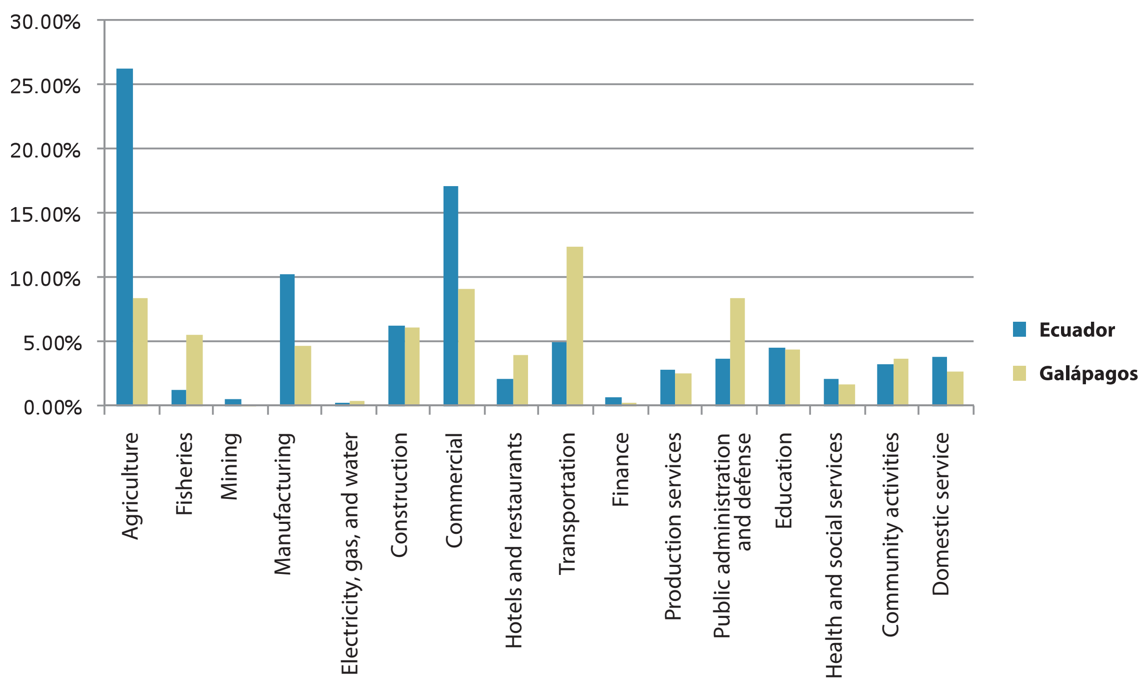


Figure 2. Distribution of the Economically Active Population (PEA) by sector in Galapagos and Ecuador, 2001. Source: INEC, 2001.

While the tourism-related sector of restaurants and hotels shows growth, it is not where the majority of change is taking place. There are other sectors that merit attention. Transportation is the largest employer (16% of the workforce in 2006 and 15% in 2001, compared to only 5% of the national workforce). Transportation has grown to represent an important part of the economy, and has significant implications for the conservation of Galapagos ecosystems (Watkins and Marin, 2008).

The sector showing the greatest employment growth is the public sector (Watkins and Marin, 2008). Between 2001 and 2006, the public sector increased to 14% of the workforce (10.3% in 2001), with an average annual increase of 4.5%. The level of public sector employment in Galapagos is more than three times the national average.

It is clear that the economic dynamics of the islands are strongly linked to the size and nature of the public sector, which in terms of employment is more dynamic than either tourism or transportation. Attention must be paid to the environmental impact and ecological footprint of the public sector, just as it is to the tourism and fisheries sectors.

International organizations are another important sub sector, which employs nearly 6% of the Galapagos workforce. This sub sector did not appear in censuses prior to 1990 and in that year it included only three people. However, it increased to 732 workers in 2001. Combined, state agencies and municipalities employ 23% of the workforce[2]. If we then add the international organizations, this percentage increases to 29%. This group represents the most important sector in terms of employment. Given its size and growth, it clearly plays a central factor in both the economy and the social fabric of the province.

Thus far this review has focused on relative employment offered by different sectors. However it is important to consider other factors, such as the relationship between different kinds of employment and the professional profile required for that activity. Positions that offer higher, more stable salaries are concentrated in administrative positions in the public and services sectors, such as banking.

Governmental service, such as education and community services, employs 75% of individuals holding professional or managerial positions. Nearly half (45%) of all mid-salaried administrative and office positions are in the public sector. Public sector jobs in administration and services also tend to be the highest paid.

[2]This figure is difficult to determine with certainty, given that the data from INEC describes public sector as a category of employment in some instances and a specific industry in others. It is difficult to cross-reference the data in ways that allow for an accurate combination of the figures over time.

Governmental agencies and international organizations recruit 52% of the workforce with a university education. The average educational level is only higher in the financial sector.

The most stable employment in Galapagos is concentrated in the public sector, which, along with international organizations, represents 37% of the salaried positions.

The origin of the workforce in Galapagos

According to the 2006 census, 22% of the Galapagos workforce was born in the archipelago (Figure 3). Compared to immigrants, the native population has greater representation in public administration, transportation, and cultural-related employment, and less representation in construction, domestic service, commerce, and tourism.

Among those born outside Galapagos, a certain level of specialization can be observed based on origin. Immigrants from Tungurahua tend to work in construction, transportation, and domestic service. Those from Manabí are concentrated in fisheries, hotel services, and domestic service. Immigrants from the richer provinces of Ecuador, Pinchincha and Guayas, tend to work in services and financial and administrative activities. In fact, 32% of the workers born in Pinchincha work in public administration, compared to 29% of Galapagos natives.

An analysis of the origin of workers in Galapagos in 2006 reveals that 2033 workers, 23% of the workforce, arrived in recent years. This means that on average, 254 additional workers arrive from outside the islands each year. The public sector recruited the most immigrants over the last eight years[3], followed by domestic service and construction. The latter two sectors provide low pay and little social recognition.

Sectors with fewer recent immigrants include fisheries, commerce, and maritime transportation. While these data suggest that the fisheries sector has ended its period of expansion, the fact that the 2006 Census did not include people with irregular residency status calls this conclusion into question.

Conclusion

The censuses of Galapagos clearly demonstrate that the public sector plays a major role in the archipelago's economy. It is the sector that has grown the most in terms of employees and it tends to generate immigration since many positions require higher levels of education and experience. Many of these jobs

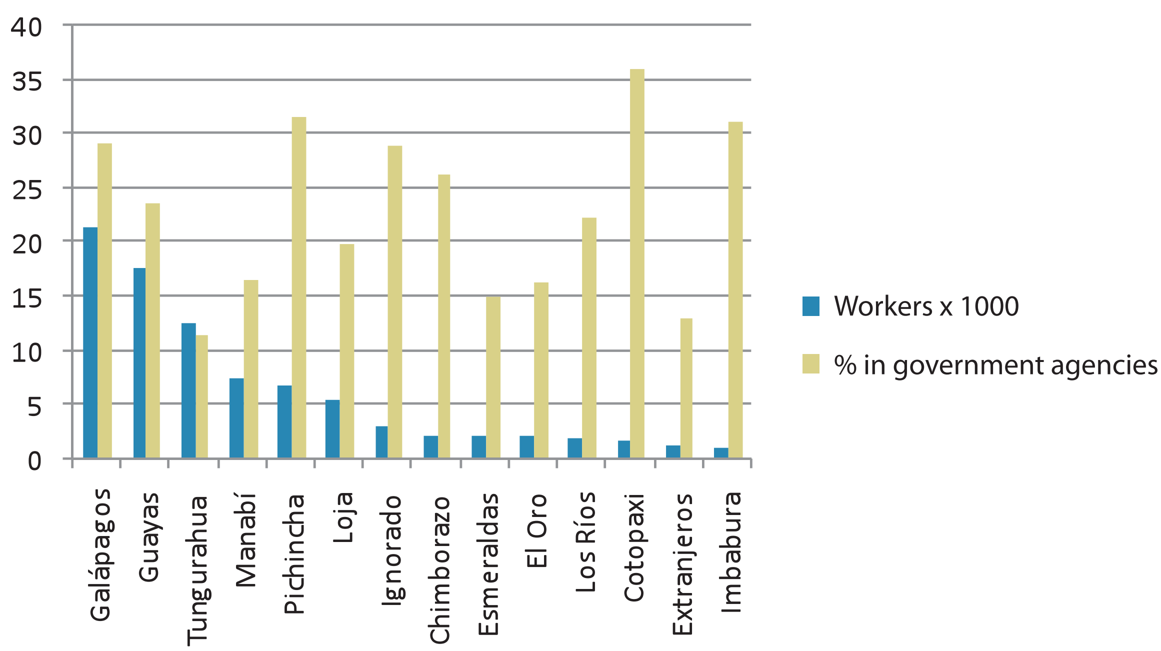


Figure 2. The birthplace of workers and the relative weight in the administrative sector in Galapagos in 2006. Source: INEC, 2006.

[3]Calculated as the number of people in excess of those that would correspond to the same proportion between workers who arrived in the last eight years and the distribution of all workers in Galapagos.

also pay higher salaries, increasing demand for domestic service and construction, which then requires additional immigration. The participation of native Galapagos residents in the public sector remains low while they are more active in transportation and commerce.

The flow of funds to the public sector results in part from political decisions, which affect where and how the money is spent and thus impacts both human behavior and social dynamics in Galapagos. Immigration based on jobs also creates greater social stratification. While some immigrants arrive to take advantage of well-paid employment, others end up in the lower rungs of the social ladder. This dynamic generates inequality, which will probably increase over time.

The current development model in Galapagos generates immigration and population growth. The most significant conclusion of this analysis is that the environmental footprint of the public sector should be analyzed with a special emphasis on how further growth of this sector could result in more accelerated immigration. This will require studying policies for contracting non-resident professionals, alternative forms of contracting short-term services, and how employment in this sector affects society in general. Another topic for additional study is the impact of the distribution of governmental income.

BIODIVERSITY AND ECOLOGICAL RESTORATION

fauna flora

galápagos

development community

Photo Biodiversity and Ecological Restoration subsection title page: Jacintha Castora Photography

Photo: Jacintha Castora Photography

Native gardens for Galapagos – can community action help to prevent future plant invasions?

Rachel Atkinson[1], Mandy Trueman[1,2], Anne Guézou[1], Patricia Jaramillo[1], Marco Paz[1], José Sanchez[1], Yolanda Sánchez[1] and Miriam Silva[1]

[1]Charles Darwin Foundation, [2]University of Western Australia

Introduction

Introduced species present the greatest threat to the unique terrestrial biodiversity of the Galapagos Islands. Analysis of data from a survey of 97% of all properties in the four inhabited islands (Floreana, Isabela, Santa Cruz, and San Cristóbal), carried out between 2002 and 2007, combined with information from the Charles Darwin Foundation (CDF) herbarium (2009), show that there are now 870 recorded alien plant species in the archipelago. Of these species at least 26% (229 species) have now naturalized (established and reproducing without help from humans) and 131 species are already invading natural areas in the archipelago (Guézou and Trueman, 2009).

The total number of alien plant species on each island is directly related to human population size, with Santa Cruz and San Cristóbal having the greatest number of species (Figure 1). However, most of these species occur in very few properties (92 species occur in only one property, 229 in less than 20), indicating recent introduction to the archipelago, probably within the last 30 years. It has been noted in the literature that most plant species take more than 50 years to become abundant and up to 150 years to naturalize (Sullivan *et al.*, 2004; Caley *et al.*, 2008). This means that it is probable that many of these species will naturalize and become invasive in the near future, as the propagation of introduced species increases alongside human population growth.

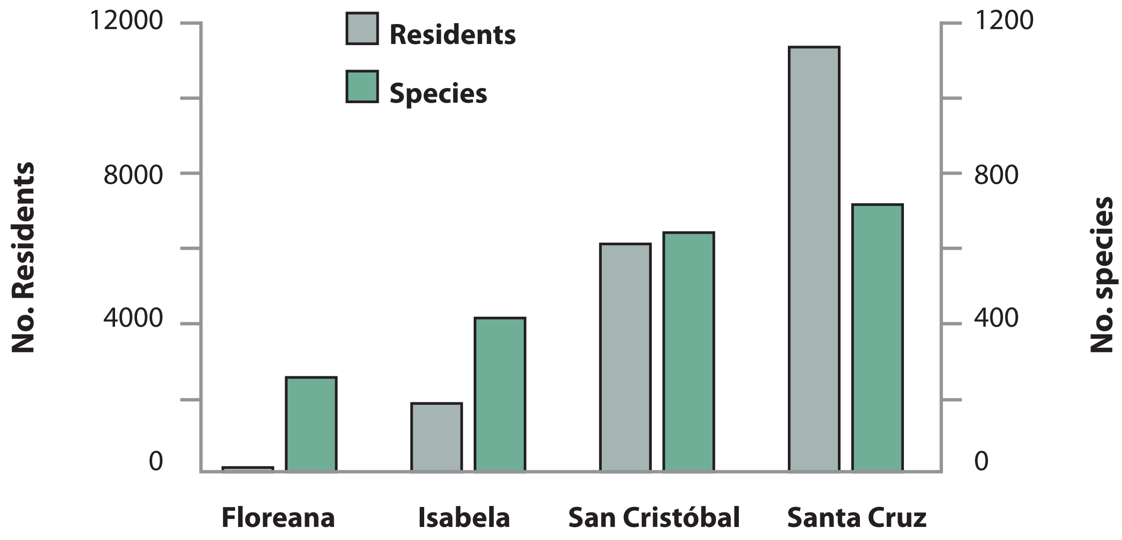


Figure 1. The total number of residents and alien plant species on each of the four inhabited islands.

Galapagos already has a quarantine system that prohibits all non-permitted plants from being brought to the archipelago. However, as explained above, new plant invasions will occur from those alien species already present. Therefore, active management within the archipelago is needed to reduce the spread of these potential invaders. In order to respond to this need, two solutions have been tested in Galapagos. The first was to eradicate species with limited distributions that posed significant threats to Galapagos in the future; the second focused on community awareness and action through a native gardening program. This paper provides a brief summary of the eradication efforts and then reports on progress of the native gardens program over the last three years, providing baseline data for monitoring the impact of this strategy.

Eradication efforts

The theoretically simple solution of completely eradicating species from individual islands (Harris and Timmins, 2002) proved to be far more difficult than expected due to the social complexities associated with introduced species removal on private land. In a pilot study of 30 plant eradication projects covering 23 species, carried out between 2001 and 2007 by CDF, only five were successful. Of the 25 unsuccessful projects, reasons for failure varied. One failed due to technical difficulty, three because of the biology of the target plants, six because the projects were too ambitious (the species had unexpectedly large distributions when detailed maps were made), ten because of lack of long-term funding after the trial finished, and six due to individual land owners not allowing the work to be completed on their land (Gardener *et al.*, 2010). The reasons for denying permission for species removal were varied, and included the active or perceived use of some species for medicine, as an ornamental, for timber, or due to sentimental attachment. In addition, several land owners denied access to their land because of worry over the integrity of the field team.

However, a targeted project in 2007-8 that focused on removal and replacement of the invasive *Leucaena leucocephala* from private gardens in Puerto Ayora proved more successful. Each of the 27 land owners with *L. leucocephala* on their land was provided with information about the species, already known to be aggressively invasive in the coastal village in San Cristóbal. If they agreed to allow removal of the species, they were offered the choice of several different natives as replacement. Although repeated visits were necessary for some of the land owners, everyone finally agreed to participate in this project and a total of 292 plants were killed (using herbicide or removed manually). All of the land owners continue to remove new seedlings from their properties. These experiences indicate that eradications may be a possible solution for plants that are currently rare, if carried out in tight partnership with the community.

As the majority of the alien plant species in Galapagos are ornamentals (Guézou and Trueman, 2009; Figure 2), minimizing the risk from this group of species is an important step in preventing future problems. To address this, a program to encourage the use

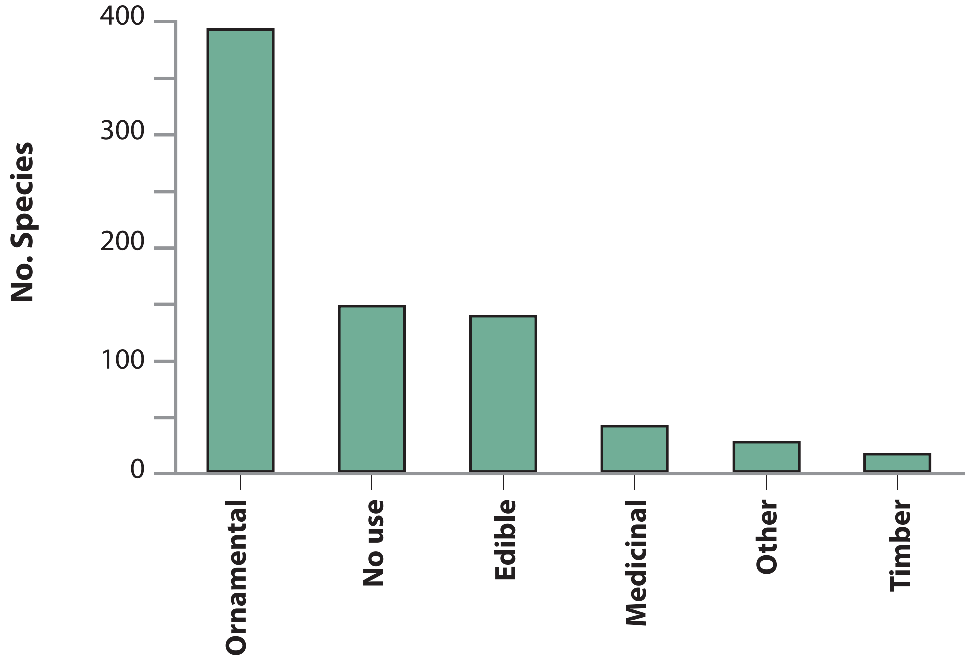


Figure 2. The different uses associated with alien plant species in Galapagos.

of native and endemic plants in gardens and public spaces in Galapagos began in 2007. This approach has proven more successful than the trial eradication programs discussed above (Atkinson, 2008).

The native garden initiative

The native garden initiative is not a new one for Galapagos. Nurseries have been producing native plants on several of the inhabited islands for over a decade, with the aim of increasing awareness of the native flora. However, the realization that many of the alien ornamentals could become problems in the near future was made only recently and provided a new energy to the initiative.

The CDF has two nurseries in Santa Cruz, one in the highlands and one in the lowlands. While the nurseries have been producing plants for the community for the last decade, the native garden project began in earnest in 2007. In 2008, CDF also reinitiated the project in the coastal village of Puerto Baquerizo Moreno in San Cristóbal. The project has also begun in Floreana, with the establishment of a small nursery in the highlands that was scheduled to open in early 2010. The Galapagos National Park Service in Isabela has a long history of gardening with natives in the village of Puerto Villamil, and still maintains a small active nursery on the island.

Data in this report come from the nurseries managed by CDF in San Cristóbal and Santa Cruz.

Santa Cruz

Data from 2007 to 2009 show a steady increase in the number of clients becoming involved in the project. In 2009, 173 different clients were provided with 7712 plants of 47 species (Table 1). Over the last two years, the gardening team has provided plants for about 200 projects, most of which have been for private gardens, although businesses, educational establishments, and public and private institutions have also become involved in the initiative (Figure 3). In addition, the gardening team has carried out landscaping projects for over 30 different clients. This includes an ambitious project for a housing development carried out in the highlands of Santa Cruz, where all of the grounds were landscaped with native species; hence the very high plant production in 2008.

San Cristóbal

Over the last two years the project in San Cristóbal has grown considerably since its beginning in 2008. In 2009, the nursery produced 2618 plants of 48 species for 44 different clients, compared to 797 plants of 32 species in 2008 (Table 1). In addition, the team created 28 gardens, which represents an increase of 160% compared to 2008. Most of these were private gardens for houses in the village, but several restaurants and hotels also became involved in the project (Figure 3).

In addition, in 2009, the project started to work with plants for reforestation projects in the highlands – a theme that has received many requests from farmers there.

Table 1. Number of clients, type of activity (native garden or reforestation), number of species, and number of plants produced in CDF's native plant program on San Cristóbal (2008-9) and Santa Cruz (2007-9).

Island	Item	2007	2008	2009
San Cristóbal	Total number of clients		14	44
	A. Native gardens		14	41
	B. Reforestation		1	3
	Number of species		32	48
	Number of plants produced		797	2 618
Santa Cruz	Total number of clients	30	129	173
	A. Native gardens	28	128	169
	B. Reforestation	2	1	4
	Number of species	24	57	47
	Number of plants produced	1 243	11 403	7 712

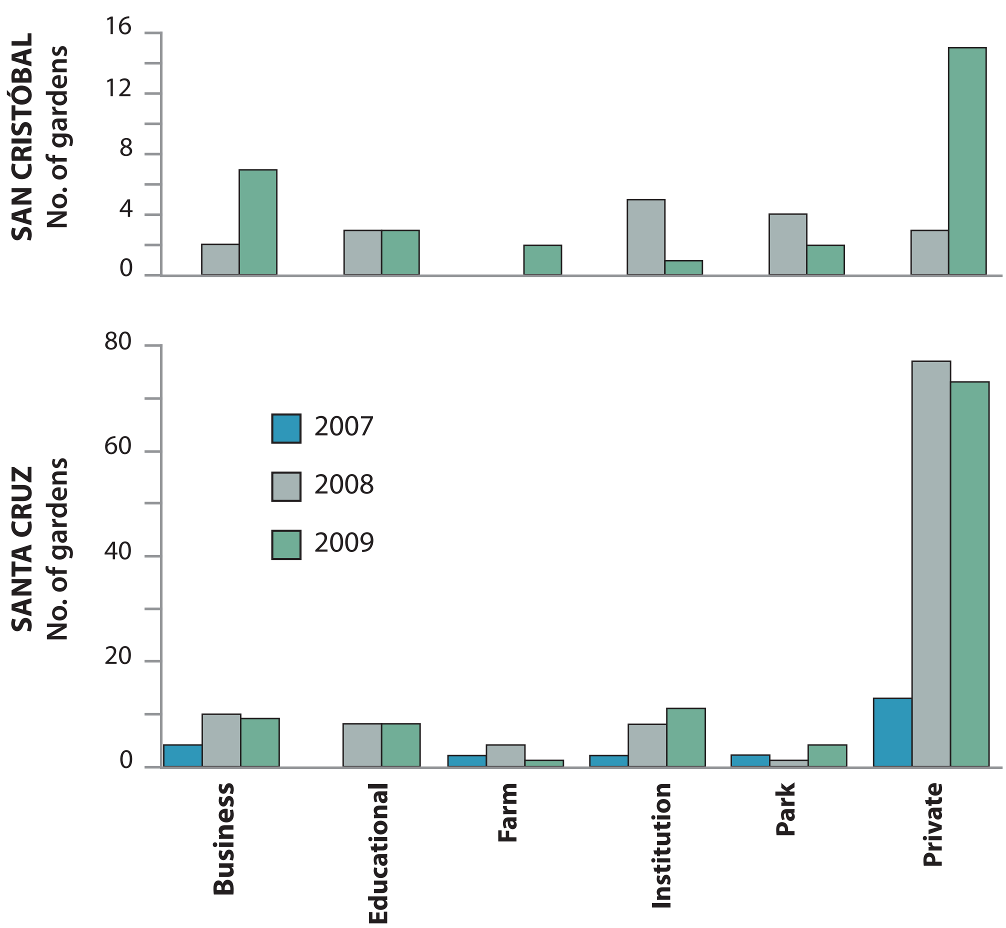


Figure 3. The types of projects for which plants were provided in Santa Cruz and San Cristóbal.

Photo: Anne Guezou

Conclusions and recommendations

While still in its infancy, the native gardens project represents an important initiative in the sustainable development of Galapagos. The data presented in this study provide a useful baseline to measure future growth of the gardening project. However, they do not directly show the impact of this project on limiting the use or spread of introduced alien species. In order to do this it is necessary to return to a subset of properties and carry out a new inventory of introduced plant species, in addition to interviewing the land owners for their reasons for changing their gardens. In this way the direct impact of the project can be assessed.

Galapagos hotels and institutions are recorded as having the highest diversity of alien species in their gardens (Trueman *et al.*, submitted) and represent an important focus for future work. This will be helped by a bold initiative from the Ministry of Tourism to increase environmental responsibility by hotels and restaurants in Galapagos through compliance to a series of standards, including the use of native species for landscaping.

An essential component to solving invasive species problems worldwide is through the support of the community. The increased awareness and knowledge of the native flora of Galapagos generated through the gardening project and its associated education project (e.g., Atkinson *et al.*, 2009) are important and positive steps to help people realize that simple actions by each and every resident can help in the conservation of the archipelago.

Photo: Celso Montalvo

Optimizing restoration of the degraded highlands of Galapagos: a conceptual framework

Mark Gardener[1], Rachel Atkinson[1], Danny Rueda[2] and Richard Hobbs[3]

[1]Charles Darwin Foundation, [2]Galapagos National Park Service, [3]University of Western Australia

Introduction

The highlands of the inhabited islands contain the most degraded ecosystems in Galapagos, with between 23 (Isabela) and 96% (San Cristóbal) altered by invasive species and agriculture (Table 1). On some islands this has resulted in the almost complete loss of unique communities; the highland Scalesia forests now cover less than 1% of their original range on Santa Cruz and 0.1% on Sierra Negra Volcano (Isabela) (see Mauchamp and Atkinson, this volume).

Table 1. Percentage of vegetation zones degraded by land clearing or invasive species in each of the four inhabited islands (adapted from Watson *et al.*, 2010); Very Humid and Humid categories have been grouped together under Humid.

Island	Vegetation Zone		
	Humid	Transition	Arid
San Cristóbal	96	23	2
Santa Cruz	86	25	0.4
Floreana	38	2	0.5
Southern Isabela	23	4	0.2

To date the goal of conservation action in these degraded areas has been to restore systems to a near pristine condition (Bensted Smith *et al.*, 2002). Despite numerous attempts and much investment, this approach has consistently failed to deliver widespread and long-term results. This failure is due to a lack of understanding of the holistic nature of degradation as well as a lack of shared vision among highland users. Unfortunately there is no magic wand for restoration; changes in abiotic and biotic factors that occur as systems degrade may be difficult or impossible to reverse sufficiently so that systems can return to their pristine state (Hobbs *et al.*, 2009). It is increasingly understood among scientists that the maintenance or restoration of ecosystem function, which includes the plethora of interactions between biological and physical elements including the human element (often termed ecosystem services), should be the ultimate goal of conservation management (Hobbs and Norton, 1996). We suggest that this should also be the focus in Galapagos. However, systems can lose rarer components of their biodiversity and therefore resilience before function begins to be affected (Schwartz *et al.*, 2000), so the goal is considerably lower than maintaining all original biodiversity.

A goal based on functionality allows us to consider that some introduced species may play a neutral or even valued role in natural communities. This important paradigm shift (that introduced species are not always bad) opens the door to potential management solutions that maintain resilient systems composed of mixtures of native and exotic elements that would never have occurred naturally, rather than trying to return systems to their unaltered state. These novel or hybrid ecosystems (Hobbs *et al.*, 2006) may be more stable and resilient to new invasions than pristine systems, require lower inputs of resources enabling improved cost effectiveness of current management practices (Seastadt *et al.*, 2008), and thus a much needed extension of areas under active management.

The objective of this paper is to review current management for restoration in the highlands and propose ways in which the paradigm shift could help refine and optimize this action. However, there is very little understanding of the ecological processes in the highlands so that much of the basic information necessary to embrace the concept of novel ecosystems and help improve management is missing. We outline a conceptual framework for the degradation process in the inhabited highlands and use this to identify knowledge gaps and key studies that need to be carried out. Furthermore, it is hoped that this conceptual framework can be used as a first step to develop a shared and realistic vision among highland users.

Current management action to restore the Galapagos highlands

Highland restoration in Galapagos to date has focused on the eradication of single species already having a significant ecological impact (e.g., vertebrates - Cruz *et al.*, 2005; Carrion *et al.*, 2007) or predicted to have future impact (e.g., plants - Buddenhagen, 2006). It has also addressed the control of widespread invasives in key areas (e.g., Buddenhagen *et al.*, 2004) and small-scale management of iconic endemic species, especially on private farmland (e.g., *Scalesia pedunculata*) (Table 2). While some of these projects have led to the successful natural regeneration of communities, especially on uninhabited and relatively pristine islands, results on the more degraded islands have been varied, with replacement of one invasive by another (e.g., Atkinson *et al.*, 2008), or simply with no positive long-term impact. This is often due to the small-scale and sporadic nature of the work, resulting from the high level of resources needed to carry out invasive species control. For example, projects such as the 200 ha Jatun Satcha on San Cristóbal, the use of *Scalesia pedunculata* as a cover crop for coffee in Santa Cruz, or weed control in critical areas of the National Park are only possible on a small scale because of the need for a continuous input of expensive labor to control key invasive weed species that transform the highlands into states that did not previously exist (including *Cedrela odorata*, *Cinchona pubescens*, *Lantana camara*, *Psidium guayaba*, *Rubus niveus*, *Syzygium jambos*, and several African grass species), These species have life history characteristics that readily out-compete indigenous Galapagos vegetation. Costs to remove invasive species from farmland range between US$500 and US$2500 per ha, with maintenance costs of about US$500 to US$1000 per ha per year depending on the land use (Scott Henderson and Jamie Recourse, pers. comms).

There are few agricultural activities that bring a high enough return to justify such an expense; potential examples include agro-tourism combined with high-value products such as coffee and bananas, or greenhouse-produced vegetable crops. This problem has led to the abandonment of about 60% of the agricultural land in Santa Cruz, land which now acts as a seed source of invasive species for the surrounding managed farms and the Galapagos National Park. A similar story is occurring in the National Park where almost all of the annual budget for weed control (estimated at US$630,000 for 2007) was spent on the control of the most invasive species in an area of less than 200 ha (Figure 1). To put this in context, it is estimated that the introduced invasive *Psidium guayaba* covers at least 90,000 ha of National Park land. Very little of

Table 2. Examples of current management practices and how our proposed paradigm shift may result in a more optimized restoration.

Current management	Examples	Result	New direction
Priority area management: iconic or single species invasive focus	Los Gemelos (*Scalesia pedunculata* and *Rubus niveus*); Media Luna (*Miconia* and *Cinchona pubescens*)	Single species benefits; ecosystem function often degraded; long-term high cost to maintain	Use maintenance of whole ecosystem function and biodiversity maintenance as aims; management uses less energy and can target larger areas
Small scale eradication	Pilot plant eradication; fire ant control	Dependent on available methodology, prevention of reinvasion, and community involvement	Species need to be chosen based on potential impact; regular evaluation needed; needs community awareness and clear lines of authority
Whole island eradication: single invasive focus	Goat, pig, and donkey eradication: Project Isabela	Successful on uninhabited islands; some unexpected and negative ecosystem impacts	Whole ecosystem response needs to be considered to ensure resources available for emerging problems
Farmland restoration	Jatun Sacha; *Scalesia* on farms	Long-term high input required; necessary in seriously threatened habitats	Redefining objective to maintain functioning rather than native-only ecosystems will lower costs and increase size of area under management; need for spatial planning and community involvement
Education	Gardening program	Raises community awareness about Galapagos flora and threat of introduced species	Increase basic environmental awareness including understanding of precautionary principle; better quarantine; shared long-term vision

the weed control budget is spent on active restoration or early detection and eradication to solve emerging problems. However, whilst plant eradication seems an attractive goal, in theory a one-off injection of funds and the problem is solved, evidence shows that it is extremely difficult (Gardener et al., 2010).

A more mechanistic-based approach

A principle barrier in successful restoration both in Galapagos and the world at large has been the lack of a mechanistic-based approach to understanding the degradation process. A better understanding of this process is the first step in the development of more efficient management practices. We can begin to define the fundamental elements of the degradation process by its representation as a state and transition model. A state is a definable type of community (e.g., pure Scalesia forest, mixed introduced and native forest, or introduced pasture), and a transition is the process by which the system moves from one state to another (e.g., land clearing or invasion of transformer species). Representation of the highlands in this way

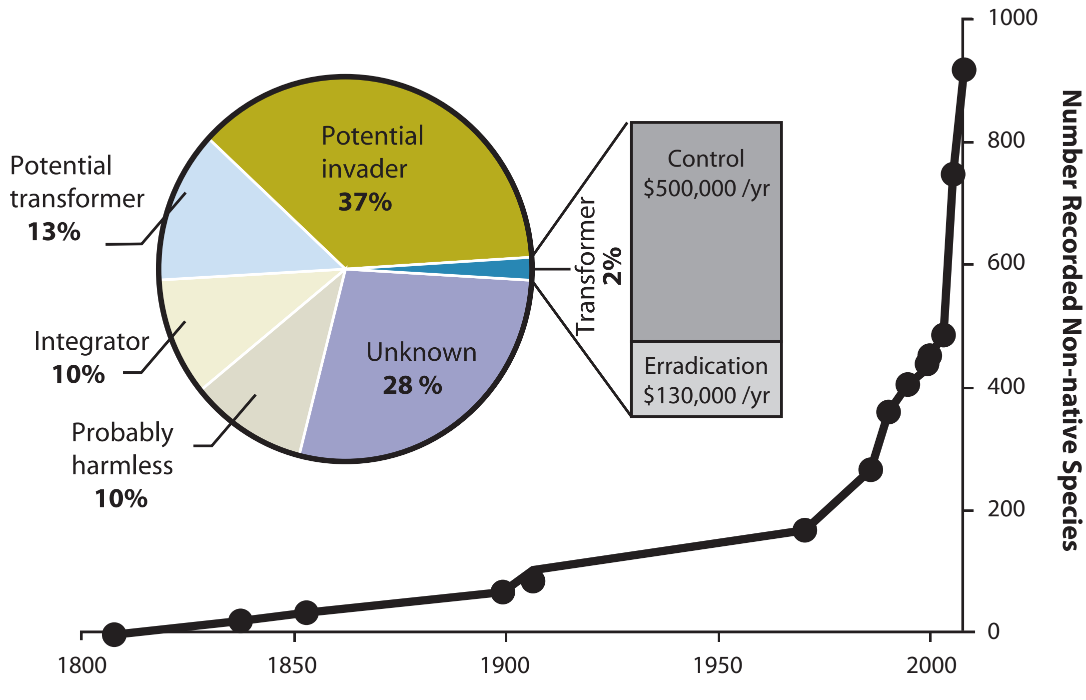


Figure 1. Numbers of non-native plant species recorded in Galapagos over the period 1800-2008. Inset: Categorization of the 919 non-native species in 2008 based on the Galapagos Weed Risk Assessment database. National Park allocation of resources for non-native plant species was US$630,000 in 2007, with all of the expenditures targeting species defined as transformers (Galapagos National Park work plan 2007).

allows for the identification of desired goals in restoration, which, as discussed above, may include hybrid or novel systems (Hobbs *et al.*, 2006). It is study and understanding of the processes that drive transitions rather than of the states themselves that will allow for successful restoration management to be developed (Hulme, 2006).

We present a state and transition model that was developed using local and international knowledge at a workshop held in Santa Cruz in November 2008 (Figure 2). It builds upon that of Wilkinson *et al.* (2005), which specifically considered Scalesia forest and introduced pasture, to encompass the whole of the humid highlands. The workshop revealed significant information gaps that need to be filled in order to allow for a better understanding of the degradation process in the highlands. The information gaps were divided into three key themes. The first addresses spatial distribution, function, and value of different vegetation states (i.e., characterizing the states), the second determines the ecological and social processes driving degradation (i.e., characterizing the transitions), and the third theme helps to develop a novel tool box to aid restoration to functioning states. A total of thirteen research projects were proposed within the themes, each the size of a PhD study, to fill the necessary knowledge and research gaps.

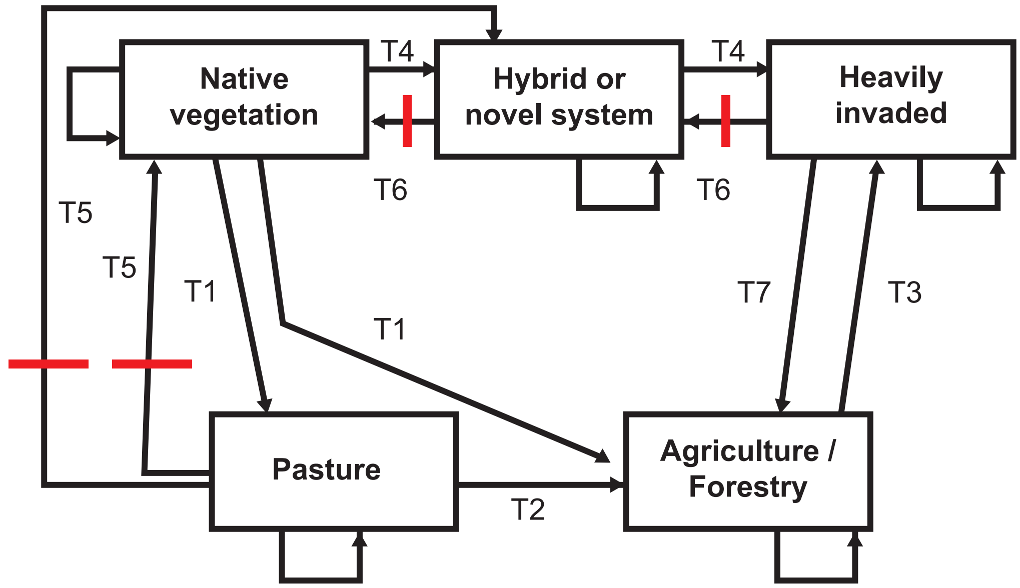
The three key themes identified in the workshop are detailed below.

a) Spatial distribution, function and value of different vegetation states

There has been no fine-scale mapping to determine what vegetation states are present in the highlands of Galapagos. At present it is assumed that states composed of introduced species have no inherent value. A crucial first step is to study their ecological function in order to determine the social, economic, and conservation value of each state. This is necessary in order to be able to identify which states can be considered as useful end points for restoration. This information can then be combined with mapping to develop a spatially explicit network of priority sites for conservation management and human livelihoods.

b) Ecological and social drivers of degradation

While we know the key invasive species in Galapagos, there has been little quantitative study on the impact they have on systems and how that impact drives degradation. An elegant exception is the work of Jäger *et al.* (2007; 2009) on the impact of the tree *Cinchona pubescens* on the treeless pampas in the highlands of Santa Cruz. Surprisingly they



T1: Clearing; **T2**: Intensive cultivation; **T3**: Abandonment; **T4**: invasion; **T5**:Removal of invasives + planting natives; **T6**: Removal of invasives; **T7**: Cultivation of crops, etc

Figure 2. A suggested state-transition model for the highlands of inhabited islands in Galapagos. Boxes represent main states and arrows represent transition or drivers between states. Red bars indicate possible biological or physical barriers preventing transitions to less degraded states.

showed that although an increase in tree density reduced abundance of native and endemic species, no extinctions occurred. Impacts of invasive species can include changes in abiotic or physical conditions (e.g., light, water, or nutrients) and changes in biotic components (e.g., vegetation structure, species composition, changes in pollination, and seed dispersal webs). In addition, changes in human land use that may be influenced by external economic pressures can also impact heavily on degradation processes. This information helps to identify barriers or thresholds to restoration and thus has important implications for successful management (Hobbs *et al.*, 2009).

c) A novel tool box to help in restoration

Currently tools used in restoration have focused on the eradication or long-term control of individual key species. The only example of an attempt to combine this with restoration has been the planting of young *Scalesia pedunculata* in areas freshly cleared of weeds. To date there is no evidence that this helps in developing resilience of the natural community to further invasion due to a lack of understanding of seedbank dynamics and the physical properties of vegetation required to control reinvasion of key weed species. Research is also required to develop new techniques to control some of the worst and most widespread weeds using an integrated approach. Techniques include biological control, changes in land use, and use of herbivores, but it is also important to increase the effectiveness of current management techniques. In addition, it is essential to develop an understanding of the economic, policy, and social pressures that lead to current land use trends and identify strategies that allow for the incorporation of restoration into these processes.

The highland areas are inhabited; they are the focus of agriculture and are also used for leisure and tourism activities. Thus, social and economic aspirations of the community who live in and use the highlands are integral components in shaping the restoration vision, and must also be considered in all stages as important components in the state transition model.

Optimizing future restoration activities

The biodiversity vision for "Galapagos 2050" clearly points to the need for restoration of the highlands of the four inhabited islands (Bensted Smith *et al.*, 2002). However, the need for a paradigm shift is obvious if we wish to optimize the use of limited resources for both research and management to maintain bigger natural areas that retain ecological function into the future. Hence, we propose a shift in highland restoration that

Photo: Jacintha Castora Photography

aims at managing much larger areas and requires fewer resources, with the endpoint being a functional and resilient system. However, at present there are significant knowledge gaps that prevent us proceeding effectively with this task. The projects discussed in this document form part of a new strategic plan for the restoration of the highlands and collaboration is actively sought in order to help us understand the degradation process.

If this scientifically led process is to produce better management options based on ecosystem function, which incorporate community aspirations and maximize biodiversity with low-cost solutions over larger areas, we need to use an adaptive management approach. This will require much tighter linking between scientists, managers, and the community in order to be able to respond quickly and effectively to results from the field, continually refining management action as a team in order to develop optimal solutions in a constantly changing world.

Acknowledgements

This conceptual framework is based on a workshop held in November 2008 entitled "Highland restoration in the Galapagos: a strategic research plan to help define effective conservation management" and attended by international experts and local government and non government institutions. The research plan created from that workshop is available from CDF. This work was funded by Galapagos Conservancy.

Photo: Jacintha Castora Photography

Galapagos in the face of climate change: considerations for biodiversity and associated human well-being

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Introduction

The Galapagos Archipelago provides a globally-unique 'field laboratory' for assessing the effects of climate change on biodiversity and a small local community. The species and ecosystems of Galapagos undergo cyclical climate shifts in accordance with the strength of El Niño seasons, which occur every two to eight years. Extremes in climate and oceanic conditions include rising sea levels and soaring sea surface temperatures. Some loss of biodiversity has apparently already occurred and future losses may be accelerated by the increasing impact of climate change upon the already stressed ecosystems (due to over-fishing, tourism, and invasive species). These losses will directly impact the local human communities as their livelihoods are primarily dependent on these threatened natural resources (Figure 1). Although local mitigation actions and increased local awareness programs about climate change should be encouraged as a general policy, such actions will not have an impact at a global scale. Attention must be directed to increasing the adaptation capacity of the local communities and, at the same time, reducing the vulnerability and increasing the resilience of the ecosystems. Responding to climate change should be used as an opportunity to bring together both biodiversity conservation and the health of the community through a unified adaptive management approach.

This article summarizes the results of the Galapagos Climate Change Vulnerability Assessment Workshop, held in Puerto Ayora,

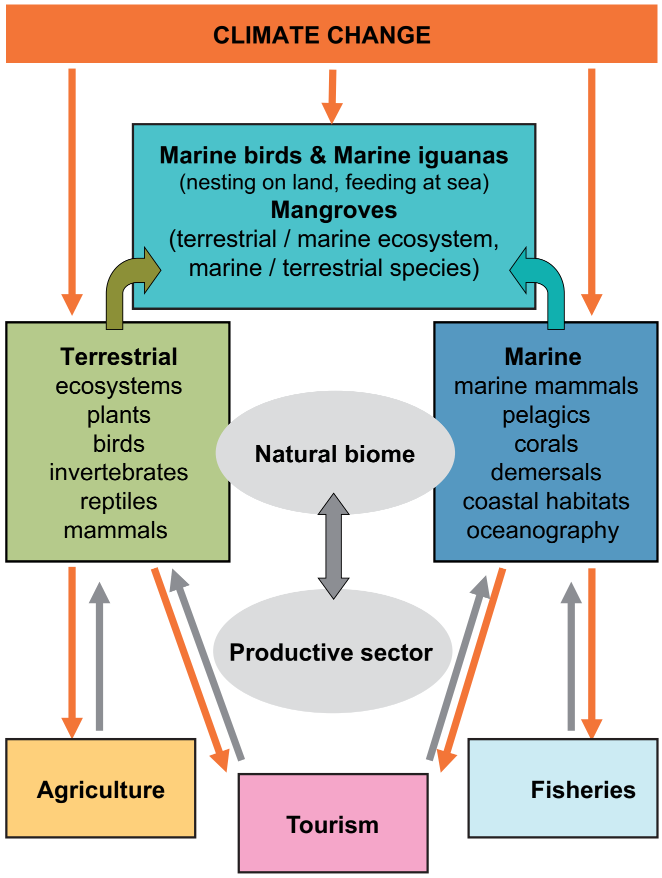

Figure 1. Theoretical diagram of potential impacts of climate change on Galapagos systems and interactions between the different components.

Galapagos, April 20-23, 2009. Over 70 participants attended the workshop, representing local, national, and international experts and scientists, local and national stakeholders, and representatives from the business sectors. The objectives of the workshop were: (i) assess existing local scientific, technical, and socioeconomic information on climate change; (ii) assess potential impacts of climate change on local ecosystems, biodiversity, and human well-being; and (iii) formulate response strategies, focusing primarily on adaptive management.

Galapagos and climate change

The Galapagos Archipelago is located within the Eastern Tropical Pacific. Key elements that characterize the Galapagos climate are: (i) the South-East tradewinds; (ii) the interaction of four warm and cool oceanic currents, including a strong subsurface current and areas of upwelling; and (iii) the climatic variability related to the El Niño Southern Oscillation (ENSO) phenomena.

Potential physical and chemical changes in the tropical Pacific Ocean resulting from global climate change will play a vital role in controlling future shifts in biology and ecosystem dynamics within Galapagos. The workshop reached a consensus that the most critical parameters will be an increase in the strength of ENSO events and a reduction in the strength of upwelling currents. Scientific studies predict that changes in water properties and circulation could impact nutrient supply, larval dispersal, and the distribution of habitat zones. Changes in wind and rainfall patterns will affect seasonality, growth patterns of vegetation, and breeding patterns and distribution of native and introduced wildlife.

The Galapagos Archipelago and the Galapagos Marine Reserve straddle two distinct El Niño (EN) Regions (Figure 2). EN Region 3, to the west of the archipelago, is influenced by the upwelling of the Equatorial Counter Current and the Cromwell Current, while EN Region 1+2 is influenced by the Humboldt Current. Predicting climate change impacts on the Galapagos at local and regional scales is difficult because of this complex setting and also due to the lack of long-term data. The currently available scenario modeling of the Intergovernmental Panel on Climate Change (IPCC) focuses primarily on the EN region 3.4, which extends west of Region 3, from 120ºW to 170ºW.

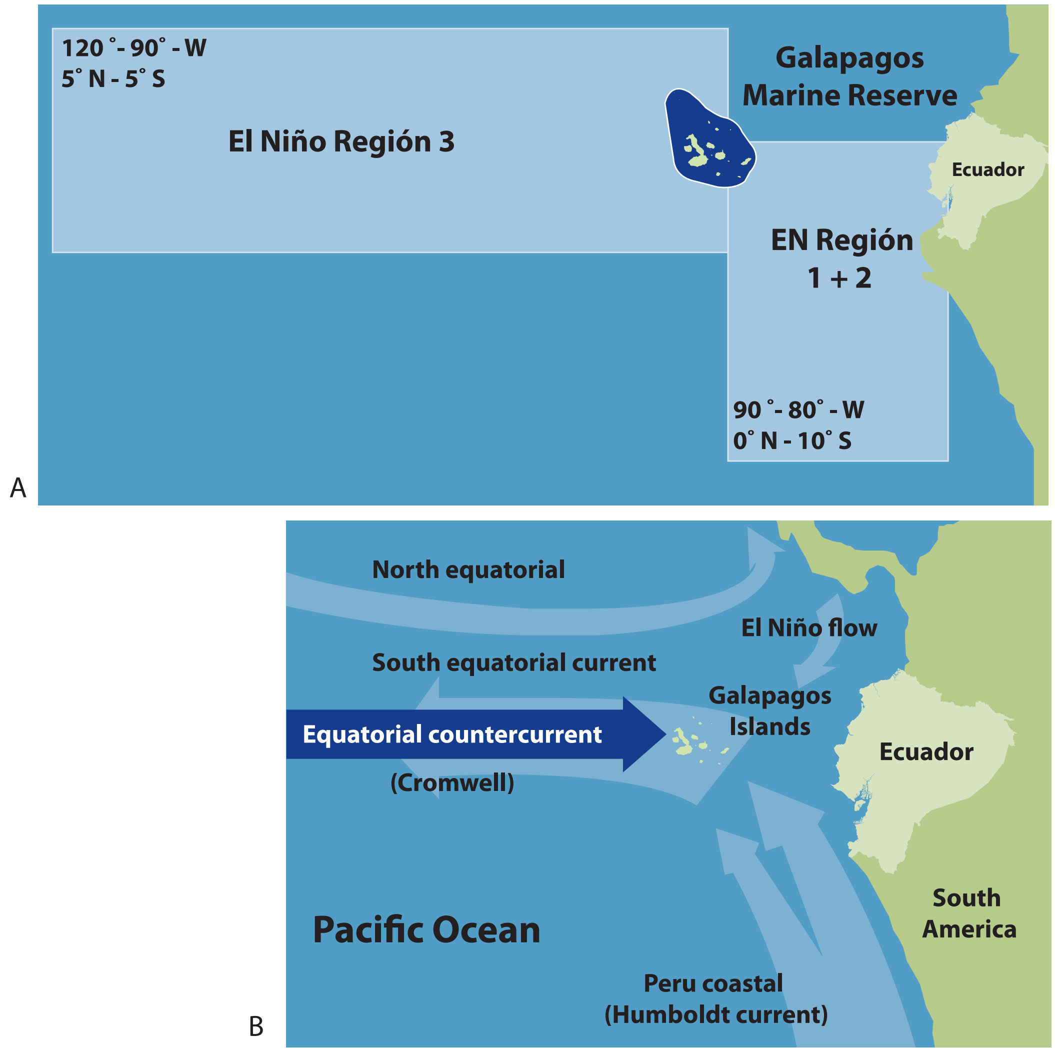

Figure 2. (A) Galapagos Archipelago in relation to the different El Niño Regions based on NOAA definitions (from CDF, 2009); (B) the oceanic currents that bathe the archipelago (www.galapagosexplorer.com). EN = El Niño.

Analysis of trends, modeling, and predictions

Long-term data sets are fundamental for determining trends in physical climate indicators, such as sea surface temperature (SST), sea level (SL), and precipitation. These data sets can then be used to carry out predictive modeling under given scenarios, such as those presented by the IPCC. Long-term climate data sets for Galapagos, with up to 55 years of data for some parameters, have recently been compiled and analyzed (Martinez, 2009; CDF, 2009). The data includes *in situ* observations and measurements, data collected during oceanographic cruises, and data obtained from satellite observation and from the scientific literature. Results of the analysis showed no definite trend in SST, SL, or precipitation in Galapagos over the last 40 years.

However, four interesting observations emerged from the analyzed data:

1. The extremes of SSTs (cool season and hot season) show a diverging trend.

2. Internal variability, including ENSO and Pacific Decadal Oscillation (PDO), dominates the analysis and masks any impact of external forces related to climate change (Figures 3 and 4).

3. Specific regions within Galapagos should be evaluated separately in terms of climate change impacts: western, central, and eastern.

4. The range in spatial and temporal variability in Galapagos due to ENSO and PDO, including SST and SL rise, is as great as the predicted changes under global climate change scenarios over longer time scales, suggesting that the local ecosystems have an inbuilt resilience to a certain degree of change.

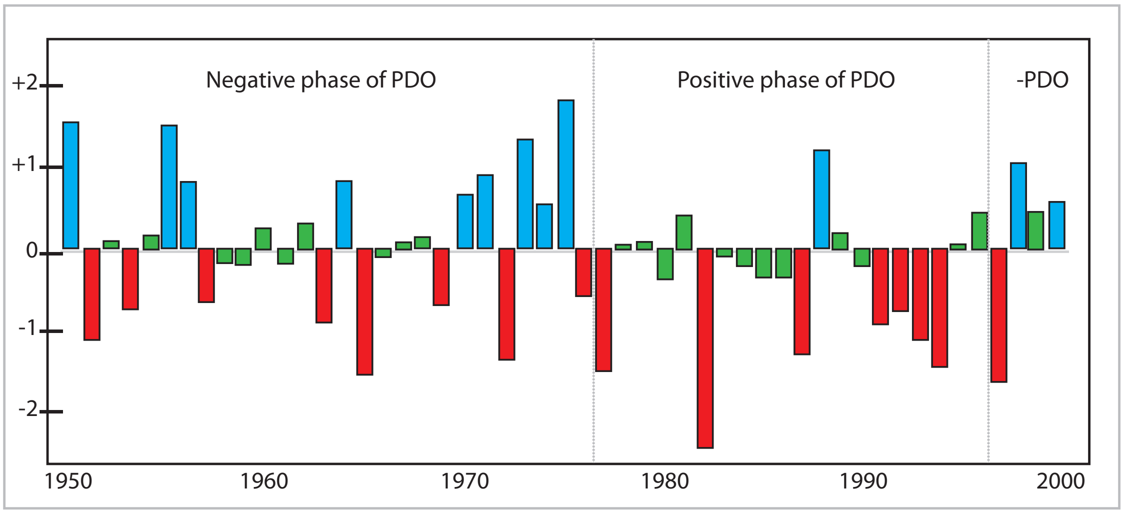

Figure 3. Time series of Southern Oscillation Index (SOI). El Niño events are colored red while La Niña's are blue. Green bars represent neutral years of SOI. Notice the decreased number of La Niña events during the positive phase of the Pacific Decadal Oscillation (PDO) (from Martinez, 2009).

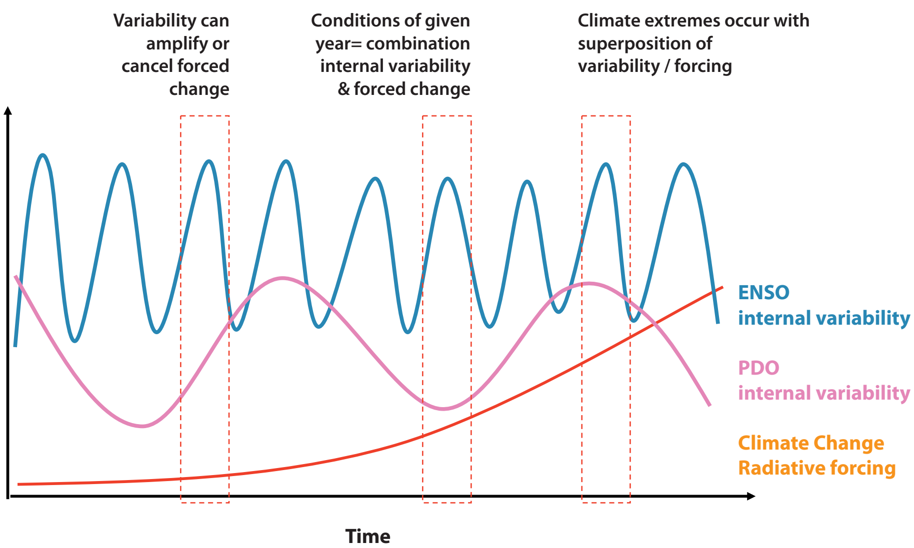

Figure 4. Diagrammatic representation of additive and subtractive combinations of different signals affecting the Galapagos climate.

Global climate change models tend to show a decrease in tropical atmospheric and oceanic circulation (Vecchi and Soden, 2007), resulting in an increase in precipitation and a decrease in upwelling. A predictive model has been run for Galapagos using the IPCC AR4 SRES A1B Emission Scenario. However, the interpretation and validity of the results are limited, as only one scenario has been used to date (Xie *et al.*, 2009).

Internal variability within the Galapagos system (resulting from ENSO or PDO cyclic events or annual seasonal changes at a smaller scale) occurs alongside external influences, such as the positive trend in radiative forcing related to global warming and climate change (Figure 4). At certain times, the magnitude from the different signals may combine in ways that mask a rising trend while at other times the combination of signals may exacerbate peak intensities giving rise to potentially disastrous climatic extremes. It should be noted that the relative magnitude of ENSO is probably much greater than that of the PDO in the Eastern Tropical Pacific.

Experts participating in the Vulnerability Assessment workshop reached consensus on several key points regarding physical oceanography changes in Galapagos, which include both climatic and non-climatic changes (Table 1).

Table 1. Summary of likely physical oceanography changes in Galapagos agreed to in the Vulnerability Assessment workshop.

Physical phenomena	Likely change	Other observation
El Niño / La Niña	Continued variability, some intense	
Sea Level Rise	More likely than not	No current trend
Ocean acidification	Likely problem	Already high due to presence of upwelling zone
Region SST	Surface ocean warming	
Local SST	Warming more likely than not	
Upwelling	Reduction more likely than not	Especially from Equatorial undercurrent
Precipitation	Increase more likely than not	

Climate impacts on marine ecosystems

The marine ecosystems of Galapagos are characterized by having a natural resilience to abrupt changes in temperature and sea level at certain temporal scales. However, as these changes intensify (becoming more frequent, abrupt, and sustained), their impact on the ecosystems, already stressed by overuse, overfishing, contamination, invasive species, and fragmentation, could be disastrous.

Reduced localized upwelling will result in decreased nutrient input into surface waters with major consequences at all trophic levels, especially top predators (sharks, penguins, pelagic fish, whales, and sea lions). This could also lead to significant long-term decreases in fisheries, already observed during strong El Niño events.

Sea level rise will affect species that nest on beaches, such as sea turtles and marine iguanas, through coastal erosion and flooding. Coastal nesting species will also suffer greater losses if the current stress by introduced predators, such as rats and cats, is not reduced. Although current trends for sea level rise in Galapagos are not yet significant, swell surges, locally know as *aguajes*, will likely cause the greatest impact. Housing infrastructure along the coast, such as along Academy Bay in Puerto Ayora, will be at risk.

Increasing sea temperatures across the archipelago may result in warm-water-tolerant corals displacing cold-water species and the migration of more tropical Pacific fish species into the northern waters of Galapagos. In addition, extreme or sustained El Niño events may cause local coral extinctions through bleaching and put even greater pressure on the larger pelagic fish.

Overall, climate change will impact many of Galapagos marine species. Among marine megafauna, fur seals appear to be the most vulnerable to increased variability related to climate change, while scavengers (e.g., lava gulls) seem to benefit from periods of warming. Organisms that reproduce all year, such as sea cucumbers (*Isostichopus fuscus*), are less vulnerable than species whose reproductive season is limited to a specific time of year, such as lobsters. However this only holds true for those species not dependent on cold-water spawning conditions or areas. In general, cold-water corals and upwelling systems will likely be the communities most vulnerable to climate change, including in particular the northern region surrounding Wolf and Darwin Islands and the western archipelago (Isabela and Fernandina).

Climate impacts on terrestrial ecosystems

In an attempt to understand the impact of climate change on the complex terrestrial ecosystems of the Galapagos Islands, these were divided primarily into the arid zone and the humid zone. Precipitation, more so than temperature, is predicted to be the main factor impacting these ecosystems. Although the humid zone on the inhabited islands has been largely modified by land-use changes related to agriculture, this zone is considered more resistant to change than the arid zone because it is dependent on cold season humidity and *garúa* and less dependent on hot season rainfall. However, if El Niño events intensify and sea temperatures are persistently higher, it is likely that *garúa* precipitation will disappear and heavy rainfall will increase. On the other hand, the arid zone is more vulnerable because changes in hot season precipitation can have drastic consequences on the flora and fauna assemblages. This zone, which until now has been inhospitable to most invasive species, could become hospitable under different climatic conditions.

Two examples of native terrestrial ecosystems especially susceptible to increased precipitation, as observed during extreme El Niño events, are the Scalesia forest in the humid zone and the Opuntia forest in the arid zone. In both cases, the die-back in these dominant species negatively impacted the many species dependent on them.

An increase in both the number and distribution of invasive species and diseases is a major concern in many of the different climate change scenarios, especially if El Niño events become more frequent or intense. Many of the invasive species are better adapted to respond to the associated changes of wetter, warmer conditions and may have an even greater impact on native and endemic species and habitats. For example, *Wasmania* fire ants and *Polistes* wasps increased their ranges considerably during past El Niños. Growth and spread of guayaba (*Psidium guajava*), an invasive fruiting tree, as well as blackberry (*Rubus niveus*) and lantana (*Lantana camara*), are enhanced by increased rainfall during El Niño events.

Climate impacts on human well-being

As marine and terrestrial ecosystems become affected by climate change, direct repercussions will be felt within the human society, from both economic and quality of life perspectives. The three primary economic sectors of Galapagos (tourism, fisheries, and agriculture) depend upon the natural resources and current climatic conditions. Global climate change will likely result in negative impacts on the unique flora and fauna of Galapagos potentially resulting in at least local extinctions, on the commercial marine resources, and on the soil, water, and climatic conditions of the windward slopes of the inhabited islands. An increase in the distribution and abundance of invasive species, including diseases, will not only affect the unique flora and fauna of Galapagos, but also agriculture and human health. All of this will have negative economic repercussions within Galapagos society and potentially for Ecuador. It is important to strategically strengthen each economic sector so that it is more resilient, including potential shifts in the types of tourism offered, fishing methodologies used, and types of crops grown.

Quality of life, including health, infrastructure, and vital resources (water, energy, waste management), among others, will be negatively impacted as global climate change intensifies, unless necessary precautions are taken. Higher temperatures and increased precipitation (almost certain to continue) will result in increased dispersal of mosquitoes, vectors for serious diseases, and the risk of epidemics such as dengue (already present in Galapagos) and eventually yellow fever and malaria (not yet present in the islands). The current conditions in the communities of Galapagos, including poor healthcare, sanitation, water quality, and little to no urban planning, will exacerbate these risks. Urban planning strategies to ensure improved construction methods, especially along the coastal corridor, must be initiated. These must include planning for flash floods in both inland and coastal towns and higher sea levels. Watershed management and water quality controls must be implemented in the near future to avoid potential disaster.

A last consideration regarding the impacts of climate change on human well-being in Galapagos is that migration pressure from the mainland could increase to unprecedented levels if the climate change impacts on the mainland (for example flooding of lowlands in coastal areas and desertification in the *páramo*) generate a large number of "environmental refugees." Historically, waves of human migration to Galapagos have resulted from local disasters in continental Ecuador. Currently this can be seen in the current migration from the Tungurahua province due to on-going volcanic eruptions.

Recommendations and adaptive management

The aim of the workshop was to generate recommendations and lines of action that will lead to adaptive management decisions to help prepare Galapagos ecosystems and Galapagos society to confront climate change (Table 2). These recommendations fall under two general goals:

- Build inter-institutional support and engage all stakeholders

- Increase ecosystem resilience to meet changing climatic conditions.

Table 2. Summary of key recommendations proposed by the Vulnerability Assessment Workshop and related lines of actions or adaptive management.

Recommendations	Lines of action/Adaptive management
Establish an inter-institutional monitoring and early-warning system to detect impacts of climate change in Galapagos.	• Generate joint databases and baseline data on oceanographic and climatic conditions. • Fill in data gaps in knowledge of physical processes (such as cool season weather dynamics).
Protect endangered species nesting sites to improve population resilience.	• Create more penguin nesting areas with artificial nesting boxes. • Increase shading of nesting beaches for marine iguanas and turtles through natural or artificial means.
Support the recommendations of the fisheries management chapter within the GMR Management Plan to create and implement fisheries regulations for open water species.	• Encourage a sustainable shift from coastal to open water fisheries. • Develop a "climate smart" marine protected area in terms of its management.
Prevent and control an increase in number and dispersal of introduced and invasive species that may result from climate change.	• Strengthen the quarantine systems: single docking harbor in Guayaquil, fumigation of cargo boats, and control of boat lights.
Promote reforestation and restoration of key ecosystem functions and ecological connectivity.	• Provide local support to agricultural sectors. • Involve community in watershed based management.
Improve social resilience through urban planning and watershed management.	• Support climate-smart urban development and planning. • Create incentives for rainwater harvesting and freshwater management.

Conclusions

The oceanic setting of Galapagos at the confluence of warm and cold water currents has given rise to the unique ecosystems and biodiversity that we know today. This same setting means that the impacts of climate change will be different here than anywhere else in the world. It is critical that the people of Galapagos prepare for these potential changes. As our ecosystems are stressed locally and our planet globally, both native and invasive species may not respond as they have in the past, due to even greater climatic extremes, increased variability, and long-term impacts. Our livelihoods will be heavily impacted not only by the physical implications of climate change but also the repercussions on the natural resources we depend on. In addition, the local community, Ecuador, and the world have a responsibility to ensure the future survival of the Galapagos World Heritage Site.

As a concluding result of the workshop, a Santa Cruz Declaration was unanimously supported by local and national authorities (Ministry of Environment, Galapagos National Park, National Oceanographic Institute, AGROCALIDAD-SICGAL, and the Municipality of Santa Cruz) as a commitment to ongoing involvement in the process of understanding the consequences of climate change and the roles of the local communities and managers to take global warming into account in decision-making processes.

This declaration and other useful resources relating to this article can be found at:

http://marineclimatechange.com/Marine_Climate_Change_Workshops/Galapagos.html

Photo: Celso Montalvo

Galapagos as a laboratory for sustainability: Lessons from the International Workshop on Sustainability of Islands in a Globalized World, Santa Cruz Island, Galapagos, 22-26 March 2010

Arturo Izurieta Valery

Charles Darwin University, Australia

"As never before in history, common destiny beckons us to seek a new beginning..."

(The Earth Charter, 2000)

When the Charles Darwin Foundation asked me to facilitate a workshop on sustainability, I believed that the workshop would produce new knowledge and contributions to help understand the situation in Galapagos and to help initiate a different process towards sustainability. The presentations by international experts on the sustainability of other islands in the world demonstrated new concepts and examples to better understand what is happening in Galapagos. Presentations by local professionals on various economic, social, biophysical, institutional, and environmental themes related to Galapagos brought us up to date on the current situation in the archipelago. Workgroups, which involved all of the workshop participants, generated new and different ways to understand where the balance between nature and humans is headed in such a fragile and unique place in the world. This article synthesizes the presentations and results of the workgroups, which were focused on systematically understanding the social, cultural, natural, and economic components of Galapagos. It ends with recommendations and suggested next steps to begin a new chapter on how to achieve sustainability in the Galapagos Islands.

The vulnerability of islands and insular geodiversity

International fora, such as the United Nations Earth Summit in Rio in 1992, the 1994 Barbados Program of Action for the Sustainable Development of Small Island Developing States, and the United Nations Conference on Small Islands in Mauritius in 2005, have slowly advanced the implementation of actions to avoid social, cultural, and ecological catastrophes in islands around the world. Unfortunately, in the more than 15 years since Barbados 1994, efforts to research and discover the best options for achieving an equilibrium for insular systems worldwide have been weak and have not received sufficient resources (López, 2010).

The lives of human populations that live and depend on resources available on islands or in their surrounding waters are often negatively affected by demands for the same resources by large, external consumers. The geographic opening of the islands (see Grenier, The geographic opening of Galapagos, this volume) to aggressive external markets has resulted in ongoing changes in the dynamics of the insular system (McKee and Tisdell, 1990). Uncontrolled development, made possible by new forms of communication and transportation, has caused irreversible damage to the unique biological, cultural, social, and geographic diversity of many islands around the world, such as Hawaii and the Azores.

Biological, cultural, social, and geologic characteristics combine with geographical characteristics to form what has recently been called "geodiversity." The original physical characteristics of a place, determined by its geology and geography, along with its biological, anthropological, sociological, and cultural characteristics unite to generate a special identity in a specific geographic space. Geodiversity can be defined as the measure of the geographic variations or the "footprint" made by humans on Earth's habitats ("Geo") at the local and regional levels (Grenier, 2010). Insular geodiversity describes the evolution of islands from their physical formation to their colonization and use by humans, and identifies which factors affect their sustainability. According to Jost (2010), geodiversity requires that natural resource management is carried out within a complex geographical system with subsystems of landscape (natural space), territory (space used by stakeholders), and social factors (perceptions).

The Galapagos Archipelago provides an excellent opportunity to study the dynamics of geodiversity. Such studies will contribute to sustainability in Galapagos and other islands. The unique and fragile natural characteristics of Galapagos, combined with its recent colonization and its consumer-oriented economic model, have generated considerable scientific interest to better understand the dynamics of sustainability in this context.

Evolution of cultural identities and geographic isolation

The cultures on the islands of New Guinea, Vanuatu, Cook, Marquesas, Hawaii, and other islands of the Pacific are the product of hundreds or thousands of years of interactions of communities (as opposed to individuals) with near and distant cultures via migration processes. Various factors, such as environmental and climatic conditions, or being located in areas prone to earthquakes, cyclones, etc., have forced groups of humans to search for other geographic locations to live and share. The migration of communities is structured with a long-term vision, where the interests in resources and territory are shared among all. In contrast, individual migration is focused on personal interests, is less organized, and generally reflects a short-term vision and little community organization (Waddell, 2010). These fundamental differences help explain where the term "immigrant" ends and the term "indigenous" begins.

Waddell (2010) also illustrates that all islands or insular systems confront immigration influences known as "transportation of landscapes," "roots and resources," and impacts due to "geographic isolation." "Transportation of landscapes" refers to the behavior that immigrants bring with them from their place of origin. In Galapagos it is easy to observe behavior and cultures brought from mainland Ecuador and other places. "Roots and resources" refers to inherited practices and cultural roots and how they are applied to the available resources in the insular context. In Galapagos, a variety of roots and inherited practices are brought from foreign landscapes to the fragile insular environment.

Human communities in the Pacific have survived in part due to their contact with other islands, where survival knowledge was shared and learned among cultures, rather than due to complete geographic isolation. In the case of Galapagos, geographic isolation has been applied more to the natural environment, particularly in terms of the evolution of species. We

Photo: Marco Rodríguez

now know that geographic isolation has important social and economic implications that are intimately related to the natural aspects of the islands. Geographic isolation is the opposite of geographic opening, a situation that also impacts the geodiversity of the islands in a globalized world.

Geographic opening and globalization

Telecommunications and efficient and rapid transportation are having an unprecedented affect on the sustainability of islands (Jacob *et al.*, 2004). These forces bring with them new ways of thinking about accumulation of material wealth that are geared more towards individual stability than collective stability. They transform the geodiversity of islands with established indigenous cultures in ways that drive these cultures to unsustainability and their eventual demise. This phenomenon, in which insular attributes are subjugated by those of nearby continents, is known as "continentalization of islands" (Grenier, 2010). As in the case of geographic isolation, continentalization can have negative impacts for cultures, making it necessary to find an intermediate point between the extremes of insular isolation (geographic isolation), on the one hand, and excessive opening to other regions (geographic opening), on the other (Waddell, 2010).

To achieve this balance and the sustainability of islands in a globalized world, various elements must be considered. Lessons learned from other islands (Seychelles, Azores, Canary Islands, New Caledonia, Fiji, Chausey, Porquerolles, Glenan, New Zealand, and San Andrés, among others) were shared during the workshop and can be applied to the case of Galapagos. Today the islands of the world share similar problems, which could be resolved or reduced with similar methods and actions, adapted to each island's realities (Cruz, 2010).

Kerr (2010) believes that controlled migratory flows accompanied by knowledge transfer and sharing are important to help respond to deficits in labor and knowledge and thus strengthen insular economies. Such mechanisms are being used successfully in San Andrés, Colombia (Bent, 2010), to import needed "brain power" and knowledge.

Another concept connected to sustainability is economic wealth related to shared resources, or the case of the "tragedy of the commons," where multiple individuals, acting independently and solely and rationally consulting their own self-interest, will ultimately deplete a shared limited resource even when it is clear that it is not in anyone's long-term interest for this to happen. When an economy is based on the natural characteristics of common property, as in the case of Galapagos, it is imperative that the "tragedy of the commons" be avoided. In Galapagos the shared resource is the national park. While everyone knows that controlled visits are key to ensuring that the resource endures, many people take visitors into the park without authorization, knowing that others will do the same. The same applies to the Galapagos Marine Reserve (GMR) where unauthorized fishermen extract resources until their combined actions result in negative repercussions on the resource.

From 1999 to 2005, economic growth in Galapagos exceeded 9% per year (Ospina, 2010). There is concern about how long this growth will continue and what its consequences might be. Kerr (2010) argues that the economic system should involve rewards and incentives for private and local government investments in natural and social capital, as well as penalties for those who act outside established norms. This type of system is supported by Lorenz and Simkins (2010) who also recommend creating taxes that will provide disincentives for new investments and promote incentives for Galapagos residents to invest in continental Ecuador. This could help to de-accelerate the economic growth mentioned by Ospina. In addition, alternative energy applications should be viewed as potentially profitable investment opportunities that are environmentally friendly and compatible with the insular reality (Sawyer, 2010). Sawyer proposes the generation of electricity from organic waste generated by the population as a source of income and clean and inexpensive electricity.

Kerr shared examples of areas that could be improved in Galapagos, such as: local control and regulations; communication and active participation; institutional capacity building; social, economic, and natural dynamics; economic monitoring and research; and conflict resolution capacity. Given that transportation is one of the key factors determining the isolation and/or geographic opening of the islands, Brigand (2010) considers it critical to clearly establish how the geographic space of the islands will be used by various stakeholders from a social point of view. This will help to establish a new geography of the archipelago based on human movements and use of both marine and terrestrial areas (Marrou, 2010). Expansion of visits to protected areas in places such as Galapagos requires an integrated monitoring system that is technically and scientifically sound and involves local participation. Brigand (2010) considers it important to balance economic development and the preservation of natural areas through the use of management tools that measure and monitor the flow of tourists and the impacts on both marine and terrestrial areas.

Elements that influence sustainability must be viewed as interdependent components of a system. David (2010) recommends a model based on a triangle comprised of economic, political, and social environments, where the terrestrial and marine areas depend on the dynamics of these environments. In other words, one cannot tackle any element within the system without considering the others. To understand the dynamics of sustainability and be able to make the best decisions at the local and regional levels, it is necessary to generate scientifically-based information (natural, social, economic) with the participation of local communities (Huchery and Izurieta, 2010). The use of and access to this information must be transparent and contribute to understanding the different parts of the system, and should be accompanied by capacity building and both formal and informal education. This information can be used to generate a series of possible scenarios that will allow the visualization of possible future outcomes prior to making final decisions. However, none of these tools, including the integrated observation and monitoring system (Brigand, 2010), will be established without a serious commitment of authorities and the local community to develop a long-term shared vision for Galapagos.

What can we say and learn about the sustainability of islands that can be applied to Galapagos?

- Galapagos does not possess its own cultural identity. As a result of the nature of the population (many recently arrived residents from different parts of Ecuador), behavior often reflects strong elements of the continental landscape. The evolution of Galapagos culture is recent and has not yet resulted in homogeneous behavior. In many ways, access to new means of communication (Internet, satellite television, mobile phones, etc.) makes it difficult to form a unique sense of insular culture. Even so, these tools can be used creatively by the local population, non-governmental organizations, and local and national governments to foster a cultural identity based on respect for natural capital as the foundation for the development of social capital.

- While striving for a Galapagos culture, flexibility should be used to allow for the arrival of new knowledge and skills through a system that will allow the migration of individuals with the potential to enrich and strengthen the local knowledge base and improve competition and initiative. Equally important is a stronger emphasis on improving both formal and informal education and avoiding loss of local social capital.

- Galapagos and other insular systems are impacted by economic globalization, as external market pressures tend to dominate local economic activity. This situation is not difficult to change. It requires clear lines of action based on strategic local participation to establish which economic opportunities to offer and where to drive the market. It is important to define strategies to regulate markets that utilize natural resources (national park and marine reserve), services (transportation, hotels, restaurants, communications, health care, naturalist guides, etc.), and products (food, souvenirs, construction material, etc.).

• Galapagos has more than two decades of experience with participatory processes, through the Participatory Management Board of the Galapagos Marine Reserve and regional planning activities. This experience makes it possible to begin to generate and organize information related to the social, economic, and natural components of the Galapagos system. The process of generating and organizing information must be participatory from the start in order to foster a sense of ownership of knowledge. Knowledge is power and this power must be based in the local community to achieve decision-making that is consistent with a shared vision for the future of Galapagos.

Next steps toward sustainability

The workgroups and plenary sessions recommended the development of a participatory process with local buy-in to construct a model to understand Galapagos as a "system." This system should give equal weight to socio-cultural, economic, and natural components. While the process could take a number of years to complete, it will lead to the identification of and agreement on common objectives for Galapagos and will generate a long-term national policy regarding what Ecuador wants from and for Galapagos that is not dependent upon the party in power.

The workshop identified three projects that will catalyze a move toward sustainability.

Island Identity Project (education): Education has been identified as the principal means to promote an insular identity that will use the protection of the natural capital as a starting point for developing human capital. Achieving a change in the mindset, attitudes, and sense of responsibility for Galapagos sustainability among the local population requires understanding the "landscape diversity" brought from the continent to Galapagos by its current inhabitants. An initial workshop will be held to promote a clear and structured process, with clear goals and objectives, to work toward a unique insular identity for Galapagos.

Project for improving and changing the insular economic system: Many variables have been identified that impact economic flows to, from, and within the islands. It is necessary to analyze all of the information available on the current economic system of Galapagos in order to determine if additional information is needed prior to holding a series of participatory workshops with local stakeholders to formulate viable economic scenarios, which include the concept of economic incentives and disincentives.

Knowledge management project to systematize and provide access to information to support decision-making: The systematization of all aspects of knowledge related to the social, economic, and natural components of "sustainable systems" is increasingly important, as is access to this knowledge by the local community, organizations, and institutions. This is a cross-cutting initiative that will impact other projects in areas such as education, economics, etc. The project must be carried out in a way that promotes participation and a sense of ownership of the information generated through a series of workshops on various aspects of sustainability. This project should work to connect the social, economic, and natural components of the Galapagos system, foster an understanding and sense of ownership of these concepts, and ensure better decision-making based on solid information.

Conclusions

The islands of the world confront common challenges of accelerated globalization. Their survival depends on how their inhabitants act when confronted with these pressures and the extent to which they do not compromise the natural integrity of the islands in which they live. But the responsibility for sustainability falls not only on those who live in the islands, but also on the rest of the world. Local and international declarations, agreements, laws, and regulations are not sufficient if we do not assume individual and collective responsibility for how we behave toward what remains of our planet. The Earth Charter (2000) invites us to reflect and change our thinking and behavior in ways that will allow us to live in harmony with all that surrounds us. International pro-island organizations, such as the Alliance of Small Island States (AOSIS), the Islands Initiative of the International Union for Conservation of Nature (IUCN), and fora such as the International Workshop on the Sustainability of Islands, hosted by the Charles Darwin Foundation, should be viewed as instruments that will generate tangible changes in behavior in insular regions such as Galapagos. The generation of knowledge through scientific research and citizen participation, the organization of and access to this information, and the consolidation of a unique insular identity, will result in a more promising future for Galapagos.

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