THE QUARANTINE CHAIN

ESTABLISHING AN EFFECTIVE BIOSECURITY SYSTEM

TO PREVENT THE INTRODUCTION OF INVASIVE SPECIES INTO THE GALÁPAGOS ISLANDS

WILDAID

ABOUT WILDAID

WildAid's mission is to end the illegal wildlife trade in our lifetimes by reducing demand through public awareness campaigns and providing comprehensive marine protection. We have successfully developed a model that strengthens the key elements of the law enforcement chain: surveillance, interdiction, prosecution, and sanction in several MPAs throughout the developing world. We work with governments in the design of strategic control and vigilance strategies that use the power of technology to increase efficacy while lowering patrolling costs. Given weak judicial systems, we also work with partners to develop innovative fining mechanisms that ensure compliance.

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Special thanks
to the following supporters & partners
who have made this work possible:

THE LEONA M. AND HARRY B. HELMSLEY CHARITABLE TRUST

IGTOA International Galapagos Tour Operators Association

iLCP INTERNATIONAL LEAGUE OF CONSERVATION PHOTOGRAPHERS

ACRONYMS

CGREG	Galápagos Regional Governance Council
CNMMP	National Council of the Merchant Marine and Ports
DIRNEA	National Directorate of the Aquatic Spaces
DIRGIN	Regional Directorate of Aquatic Spaces and the Coast Guard
GMR	Galápagos Marine Reserve
GNP	Galápagos National Park
GNPS	Galápagos National Park Service
INGALA	Galápagos National Institute *(former regional planning entity for Galápagos)*
LOREG	Special Regime Law for the Galápagos Islands
MTOP	Ministry of Transportation and Public Works
RCTEI	Regulation for Total Control of Introduced Species
SICGAL	Galápagos Inspection and Quarantine System
SOTMCG	Galápagos Optimized Maritime Cargo Transportation System
AGROCALIDAD	Ecuadorian Agriculture Quality Assurance Agency
UNESCO	United Nations Educational, Scientific and Cultural Organization
GEF	Global Environmental Fund
SPTMF	Under Secretary of Ports and Maritime/Riverine Transportation
MAE	Ministry of Environment of Ecuador
FCD	Charles Darwin Foundation

ASSESSMENT OVERVIEW

The greatest threat to biodiversity in the Galápagos Islands is the introduction of invasive species. Once a species is introduced, it may be too late or costly to implement a successful eradication program and irreversible damage may occur to native or endemic species of plants, animals, or insects. In recent years, the biological isolation of the archipelago has been significantly reduced given the growing number of planes and cargo reaching the islands. As tourism and population numbers increase exponentially, so do the threats of introducing invasive species.

In this assessment, WildAid will analyze the maritime cargo system that serves as the umbilical cord for the economy and human life on Galápagos. We will evaluate all aspects of the current shipping system: mainland and island port facilities, qualifications of biosecurity personnel, equipment, cargo handling at both embarkation and arrival, and cargo vessel standards; essentially all key links in the quarantine chain. We will illustrate that there is an urgent need to improve the efficiency and efficacy of maritime cargo handling that will involve the participation of the Ministries of the Environment, Transportation, and Agriculture and Fisheries, the Galápagos Governance Council, local municipal government offices, among others. We also include a 30-year cargo growth forecast using current demographic trends to inform decision-makers on the future scale of actions required for a biosecure maritime cargo system. Large investments will be required in infrastructure, personnel, and recurring outlays in the not-so-distant future. The assessment concludes with a series of recommendations to improve current inspection and quarantine procedures along each link of the quarantine chain as well as implications for the future.

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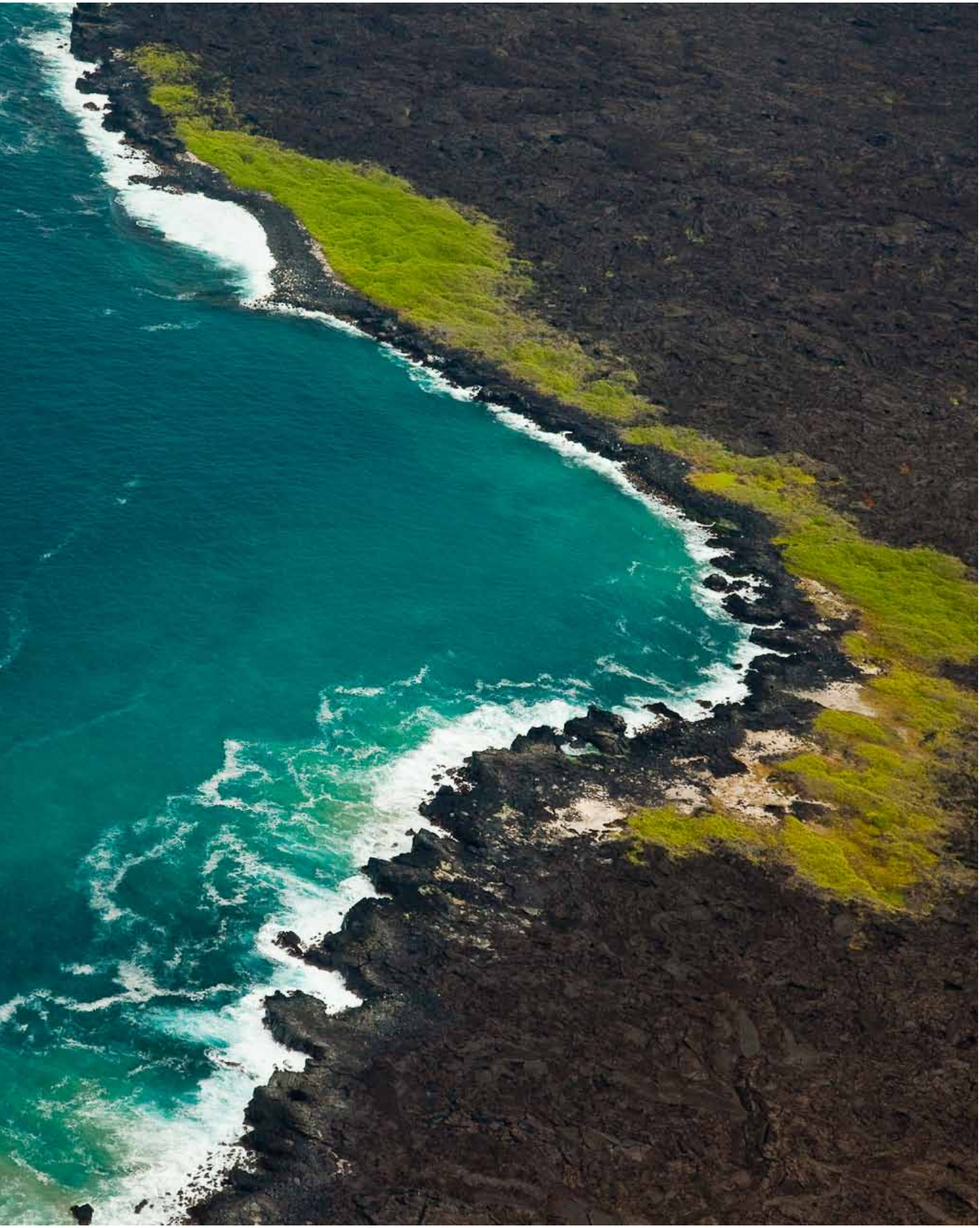
INTRODUCTION

THE GALÁPAGOS ISLANDS OF ECUADOR

The Galápagos Islands were formed 3-5 million years ago when deep ocean volcanoes erupted (Grehan 2001). Situated just below the equator, the archipelago is 1,000 km off the coast of Ecuador in the Pacific Ocean. It is composed of 13 large islands and 100 smaller islands and islets that make up 7,880 km^2 of land. Their unique geographic and geologic characteristics helped produce the unique biodiversity that is found there today, earning them the distinction of a "living laboratory of evolution" among scientists and researchers.

Recognizing their international importance, the government of Ecuador created the Galápagos National Park (GNP) in 1959, which now protects 97% of the archipelago's total land area and designating the remaining 3% for urban and rural human use. In 1979, the islands were declared one of the first United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites, and in 1984, became a UNESCO Man and the Biosphere Reserve. During the 1980s and 90s, global interest in the fishing and tourism industries led to extensive extraction and population growth in Galápagos until 1998, when the Special Regime Law for the Galápagos Islands (LOREG) was passed. The LOREG established a legal framework to ensure the conservation and economic autonomy of the archipelago, and included the creation of a formal entity for the prevention of species introductions. The organization, the Galápagos Inspection and Quarantine System (SICGAL), is responsible for monitoring activities within Galápagos and preventing the transmission of non-native organisms between islands. The 1998 law also established the Galápagos Marine Reserve (GMR), which extended the marine protected area up to 40 nautical miles from a baseline around all of the islands, and today it is the fourth largest marine reserve in the world at approximately 133,000 km^2.



THE QUARANTINE CHAIN 2012 // GALÁPAGOS

THE THREAT OF INTRODUCED SPECIES

Despite increasing regulatory frameworks established under the LOREG, the rate of non-native introductions has remained steady in recent decades. The combination of booming tourism and fishing industries with weak biosecurity controls has directly compromised the isolation of Galápagos. Between 1980 and 2000, the archipelago's annual population growth rate was over 6%, twice the rate of the mainland. Of particular concern was the number of air and sea pathways for species introductions (UNESCO 2006, 2010). At present, 11 air and seaports form a bridge between the islands and the mainland ***(Figure 1)***.

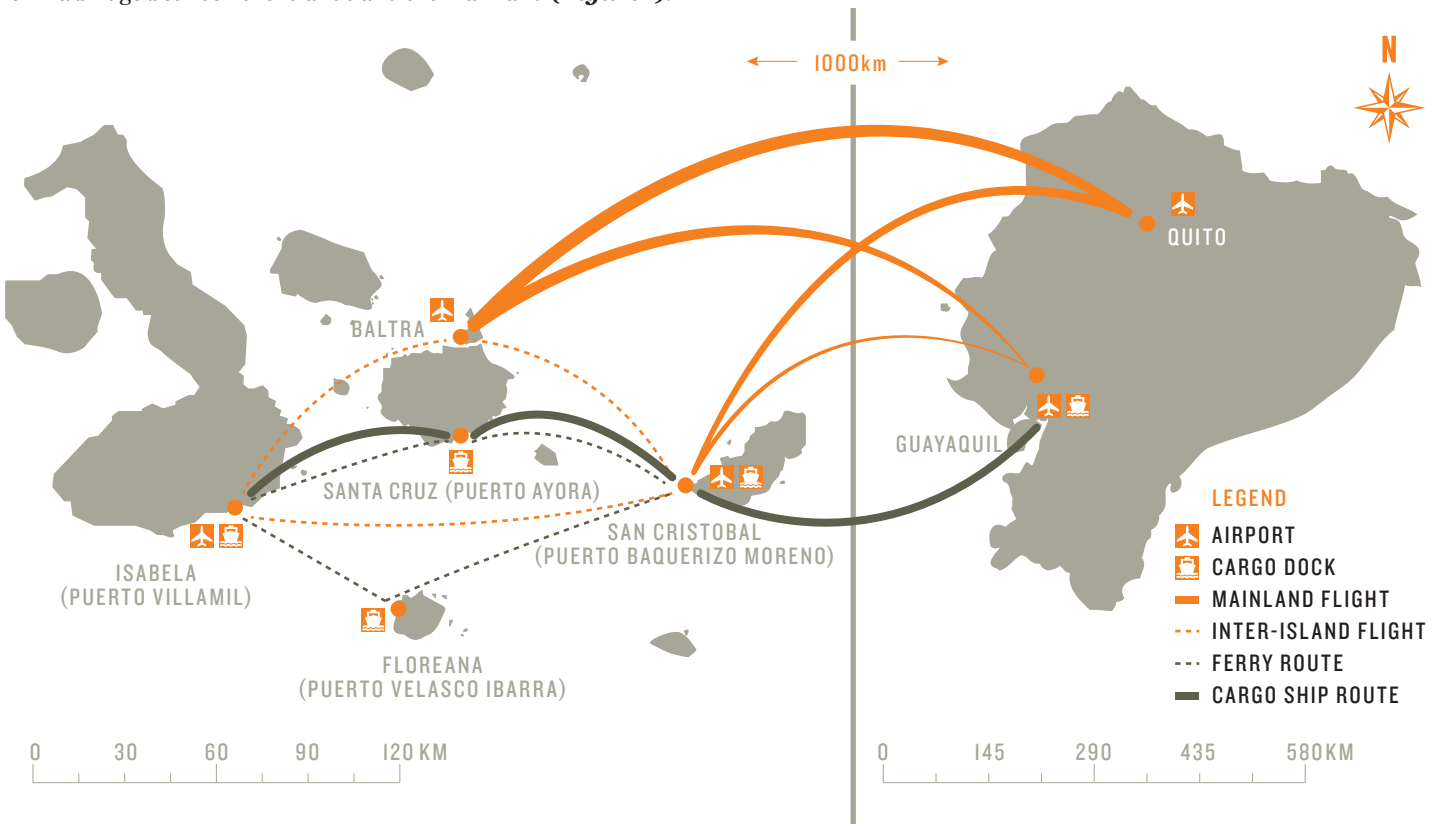


Figure 1 //
MAP OF AIR AND SEA PATHWAYS BETWEEN THE GALÁPAGOS, THE MAINLAND AND THE ISLANDS.

Three airlines operate over 40 flights per week to the Baltra and San Cristóbal Island airports from Quito and Guayaquil, transporting between 83-87 passengers per flight (SICGAL annual report 2011). It is expected that in 2012, approximately 2,870 (same as 2011) flights will carry over 200,000 visitors to the archipelago, in addition to residents traveling to and from the mainland ***(Table 1)***. Inter-island airlines have the capacity to provide over 50 passengers daily access from Baltra to Isabela and San Cristóbal Islands, which is augmented by multiple 18-26 passenger ferry boats that depart daily from local ports. In addition to cargo ships and ferries, increasing numbers of private yachts and tour boats circulate in and around the GMR, all with the potential to distribute introduced species.

Table 1 // TRAVEL TO AND BETWEEN THE GALÁPAGOS ISLANDS IN 2011.

Mode of Transport	*Number of Trips*
Commercial flights	2,870
Private flights	82
Inter-island flights	1,889
Cargo boat trips	224
Inter-island ferries	8,726
Privately-owned yachts and sailboats	326

Source: SICGAL annual report 2011

Tourists also exert pressure on already-strained local resources by creating a floating population in the archipelago. If 100,000 visitors remain in the islands for an average of seven days over the course of a year, for example, they are the functional equivalent of an additional 2,040 residents per day requiring food, water, energy and other commodities. ***Table 2*** summarizes the sharp growth in population and the associated demand for imported goods, since the 1970s.

Table 2 // SUMMARY OF GROWTH IN THE NUMBER OF RESIDENTS, VISITORS, PASSENGER FLIGHTS AND MARITIME CARGO ARRIVING TO THE GALÁPAGOS, 1970 TO 2010.

Year	*Residents*	*Visitors*	*Floating Visitor Pop* [1]	*Commercial Flights*	*Number Cargo Ships*	*Maritime Imports (Tons)*
1970	3,250	4,500	92	26	1	200
1980	6,201	17,445	356	89	2	833
1990	9,785	41,192	841	304	3	3,467
2000	15,003	68,856	1,405	1,033	5	14,423
2010	25,123	173,296	3,536	2,704	7	56,142

Sources: Zapata and Martinetti 2011, GNPS 2011, INEC 2010, SICGAL annual report 2010

[1] The floating visitor population is calculated by dividing the number of annual visitors by seven (assuming each visitor stays one week), and by seven again to calculate the number of visitors per year.

Although the annual rate of increase among the permanent island population has slowed in the last decade to 3.2-3.8%, it is still nearly twice that of the population growth rate on the mainland at 2.07% (INEC 2010). Such rapid growth in resident and visitor populations could mean that as soon as 2040, residents and visitors to Galápagos will require over 150,000-160,000 tons of imported goods per year, more than triple the demand today. This level of inputs not only overwhelms current port infrastructure, but also presents the greatest threat to the archipelago's ecosystems.

While the impacts that species introduced via cargo transport can have on the islands' native

flora and fauna are virtually limitless, "unseen" pests and plant diseases also affect the health and economic welfare of the resident human populations. Fresh produce is a known vector for plant diseases and soil nematodes, along with insects such as fire ants and fruit flies attracted to ships' external lights during nighttime travel. Two mosquito species (Aedes aegypti and Culex quinquefasciatus) were recently introduced to the islands, and are vectors for introduced pathogens that cause serious harm to humans and animals (Merlen 2009; Eastwood et al. 2011). Low compliance with, or inadequate application of, the required ship inspection/fumigation procedures increases the likelihood that diseases like West Nile Virus and avian influenza, to which native bird populations have little or no immunity, will arrive to the Galápagos in the coming years (UNESCO 2006). Avian malaria (Plasmodium relictum) has already been detected in the dwindling populations of Galápagos penguins (Gardener and Grenier 2011). In 2007 the UNESCO World Heritage Committee added Galápagos to the list of World Heritage Sites in Danger, the principle reason being the continued introduction of invasive species and the lack of effective controls. Although the decision was reversed in 2010 due to Ecuadorian government response, the Committee continues to monitor progress and will carry out a comprehensive evaluation in 2014.

MARITIME AUTHORITIES AND RESPONSIBILITIES

In 2005, INGALA conducted a study of the Optimum System for Maritime Cargo Transport to Galápagos (SOTMCG) to improve system deficiencies highlighted from the LOREG. ***Table 3*** provides a breakdown of responsibilities by institution.

Table 3 // SUMMARY OF INSTITUTIONS INVOLVED IN THE SOTMCG.

Institution	*Role*
Galápagos Governance Council (CGREG) – formerly INGALA	Provincial-level government entity established with the 2008 revised Ecuadorian Constitution to coordinate sustainable development in accordance with conservation in a World Heritage Site. Emphasizes the transparent management of environmental resources, assumes responsibility for urban and rural planning associated with the goals of the SOTMCG project, approved in 2008.
National Council of the Merchant Marine and Ports (CNMMP)	Develops and coordinates shipping policies at the national level, the highest marine advisory body to the Government of Ecuador.
National Directorate of Aquatic Spaces (DIRNEA)	Acting Maritime Authority of Ecuador and is responsible for political and strategic planning in maritime safety of life at sea and marine pollution issues.
Regional Island Directorate of Aquatic Spaces and the Coast Guard (DIRGIN)	Galápagos region entity that reports to DIRNEA. Principal office in Puerto Baquerizo Moreno on San Cristóbal Island, with Harbor Master's offices on the four remaining inhabited islands.
Ministry of Transportation and Public Works (MTOP)	Assumes all political and regulatory tasks related to the management of the maritime transportation sector (ports, crew and vessels), with the exception of safety issues, which remain under DIRNEA.
Agrocalidad-SICGAL	In charge of quarantine activities and preventing species introductions, this branch of Agrocalidad is considered the first barrier against the potential threats to the biodiversity of Galápagos.
Galápagos National Park Service (GNPS)	Reports to the Ministry of the Environment, in charge of protected area management, ensuring conservation regulations are observed. Monitoring and management of touristic and fisheries activities. The GNPS is the environmental authority of the province.
Galápagos Island Municipalities (Santa Cruz, San Cristóbal, and Isabela)	Control dock infrastructure and activities within maritime entry and exit points, including tourism (day tours, live-aboard cruise stop-overs, bay tours), inter-island transportation, and shipping.

In summary, there are eight institutions involved in the implementation of the SOTMCG, however, MTOP, and SICGAL will play increasingly principle roles in maritime biosecurity. In 2013, SICGAL will be converted into an autonomous biosecurity agency located under the Ministry of the Environment, alongside the GNPS once an amendment to the Galápagos Law is approved by Congress.

LEGAL FRAMEWORK REGARDING CARGO SHIPPING

Article 54 of the Special Law for the Galápagos (enacted in May 1998) assigned air and seaport inspection and quarantine controls to the Ecuadorian Ministry of Agriculture and Agrocalidad-SICGAL. Other laws and regulations apply to marine activities in and around Galápagos, including:

- Total Control of Introduced Species Act (RCTEI), 2003
- The National Port Administrative Act
- The General Law for Sea and Riverine Transport
- Aquatic Transport Strengthening and Development Act, and corresponding activities
- The National Port Activities Act

The RCTEI set regulations for cleaning, disinfection, and fumigation procedures to be applied on all vessels destined for Galápagos and charged SICGAL with ensuring that those requirements be met. All vessels were required to have disinfection certificates beginning in 2005. On July 22, 2005, the International Maritime Organization (IMO) approved Resolution MEPC.135(53) designating the Galápagos archipelago as a particularly sensitive sea, thereby creating further restrictions for the entrance of foreign vessels.

Since 2008, a variety of resolutions related to maritime travel, environmental security, and cargo shipping were passed within the acting Galápagos governance and maritime authorities (Appendix 1). The existing regulatory framework includes resolutions to mandate the use of approved shipping containers and port infrastructure (019/08), to require International Association of Classification Societies (IACS) Certification for cargo ships, IMO Marine Environment Protection Committee (MEPC) recommendations regarding ballast water management, and SICGAL certification for cargo ships (028/10), the application of bio-secure standards to Guayaquil´s docks and the initiation of studies for a new cargo loading site on the mainland (CSA 135-02), and new requirements for ship infrastructure designed to prevent the transfer of insects between the mainland and the archipelago (CSA 126).

WILDAID INVOLVEMENT IN BIOSECURITY

WildAid has provided technical assistance to the SOTMCG since 2009 and has been critical in laying the groundwork for the resolutions listed above. The SOTMCG project goals include:

1. Implementing biosecurity controls on ships and at ports (inspection procedures)
2. Requiring that ships comply with sanitary and technical regulations
3. Improving port infrastructure and inspection equipment on the mainland and on the islands
4. Raising community awareness of the health and environmental impacts of maritime cargo imports
5. Ensuring that products are safely delivered to island consumers
6. Confirming point of origin of all providers transporting goods to the islands

In 2010, in collaboration with the GNPS, CGREG, the SICGAL, and DIRNEA, WildAid directed a three-phase study designed to overhaul the current shipping model and elaborated a detailed action plan (Cervantes K., Rosero O., Martinetti M., Araujo E.) focused on the following four key components of the maritime quarantine chain:

1. Inspection and quarantine procedures
2. Dock/storage facilities in Guayaquil
3. Cargo vessels traveling to Galápagos
4. Dock facilities in Galápagos

BIOSECURITY & CARGO TRANSPORT TO THE GALÁPAGOS ISLANDS:

SYSTEM-WIDE ANALYSIS

INSPECTION AND QUARANTINE PROCEDURES

SICGAL inspectors at ports of departure on the mainland and arrival in the islands are the first line of defense in the mitigation of the risk of introduced species to Galápagos. This initial barrier is weak, given that all products are allowed to board ships in Guayaquil without previous quarantine sampling, inspection and treatment. Inspectors lack technologically advanced equipment, meaning that all tasks are performed manually and under the pressure to rapidly load and unload. Additionally, there are no official statistics that allow managers to classify the cargo, based on its type, nature, weight, origin, destination, and most importantly, association with specific biological threats.

In 2011, 803.4 tons of the top fresh food imports including potatoes, bananas, plantains, yucca, onions, among others, were sent to the islands on a monthly basis onboard cargo ships, and according to the institution's employees, ***only 1-2% was inspected upon departure or arrival. This is a direct result of a four-fold increase in cargo since 2000*** without an accompanying increase in SICGAL personnel. Based on the information in ***Table 4***, an alarming trend is observed in the difference in product retention numbers between cargo departure/arrival ports, and air departure/arrival ports. Only 5-10% of retentions occur at the cargo departure port in Guayaquil, which should be the first barrier for species introductions to the archipelago. The overwhelming majority of retentions are made upon arrival during the verification process, emphasizing the vulnerability of the system.

AEROSOL SPRAY / FUMMAGATION OF COMMERCIAL FLIGHTS MANDATORY SINCE 2006.

TABLE 4 // ORGANIC FOOD PRODUCTS AND PRODUCT RETENTIONS FROM MARITIME CARGO, 2009 – 2011 (SICGAL)

	2009	2010	2011
Tons of 16 most common fresh food products transported by ship	*7,811.2*	*7,581.7*	*9,640.9*
Total number of cargo ship voyages:			
Santa Cruz	*93*	*97*	*73*
San Cristóbal	*93*	*80*	*65*
Isabela	*40*	*61*	*38*
Floreana	*8*	*12*	*12*
SICGAL product retentions			
At cargo departure port (percent total)	*39 (11)*	*11 (3)*	*15 (5)*
At cargo arrival ports (percent total)	*324 (89)*	*348 (97)*	*281 (95)*
At air departure ports (percent total)	*962 (54)*	*1,191 (55)*	*1,163 (55)*
At air arrival ports (percent total)	*807 (46)*	*958 (45)*	*950 (45)*

Simply put, as trade increases in Galápagos, the system capacity to halt or detect the biological threats becomes totally overwhelmed. If current growth trends continue, by 2040, some 1,250 tons of organic cargo will require inspection every month. Inorganic materials traveling to Galápagos have also been identified as vectors for invasive species or classified as highly toxic materials including gas cylinders, beverage crates, fuel, and welding supplies. This assessment identifies five key components of SICGAL's structure and capacity that severely limit the organization's efficacy in cargo operations ***(Table 5)***.

Table 5 // SICGAL LIMITATIONS AND RELATION TO MARITIME CARGO SHIPPING.

SICGAL Limitation	*Description*
The number of SICGAL employees has not increased	Between 2002 and 2010, the number of SICGAL inspectors decreased by 25%, from 40 to 30. In that time span, cargo imports increased by 60%. Currently, 41 inspector`s are responsible for all air and seaports in the mainland and Galápagos Islands.
Inspectors do not have adequate training and automated equipment	No comprehensive capacity-building plan has been implemented to focus on strengthening inspection skills and knowledge. In a 2012 institution-wide evaluation, Guayaquil inspectors performed worse than their Galápagos counterparts despite having overall higher education levels (Appendix 2). Large port operations are equipped with facilities and machinery to aid in the inspection process. In the small area available to Guayaquil inspectors, there is no room for such equipment, or even inspection tables. Inspections are conducted by hand at the time of product arrival, and in the rush to complete loading, there is little emphasis on drawing inspection samples. Inspectors in Galápagos use only hand-held tools for verification of product content and sanitary conditions. They are not trained in entomology, and rarely can identify a potential biological threat. Legally established response procedures if a suspected pest is found are rarely carried out, creating the most critical failure in the Galápagos quarantine system, as any pest that boards the ship will be transported directly to island ports.
SICGAL is not an autonomous entity	According to SICGAL's technical advisor, David Cruz, the institution's greatest weakness is that it is one branch of a larger institution. SICGAL possesses the legal right to carry out inspection and quarantine procedures, but does not have access to financial resources to achieve its purpose. Currently, SICGAL does not have a unified checklist for arrival sanitary inspections of ships or cargo.
Knowledge is not transferred to new employees	Fewer than 10 of the current SICGAL employees were part of the organization a decade ago, and there is a strong correlation between the amount of time an inspector remains with the organization and their level of knowledge about current threats to the islands (Zapata 2006: 101). As with other Ecuadorian public institutions, budgets and staff are normally valid for one year only. Appointees to staff and administrative positions are frequently dictated by political decisions rather than operational goals or technical qualifications.

GUAYAQUIL DEPARTURE PORT OPERATIONS

Since the inception of SICGAL, three docks in Guayaquil have been used for the loading of cargo destined for Galápagos, with most traffic departing from the Caraguay dock. In 2010, with technical support from WildAid, the CGREG and MTOP outlined a plan for regulating cargo facilities and services in Guayaquil. By January 2010, the CGREG and WildAid invited the UNESCO World Heritage Committee to visit the facilities that were approved for Galápagos cargo operations, and to review a long-term plan for constructing a dedicated Galápagos maritime terminal in Guayaquil. Following the UNESCO report, MTOP applied international criteria for clean port operations, leaving only the Store Ocean terminal in operation. In 2011, with WildAid's assistance, the Ecuadorian government agreed to transfer a two-hectare site adjacent to Store Ocean for a specialized biosecure terminal, slated to begin construction by mid-2013.

Currently, food and other products are delivered to Store Ocean in private vehicles arriving on or just before the anticipated departure date. Vehicles are allowed to reach pier side without any control. This results in a chaotic cargo inspection, registration and loading process. The process is complicated by the lack of industrial cargo packing materials (containers and/or pallets). Most of the cargo is loaded as "loose cargo," in sacks, bags, or cardboard boxes. This compromises biosecurity departure controls, as loose cargo is especially vulnerable to damage. Stevedores, unregulated non-union dockworkers, carry out the bulk of loading operations through a direct arrangement with ship managers or merchants ***(Image 1)***.

Image 1 //
STEVEDORE LOADING POTATOES ONTO A CARGO SHIP USING WOODEN PLANKS.

The SICGAL inspector must declare that products loaded onto the ship have been inspected and comply with the list of approved containers – sealed boxes, crates, or plastics – for perishable items traveling to Galápagos. SICGAL obtains a list of the owners and recipients of all food products in transit to each island, the number of packages and total weight. This list is emailed from the Guayaquil cargo manifest to the corresponding island office. However, cargo that is to be paid for on delivery is not on the manifest, meaning that there is no register of it having been inspected prior to departure. In addition, covered storage available for SICGAL use is limited to an area six square meters, and throughout the week it is filled with non-perishable items such as cement and wood, so that food arriving later in the week is left outside, exposed to the elements. Wood used for bracing cargo on board is required to be fumigated, and inspectors spray it with aerosols in the open air.

In contrast, efficient ports utilize pallets as well as 40-, 20- or 10-foot metal containers to facilitate clean and safe loading. All cargo should arrive to the terminal at least one day in advance for quarantine procedures. To speed up heavy cargo manipulation, docks should have at least two cranes (10 to 40

tons). Currently, only the San Cristobal dock possesses one 10-ton crane, and only one cargo carrier to Galápagos uses smaller 10-foot containers. Industrial-quality packaging and product cleaning prior to packaging, are necessary aspects of a quarantine system. To this end, Lindblad Expeditions, a progressive Galápagos tourism operator, is already performing a pilot project on specific vegetables (mostly potatoes) that addresses both issues.

MARITIME TRANSPORT BETWEEN THE MAINLAND AND GALÁPAGOS

Currently, approximately 60,000 tons of goods are transported to Galápagos per year, by four ships ***(Table 6)***. In 2011, the seven ships listed in ***Table 8*** were in operation; however, under new requirements according to Resolution 028/10 and applied in January 2012, four of them have been removed from the fleet. According to one ship owner, the largest ships (the M/Ns Galápagos and San Cristóbal) are operating at 70%-75% of cargo capacity. The trip from Guayaquil to Galápagos takes 52-72 hours, depending on wind and currents. Inter-island travel takes place at night, with ships arriving at port in the early morning.

Table 6 // DETAILS OF THE SEVEN CARGO SHIPS SERVING THE GALÁPAGOS ISLANDS.

Ship name	*Galápagos*	*San Cristóbal*	*Floreana*	*Paola*	*Angelina*	*Virgen de Montseratte*	*Marina 91*
Owner	*Transnave*	*Galacargo*	*Galapagueña Corp*	*Galapagueña Corp*	*Opera 3*	*Arvitres*	*Navjero Insulares*
Length (m)	*74.7*	*67*	*74.8*	*52.1*	*58.9*	*46.3*	*50*
Width (m)	*14.2*	*10.4*	*6.7*	*8.6*	*11*	*8.6*	*8.6*
Cargo (tons)	*1,701*	*950*	*1,473*	*162*	*701*	*294*	*220*
# Fridge	*1*	*2*	*1*	*1*	*1*	*1*	*1*
# Freezer	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Passed SICGAL Standards	*Y*	*Y*	*Y*	*Y*	*N*	*N*	*Y*
Passed GNP Standards	*Y*	*Y*	*Y*	*Y*	*N*	*N*	*N*
Currently Operating	***Y***	***Y***	***Y***	***N***	***Y***	***N***	***N***

Ships carry on average 800-900 tons of goods per trip, the makeup of which is outlined in ***Figure 2***. Shipments contain an unorganized mixture of fresh fruits, vegetables, grains, beer crates, construction materials, furniture, fertilizers, vehicles, tires, and gas cylinders.

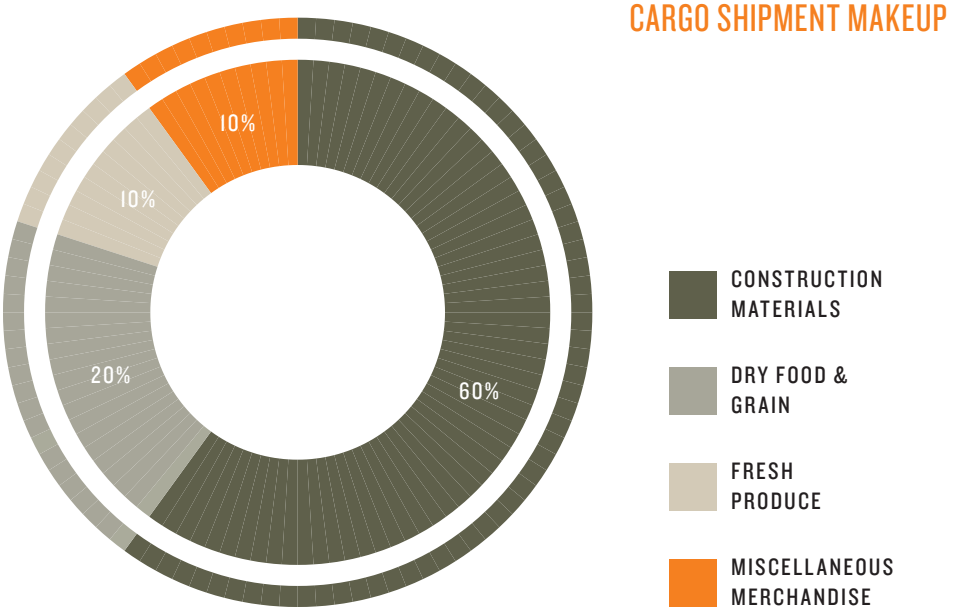


Figure 2 // BREAKDOWN OF CARGO CONTAINED IN A TYPICAL SHIPMENT TO GALÁPAGOS.

Gasoline is transported separately on a monthly basis ***(Image 2)***, Galápagos cargo ships make around 17 trips a year in 21-day itineraries that are regulated by the Ministry of Transportation ***(Figure 3)***. A three-island trip, therefore, means that by the time cargo reaches the most distant port of Isabela (about 12-13 days after departure from Guayaquil), products can be severely damaged. Ships are not obligated to insure the cargo they carry, and therefore are not responsible for losses or environmental liabilities associated with rotten organic goods (insects, bacteria, and other undesired species). As of October 2012, the CGREG and WildAid are preparing an environmental insurance requirement that will be applied to all cargo ships.

While legal requirements for cleaning and fumigation of cargo ships have been in place since 2005, SICGAL cites an early compliance of 30%. The application of SICGAL's 2009 certification system has improved compliance to 95% ***(Image 3-5)***.

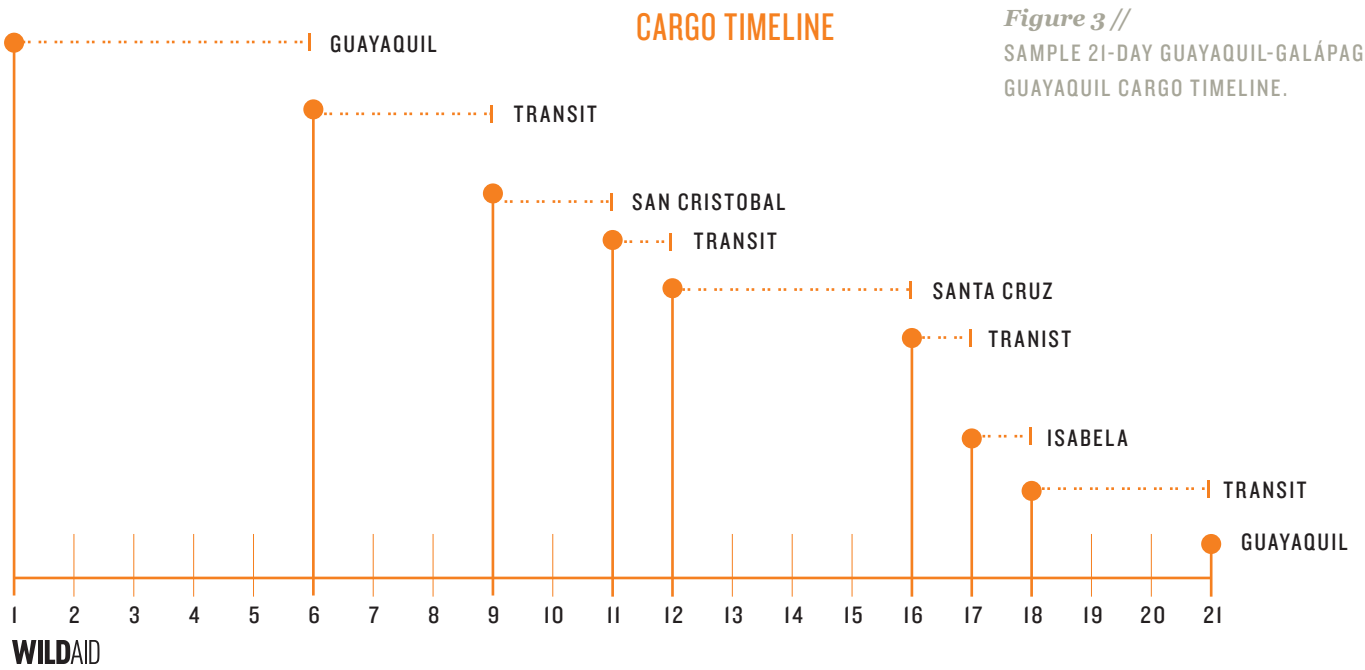


Figure 3 //
SAMPLE 21-DAY GUAYAQUIL-GALÁPAGOS-GUAYAQUIL CARGO TIMELINE.

Image 2 *// Bigue*
M/V PUNA UNLOADING FUEL AT PUERTO BAQUERIZO, SAN CRISTOBAL ISLAND.

Image 3 *// Brewington*
CARGO CONDITIONS AND HAPHAZARD STACKING OF CONTENTS.

Image 4 *// Brewington*
CARGO CONDITIONS AND HAPHAZARD STACKING OF CONTENTS.

Image 5 *// Brewington*
STANDING WATER ON CARGO DECK SERVES AS BREEDING GROUND FOR DISEASE VECTORS SUCH AS MOSQUITOES.

IMPORT OF LARGE PASSENGER TOURISM VAN

GALÁPAGOS ARRIVAL PORT OPERATIONS

Upon arrival to every island port, SICGAL inspectors and port authorities authorize the unloading of the ship and subsequent cargo activities.

UNLOADING

Following a brief visual inspection of ship conditions and cargo documentation by a SICGAL inspector and a Harbor Master official, unloading proceeds without SICGAL oversight. Santa Cruz receives approximately 61% of all cargo and unloading requires on average six days. On San Cristóbal, which receives 30% of cargo, unloading generally takes three days, and on Isabela unloading takes 1-2 days[2].

Cargo ships are equipped with a limited-capacity crane (10-20 tons) that is used to transfer pallets of cargo from the holds onto small wooden and metal barges ***(Image 6)***. The barges are privately owned and operated, with a carrying capacity of 2-6 tons. There are no regulations in place to inspect, clean, fumigate, or evaluate their safety and operational performance, and they are used to transport all cargo, from food to fuel. Generally, ships unload food and other organic products first, followed by construction materials, gas containers, and other non-perishable items. Cargo unloading in Galápagos normally takes place from 8:00 AM - 5:00 PM while most international ports operate on a 24-hour schedule.

[1] Figures determined from Harbor´s Master and SICGAL records of arrivals and departures between March and June 2012).

Each island possesses distinct unloading operations:

a. On San Cristóbal, cargo is palletized and unloaded by barge. Pallets are then transferred to a dedicated cargo unloading dock where a new crane and inspection station have been installed to facilitate rapid and safe cargo handling.

b. On Santa Cruz, cargo is transferred to barges and unloaded by hand at the dock, which has a limited and crowded area for cargo operations ***(Images 7 & 8)***.

c. On Isabela, barges arrive directly to the shore where they are unloaded by hand. Because Isabela's bay is undergoing a rapid sedimentation process, barges can only operate at mid or high tides ***(Image 9)***. In addition to cargo, the dock area receives traffic related to passengers, fishermen, livestock and fuel, elevating the risk of cross-contamination or accidents.

RETURN SHIPPING

There are no inspections of products that are shipped from the Galápagos to the mainland. After cargo is unloaded, the same barges used to transport food are loaded with garbage, recyclable material, and other potential contaminants for the return voyage ***(Image 10)***. Additionally, Galápagos police indicate that cargo ships are occasionally used to transport shark fins, sea cucumbers, and other marine resources to the mainland. Inspections of ship stores and holds prior to departure from the archipelago are cursory, as returning vessels are not considered a biosecurity risk.

Image 6 //
AN EMPTY CARGO BARGE.

Image 7 //
UNLOADING OPERATIONS AT SANTA CRUZ.

Image 8 //
UNLOADING OPERATIONS AT SANTA CRUZ.

Image 9 //
BARGES TRANSPORTING GASOLINE GROUNDED IN ISABELA'S BAY DURING LOW TIDE.

Image 10 //
RECYCLING AND TRASH THAT NEEDS TO BE RETURNED TO GUAYAQUIL.

BIOSECURITY & THE CARGO TRANSPORT SYSTEM TO THE GALÁPAGOS

PROJECTED POPULATION & TOURISM GROWTH

The Galápagos resident population annual growth rate has historically been twice that of the Ecuadorian mainland, and according to 2001 and 2010 census data, it remains very high, at 3.2%. Predictions for the next 30 years suggest that the Galápagos resident population could reach 60,000 ***(Figure 4)***.

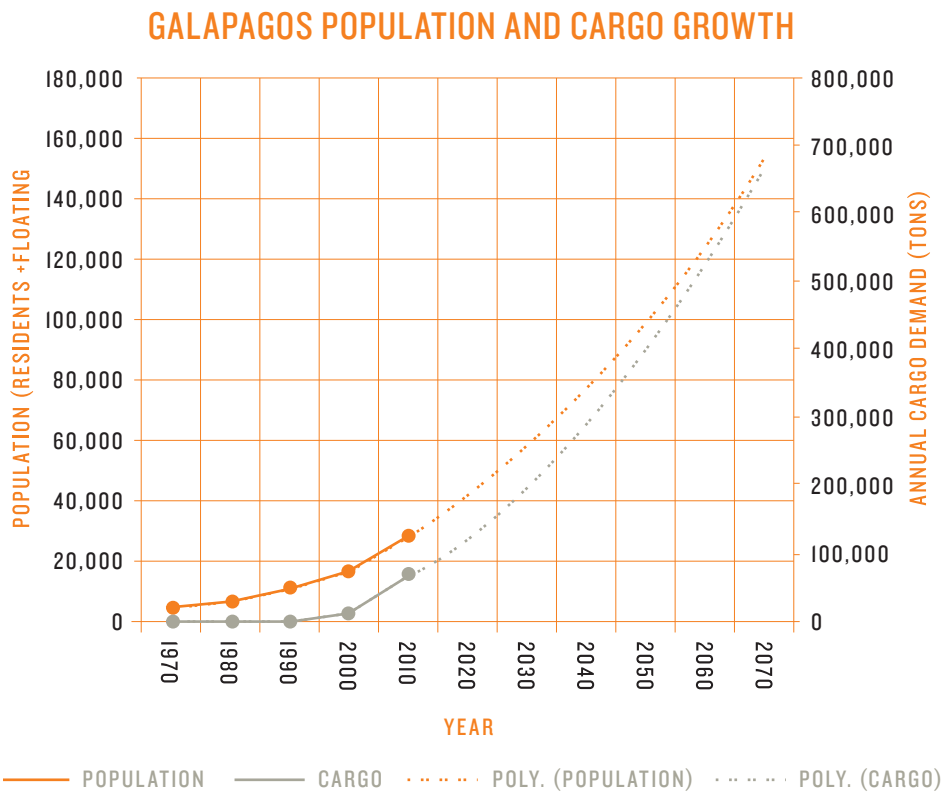


Figure 4 //
PROJECTED GROWTH IN THE GALÁPAGOS RESIDENT POPULATION THROUGH 2040.

THE QUARANTINE CHAIN 2012 // GALÁPAGOS

The floating population in Galápagos, made up of foreign and Ecuadorian visitors, could reach 900,000 per year by 2040 ***(Figure 5)***. This would equate to an additional 17,000 residents year-round, further straining the capacity of the maritime shipping system.

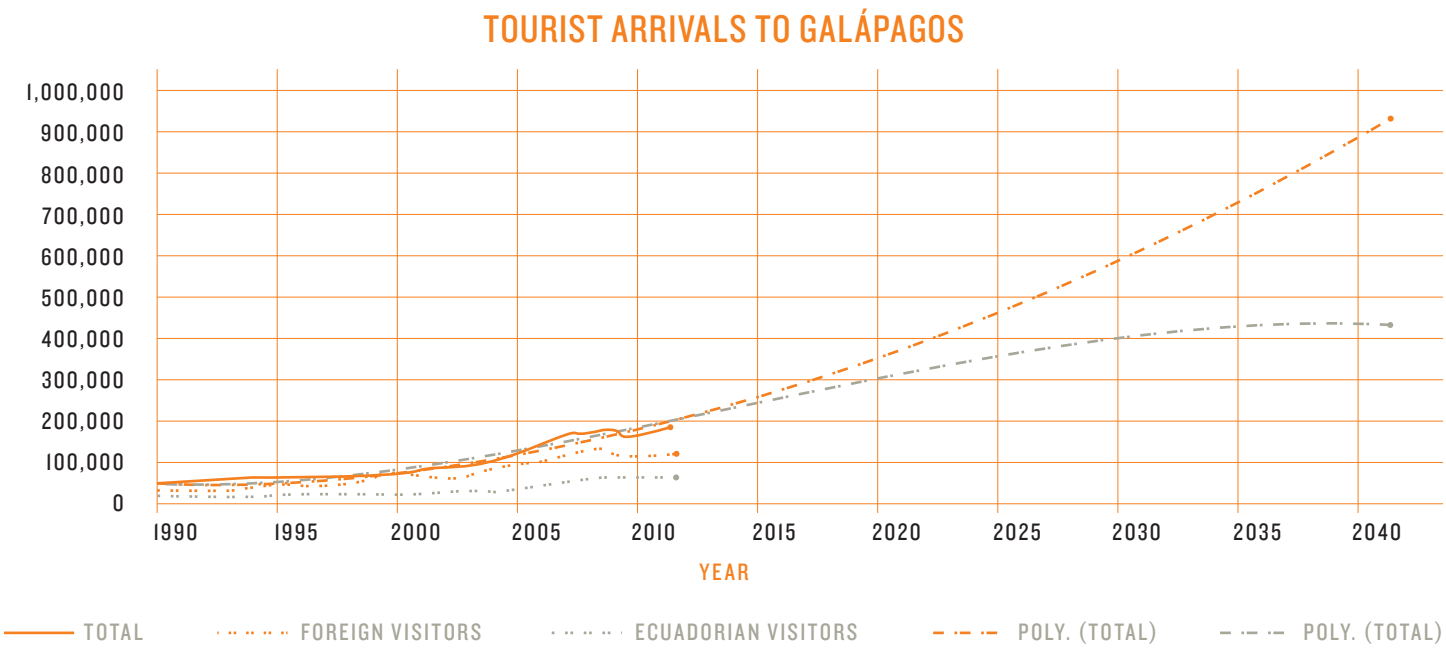


Figure 5 //
PREDICTED GROWTH IN THE GALÁPAGOS VISITOR POPULATIONS THROUGH 2040. SECOND-ORDER POLYNOMIAL (RED), AND THIRD-ORDER POLYNOMIAL (YELLOW).

PROJECTED CARGO GROWTH

If we assume that there is a direct relationship between population growth in Galápagos and the demand for imported cargo, we can predict the growth in maritime imports based on existing shipping and population data. For example, in 2010 we know that there were 28,659 inhabitants of the islands (permanent plus floating population), requiring approximately 56,000 tons of cargo.

$$Cargo_i = \frac{Population_i \times Cargo_{i-1}}{Population_{i-1}}$$

WHERE:

$Cargo_i$ = Volume of cargo for year$_i$
$Population_i$ = Population for year$_i$
$Population_{i-1}$ = Population for year$_{i-1}$
$Cargo_{i-1}$ = Cargo volume for year$_{i-1}$

The total estimated annual demand in 2040 will be approximately 150,000 tons, with the assumption that the associated population (permanent residents plus floating visitors) will be 75,000 ***(Table 7 & 8)***.

Table 7 // FORECASTED ANNUAL CARGO DEMAND (TONS) ALONGSIDE POPULATION GROWTH BY PORT.

		2010		2040	
Port	100%	Population	Cargo	Population	Cargo
		27,619	56,000	74,617	150,000
San Cristóbal	28.50%	7,871	15,960	21,266	42,750
Santa Cruz	61.50%	16,986	34,440	45,889	92,250
Isabela	8.50%	2,348	4,760	6,342	12,750
Floreana-Baltra	1.0%	276	560	746	1,500

Table 8 // FORECASTED MONTHLY CARGO DEMAND (TONS), BY PORT.

Year	*Guayaquil (100%)*	*San Cristóbal (28.5%)*	*Santa Cruz (61%)*	*Isabela (8.6%)*	*Floreana-Baltra (2%)*
2010	*4,500 - 5,000*	*1,425*	*3,050*	*430*	*100*
2040	*12,083 - 12,917*	*3,681*	*7,897*	*1,111*	*258*

CONGESTION ANALYSIS FOR CARGO TRANSPORTATION

In order to identify options for the future of Galápagos maritime cargo transport, the following key questions must be addressed:

- What are the indicator variables and their impacts such as ship size, cargo capacity, frequency of arrival, loading/unloading times, and cargo volume?
- Noting that the current system transports approximately 4,500-5,000 tons of cargo per month, what is the maximum amount of cargo that can be managed under existing conditions?
- When will the current system exceed its limit to provide adequate cargo volume to the Galápagos population?
- What are the impacts of modifying different variables for alternative cost/efficiency scenarios in the future?

To forecast cargo congestion, we use the Erlang formula, which calculates the blocking probability of an event on arrival to a system. It is assumed that arrivals follow a Poisson, or skewed-tailed, process and are independent of one another. If an arrival is not served immediately, it creates congestion. Poisson regression analysis is appropriate when the events are independent in the sense that the arrival of one will not make another more or less likely, but the probability per unit time of events is related to covariates such as time of day (Tadashi 2003). Poisson is also used for rate data, where event rates can be calculated as events per unit time, which allows the observation window to vary for each unit. For our purposes, the events are cargo ship arrivals, and predictors incorporated into the system include equipment, infrastructure, and procedures related to the shipping system (El-Naggar 2010). Annex 3 illustrates the itineraries of the four cargo ships that served Galápagos between March - June 2012 and demonstrates cargo ship congestion as a function of the frequency of arrivals to the different ports and the length of stay at each one.

In our analysis, Pb is the probability that a new ship arriving at a port is rejected, or blocked, because the available port is busy:

$$P_b = B(E,m) = \frac{\frac{Em}{m!}}{\sum_{1=0}^{i} \frac{E^i}{i!}}$$

WHERE:

P_b = the probability of blocking
m = the number of available ports (in this case, 1)
E = is the total amount of traffic, in Erlang units $E = \lambda * h$
λ = is the average number of ships arriving per unit of time (day)
$1/\lambda$ = is the average time of arrival of ships to port
h = the average stay in port

In modern port operations, the key factor for improving function and efficiency is h, the average stay at port. A system is considered stable when the arrival rate is less than the average stay at port.

Based on Appendix 3 data acquired for the four operating cargo ships over 117 days, we obtained the Erlang model parameters shown in ***Table 9***. The number of ships that arrive per day (λ) was calculated based on the actual arrivals per port, divided by 117. In order to have one ship in port at a time, as the system is designed to handle, we took the inverse of λ to determine the optimum arrival rate (1/ λ), or how many days should pass before a new ship can arrive to port to avoid congestion. The average stay (or loading/unloading time) for each ship in port (h) should therefore be less than 1/ λ, but as ***Table 11*** shows this is not the case in Guayaquil and Santa Cruz where both ports experienced congestion: days of operation when two or more ships were loading and unloading simultaneously.

Table 9 // ERLANG PARAMETERS CALCULATED FOR A 117-DAY PERIOD IN 2012.

Parameter	*Guayaquil (100%)*	*San Cristóbal (28.5%)*	*Santa Cruz (61%)*	*Isabela (8.6%)*	*Floreana-Baltra (2%)*
Number of ships/day (λ)	*0.1880*	*0.1709*	*0.1880*	*0.1368*	*0.1880*
Arrival rate (1/ λ)	*5.32*	*5.85*	*5.32*	*7.31*	*5.32*
Average stay in port (h)	*5.95*	*3.15*	*6.11*	*1.69*	*1.83*
Days of operation	*131*	*63*	*110*	*22*	*22*

Using these figures we calculated the remaining initial parameter values for the model:

- Total number of days sampled: 117 (3.9 months)
- Number of ships: 4
- Arrivals per month/number of ships: 1.41 (number of times each ship completes a circuit within a month)
- Time required for a complete circuit: 22 days (0.71 months)

The number of ships arriving per day, λ, is very low, indicating a "slow" system ***(Table 10)***. Meanwhile, the average stay in port per ship, h, is very high, indicating an inefficient system due to slow loading and unloading speeds. Each ship transports, on average, 886.36 tons per trip, and with four ships operating, 5.64 complete trips are made per month to accommodate all of the cargo. Under these conditions, when the cargo volume reaches 5,500 to 6,000 tons per month, which is forecasted by 2015, **a new ship will need to be added** to the fleet to meet the increased demand.

Table 10 // INITIAL ERLANG PARAMETERS CALCULATED USING DATA FROM 2011 AND 2012.

Parameter	*Guayaquil (100%)*	*San Cristóbal (28.5%)*	*Santa Cruz (61%)*	*Isabela (8.6%)*	*Floreana-Baltra (2%)*
Cargo/month (tons)	*5,000*	*1,425*	*3,050*	*430*	*100*
Cargo volume/ship (tons)	*886.36*	*277.88*	*540.68*	*104.81*	*17.73*
Total cargo/117 days	*19,500*	*5,558*	*11,895*	*1,677*	*390*
Total ship arrivals/117 days	*22*	*20*	*22*	*16*	*22*
Total ship arrivals/month	*5.64*	*5.13*	*5.64*	*4.10*	*5.64*
Days of cargo operation/117 days	*131*	*63*	*110*	*22*	*22*
Calendar days of operation	*117*	*63*	*110*	*22*	*22*
Calendar months of operation	*4.37*	*2.10*	*3.67*	*0.73*	*0.73*
λ, ships/day	*0.1880*	*0.1709*	*0.1880*	*0.1368*	*0.1880*
*Loading/unloading speed (tons/hour)**	*12.40*	*7.35*	*9.01*	*6.35*	*1.48*
h, average stay in port/ship (days/month)	*5.95*	*3.15*	*6.11*	*1.69*	*1.83*
h, average stay in port/ship (hours/month)	*142.91*	*75.60*	*146.67*	*40.62*	*44.00*
Number of trips/month	***5.64***				

**Unloading in Galápagos only takes place during normal business hours.*

As ***Table 9*** demonstrates, Guayaquil and Santa Cruz are already overloaded with arrival rates (1/λ) greater than the stay in port (h). Loading/unloading speeds are also extremely inefficient: 12.4 tons per hour in Guayaquil, with only 7.35, 9.01 and 6.35 in San Cristóbal, Santa Cruz, and Isabela, respectively. This is the main cause of the current system overload.

REQUIREMENTS FOR CARGO TRANSPORT SYSTEM IN 2040

We calculate the projected requirements for the maritime cargo transport system in 2040 using three different scenarios:

A. Port efficiency remains the same, but the number of ships increases;

B. Port efficiency in Guayaquil increases, but Galápagos port efficiency remains the same;

C. Guayaquil port efficiency increases, and Galápagos cargo is delivered to a single hub.

// SCENARIO A

For Scenario A, we apply the following assumptions to calculate the parameters presented in ***Table 11***:

- Cargo demand corresponds to the projected population (12,915 tons/month)
- Average ship capacity remains the same (886.36 tons)
- Speed of loading/unloading remains the same (between 1.5 and 12 tons/hour)
- Loading/unloading in Guayaquil and Galápagos takes place 9 hours/day
- Time to complete a single cargo rotation remains the same (22 days)
- Number of ships will be determined

According to ***Table 11*** calculations, 11 ships would be needed in order to accommodate the increase in cargo by 2040. This would cause extreme amounts of congestion at ports overwhelming the existing infrastructure.

Table 11 // ERLANG PARAMETERS CALCULATED FOR 2040: SCENARIO A

Parameter	*Guayaquil (100%)*	*San Cristóbal (28.5%)*	*Santa Cruz (61%)*	*Isabela (8.6%)*	*Floreana-Baltra (2%)*
Cargo/month (tons)	*12,917*	*3,681*	*7,879*	*1,111*	*258*
Cargo volume/ship (tons)	*886.36*	*277.88*	*540.68*	*104.81*	*17.73*
Total ship arrivals/month	*15.00*	*13.25*	*14.57*	*10.60*	*14.57*
λ, ships/day	*0.5043*	*0.4444*	*0.4872*	*0.3590*	*0.4872*
h, average stay in port/ship (days/month)	*5.95*	*3.15*	*6.11*	*1.69*	*1.83*
h, average stay in port/ship (hours/month)	*1,041*	*501*	*874*	*175*	*175*
Navigation time (hours)	*72*	*72*	*7*	*7*	*7*
Loading/unloading time (hours)	*143*	*76*	*147*	*41*	*24*
Number of trips/month	*15*				
Rotation time/ship (days)	***22***				
Number of trips/month	***11***				

// SCENARIO B

For Scenario B, we obtained data from the Port Authority of Guayaquil regarding optimum cargo loading and unloading speeds. According to their records, cargo that is packaged in 20 or 40-foot containers can be loaded/unloaded at 300 tons/hour, while loose cargo loading/unloading speeds are 40 tons/hour (per crane). In Galápagos, loose cargo loading rates range from 1.5 – 9 tons per hour. We apply the following assumptions to calculate the parameters presented in ***Table 12***:

- Cargo demand corresponds to the projected population (12,915 tons/month)
- Average ship capacity remains the same (886.36 tons)
- Speed of loading/unloading in Guayaquil's departure port is increased to 25 tons/hour. Loading/unloading speeds in Galápagos remain the same
- Loading/unloading in Guayaquil and Galápagos takes place 9 hours/day
- Time to complete a single cargo rotation will be determined
- Number of ships will be determined

According to ***Table 12*** calculations, Scenario B does not present a viable solution to the forecasted cargo demand, as 11 ships will still be required. The increased efficiency in the Guayaquil port does reduce the rotation time, but does not solve the greater congestion problem. It is evident that a viable solution will require increased efficiency at both ports in Guayaquil and Galápagos.

Table 12 // ERLANG PARAMETERS CALCULATED FOR 2040, SCENARIO B.

Parameter	*Guayaquil (100%)*	*San Cristóbal (28.5%)*	*Santa Cruz (61%)*	*Isabela (8.6%)*	*Floreana-Baltra (2%)*
Cargo/month (tons)	*12,917*	*3,681*	*7,879*	*1,111*	*258*
Cargo volume/ship (tons)	*886.36*	*277.88*	*540.68*	*104.81*	*17.73*
Total ship arrivals/month	*15.00*	*13.25*	*14.57*	*10.60*	*14.57*
λ, ships/day	*0.4860*	*0.4416*	*0.4858*	*0.3533*	*0.1246*
Loading/unloading speed (tons/hour)	*25.00*	*7.35*	*9.01*	*6.35*	*1.48*
h, average stay in port/ship (hours/month)	*2.95*	*3.15*	*5.00*	*1.38*	*1.00*
Navigation time (hours)	*72*	*72*	*7*	*7*	*7*
Loading/unloading time (hours)	*71*	*76*	*147*	*41*	*24*
Number of trips/month	*15*	*13*	*15*	*11*	*15*
Rotation time/ship (days)	*20*				
Number of trips/month	***11***				

// SCENARIO C

In order to create a system that can handle the projected cargo demand for 2040 using ships of the same size as today, improvements must be made to Galápagos port infrastructure. The institutions involved with the SOTMCG have discussed the possibility of creating a single port in the Galápagos, likely on Santa Cruz Island, for the receipt of all cargo. After cargo is inspected and unloaded, self-propelled barges would distribute cargo to San Cristóbal, Isabela, and Floreana Islands. To calculate cargo system demands based on this third scenario ***(Table 13)***, we apply the following assumptions:

- Cargo demand corresponds to the projected population (12,915 tons/month)
- Average ship capacity remains the same (886.36 tons)
- Speed of loading/unloading in Guayaquil's departure port is increased to 25 tons/hour. Loading/unloading speed in the single Galápagos hub is 25 tons/hour
- Loading/unloading in Guayaquil and the single Galápagos hub takes place 24 hours/day
- Time to complete a single cargo rotation will be determined
- Number of ships will be determined

Table 13 // ERLANG PARAMETERS CALCULATED FOR 2040, SCENARIO C.

Parameter	*Guayaquil (100%)*	*Galápagos Hub (100%)*
Cargo/month (tons)	*12,917*	*12,917*
Cargo volume/ship (tons)	*886.36*	*886.36*
Total ship arrivals/month	*15.00*	*15.0*
λ, ships/day	*0.4860*	*0.4860*
Loading/unloading speed (tons/hour)	*25.00*	*25.00*
h, average stay in port/ship (hours/month)	*1.48*	*1.48*
Navigation time (hours)	*72*	*72*
Loading/unloading time (hours)	*36*	*26*
Number of trips/month	*15*	*15*
Rotation time/ship (days)	***9-10***	
Number of trips/month	***5***	

According to ***Table 13,*** Scenario C does provide a viable alternative for the maritime cargo system as the creation of a hub terminal and faster loading/unloading speeds would dramatically increase the efficiency of the system without requiring investment in more ships. However, this scenario would require 24 hour/day port operations and would involve substantial investment in port infrastructure in both Guayaquil and Galápagos. Investment in subsidiary island ports would also be needed to increase efficiency. One Guayaquil and Galápagos hub terminal also permits the concentration of quarantine controls/resources.

OPTIMUM CARGO VESSEL SIZE

The next issue to be addressed is the appropriate size of cargo ships. Currently cargo ships have a maximum cargo capacity of 1,400 to 1,500 tons. We will use this profile to determine whether five ships can handle the forecasted 2040 growth in cargo.

Table 14 // ESTIMATED NUMBER AND CAPACITY OF VESSELS TO MEET GALÁPAGOS CARGO DEMAND BY 2040.

Parameter	*2012*	*2040 Minimum*	*2040 Maximum*	*Observations*
Number of ships	*4*	*5*	*5*	
Cargo capacity/ship (tons)	*1,200*	*1,400*	*1,500*	*Keeping the same type of ship as today*
Turn around time (weeks)	*3*	*1.43*	*1.43*	*21 days (current), 10 days (optimum)*
Number of annual trips/ship	*17.33*	*36.36*	*36.36*	
Number of annual trips (total)	*69.33*	*181.82*	*181.82*	
Estimated cargo capacity (tons/year)	*83,200*	*254,545*	*272,727*	
Percent occupancy	*75%*	*75%*	*75%*	
Actual cargo capacity (tons/year)	*62,400*	*190,909*	*204,545*	
Cargo demand (tons/year)	*60,000*	*150,000*	*160,000*	*Current and projected cargo volume*

According to ***Table 14***, five ships with 1,400-1,500 tons of cargo capacity will be sufficient to sustain 150,000 tons of cargo.

MARITIME TERMINALS AREA REQUIREMENTS

Future area requirements for cargo terminals must also be calculated according to the number of tons that each one will receive during unloading operations. The minimum terminal operation areas for the Galápagos quarantine chain are calculated in ***Table 15***.

Table 15 // ESTIMATED CARGO TERMINALS OPERATIONAL AREA TO MEET GALÁPAGOS CARGO DEMAND BY 2040.

Parameter	*Criteria*	*Guayaquil*	*Hub*	*San Cristóbal*	*Santa Cruz*	*Isabela*
Cargo load per trip and Destination		*1,400*	*1,400*	*399.0*	*7879.4*	*1,110.9*
Unloading speed		*40.00*	*40.00*	*15.00*	*15.00*	*15.00*
Cargo handling space	*2x Cargo per Trip*	*2,800*	*2,800*	*798.0*	*1,708.0*	*240.8*
Storage space	*Tons x 3m²*	*8,400*	*8,400*	*2,394.0*	*5,124.0*	*722.4*
Trucks in cargo area		*3*	*3*	*2*	*2*	*1*
Trucks in waiting area		*6*	*8*	*4*	*4*	*2*
Trucks Loading area m²	*50m²/truck*	*150.00*	*150.00*	*100.00*	*100.00*	*50.00*
Trucks waiting area m²	*50m²/truck*	*300.00*	*400.00*	*200.00*	*200.00*	*100.00*
Quarantine area m²	*10% of cargo x 3m²*	*840.00*	*840.00*	*239.4*	*512.40*	*72.24*
Operations Offices area	*m²*	*500*	*500*	*150*	*150*	*150*
Cargo reception/inspection area	*m²*	*1,500*	*1,500*	*150*	*150*	*150*
Required Operational area	***m²***	***11,690***	***11,790***	***3,233.4***	***6,236.4***	***1,244.6***
Required Administrative area (*)	***m²***	***17,535***	***117,685***	***4,850.1***	***9,354.6***	***1,867.0***
TOTAL Area Required	***m²***	***29,225***	***29,475***	***8,083.5***	***15,591.0***	***3,111.6***

(*) Administrative Area: Parking lots, roads, sidewalks, garbage disposal, quarantine, specialized cargo (that requires separation), SICGAL &Terminal offices, perimeter protection, etc.

According to ***Table 15***, the minimum terminal area for Scenario C requires 2.9 hectares at both the Guayaquil and Galápagos hub terminals. Based on this calculation, we cannot place the Galápagos hub terminal within already constrained urban areas, but must select a site that possesses sufficient area as well as maritime and terrestrial access pathways.

THE QUARANTINE CHAIN 2012 // GALÁPAGOS

SELECTING A CARGO HUB

Oceanographic & atmospheric conditions pose difficulties for port development in Galápagos. With the exception of San Cristóbal, Galápagos ports are not located in optimum leeward regions of the islands ***(Figure 6)***. For the construction of a new port of any size, this should be a basic condition unless port protection infrastructure (i.e. breakwater barriers) is developed, which would not be environmentally viable in the Galápagos.

Other factors that must be considered when selecting an appropriate site for building a maritime port are:

- Anchorage space is needed to host up to two cargo ships at a recommended depth between 8 and 12 meters at low tide
- Low tide depth at pier side a minimum 5 meters
- Terminal should have existing road access or a nearby road
- Low or no sedimentation at the pier and surroundings (access channel)
- Low or no port protection developments required
- Wave height ~ 0.5m
- Current intensity and direction not to affect ship docking and operations alongside ship
- Wind intensity and direction not to affect ship docking and operations alongside ship
- Inland space area for cargo handling, according to a 50 years growth projection
- Minimal to no impact on protected areas

Given the analysis of the aforementioned factors and island coastlines, we recommend the northern coast of Santa Cruz (Itabaca Channel) as an appropriate sector for a Galápagos hub port facility ***(Figure 7)***. However, this recommendation is preliminary and would require further studies, such as oceanographic, atmospheric, geological, hydrographic, and environmental impact.

Figure 6 //
PREDOMINANT WIND AND OCEANIC CURRENT DIRECTIONS IN THE ARCHIPELAGO.

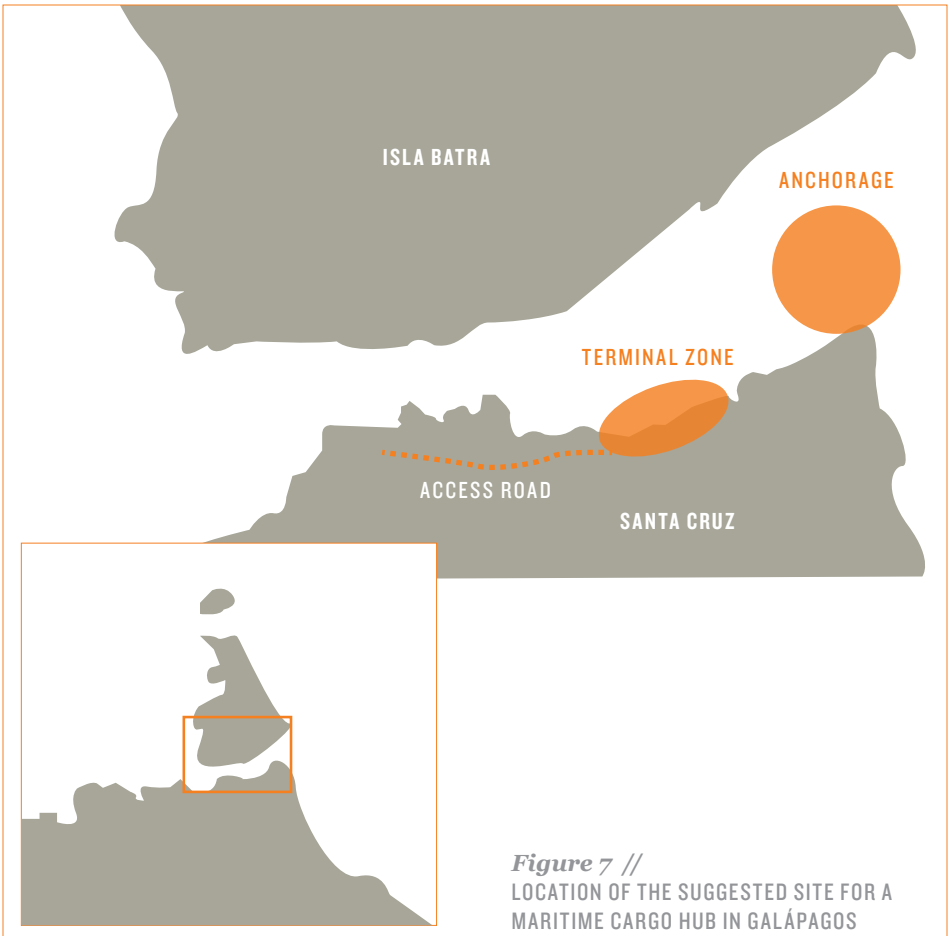


Figure 7 //
LOCATION OF THE SUGGESTED SITE FOR A MARITIME CARGO HUB IN GALÁPAGOS

PORT INFRASTRUCTURE INVESTMENT ESTIMATES

Our initial congestion analysis resulted in three possible scenarios: two of which would require the operation of eleven vessels to handle the forecasted cargo increase and one in which only five vessels were needed. We will demonstrate that Scenario C is the ideal option as the infrastructure development required for the operation of eleven vessels is far more expensive and ultimately there is not enough area available for multiple terminals, berths and/or piers. We return to the Erlang formula for determining the required number of docks. If we apply a 15% referential probability of finding an occupied dock, we can determine the required number of docks for Scenarios B and C.

Table 16 // DOCK AND BERTH REQUIREMENTS FORECAST BY 2040.

Location	*Scenario*	*TM per month*		*λ*	*h*	*Number of Berths or Docks*
		2011	*2040*			
Guayaquil	Scenario B. 2040	5,000	12,917	0.4860	2.95	3
	Scenario C 2040	5,000	12,917	0.4860	1.477	1
P. Baquerizo	Scenario B. 2040	1,425	3,681.35	0.4416	3.15	2
P. Ayora	Scenario B. 2040	3,050	7,879.37	0.4416	6.11	4
Destino: P. Villamil	Scenario B. 2040	430	1,110.86	0.3533	1.69	1
HUB Port	Scenario C, 2040	n.a.	12,917	0.4860	1.477	1

According to ***Table 16***, there are major investment differences when comparing Scenarios B and C. It is clear that Scenario B would require investments for multiple docks whereas Scenario C would only require one terminal at both Guayaquil and Galápagos.

Estimated costs for infrastructure and development are shown in ***Table 17***. The figures presented here are not one-time investments, but rather refer to a 5-7 year period.

With respect to Scenario B, investments will be required for three additional port facilities in Guayaquil, seven additional cargo boats, and new port facilities in both Santa Cruz and Isabela Islands, with related access routes and equipment needs, such as cranes, forklifts, and platforms for a total cost of around $50 million. In addition, Scenario B would require additional docking sites for the increased number of cargo vessels. With the construction of a single Galápagos receiving hub in Scenario C, most existing dock facilities and cargo boats can be salvaged and augmented with the necessary equipment for a projected $33 million. This option also requires the implementation of an inter-island transportation system using self-propelled barges.

All of the above calculations are initial projections, and the design of any maritime terminal as well as the definition of the needed barges will require specific and detailed studies. For example, detailed cargo statistical sampling and registers for all shipments are needed for infrastructure and equipment planning.

Table 17 // ESTIMATED FACILITIES & INFRASTRUCTURE COSTS TO MEET GALÁPAGOS CARGO DEMAND BY 2040.

Investment	*Unit Cost*	*Scenario B*	*Scenario C*
		Qty	*Qty*
Dock construction (Guayaquil)	$7,000,000	*3*	*1*
New dock equipment (Guayaquil)	$1,200,000		1
New dock construction (Galápagos hub)	$9,000,000		*1*
New dock equipment (Galápagos hub)	$1,200,000		*1*
New access road Galápagos hub (2.5 km)	$5,000,000		*1*
Cargo boat (additional)	$1,800,000	*7*	*1*
New dock construction (Santa Cruz)	$4,000,000	*1*	
New access road Santa Cruz (2 km)	$4,000,000	*1*	
New dock construction (Isabela)	$4,000,000	*1*	
Existing dock amplification (San Cristóbal)	$1,000,000		*1*
Dock equipment (San Cristóbal)	$500,000	*2*	*1*
Existing dock amplification (Santa Cruz)	$2,200,000		*1*
Dock equipment (Santa Cruz)	$1,000,000	*2*	*1*
Existing dock amplification (Isabela)	$1,250,000		*1*
Dock equipment (Isabela)	$600,000	*1*	*1*
Existing dock amplification (Floreana)	$800,000	*1*	*1*
Dock equipment (Floreana)	$500,000	*1*	*1*
Total		***$50,500,000***	***$33,050,000***

SUMMARY OF RISKS & RECOMMENDATIONS

In spite of a growing recognition within the Galápagos conservation and scientific communities regarding the threats associated with maritime transport of cargo to the archipelago, it remains the primary risk factor for the undetected entry of plants, insects, animals, and other organisms. This situation is complicated by the forecasted cargo growth that will overwhelm existing physical capacities. Partial solutions could worsen existing problems and infrastructure and investments should be considered based on projections for a minimum of 30 years.

The institution in charge of inspection and quarantine procedures at departure and arrival ports, SICGAL, is largely unable to perform its duties due to a reduction in personnel, a general lack of knowledge and training, lack of control over financial resources, and high institutional turnover. Current shipping regulations and their corresponding inspection criteria are not sufficient to control the introduction of non-native species via maritime cargo. Although new regulations regarding ship safety were incorporated into law in 2009, and the requirement of a Galápagos Operations Permit was added in 2011, the situation of the shipping terminals – particularly the embarkation point in Guayaquil – has not been resolved. Dock facilities in Guayaquil, slated for renewal in 2013, remain substandard for carrying out the necessary inspection and quarantine procedures of cargo and containers prior to departure. The cargo ships currently operating within the GMR are IACS certified, but periodic inspections must be set in force to confirm their compliance.

With the rapid growth of the islands' residents, visitors, and associated import demand, past quarantine legislation is unlikely to be effective in addressing future threats. As a result, WildAid has provided a series of policy and management recommendations for the four primary aspects of cargo transport:

1. Inspection and quarantine procedures
2. Dock facilities in Guayaquil
3. Cargo vessels traveling to Galápagos
4. Dock facilities in Galápagos.

INSPECTION AND QUARANTINE PROCEDURES

THE PROBLEM	RECOMMENDATION
Low Number of Inspectors	
Since 2002, the number of SICGAL inspectors has not kept up with the growth in cargo. The Guayaquil maritime port is severely understaffed, and inspectors must rotate between the air and sea ports.	SICGAL technical coordinator David Arana believes that the institution needs at least 50% more inspectors at each port by 2014, if they receive autonomy and/or funding in the coming transition into a bio-security agency. Additional staff will need to be concentrated at the Galápagos hub port if this scenario is followed. Otherwise SICGAL should refocus funding from Galápagos-based monitoring programs to the port in Guayaquil.
Inadequate Training and Equipment	
Inspectors are not trained in entomology, and rarely can identify insect species that could pose a significant risk to the islands. Due to the compressed timeframe during loading/unloading operations, less than 2% of organic products are physically inspected. Inspections are not carried out under safe operating conditions for SICGAL personnel, particularly during unloading operations. Inspection equipment is outdated and insufficient for carrying out legally established response procedures.	An entomologist or a highly trained monitoring technician is needed on every inspection for real-time analysis of insects collected. Inspectors in Guayaquil must be trained to follow established criteria in Resolution No. CSA-126-2010 before authorizing ships to depart. Inspection tables, x-ray machines, and handheld equipment is necessary to conduct the 20% of product inspections recommended by the US Department of Agriculture. Inspectors in Galápagos need a minimum of two hours to complete a full ship inspection, which should be carried out in all areas of the vessel at the discretion of the inspector instead of the captain or a member of the crew. Inspectors should be equipped with appropriate protective clothing, and must have the authority to delay all operating procedures until the inspection is complete. The following minimum equipment should be required: • Insect aspirators (handheld and backpack) • Waterproof notebooks • Collection kitsw • Digital camera • Waterproof boots with hard soles and steel toes • Hardhats • Headlamps or flashlights • Waterproof jackets or coveralls • Reflective vests • 2-way handheld radios • Flashlights • Multi functional knife
SICGAL Lacks Autonomy	
SICGAL has the legal right to carry out inspection and quarantine procedures, but does not have access to financial resources to achieve its purposes.	LOREG revisions include the establishment of a Galápagos Biosecurity Agency, located under the administration of the Environmental Ministry, and which is expected to perform the functions of SICGAL with institutional independence, sanctioning authority and financial autonomy.
Low Knowledge Transfer	
SICGAL has high turnover among inspectors, supervisors, and technical coordinators. Training programs are not continuous; knowledge is not transferred to new employees.	The latest standard operating protocols were revised in 2006, and are rarely applied due to the complexity and length of the documentation. Existing protocols need to be revised and updated to include inter-institutional coordination for facing multiple threats, and the use of modern equipment. A streamlined reference catalog should be developed to facilitate rapid application in field operations. A comprehensive training program for a minimum of three years should be defined and executed, subject to bi-annual evaluations. WildAid initiated such a program in 2012.

MARITIME TERMINAL AND DOCK FACILITIES IN GUAYAQUIL

THE PROBLEM	RECOMMENDATION
Unsanitary Dock Conditions	
The current dock being used for cargo transport in Guayaquil (Store Ocean) does not meet minimum biosecurity, health or safety requirements for the preparation of vessels and cargo destined for the Galápagos Islands.	With the recent acquisition of a two-hectare area next to Store Ocean, a shipping and cargo inspection facility must be created to comply with biosecurity, health and safety standards. A cargo registration process must be performed in order to obtain a complete sample of the goods being sent to the islands, and classify them according to type, weight, origin, and association with invasive species for which they act as vectors. A decision-making database should be generated for cargo reception.
Fumigation Procedures	
The required fumigation procedures prior to departure are not adequate to eliminate insects, nor are they applied in all areas of the ship.	Fumigation providers should use a dry air fogging method for insect control, rather than the pump application presently employed. It is impossible to adequately fumigate a ship that has already been loaded with cargo, in the event that it arrives to Galápagos without proper documentation. Fumigation should include living quarters, galley and holds. Although chemical methods may limit the establishment and spread of some pests, all ships should be thoroughly cleaned and disinfected prior to every departure as a basic operating procedure.
Loading Operations Limitations and Risks	
Traps designed to detect insects among cargo destined for Galápagos are underutilized, primarily because ships are hastily loaded to minimize dock fees. Loading operation is overwhelmed (loading time is longer than the arrival time of the next ship). Transportation system will not be able to cope with cargo demand in Guayaquil. Cargo docks are easily accessed by merchants.	Organic cargo should be cleaned on-site and packaged in approved containers prior to its embarkation. UV radiation should be applied during quarantine before cargo is loaded onto the ship (at least 24 hours in advance), during which time permanent traps can also be used to monitor the presence of hazardous insects. To streamline the loading process, treatments should be applied overnight. Terminals must have 2 – 20 ton cranes to cope with the current cargo demand. In the future, 20-ton cranes will be required in order to manage containers. Cargo loading speeds should be a minimum of 25 tons/hour. Stevedore services must be organized according to national regulations applicable to port services operators.
Cargo Packaging and Authorization	
Cargo packaging does not meet legal container requirements, and inspectors overlook this and other infractions under instructions from the Harbor Master to allow merchants to load their products.	Organic products should be packaged according to regulations both to facilitate rapid inspection procedures and to minimize contamination risks by certain products. Pallets, preferably made of plastics, should always be used. The system should migrate to containers over the long term, once all terminal facilities and infrastructure are available. Containers should be of the controlled atmosphere type in order to keep biological risks to a minimum in transit. The conversion of all shipments to Galápagos to the use of containers would increase the safety, efficiency and coordination of nearly every aspect of maritime cargo transport and biosecurity control.

Continued

MARITIME TERMINAL AND DOCK FACILITIES IN GUAYAQUIL *Continued*

THE PROBLEM	RECOMMENDATION
Ship and Hull Conditions	
Hull inspections and cleaning regiments are not currently being carried out at regular intervals, due to a lack of personnel and poor visibility in the waters surrounding existing cargo docks. Cables that connect cargo ships to the dock are vectors for introduced species to board the ship. Anchors and chains can facilitate the transport of starfish and crustaceans to the islands. Living quarters, galley, holds, bilges and ballast tanks can represent additional biological or chemical threats.	Facilities and inspection protocols should be upgraded to comply with criteria established in Resolution No. 28-2010 to prevent marine environmental contamination. SICGAL and MTOP inspectors must be trained to perform hull inspections prior to ship departure and to recognize unlawful conditions that pose potential threats to the Galápagos marine environment. The Coast Guard, the Ecuadorian National Police, SICGAL and the GNPS should coordinate to perform ship and cargo inspections at departure and arrival points.

CARGO TRANSPORT TO GALÁPAGOS

THE PROBLEM	RECOMMENDATION
Environmental Exposure in Transit	
The two to three day voyage to Galápagos from Guayaquil, and prolonged inter-island transport, provides ample time for seeds to germinate and for larvae to mature or hatch. Food products stored outside of refrigerated containers also deteriorate during this time.	Increased efficiency of loading and, particularly, unloading operations in Galápagos ports will dramatically reduce product deterioration during transit. Perishable items should reach local markets no more than seven days after loading in Guayaquil. Compliance with product packaging requirements further minimizes biological risks, as does proper refrigerated storage.
Unregulated Ship Lights	
Flying insects are attracted to ship lights during nighttime travel, increasing the risk of contamination by mosquitoes and the arrival of infectious diseases.	All ships are now required to utilize UV lamps that minimize this risk; however, ship compliance with required upgrades needs to be enforced. While UV lights restrict the arrival of some insects, other measures must be taken to avoid their attraction, including sealed and climate-controlled storage of food and beverages used during the voyage.
Unsanitary/Unsafe Deck Conditions	
Stagnant water and open garbage containers on board the ship are breeding grounds for insects, in addition to presenting a human health hazard. Cargo is stowed in walkways and other open spaces, preventing passage in the event of an emergency.	The transition to an IACS-certified cargo fleet should reduce the crowded and unsafe cargo storage conditions found on some of the ships that are currently operating, while regulating garbage disposal and containers. Ship inspectors should not authorize the departure of a ship from Guayaquil without ensuring that it meets requirements for safe and sanitary cargo transport.
Products in Mixed Storage	
The mixed storage of food products among building materials, wood, gas containers, tires, and other merchandise increases the risk of species cross-contamination. Because certain products are scarce in Galápagos, residents consume those that arrive even damaged or contaminated, posing a human health risk and increasing the probabilities of generating a biological hazard. Gas containers and beer crates in particular are known vectors for insects that can be transferred to food containers during the ship's voyage.	In the long term, all ships should be capable of loading and unloading cargo packed in full- or half-size containers. Meanwhile, an immediate shift to pallets should be required. The use of containers will not only increase the turn-around time for unloading in the islands, thereby increasing the time to market for perishable products, but will also limit damage and exposure of those products to the elements during transit. Prior to container sealing, disinfection of the inner cargo must be performed.
Wastewater, Bilges, and Ballast Water Contamination	
Ballast water is a vector for the transport of invasive marine species. Bilges discharge within harbor zones is a common infraction. Wastewater treatment plants are often inoperative or malfunction, generating microbiological risks when discharged directly in closed waters or near the coast	Periodic sampling of ballast waters shall be performed in order to confirm the absence of contamination or pollution risks. Ballast waters should be replaced 20 nautical miles before arrival to the Galápagos. Bilges should be empty and dry once ships arrive to the first port of call in Galápagos. Inspectors must confirm that wastewater treatment equipment is 100% operational and crew is capable of correct operation.

DOCK FACILITIES IN GALÁPAGOS

THE PROBLEM	RECOMMENDATION
System Capacity Collapse	
Santa Cruz cargo handling capacity has been surpassed, with unloading time taking 6.11 days, while a new ship is arriving every 5.32 days.	An immediate plan to stabilize cargo-handling capacity is required. A professional port cargo services operator is recommended, as well as a renovation of the existing dock and the inclusion of cranes. These actions must be taken in the year 2013, as cargo growth will make this problem unmanageable on Santa Cruz.
Loose Cargo, Loading and Unloading Operations	
Inspectors ignore obvious violations of shipping regulations and do not insist on having access to all areas of the ship.	The CGREG must require that all involved entities coordinate inspections at arrival to the first port of call in the Galápagos region. Inspections at other ports could be performed on a random basis in order to detect other irregular activities.
Documentation of the inspection does not cover all relevant details of ship operation and cargo transport.	Inspectors must adhere to checklists and be ready to quarantine, or in some cases, deny, off-loading if cargo and ship regulations are not met. This requires a clear definition of SICGAL's authority and institutional capacity, including assurance that an inspector's job security is not threatened by pressure from other institutions involved in maritime operations.
Illegal transport conditions such as damaged or dirty cargo, standing water, open garbage, and inspectors ignore unsanitary handling procedures.	SICGAL must call for the support of other maritime and civilian authorities when irregular situations are detected. Problems such as drug trafficking, illegal migration, safety threats, pollution, etc., call for multi-lateral support.
Because cargo is unloaded in haste, products destined for one island may be mistakenly left on another, causing merchant losses in time and profits.	The time required for a thorough inspection should be included in standard cargo off-loading procedures, with a two hour minimum to facilitate inspection of all areas of the ship – especially those that are not traditionally used for cargo storage.
There is not a complete cargo manifest for ships leaving ports.	SICGAL & MTOP must generate a complete cargo manifest for all ships prior to departure.
Narcotics and wildlife are being trafficked aboard cargo vessels.	There is a need for narcotics inspections at departure and arrival using sniffer dogs.
Overall Port Operations Performance	
Cargo is transferred from ship to dock without supervision, in barges that are not sanitized or inspected.	The barges must be incorporated into SICGAL's inspection system. Municipal employees should supervise off-loading procedures to ensure port infrastructure is utilized correctly and safely.
With the exception of San Cristóbal, unloading facilities are the site of a chaotic mix of activities creating operational hazards and the potential for cross contamination.	On Isabela and Santa Cruz it is imperative to construct facilities for cargo handling that include reception areas for containers, cranes, and inspection stations to facilitate orderly loading and unloading supervised at all times by SICGAL personnel.
Unloading performance is low and operations only take place 9 hours/day.	A hub terminal should be designed to optimize unloading rates and avoiding unnecessary investments in infrastructure within the current harbors. Current physical facilities should not be considered for future total cargo handling. The best site for this purpose is the northern coast of Santa Cruz at Itabaca Channel. Inter-island transportation will use self-propelled barges with capacities of 100 – 125 tons. Barges should be able to operate under current tidal limitations.

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ANNEX I:
KEY RESOLUTIONS RELATED TO GALÁPAGOS MARITIME CARGO SHIPPING SINCE 2008.

RESOLUTION	DATE	DESCRIPTION
03-CI-21-I-2008	Jan. 2008	INGALA, now the CGREG, approved the initiation of the SOTMCG for the regulation of ships carrying cargo to the archipelago.
019/08	Aug. 2008	The CNMMP established that all ships delivering food and other goods to Galápagos should be equipped to avoid the unintentional introduction of non-native species to the archipelago, and mandated that they be certified by IACS and maintain conditions for a) the transport of foods with associated storage and container requirements; b) operation of a crane for loading/unloading; c) hull treatments; d) ballast water elimination; and e) fumigations prior to each voyage.
15-CI-04-IX-2008	Sept. 2008	INGALA approved the study and creation of dedicated cargo docks on all populated islands beginning with San Cristóbal, requested the use of the Caraguay dock for cargo loading in Guayaquil, and initiated the remodeling of the TIMSA dock in Guayaquil, now known as Store Ocean.
CSA-103-12-2008	Dec. 2008	SICGAL designed a list of approved and required container types for all organic products commonly transported to Galápagos.
CSA-119-08-2009	Aug. 2009	SICGAL approved new fumigation/disinfection procedures for cargo ships, in cooperation with DIRNEA and the GNPS.
CSA-121-12-2009	Dec. 2009	SICGAL finalized a list of required refrigerated products for transport to Galápagos and notified ship owners and DIRNEA of its execution.
CSA-126-2010	Apr. 2010	SICGAL established a list of vessel upgrades to prevent the attraction and dispersion of insects during maritime transport between Guayaquil and Galápagos, and between islands. Required that all vessels be inspected prior to receiving authorization to disembark from Guayaquil.
028/10	Dec. 2010	The CNMMP resolved to require an Island Operating Permit (POI) for all ships traveling within the GMR, to be obtained based on insurance policy requirements, quarantine and biosecurity facilities, environmental conservation and marine security, IACS certification, and cargo transport facilities.
CSA-135-02-2011	Feb. 2011	SICGAL recommended that the Caraguay dock in Guayaquil be closed for cargo packaging and loading of products destined for Galápagos, as it constitutes a high risk for pest and disease introduction. All institutions involved requested the creation of an alternative dock dedicated for Galápagos cargo handling.
010-CGREG-2011	Feb. 2011	The CGREG approved the required procedures for obtaining a POI for all ships transporting cargo to Galápagos. Ship owners were notified that they must meet the requirements by July 1, 2011.
024-CGREG-2011	May 2011	The CGREG declared four of the six cargo ships operating at that time unable to obtain IACS certification without significant investments, but acknowledged that the two remaining ships would be unable to meet the demand for goods in Galápagos. The deadline for all ships to obtain certification was delayed until Jan. 1, 2012.

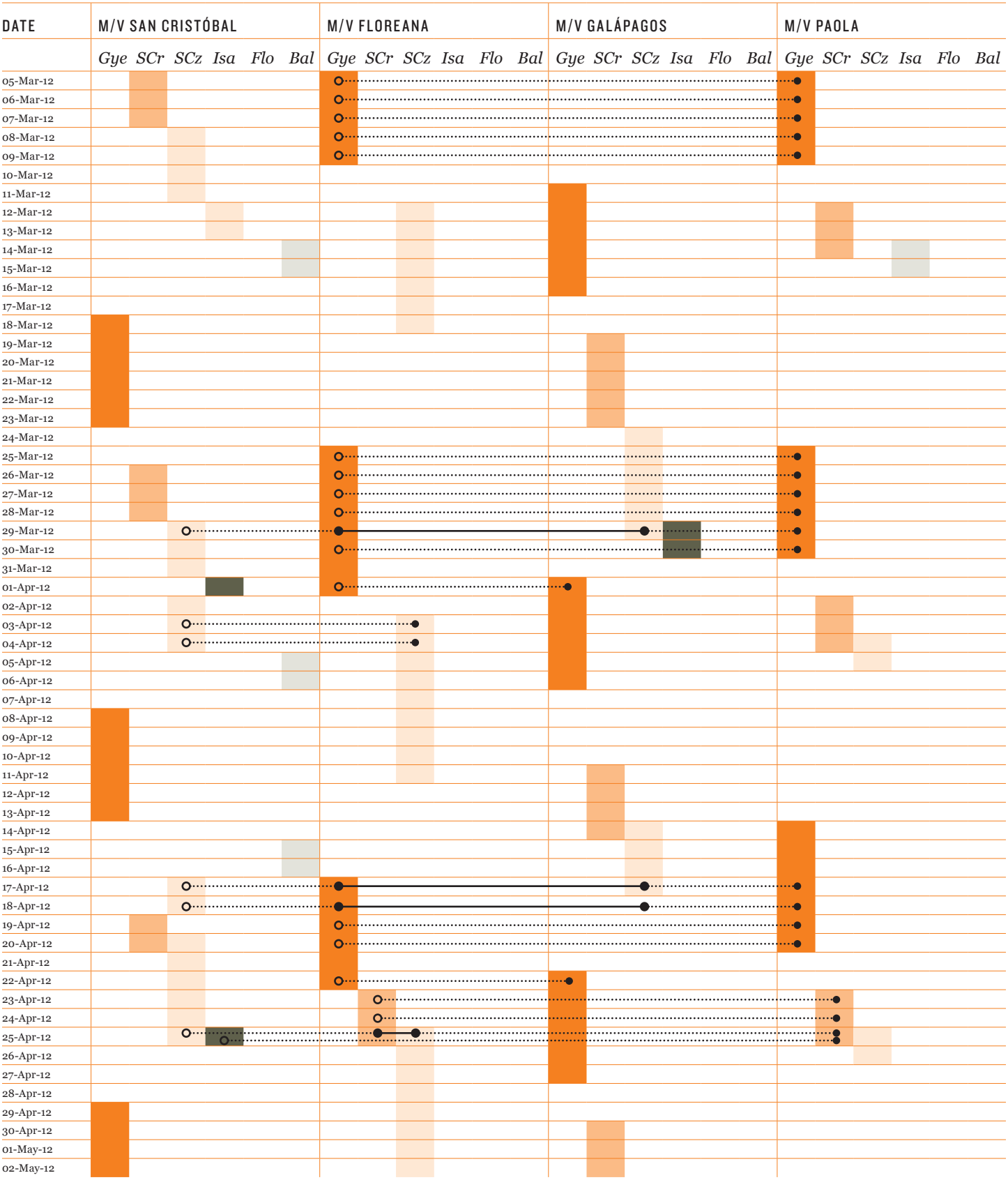
ANNEX 2:
PERCENTAGE SCORES FOR SICGAL INSPECTORS EVALUATED IN FEBRUARY 2012.

Sections with an overall score of 50% or less are highlighted.

TEST SECTION	GUAYAQUIL	QUITO	SANTA CRUZ	SAN CRISTÓBAL	ISABELA	ALL
The inspector understands the most important general issues in Galápagos, especially the problem of introduced species.	63.92	86.50	84.46	77.29	91.67	78.00
The inspector understands the importance of SICGAL, within the framework of the objectives of conservation and sustainable development of Galápagos	63.38	82.50	80.86	81.14	91.67	76.78
The inspector understands legally appropriate penalties, particularly for protocol violations, and the administrative disciplinary process	75.29	81.70	75.86	69.57	84.67	75.98
The inspector has a general knowledge of the Galápagos Islands, especially their geography, geology, natural history and native biodiversity	45.50	59.40	74.36	60.29	71.67	61.49
The inspector understands the concepts and principles governing systems of international quarantine	52.33	79.60	64.50	25.43	50.00	55.05
The inspector knows the islands' health history, including zoonotic diseases and affected people, and the relationship between health problems historical and socioeconomic development of Galápagos	33.46	56.50	67.61	36.64	55.33	50.07
The inspector understands the laws that support the different activities performed by SICGAL	10.25	70.60	49.25	23.71	39.83	35.39
The inspector is aware of aspects of human history and population of the Galápagos Islands	9.50	51.00	37.93	20.79	54.67	29.50
The inspector knows the historical background to the creation of SICGAL	7.29	32.50	31.25	35.71	37.50	25.61
The inspector knows about international organizations, treaties and agreements related to agricultural health	0.00	6.60	23.79	0.00	0.00	8.93
Number of inspectors	12	5	14	7	3	41
Average number of months inspectors have worked with SICGAL	59	119	56	78	94	69

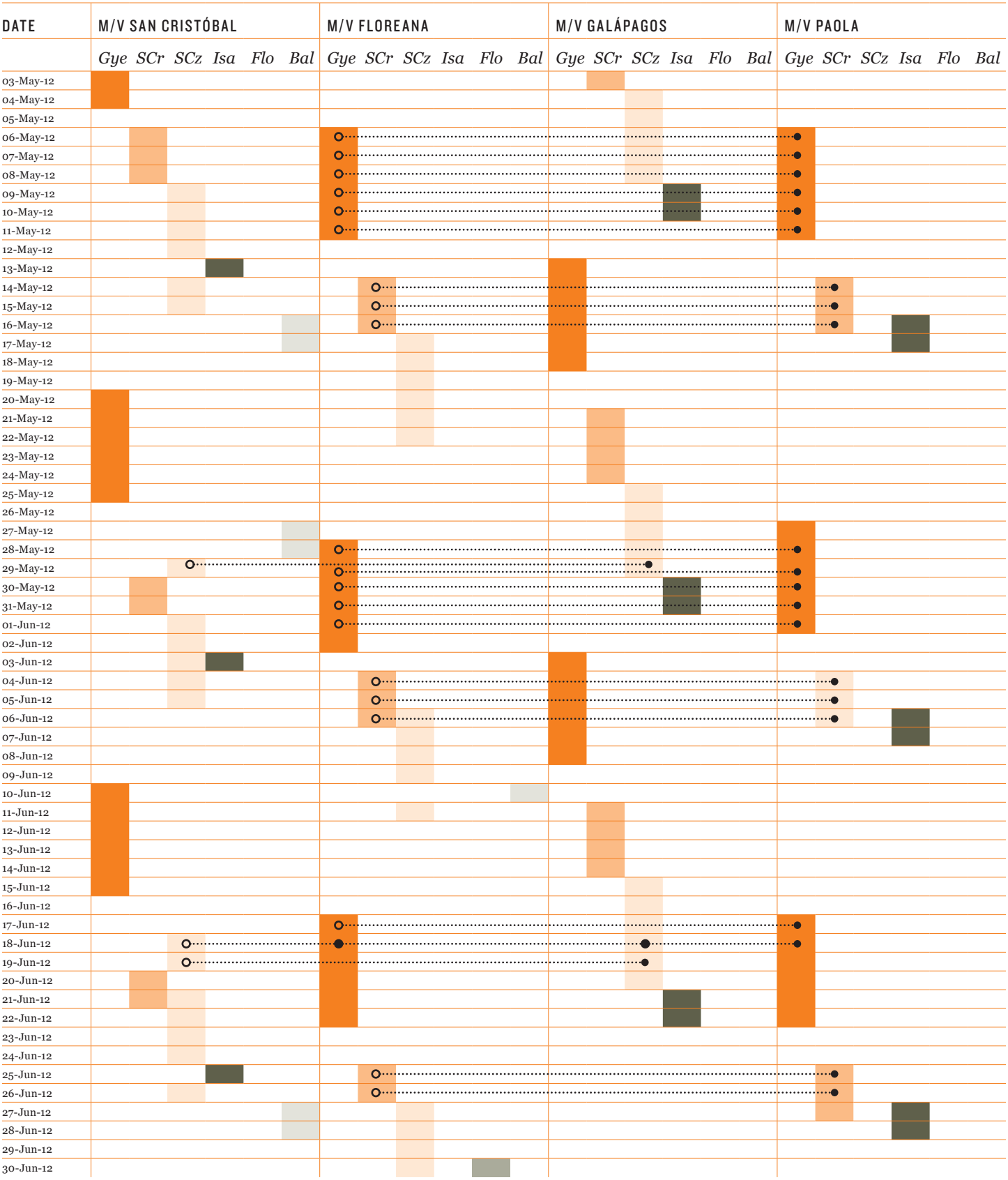
ANNEX 3:
STATISTICAL SAMPLING OF CARGO VESSEL PER TRIP PORTS

GUAYAQUIL | SAN CRISTÓBAL | SANTA CRUZ | ISABELA | FLOREANA | BALTRA



ANNEX 3:
STATISTICAL SAMPLING OF CARGO VESSEL PER TRIP PORTS *Continued*

GUAYAQUIL | SAN CRISTÓBAL | SANTA CRUZ | ISABELA | FLOREANA | BALTRA



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