Shorebirds & Shrimp Farming

Assessment of Shrimp Farming Activities on Shorebirds in Central America

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I. EXECUTIVE SUMMARY

The Pacific Coast of Central America has approximately 3023 km of coastline, but only certain areas are suitable for shrimp farming. These farms are developed on sites with very specific conditions, particularly where they can access adequate water exchange that meets the requirements of the entire shrimp farming cycle. Shrimp farms are generally developed in key natural habitats for migratory and resident shorebirds, such as intertidal mudflats, natural salt flats, mangroves, white sand and gravel beaches, marshes, and seasonal freshwater wetlands. These natural habitats are crucial for determining the assemblage of shorebirds that will be found in shrimp farms.

Shrimp farming in Central America began during the 1970s; Honduras and Panama pioneered its development in the region. Beginning in 1990, under a new framework of market economy and following a worldwide boom in shrimp farming activities, national and foreign investors began operations throughout Central America. Since then, the trend of shrimp farming has been one of continuous growth. Currently, the governments of Central American countries have granted a 20-year concession for approximately 63,815 hectares; 75% have been conceded to transnational and national companies, while the remaining 25% is distributed among individual producers, cooperatives and associations. The areas under production vary from year to year depending mainly on environmental conditions and market demands.

The Gulf of Fonseca is a geographical area shared politically between El Salvador, Honduras and Nicaragua, where almost 80% of the area dedicated to the production of Central American shrimp is located, with 51,164 hectares under concession (out of which 41,776 hectares are under cultivation). For the most part, shrimp farms in Central America have been set up in areas of natural salt flats with scarce vegetation. Although various information sources have historically attributed the deforestation of mangroves to shrimp farming activities, detailed analyses carried out in Mexico and Brazil show that in fact the natural salt flats are the habitats that have been largely transformed by shrimp farming. However, the ecological and hydrological functionality of these habitats is not fully understood, in particular regarding its use and its importance for shorebirds.

During the first half of 2018, the main exporter from Central America in terms of volume of shrimp produced was Honduras (12,851 metric tons on 24,662 ha) followed by Nicaragua (12,181 metric tons on 21,182 ha), Guatemala (4243 metric tons on 1650 ha), Panama (4103 metric tons on 9886 ha), Costa Rica (350 metric tons on 1600 ha) and El Salvador (7 metric tons on 933 ha). The greatest amount of shrimp was imported by the United States, followed by Spain, China, Taiwan, France and Mexico. The main production system is semi-intensive, which is comparatively (at least "a priori") more friendly for the environment. However, Guatemala and Costa Rica have begun producing by means of intensive and hyper-intensive systems, which results in a decrease in the production surface area, but an increase in the overall volume produced. If the waste generated through this system is not properly treated, it could cause considerable ecological damage.

Part of the current trend of the shrimp market is directed towards a more discriminating final consumer, with greater access to information and strong environmental awareness, who demands traceability systems for the products they consume. In general, large companies implement traceability systems where it is possible to monitor the product throughout the entire production cycle, from the larval stage right through to the final market. Most of these have integrated systems with their own research laboratories to produce larvae, fertilizers and feed. The main difference between shrimp farming in the Central American market and the Asian Pacific market, the largest producer with 70% of the global shrimp volume, is that the Asian market is supplied by thousands of small producers, mainly with intensive systems, many environmental problems and impacts, and without any traceability.

As a result of the strong competition from the Asian market, the Central American industry has a range of certifications at its disposal for applying to its aquacultural production, such as Best Aquaculture Practices (BAP), GlobalGap, Aquaculture Stewarship Council (ASC) and the European standards ISO22000 and ISO14000. Furthermore, two companies were identified during this evaluation with organic production certified by Naturland; one in Honduras (SeaJoy) and another in Costa Rica (Terranova Marina), which sell their products to the European Union for a 'Premium' market. With the exception of Naturland, no other certification body highlights shorebirds due to the specificity of the subject. Although they form part of the certification item 'biodiversity and protected areas', the documents consulted only include listings of bird species, but do not include surveys with true field data and indicators that can be used to determine the functionality of the certified farms and their overall contribution towards the conservation of shorebirds.

A total of 50 species of shorebirds have been recorded in Central America, out of which 27 of these species make general use of the shrimp farming infrastructure. In the Gulf of Fonseca region, species with biogeographic populations greater than 1% have been observed moving between natural habitats and the shrimp farms; among the key species found we can mention Wilson's Plover (*Charadrius wilsonia),* Semipalmated Plover (*C. semipalmatus),* Short-billed Dowitchers (*Limnodromus griseus),* Whimbrel (*Numenius phaeopus)* and Willet (*Tringa semipalmata)*. Among the shorebird assemblage, 25 of the species reported to date in shrimp farms have been observed.

It has been confirmed that birds make use of shrimp farms in Nicaraguain a similar way as they do in México. This include some of the folloing species: Willet (*Tringa semipalmata*), Marbled Godwit (*Limosa fedoa*), Whimbrel (*Numenius phaeopus*), Long- and Short-billed Dowitchers (*Limnodromus spp.*), American Oystercatcher (*Haematopus palliatus*), Black-necked Stilt (*Himantopus mexicanus*), American Avocet (*Recurvirostra americana*), Wilson's Plover (*Charadrius wilsonia*), Semipalmated Plover (*Charadrius semipalmatus)*, Western Sandpiper (*Calidris mauri*) and Semipalmated Sandpiper (*Calidris pusilla*).

Research carried out on various farms along the coast of Sinaloa, Mexico, has brought to light some potential best practices that could contribute towards the conservation of shorebirds. In particular, while working together with the farmers, certain management measures were identified for the post-harvest period while pond drying activities are carried out, which could work in favour of the conservation of shorebirds without incurring additional costs for the producer.

Throughout this evaluation, two case studies were developed (a farm in Panama and another in Nicaragua) to document current production processes (see annex 3), to identify any potential 'shorebird friendly' criteria and, finally, to apply the conditions that will help to consolidate the optimal specific conditions for shrimp farms (i) to act as functional areas that are available for use by shorebirds; (ii) to ensure that the use of any products that could potentially influence this use are traceable; (iii) provide safety and shelter for shorebirds; and finally (iv) are used by shorebirds.

Campa Shrimp Farm, Nicaragua
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Mudflats on the Gulf of Fonseca, Nicaragua
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III. KEY CONCEPTS

Benefit: When shrimp farms provide services to shorebirds such as food, rest, shelter, safety, nesting areas that favour their winter survival and preparation for the reproductive success.

Certification: Is a procedure through which an agency provides a written guarantee that a product, process or service meets a series of requirements.

Intensive Cultivation: A system with extremely high production rates in small pond sizes (0.01 to 5 hectares) and stocking densities between 36 - 110 orgs/m2 (15,000 - 18,000 lbs/ha/cycle). This requires a greater investment in terms of operating capital, equipment, skilled labour, feed, nutrients, chemicals and antibiotics. They also employ the use of mechanical aeration systems for the circulation and aeration of pond water (Tobey *et al*. 1998, Dávila 2016).

Mangroves: Mangrove forests are vegetation communities comprised of facultative halophytic plants which become established along the intertidal belt bordering bays, coastal lagoons, estuaries, deltas and river mouths. These forests are made up of at least six species of trees: *Rhizophora mangle, Laguncularia racemosa, Avicennia germinans, Conocarpus erectus, Rizophora harrisonii and Avicennia bicolor*. There are associations between mangrove species which depend upon the influence of the tides.

Natural Salt Flats: Tidal salt flats that are formed in macro-tidal coastal regions and semi-arid climatic conditions (Zitello 2007). They are hypersaline plains where salts are precipitated as a result of a combination of occasional tidal flooding and high evapotranspiration rates. These salt flats occur beyond the edge of mangrove forests and are also referred to locally as tierras albinas, playones, and saladares.

Shrimp Farming: An aquaculture-based activity that focuses on the production of shrimps and prawns within a controlled environment. The production systems are variable and are usually comprised of ponds, water reservoirs, dikes and protected areas.

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Ponds: Artificial wetlands within the farms with variable sizes ranging between 1 and 20 hectares and a maximum depth of 1.20 meters, which once harvested dry-out with small shallow pools remaining.

Semi-Extensive Cultivation: A system with average production rates in pond sizes ranging from 5 to 20 hectares with stocking densities of 10 - 35 orgs/m2 (7500 - 10,000 lb/ha/cycle). It includes a more complex pool system, the introduction of a nursery phase, the installation of a pumping system to regulate water exchange, skilled management, labour, the purchase and rationing of shrimp feed, and an increase in the use of diesel or electric power. Pumps exchange water at a daily rate of 10 to 30 percent (Tobey *et al.* 1998).

Usage Criteria: Refers to the functional quality brought together by the practices that benefit shorebirds and that lead to a process of ongoing improvement with changes and adaptations that are necessary under each circumstance to improve shorebird use of shrimp farms.

Vertical Integration Business System: Companies that acquire, create or merge with other companies that develop some of the integral phases of the production process of the goods or services they offer, such as intermediaries, suppliers, distributors. In the case of the shrimp farming sector, they can include larvae laboratories, processing plants, export services, import, etc.

Torrecilla Shrimp Farm, Nicaragua
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IV: INTRODUCTION

Shorebirds are comprised of species from the order Charadriiformes that include sandpipers, oystercatchers, phalaropes, and plovers. These birds play a key role since they connect biodiversity on a global scale. Fifty species of shorebirds have been recorded in Central America, of which 43 are migratory and breed in the United States and Canada. At a global level, 45% of Arctic shorebird populations are decreasing (Zockler *et al.* 2013). Although the ultimate reasons behind this overall decline are unknown, the loss and alteration of wetlands seem to be one of the main causes (Morrison *et al.* 2001, Delany *et al*. 2009).

Large areas of coastal wetlands in tropical and subtropical regions originally occupied by mangroves and salt flats have been transformed into aquacultural production areas (38%), mainly dedicated to shrimp farming (Valiela *et al.* 2009). As a result, understanding how the alteration of coastal wetlands associated with shrimp farms affects migratory shorebirds could help mitigate the decline of their populations and, ultimately, reduce the loss of biodiversity (Navedo and Fernández 2018). Beyond its impact, however, understanding what opportunities shrimp farming offers to shorebirds and biodiversity is essential to promote sound environmental practices and management actions within areas of aquacultural development.

Shrimp farming began in Central America during the 1970s as an alternative for achieving food security and in response to the decline in deep sea fishing activities due to the overharvesting of wild shrimp. However, due to technical problems and a lack of specific knowledge, these first experiences were not very successful. Nevertheless, in the late 1990s, shrimp farming activities spread rapidly and became an increasingly important export industry, largely resulting from government assistance, financing, university-based technical collaboration and legislative permissiveness (Queiroz 2015).

As production areas grew and expanded throughout the 1990s, so did concern regarding the degradation that these activities could be generating. In the Gulf of Fonseca and surrounding areas, the discussion focused on the following points: (i) mangrove destruction, (ii) the loss of seasonal lagoons, (iii) the effect on fishing, and (iv) the deterioration of water quality (Wille 1993); all these compounded with conflicts between industry and fishermen and the local communities.

Although these concerns have been well-founded, the last 20 years have brought about advances in technology, best practices and site selection for aquacultural activities that have resulted in a significant mitigation of these risks and environmental damage, and the greater use of aquaculture in the management of resources has changed the role that aquaculture can play, and does play, in conservation (Froehlich *et al.* 2017). Although mangrove destruction has been an ongoing issue in aquaculture, it was found that 75% of the shrimp culture in northern Sinaloa, Mexico was carried out on salt flats and only 1% was implemented in mangroves (Berlanga-Robles *et al.* 2011). In the case of north-eastern Brazil, contrary to what was described in literature, Zitello (2007) found that in reality the salt flats of the study area were experiencing the greatest destruction as a result of the development of shrimp farming activities, and not the mangrove forests. The same trends can be observed in the Gulf of Fonseca, where the salt flats are once again the main ecosystem being replaced by the shrimp farms. The impact this has on the biological integration, the hydrology and the importance for biodiversity, including the nearby mangrove forests, is still unknown.

Recent studies in Sinaloa, Mexico, have shown that the recently harvested ponds in shrimp farms were regularly used as alternative foraging sites by a significant number of migratory shorebirds during the non-breeding season (October-February) (Navedo and Fernández 2018). In this sense, preliminary data from the Delta del Estero Real, Nicaragua, confirm the use of the ponds during the harvest periods as well as the use of the dikes as roosting areas (Reyes *et al.* 2018).

This analysis of shrimp farming and shorebirds has been promoted by the Executive Office of the Western Hemisphere Shorebird Reserve Network (WHSRN), National Audubon Society and Quetzalli Nicaragua with the support of the Universidad Austral de Chile and several other organizations. The analysis forms part of the actions identified and recommended under the Pacific Americas Shorebird Conservation Strategy (Senner *et al.* 2016) and seeks to understand the status and distribution of shorebirds in relation to shrimp farming and their management practices along the Pacific coast of Mesoamerica, with a special emphasis on the Gulf of Fonseca. The process behind this document intends to create a joint alliance based on research, validation and the establishment of management protocols at a productive scale to achieve a more sustainable development of shrimp aquaculture in Central America, specifically taking shorebirds into greater consideration.

The goal is to build the foundations for a future sustainable management plan before, during and after shrimp harvest activities in collaboration with industry, government institutions, scientists and NGOs dedicated to the conservation and sustainable use of the natural resources.

This document is divided into four sections: (i) the first deals with the presence of shorebirds and their use of the shrimp farms and the information available in Central America; (ii) the second section takes a geographical focus and examines each of the countries; (iii) the third analyzes the industry; and (iv) the fourth focuses on a conceptual model and results chain developed during a workshop carried out in January 2019.

V. OBJECTIVES

1. Evaluate the status and distribution of shorebirds in relation to the shrimp farming areas along the Pacific coast of Central America, with a special focus on the Gulf of Fonseca.

2. Document existing information on the management practices of shrimp farms and the potential impacts these have on shorebirds in the Gulf of Fonseca.

3. Build a conceptual model and results chain to address conservation challenges and opportunities for shorebirds in relation to shrimp production.

Acuícola Real Shrimp Farm, Nicaragua
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VI. SHRIMP FARMING AND ITS INTERACTION WITH SHOREBIRDS

6.1 GENERAL ASPECTS OF THE SHOREBIRDS

Shorebirds are a group of waterbirds of the order Charadriiformes that include sandpipers, oystercatchers, phalaropes and plovers. These birds play a key role since they connect biodiversity on a global scale. Many species are migratory, breeding in the United States and northern Canada and migrating to Mexico, Central America and South America. Throughout their two annual trips, shorebirds use a series of critical stopover sites to rest, feed and transition between the Arctic tundra and a variety of habitat types along the way. These habitats are shared with resident species and other migrants.

In the Americas, three primary geographic areas of shorebird migration have been identified: the Pacific Flyway, the Mid-Continental Flyway and the Atlantic Flyway (Map 1). These flyways follow topographical features and depend on the food, shelter and abundance of water along the way. Central America falls within the three migratory flyways, and while it is primarily species and populations from the Pacific and Midcontinent flyways that occur, some birds from the Atlantic Flyway also migrate to the region. One example is American Oystercatcher (*Haematopus palliatus*) which breed along the East Coast of the United States and winter in the Gulf of Fonseca.

Shorebirds show great fidelity to the sites they occupy during their annual cycles and often depend on a just a few key sites for breeding, wintering and staging during migration. In particular, these long-distance migratory birds.

Map 1: Map of shorebird migration routes, including the Pacific, Midcontinent and Atlantic flyways.

Acuícola Real Shrimp Farm, Nicaragua
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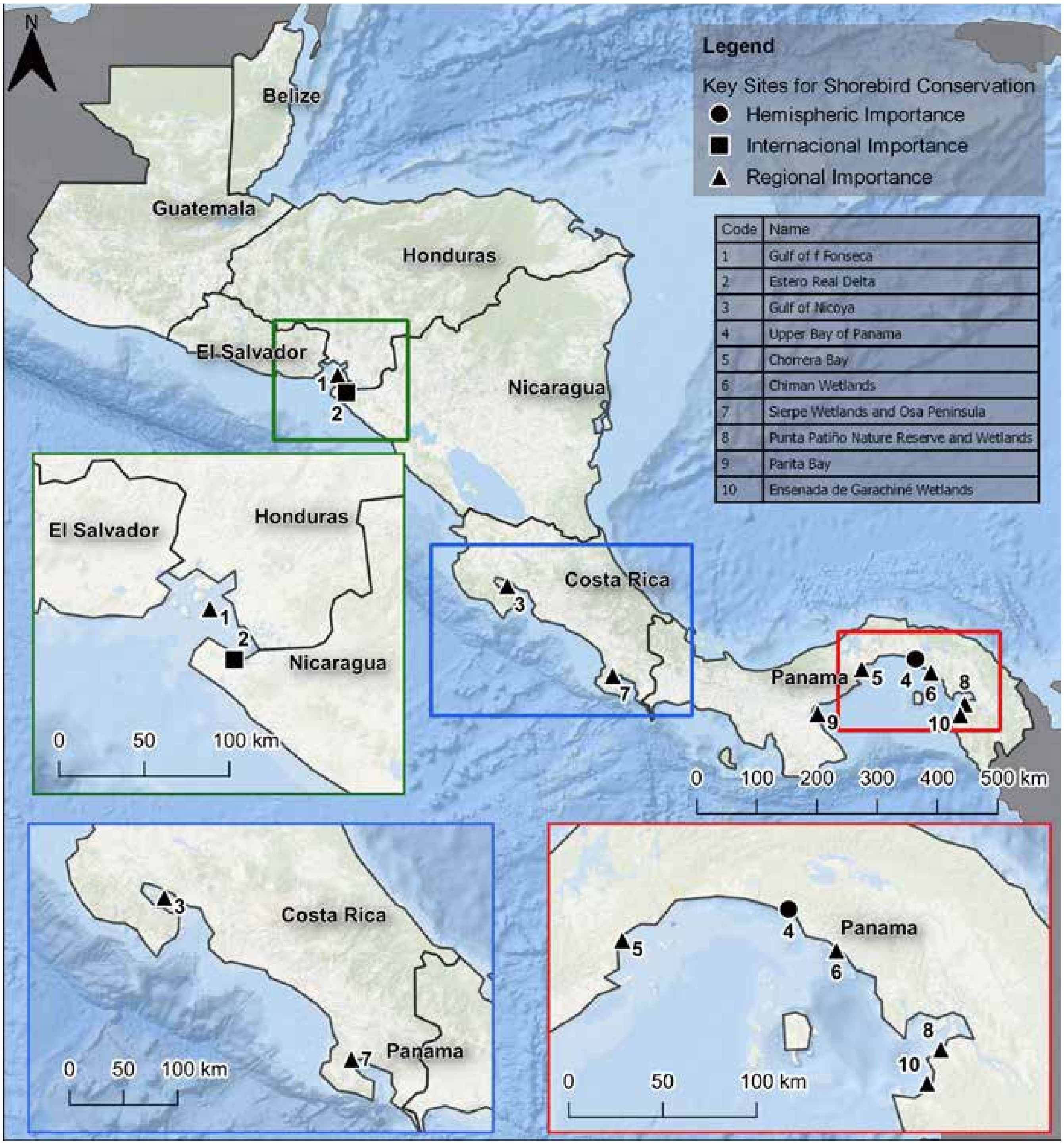
depend on a series of wetlands and coastal habitats that offer them sufficient possibilities to feed themselves and regain strength for their demanding migrations. The dependence of many species of shorebird on a few key sites is the basis for the Western Hemisphere Shorebird Reserve Network (WHSRN) – a grass-roots, voluntary network of public and private partners works to protect the most important breeding, stopover, and wintering habitats for shorebirds throughout the Americas To be part of WHSRN, a site must meet criteria based on shorebird numbers or a percentage of the biogeographic population (BP) of any species that use the nominated site. According to these criteria, the site is allocated to one of the following categories: 1- Site of Hemispheric Importance (500,000 shorebirds per year or 30% BP of a species); 2- Site of International Importance (100,000 shorebirds per year or 10% BP of a species); 3- Site of Regional Importance (20,000 shorebirds per year or 1% BP of a species). In Central America, the Delta del Estero Real in the Gulf of Fonseca, Nicaragua (international importance) and the Upper Bay of Panama, Panama (hemispheric importance) are part of WHSRN.

Map 2: Key Sites for Shorebird Conservation



Shorebirds are distributed over a wide range of ecosystem types depending on their accessibility and the benefits they offer, including from pastures, inland lagoons, seasonal lagoons, mudflats, sandy coasts, rocky coasts, intertidal zones, among others. Most shorebird species prefer coastal habitats, such as *Calidris sp., Limnodromus sp., Numenius sp., Charadrius sp., Haematopus palliatus, Tringa sp.*, among others, that are distributed throughout the Pacific coast of Central America with significant numbers recorded in specific sites, such as the Bahía de Jiquilisco in El Salvador; Punta Raton in Honduras and Delta del Estero Real in Nicaragua, both within the Gulf of Fonseca; Gulf of Nicoya in Costa Rica; and the Upper Bay of Panama in Panama. On the other hand, there are also species that tend to settle in inland ecosystems, such as grasslands, inland lagoons and seasonal lagoons. Some of these species include *Gallinago delicata* and *Charadrius vociferus*, which are both migratory species, as well as resident species such as *Jacana spinosa*, *Burhinus bistriatus* and *Vanellus chilensis* (which has recently spread into Central America), which have been reported at various altitudes in inland areas of Central American countries. In the case of the phalaropes, they prefer continental waters or coastal and inland lagoons.

To understand the use that shorebirds make of the shrimp farms, it is necessary to adopt an ecosystem approach at a local, regional and international spatial scale. In the particular case of the Gulf of Fonseca, as a conservation and management unit, research efforts have been carried out since 2013 to generate knowledge about shorebirds led by SalvaNATURA, the Honduran Ornithological Association, and Quetzalli Nicaragua with the support of WHSRN/Manomet, Point Blue and BirdLife International. Since 2016, Quetzalli, with the collaboration of the Austral University of Chile and WHSRN/Manomet, has begun surveying shorebirds in shrimp farms and surrounding habitats. This information is the bedrock of information on shrimp farming and shorebirds in Central America, particularly for the Delta Estero Real.

6.2 SPECIES COMPOSITION AND ABUNDANCE

There are 50 species of shorebirds recorded in Central America; 42 of these species are migratory, of which 10 are passage migrants wintering in habitats further south that include Costa Rica, Panama and South America (see Annex 1 for a complete list). Five species are resident and three have migratory and resident populations. During the analysis, no publications were found referring to shorebirds in shrimp farms or neighbouring habitats in Guatemala, Costa Rica, or Panama; consequently, the information presented below is based on existing data for the Gulf of Fonseca and Sinaloa state, Mexico.

The composition and abundance of shorebird species found in shrimp farms depends on the presence of shorebirds in the natural habitats surrounding the shrimp farms -such as intertidal mudflats, natural salt flats, mangroves and others- as well as the ecology of the shorebirds and their habitat use. In the following section, the composition and abundance of the birds in the Gulf of Fonseca is analysed first, followed by a focus on Sinaloa state, Mexico, and then the Delta del Estero Real in Nicaragua where shorebird monitoring in shrimp farms has been initiated.

To date, two simultaneous bird counts have been carried out within the three countries on the Gulf of Fonseca, including some shrimp farms. Table 1 presents the seven species with the highest counts in the Gulf without distinction of habitat. 38.6% of the entire biogeographic population of *Charadrius wilsonia* was found, of which 32% was recorded on the mudflats of the Delta Estero Real in Nicaragua. This was followed by *Calidris pusilla* with 4.40%, also with a greater occurrence in Nicaragua; *Charadrius semipalmatus* with (2.68%) and *Limnodromus griseus* with 1.92%, being more

Tabla 1: Focal species and their percentage of biogeographic population in the Gulf of Fonseca

SPECIES	Feb 2017	May 2018	Biogeographic Population	% of Biogeographic Population
American Ostercatcher (*Haematopus palliatus)*	173	11	12,500	0.86
Wilson's Plover *(Charadrius wilsonia beldingi)**	2898	118	7.500	38.64
Semipalmated Plover *(Charadrius semipalmatus)*	4027	492	150,000	2.68
Wimbrel *(Numenius phaeopus)*	1156	114	40,000	2.89
Western Sandpiper *(Calidris mauri)*	11,047	399	3,020,000	0.36
Semipalmated Sandpiper *(Calidris pusilla (Western)*	4406	0	100,000	4.40
Short-billed Dowitcher *(Limnodromus griseus)*	1353	118	75,000	1.92

Source: Van dort (2017); Van dort (2018) & Reyes *et al* (2018)

abundant in Honduras and El Salvador (Van Dort 2018, Reyes *et al.* 2018).

In 2017 and 2018, shorebirds were recorded in every month of the year in the Gulf of Fonseca. Shorebirds alternate between natural habitats and shrimp farms, depending on the dynamics of the tides and the local conditions of each site. Understanding this interaction is essential to determine the abundance and diversity of birds; in the particular case of the Delta del Estero Real, it has been observed that at low tide the birds make use of intertidal habitats (mudflats, exposed river banks), salt flats, freshwater wetlands and relocate at high tide to roosting sites such as shrimp farms, mangroves, salt evaporation ponds and salt flats if they are flooded. These salt flats dry completely between the end of December and January, depending on the previous winter, evaporation levels, etc.

Twenty-three species have been recorded to date on the shrimp farms of the Gulf of Fonseca (23 in Nicaragua and 12 in El Salvador). In the Delta del Estero Real, comparative surveys of shorebirds on intertidal mudflats (at low tide) and nearby shrimp farms (high tide) showed significant maximum counts of *T. semipalmata and N. phaeopus* during the autumn migration of 2018.

Table 2 presents the highest counts recorded during the months of February, May and August in both habitat types (Reyes et al. 2018). We have observed in recent years that birds tend to feed on the mudflats and congregate on dikes and empty ponds, which are used as roosting sites, since the loss of roosting sites is greater than the loss of feeding ground.

TABLE 2: Maximum number of shorebird species observed during August (migration) and February (wintering) in the Delta Estero Real on the Gulf of Fonseca.

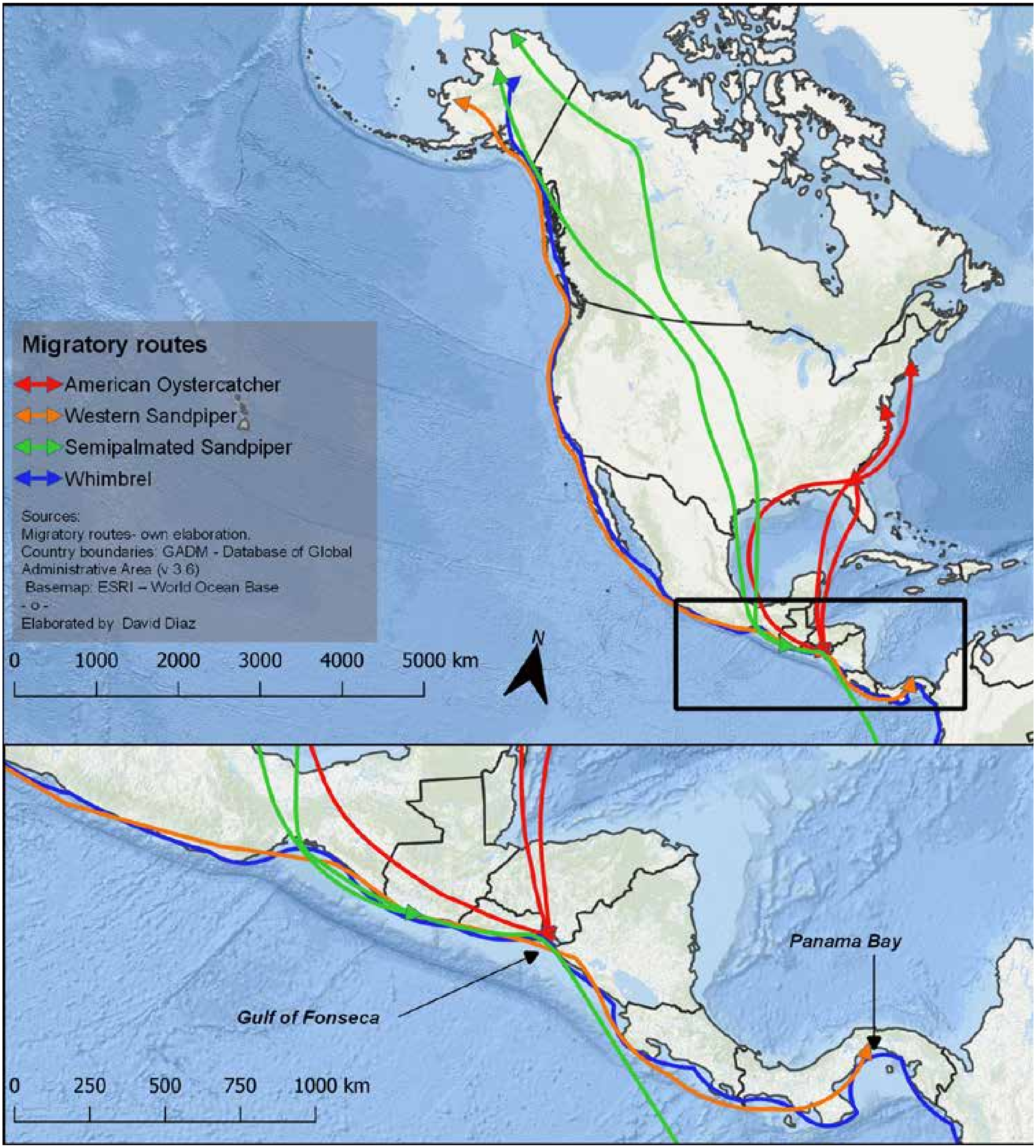
SPECIES	Month/Year	Delta Estero Real		Biogeographic Population	% of Biogeographic Population
		Mudflats	Shrimp Farms		
Wilson's Plover *Charadrius wilsonia beldingi**	Febrero 2017	2,000	1,900	7,500	26.66
Willet *Tringa semipalmata*	Agosto 2018	1,426	3,326	140,000	2.3
Whimbrel *Numenius phaeopues*	Agosto 2018	145	607	40,000	1.5
Black-necked Stilt *Pluvialis squatarola*	Mayo 2018	527	427	262,000	0.2
Ruddy Turnstone *Arenaria interpres*	Mayo 2018	64	163	45,000	0.36
American Ostercatcher *Haematopus palliatus**	Febrero 2017	86	87	12,500	0.70
Semipalmated Plover *Charadrius semipalmatus**	Febrero 2017	1,200	30	150,000	0.80

* Biogeographic population estimates by Andrés et al. 2012; Senner. *et al* 2016 Reyes *et al*. 2018

Since 2014, the Migratory Shorebird Project (MSP) has been carrying out migratory bird counts every year between January 15 and February 15. Volunteers from all Central American countries have participated, with the exception of Belize and Guatemala. Unfortunately, the model does not allow for the extraction of data that correspond exclusively to shrimp farms.

Map 3: Migratory Routes for four migratory species

We will now analyze the five most abundant species based on field observations, eBird reports, and MSP that describe and better understand the interaction they have with shrimp farms, where they rest or feed temporarily. Map 3 shows the migratory routes for two of the species described below.



American Oystercatcher
(Haematopus palliatus)

Conservation Status:
Birds of Conservation Concern - (USSCPP, 2016)
Least Concern (LC) (BirdLife International, 2016)

Population Trend: *Stable*

Population: *20,000 individuals (Senner et al, 2016)*

The American Oystercatcher (*Haematopus palliatus*) is considered a species of "Great Concern" in the US Shorebird Conservation Plan (USSCP 2016), though it is considered Least Concern at a global level (IUCN 2018). The subspecies *Haematopus p. palliatus* is found on the east coast of the United States and Mexico, on both coasts of Central America, in the Caribbean, and the east and north coasts of South America. In the Gulf of Fonseca, the migratory population from the east coast of the US overlaps with a small resident population (with maximum counts of up to 11 individuals in May).

In Central America, three sites have been identified with important concentrations of the oystercatcher: Punta Raton and Condega in Honduras (with up to 116 individuals) and the mudflats of the Delta del Estero Real and neighbouring shrimp farms in Nicaragua (with 89 individuals) and the mouth of the Río Guascarán in El Salvador (24 individuals recorded). During the simultaneous census of February 2017, 0.70% of the biogeographic population was recorded; assuming that the subspecies observed, both resident and migrant, were indeed *H. p. palliatus.*

According to the bird counts in the Delta del Estero Real, the migratory population has increased from 32 individuals during 2012-2013 to 87 individuals in 2016-2017 (Jarquín *et al.* 2017). Twelve of these individuals were ringed when leaving their nesting areas in Virginia (1 individual), North Carolina (3 individuals), Georgia (4 individuals) and Florida (4 individuals). Below are the details of the individuals observed with their codes and band colours, as well as the dates and locations they were banded. The banding of these individuals has allowed us to understand the movement patterns of this species in each of the different habitats within the Gulf of Fonseca; in particular the use they make of the dikes and ponds in nearby shrimp farms.

Map 4: Concentrations of Oystercatchers in the Gulf of Fonseca

Source: migratoryshorebirdproject.org

Table 3: Codes and colours of the bands of American Oystercatchers observed in the Delta Estero Real

Band	6F	F6	48	F3	47	91	CP	49	CHK	AK3	C1P	AMH
Date	may-06	sep-05	may-15	sep-05	may-15	Jun 15	jun 09	jun	jul-13	2018	2017	2018
Site	Vir	Ga	FL	Ga	FL	FL	CN	FL	CN	Ga	CN	Ga

Vir: Virginia, Ga: Georgia, FL: Florida, CN: North Carolina, USA

The oystercatchers feed mainly on the intertidal mudflats at low tide. During the high tide they roost either along the dikes, in the empty ponds of shrimp farms of the Delta del Estero Real, or along the beach at Condega in Honduras. The resident population is made up of approximately five pairs; one of which was observed on the sand and gravel beaches of Punta San José (Delta del Estero Real).

In 2018, considerable disturbance was observed during the shrimp harvest season in Acuícola Real, particularly along the dikes where the shorebirds rest among the cormorants. The use of gunpowder is one of the practices allowed on shrimp farms as a deterrent for cormorants that feed on the shrimp; however, since October 2018 an almost excessive increase in the use of gunpowder in the roosting areas of shorebirds has been noted. This has drastically affected the presence of the birds not only in the roosting areas, but also in the surrounding feeding areas.

Wilson's Plover (*Charadrius wilsonia beldingi*)

Conservation Status:
Birds of Conservation Concern BCC - (USSCPP, 2016)
Least Concern (LC) (UICN, 2018)

Population Trend: *Declining*

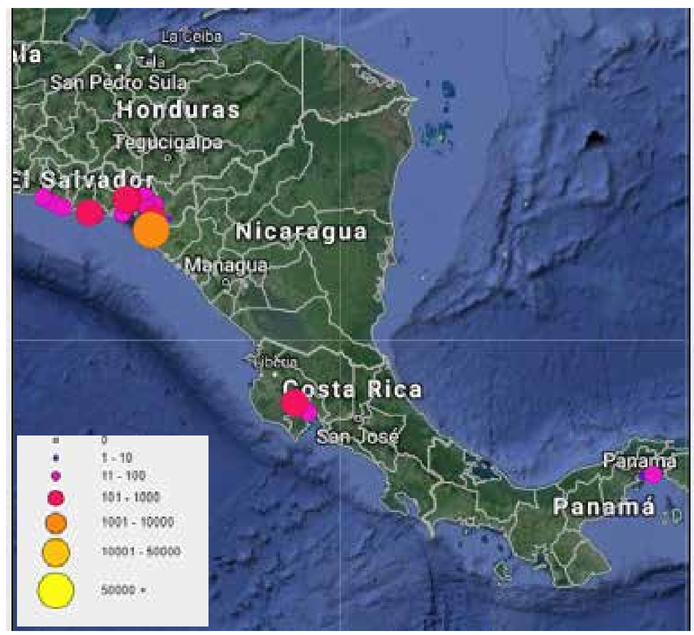
Población: 8,600 *individuos (Senner et al, 2016)*

Wilson's Plover (*Charadrius wilsonia*) is a declining species considered to be of "Great Concern" by the US Shorebird Plan (USSCP 2016). Three subspecies are recognized for this species; two of which might be present in Central America. *C. wilsonia wilsonia* breeds along the Atlantic coast of the United States, from Virginia to Florida, along the US Gulf Coast and Gulf of Mexico, and in the Bahamas and Greater Antilles. Meanwhile *C. w. beldingi* is found from the Pacific coast of southeastern Mexico to central Peru (Zdravkovic 2013). Based on records of individuals banded in Louisiana, it would appear that the nominate subspecies occurs in the Gulf of Fonseca, in addition to *beldingi.*

In the Gulf of Fonseca, congregations have been high with maximum counts during 2014-2015 ranging from 2,000 - 4,000 individuals, representing 45.80% of the biogeographic population (Morales & Jarquín 2014). These estimates have remained constant in recent years. During the first simultaneous census carried out in February in the Gulf of Fonseca, 2,898 individuals were recorded (26.6%). In contract, during a simultaneous census in May, when the migrants were mostly back in their reproductive areas, 118 individuals were recorded (Van Dort 2017. 2018).

In terms of abundance, the highest counts of *C. wilsonia* were observed in an empty shrimp pond during December 2012, as well as in the intertidal mudflats and along shrimp farm dikes; with an estimated total of 7200 individuals. In Honduras and El Salvador, individuals have been found nesting along the edges of salt evaporation ponds; in Nicaragua, two nests were found in salt flats. The resident population is apparently only a small fraction when compared to the migratory population that uses the mudflats, mangroves, salt flats and empty shrimp ponds to rest or feed every year.

Map 5: Sites where Wilson's Plover was recorded during the MSP counts



Source: http://www.migratoryshorebirdproject.org

Willet *(Tringa semipalmata)*

Conservation Status:
Birds of Conservation Concern BCC - (USSCPP, 2016)
Least Concern (LC) (Birdlife International, 2018)

Population Trend: *Stable*

Population: *160,000 individuals (Senner et al, 2016)*

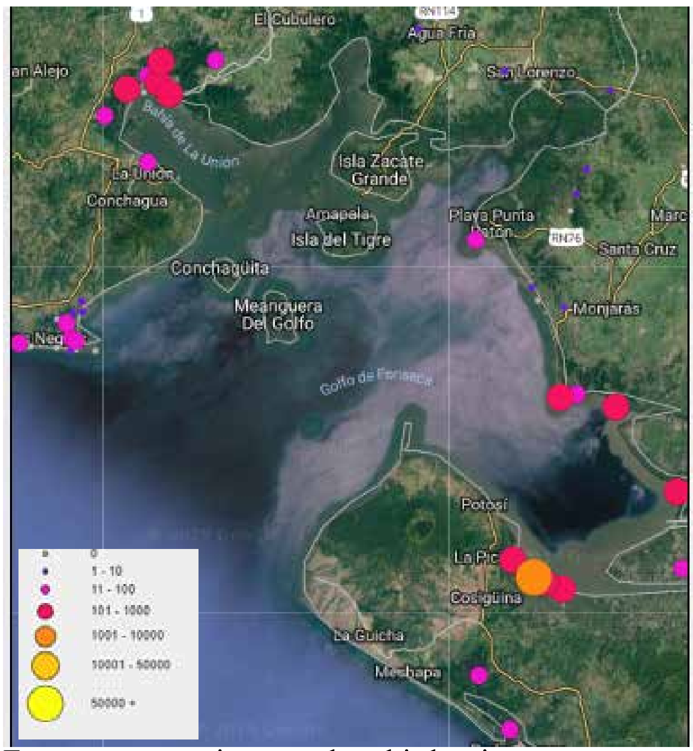
The Willet (*Tringa semipalmata*) is one of the most abundant species and has considerable tolerance to anthropic impact (Canevari *et al.* 2001). Morphologically and vocally, two subspecies are identified with largely disjunct reproductive distributions in North America. *T. s. semipalmata* breeds in coastal brackish marshes along the Atlantic and Gulf coasts in eastern North America and the West Indies. *T. s. inornata* breeds in the wet grasslands and inland prairies of northwestern North America (Oswald *et al.* 2016). The subspecies *inornatus* is distributed along the Pacific coast from the United States down to south-central Chile. The subspecies *semipalmata* is distributed from the east coast of the United States, the islands of the Caribbean and the north coast of South America (García-Walther 2017).

In the Gulf of Fonseca, *Tringa semipalmata* feeds during low tide in the mudflats and riverbanks that form in the estuaries. When the tide rises, they move to rest on the edges, dikes and empty ponds of the shrimp farms and mangrove trees.

In the Delta del Estero Real, an increase in the estimation of individuals has been observed between 2012 and 2015 ranging from 2000 to 6000 individuals, which represents 3.75% of the biogeographic population. During the migration period of July, August and September, important numbers have been observed in a single day, using the dikes and empty ponds of the shrimp farms. When the water level of the water reservoirs drops, it is also possible to see them roosting in large numbers.

A total of 5218 individuals were estimated during the simultaneous trinational shorebird count in the Gulf of Fonseca carried out in February 2017 (Van Dort 2017). In May 2018, during the second trinational shorebird count in the Gulf of Fonseca, a total of 252 individuals were registered in the three countries as a result of it being the migration period.

Map 6: Survey sites for Willets in the Gulf of Fonseca



Fuente: www.migratoryshorebirdproject.org

Whimbrel *(Numenius phaeopus)*

Conservation Status:
Birds of Conservation Concern - (USSCPP, 2016)
Least Concern (LC) (Birdlife Internacional, 2018)

Population Trend: *Decreasing*

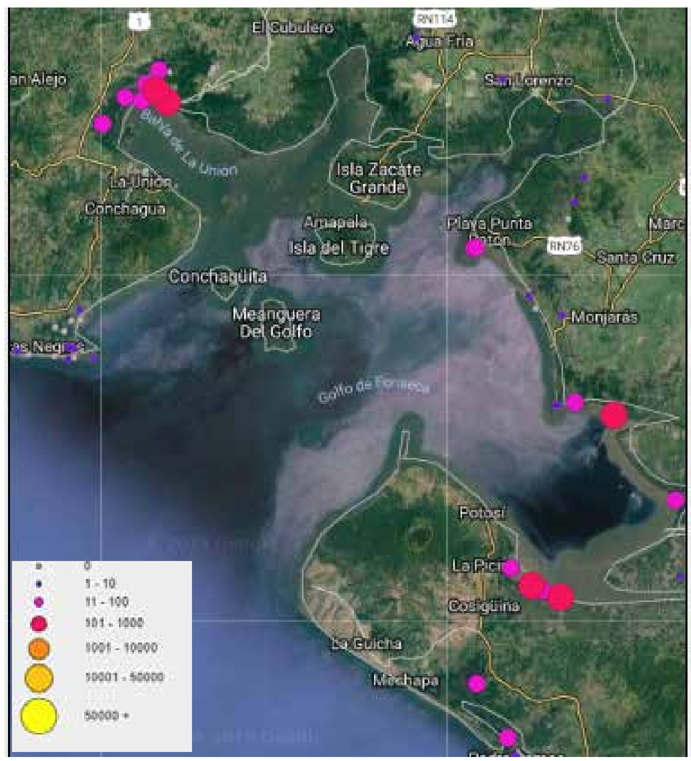
Population: *40,000 individuals (Senner et al, 2016)*

The Whimbrel (*Numenius phaeopus*) is well adapted to various types of coastal habitat. They inhabit wetlands, estuaries, areas with low vegetation, cultivated fields, as well as dry and flooded grasslands near the coast (García-Walther. 2017). Although usually a solitary bird, Whimbrels can sometimes be found in small and medium-sized groups in places where food is abundant or in roosts (Canevari *et al.* 2001). In the western hemisphere, the species breeds in Alaska, northwest Canada, and to the west and south of the Hudson Bay. During the non-breeding season (boreal winter), *N. phaeopus* are found along the coastal regions of Mexico, Central America, and South America, with smaller numbers along the Pacific, Gulf, and Atlantic coasts of the United States.

The North American subspecies *N. p. hudsonicus* is considered as a species of conservation concern. Shorebird conservation plans from both the United States and Canada designate the species as a high conservation concern due largely to declining population trend and low relative abundance, at least regarding the eastern population (Wilke & Johnson-González 2010).

In the Gulf of Fonseca, small groups have been observed in the mudflats, salt evaporation ponds, mangroves and shrimp farms in search of food and shelter. The greatest number of records for the species in the Delta del Estero Real was during surveys in 2014, with a total of 1118 individuals recorded. During the first trinational shorebird count in the Gulf of Fonseca, carried out in February 2017, a total of 1156 individuals were recorded representing 2.8% of the biogeographic population, being found mainly in the intertidal mudflats and wetlands.

Map 7: Survey sites for Whimbrels in the Gulf of Fonseca



Source: www.migratoryshorebirdproject.org

Short-billed Dowitcher (Limnodromus griseus)

Conservation Status:
Birds of Conservation Concern - (USSCPP, 2016)
Least Concern (LC) (UICN, 2018)

Population Trend: *Decreasing*

Population: *75,000 individuals (Senner et al, 2016)*

The Short-billed Dowitcher (*Limnodromus griseus*) winters from the center-north of the United States down through to the Tropic of Capricorn following both coastlines (Piersma 1996). One part of the population migrates along the Pacific coast and winters from the north of California down to Peru. Another part of the population migrates across the Great Plains of the United States down to Central America and settles along both coasts. Finally, there is a third population that migrates along the Atlantic coast and across the Caribbean to Brazil (Canevari *et.al.* 2001). The species is classified as being of Least Concern and is not believed to be at risk of becoming Vulnerable, despite some evidence of population decline (IUCN 2018).

A total of 701 individuals were recorded during the monitoring activities carried out on the mudflats of the Delta del Estero Real in 2014, corresponding to the months of January, February and March. The data from the first trinational shorebird count in the Gulf of Fonseca during February 2017 indicated the presence of 1353 individuals observed mainly on the intertidal mudflats and wetlands; this figure represents 1.8% of the biogeographic population. During the simultaneous survey in May 2018, a total of 195 L. griseus were observed, with most found in El Salvador (Van Dort 2017. 2018).

Map 8: Bird count sites for Short-billed Dowitcher in the Gulf of Fonseca

Source: migratoryshorebirdproject.org

Other abundant shorebird species in the region include Semipalmated Sandpiper (*Calidris pusilla*) and Western Sandpiper (*C. mauri)*, distributed mainly along coastal areas and intertidal zones. In the Delta del Estero Real, groups of up to 11,000 individuals of these two species have been observed in recently harvested shrimp ponds. However, numbers appear to have declined since 2012-2013 when the highest counts were made.

The Gulf of Fonseca works as a whole system where birds move according to the availability of habitats, based on the shifting tides and the availability of ponds.

Among other species present in large number are Black-necked Stilt (*Himantopus mexicanus*), Stilt Sandpiper (*Calidris himantopus*), Least Sandpiper (*C. minutilla*), and Lesser Yellowlegs (*Tringa flavipes)*. These are the species that mostly use the shrimp farms and salt flats when available. In the case of the Red Knot (*Calidris canutus*), although not very abundant, there have been observation of individuals banded in Louisiana.

6.3 FUNCTIONAL USE OF SHRIMP FARMS AND SURROUNDING NATURAL HABITATS

The functional use of shrimp farms by shorebirds is determined by a series of conditions, the main one being the distribution and abundance of birds in the natural habitats surrounding the shrimp farms. The second condition is linked to the tidal cycles, especially in coastal areas such as the Gulf of Fonseca where tides restrict daily access to feeding areas; an additional variable are the spring and neap tides. In Sinaloa state, Mexico, it was found that there was an 80% reduction in feeding areas with the spring tides and an overall decline in the abundance of shorebirds, which then increased again during the neap tides (Fonseca *et al.* 2017). The third condition depends on the wetlands and their water levels that decrease as the dry season advances (January - April).

Figure 1 presents the conceptual model of the ecosystem approach for the use of shrimp farms and surrounding habitats by shorebirds. It can be seen that natural habitats such as intertidal mudflats, salt flats and temporary lagoons provide benefits such as feeding grounds, rest areas, breeding areas, shelter and safety. These habitats provide benefits at various moments of the day or season.

For example, birds feed on the intertidal mudflats and on the edges of the river estuaries that are formed at low tide; once the tide rises, they move on to the shrimp farms, salt flats, marshes and mangroves. On the shrimp farms, birds find alternative feeding areas during harvest, and although these may only be ephemeral, they are of crucial importance (Navedo and Fernández 2018).

The dikes that are open and clear of vegetation are constantly used by shorebirds as roosting places. For more than four years, a high frequency of use of and fidelity to certain dikes of the shrimp farms has been observed during high tide.

The combined area of shrimp farming covers more than 50,000 hectares in the Gulf of Fonseca and is accessible to birds at least two or three times a year. The availability of this habitat coincides with the southbound migration (July - September) but less so with the northbound migration (March - April). One of the current production trends is a move toward more continuous cycles, leaving a very short post-harvest period (2 - 5 days maximum) where the ponds are accessible for the birds, but with a greater availability during different months, due to the alternation between stocking and harvesting activities.

Delta del Estero Real, Nicaragua
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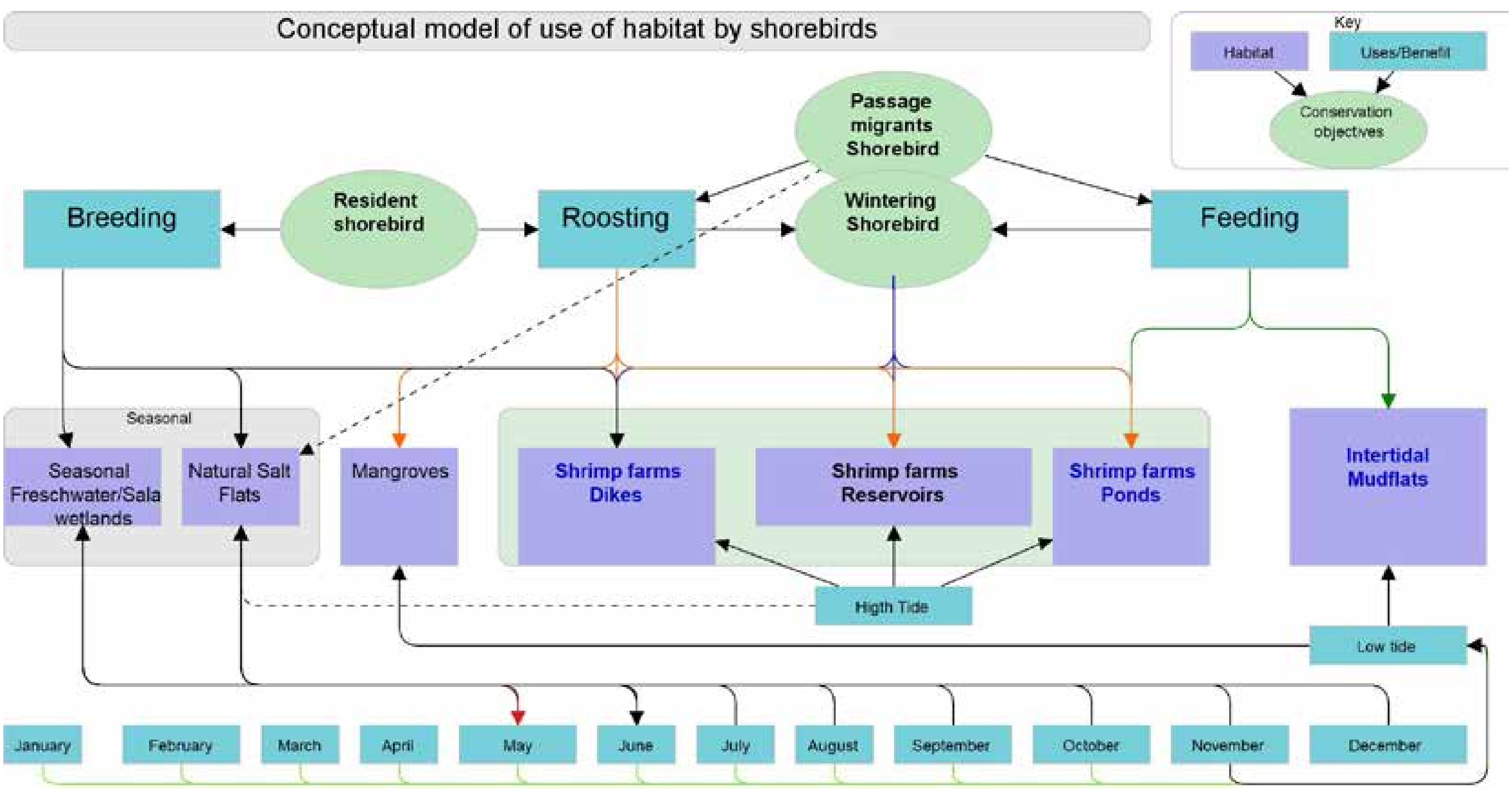
Once the water is drained, if the ponds are refilled immediately to begin a new production cycle, the management system does not allow time for the shorebirds to make use of the ponds for foraging (Navedo *et al. 2015*). The more traditional method is to carry out a sanitary drying when the ponds are left without water for at least 15 to 60 days, which also decreases their utility for shorebirds.

Shorebirds make use of the ponds while they maintain their post-harvest humidity during an average period of three to five days. When the ponds are completely full of water (1.20m) they become inaccessible for shorebirds. During this time, the birds use the dikes devoid of vegetation as roosting areas during the high tide until the natural habitats become available again, particularly the mudflats. For example, a group of oystercatchers that feeds on the mudflats of the Delta del Estero Real in Nicaragua usually moves on to the dikes of the nearby shrimp farm, and other times to the marshlands of Punta Condega in Honduras and most likely other sites that we have not yet identified.
As a result of the last few years of observations in the Delta Estero Real, some patterns of use can be anticipated:

- The shrimp farms located closest to the intertidal mudflats or other natural habitats that function as key feeding areas will have a greater abundance and richness of shorebird species.

- Shrimp farms offer complementary food areas during the harvest period, especially for *Tringa semipalmata, Numenius phaeopus, and Himantopus mexicanus* (*Navedo et al. 2015*); with the addition of *Limnodromus griseus, Charadrius semipalmatus and C. wilsonia* in the Gulf of Fonseca. Recent studies in Sinaloa state, Mexico, have shown that recently harvested ponds in shrimp farms were regularly used as alternative foraging sites by a significant number of migratory shorebirds during the non-breeding season Oct-Feb (Navedo and Fernández 2018). For the most part, once the ponds are empty, the first three days will be intensively used by shorebirds, but if a pond continues to maintain a water level for more days, the birds will continue to use it (Navedo *et al.* 2015). In this sense, preliminary data from the Delta del Estero Real (Nicaragua) reaffirm the use of ponds during the harvest.

Figure 1: Conceptual model of use of habitat by shorebirds



- The dikes that are completely devoid of vegetation, or those with up to 30% low vegetation cover, have the greatest potential for being used as roosting places. These dikes are mostly used by *Haematopus palliatus, Tringa semipalmata y Pluvialis squatarola.*

- Dikes which border mangroves are used less by shorebirds.

Table 4 summarizes the use of various habitats by several species of shorebirds showing the functioning and complementarity of the different habitats surrounding the shrimp farms, where the existing shrimp farms play an important role in the daily life cycle of the shorebirds that make use of Delta Estero Real.

Table 4: Shorebird use of habitats in the Delta Estero Real, Gulf of Fonseca

HABITAT	USES	SHOREBIRD SPECIES	NOTES
Intertidal Mudflats	Feeding	**20 species in total** *Tringa semipalmata* *Haematopus palliatus* *Pluvialis squatarola* *Numenius phaeopus* *Calidris mauri* *C. pusilla* *C. semipalmatus* *Charadrius wilsonia* *Limnodromus griseus* *Limosa fedoa* *Calidris canutus* *Calidris virgata* *Calidris minutilla* *+ 6*	Accessible twice a day during low tide.
Natural Salt Flats	Feeding	*Calidris Himantopus* *Himantopus mexicanus* *Tringa flavipes* *Tringa melanoleuca* *Phalaropus tricolor*	Used only when filled with water
	Nesting	*Charadrius wilsonia* *Himantopus mexicanus*	
	Roosting	*Calidris mauri* *C. pusilla*	
Seasonal Freshwater Wetlands	Feeding	*Jacana spinosa* *Calidris melonotos* *Calidris minutilla* *Himantopus mexicanus*	
Mangroves/ Salt marshes	Roosting Safety Refuge	*Numenius phaeopus* *Calidris mauri* *C. pusilla* *Tringa semipalmata* *Calidris canutus* +	
Sand-Gravel Beaches	Nesting	*Haematopus palliatus*| *Charadrius wilsonia*	Temporary use, only for nesting or roosting.
	Feeding Roosting	*Calidris alba*	

HABITAT	USES	SHOREBIRD SPECIES	NOTES
Shrimp Farms	Feeding Roosting Safety	23 species *Himantopus mexicanus* *Tringa flavipes* *Tringa melanoleuca* *Charadrius collaris** and another 20 species on the mudflats	Feeding only briefly during the first few days post-harvest
	Nesting	*Himantopus mexicanus*	

Compiled by the authors: based on surveys and opportunistic observations in the Delta del Estero Real 2012-2018

6.4 DYNAMICS OF THE FOOD AVAILABILITY AND REST AREA

Shorebirds experience strong energy demands associated with their demanding migratory flights, which is precisely why they are so closely associated to sites with abundant and predictable food resources (Carmona 2007). These birds choose foraging areas based on exogenous factors, such as food availability, and the risks and energy expenditure associated with the trip (Folmer *et al.* 2010). Furthermore, there is widespread consensus that food resources are the ultimate limitation in terms of restriction on the size of the bird population (Baker and Miller 2009). It is consequently of upmost importance to know where these sites are located and understand the external influences to which they are exposed due to the development of economic activities from a broader geographic focus.

Shorebirds feed mainly on benthic organisms, including polychaetes, crustaceans, mussels, sea lice, marine insects, among others. In the case of Central America, there is little knowledge regarding the different benthic species that shorebirds feed on, and their abundance, biomass and temporal variation are unknown. A number of factors affect the feeding dynamics of birds; among the main physical factors that affect the substrates are the tide, temperature, wind and light that have an effect when reducing feeding time or speed, by modifying the feeding behaviour or its physiology or making invertebrate prey less available, either because they move to greater depths or because they become less active (Carmona 1999).

Another factor is the texture and degree of saturation of the substrate caused by tidal flooding making the substrate easier to penetrate, thus increasing the activity of the invertebrates and making them more accessible for the birds to capture.

Along the Pacific coast of Central America there are a series of specific sites; these specific sites are embedded in complex estuarine systems with various habitat types, such as the intertidal mudflats which emerge twice a day during low tide, natural salt flats, mangroves, shrimp farms and seasonal freshwater wetlands. One of the most conspicuous species that can exemplify just how the dynamics of food availability and roosting grounds work is the American Oystercatcher with two specific movement patterns that also apply to other species:

-Pattern 1: The tide goes out and they feed in the mudflats that are located in the Delta del Estero Real in Nicaragua; the tide comes in and they move to the dikes of the nearby shrimp farms, which are closest to their main feeding grounds, to rest. Taking into account just how crucial the additional energy expenditure would be if they had to resort to other more distant areas, this pattern could be the one that they use the most. When oystercatchers use the shrimp farm infrastructure as a roosting area, rarely are the birds observed feeding, even when the ponds are accessible to them. The dikes of the Acuicola Real shrimp farm are essential to the oystercatchers as roosting area; once the tide comes in, they move to the dikes while they wait for the low tide to return and clear their feeding sites that are less than 100 meters away.

A similar movement occurs with other birds that feed on the riverbanks when the tide goes out, and later move to the mangroves and shrimp farms nearby to rest (and feed if they have been recently harvested); this has been observed especially with T*ringa semipalmata, Numenius phaeopus, Charadrius wilsonia* and all *Calidris* species.

-Pattern 2: The tide goes out and the birds feed on the mudflats of the Delta del Estero Real, Nicaragua; when the tide comes back in, they move to the roosting grounds in Punta Condega, Honduras. This pattern has been identified thanks to the ringed oystercatchers and the simultaneous counts that have been carried out in joint collaboration with the organizations that work with shorebirds in the Gulf of Fonseca. The same ringed oystercatcher individuals that were observed during the morning counts in Nicaragua (black 6F, red 48, 47, green CP) were again observed in the afternoon at Punta Condega. Large groups of the following species have also been observed moving towards Honduras: *Calidris mauri, C. pusilla, C. semipalmatus, Charadrius wilsonia and Tringa semipalmata***.** This pattern highlights the need to work at a landscape level.

6.5 FARMER PERCEPTION OF SHOREBIRDS AND PREDATOR MANAGEMENT PRACTICES

When farmers are consulted about shorebirds, they immediately associate them with cormorants, gulls, herons and pelicans; these are the "problem" species that feed on shrimp and represent a huge loss for the economy of shrimp farms. Despite the conspicuousness of the shorebirds that move around in large flocks, they are almost unnoticed by the farmers. Furthermore, shorebirds are often generalized as a threat to shrimp production.

Recently shorebirds have been observed roosting in the same areas on dikes as cormorants and herons. This is a potential problem as the management practices used to control cormorants as predators can also affect the shorebirds. In the case of the shrimp farms, the main predators identified are waterbirds such as cormorants and gulls. According to recommendations made, predation by birds should be minimized by non-lethal methods, using mechanisms that are effective but harmless to the environment; these include nets, pyrotechnic devices, sound deterrents or the employment of staff to scare away birds.

6.6 WORKING TOWARDS A SHOREBIRD-FRIENDLY SHRIMP PRODUCTION

Shorebirds and waterfowl make use of the shrimp farm infrastructure as part of an integrated system of habitats surrounding the shrimp farms and from which they obtain benefits. The farms offer roosting areas, where it is important to guarantee security and shelter at least in the areas of highest concentration. The production influences the natural feeding areas from where the water of the shrimp farms is obtained and exchanged.

Recent studies in Sinaloa state, Mexico, have shown that freshly harvested ponds in shrimp farms were regularly used as alternative foraging sites by a significant number of shorebirds during the non-breeding season between October and February (Navedo *et al.* 2015, 2017). Preliminary data from the Delta del Estero Real (Nicaragua) reaffirm the use

Acuícola Real Shrimp Farm, Nicaragua
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of the ponds during harvest, as well as the regular use of the dikes closest to the feeding areas as roosting places (Reyes *et al.* 2018). Casual observations in Panama also confirm that shorebirds are making use of this artificial habitat.

An important issue to assess is that as the freshwater wetlands begin to dry (December-January) and the reproductive season for some of the waterbirds species begins, this exerts greater pressure on the ponds; consequently, the management of wetlands beyond that of the shrimp farms is a matter to which greater attention should be paid. In addition to providing alternatives to the livelihoods of the local communities, wetland management practices could potentially provide a service to the producer by decreasing the incidence of waterbirds that feed on sick shrimp, or in other cases feed on healthy shrimp thus affecting the production and generating a considerable economic impact for the producer.

As part of this assessment, a series of usage criteria have been identified "a priori" for the shrimp farms in terms of infrastructure, production, and market, as well as their contribution towards the fulfilment of the Sustainable Development Goals of the United Nations. Four qualitative attributes have been proposed (Friendly, Potentially Friendly, Not Friendly, Unknown) and are approached as an initial exercise in the case study. The characteristics of each area to meet the criteria of each attribute should be discussed in depth and validated in joint collaboration with the industry. As a result, it is expected to generate Friendly Environmental Practices with both migratory and resident shorebirds.

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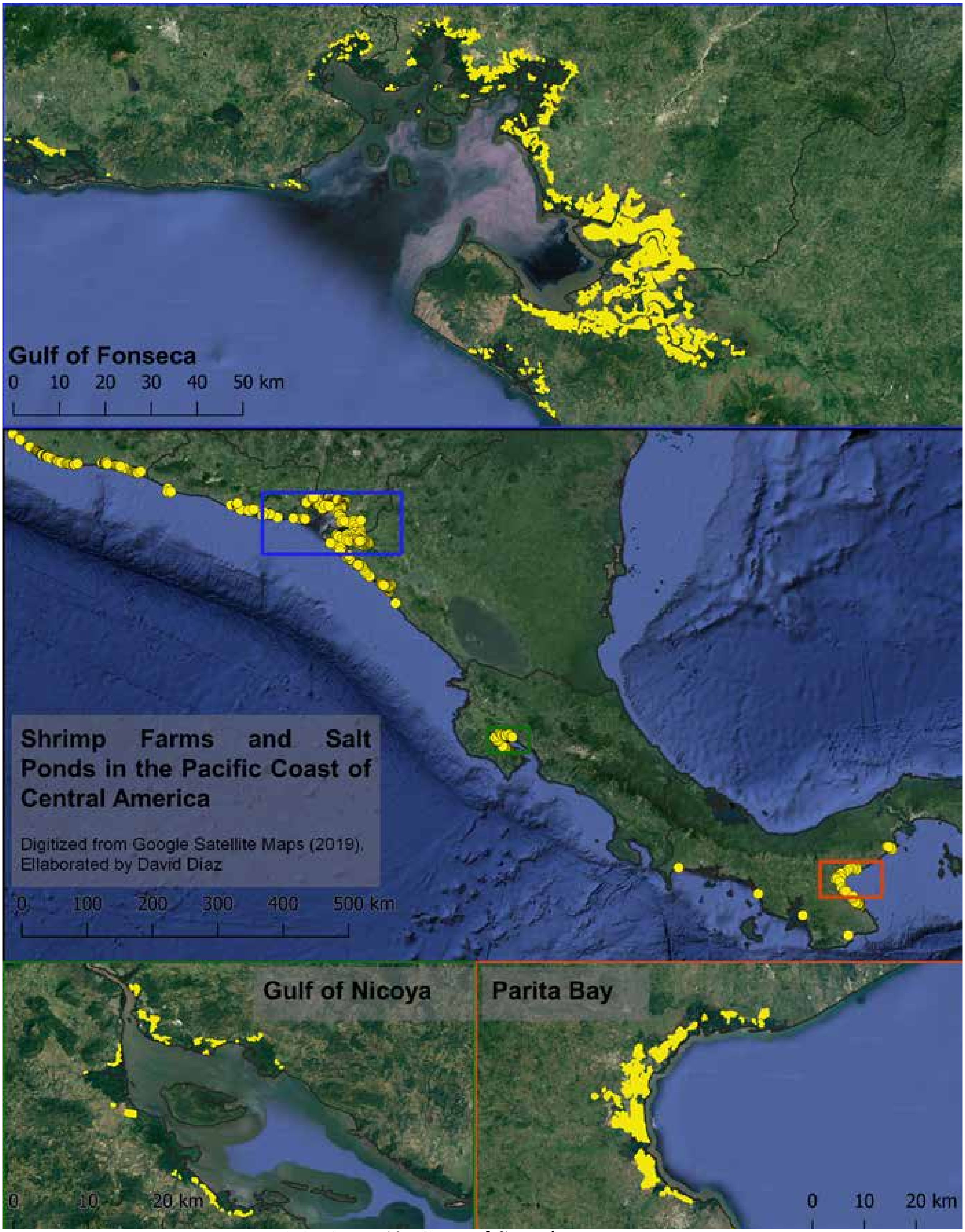
VII. GEOGRAPHIC FOCUS



Map 9: Shrimp Farms and Salt Ponds in the Pacific Coast of Central

7.1 SUMMARY

The geographic focus of this study is the Pacific coast of Central America, and more specifically the Gulf of Fonseca, where 78% of the entire shrimp farming activities of the Central American region are carried out. In Central America, birds that use the Pacific, Midcontinent and part of the Atlantic flyways converge during their southern migration to winter (see Map 1); consequently, the strategies that are promoted for the conservation of shorebirds must contemplate actions at a broad scale, taking into account the breeding areas of the birds, migration routes and shrimp producers and consumers.

Located along the Pacific flyway is the Gulf of California, where 96% of the shrimp farming in Mexico is carried out. We have not included this area in this analysis due to fundamental differences that merit an independent analysis, such as the volume of its production, its context and primarily domestic consumer market, while the Central American market is mainly focused on export.

In Central America, a total of 63,815 hectares have been concessioned for shrimp production distributed in six countries, of which 44,320 hectares are in production.

Figure 2 summarizes the distribution of shrimp farming by country. In general, more than 70% of the shrimp farming activities are managed by private companies and individuals, while the remaining 30% are carried out through collective initiatives such as associations and cooperatives.

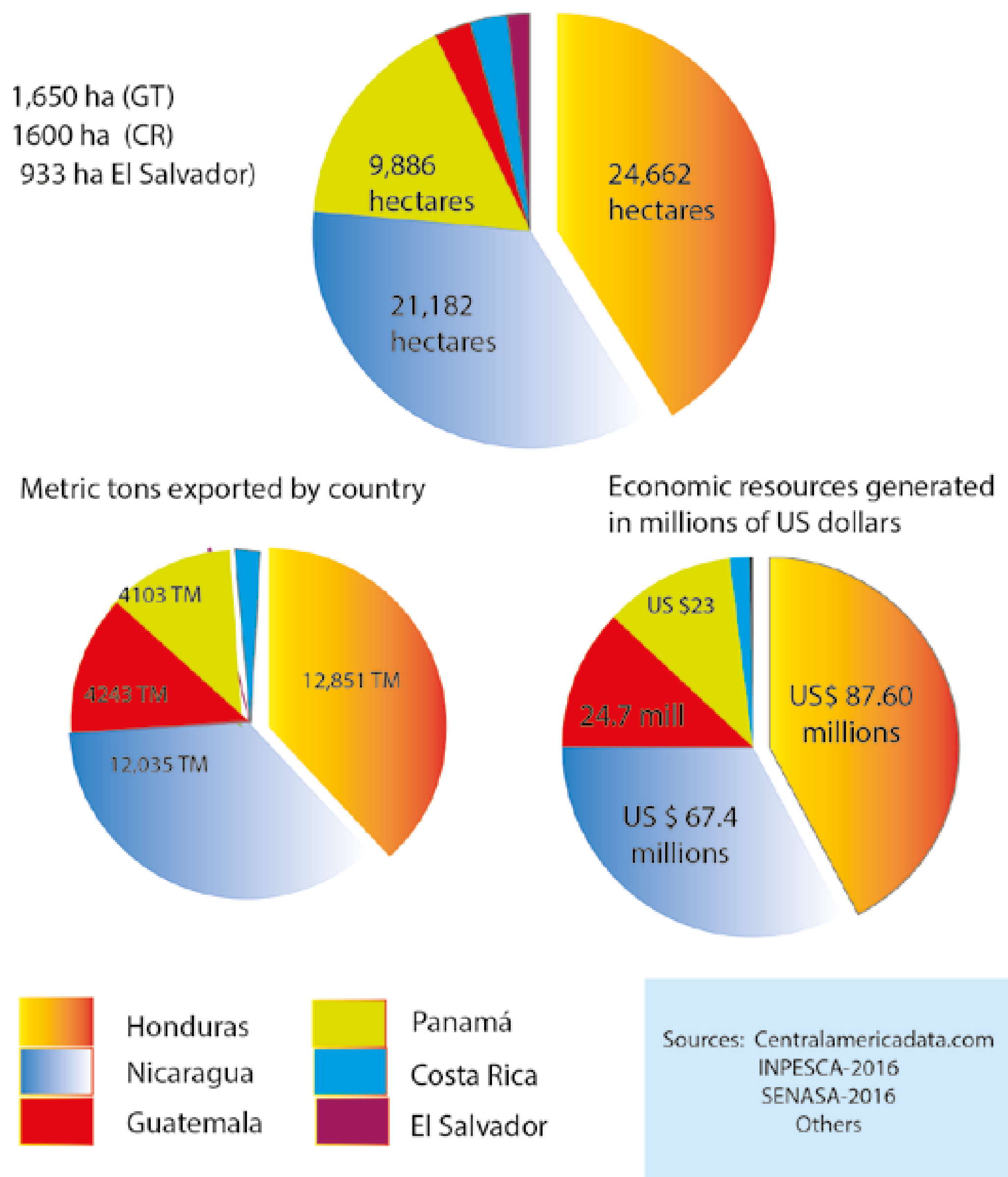


Figure 2: Breakdown of shrimp farming in Central America in terms of surface area (hectares), income generated (US$) and volume (metric tons) produced during the first semester of 2018

7.2 CENTRAL AMERICAN

This shrimp farming and shorebird analysis was carried out along the Pacific coast of the Central American isthmus, which extends 3023 km between Guatemala and Panama. Pacific Central America is geographically comprised of six countries (Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama) and covers a total area of 522,760 km².

At the interface between the land and the sea, a narrow strip is formed where highly dynamic ecotonal ecosystems are dominated by geomorphological processes, where on the one hand there is the action of tides and waves, while on the other hand the fresh water and continental sediments (Calmus et al. 2017). Along the coastline, a diversity of habitats exist including seasonal freshwater wetlands, estuaries with mangrove forests, natural salt pans (salt flats), intertidal mudflats, sand-gravel beaches, shrimp farms and salt mines.

Throughout Central America, there are approximately 67,534.28 hectares of currently concessioned areas for shrimp farming; 74.8% of this area is concentrated in the Gulf of Fonseca, where this study focuses on a more complete analysis and one of the case studies is carried out. In terms of its geography, Central America has coastal zones along the Pacific and the Caribbean, separated by a central mountainous region. The Pacific coast is where the soils are more apt for agriculture and aquaculture, among other economic activities, and this has resulted in it becoming the most densely populated and developed area. The Pacific is also the area with the highest agricultural production, with 47.3% of the population in absolute poverty (The World Bank 2015).

Central America is also located along the Pacific migratory flyway for thousands of Neotropical shorebirds. So far, 50 species of shorebirds have been identified and two key sites have been integrated into the Western Hemisphere Shorebird Reserve Network; one is the Delta del Estero Real in the Gulf of Fonseca in Nicaragua, and the second is the Upper Bay of Panama Bay, of International and Hemispheric Importance, respectively.

7.3 GULF OF FONSECA

Shrimp farming activities in El Salvador, Honduras and Nicaragua have developed mainly in the Gulf of Fonseca, specifically in the departments of La Union, Valle and Choluteca and Chinandega, respectively with 50,144 hectares under concession and approximately 80% of this area under production (see Map 2). The Gulf basin includes 409 kilometres of coastline, with an aquatic surface area of 2015 km2 and an approximate territorial extension of 22,000 km2 (PROARCA 2010). The Gulf harbours a diversity of habitats, including intertidal mudflats, estuaries, sand-gravel beaches, temporary freshwater wetlands, mangroves and natural salt flats.

The climate of the region is classified as a Tropical Savanna and has an annual precipitation of less than 1800 millimetres, irregularly distributed with six months of higher average monthly rainfall greater than 240 millimetres, followed by six months of lower average rainfall of less than 28 millimeters. The rainy season begins in May and ends in November. Maximum temperatures of 45ºC and average temperatures of 27oC have been recorded (OEA 1974).

The tides in the Gulf are mixed, semidiurnal with an average height of 2.79 meters at high tide and 0.23 meters at low tide. Approximately 15,000 hectares of intertidal mudflats become available as a feeding ground for shorebirds at low tide. Depending on the spring or neap tides, the availability of the feeding area is also affected both in terms of maximum extent and time exposed. Roosting areas are also affected by the tides; the areas of mangroves and beach where shorebirds roost become reduced and they are forced to make use of the dikes of the shrimp farms.

Mexico was originally intended to be included in this analysis, but due to the extent and differences in production systems, markets, etc. only Central America was included. Nevertheless, a summary of information on shrimp farming in Mexico has been included below for comparative purposes and considering that the country forms part of the same migration flyway.

7.4 MÉXICO

In Mexico, shrimp farming activities are mainly carried out within the Gulf of California area, in the State of Sinaloa, Sonora and Nayarit, where 96% of the shrimp farms are located. The Gulf is a narrow subtropical inland sea more than 1200 km long, between 80 and 200 km wide, and an approximate area of 160,000 km2. This coastal area is home to almost 8 million people, including a number of indigenous groups, and represents the most productive region of the country in terms of fishing industry (Calmus *et al.* 2017).

It has been estimated that Mexico has 236,000 hectares of potential area for the development of shrimp farming (Martínez-Córdova *et al*. 2009) and 86,482 hectares currently under production. The shrimp production system in Mexico differs from that of Central America in the sense that 90% of its production goes towards national consumption and the remaining 10% or less is exported to the United States. Approximately 12,202 tons of shrimp produce was recorded in 2017 (Téllez 2017).

7.5 GUATEMALA

Guatemala has a coastal extension of 254 kilometers; however, there are few suitable areas for the implementation of aquacultural activities. Most of the coastal areas in Guatemala have limited access to estuaries, bays or sea waters that are optimal for the development of aquaculture.

The few areas with access to water are expensive and mostly on sandy soils adjacent to undesirable agricultural areas due to the use of pesticides. The development of shrimp farming in Guatemala has been a tough challenge in the midst of several obstacles, including socio-political problems, volcanic eruptions, floods and the diseases that have plagued the shrimp aquaculture industry. Shrimp farming activities are found along the southern coast; mainly along the rivers in the departments of San Marcos, Retahluleu, Suchitepequez, Escuintla, Santa Rosa and Jutiapa. Currently 1650 hectares are under production with 120 producers in 44 shrimp farms (Dávila 2016). During the first quarter of 2018, Guatemala ranked third in terms of the highest production in Central America, using intensive and hyper-intensive production systems. No additional detailed official information was available to further analyze the shrimp industry in Guatemala.

7.6 EL SALVADOR

Within the Gulf of Fonseca, El Salvador has mainly low-scale shrimp farming activities, developed by cooperatives and small-scale producers that form small and medium enterprises. By 2018, the official database of El Salvador had records of a total of 44 concessions with 933.27 hectares that have been set aside for shrimp production; 153.75 hectares have been allocated to 5 concessionaires in the Gulf area and 779.52 hectares operate within the department of Usulután, the majority of which are located within the municipality of Jiquilisco. The following table shows the distribution of this land by size.

Table 5: Distribution of land in El Salvador under operational shrimp farming activities (2018)

Range (hectares)	Number of Farms	% of Total Farms	Size (hectares)	% of Total Area
0-20	29	65.90	267.86	65.90
21-100	15	34.09	665.41	34.10
Total	44		933.27	

Source: Portal transparencia - MARN (2018)

Furthermore, there are 846.29 hectares of salt mines in El Salvador, in both the Bahía de Jiquilisco and Bahía La Union. Many of these small-scale producers use combined systems where they produce salt in the summer (December - April) and shrimp in the winter (May - November). Both the Bahía La Union and Bahía de Jiquilisco form part of the national system of protected areas.

7.7 HONDURAS

During the first semester of 2018, Honduras ranked as the country with the largest volume of shrimp production in Central America, with 12,851 metric tons which generated US$ 87.6 million dollars (www.centralamerica.com 2019). For many years Honduras has ranked as the third country in Latin America with the highest production, after Ecuador and Mexico. Shrimp is the third most important export item for Honduras with a contribution of 1.7 % to the gross domestic product.

Table 6: Distribution of land in Honduras under operational shrimp farming production and some salt mines

Size Range (hectares)	Number of Farms	% of Total Farms	Size (hectares)	% of Total Area
0-20	308	76	2,162	9
21-100	61	15	2,770	12
101-200	16	4	2,201	9
201-300	8	2	1,984	8
301-400	3	0.74	1,071	4
+500	5	10	14,394	58
	406		**24,662**	

Source: SENASA, 2016

The shrimp farms have been established mainly on salt pans, old salt ponds, seasonal lagoons and mangroves located near the estuary of the Gulf of Fonseca (Pratt and Quijandria 1997). It is estimated that Honduras has a total of 30,000 hectares with strong shrimp farming potential; 24,662.12 hectares are currently under concession and in production (SENASA 2016). This figure appears to include, for the most part, small-scale producers that produce shrimp during the winter (May - November) and salt in summer (December - April). 61.90% of the production area (15,267 hectares) is concentrated in the San Bernardo region bordering Nicaragua and is the area closest to the Delta del Estero Real WHSRN site. The region of Marcovia has 3958 hectares, Punta Ratón has 2840 hectares and San Lorenzo has 1681 hectares.

The Governments has granted a total of 406 farms under concession; 308 of these farms are in the hands of small-scale producers that barely make up 8.60% of the areas under concession; meanwhile: 58.36% of the concessions are in the hands of five large companies, Grupo Granjas Marinas, Grupo Deli-SeaJoy, Grupo Nova, Grupo Litoral, and Santa Ines.

In the Honduran portion of the Gulf of Fonseca, several main ecosystem types stand out: mangrove forests associated with intertidal mudflats, natural salt flats and temporary freshwater wetlands; the latter make up most of two protected areas that were established after the shrimp farms had been set up. In 1999, El Jicarito was declared a Habitat and Species Management Area through Legislative Decree No. 5-99-E; it covers an area of 6897 hectares and the reserve borders communities, marshes and several shrimp farms, including Camaronera Fonseca and Granjas Marinas San Bernardo. The El Jicarito Reserve is also a Ramsar site.

7.8 NICARAGUA

During the first semester of 2018, Nicaragua was emerging as the Central American country with the second highest production of shrimp in metric tons, according to www. centralamericadata.com. The shrimp farms have been established mainly in the areas of natural salt flats that surround the Río Estero Real marshland; the first line of coast is comprised of a sand-gravel beach, followed by approximately 20-60 meters of a mangrove association of Botoncillo (*Conocarpus erectus*), Black Mangrove (*Avicennia germinans*) and thorny shrubs. In the marshlands, the first line of vegetation is comprised of Red Mangrove (*Rhizophora mangle)* forests in association with other species of mangrove, followed by the salt flats with limited vegetation (many of which are nowadays shrimp farms) and seasonal freshwater wetlands.

Nicaragua has 39,250 hectares of aquaculture; 72% of this area (28,150 hectares) lies within the Delta del Estero Real estuary complex (Coze Saborío 1999). Currently 21,182 hectares have been granted under concession, of which 4000 hectares correspond to applications in progress and 15,274 hectares are in production, some of which were still in the process of being requested (INPESCA 2016).

Table 7 presents the distribution of land under shrimp production according to their size in hectares; although the statistics are not precise, in 2016, 43.32% of the concessioned areas were located on 12 farms that belong to five business groups that operate at a national and international level.

Table 7: Distribution of land in Nicaragua under concession for shrimp farming production

RANGO	# FINCAS	% TOTAL	AREA	% AREA
0-20	22	17	231	1
21-100	53	41	3108	15
101-200	23	18	3,248	15
201-300	13	10	3,172	15
301-400	5	4	1839	9
+500	13	10	9,585	45
	130		**21,182**	

Fuente: impesca 2016

Shrimp farms in Nicaragua have been developed within the Estero Real and Apacunca Natural Reserve, declared in 1983, but yet to be effectively implemented and managed. In 2001, this area was declared a Ramsar site and then in 2008 it was designated by Birdlife International as an IBA (Important Bird Area); more recently, in 2016, the intertidal mudflats area was declared a Shorebird Reserve by the Hemispheric Council of the Western Hemisphere Shorebird Reserve Network.

7.9 COSTA RICA

In Costa Rica, approximately 1146 hectares correspond to shrimp farming areas. Shrimp production in Costa Rica began in the 1970s, although the initial experiences were not very successful (Mena 1987, Tejada 1991). In the 1980s, when salt prices dropped, the salt farmers set out find new options, including shrimp farming (Tejada 1991). Many salt producers began to convert their salt ponds into shrimp farms and develop semi-intensive systems during the rainy season (Robles 2011). The area under cultivation has remained stable because the country does not grant new permits for the installation of projects, because priority has been given to the use of the land for tourism and urban planning purposes, which has raised its value.

There were also a few groups of rural producers that initially engaged in salt extraction but eventually shifted to shrimp farming, and the State provided them with economic support and technical assistance (FAO 2014). Most of the shrimp producers are small and medium farmers who have few complementary activities. We were unable to obtain official and up-to-date information on the areas under concession and those in production in Costa Rica.

7. 10 PANAMA

Panama has a total of 1701 km of Pacific coastline along which 80% of the Panamanian population lives. 72.41% of the shrimp farming activities are carried out by companies (63), while 26.44% is carried out by individual producers (23), and only 1.1% (1) is run by the state (FAO 2007). Panama is ranked as the third country in Central America with the largest production area of shrimp culture with a total of 9886.68 hectares, distributed mainly within the provinces of Coclé (5,603.41 ha), Herrera (1442.62 ha), and Los Santos (588.60 ha). The distribution of the production area in Panama follows the same trends as the other countries in the region; where 49.74% of the production area is under the concession of seven larger shrimp farms; meanwhile, in the case of smaller farms, 4% of the production area is covered by 39 farms, mostly run by individual producers.

Table 8: Distribution of land in Panamá under operational shrimp farming production

Range (hectares)	Number of Farms	% of Total Farms	Area (hectares)	% of Total Area
0-20	39	45	404	4
21-100	28	32	1,389	14
101-200	8	9	1,410	14
201-300	1	1	295	3
301-400	4	5	1,470	15
+500	7	8	4918	50
	87		**9,887**	

Source: De León (2008) ARAP .

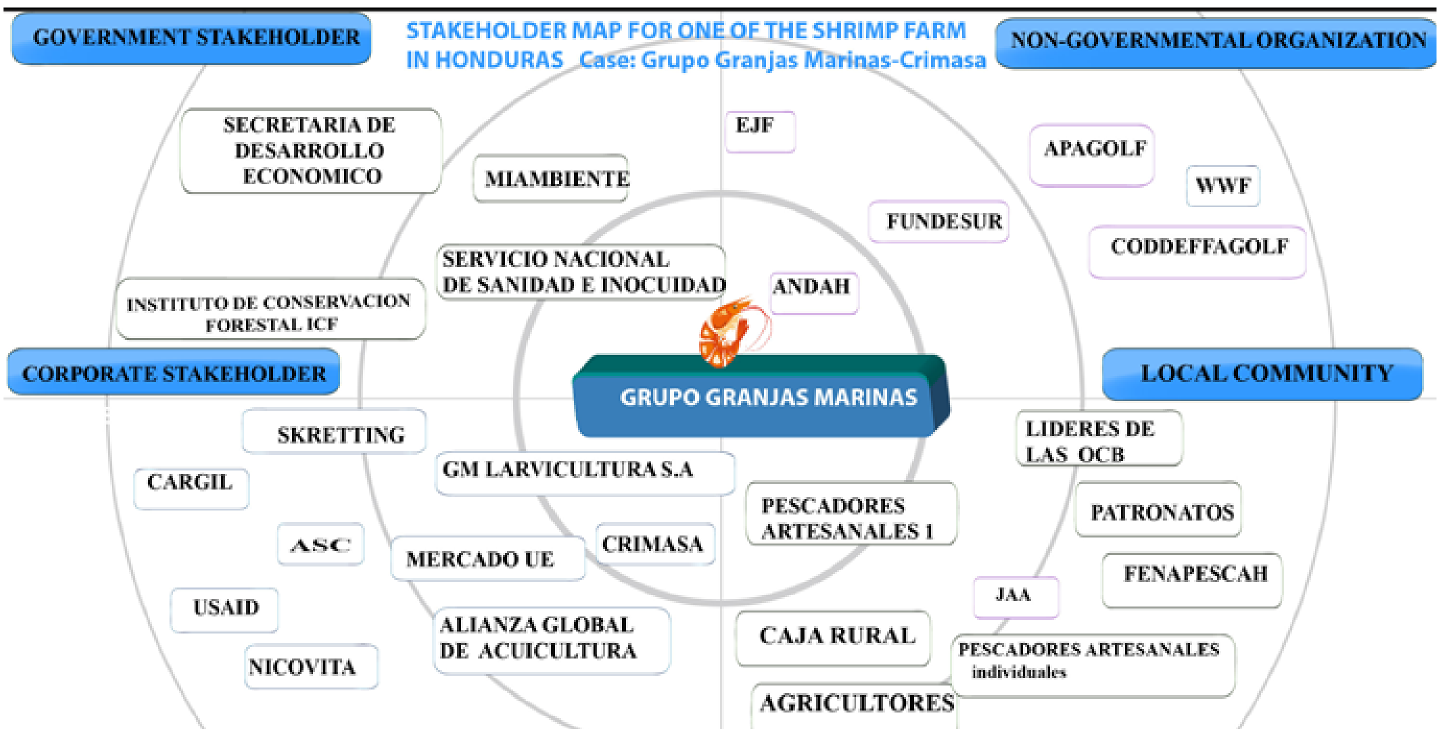
VIII. STAKEHOLDERS

For the purpose of this analysis, we have identified four groups of stakeholders. Producers and suppliers: the producers are directly linked to the production of shrimp and with whom it is necessary to establish a direct relationship to encourage actions that are friendly to shorebirds and the environment; meanwhile, the suppliers have a direct involvement with these producers. The local communities are external stakeholders, but they exert a significant amount of influence on the industry due to their proximity to the shrimp farms. The third group is the governmental stakeholders, which includes various institutions that grant and monitor the concessions and provide technical support. The fourth group includes Non-Governmental Organizations (NGOs), academia and others that are also of an external nature and for the most part accompany research processes and provide management and scientific support from a conservation perspective, among other functions.

Figure 3 maps out the composition of the key stakeholders linked to the CRIMASA shrimp farm in Honduras, taking into account the four groups of stakeholders.
The stakeholders with the greatest power or influence are located closest to the center of the vortex, and as they move away from the vertex they have less power or influence. The dynamics of the stakeholders can vary from year to year, and some might even leave the map while others might enter.

Over the last 25 years, shrimp farming activities in Central America have gradually evolved from a community-based and collective approach, which has not prospered for technical reasons and a lack of industrial and economic know-how, into an activity that is now mainly in the hands of the private sector, and in particular multinational and small-scale enterprises, though there are also cooperatives, associations, and individual small-scale producers.

Figure 3: Stakeholder map for one of the shrimp farms in Honduras (based on WWF, 2017)



8.1 CORPORATE STAKEHOLDERS

At a regional level, 70% of the Central American shrimp production is in the hands of large transnational corporations that operate in more than one country in Latin America. The evolution of shrimp farming and the companies involved have led the business sector to develop a vertical operation system with improved infrastructure, research and development to enhance the management of the life cycle of shrimp; these include genetic laboratories, production farms, processing plants and marketing areas. These companies often provide services to other medium and small-scale producers. For instance, Acuamaya in Guatemala provides larvae to companies in Costa Rica; the Farallón group sells Fertimax to Honduras; and Acuamar in Nicaragua sells its products to the Sahlman group.

Table 9: Main shrimp companies of Central America

Countries	Corporate Stakeholders	Brands	Type/Farms	Size (ha)
Honduras	- Finca Camaronera Grupo Granjas Marinas san Bernardo (GMSB) - Finca Camaronera Criaderos Marinas S.A. (CRIMASA) - Finca Camaronera del Pacifico-Honduespecies (CADELPA-HONDUESPECIES) - Finca Camaronera Acuaquicultivos de Honduras (AQH)	SeaFarm-San Bernardo Aquafinca	Vertical Integration 5 farms	+9,000
Honduras Nicaragua Y Ecuador	**Grupo SeaJoy/Deli/Cooke** Biomar S.A. Fonseca Acuaculture Aquacultura Torrecillas S.A.	SeaJoy Organic SeaJoy All Natural	Vertical Integration 3 fincas	+3,000
Nicaragua Panamá México y Venezuela	**Grupo Farallones** Finca Acuícola Real Finca Seafood Int - Los Piches Finca Acuícola Chame	Farallones ® Afrodisia ® Portobello ®	Vertical Integration 3 fincas	+3000
Nicaragua y Guatemala	**Grupo Nueva Pescanova** Las Rosas San Marino	Pescanova®	Vertical Integration 22 fincas	+5,000
Guatemala	Acuamaya	Tikal®, Crystal Ponds®, Las Joyas®	Vertical Integration	400

Within the Gulf of Fonseca there are 612 concessioned farms, of which approximately 46 are companies with a production area of 18,717.06 hectares (76%). The following table lists the largest companies with shares in several of the Central American countries.

In Nicaragua, the productive sector is divided into three groups and is constantly changing due to the cession of concession rights in favor of companies and individual producers. 79.15% of the concessions are in the hands of the business sector. Six business groups represent 43.32% of the production with 12 farms (Inpesca, 2016).


Delta del Estero Real, Nicaragua
©Salvadora Morales

8.2 BUSINESS ASSOCIATIONS

In both Honduras and in Nicaragua the shrimp farms have organized themselves into associations. In the case of Nicaragua, Asociación Nicaraguense de Desarrollo de Acuicultura (ANDA) is made up of 7 companies; in the case of Honduras, Asociacion Nacional de Acuicultores de Honduras (ANDAH) is composed of 406 producers, processors, exporters and suppliers of inputs and services for the development of aquaculture. The same trend is followed throughout the rest of the Central American countries, where the producers are also organized. ANDAH plays an active role in the development of activities and in the unity of the shrimp farming sector while negotiating with government stakeholders and maintaining an open dialogue between shrimp farms. In the case of Guatemala, the products are organized by Agexport Acuicultura y Pesca, with 13 associated shrimp companies that export their products to various markets, in addition to members from other sectors of the productive chain.

8.3 IMPORT & EXPORT COMPANIES

The production system for shrimp aquaculture is largely vertical, with 70% of the production in the hands of business groups that are in many cases responsible for the entire process, from larva producing laboratories and genetic research right through to the production and export to the final market. However, some of these groups also use the services provided by some importing companies, such as Seafood Lion which has considerable experience in the market. Smaller companies, such as AQUAMAR, sell their export products to larger companies such as SAHLMAN.

Some companies that provide import services for products advise exporters on issues such as the environment, sustainability, quality control, packaging, logistics, regulatory issues and distribution, thus improving performance. Importers usually offer their products on their websites targeting final markets and destinations; however, they do not always mention the place of origin. Many companies export their products directly and make arrangements with supermarkets. It has not been easy to obtain data and other information from the importing companies, since it is considered sensitive data. The following table presents some of the companies identified.

Table 10: Import and export companies identified in Central America

IMPORT COMPANIES	COUNTRY	DESTINATION
Lyon Seafood www.lyons-seafoods.com	Nicaragua Honduras	United States, Europe
AmericanFood Imports www.americanseafoodimports.com		United States: New York, New Jersey, Connecticut, Massachusetts, Rhode Island, New Hampshire, Vermont, Pennsylvania, Delaware, Maryland, Washington DC, Virginia, North Carolina, South Carolina, Georgia, Florida, Chicago, Illinois.
SEA WIN INC www.seawin.com	Nicaragua,	United States (California)
Pacific Northwest seafood industry www.pafco.net	Nicaragua, Panamá, Honduras	United States (Seattle) and Spain
ZUGGS, LLC www.zuggsllc.com	Panamá, Nicaragua, Guatemala	United States (Florida)
MAXFIELD GROUP INC. maxfieldseafood.com	Costa Rica	United States

8.4 INDIVIDUAL PRODUCERS, ASSOCIATIONS AND COOPERATIVES

The first attempt to promote shrimp farming in the Central American region was carried out by local fishing communities that lived close to the potential habitat. In this context, both El Salvador and Nicaragua created associations and cooperatives of small-scale producers as part of their post-conflict strategies. However, the lack of technical and scientific knowledge of shrimp farming and the limited capacity at the time, compounded by a lack of investment, caused the activity to fail. Currently, the associations, cooperatives and individual producers cover 30% of the production; some of these medium-sized individual producers have up to 95 hectares, particularly in Nicaragua and Honduras (Inpesca 2016, Senasa 2016).

Although numerous in terms of the number of farms, these relatively small-scale producers cover a relatively small area. In the case of Honduras, there are more than 300 small producers who in many cases have combined systems of salt production in summer with shrimp production in winter. In the case of El Salvador, there are mostly small producers, with the exception of two important medium-sized companies located in the Bahía de Jiquilisco.

8.5 INTERNATIONAL, NATIONAL AND LOCAL MARKETS

Shrimp farming in Central America has developed based on the international market, with practically 90% of the companies exporting their production. The Central American countries exported a total value of US $90 million worth of shrimp products (15,204 metric tons) to the international market during the first semester of 2018. This was a 76% increase on the value exported during the same period in 2017. Honduras led the export volume with 12,851 metric tons (worth US$ 87.60 million), followed by Nicaragua, Guatemala and Panama with 12,035 metric tons (US$ 67.4 million), 4243 metric tons (US$ 24.7 million) and 4103 metric tons (US$ 23), respectively. Costa Rica exported 128 metric tons and El Salvador exported 7 metric tons.
The following figure shows that at a continental level, the main destination for exports is the United States with 25.85% (3750 metric tons), which represents the main market for Central America; followed by Mexico with 8.84% (1282 metric tons), Guatemala with 7.15% and Costa Rica with 3.59%. Mexico, which is one of the main markets of Honduras, has recently issued new regulations that have disrupted the sale of products to that country; this has been a measure taken by Mexico to protect its domestic producers. During the first quarter of 2018, the sales were led by Honduras meanwhile the export volume was led by Nicaragua.

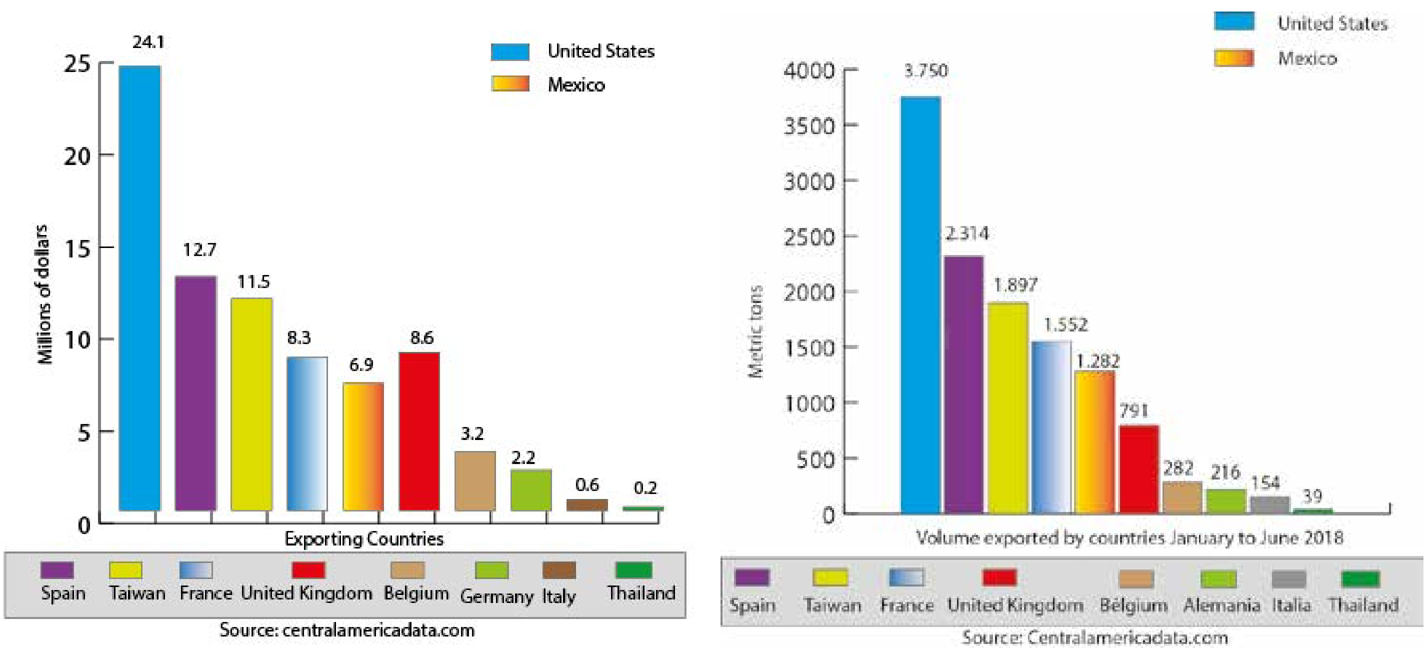


Figure 4: Volume exported and revenue generated by exporting countries from shrimp between January and June 2018.

The second largest export market is Spain with 2314 metric tons, followed by Taiwan with 1897 metrics tons, then France and the United Kingdom. For the most part, the European market has stricter standards and requires that products be certified. In the case of Nicaragua and Honduras, very few of their products are commercialized locally, and are mostly exported to other markets, including other Central American countries (Costa Rica and Guatemala). However, during the preparation of this report we were unable to obtain specific data regarding the local market.

8.6 GOVERNMENT STAKEHOLDERS

Government stakeholders vary from one country to another depending on their policies, processes and programs. The development of shrimp farming has been carried out on salt flats, mangroves and beaches that are owned by the state. Before the shrimp farming boom, the process of designating protected areas in Central America had already taken place; in the Gulf of Fonseca, several protected areas were declared between 1983 and 1987, including Delta Estero Real in Nicaragua, Jicarito in Honduras, and Bahía La Unión in El Salvador.

Shrimp farming activities in the region were subsequently developed after the designation of these protected areas and under different country contexts. Consequently, environmental institutions represent one of the main stakeholders in the region.

In the case of Honduras, shrimp farming activities were stimulated by loans and technical assistance provided through USAID and the Export Development and Services project (EDS) and the Federación de Asociaciones de Productores y Exportadores Agropecuarios y Agroindustriales de Honduras (Federation of Agricultural and Agro-industrial Producer and Exporter Associations of Honduras) - FEPROEXAAH (Dewalt 1996).

In the case of Nicaragua, during the 1980s, aquaculture was considered one of the development priorities to help mitigate poverty and generate economic growth. The first studies to determine suitable productive areas were carried out by the Food and Agricultural Organization (FAO) in 1988 and were initially trials run by cooperatives. Following a change in policies and a more favorable environment for investment, investors began developing the industry. Currently, the main stakeholders of governmental institutions that influence all countries are related to the environmental and conservation sectors, the fisheries and aquaculture institutions, among others that have more of an indirect impact.

The following table illustrates an example. The various Central American governments in the region play different fundamental roles in the export process; some of the most important of these include the institutions that monitor and guarantee the safety and quality of the products, as well as the ministries of fisheries and aquaculture that grant the concessions. At a local level, the municipalities work as decentralized entities that monitor the shrimp farms from their environmental departments. El Salvador is currently investing heavily through the Ministry of Economy to promote the development of the industry.

Bay of San Lorenzo, Gulf of Fonseca, Honduras
©Salvadora Morales

Table 11: Governmental institutions of Countries on the Golfo de Fonseca that have responsabilities related to shrimp farming

COUNTRY	SANITARY CONTROL / CONCESSIONS	CONSERVATION AND ENVIRONMENT	OTHERS
Honduras	Secretaria de Agricultura y Ganadería (SAG) de Honduras. Servicio Nacional de Sanidad Agropecuaria – SENASA, Honduras	Instituto Nacional de Conservación y Desarrollo Forestal (ICF) Secretaría de Energía Recursos Naturales Ambiente y Minas MI AMBIENTE.	CODDEFFAGOLF Comité para la Defensa de la Flora y Fauna del Golfo de Fonseca Alcaldía Municipal de Choluteca.
Nicaragua	Instituto de Protección y Sanidad Agropecuaria (IPSA) Instituto Nacional de Pesca (INPESCA), Nicaragua.	Ministerio del Ambiente y Recursos Naturales (MARENA Alcaldía Municipal de Tonalá Alcaldía Municipal de El Viejo. Alcaldía Municipal de Somotillo	
El Salvador	Ministerio de Agricultura y Ganadería de El Salvador (MAG) Ministerio del Ambiente y Recursos Naturales (MARN)	Ministerio del Ambiente y Recursos Naturales (MARN)	Ministerio de Economía Consejo Nacional de la Micro y Pequeña Empresa (CONAMYPE)

8.7 ACADEMIC STAKEHOLDERS AND NON-GOVERNMENTAL ORGANIZATIONS

Since the very beginning of aquacultural activities, academia has played a fundamental role in its development at a global level. Since 1967, Mexico has developed an aquacultural research program in joint collaboration between the National Autonomous University of Mexico, the University of Sonora and the Monterrey Institute of Technology and Higher Education. Some of the first results came from the technical efforts from the Science and Technology Research Centre of Sonora (Martínez et al. 2009). During the 1990s, when shrimp farming activities began to boom, these universities played a key role in the transfer of knowledge and expertise through student exchanges and research centers throughout Central America. The main contribution that academia offers is the generation of knowledge through the theses of its students.

The University of San Carlos in Guatemala offers an undergraduate degree in Aquaculture; many students focus their graduation theses on various topics related to the production of shrimp and other species in the Centro de Estudios del Mar y Acuicultura (Centre of Marine and Aquaculture Studies).

The Universidad Autónoma de Honduras trains professionals as Aquacultural Technicians preparing them to manage the running of shrimp and tilapia farms, from the initial larval process right through to stocking, breeding and cultivation. Recently, the Asociación Ornitológica de Honduras (ASHO) has been carrying out bird censuses and generating baseline information on shorebirds in the Honduran portion of the Gulf of Fonseca, thus complementing the information generated by the universities.

Celebration of the Designation of Delta del Estero Real as a WHSRN site in Nicaragua ©Salvadora Morales

In 1993, the Central American University in Nicaragua, with support from the Japanese cooperation agency, installed a Centro de Investigación del Camarón - CIC (Shrimp Research Centre) which offered training, technical assistance, research, credit and production through its projects based on a learning-teaching approach. In 1996, the CIC became the Centro de Investigación de Ecosistemas Acuáticos - CIDEA (Aquatic Ecosystem Research Centre) with five laboratories specialized in chemistry, microbiology, plankton, nutrition and humidity.

These labs continue to work to this day, and for almost 15 years they have provided a water quality monitoring service to the shrimp companies. Although the initial idea behind the creation of the CIC was aimed at working with cooperatives in Puerto Morazán, since its creation, the institute has carried out a series of research projects at the undergraduate thesis level, as well as research courses and the creation of a training program (UCA 2010). In 2000, with the support of a USAID project, collaboration was obtained from several universities in the United States. Around 79 research projects were developed, though none of them were related to the biodiversity present at and used by the farms (UCA 2010).

The UNAN León offers a degree in Aquacultural Engineering and some of the students carry out their research on shrimp farms. The SEAJOY group has signed an agreement with the university that enables students to carry out their research in this area.

Based on the review of research carried out during this analysis, we did not find any research work from the institution related to birds. Mexico is making more of a breakthrough regarding the level of their master's and research theses through the National Autonomous University of Mexico.

Table 12: Non-Governmental Organizations in Central America that have influence on shrimp farming and conservation.

GUATEMALA	
Fundación para el desarrollo y la conservación (FUNDAECO)	https://fundaeco.org.gt/fundaeco.org.gt/
Wildlife Conservation Society-Guatemala (WCS)	https://guatemala.wcs.org/
Universidad de San Carlos (USAC)	www.usac.edu.gt/
HONDURAS	
Fundación para el Desarrollo de la Zona Sur (FUNDESUR)	
Asociación Hondureña de Ornitología (ASHO)	avesdehonduras.org/
Universidad Nacional Autónoma de Honduras (UNAH)	www.unah.edu.hn/
EL SALVADOR	
SalvaNatura Fundación Ecológica	www.salvanatura.org/
Asociación de Educación Popular-PROCARES (CIAZO)	www.ciazo.org.sv
Fundación Salvadoreña para la promoción Social y el Desarrollo Económico/ UICN	www.funsalprodese.org.sv
NICARAGUA	
Quetzalli Nicaragua	www.grupoquetzalli.com
Universidad Centroamericana UCA – CIDEA	www.uca.edu.ni/
COSTA RICA	
Unión de Ornitólogos de Costa Rica	www.uniondeornitologos.com
PANAMA	
Sociedad Audubon de Panamá	www.audubonpanama.org
INTERNATIONAL	
Western Hemisphere Shorebird Reserve Network (WHSRN)	www.whsrn.org
Manomet.inc	www.manomet.org
Point Blue Conservation Science/Calidris	www.pointblue.org
National Audubon Society	www.audubon.org
Universidad Austral de Chile	www.uach.cl

8.8 LOCAL COMMUNITY STAKEHOLDERS IN THE GULF OF FONSECA

In almost all of the shrimp farming areas, communities are located outside of the concession areas and with only limited access to these areas. The latter is partly the result of the infrastructure developed (usually water channels) which limits access to the shrimp farms. Although we were unable to find precise data, the main activities undertaken by local communities in the area are fishing, agriculture and livestock production. Fishing activities are mainly focused on fish, fire shrimp, scallop harvesting (on the mudflats) and crabs. In El Salvador and Honduras, they also produce salt in the summer and shrimp in the winter. Many members of the communities work for the shrimp farm companies. Although the communities have some level of organization, additional efforts are still required to foster collective leadership and management skills.

Honduras: the key stakeholders identified at a community level depend on the specific areas within which shrimp farming is generally carried out. For the most part the communities interact very little with the large shrimp companies. Among the main ones identified are the leaders of the OCB (Organizaciones Comunitarias de Base), Patronatos, JAA (Junta Administradora de Agua), Caja Rural Pescadores Artesanales and Pescadores Artesanales Organizados, as well as individual farmers.

Nicaragua: the communities near the Delta del Estero Real are mainly individual fishing villages organized into productive cooperatives. Five municipalities converge in this area: Puerto Morazán, Somotillo, El Viejo, Villa Nueva and Chinandega. There are 19 communities with a total of 18,383 inhabitants; the most populous communities are Tonalá, Palo Grande and Ranchería (FUNDAR-NICATIERRA 2006). To date, the communities are not organized nor are there activists within their community. In terms of their primary activities, these communities are comprised of fishermen, scallop harvesters and farmers.

El Salvador: the communities are organized into Asociaciones de Desarrollo Comunal - ADESCOs (Community Development Associations); each ADESCO has its board of directors and are governed by statutes, which are created together with the municipality.


White Pelicans in the Reservoir of the Acuícola Real Shrimp Farm, Nicaragua.
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IX. ANALYSIS OF THE SHRIMP FARMING PRODUCTION SYSTEM IN CENTRAL AMERICA.

9.1 BACKGROUND ON SHRIMP FARMING AND LAND USE CHANGE

Aquacultural activities in Central America began during the 1970s and were promoted mainly by programs of the Fisheries and Aquaculture Department of the United Nations (FAO); by 2009, aquaculture provided 42% of the shrimp consumed globally. Worldwide, the main producers are China, Vietnam, Indonesia and India; between 75-80% of the production is carried out in the Asia-Pacific region (FAO 2017). In Latin America, the largest producers are Ecuador, Mexico and Brazil, followed by Honduras and Nicaragua; however, Brazil and Mexico only produce for internal consumption and do not export. Shrimp farming in Latin America represents an important economic activity that supports thousands of families through both direct and indirect employment.

In Central America, Honduras leads the production of shrimp; by 1996, there were 13,620 hectares under production which have now expanded to well over 24,662 hectares (ANDAH, 2016), although these figures apparently also include the salt producing farms. The following table illustrates the growth of shrimp farming in the region over a 10-year period, as well as the potential area available for aquacultural expansion.

Table 13: Distribution of shrimp farming production in Central America and Mexico between 1996 and 2016

COUNTRIES	HECTARES		AVAILABLE HABITAT
	1996	2016	
México	20,000	86, 438	230,000
Guatemala		1,650	
Honduras	**13,620**	24,662	30,000
El Salvador		933	
Nicaragua	4,000	21,182 (15,274 en producción)	39,000
Costa Rica	800	1600	
	40,520	146,351	317,280

Total for Central America in 2016: 59,913 hectares / Total for Mexico in 2016: 86,438 hectares

To analyze the land use changes in the Gulf of Fonseca, field visits were combined with a revision of the Google Earth image sequence (1985 to 2016) and a review of recent literature in the area. The existing studies do not allow for a direct comparison due to the differences in the methodology used and the geographic areas that they cover. Alfaro (2009) considered that the mangroves and salt flats along the Pacific coast are gradually becoming replaced by the productive systems.

Some 51,862 hectares of mangrove forest and 37,991 hectares of mangrove shrubbery have been estimated, which includes Jiquilisco Bay, the Gulf of Fonseca and Padre Ramos. A more recent analysis estimates 101,994 hectares of mangrove but includes the area of Corinto.

A visual interpretation of Google Earth images reveals that the mangrove forest cover has not been significantly displaced by shrimp ponds (see Annex 3). Instead, the most displaced ecosystems have been the natural salt flats (salitrales) with sparse vegetation, also referred to locally as suelos albinos or playones salitrales, and in some cases as manglares arbustivos. Further studies focused on the dynamics of this land use change in the area are required. Similarly, Zitello (2007) found that in northeastern Brazil, contrary to what is described in literature, the extensive salt flats were those that suffered the greatest destruction as a result of shrimp farming, and not the mangrove forests. It was also found that 75% of the shrimp culture in Mexico had been built up in the salt flats and only 1% in mangrove forests (Berlanga-Robles *et al*. 2011). When the winters have significant rain, some of these salt flats fill up with water between November and December and subsequently start to dry up as the summer progresses.

Unfortunately, no information is available on the importance of these salt flats or their use by shorebirds prior to their change in land use. Preliminary data from the breeding season of 2018 show that the resident population of *Charadrius wilsonia* nested on the salt flats (Reyes et al. 2018), as well as on the dikes of shrimp farms and salt ponds in Honduras, which suggests that this habitat was potentially used as a reproductive habitat for this species. We consider that it is very important to understand the dynamics of the remnant salt flats and the use that the birds make of them.

It is worth mentioning that the areas with the highest potential for shrimp farming have been almost completely concessioned. The few remnants of salt flat habitat are located within these concessions or in some cases within the boundaries of protected areas. Taking into consideration the continuous expansion of shrimp farming, ***it is likely that this habitat type will soon be entirely lost; or perhaps the shrimp farming expansion process could plan reserve areas to safeguard the natural habitat.*** In the case of mangroves, some shrimp farms such as Fonseca in Honduras and CAMPA in Nicaragua already employ practices which use mangrove areas as part of the farm's water filtration and cleaning system, prior to entering its reservoirs. As such, mangroves are included as reserve areas within the boundaries of their concessions.

9.2 SPATIAL DISTRIBUTION AND LANDSCAPE CONTEXT

To function optimally and sustainably, shrimp farms must be located in areas where there is good water quality and sufficient circulation. Shrimp farms in Guatemala, with its 253 kilometres of coastline, are distributed throughout different sectors of the southern coast, usually with limited access to water. The wetlands from which the shrimp farms extract their water are quite small, such as Escuintla with 18 of the 41 active farms, followed by Santa Rosa with 13 farms (Tay 2014). 52% of the farms use an intensive system, meanwhile 1% are hyper-intensive and 47% semi-intensive.

Honduras, El Salvador and Nicaragua, with 858 kilometres of coastal zones, share a complex system of wetlands in the Gulf of Fonseca (409 kilometres of coastline) with a potential of approximately 60,000 hectares suitable for the development of shrimp farming. Furthermore, El Salvador and Nicaragua have important production areas in the Bahía de Jiquilisco (El Salvador) and the Estero Padre Ramos and Corinto (Nicaragua). A variety of important habitats for birds are found in this area, among which are intertidal mudflats, salt pans or salt flats, marshlands, mangroves, freshwater wetlands, sand-gravel beaches, salt ponds and shrimp farms.

Costa Rica has 837 kilometres of coastline but concentrates its production in the Gulf of Nicoya where mangroves, salt flats and shrimp farms are found. Of all the Central American countries, Panama has the greatest extent of Pacific coastal zones with 1075 kilometres, and an estimated 18,000 hectares of suitable areas for the development of shrimp farming; however, the climatic conditions are not favourable resulting in a high incidence of diseases. Consequently, shrimp farms are currently found in only four departments: Panamá, Herrera, Los Santos and Veraguas. In the case of Costa Rica, Panama and Guatemala, as a result of having reduced areas for shrimp culture, the tendency is to shift towards more intensive systems.

9.3 MODIFICATION OF LANDSCAPE AND HYDROLOGICAL PATTERNS

At a landscape level, several protected areas have undergone major landscape changes, including salt flats, and to a certain extent mangrove area transformed into shrimp ponds or water reservoirs. In the Gulf of Fonseca, there are different experiences within the shrimp farming areas of each country. For example, in El Salvador and Honduras, shrimp farming was established before the protected areas; however, in the case of Nicaragua, the protected area was established first and then the shrimp farming activities were carried out right in the core area of the nature reserve. Table 14 shows the protected areas on the Pacific coast of Central America that are located within the vicinity of the shrimp farms.

Table 14: Protected areas within the vicinity of the Shrimp farms in Central America

COUNTRY	MANAGEMENT CATEGORY	HABITAT TYPE	COMMUNITIES
Guatemala	Reserva de Uso múltiple Monterrico 2800 has	Mangroves, Beaches	Madre vieja, El Pumpo, La Candelaria
	Parque Nacional Hawái 31 hectáreas Sicatepeque-Narajo 2,000 ha		
	Reserva Privada, La Chorrera, Manchón Guamuchal 13,500 ha		
El Salvador	Complejo Cachagua y Bahía de la Unión	Mangroves	
Honduras	Área de Manejo de Hábitat por Especie 1. Bahía de Chismuyo. Area: 316 KM2 2.Bahía San Lorenzo 3.Los Delgaditos Área: 18.15 (1,815 Ha) 4. Iguana-Punta Condega 5. San Bernardo 6.La Berbería 7.Jicarito:Área 6,897 hectáreas	Wetlands, mangroves, marshes, wetlands and mangrove fishing communities.	El Cubulero, El Conchal, San Lorenzo, Valle Nuevo, El Capulín, Calicanto, Los Guatales, Las Playitas, Playa Grande, Costa de los Amates, El Aceituno, Nacaome, El Guanacaste, Amapala y Alianza.
Nicaragua	Reserva Natural Delta Estero Real-humedales de Apacunca. Reserva de Aves Playeras	Intertidal Mudflats, Mangroves, Salitrales, Shrimp Farms, Beaches, Freshwater Wetlands.	Potosí, Pueblo Nuevo, Tonalá
Costa Rica			
Panamá	Parque Nacional Sarigua 8,000 has	Desert	Herrera

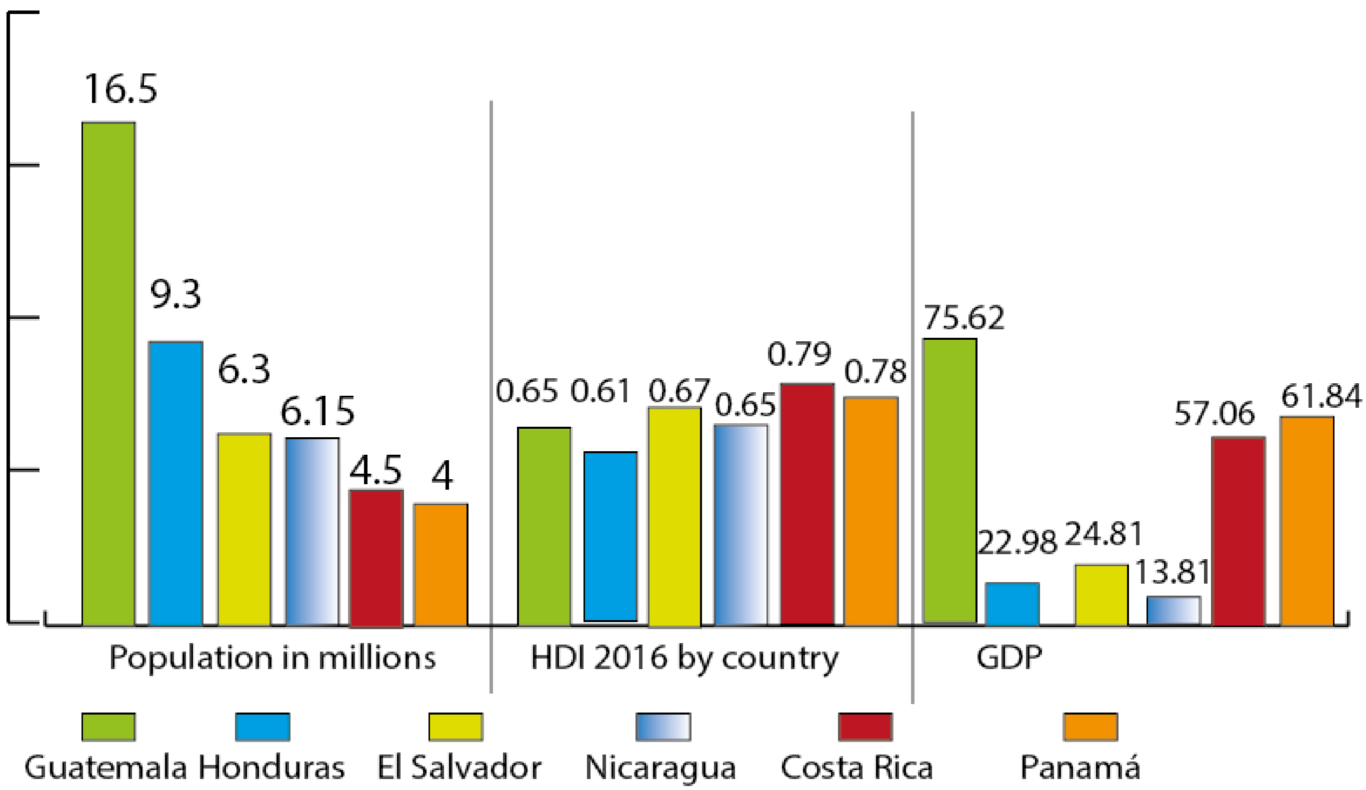
At a landscape level, the river basin approach is of vital importance for the shrimp farming areas and natural shorebird habitats, considering that most of the sediments that end up in the wetlands come from further upstream. The hydrological basin of the Gulf of Fonseca occupies approximately 22,000 km2. The overall basin is comprised of 14 smaller tributary basins, the largest being Choluteca, followed by Río Negro, Rio Estero Real, Nacaome, Goascaran and Sirama. The majority of the shrimp farms are located towards the bottom end of the basins, where the tidal effects are strongest, and the water exchange of the reservoirs and shrimp ponds is greatest. In terms of changes in the hydrological pattern, the most significant element for which no information appears to be readily available is the role that was played by the salt flats (now largely replaced by shrimp ponds).

9.4 SOCIOECONOMIC CONTEXT

The Human Development Index (HDI) is an indicator created by the United Nations Development Program (UNDP) to help determine the level of development of the countries around the world. One of the main social problems around the Gulf of Fonseca is its extreme poverty (a situation which also applies to Guatemala). The population of the Gulf of Fonseca region is estimated at more than 750,000 people, spread out among 19 coastal municipalities.

Access to basic services in the main localities is limited and the vast majority of rural households in the communities lack a clean, reliable drinking water supply, solid waste collection and wastewater treatment, all of which contributes towards the spread of diseases. Job prospects are limited to shrimp farms, and traditional/subsistence fishing and subsistence agriculture, which are being affected by climate change and the decline in fish stocks. Socio-economic development of a country can be measured in the following two ways: the HDI and the Gross Domestic Product (GDP). The following table presents the HDI and GDP by country, where we can see that Costa Rica and Panama have the highest rates in both cases, meanwhile, Nicaragua has the lowest GDP in the region, and Honduras the lowest HDI in 2016.

Figure 5: Distribution of HDI and annual GDP in the Central American countries



Acuícola Real Shrimp Farm, Nicaragua.
© Michael Gutierrez

9.5 SOCIAL IMPACTS

The social impacts vary considerably from the local, national and international levels depending on the type of aquaculture and the policies of each country. Undoubtedly, aquaculture produces important social and economic impacts, both directly and indirectly, for people living in the nearby communities. Prior to the installation of the shrimp farms, the areas were not inhabited and the nearby communities were dedicated to artisanal fishing. As a result of the growth of aquaculture at the business level, new jobs were created. Some conservation organizations also initiated complaints regarding the destruction of natural habitats, although many of these complaints had no scientific backing. It is therefore a pending task to demonstrate with scientific data the positive and negative impacts of shrimp farms towards the environment in general in Central America.

In general, the perception of the shrimp farms is positive on the part of the communities, although there is still a process of strengthening corporate social responsibility programs, which could be aimed more at undertaking and improving the living conditions of the farm workers' families. Aquaculture has evolved in recent years to become a vertical system, which allows for more job opportunities within the communities, from larvae laboratories, farms, processors and transport. In the case of Honduras, 27,000 direct and indirect jobs have been generated, benefiting 160,000 people. Similar figures are given in Nicaragua. In El Salvador, where the activity is led by small-scale associations and cooperatives, the main constraint to further development is the high production costs, which are impossible for these groups to assume to develop shrimp farming and generate a positive social and economic impact in their communities.

9.6 SHRIMP FARMING POLICIES AND REGULATIONS

At national and international levels, there is an extensive legal framework for a wide range of aquacultural activities and their value chains, which covers issues such as the control of aquatic animal diseases, food security, and biodiversity conservation. The general legal framework is particularly strong in relation to the processing, export and import of aquatic products. The recognized authorities are normally qualified to verify compliance with mandatory national and international legislation (FAO 2011). For non-binding issues such as environmental sustainability and socio-economic aspects, voluntary certification provides an opportunity to improve their practices and demonstrate to an increasingly demanding market that their production systems take into account the environment and the people who live around them.

The policies and regulations vary from one country to another. The goal of the laws and policies has been to organize and promote the development of aquaculture. At a Central American level, the first law that was developed to regulate aquaculture and fishing was created in El Salvador in 2001, followed a year later by legislation in Guatemala and Nicaragua. In the case of El Salvador, a new proposal was submitted in 2017 to modernize the legislation on fisheries and aquaculture, taking into consideration the limitations set by a lack of investment in laboratories, technologies, capital and training, as well as a lack of incentives for investment. Honduras has the most modern law that was updated and approved in 2017, adapting itself to the latest conditions of the country's economy and national and international policies. The unity shown by the Aquaculture Association has been key to this process. The details of the approved laws can be seen in Table 15.

Workshop Integrating shorebird conservation and shrimp farming in Central America, Panamá

Table 15: Policies, laws and decrees that regulate aquaculture in Central America

COUNTRY	POLICIES	YEAR
Guatemala	Ley de Acuicultura y Pesca (Law on Aquaculture and Fisheries)	2002
	Reglamento de la ley general de pesca y acuicultura (Regulation of the General Law on Fisheries and Aquaculture)	2005
El Salvador	Política Nacional de Pesca y Acuicultura (National Policy on Fisheries and Aquaculture)	2016-2030
	Ley General de Ordenación y promoción de pesca y acuicultura (General Law on the Management and Promotion of Fisheries and Aquaculture)	2017
Honduras	Ley General de Pesca y Acuicultura (Law on Fisheries and Aquaculture)	2017
Nicaragua	Reglamento de ley 489, ley de pesca y acuicultura (Regulation of Law 489, Law on Fisheries and Aquaculture)	2005
	Decreto Lineamientos de políticas para el uso sostenible de los recursos pesqueros y acuícolas (Decree on Policy Guidelines for the Sustainable Use of Fishery and Aquaculture Resources)	2001
	Acuerdo Interinstitucional INPESCA, IPSA, MARENA, MIFIC, PRONICARAGUA (Interinstitutional Agreement between INPESCA, IPSA, MARENA, MIFIC and PRONICARAGUA)	2015
	Normas técnicas NTON Acuicultura NTON Aquaculture technical standards	2002

Costa Rica	Ley de Pesca y Acuicultura Law on Fisheries and Aquaculture	2005
	Plan Nacional de Desarrollo de la Pesca y la Acuicultura de Costa Rica National Plan for the Development of Fisheries and Aquaculture of Costa Rica	2013
Panamá	Ley de Acuicultura y Pesca Law on Aquaculture and Fisheries	2005
International	Declaración y Estrategia de Bangkok para el Desarrollo de la Acuicultura Más Allá del Año 2000. Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000	2000

9.7 OTHER POLICIES AND TECHNICAL GUIDELINES

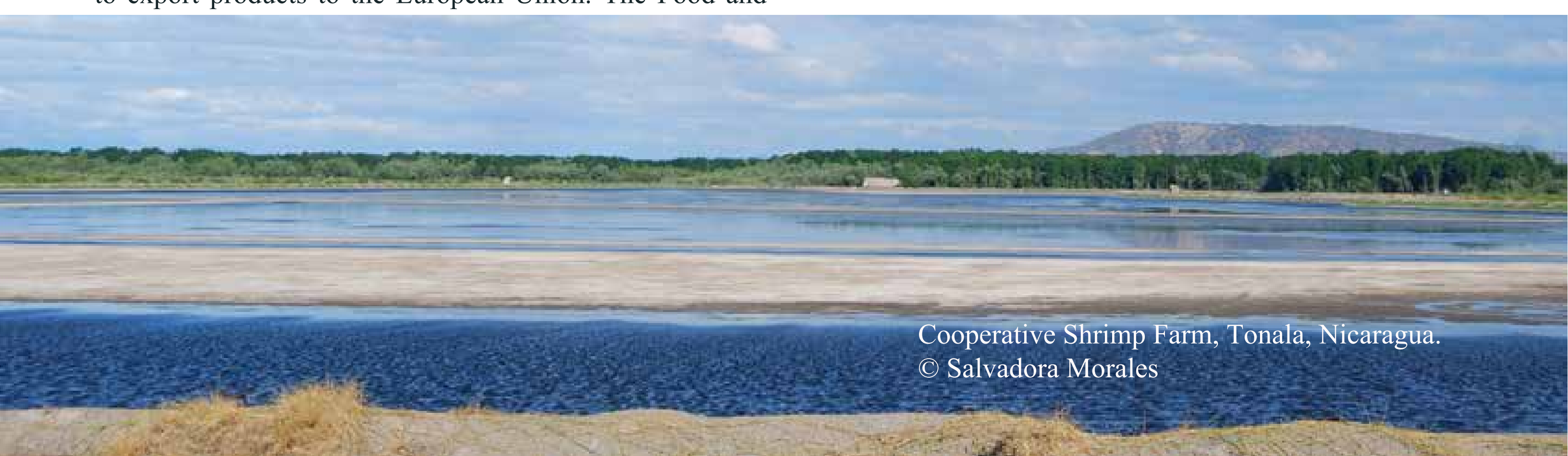
The FAO is promoting an ecosystem approach to aquaculture as a management strategy. This requires an adequate political framework whereby the strategy is developed through several steps: (i) the scope and definition of the ecosystem boundaries and the identification of stakeholders; (ii) the identification of the main problems; (iii) the prioritization of topics; (iv) the definition of operational objectives; (v) the preparation of an implementation plan; (vi) the corresponding application process, which includes reinforcement, monitoring and evaluation; and (vii) a long-term policy review. All these are steps informed by the best available knowledge (FAO 2010).

Regulation of the shrimp importing countries: Shrimp farmers need to know the regulatory standards of their country and of the countries where their product will be sold and consumed. In most countries, regulatory authorities are created in order to protect the "safety" of consumers. Most countries have specific regulations for the safety of products produced and imported. In many cases, these regulations influence the quality of the product. The standards of regulatory agencies are based on rules and measures for product safety and quality. In environmental terms, one of the most demanding set of regulations is that established by the European Union. Here, an initial question is whether the country is included in the list of countries authorized to export products to the European Union. The Food and Veterinary Office is responsible for assessing whether the country complies with European health standards; among which is the question of residual veterinary medication. In order to be authorized to export aquaculture products, countries must first submit an annual residue monitoring plan to the European Union.

9.8 PRODUCTION PRACTICES, SCALE AND CALENDAR

Shrimp farming production in Central America has reached 3.2 million tons, of which 75% comes from the species *Litopenaeus vannamei.* This production represents approximately 2% of the global production; however, for the Central American countries, this represents a considerable proportion of the economy of each country, as the industry creates employment and benefits society. Large companies have a vertical or integrated system with traceability systems that allows them to have control at all stages of the farming process right through to the final consumer.

In Asia, despite maintaining 75% of the global production, there are thousands of small shrimp farms with hyper-intensive systems, high-density stocking rates and a greater tendency to use antibiotics and prohibited products to guarantee shrimp survival. Furthermore, the supply chain is fragmented, which makes it impossible to maintain constant and reliable traceability. In addition, the environmental impact is questionable and tends more towards a negative



Cooperative Shrimp Farm, Tonala, Nicaragua.
© Salvadora Morales

value, taking into consideration the intensity of the crop, the massive volume of product, the use of skilled labor and the fact that the industry is subsidized by the government (Liao 2018).

In Latin America, the size of farms ranges from medium to large, with pond sizes typically of 10-30 hectares. The stocking rates are semi-intensive with medium to low densities and the use of antibiotics has not been detected; if this were the case, however, the level of use is so low that it has not been identified. The traceability is more reliable, the environmental impact is lower and the social impact more positive than in Asia. Central America has more integrated and traceable systems, there is a greater awareness regarding the environment. The production is more specialized in terms of primary products, with a more natural production making it more competitive and the investment is overwhelmingly private.

9.8.1 PRODUCTION SYSTEMS

The shrimp production systems in Central America are mainly semi-intensive (<12 ind./m2 and >5 ind./m2) and extensive (<5 ind./m2) (Hernández 2014). Guatemala is the only country where intensive and hyper-intensive (>12 ind./m2) systems are carried out, making up 46% of the country's shrimp farms (Tay 2014). The rest of the countries use the semi-intensive system with stocking rates of around 8 to 12 post-larvae per m2 during the dry season and 10 to 16 post-larvae per m2 during the rainy season. The production system is divided into several phases. Sometimes higher densities are stocked to counter for the loss suffered from predation by waterbirds, such as cormorants. A key part of semi-intensive systems is monitoring the carrying capacity of each pond, and the areas from where they are filled and into which they discharge, so that it does not affect the environment.

Seed Production Phase (20 - 22 days)

Since the beginning of shrimp aquaculture, one of the main concerns of the environmental sector was the extraction of larvae from the natural environment; however, the industry and science have worked together in the installation of its laboratories, thus taking control of the process right from the beginning and without extracting from nature. In most cases, business groups today have their own laboratories, and start with selected breeders and include the larvae and post-larvae phase. At this stage there is no interaction with shorebirds. The capture of post-larvae from the natural environment is no longer practiced, with the exception of small-scale salt producers who let wild larvae enter their ponds in winter; but even the small farmers are starting to use laboratory products, such as in the case of El Salvador.

Nursery Phase or Raceways (15 days)

The post-larvae are incorporated into the nurseries, which are smaller ponds than those used for the grow-out phase and are left there to feed until they become juveniles. A new technique is the use of raceways that ensures greater control over post-larvae and there is a greater survival rate; however, it requires considerably more investment in infrastructure and has a greater carbon footprint, because more electricity is consumed. Not all shrimp farms have nurseries.

Grow-out phase (90 - 120 days)

During this stage, the post-larvae are moved from the nursery to grow-out ponds where they will remain until they reach an ideal marketable size. This stage lasts between 95 - 120 days. There are various feeding techniques depending on the companies and the specific management involved, and usually require feeding twice a day. Shrimp are omnivorous and feed on plankton and concentrate feed. Several companies provide nutritional products, including Cargill, which has its plant in Nicaragua, Areca in Guatemala, and Skretting in Nicaragua and Honduras. Balanced concentrate feed carries a mixture of protein (from animal or vegetable origin), carbohydrates, fibre, calcium, phosphorus and amino acids, among other elements. In addition to the feed, during this stage, the water is also fertilized to promote primary production (phytoplankton). The industry has also innovated in terms of the availability of organic products that allow for a better management of water turbidity, solid waste management and other necessary elements. Only in the case of a disease outbreak are specific products applied to overcome the crisis. During this phase, the ponds are full and not in use by the shorebirds, with the exception of the dikes.

Harvest Phase

During this stage, the water level of the shrimp ponds is lowered in preparation for the harvest. Harvests are usually carried out at night and when the tide is low. Once all the shrimp have been removed and the ponds are free of water, this is the "friendliest" time for shorebirds. Depending on the market and the season, the type of treatment that each pond will receive is planned. This stage coincides with a greater use of the ponds by the shorebirds, particularly during the first two to three days post-harvest. Advances in technology and knowledge have resulted in many companies employing ongoing cycles of stocking and harvesting, leaving the ponds empty on average two to four days at the most. The amount of time that the ponds are left without water depends on the conditions found on their bottoms; for example, if a pond has a high density of mollusks, they will leave it to dry for up to a week which gives them enough time to die from oxygen exposure. It is worth mentioning that harvests are carried out based on market requirements and often depend on shrimp size and weight, making the exact timing of harvests difficult to predict under this model.

During the post-harvest phase, ponds are treated with chlorine, lime and other products such as pesticides and algaecides and in most cases are prepared for the new stocking immediately after treatment. The various treatments, such as soil fertilization, are carried out in wet conditions. During this process the ponds are full of water and are not used by shorebirds, with the exception of the edges and dikes; however, if a post-harvest treatment is indeed carried out, the birds will make use of it mainly as a rest area. The greatest threat during this stage is that the shorebirds may be deterred from their roosting areas that they share with the cormorants.

Stocking Phase

This phase varies considerably based on the individual practices of each shrimp farm. After being treated, the ponds begin a new process of filling that can last several days. In some cases, there are ponds that will fill only a few centimetres of water over several days. This is another moment in which there is an interaction between the shorebirds and the shrimp production process, but this also depends on the timing. If the pond is filled too quickly, it reaches a depth that is not accessible for shorebirds. Shrimp farms in Central America use staggered production calendars. We were able to identify three types of production cycles (see Table 16). Type 1 is based on the traditional calendar, with usually two, three or even four shorter production cycles, leaving the ponds exposed during different months with shorter periods of time. In the Gulf of Fonseca, most shrimp farms apply

Table 16: Shrimp harvest calendar

Ciclos	Siembra	Cosecha	Notas
Type 1 (cycles 1 & 2)	15 January June/July	April/May October/November	Pond drying 30 to 40 days in October & December
Type 2 (cycles 1,2,3 & 4)	Staggered	Staggered	There may be harvest every month. Pond drying every 2 years or more
Type 3 (1 long cycle)	February	October	Southern Costa Rica

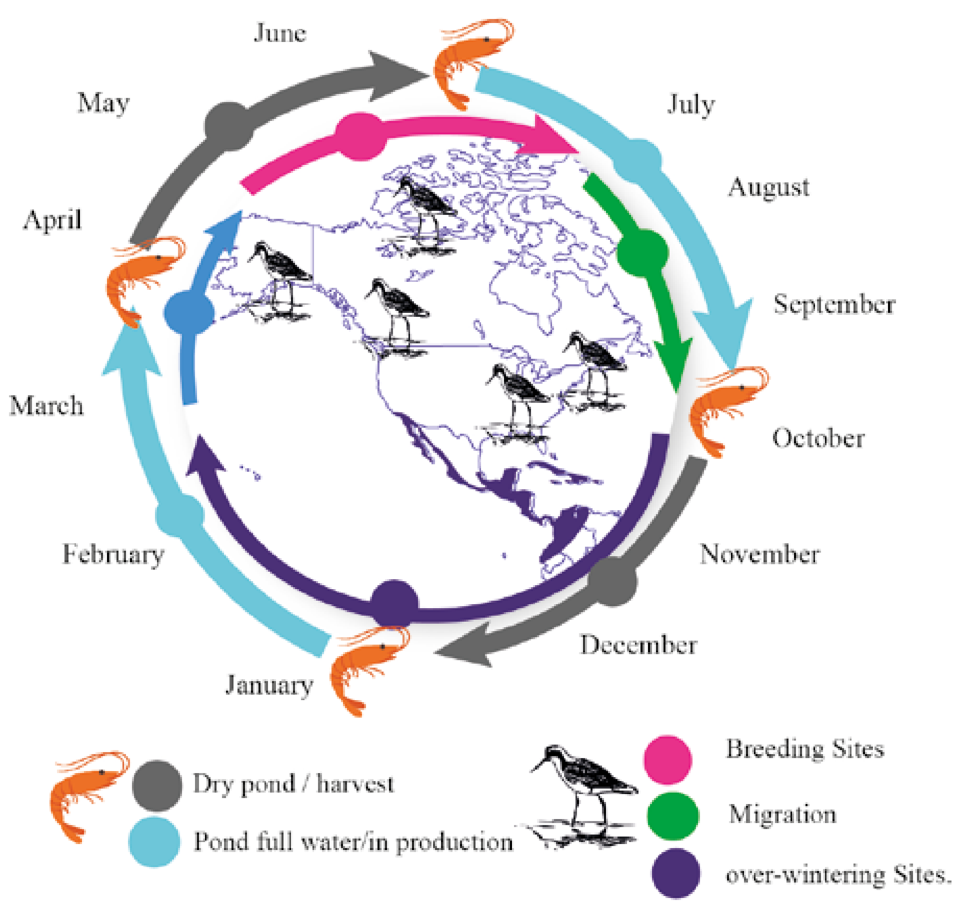


Figure 6: Shrimp harvest calendar and annual cycle of the shorebirds

two types of production cycles. They have been able to overcome the problems associated with not drying the ponds and nowadays the cycles are more continuous. It is often the case that various different production cycles are employed on the farms, because while one cycle is being harvested, for example, another one is being stocked, so there are often empty ponds available for two to three-day periods for the birds to use. In other cases, there are two production cycles that harvest around November-December, seed in January, and then harvest again in May-June.

Processing phase

Once harvested, the shrimp are processed in plants that are often located outside the areas of production; however, there are also cases where the processing plants are located near the key bird areas, so the constant monitoring of wastewater (which is usually full of organic matter) and its final disposal, is necessary throughout the entire processing phase. In other countries, such as Colombia, the waters are discharged back into the ocean once treated (we do not have data regarding the case in Central America).

Export and Market Phase

The final consumers are becoming increasingly demanding in terms of access to information regarding the origin of the products that they consume through the traceability systems and that these products must be environmentally and socially sustainable. Regarding market and trends, this product appeals highly to millennials as a premium product; these potential consumers are more demanding in terms of access to product information such as transparency, the ingredients used in their feed, food miles, what impact the product has had in the environment, that products are produced sustainably in terms of their environmental and social impact, among others. There are approximately two billion potential consumers worldwide within the demographic segment of the market to which shrimp are exported, with a purchasing power worth 200 billion US dollars. In the United States alone, there are approximately 92 million millennials who are becoming the largest and economically most powerful group on the planet.

Latin America has the capacity to influence this market but requires commercial alliances and communication campaigns that could help to integrate this potential market. From this perspective, the market can influence a win-win relationship whereby shorebirds are integrated into the equation as fundamental elements that are favoured during their migration and winter residence, while also maintaining the resident birds.

Spain is one of the main markets in Europe; a study shows that 75% of consumers state that the determining factor in their purchase decision is the price-quality ratio, followed by the related health aspects. With this in mind, 75% of consumers would be willing to pay more for a product that, in addition to being functional, contributes to the sustainability of the environment. Furthermore, the results of the survey and data obtained from other sources and studies reflect that citizens are becoming increasingly familiar with concepts and aspects linked to sustainability and responsible consumption, though they might not always understand exactly the meaning or the scope of these concepts.

9.8.2 PRODUCTION INFRASTRUCTURE

The infrastructure built for shrimp farming production forms part of the quality criteria that we have selected for this case study. In order of importance, both in terms of production and the analysis of shorebird use, these would be the grow-out ponds followed by the dikes.

GROW-OUT PONDS

The ponds have been built, for the most part, following the designs and techniques recommended for shrimp aquaculture. Depending on the size of the farm, up to 95 ponds can be found of different sizes ranging from 10 to 20 hectares. The ponds are filled to an approximate depth of 1.20 meters during periods of 90 to 120 days on average. During this stage, the ponds are not available for shorebird use, and therefore cannot be considered “shorebird friendly”. Once the ponds have been harvested, they become readily available for shorebirds and other waterbirds, and this is the stage that can be considered as “most friendly” because it offers an opportunity for feeding that, although it might appear to be ephemeral, is of great importance to the shorebirds. Through this analysis, an initial effort has been carried out to identify the specific conditions that influence the use of shrimp farms by shorebirds, as well as to determine their importance for the shorebirds in terms of habitat (availability); the effectiveness of the use, the traceability of its products, and the safety that they offer to the birds that make use of the farms. These variables still need to be properly documented and scientifically validated in order to generate specific recommendations for their management (Annex 3).

DIKES

The ponds are separated by dikes of various dimensions; many in the larger shrimp farms are used for the internal transport of vehicles for moving the feed or harvests, as well as for the daily monitoring activities, such as measuring pH and turbidity levels and the growth of the shrimp.

The dimensions of these dikes are as follow: base: 9m – 3m; crown: 3m – 1m; height: 1m – 2m; slope ratio: 3:1 – 1:1. These dimensions are the same as those recorded in various other countries. Over the last four years, we have observed the use that shorebirds make of this infrastructure that is available all year round under certain specific conditions; for example, a dike with vegetation or frequently used as a road cannot be used by the shorebirds. It has also been observed that pond edges with very steep slopes are used only occasionally by shorebirds, mainly where there is no vegetation and when a fringe of sand exists between the dike and the water edge.

WATER RESERVOIRS AND NURSERIES

Many of the shrimp farms include a water reservoir area from where they make the daily exchange of water required by the pond management. Within the first 40 days, the water exchange represents a maximum of 10% but in reality, this depends on the individual circumstances and the needs of each pond. This is usually associated to the degree of turbidity due to factors such as an algal bloom, which in turn consumes oxygen and affects the shrimp. Depending on the amount of water used from the reservoir and the level at which the water sits, this space can be used by shorebirds as alternative roosting sites; however, if they are deep, they are not used. Another type of infrastructure found on shrimp farms are the nurseries, although in some cases, farms have begun to replace these nurseries with raceways, which have more intensive use.

RESERVE AREAS

Some farms include reserve areas in their best practice plans, which are mostly mangrove areas that serve as a pre-filter for water before it reaches the reservoir. In other cases, we were able to observe natural salt flats set aside as reserve areas, which include active nesting colonies of waterbirds. It is extremely important to include areas of natural salt flats as part of the reserves, whether these are within the farms or the protected areas, since little is known about the impact generated by the change of land use from salt flats to shrimp ponds. In this manner, shrimp farms can contribute towards the protection of remnant patches of natural habitat.

Dikes at Acuícola Real, Shrimp Farm,. Nicaragua.
© Salvadora Morales

9.8.3 USE OF CHEMICALS AND OTHER ELEMENTS WITHIN THE PONDS

Shrimp production in the Gulf of Fonseca is a fairly natural system, with the use of chemicals only when it is extremely necessary. We have identified the following as the very basic products used in the process:

- Chlorine for disinfection
- Urea to fertilize the water at 10%
- Insecticides (cypermethrin) against the outbreak of ghost shrimp
- Calcium hydroxide as a disinfectant and preventive measure against diseases (taura syndrome)
- Probiotics to improve the soil quality of the bottom of the pond.

Under highly specific conditions, records were found of the use of Malathion to control ghost shrimp, which is considerably harmful to the environment; this practice has since been prohibited. Artificial feed is often added to the semi-intensive production systems to maximize the production capacity per area. One of the trends is based on the formulation of non-polluting feed to avoid excess fiber, carbohydrates, proteins and phosphorus for which highly digestible protein sources are necessary. The main environmental effect of the feed is the excessive levels of nitrogen and phosphorus that end up in the effluent and their accumulation in the environment (Poveda 2000).

Shrimp require specific concentrations of the main anions (bicarbonates, sulfates and chlorides), as well as the elemental cations (calcium, magnesium, potassium and sodium) (Moreno 2010). In terms of nutrition, the main nutrients used in the formulation of balanced foods, as well as other elements are the following:

Proteins and amino acids: A wide range of sources are used including soybean and marine animals (fish meal, shrimp head, squid meal). The best source of energy is derived from grains such as wheat, corn, rice. Fish oil is also used as a source of energy.

Lipids and carbohydrates: The main sources of carbohydrate are wheat flour, sorghum, corn, medium quality flour and rice bran. The main sources of lipids include fish oil, cod liver oil and squid oil; soy lecithin is used as a source of phospholipids. This corresponds to 8% of the basic diet. The feed is the main source of nitrogen (López 2013).

Minerals and vitamins: Macronutrients such as phosphorus and calcium minerals are mainly required; phosphorus is found in a solid state in many green plants or grains in non-digestible form. Ascorbic acid (vitamin C) is a water-soluble antioxidant at a ratio of around 100 mg/kg of dry matter; chemically modified forms of vitamin C (two forms derived from phosphate) are being used. Forms derived from phosphate, such as ascorbic acid mono-phosphate and ascorbic acid polyphosphate, are readily available (Talavera 1998). Propionic acid (propionate) is included in feed at a rate of about 0.5%.

Antibiotics: Some feeds are medicated and contain 2,000 - 4,000 mg/kg of the following antibiotics: oxytetracycline, oxalinic acid, sulfamerazine, sulfonamides (López 2013). The prolonged use of antibiotics can lead to the development of antibiotic-resistant pathogens and upset the trophic hierarchy of fragile estuarine ecosystems.

Pigments: Astaxanthin, a common pigment derived from beta-carotene and found in shrimp and crabs.

Probiotics: Probiotic bacteria are live microorganisms that, when administered as supplement, generate benefits such as increased feed conversion, disease resistance and improved water quality (Díaz and Martínez-Silva 2009). Among the main bacteria used we can mention *Bifidobacterium, Lactobacillus and Streptococcus.*

Dikes at Acuícola Real, Shrimp Farm, Nicaragua.
© Salvadora Morales

Antioxidants: Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are mainly added to the feed, as well as other antioxidants such as vitamins E and C.

Preservatives: Chemical components intended to avoid the toxin generated by a fungus.

9.8.4 WATER DISCHARGE FROM PONDS

The reservoirs take on water from the pumping stations that extract the water on a daily basis from the nearby wetlands. Water replenishment is carried out based on the need or requirement at the time; at the beginning of the process the replenishment is approximately 5%, but as time goes by this can increase up to 20% or 30%. The main problems associated with the discharge of water are often the result of a poor site selection for the establishment of the shrimp farms, mainly due to ignoring the carrying capacity of the bodies of water for the intake and discharge processes. Another technical recommendation is that the site for water intake should not be the same place for water discharge. The Gulf of Fonseca is an estuarine system; during the dry season, water enters through the surface and exits through the bottom, meanwhile during the rainy season, the water is discharged from the surface and taken in through the bottom.

In Colombia it has been observed that the water that leaves the system has a lower BOD5, nitrate and ammonium concentration than the water that enters. The processes that take place in the ponds remove around 122 grams of organic matter per kilogram of shrimp produced. However, levels of nitrite and phosphate do increase in the water that leaves the system (Hernández 2015).

Sea Joy awareness activities, Nicaragua.
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X. ENVIRONMENTAL STANDARDS AND CERTIFICATIONS

10.1 RESUMEN DE LA SECCION DE ESTANDARES Y CERTIFICACIONES

This sections covers standards and certifications, which have been identified as a potential strategy for the promotion and implementation of shorebird-friendly practices in the shrimp farms based on certain criteria, norms and obligations. Three pathways have been identified; the first is based on a process of adapting and/or updating existing standards that are creditable through an existing certification program. The second proposes creating a new certification program that involves setting goals, developing a new standard, carrying out public consultations, with the gradual approval and step-by-step implementation with the stakeholders. A third path is based on the implementation by the producers of actions identified in the internal environmental management plans of the companies.

With this background in mind, this section addresses the certification process from the development of a standard and its accreditation and certification. There are several forms of certification and the most commonly used are those carried out by third parties that are developed by an independent entity, who performs the audit and issues certificates that establish that the process meets the criteria or standards. There are currently a number of standards and companies that provide these certification services. Although not all have been included, the table below summarizes the principal schemes.

Table 17. Standards and companies that provide certification services in Central America

ENVIRONMENTAL AND TRADEMARKS	QUALITY	PRODUCTION	SOCIAL	DESIGNATION OF ORIGIN
Management Systems ISO 14001 EMAS Verification (EU) Carbon Footprint Verification ISO 14067	Food Security Management Systems ISO 2200 Iso 9001:2015 Certified Quality	Global Aquaculture Alliance (BAP) Aquaculture Stewardship Council (ASC) Naturland Global GAp	Ethical Trading Initiative (ETI) ISO 560000 Fairtrade	Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI)

The certifications for the consumer represent a seal of guarantee on the environmental attributes that the products declare. In some cases they are promoted by the regulations of commercial blocks such as the European Union or consumer councils, conservation organizations, etc. The cost of a certification depends on the specific factors of the process to be certified; on average, the costs can range from 3000 USD to 20,000 USD. The certifiers work with accredited certification bodies with audits are carried out by trained inspectors and auditors.

10.2 HOW CERTIFICATIONS WORK

Certification is a procedure through which an agency provides a written guarantee that a product, process or service meets a series of requirements (FAO 2010). In this way, the certifying body issues a certificate or document that indicates that a product, service or process complies with the standards included in a certification system. Within the aquaculture sector, certification can be applied to a process followed by a production unit (such as a pond, cage, farm, processing plant), a specific product or products or the inputs that are applied to the system before or during production.

According to OESA (2017), aquaculture certification systems consist of three main components:

Standards: The standards establish the necessary requirements and indicators for certification. They must reflect the objectives that are sought and the results that are expected from the implementation of the certification system. Among the institutions that establish standardized norms we can mention the International Organization for Standardization (ISO)., ISEAL which is an association of sustainable standards, and ASTM International as a leader in the development and delivery of voluntary consensus standards.

Accreditation: This is the procedure through which the competent body evaluates and certifies the product, process or service in accordance with the regulations in force. In order to guarantee the quality of the accreditation and certification process, the International Accreditation Forum (IAF) was established as the global entity under which all accreditation bodies are associated, which assesses compliance in the fields of management, products, services, personnel and other evaluation programs. In the case of the European Union, the European Accreditation (EA) formed by 39 European accreditation bodies was created and represents the European accreditation bodies before the IAF.

Certification. The procedure through which a certification body or entity guarantees that a product, process or service conforms to the specified requirements. The certification contributes towards the technological development of the organizations, generates a better positioning, and facilitates the creation of new markets. The certification process can be classified as follows:

First party certification. The conformity assessment is carried out by the person or organization that provides the product (for example, producers or producer organizations report on their compliance with a set of standards)

Second party certification. The conformity assessment is carried out by a person or organization that has a user interest in the products (for example, retailers, consumers and their organizations).

Third party certification. An entity independent from both the supplier and the consumer organizations performs the audit and issues certificates that establish that a product or process complies with a specific set of criteria or standards.

Fourth party certification. Although not mentioned by ISO, some organizations also mention a fourth party certification. This form of certification involves government agencies or multinational companies. The UN Global Compact, for example, lists environmental, labour and human rights principles for companies to follow. Corporations send updates online for others (such as NGOs) to examine.

In the certification process there are several components involved and the accreditation body is generally accredited and recognized by the accreditation institutions, such as IAF, ASI (Assurance Services International), among others. They evaluate based on specific requirements that are expressed as standards; these norms may be either mandatory, and set by governments that regulate production or trade, usually Harzard Analysis Critical Control Point (HACCP) or voluntary that are generally designed to distinguish farms according to their quality criteria, for example ASC.

The quality of a process can also be expressed through principles and codes of conduct that describe the philosophical basis of production, trade and consumption of a product aimed at guiding stakeholders towards sustainability. The implementation of these principles is achieved through the development of best practices that generally address issues of importance for a specific product or production system. Best practices are different from mandatory or voluntary standards; among the better-known examples we can mention Best Management Practices (BMPs) that include relevant practices for environmental protection, social responsibility and disease management; Good Aquaculture Practices (GAPs) that address food security, and Best Aquaculture Practices (BAPs).

For the purpose of this assessment, we reviewed the main existing standards and the voluntary certification schemes that can contribute towards the conservation of the shorebird assemblages that make use of the shrimp farms. Besides the different standards, relevant norms and principles were also revised that could contribute most; however, none of the existing schemes are related to the main quality criteria that could benefit birds because it is quite a specific issue that has only recently been placed on the agenda. Nevertheless, retailers are an important link in the certifications chain, since they are the point of entry through which the product reaches the final consumers and have a considerable amount of economic power. The retailer's decision to support or demand a certification can have a significant impact on value chains of shrimp and the development of certification schemes, as do the importers by linking exporting companies and producers in developing countries with the retailer (Vacilev 2014).

The certifications are separated into the following groups: Environmental and Trademarks (ISO 14001; EMAS-EU Verification; ISO 14044); Quality (ISO 22000, ISO 9001); Production (Global Aquaculture Alliance (GAA), Aquaculture Certification Council, Marine Stewardship Council (MSC), Aquaculture Stewardship Council (ASC); and other Social certifications (Fairtrade, ISO 26000, ETI - Ethical Trading Initiative and Geographical Indication).

Below are some of the main voluntary standards and certifications:

10.3 ISO STANDARDS AND NORMALIZING ORGANIZATIONS

The International Organization for Standardization (ISO) is the largest and most renowned standards and norms developer in the world. This international organization is comprised of members from 162 countries and has a general consultative status under the United Nations Economic and Social Council. The standardization bodies of each country propose standards that are obtained by consensus during meetings attended by representatives of the industry and state agencies. A number of shrimp farming companies adapt ISO standards to their management systems, particularly the ISO 22000 food safety, ISO 14001 environmental management, and ISO 90001 quality management systems.

The key principles in the development of ISO standards are the following:

(i) ISO standards respond to a market need: ISO does not decide when to develop a new standard, but rather responds to a request from the industry or other interested parties, such as consumer groups. Normally, an industrial sector or group communicates the need for a standard to its national member who in turn communicates this request to ISO.

(ii) ISO standards are based on the opinion of global experts: ISO standards are developed by groups of experts from around the world, which are part of larger groups called technical committees. These experts negotiate all aspects of the standard, including its scope, key definitions and content.

iii) ISO standards are developed through a multi-stakeholder process: the technical committees are comprised of experts from the relevant industry, but also from consumer associations, academic institutions, NGOs and government.

(iv) The development of ISO standards is a consensus-based approach and comments from all interested parties are taken into consideration.

In Central America, El Salvador, Panama and Costa Rica are full members that market and adopt ISO international standards at the national level; meanwhile Nicaragua, Honduras and Guatemala are correspondent members that observe the development of ISO standards and strategy by attending ISO technical and policy meetings as observers. Correspondent members can market and adopt international standards at a national level. The following table lists the normalizing organizations of the Central American countries.

Table 18: Normalizing organizations in Central America

COUNTRY	ISO ORGANIZATION	NOTES
Guatemala Correspondent Member	Comisión Guatemalteca de Normalización (COGUANOR) info-coguanor@mineco.gob.gt	Ascribed to the Ministry of Economy. The main function is to develop standardization activities that contribute towards improving the competitiveness of national companies and raise the quality of products and services offered by these companies in the national and international markets. The technical standards that COGUANOR creates, publishes and disseminates are of voluntary observance, use and application.
El Salvador Member	Organismo Salvadoreño de Normalización (OSN) normalizacion@osn.gob.sv	This is an institution of public law, with legal status and its own assets, of a technical nature, with economic, financial and administrative autonomy and is the highest authority in terms of Standardization.
Honduras Correspondent Member	Organismo Hondureño de Normalización, OHN sgomez@hondurascalidad.org	This is a technical government organization; member of the National Quality System (SNC), and responsible for standardization in Honduras. It facilitates the participation of public and private operators and actors in the preparation and adoption of technical standards through technical committees that bring together experts and interested parties.
Nicaragua Correspondent Member	Dirección de Normalización y Metrología (DNM) normalizacion@mific.gob.ni	Through this organization, the Ministry of Development, Industry and Commerce, coordinates and supervises the National Standardization System, whose general objective is to promote the continuous improvement of production processes and the quality of processes and services.
Costa Rica Member	Instituto de Normas Técnicas de Costa Rica (INTECO)	EThis is an independent association constituted in 1987. It is a private, non-profit organization, with representatives of the public and private sectors of the Costa Rican economy. The Government of the Republic recognizes INTECO as the national standardization body. INTECO began its quality system registration activities in 1995, under agreement with AENOR.
Panamá Member	Comisión Panameña de Normas Industriales y Técnicas (COPANIT)	The executive arm of COPANIT is the DGNTI (Dirección de Normas y Tecnología Industrial), and its main objectives are: - develop standards through technical committees; and - implement programs related to standardization, quality certification, metrology and conversion to the International System of Units.

ISO 14001 ENVIRONMENTAL MANAGEMENT SYSTEMS

ISO 14001 is the international standard for environmental management systems (EMS), which helps organizations to identify, prioritize and manage environmental risks as part of their usual business practices. The ISO 14001 standard requires that the company create an environmental management plan that includes environmental objectives and goals, policies and procedures to achieve those goals, defined responsibilities, personnel training activities, documentation and a system to control any changes and progress made. This standard encourages innovation and productivity; the company will have the opportunity to reduce costs related to waste management, break down barriers for export, and reduce the risk of penalties. The ISO 14001 standard describes the process that the company must follow and demands respect for the national environmental laws. However, it does not establish specific productivity performance goals. The ISO 14001 certification system includes the following:

- Object and field of application
- Norms for consultation
- Terms and definitions
- Requirements of the environmental management system.
- General requirements (environmental policy, planning, implementation and operation, verification, management review).

ISO 90001 QUALITY MANAGEMENT SYSTEMS

This standard falls under the ISO 90000 series and is the most suited standard for aquaculture. The adoption of a quality management system is a strategic decision for an organization that can help it improve its overall performance and provide a solid basis for sustainable development initiatives. The potential benefits for an organization to implement a quality management system based on this International Standard are: a) the ability to regularly provide products and services that meet customer requirements and the applicable legal and regulatory requirements; b) facilitate opportunities to increase customer satisfaction; c) address the risks and opportunities associated with their context and objectives; and d) the ability to demonstrate compliance with specified quality management system requirements. Among the main features of this standard are:

- Reach
- Normative references
- Terms and definitions
- Context of the organization: The entity has to identify relevant internal and external processes of the strategic direction (concepts, needs and expectations, scope of the system, quality management system)
- Leadership (leadership and commitment, politics and commitment, quality policy, organizational roles, responsibilities and authorities)
- Planning: A risk management system is not required, but the organization must identify those that may affect the quality system.
- Support (resources, competence, awareness, communication, documented information).
- Operations
- Performance evaluation (monitoring, measurement, analysis and evaluation), internal audit, management review
- Improvement (generalities, non-conformities and corrective actions).

ISO 22000 FOOD SAFETY MANAGEMENT SYSTEMS

ISO 22000 is a certifiable international standard, which specifies the requirements for a Food Safety Management System, by incorporating all the elements of Good Manufacturing Practices (GMP) and the Hazard Analysis and Critical Control Points system (HACCP), together with an adequate management system, which allows the organization to demonstrate that the products it supplies comply with the requirements of its customers, as well as the regulatory requirements that are applicable to them in terms of food safety. ISO 22000 has a common system throughout the supply chain, improving transparency through the food chain since it represents a common system for all the "stakeholders" across the chain; primary producers, manufacturers of compound feed, food processors, transport, storage, catering & restaurants, packaging, cleaning and disinfection agents, ingredients and additives, service providers, and equipment manufacturers.

10.4 VOLUNTARY CERTIFICATIONS

There are a number of voluntary certifications worldwide; we will address three of the most implemented schemes in Central America at present. The existing certifications have different beginnings, the oldest being the Global Aquaculture Alliance (GAA) which started in 1997 as an association of producers and importers (GAA 2014) and established the Best Aquaculture Practice (BAP) certification. GlobalGAP was driven by retailers and producers, who up until the year 2000 had created modules for various species, including shrimp; this organization is based in Germany and USA. The Aquaculture Stewardship Council (ASC) is the most recent certification established by the World Wildlife Fund (WWF) and the Sustainable Trade Initiative (IDH), based in the Netherlands. Naturland is an organic certification association that was created by farmers and is based in Germany.

The governance systems of the boards that make the decisions and approve the final standards are reflected by their background and proprietorship. The case of GAA is comprised of representatives of the industry, as well as GAA and BAP staff; meanwhile, ASC is integrated by IDH, WWF, and the aquaculture and food industry.

NATURLAND.

Naturland is the primary organic label in shrimp farming. Only in Honduras were we able to identify the Deli Group as a certified producer of organic shrimp. Organic production offers a path towards sustainability and is emphasized because it works based on the nutrient cycles and without the use of synthetic fertilizers. The standards of Naturland are more reliable and rigorous compared to those of ASC and result in a true "organic production system" (Naturland 2013).

Among the principles included for organic aquaculture are:

- Selection of farm construction and the protection of the adjacent ecosystems.
- Prevention of conflicts with other users of aquatic resources.
- Prohibition of the use of chemical products.
- Promotion of the use of remedies and natural treatments in the case of diseases.
- Promotion of the use of feed derived from organic agriculture.
- Prohibition of the use of fishmeal as feed.
  Prohibition of genetically modified organisms. (Source: Naturland 2018)

BAP CERTIFICATION (BEST AQUACULTURE PRACTICES)

One of the first steps the shrimp industry took towards achieving sustainable development was to form the Global Aquaculture Alliance (GAA). It is a powerful industry consortium that developed a set of standards known as Best Aquaculture Practices (BAP) and uses the Missouri-based aquaculture certification board as its exclusive certification body. This code is based on Article 9 of the FAO's Code of Responsible Fisheries (FAO 1995) and allows shrimp producers to work within an environmentally and socially responsible framework, as well as providing food safety and monitoring production.

The GAA database includes a greater number of certifications covering the production chain, farms, processing plants, nurseries and food factories in Central America. Honduras is the country with the highest number of certifications (18), followed by Guatemala (7), and Nicaragua, Panama and Costa Rica with at least three certifications each. Its process includes the annual site inspections and discharge sampling but allows the use of antibiotics and chemicals. Like the ASC, GAA and BAP have a detailed regulation regarding shrimp feeds. However, in environmental terms it is less systematic since it only requires an environmental impact assessment (FAO criteria) if this is required by national legislation.

GLOBALGAP

GLOBALGAP (formerly known as EUREPGAP) was founded in 1997 by the retail sector together with supermarkets in continental Europe. These retailers decided to introduce an independent verification system as a basis for supplier compliance; establishing voluntary standards for the certification of agricultural products throughout the world. It is made up of members from the food industry, including suppliers from various sectors such as food manufacturing, aquaculture and staple crops. The Board of Directors and a secretariat are drawn from the members. GLOBALGAP is governed by a Steering Committee and chaired by an independent president. The GLOBALGAP Certification is developed and defined by several Discussion Groups, five Technical Committees and the Committee of Certification Bodies. The National Technical Working Groups provide support to the committees at the local level. The Integrity Surveillance Committee (ISC) evaluates nonconformities and applies corrective measures and sanctions.

The GLOBALGAP Certification takes on a comprehensive approach and covers the following key areas of sustainability:

- Food safety: In compliance with the Global Food Security Initiative (GFSI) at the farm level.
- Environment: Includes the criteria for Protected Areas and a mandatory Environmental Impact Assessment (which covers biodiversity) and Management Plan.
- Traceability: From broodstock to seeds and feed used in aquacultural activities. Identification by batch of the aquacultural product and the fish feed used.
- Worker welfare: Mandatory assessment of social practices; living conditions, health and occupational safety of workers.
- Animal welfare: Specific to the species produced with consideration to the cohabiting species (such as the cleaning fish, wrasse, in the case of salmon).

CERTIFICACIÓN ASC

ASC aims to become the world's leading labelling and certification program for responsibly grown marine products. The main objective is to manage the global standards for responsible aquaculture that were developed through the WWF aquaculture dialogues. The purpose of the standard is to provide a means to measurably improve the environmental and social performance of shrimp farming operations. The ASC works with independent third-party certification organizations that provide the certification of production operations for which the standards have been approved by ASC.

ASC standards are developed according to guidelines set out by the global membership association for credible sustainability standards known as ISEAL. ASC has open, transparent and multi-stakeholder performance metrics based on science. It aims to achieve effectiveness by minimizing the environmental and social footprints of commercial aquaculture by addressing key impacts. The added value of ASC is that it connects the farms to the market by promoting responsible practices through a consumer logo. ASC includes a complete set of requirements including principles, criteria and indicators to be evaluated; out of a total of seven principles. Here we shall focus only on the most relevant ones.

Principle 1: Comply with all applicable national and local laws and regulations. Criteria 1.1: Documented compliance with local and national legal requirements; 1.1.2: Transparency in terms of legal compliance.

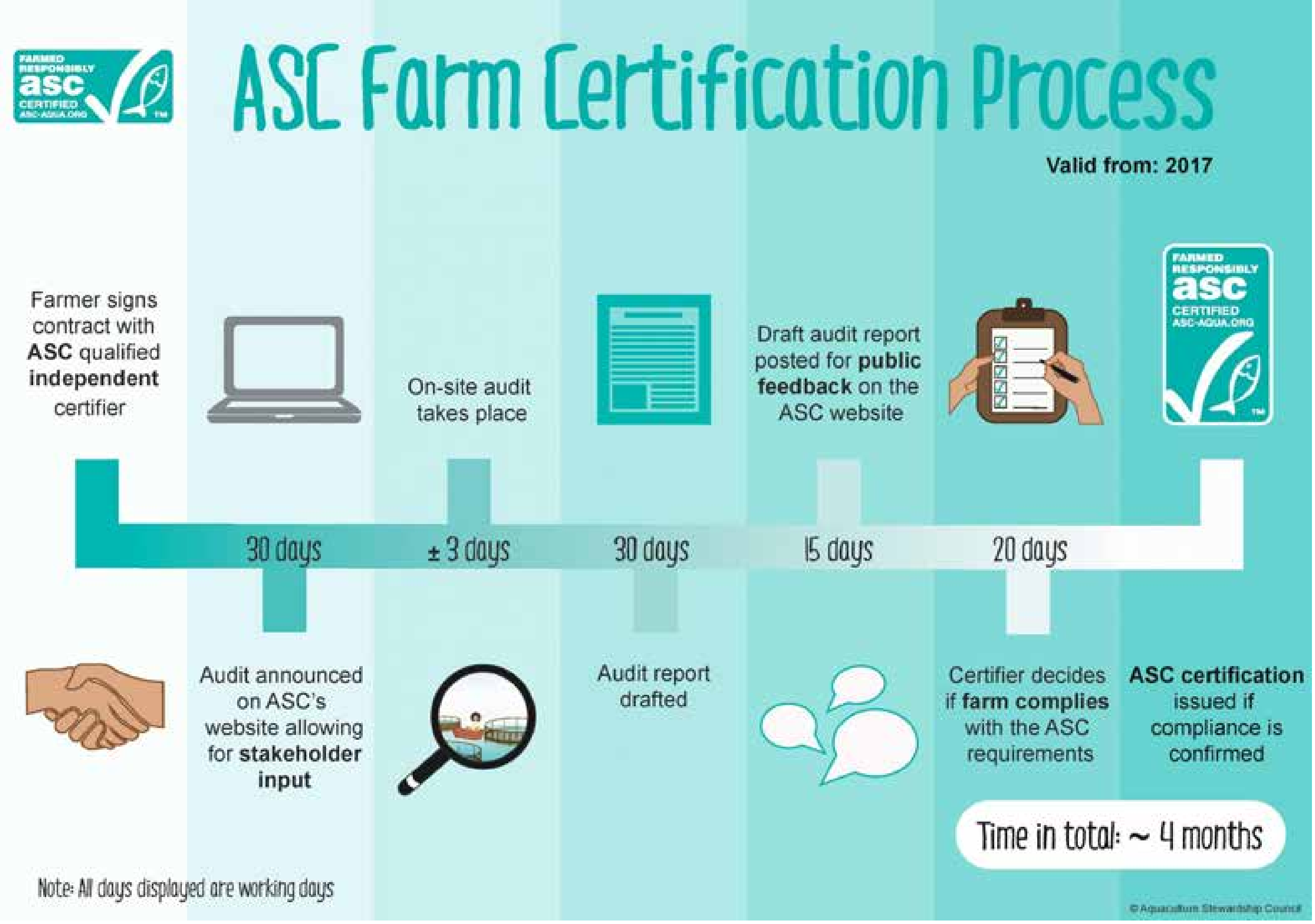


Figure 7: ASC Farm Certification Process

Principle 2: Farms set-up in suitable environmental locations where they help conserve biodiversity and important natural ecosystems. Criteria: 2.1: Environmental impact assessment on biodiversity (B - EIA); 2.2: Conservation of protected areas or critical habitats; 2.3: Consideration of critical habitats for threatened species; 2.4: Environmental corridors, barriers and buffer zones; 2.5: Prevention of salinization of freshwater and soil resources.

Principle 3: Develop and operate farms in consideration with the surrounding communities; with criteria such as transparency when providing jobs, with fair and transparent contracts.

None of these criteria explicitly take into account shorebirds or the most threatened ecosystems, such as the natural salt flats, within the certification standards or process.

There are currently nine farms in Honduras and two farms in Nicaragua that are certified by the ASC; with Granjas Marinas and SeaJoy being the pioneering groups in becoming certified. Another seven farms are under evaluation, adding the Honduran groups Rivera Marina and El Faro to the certification process. So far, there are no companies certified under these standards in any of the remaining Central American countries according to the ASC database consulted.

Salt Flats at Playones de Catarina, Nicaragua
© Salvadora Morales

XI. CONCEPTUAL MODEL AND RESULTS CHAIN

11.1 GEOGRAPHICAL SCOPE

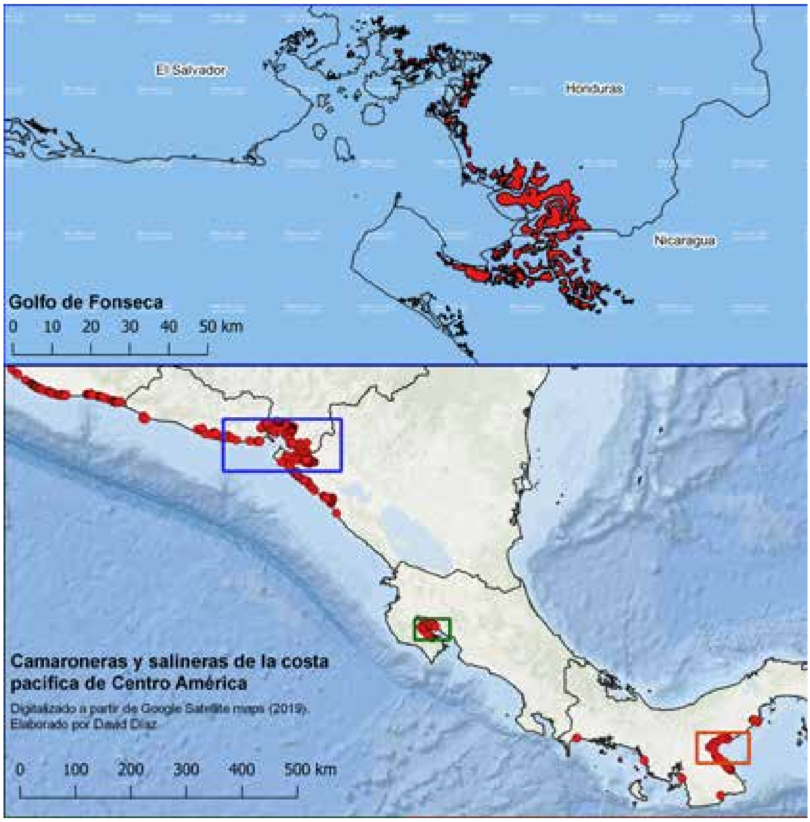
The “Shrimp Farming and Shorebirds” initiative of the Western Hemisphere Shorebird Reserve Network, the National Audubon Society and Quetzalli Nicaragua defined the Pacific coast of Central America as the project area, with a specific focus on the Gulf of Fonseca (see map 10). Shrimp farms and the natural habitats that surround them are within a region of considerable importance for shorebirds.

Under the framework of the Pacific Americas Shorebird Conservation Strategy, shrimp farming was identified as a threat mainly in the areas of coastal habitats such as mangroves and natural salt flats. This assessment has reviewed the status and distribution of shorebirds in relation to the areas of shrimp farming, while addressing the challenges and opportunities for the conservation of birds, their surrounding habitats and a sustainable production.

11.2 SITE DESCRIPTION

The Gulf of Fonseca, shared between El Salvador, Honduras and Nicaragua, is comprised of approximately 44,320 hectares of natural salt flats (referred to locally as tierras albinas) and mangroves that have been transformed into ponds for farming shrimp. These shrimp farms exchange their waters with the Gulf of Fonseca which has extensive intertidal mudflats, one of the main feeding grounds for shorebirds in the Gulf, and remnants of natural salt flats, one of habitats most threatened by land use change. Guatemala, Costa Rica and Panama have also experienced significant changes in land use.

Map 10 : Map of Shrimp Farming Areas in Central America



- Vision -

Inspire shrimp farmers to incorporate within their production standards the concepts of social and environmental sustainability and the conservation of shorebirds and the natural habitats that surround them; thus connecting the conservation community, local communities, governments and market in the process.

11.3 CONSERVATION TARGETS

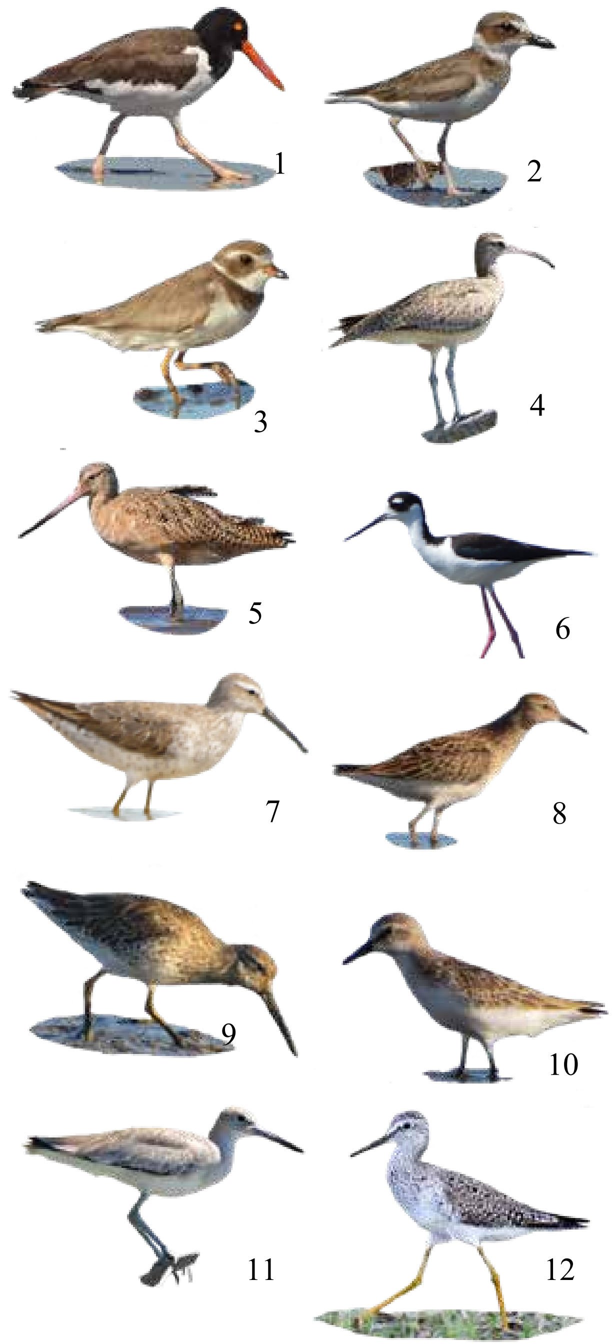
The conservation targets of this project include the coastal ecosystem complex that surrounds the shrimp farms, wintering populations of migratory shorebirds, migratory shorebirds on passage and the resident shorebird populations. As part of the process, 11 species of shorebirds have been proposed as focal species to represent the three shorebird groups, based mainly on the records within the shrimp farms and the biogeographical importance that the recorded population represents, as well as the use that they make of the habitats.

The migratory birds start arriving on their wintering grounds in October and begin their return journey in February and March. Passage migrants from South America have a spring migration peak between April and May and make use of these sites as stopovers before continuing their journey north or south.

During the autumn migration, which peaks between the months of July-August, a greater use of the shrimp pond dikes and nearby mudflats has been found. In the case of the resident birds, the breeding season begins between April and June. We found evidence of nesting in the salt flats, which are considered the most highly threatened habitat due to conversion into shrimp ponds.

Focal Species	Photo	Mudflats	Shrimp Farms	Salt Flats	Wetlands	Sand-Gravel	Mangroves	Salt Mines
American Ostercatcher *(Haematopus palliatus)*	1	●	●			●	●	●
Wilson's Plover *(Charadrius wilsonia)*	2	●	●	●				●
Semipalmated Plover *(Charadrius semipalmatus)*	3	●	●	●				●
Whimbrel *(Numenius phaeopus)***	4	●	●	●			●	●
Marbled Godwit *(Limosa fedoa)*	5	●	●					
Black-necked Stilt *(Himantopus mexicanus)***	6		●	●	●			
Stilt Sandpiper *(Calidris himantopus)*	7			●	●			
Pectoral Sandpiper *(Calidris melanoto)*	8			●	●			
Short-billed Dowitcher *(Limnodromus griseus)*	9	●	●	●			●	
Semipalmated Sandpiper *Calidris pusilla**	10	●	●					
Willet *Tringa semipalmata***	11	●	●				●	●
Lesser Yellowlegs *Tringa flavipes*	12		●	●				

* Species with more than 1% of the biogeographic population.



Mudflats on the Delta del Estero Real, Nicaragua
© Salvadora Morales

11.4 CONSERVATION CONTEXT

The development of shrimp farming in Central America began during the 1970s, but it wasn't until the 1990s that the industry began to take off. The governments of Central American countries have currently granted the shrimp industry approximately 67,384 hectares in concession over a 20 year period; 75% has been concessioned to international and national companies, while the remaining 25% has been distributed among individual producers, cooperatives and associations. The areas where shrimp farms have been established were for the most part uninhabited, typically used by fishing communities for winter season fishing. With the exception of Guatemala, shrimp farming in Central America is carried out using semi-intensive systems, which are more natural and have a greater potential for incorporating conservation actions. Furthermore, organic shrimp farming is a more recent trend that allows for a greater positive environmental impact. The small cooperatives and producers, with less financial potential, stock the remnant natural salt flats only during the winter months (June-December) taking advantage when these areas are flooded.

In Central America, a total of 50 species of shorebirds have been recorded; according to Birdlife International (2016), 30 of these species have declining population trends and four species are near threatened (see Annex I). Five species occur in site-based congregations that exceed 1% of their biogeographic population (*Charadrius wilsonia, C. semipalmatus, Limnodromus griseus, Numenius phaeopus and Tringa semipalmata*). Shorebirds alternate between various habitat types (mudflats, mangroves, salt flats, beaches and shrimp farms) depending on the tides and water levels in nearby wetlands. The main habitats affected by shrimp farming in Central America are the natural salt flats, followed to a much lesser extent by mangroves. It is worth mentioning that the salt flats are now completely fragmented and very little of this habitat type remains.

There is a growing interest in improving the environmental practices associated with products that are primarily destined for export to North American and European markets; as a result, a number of companies are investing in the certification of their production processes.

The internal market within Mexico and Central America is less demanding, with the exception of Honduras which has a growing specialist market. Much tension has existed in the past between the industry and the conservation community resulting from environmental complaints that some organizations have made, often without solid evidence. Consequently, a more harmonious working environment must be created in order to carry out actions based on the opportunities offered by the industry and the consumer, as well as research, conservation and government institutions. A special effort must be made to include local community welfare within the corporate social responsibility programs, and in particular with the cooperatives that farm the smaller fragments of natural salt flats, which are considered the most threatened habitat.

In Central America, and particularly within the Gulf of Fonseca, there are laws and regulations that control the shrimp farming activities; however, state institutions have little presence in these areas. The institutions that exercise a greater control over the industry are those related to the sanitary control of the export products, and it is the market that demands the fulfillment of all these regulations.

Acuícola Chame Shrimp Farm, Panama
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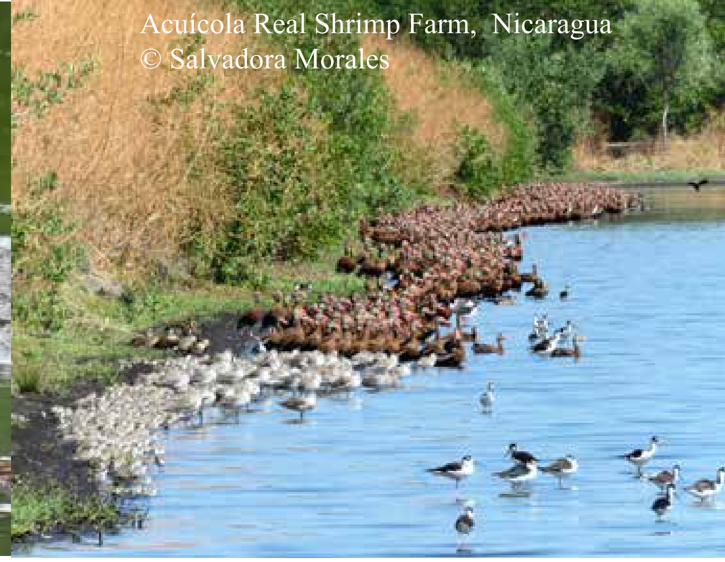

Acuícola Real Shrimp Farm, Nicaragua
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11.5 BENEFITS OF SHRIMP FARMING

Most shrimp farming in Central America uses a relatively "natural" semi-intensive production system, and most of the companies implement vertical integration and traceability that allow for monitoring at different stages of the production processes, which creates a number of opportunities to benefit shorebirds. One of the proven benefits of shrimp farms, in the case of Mexico, is that they provide a trophic subsidy (food flow from one system to another) that is very important, in spite of only being ephemeral. Shorebirds feed in the ponds once these have been harvested. At least 43,000 hectares become available for temporary feeding just within the Gulf of Fonseca. Although the quality of this diet still remains to be determined, it is expected that there would be a strong influence from the type of feed supplied to the shrimp, as well as the fertilizers (both organic or inorganic) that are used in ponds that could also directly influence the diversity of species abundance and microfauna biomass in the intertidal zone and surrounding habitats.

The farms also offer supra-tidal roosting areas on the dikes, particularly those that do not have vegetation or have recently been repaired or received maintenance, and the material is relatively fresh and similar to the bottom of the ponds. For the most part, shrimp farms extract sediment from the bottom of ponds to maintain or repair the dikes. Preliminary data indicate very high concentrations along the dikes during the month of July, when migratory birds pass through the Delta del Estero Real during their soutbound migration. It is likely that these dikes and mudflats are key sites used as stopovers by passing migratory birds, which only use them for a limited time to rest and recover before continuing on their southward migration. During the month of July 2018, groups of *Tringa semipalmata* representing more than 3% of their biogeographic population were observed in a single day. If the dikes are covered with vegetation or mangrove species are planted along them, they cease to be used by shorebirds.

For resident shorebirds, shrimp farms potentially offer ideal nesting areas, especially for *Himantopus mexicanus* and *Charadrius wilsonia*. Furthermore, waterbirds such as gulls and herons could provide a benefit by removing shrimp that have died from disease (such as white spot virus, vibriosis), thus providing a service to the shrimp farms by helping to limit the spread of the disease. However, this requires a more complete analysis to determine whether this is indeed a benefit or, on the contrary, if it represents a threat to the shrimp farms considering that these birds could potentially become responsible for pathogen distribution. In socioeconomic terms, large companies provide job opportunities to local communities that have limited employment options and are dependent on the natural resources that surround them.

Willet on the Delta deln Estero Real Mudflats. Nicaragua
© Salvadora Morales

11.6 MAIN THREATS

Among the main threats to shorebirds identified as being directly linked to shrimp farming are:

i. Loss of feeding, nesting and roosting habitat
ii. Disturbance resulting from productive activities
iii. Habitat degradation resulting from anthropogenic activities

Using the open standards methodology to evaluate threats, the greatest threat was identified as the ***loss of habitat, followed by habitat disturbance and degradation***. In terms of degradation, there is still much to document regarding the impacts of shrimp farming. One of the potential direct or indirect effects of shrimp farming on shorebirds that requires investigation is to the degradation of the mudflats and of water quality resulting from aquacultural activities. However, much of the pressure also comes from further upstream where there are large areas of monoculture crops such as sugarcane, peanuts and rice, as well as livestock production and wastewater from communities and towns.

LOSS OF HABITAT FOR FEEDING, NESTING AND ROOSTING

The natural salt flats have suffered the greatest in terms of habitat loss; at least 42,000 hectares have been replaced by bodies of water linked to the shrimp farms, and the remaining areas are small and highly fragmented. Given that shrimp farming continues to be a growing industry, the areas that have not yet been occupied are at risk of being converted into shrimp farms in the near future. Central America appears to have not suffered significant losses in terms of mangrove forest cover. The older farms that have been operating for over 20 years have begun to suffer from sedimentation. After a pond drying process, the sediments are used for maintenance and repair of the dikes, and any excess is dumped in the surrounding areas. A majority of the larger shrimp farms will soon reach 20 years of operational life.

Among the resident shorebirds, both *Charadrius wilsonia* and *Himantopus mexicanus* have been found to nest in the salt flats; in addition to these, other species that have potentially suffered most from this change include Tringa flavipes, Calidris himantopus and C. melanotos which also make use of this habitat. Although no information exists prior to the change in land use of the salt flats and the role they played, they were possibly important roosting areas that have now been replaced by shrimp farm dikes (as a roosting habitat).

DISTURBANCE RESULTING FROM FARMING ACTIVITIES

Disturbance along the dikes and in the shrimp farm ponds of shrimp farms may be a significant concern for roosting birds. As a result of the loss of roosting sites due to the change in land use, shorebirds may have no option but to use the dikes of the shrimp farms near their feeding sites. The most marked disturbance observed in the Gulf of Fonseca is in roosting areas in shrimp farms near the WHSRN site in the Delta del Estero Real, where exploding gunpowder is used to scare away the birds. The use of gunpowder as a control mechanism is employed throughout the Central American region. Some dikes are used as roosting areas during high tides. In these areas the shorebirds mix with cormorants and gulls, both of which are considered predators of shrimp and gunpowder is used to scare them away. These non-lethal mechanisms are considered good practices by the shrimp farming industry.

Observations over the past five years have revealed the regular use of the dikes by wintering populations of *Haematopus palliatus, Tringa semipalmata, Pluvialis squatarola, Charadrius wilsonia and Calidris spp*., among others. During the migratory season of 2018-2019, more than 3% of the biogeographic population of *T. semipalmata* was observed along the dikes of the Acuicola Real shrimp farm in Nicaragua. Since October 2018, an increased use of gunpowder to scare away the birds has been observed. Consequently, a population of *H. palliatus* that regularly used the dikes has been forced to abandon not only these dikes, but also the nearby mudflats where they fed. It was notable that the birds were viably agitated in the presence of humans, and more so with the sound of exploding gunpowder. It is necessary to identify the dikes that are used or could potentially be used as roosting places and work with the personnel in the surveillance departments to take the necessary measures regarding management practices and environmental awareness and avoid scaring away the shorebirds from the dikes.

Other disturbances, albeit with less of an impact, occur on the intertidal mudflats of the WHSRN site where local community members harvest benthic organisms, such as clams (Casco de Burro *Anadara grandis*) in the same areas where shorebirds feed. These resource gatherers also often walk along the beaches with their dogs, which is another source of disturbance for shorebirds.

HABITAT DEGRADATION RESULTING FROM ANTHROPOGENIC ACTIVITIES

The muddy and sandy tidal flats that are formed in deltas, river margins, and gulfs are key feeding areas that become available to shorebirds twice a day during low tide. These areas are exposed to surface runoff, which brings diffuse pollution from monocultures of sugarcane, peanuts, shrimp and other crops in the area. Furthermore, organic material from the local inhabitants and surface runoff from all tributaries of the high and middle basin, increase the levels of nutrients and pollutants. There is limited information regarding the state of the mudflats where the birds concentrate for feeding, such as the physical and chemical parameters of the water, the abundance and density of the benthic biofilm communities (diatoms) and other important elements.

In addition to these sources of pollution from upstream in the watershed, there are aquaculture residues that must also be taken into consideration. The type and quantity of aquaculture residues depends on the farming system and the type and management of the inputs into the system. In order to guarantee a successful harvest, the quality of the water must be maintained by preventing the accumulation of solid waste that can cause oxygen depletion and ammonia toxicity through decompose. The feed used in shrimp farms contains high levels of oxygen; when the amount of nitrates and other nutrients becomes excessive, it can lead to eutrophication and algal blooms that can become a significant environmental problem. Limited information was obtained during this assessment regarding waste management within the area. Given the predominance of semi-intensive production systems it is hoped that it might not be a major issue, but this needs to be investigated further.

Incidence of diseases: In Central America is a matter of great concern and is linked to chemical and antibiotic residues; in general, the abuse of chemical substances can also kill off the effective microbe populations, thus breaking the balance in the ecological system of aquatic fauna and creating pathogen resistance. During this study, we were unable to find published information related to waste management in the focal area, but we did find the use of cypermethrin insecticide for the control of phantom shrimp, which is employed only when there is an outbreak. This treatment is generally carried out prior to stocking the ponds; in the past, Malathion was used with low residual power.

Water pollution: Effluents from farms can cause adverse effects in coastal waters through increased nutrients, organic matter and suspended solids. Nevertheless, the negative effect of the effluents is less if the farms are properly managed and good conditions are maintained in terms of soil and water quality (Boyd 2001). In the case of the Gulf of Fonseca, the industry sector in Nicaragua has carried out water quality monitoring over 15 years at different points in the Estero Real; however, these data are not publicly available.

Modification of the landscape and hydrological pattern

At a landscape level, the protected areas have experienced most changes, as the salt flats were transformed into shrimp ponds or other water bodies. These areas would fill temporarily, mainly during winter (May to December). With the greatly reduced extent and fragmentation of the salt flats, the hydrological cycle has almost certainly been significantly altered. Within the Gulf of Fonseca, there are different experiences in each country with regard to protected areas and shrimp farming; for example, in El Salvador and Honduras, shrimp farms were first established and then the protected areas were declared. The opposite occurred in Nicaragua, where the protected area was established first and then the shrimp farming activities began right in the core area of the Nature Reserve.

A more detailed assessment of the conversion of natural salt flats to shrimp ponds and its impact on hydrological pattern is urgently needed, in particular with regard to the construction of the channels that carry water to the reservoirs of the shrimp farms.

11.7 KNOWLEDGE GAPS RELATING TO SHOREBIRDS

In Central America there are large gaps in the basic knowledge regarding shorebirds and the specific sites where both resident and migratory species congregate. Among the most significant gaps are:

1. Limited knowledge and recognition of critical shorebird habitats, as well as the resources that the birds need to survive throughout their annual cycle. In general, these gaps are greatest in Guatemala and Costa Rica, particularly with regard to the use of shrimp farms by shorebirds. Nicaragua is the country where most information has been generated about shorebird use of shrimp farms, with Honduras and El Salvador now starting, but more research is required.

2. Limited knowledge and poor documentation of patterns of use and distribution of shorebirds from an ecosystem approach, including movements between natural habitats and productive areas, and between foraging and roosting areas.

American Oystercatcher, Acuícola Real Shrimp Farm, Nicaragua
© Salvadora Morales

3 Little knowledge about specific migration routes, from breeding areas to migration stopover and wintering areas. This includes limited information about specific threats in the wintering and migration areas, as well as the search for mitigation options.

4 Limited efforts to identify opportunities and develop guidelines to improve shrimp production practices that can favor shorebirds in coastal areas. These practices may include measures to increase the potential time of use of the ponds after harvest.

5 Limited development of conservation and management initiatives at a landscape level, identifying potential shrimp markets on the Pacific and Atlantic migration routes and connecting them with breeding areas.

6 Lack of knowledge regarding the ecological use and importance of the remnant salt flats for shorebirds throughout the Neotropics.

7 Lack of a baseline regarding the conservation status of habitats and the potential food of shorebirds (benthos) in both the shrimp ponds and mudflats.

8 Little knowledge about the body condition of the shorebirds that use human-modified wetlands as alternative foraging areas (for example, the amount of heavy metals and other pollutants), and the potential effects on the individuals and species.

9 Lack of knowledge of the ecosystem services that shorebirds could provide to local communities and shrimp farms.

10 Need for a more in-depth analysis of shorebirds as potential vectors / control agents of pathogens.

Delta del Estero Real Mudflats. Nicaragua
© Salvadora Morales

11.8. STRATEGIES AND PRIORITIZED ACTIONS

The prioritization of strategies and actions was carried out through a face-to-face workshop on Shorebirds and Shrimp Farms with the participation of environmentalists, researchers and industry. During the workshop the Open Standards for Conservation Practice methodology was used to build a conceptual model and identify the most appropriate actions to reduce threats where the six main strategies and actions identified were prioritized. The main contributing factors for each of the threats were identified, ranging from a lack of enforcement of laws and policies for wetlands and protected areas, an increased demand for shrimp, climate change, limited institutional capacity and various other threat factors that can be observed in the Conceptual Model and Result Chain Annex 5.

STRATEGY 1: RESEARCH THE NEEDS OF THE SHOREBIRDS IN THE SHRIMP FARMS AND SURROUNDING HABITATS

It is necessary to better understand the use that shorebirds make of the shrimp farms and the different variables that affect their use. Factors such as the distance between the feeding areas and shrimp farms, or the presence of nearby salt flats and mangroves are factors that could play a role in determining the presence of birds. Special attention should be given to the remnant salt flats in Central America before they disappear completely as a result of land use changes, bearing in mind that their ecological function and use by shorebirds is poorly understood. Under this perspective, it is important to strengthen the capacities of national research teams, support inter-institutional relations and build alliances with national and international universities.

ACTIONS

- ■ Identify critical nesting and roosting sites.
- ■ Study the body condition of shorebirds.
- ■ Improve knowledge on the usage and distribution patterns in habitats and map wetland ecosystem complexes.
- ■ Study the quality of the food resources available to shorebirds in the ponds (polychaetes, etc.).
- ■ Improve knowledge of the ecological function and use of salt flats and other wetlands for shorebirds.
- ■ Identify specific threats for each of the critical sites, including climate change, and the presence of heavy metals and other pollutants.
- ■ Develop guidelines for best production practices to help reduce habitat degradation.
- ■ Identify and map the roosting areas of shorebirds inside and outside of the shrimp farms that are most likely to be affected by disturbance.
- ■ Innovate with new techniques to scare off birds that predate shrimp to help reduce disturbance to shorebirds
- ■ Carry out research on potential good practices.

Code: Types of threat

Degradation ■

Loss of Habitat ■

Disturbance ■

STRATEGY 2
MANAGEMENT AND PROTECTION OF NATURAL HABITATS INSIDE AND OUTSIDE THE PRODUCTIVE AREAS

The management and protection of the habitats surrounding the shrimp farms, in both the municipal areas and in the concessioned areas for shrimp farming, are essential for the conservation of passage migrant, winter visitor and resident shorebirds. The specific conditions in each area vary from one country to another. However, in general terms there is very little investment made in the management of protected areas in the region.

STRATEGY 3
AWARENESS AND TRAINING FOR PRODUCERS, LOCAL COMMUNITIES AND AUTHORITIES.

Some of the conflicts between wildlife, particularly shorebirdsm producers and communities could decrease with increasing levels of knowledge about shorebirds. During the migration seasons, there is a greater need to take action. The process must involve the different actors, not only the producer but also the final consumer in the United States, Europe, Asia, Mexico, and Central America

ACTIONS

- Increase the knowledge of producer, communities and governments on the needs to conserve and manage the habitats of shorebirds, and the benefits of such measures.
- Develop awareness campaigns for shrimp consumers to promote a “shorebird-friendly production”.
- Develop awareness campaigns on the specific needs of shorebirds among producers, community members and officials.
- Producers trained in shorebird and waterbird identification and basic ecology.

ACTIONS

- Management and protection of critical points inside and outside the shrimp farms
- Implementation of good practices for the benefit of shorebirds by the producers.
- Management of specific areas with humidity control by members of the community.
- Development of new alternatives for livelihoods among producers.
- Implementation of corporate responsibility programs that involve joint actions with the communities.
- Identify critical nesting sites in salt flats, shrimp farms and beaches.
- Promote integrated programs (improved market prices, improved production) that help to reduce land use change.
- Create a system of economic incentives to protect salt flats as a threatened habitat.
- Humidity management in the nearby wetlands for the use of waterfowl in the summer and decrease the incidence of waterfowl in Shrimp ponds and disturbance in dikes.

STRATEGY 4
CERTIFICATION DEVELOPMENT AND/OR UPDATE

For the countries that export their produce, the market is the main regulator of the shrimp industry; for some of the shrimp producers, this is the most important connection to help find niche markets that can provide better prices. Despite being one of the highest biodiversity conservation priorities on the farms, shorebirds have been left out of the equation when it comes down to current certification schemes. There are several possible paths that can be taken regarding certification, such as the creation of a new "Shorebird Friendly" label or to create a module within one of the existing shorebird certification schemes. Another option would be the inclusion of best practices that are friendly to shorebirds within the state regulations of the producing country or the exporting country. These scenarios can be complemented with other strategies listed above. Among the actions identified for this strategy are:

ACTIONS

- Create a manual of best management practices for shorebirds in shrimp farms.
- Develop a standard for Shorebird Friendly Shrimp
- Carry out workshops with various stakeholders to consult and create standards that meet international requirements and complement other existing certifications.
- Implement a process of "Best Practices" as a pilot program.
- Present to the governments the potential regulations identified that should be integrated as part of the local or national policies.

Two other strategies were prioritized: 1). To allow producers to contribute towards the conservation of coastal wetlands; and 2). To develop incentives to improve cooperation among producers. However, the specific actions for these two strategies remain to be identified.

Ruddy Turnstone and Short-billed Dowitcher at Delta del Estero Real. Nicaragua
© Salvadora Morales


Visit to Fonseca Shrimp Farm, Honduras

xii. RECOMMENDATIONS AND NEXT STEPS

This analysis represents a baseline reference on shrimp farming and shorebirds. It is a compilation of the information available in Central America on both subject matters, as well as the current and future opportunities for synergies between shrimp farming and shorebird conservation. There is limited access to information from institutions, companies and research entities. In the case of the governments, with the exception of El Salvador, their transparency portals do not provide much information, and despite the efforts made, we were unable to gain official access in some countries. In the case of the companies, there is a general distrust on behalf of the shrimp farming sector towards conservation organizations which results from clashes in the past between both, although this type of conflict has occurred more in Asia and Ecuador. In Central America, however, most systems are quite natural and relatively few conflicts have occurred between producers and communities, especially as the companies begin to work closely with the communities and they become better informed.

Shrimp farming offers many opportunities to work together towards the conservation of shorebirds. However, it is essential to generate information regarding which concrete steps should be taken, which are the exact sites that require urgent protection and which productive measures require adjustments to reduce the disturbance of the shorebirds in the productive sites and places of common access to the communities.

Among the main recommendations generated, we can mention the following:

- Consolidate the Shorebird and Shrimp Farms Working Group conformed by researchers, producers, government institutions, and universities and develop a joint work plan responding to the exercises of the results chain.
- Establish alliances between local and international organizations to exchange knowledge and strengthen capacities to develop banding programs and to use other more advanced technologies, etc.
- Strengthen capacities of local organizations for the research, publication and negotiation of joint processes and include the teaching of post-graduate subjects in Central American universities related to sustainable aquaculture and ecosystem services.
- Establish alliances with the shrimp farming industry by exploring its various international connections, as well as at the Central American level, to facilitate joint work and financing.
- Work together to create an integrated system for monitoring the use of shrimp farms by shorebirds, specifically in recently harvested ponds.
- Begin an approach with the international market, focused on shrimp consumers, to create greater awareness towards a more responsible production of shrimp.
- Evaluate the possibility of creating a new "Shorebird Friendly" standard that complements the management measures of shrimp farms and connects markets and reproductive areas of shorebirds. Another alternative is to establish alliances with the certifiers to include shorebirds within their existing standards.

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ANNEX I

SHOREBIRDS OF PACIFIC CENTRAL AMERICA, THEIR HABITATS AND CONSERVATION STATUS

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The List of Shorebirds of Pacific Central America was developed as part of the "Shorebird and Shrimp Farming Assessment". Biologists from each of the Central American countries with a Pacific shoreline helped compile abundance data for each species, and to assess habitat use for each of the following habitat types: intertidal mudflats, mangroves, natural salt flats, freshwater & brackish wetlands, shrimp farms, salt mines and grasslands. The scale of abundance followed that used by the Migratory Shorebird Project; this scale is based on maximum counts in natural habitats at sites of shorebird importance in each country. The conservation status and population trends used by the Red List of the International Union for the Conservation of Nature (IUCN) was employed; the data are based on the 2016 assessment of the global populations of each species that determines the degree of threat and population trends.

All Central American species are in one of two categories: Near Threatened (NT) and Least Concern (LC). The population trends are Declining, Increasing, Stable or Unknown (?).

In summary, a total of 50 species of shorebird have been recorded in Central America. Panama has the greatest number of species (48), followed by Nicaragua with 46 species, El Salvador and Costa Rica with 44 species and Guatemala and Honduras with 42 species. Four species are considered globally Near Threatened and at least 30 species have declining populations. In terms of habitat, the greatest number of species (31) can be found in the grasslands, followed by 27 species in the shrimp farms and 21 species in the salt flats. The latter is potentially the habitat that suffered the most fragmentation and is subject to degradation as a result of land use change.

CODE

Habitat and Species

HABITAT	SPECIES
Intertidal Mudflats	23
Mangrove	13
Sand-Gravel	15
Salt Flat	21
Freshwater & brackish wetlands	26
Shrimp Farm	27
Salt Pan	23
Grassland	31

Scale of Abundance

1-10
11-100
101-1000
1001-10,000
10,001-50,000
+ 50,000

Conservation status And population trends

NT	Near Threatened
LC	Least Concern
	Declining
	Increasing
	Stable
?	Unknow

IUCN REDLIST - TREND	SPANISH NAME FAMILY	SCIENTIFIC NAME/ENGLISH	Status+	COUNTRIES OF CENTRAL AMERICA						MAIN HABITATS							
				Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Mudflat	Mangrove	Sand-Gravel	Salt Flats	Freshwater & brackish wetlands	Shrimp Farm	Salt Pan	Grassland
Burhinidae	**Alcaravanes -Thick-knees**																
▬	Alcaraván Americano	*Burhinus bistriatus* | Double-striped Thick-knee	R	●	●	●	●	●					■	■	■	■	■
RECURVIROSTRIDAE, Cigueñas y Avocetas - Stilts and Avocets																	
↑	Cigüeñuela Cuellinegra	*Himantopus mexicanus* | Black-necked Stilt	R, M	●	●	●	●	●	●	■	■		■	■	■	■	■
▬	Avoceta Americana	*Recurvirostra americana* | *American Avocet*	M	●	●	●	●	●	●					■	■	■	■
HAEMATOPODIDAE	**Ostreros -Oystercatcher and Lapwings**																
▬	Ostrero Americano	*Haematopus palliatus* | American Oystercatcher	R, M	●	●	●	●	●	●	■		■			■		■
CHARADRIIDAE Chorlitos - Plovers																	
↑	Tero	*Vanellus chilensis* | Southern Lapwing	R			●	●	●	●					■		■	■
↓	Chorlito Gris	*Pluvialis squatarola* | Black-bellied Plover	M	●	●	●	●	●	●	■	■	■	■	■	■	■	■
↓	Chorlito Dorado	*Pluvialis dominica* | American Golden-Plover	P	●	●	●	●	●	●					■			
↓	Chorilito D. del Pacífico	*Pluvialis fulva* | Pacific Golden-Plover	V				●	●						■			
↓	Chorlitejo Collarejo	*Charadrius collaris* | *Collared Plover*	R	●	●	●	●	●	●				■	■		■	■
↓	Chorlitejo Picudo	*Charadrius wilsonia* | Wilson's Plover	R,M	●	●	●	●	●	●	■	■	■	■	■	■	■	■
▬	Chorlitejo Semipalmeado	*Charadrius semipalmatus* |Semipalmated Plover	R,M	●	●	●	●	●	●	■	■	■	■	■	■	■	■
NT	Chorlitejo Nivoso	*Charadrius nivosus* | Snowy Plover	M	●	●	●	●	●	●			■					
NT	Chorlitejo Chiflador	*Charadrius melodus* | Piping Plover	M			●	●	●				■					
↓	Chorlitejo Tildío	*Charadrius vociferus* | Killdeer	M	●	●	●	●	●	●	■				■		■	■
JACANIDAE	**JACANAS**																
?	Jacana Centroamericana	*Jacana spinosa* | Northern Jacana	R	●	●	●	●	●	●				■	■			■

IUCN REDLIST - TREND	SPANISH NAME FAMILY	SCIENTIFIC NAME/ENGLISH	Status+	COUNTRIES OF CENTRAL AMERICA						MAIN HABITATS							
				Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Mudflat	Mangrove	Sand-Gravel	Salt Flats	Freshwater & brackish wetlands	Shrimp Farm	Salt Pan	Grassland
▬	Jacana Carunculada	*Jacana jacana* | Wattled Jacana	R					🟣	🟣					■			
SCOLOPACIDAE	**CORRELIMOS - Sandpipers**																
⬆	Pradero	*Bartramia longicauda* | Upland Sandpiper	P	•	•	🟣	•	🟣	•					■			■
⬇	Zarapito Trinador	*Numenius phaeopus* | Whimbrel	M	🟣	🟣	🟠	🔴	🔴	🔴	■	■	■			■	■	■
⬇	Zarapito Piquilargo	*Numenius americanus* | Long-billed Curlew	M	•	•	•	•	•	•	■		■			■	■	■
⬇	Piquiaguja de Hudson	*Limosa haemastica* | Hudsonian Godwit	P	•	•	•	•	•	•					■			
⬇	Piquiaguja Canela	*Limosa fedoa* | Marbled Godwit	M	🟣	🟣	🔴	🟣	🔴	🔴	■					■		■
⬇	Vuelvepiedras Rojizo	*Arenaria interpres* | Ruddy Turnstone	M	🟣	🟣	🔴	🔴	🟠	🟠	■	■	■			■		■
▬	Vuelvepiedras Negruzco	*Arenaria melanocephala* | Black Turnstone	V				🟣								■		
NT	Correlimos Grande	*Calidris canutus* | Red Knot	M	🟣	🟣	🟣	🟣	🟣	🔴	■	■	■			■		■
⬇	Playero de Rompiente	*Calidris virgata* | Surfbird	V	🟣	🟣	🟣	🟣	🟣	🔴	■				■		■	
⬆	Correlimos Patilargo	*Calidris himantopus* | Stilt Sandpiper	M	🟣	•	🔴	🟣	🟣	🔴				■	■	■	■	■
⬇	Playero Zarapito	*Calidris ferruginea* | Curlew Sandpiper	M						•	■							
?	Correlimos Arenero	*Calidris alba* | Sanderling	M	🟣	🟣	🔴	•	🔴	🔴	■					■		■
⬇	Correlimo Comun	*Calidris alpina* | Dunlin	M	•	•	•	•	•	•								
▬	Correlimos Pasajero	*Calidris bairdii* | Baird's Sandpiper	P	•	•	🟣	•	🟣	•							■	■
⬇	Correlimos Menudo	*Calidris minutilla* | Least Sandpiper	M	🔴	🔴	🟠	🟠	🟠	🟠	■	■		■	■	■	■	■
⬇	Correlimos Lomiblanco	*Calidris fuscicollis* | White-rumped Sandpiper	P	•	•	🟣	•	•	🟣						■		
NT	Prederito Pechianteado	*Calidris subruficollis* | Buff-breasted Sandpiper	P	•	•		🟣		🔴				■				■

IUCN REDLIST - TREND	SPANISH NAME FAMILY	SCIENTIFIC NAME/ENGLISH	Status+	COUNTRIES OF CENTRAL AMERICA						MAIN HABITATS							
				Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Mudflat	Mangrove	Sand-Gravel	Salt Flats	Freshwater & brackish wetlands	Shrimp Farm	Salt Pan	Grassland
▬	Correlimos Pechirrayado	*Calidris melanotos* | Pectoral Sandpiper	P	●	●	●	●	●	●				■	■			■
▬	Playero Acuminado	*Calidris acuminata* | Sharp-tailed Sandpiper	V						●								■
NT	Correlimos Semipalmeado	*Calidris pusilla* | Semipalmated Sandpiper	M	●	●	●	●	●	●	■	■		■	■	■	■	■
↓	Correlimos Occidental	*Calidris mauri* | Western Sandpiper	M	●	●	●	●	●	●	■	■	■	■				
↓	Agujeta Común	*Limnodromus griseus* | Short-billed Dowitcher	M	●	●	●	●	●	●	■	■	■	■	■	■	■	■
?	Agujeta Piquilarga	*Limnodromus scolopaceus* | Long-billed Dowitcher	M	●	●	●	●	●	●	■				■			
↓	Agachadiza Común	*Gallinago delicata* | Wilson's Snipe	M	●	●	●	●	●	●					■			
↓	Andarríos Alzacolita	*Actitis macularius* | Spotted Sandpiper	M	●	●	●	●	●	●	■		■	■	■	■	■	■
↓	Andarríos Solitario	*Tringa solitaria* | Solitary Sandpiper	M	●	●	●	●	●	●	■			■	■			
↓	Correlimos Vagabundo	*Tringa incana* | Wandering Tattler	M	●	●	●	●	●	●			■					
▬	Patiamarillo Chico	*Tringa flavipes* | Lesser Yellowlegs	M	●	●	●	●	●	●	■		■	■	■	■	■	■
▬	Playero Aliblanco	*Tringa semipalmata* | Willet	M	●	●	●	●	●	●	■	■		■		■	■	
▬	Patiamarillo Chico	*Tringa flavipes* | Lesser Yellowlegs	M	●	●		●	●						■	■	■	
▬	Patiamarillo Grande	*Tringa melanoleuca* | Greater Yellowlegs	M	●	●	●	●	●	●					■	■	■	■
	PHALAROPODINAE	FALAROPOS															
↑	Falaropo Tricolor	*Phalaropus tricolor* | Wilson's Phalarope	P	●	●	●	●	●	●					■	■		
↓	Falaropo Cuellirrojo	*Phalaropus lobatus* | Red-necked Phalarope	P	●	●	●	●	●	●					■			
?	Falaropo Rojo	*Phalaropus fulicarius* | Red Phalarope	P	●	●		●	●	●					■			

ANNEX II. CASE STUDY

SHRIMP FARMING AND SHOREBIRDS IN PANAMÁ AND NICARAGUA

Case: Acuícola Chame; Grupo Farallón, Panamá and Finca Torrecilla, Grupo SEAJOY, Nicaragua.

FINCA CHAME – Profile

Name of The Farm	Acuícola Chame, Grupo Farallón S.A.
Area Under Concession	497.32 hectares
Area Under Produccion	489.60 hectares
Produccion System	Semi-intensive / Extensive
Stocking Rate	5 ind./m^2
Certifications	HACCP, BRC
Traceability Mechanisms	ERP system
Number of Harvers	Ongoing cycles with pond drying every two years (October-December) and stocking in January 2019
Feed	Nicovita, Areca, Aquanasa
Water Sourcing and Exchange Points	ESTERO PAC
Natural Habitats	WHSRN Bahia de Panama (60 km); Mangrove Forest (1 km); White Sand Beach (2 km)
Markets	20% United States, 80% Belgium, France, Italy, Spain, Taiwan
Nearby Communities	Libano Community
Birds Data	10 species of shorebirds *540 individuals
* Bird data only available from a visit carried out on 30 October 2018	

I. PRESENTATION

As part of the Shorebirds and Shrimp Farming assessment, two case studies were prepared with the purpose of understanding the operations of at least two shrimp farms, and to help determine actions that could help make shrimp farming more shorebird friendly. In the case of Acuícola Chame, more information was gathered on their processes. In the case of Finca Torrecilla, we worked with the company's environmental quality team on the analysis of the tool applied on the farm. It is worth mentioning that the tool is in the process of construction and validation.

A total of 27 species of shorebird have been identified making use of shrimp farms throughout Central America; populations of 15 of these species are declining, and two species are globally Near Threatened. The semi-intensive production system used in many Central American shrimp farms could make a greater contribution towards the conservation of these birds, through the provision of roosting and foraging habitat as a result of management of the ponds and dikes; nevertheless, a more detailed analysis of the production systems is required.

II. METHODOLOGY

The analysis focused on those shrimp farms in Central America with semi-intensive systems that interact with neighbouring important natural habitats for shorebirds. For the purpose of the analysis, a set of attributes was used, scored using the following three categories: Friendly (3), Almost Friendly (1 to 2), and Unfriendly (0) with regard to shorebird habitat. Each attribute was taken into account in order to identify, evaluate and select potential proposals for friendly practices for shorebirds.

Attributes are considered “Friendly” (3) when it has been identified that under certain conditions they benefit shorebirds. They are considered “Almost Friendly” when they have the potential to benefit shorebirds but require some adjustments and management on the part of the producer; depending on the costs there are two levels (1 and 2). Attributes are considered “Unfriendly” when there is no chance of benefiting shorebirds. Each attribute was scored and the degree of certainty of the value assigned was estimated based on the available information, gray literature and published material. The degree of lack of knowledge was also estimated, which implies the need for further investigation, where a 3 requires a greater degree of knowledge. The application of the tool in the case studies was carried out in joint collaboration with the Good Environmental Practices team that works with the farm (SeaJoy) and the staff assigned by the shrimp farms.

A tool was developed to measure the following attributes: (i) Availability: the possibility of a specific area being available for use by shorebirds; there are several factors that could affect its availability. (ii) Security: measures taken to reduce disturbance of shorebird use of shrimp farm infrastructure; for example, noise, road closure, disturbance through the use of explosives. (iii) Efficiency: an area may be available and safe, but it is not efficient unless it is used; to increase its efficiency, a series of measures can be implemented (such as, for example, vegetation management). (iv) Traceability: refers to internal processes within the farms, which are part of the traceability processes that follow all stages of production, transformation and distribution; in this particular case, it mainly applies to the products that are used during the production process on the farm (fertilizers, insecticides, antibiotics).

As part of the study, the attributes were analyzed using a list of use criteria based on shrimp farming infrastructure and production processes, and more specifically for empty ponds and dikes.

III. RESULTS

3.1 GENERAL INFORMATION REGARDING ACUÍCOLA CHAME

Grupo Farallon is a group of innovative Panamanian investment companies with more than 25 years in the shrimp industry. It has an integrated production system that guarantees the traceability of its products. They are currently part of the larval laboratory group of the brand Mega Larvas, which has an ongoing genetic improvement program to increase the survival, growth and resistance to diseases. BioTech is the company dedicated to research, development and commercialization of biotechnological solutions for the aquaculture industry. In 2015, the probiotic FSM was awarded third place by the National Secretariat of Science, Technology and Innovation (SENACYT) and the Chamber of Commerce, Industries and Agriculture of Panama (CCIAP). In 2018, its Fertimax organic fertilizer project with high protein and nutritional values was selected as one of the seven most innovative projects in the country. The group had more than 3,000 hectares of farms in Panama, Nicaragua, Venezuela, Mexico and Thailand. Its processing plant in Panama (Ocean Farms), has the BRC certification, registered in the European Union (73-P) and FDA Registration 19833571576. However, they are not yet subscribed to any form of voluntary environmental certification.

3.2 LOCATION OF FACILITIES

Acuicola Chame: located 65 kilometers west of the province of Panama in the region of Punta Chame, on the edge of the Chame Bay. It is located within the hydrographic basin of the eastern foothills of the Cordillera Central, on the Pacific side, where the Chame River flows out to sea. The bay is surrounded by 6,407 hectares of mangrove forests, of which 727.84 ha are located in Punta Chame (Berdiales 2009). The dominant plant species in this area are the red mangroves (*Rhizophora mangle and R. racemosa*). The black mangrove and salt mangrove (*Avicennia germinans and A. bicolor*) are found in pure and mixed stands. In this area, windsurfing is popular as a result of the very windy conditions.

3.3 Main Stakeholders

For the purpose of this analysis, the stakeholders that engage in the processes were categorized into four groups. These four groups include government entities, non-governmental organizations and civil society, communities, and the business sector (which includes the entire chain of suppliers of the Farallón Group and more specifically the Acuícola Chame).

The figure 1 was built based on interviews with the farm manager and consultations with technicians from the environmental authority. At the time this map was drafted, no NGOs associated with shrimp farming were identified as being present.

For intervention projects, it is key to identify in a concrete manner the possible stakeholders that will be engaged, the type of relationships that will be established and the level of participation of each one of them. Validating a shorebird friendly shrimp farm implies an understanding of how the different actors involved in the process are currently related. When the stakeholder map was drawn up, two groups of predominant stakeholders were identified: government stakeholders and business stakeholders. The government is currently active and involved in the processes of the company, as specified in the specific roles and actions identified in the table below.

Figure 1: Stakeholder Map

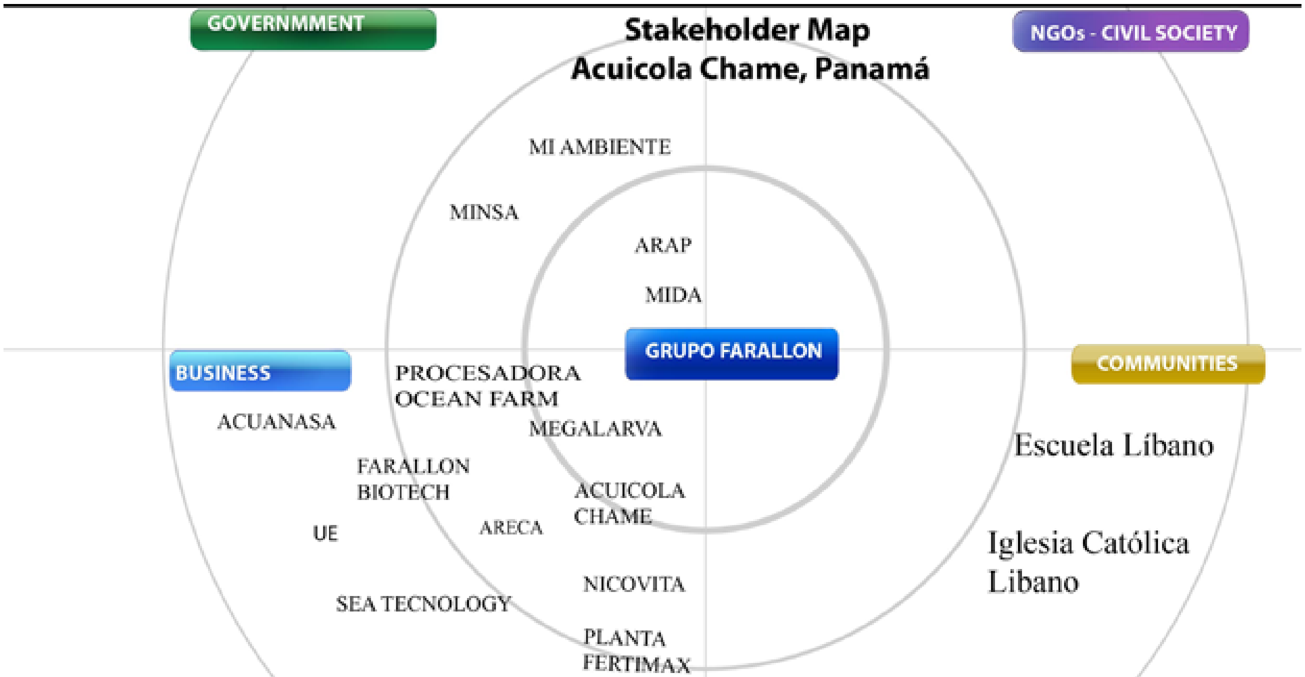


Table 1: Stakeholder and Main Role

STAKEHOLDER	MAIN ROLE
Instituciones Gubernamentales	
MINSA Dirección General de Salud Ambiental (DIGESA) / Department of Environmental Health	Application of the mandatory HACCP system for companies that offer food products; this includes monitoring of sanitary policies, use of chemical substances and pesticides.
Autoridad de Recursos Acuáticos de Panamá (ARAP) / Water Resources Authority of Panama	This is the governing body of the State that ensures the compliance and enforcement of laws and regulations related to marine and coastal resources and aquaculture; it grants concession licenses and monitors them.
Ministerio de Desarrollo Agropecuario (MIDA) / Ministry of Agricultural Development	Promotes the "Panamá Exporta" (Panama Exports) seal; a brand focused on promoting the export of quality products. Once the products comply with the established guidelines, they can include the brand logo on the packaging and final packaging. This year the company exported its first container using the country seal.
Ministerio de Industria y Comercio Internacional (MICI) / Ministry of Industry and International Trade	Promotes industry investment; this year the Ministry participated in the largest seafood fair in North America. MICI promotes the participation of seafood companies in these fairs to help find new markets.
No NGOs or academic institutions were identified working in the area of direct influence of the farm.	

3.4 SHOREBIRD USE OF THE FARMS

The information regarding the use that shorebirds make of the shrimp farm is limited to a visit carried out under the framework of this analysis. Of the 45 species of shorebirds reported for Panama, only ten were recorded during the visit to the shrimp farm.

A total of 540 individuals with a nominal scale of abundance from rare to uncommon were observed during the visit at the end of October. *Tringa semipalmata* (83 individuals) were observed using the dikes. *Calidris pusilla/mauri* (348), *Calidris minutilla* (52) and *Himantopus mexicanus* (27) were found using the drying ponds that were on their fifth day post-harvest. *Limnodromus griseus* (11) were also observed roosting on the reservoir that had a low level of water. Waterbirds, including the Neotropical Cormorant (*Phalacrocorax brasilianus*), represent one of the main threats (after diseases) to shrimp production in Panama. Although this is not the main purpose behind this study, it would also be interesting to assess the abundance of this species in shrimp farms and to explore possible joint solutions. We found 540 individuals from 10 different species of shorebirds species, none of these were common, frequent or abundant species according to the nominal scale of abundance used.

Table 2: Abundance and shorebird use of Finca Chame

Nominal Scale of Abundance	Category	Number of Speciess	Total Individuals	Activity
1 a 10	Rare	5	19	Roosting
11 – 100	Uncommon	5	521	Feeding
101 – 1000	Common	0	0	
1001-10,000	Frequent	0	0	
10,001 - 50,000	Abundant	0	0	
Más 50,000	+	0	0	

3.5 PRODUCTION PRACTICES IN ACUÍCOLA CHAME

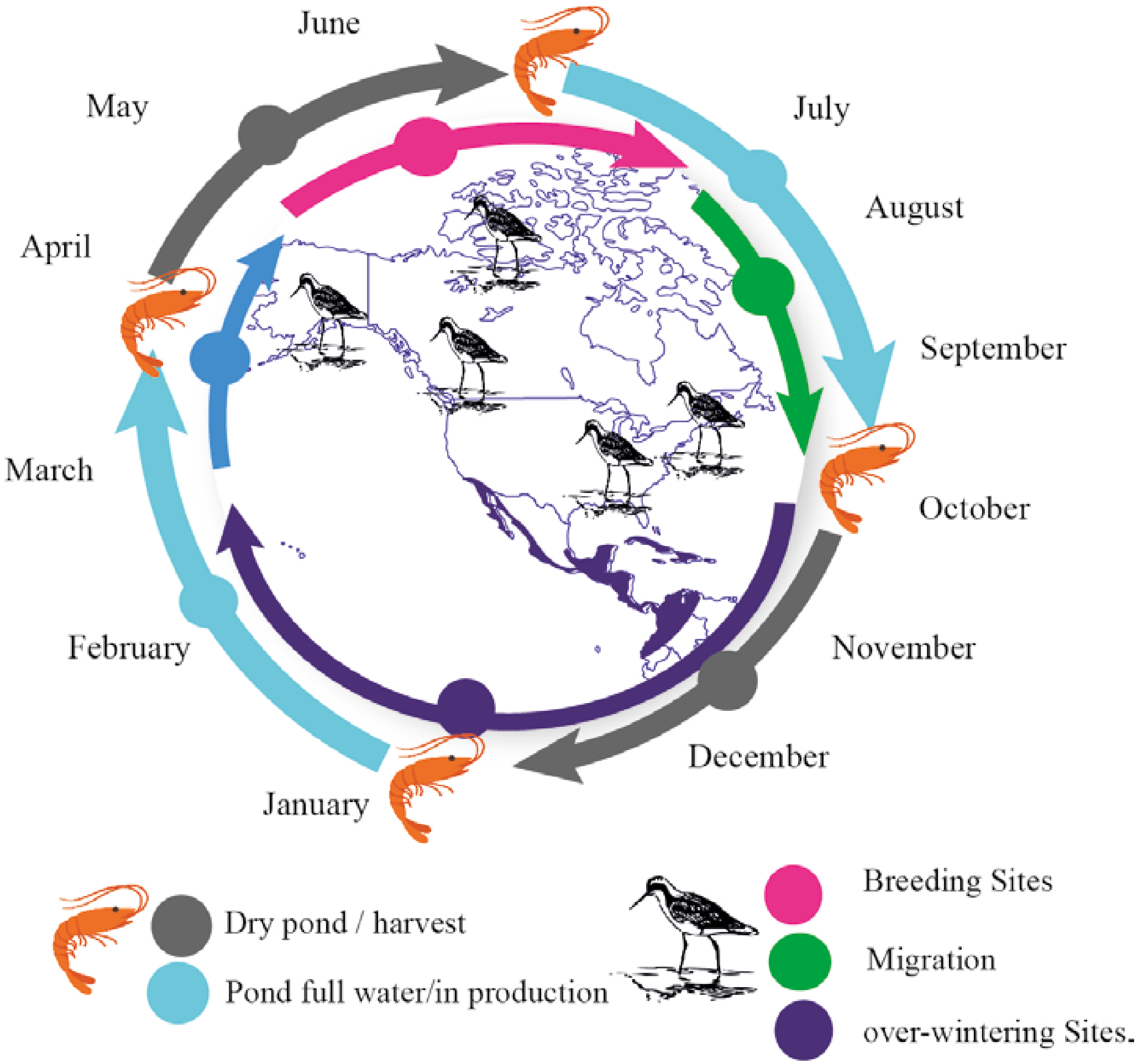
Finca Acuícola Chame has an integrated production system, with the exception of feed products that are imported by the distribution companies. They have a traceability system from the brood-stock reared in the shrimp larvae laboratory, to the processing plant, and right through to the European and American markets.

For the purpose of implementing good practices that benefit shorebirds, post-harvest production processes should be considered, such as pond drying and preparation taking into consideration the application of natural or chemical products to the ponds.

HARVEST SEQUENCE

The harvest sequence varies from one year to another. In the case of Acuícola Chame, following two consecutive years of cultivation, they cease stocking the ponds in order to carry out a sanitary drying process of each harvested pond. This drying process begins during the month of October and continues until the following January. When no sanitary drying is carried out, there are 2.5 to 3 harvest cycles per year, which requires filling the ponds almost immediately after harvesting, leaving little time for shorebird use. Figure 2 overlays the migratory cycle of the shorebirds with the harvest cycle of the 2018-2019 shrimp farming season.

Figure 2: Shrimp Harvest Calendar



3.6 RELEVANT PRACTICES

Pre-stocking Preparation: Every two years, a sanitary drying process is carried out by closing the sluices of the ponds so that water cannot enter; these ponds are on average between 10 and 20 hectares. The bottom of the ponds are exposed to sunlight once the October to January harvest cycle is completed. Prior to restocking, the pond are filled over an average of 5 days. In the case of continuous cycles, once the ponds have been harvested, chlorine is applied in the areas where water still remains, and then the pond is refilled for stocking. The water level is maintained at an approximate depth of 1 meter.

Grow-out Phase: The grow-out phase usually takes between 90 to 120 days; when the climatic conditions, or particular conditions of the shrimp (molting) are not optimal, it may take up to 160 days. Panama has suffered from the incidence of diseases due to the high climatic variability to which the shrimp farms are exposed, which generates a high stress index on the shrimp, making them apparently more susceptible to diseases. Diseases represent one of the main economic constraints of shrimp farming, resulting in a reduced productivity. Although the genetic program focused on improving disease resistance in shrimp is ongoing, the incidence of diseases is of high concern in Central America. Climate variability is among the main factors that affect oxygen and pH levels, sometimes triggering diseases such as the White Spot Syndrome Virus (WSSV) and the Taura Syndrome (TS), among others.

During the first stage of growth, the shrimp are fed with Fertimax once a day; this product helps to increase primary production (natural food), a set of organic components that provide the aquatic environment with protein, carbohydrates, fiber and living organisms that increase the levels of the phytoplankton (diatomaceous algae of high protein and nutritional content) in the aquaculture system, thus resulting in an explosive increase of zooplankton (rotifers and copepods).

THOR is applied once a month; this is a bio-degrader of organic matter based on bacteria that treat the bottom of the shrimp ponds. The shrimp are fed once a day, using different brands of balanced feed that are usually imported: ARECA (Guatemala), NICOVITA (Peru); Acuanasa (Panama). Prior to their application in the ponds, probiotic FSMA is added to the feed; this contains lactobacilli, yeasts and fermentation products that protect the shrimp against the most common vibrio bacteria, while improving the overall health of the animal.

The use of antibiotics is avoided as much as possible. Calcium hydroxide is one of the few products that are used only if necessary. Previously, urea and calcium carbonate were used, but these products are no longer employed due to the innovated products that the Farallón Group has developed, such as Thor, Fertimax and FSMA.

Infrastructure: Acuícola Chame carries out direct stocking of its ponds, thus avoiding the need for a nursery. There are a total of 296 hectares of ponds and reservoirs; these reservoirs provide the water for filling the ponds and also lower their levels at the end of the harvest when there are fewer active ponds. Most of the shorebirds observed during the visit were actually in the reservoir areas. The majority of the dikes were clear of vegetation.

WATER MANAGEMENT DURING HARVEST AND POSTHARVEST

Maintaining water quality is essential to ensure the success of shrimp farms. The composition of the water of a pond changes continuously, depending on factors such as the weather, the season and changes in temperature. The shrimp farm has a reservoir of water that is filled daily with the high tides; the water is transferred from the wetland to the reservoir and then from the reservoir to the ponds. During the first 40 days, the water exchange rate is around 5% (new water that enters to the pond and used water release); As the shrimp gradually increase in size, the exchange rate increases up to 30% until the ponds are completely emptied when harvesting.

3.7 ANALYSIS OF SHOREBIRD USE OF THE SHRIMP FARMS

To assess shorebird use of shrimp farms, a tool was developed combining criteria for both attributes and usage, with the purpose of evaluating Availability (whether or not they are available for shorebird use), Efficacy (whether or not the birds are making use of them), Security (whether or not the birds are safe) and Traceability of the products that are used in the ponds. The implementation of this tool required the joint collaboration between farmers and the evaluation team. The pilot analysis was carried out at Finca Chame (Panama) and Finca Torrecilla (Nicaragua) and requires the validation and the inclusion of more samples in a subsequent analysis. The most important use criteria were identified and applied to the empty ponds and dikes.

Table 3 summarizes the results of the analysis for each of the use criteria in the empty ponds, while Table 4 presents the results of the analysis of the Dikes. The values are only as a reference where the value 3 represent more friendly shrimp farm (a pond/dike 3 it will be full of shorebirds) and 0 Unfriendly (no birds in the pond/dike).

Table 3: Results from the pond analysis at a "friendly" level in shrimp farms used by shorebirds

USE CRITERIA FOR EMPTY PONDS / FACTORS		CHAME	TORRE
Availability	Stage of use, Distance from natural habitat	1.64	1.77
Efficacy	Use by birds	1.50	1.71
Traceability	Pre-stocking, Grow-out and Harvest	2	1.75
Average		1.77	1.74

Table 4: Results from the dike analysis at a "friendly" level in shrimp farms used by shorebirds

USE CRITERIA FOR EMPTY PONDS / FACTORS		CHAME	TORRE
Availability	Access Distance from natural habitat	1	2.14
Security	Disturbance, farm staff	0.57	0.57
Efficacy	Use by birds	0.75	0.75
Average		1.77	1.74

ANALYSIS OF SPECIFIC CONDITIONS THAT AFFECT AVAILABILITY

The availability of shorebird habitat in shrimp ponds and on dikes is determined by the sum of specific conditions among which are: (i) period of use of the ponds (empty, dry and full), (ii) distance to natural habitats that provide benefits to shorebirds such as food or roosting, and (iii) type of management that occurs in shrimp farms (semi-intensive, extensive). In the analysis carried out for Acuícola Chame using the tool, it was found that availability is "Almost Friendly" with an average score of 1.40 out of 3, which represents the most friendly level of the estimated element. Availability is mainly affected by the distance identified between the farm and important areas for shorebirds. Panama Bay is 60 kilometers away from Acuícola Chame. The areas surrounding the shrimp farm have no information on the distribution and abundance of shorebirds. Although more data are required to validate the premise, the closer a natural area with important congregations of shorebirds is, the more likely it will be used by the birds.

Finca Torrecilla obtained a score of 1.77 (with an accuracy of 2.7 out of 3). It would appear that the factor that mostly affects the availability of the farms for birds to make use of them is their distance from the intertidal mudflats; however, another important fact is that Torrecilla is surrounded by natural salt flats and mangroves. Although this increases the value of the farm, paradoxically this could also be a determining factor in limiting the use of ponds and dikes by the birds, if they prefer to use the surrounding mangroves or salt flats to roost. Nevertheless, further research is required regarding shorebird use of salt flats.

The availability of ponds is limited to harvest days that range from two to three cycles per year, depending on market demand. Depending on the state of the ponds, there is certainty that the birds will use the ponds during the first three days post-harvest; however, as the pond loses moisture as it dries (from day 4 onwards), the birds find it more and more difficult to feed from the dry bottom and the number of benthic organisms decreases as a result of birds foraging and the cessation of reproduction due to the adverse conditions found while drying.

The availability of the dikes is affected by other factors such as (i) access to open dikes by shorebirds (with or without vegetation), (ii) the presence of natural habitats nearby, and (iii) the use of the dikes to transport feed and produce.

The average values for Finca Chame and Finca Torrecilla were 0.77 and 2.14, respectively; this higher value for Torrecilla is mainly a result of it being surrounded by natural salt flats and mangroves. Furthermore, in the case of Torrecilla, despite the fact that the dikes have favorable specific conditions (without vegetation), availability is affected by their frequent use for transportation, both by water and by land.

Tabla 5. Specific conditions for evaluating the Availability of shorebird use in ponds and dikes of Finca Torrecillas

FACTOR	USE CRITERIA FOR THE PONDS	EMPTY PONDS		
Specific conditions for evaluating Availability		Attribute	Certainty	Desc.
Period of Use	Pond empty for 2 or 3 days	2	3	2
	Pond empty with 10cm of water		3	0
	Pond empty and dry for 15 days or more with sanitary drying	0	3	3
	Ongoing production cycles (maximum of 4 cycles per year without drying)	1.5	2	1
	Traditional harvesting cycles (2 cycles per year and a sanitary drying of 40/60 days)		3	2
Management	Semi-intensive/extensive systems (stocking densities of 16 ind./m2)	3	3	0
Transport	Frequently used for traffic by vehicles	2	2	0
	Average values	1.7	2.71	1.14

FACTOR	USE CRITERIA FOR THE PONDS	EMPTY PONDS		
Specific conditions for evaluating Availability		Attribu-te	Certain-ty	Desc.
Dike Access	Vegetation on the dikes	3	3	2
	Sloped dikes	1	3	2
	Frequently used for traffic	2	2	1
Surrounding Natural Habitat	Distance to the natural salt flats	3	1	3
	Distance to the intertidal mudflats	2	3	0
	Distance to the edges of rivers and mangroves	3	3	0
	Distance to the intermittent freshwater wet-lands	1	3	0
	Average values	2.14	2.57	1.14

ANALYSIS OF THE SPECIFIC CONDITIONS AFFECTING TRACEABILITY IN THE PONDS

A key factor that determines the use that shorebirds make of the ponds depends on the condition of the pond bottoms once they have been harvested. The composition of the bottom substrate will depend to a great extent on the feed, fertilizers, medicinal products, etc. that were used during the grow-out phase. The shrimp farms that export their products are obliged to use traceability systems that provide important information regarding chemical inputs to the substrate. Consequently, the use of the products was evaluated and has been referred to, within this context, as traceability. Both farms make use of traceability software; however, a deeper analysis is required of the elements used by the farms and how they vary one to the other.

The traceability was assessed from two pre-stocking and grow-out conditions; various factors play a role in both periods. For example, during the pre-stocking phase the bottom of the ponds is prepared, and in some cases products such as lime, chlorine and fertilizers are used. During the grow-out phase, the most influential factors are the type of feed, the organic and inorganic fertilizers and the use of medication to treat diseases when necessary.

At both sites traceability obtained the highest value, in comparison to effectiveness, availability and security. This is mainly due to the strong tendency of using natural products. Among the specific conditions evaluated, the highest values were attributed to the application of organic fertilizers, certified conventional feeds, and those that do not apply carbon hydroxide but rather employ the use of probiotics that are natural primary producers. However, a more detailed analysis is required on the effects of the use of lime on the biodiversity of the pond bottoms.

Tabla 6: Specific conditions for evaluating the Traceability that potentially influences shorebird use of ponds in Finca Torrecillas

FACTOR	CRITERIO DE USO PARA ESTANQUES	EMPTY PONDS		
Specific conditions to evaluate Traceability		Attribute	Certainty	Desc.
Pre-Stocking	Use of chlorine	2	2	2
	Non-use of calcium oxide (lime)		1	2
	Application of organic fertilizer (fertiplus)	3	1	3
	Non-use of chemical fertilizer (to be confirmed)	2	1	3
	Non-use of chemical treatment to eliminate Ghost Shrimp	3	3	0
Grow-out	Organic feed		1	2
	Certified conventional feed	3	1	2
	Conventional feed		1	
	Antimicrobial use (antibiotics)	3	0	
	Calcium hydroxide	3	0	
	Use of probiotics	2	2	
Birds	Shorebirds as pathological agents of shrimp diseases		0	
	Average values	1.90	1.1	2.16

ANALYSIS OF THE SPECIFIC CONDITIONS THAT AFFECT THE EFFECTIVENESS OF THE USE OF PONDS AND DIKES BY SHOREBIRDS

Efficacy was measured in terms of the observed use and abundance of shorebirds in the shrimp farms. In the case of Acuícola Chame, a count of 0.56 / 3 with a certainty of 0.4 / 3 was obtained; very low scores due to the limited information available on shorebirds in the area. In the case of Torrecilla, a value of 1.7 was obtained in ponds and 0.75 on the dikes. It is likely that these low values for the efficacy of the use of shrimp farms are due to the fact that they are surrounded by mangrove areas and remnants of natural salt flats, and it is normal that birds would make more use of natural habitat than of artificial habitat. Another determining factor could be the distance from the intertidal mudflats where they concentrate to feed. It is also likely that the efficacy will be affected by the quality of the pond bottom composition, as was discussed in the previous section, or that it is affected by safety elements as noted below.

Tabla 7: Specific conditions for evaluating the Efficacy that could potentially influence the shorebird use of ponds in Finca Torrecillas

FACTOR	USE CRITERIA FOR THE PONDS	EMPTY PONDS		
Specific conditions to evaluate Efficacy		Attribute	Certainty	Desc.
Post-harvest for shorebird populations	Harbors 60% of the recorded species in the main area	1.5	1	2
	Abundance of shorebirds	1	0	3
	An important biogeographical population makes use of the ponds***			
Distance to the Natural Habitats	Distance to the natural salt flats	3	1	3
	Distance to the intertidal mudflats	2	3	0
	Distance to the edges of rivers and mangroves	1	3	0
	Distance to the seasonal freshwater wetlands	1	3	0
Season	Ponds available during the winter season (November - March)	1	2	0
	Ponds available during the southward migration (July - September)	1	2	0
	Ponds available during the northward migration (March - May)	1	1	0
	Average values	1.45	0.3	1.67

Tabla 7: Specific conditions for evaluating the Efficacy that could potentially influence the shorebird use of ponds and Dikes in Finca Torrecillas.

FACTOR	SPECIFIC CONDITIONS TO EVALUATE EFFICACY	DIKES		
Specific conditions to evaluate EFFICACY		Attribute	Certainty	Desc.
Post-harvest for shorebird populations	Records ≤ 15 shorebird species	1	1	1
	Records ≥ 20 shorebird species	0	0	2
	Maximum counts of 1 to 10 shorebird individuals	1	0	2
	Counts of 11 to 100 shorebird individuals	1	0	2
	Counts of 101 to 1000 shorebird individuals	2	2	2
	Counts of 1001 to 10,000 shorebird individuals	0	0	2
	Counts of 10,001 to 50,000	0	0	2
	One or more species with biogeographical population ≥ 1%	0	2	2
	One or more species with biogeographical population ≥ 10%	0	2	2
Vegetation status	Dike without vegetation or with vegetation at a ratio of 30/70	2	2	2
	Dike with nearby mangroves	1	2	1
	Dike with constant traffic	1	2	1
	Average values	0.75	0.62	1.75

ANALYSIS OF THE SPECIFIC CONDITIONS THAT AFFECT THE SECURITY IN TERMS OF SHOREBIRD USAGE OF PONDS AND DIKES

Security was measured only for the dikes. The score obtained for Acuícola Chame was 0.57/3. When assessing Security in greater detail, it was noted that this was affected mainly by the specific conditions regarding staff. If the staff is not able to differentiate between waterbirds that feed on the shrimp and the shorebirds that do not, the latter could also be affected when using certain techniques to scare away the predatory waterirds, since both groups of birds are affected to almost the same degree.

It is also important, regarding Security, to identify the specific dikes that the birds use; in general, there is a high degree of fidelity towards reusing the same dikes during migration or at some point during the daily feeding cycle.

The value of 0.57 indicates that the Security for the birds in the shrimp farms is very low. This value indicates that the knowledge base for identifying recommendations must be enhanced in order to improve the Security aspects for the birds on the farm.

VI. CONCLUSION AND RECOMMENDATIONS

The assessment tool attempts to identify the main factors that affect shorebird use of the shrimp farms. The two farms surveyed and visited have different production processes, especially regarding the use of products during the grow-out process and the preparation of the pond bottoms. It was not possible to obtain some information from Torrecilla during the timeframe available for the assessment; however, it was possible to carry out the complete exercise of the tool and compare the values. A number of shorebird censuses have been carried out in Finca Torrecilla at different times and in general a low abundance of shorebirds has been recorded.

In the case of Acuícola Chame, only one visit was carried out during the low tide and at noon; in spite of the time and the state of the tide, a number of shorebirds were observed mainly in the reservoir, harvested ponds and on the dikes (which are rocky). No specific information exists regarding the diversity and abundance of shorebirds in the natural habitats surrounding the shrimp farm.

Among the main recommendations, we can mention:

- Consolidate the understanding of the positive or negative impacts regarding the traceability elements of shrimp farms, by making the farmers aware of the importance of taking into account the impact on bird populations.

- Identify specific areas within the shrimp farms where shorebirds concentrate on dikes and ponds (taking into consideration that their use of the ponds is opportunistic and depends entirely on the harvest stage).

- Determine the abundance of shorebirds in natural habitats other and critical points of congregation (if any) in the surrounding areas. Most likely, the birds that use the ponds will be closer to these areas.

- Build the capacity of the monitoring and vigilance teams of the farms in terms of shorebird identification. This knowledge will be essential in order to improve shorebird safety, which is affected when they mix with other waterbirds such as cormorants and gulls.

- Undertake research on the alternative management of waterfowl that feed on shrimp, such as mechanisms to scare off waterfowl without harming shorebirds.

- Establish a year-round monitoring program for shorebirds; particularly during the two periods of passage migration, and the reproductive season of the resident shorebirds.

ANNEX 3: LAND-USE CHANGE 1985-2015 AT SAN BERNARDO, HONDURAS AND PLAYONES DE CATARINA IN NICARAGUA, GOLFO DE FONSECA

San Bernardo, Honduras

ANNEX 4: Prioritized Strategies and Actions by Habitat and Threats

STRATEGIES	Threat			Habitat							
	Habitat Loss	Disturbance	Degradation	Mudflats	Shrimp Farm	Salt Flats	Mangrove	Wetland	Sand-Gravel	Salt Pan	Breending Areas
STRATEGY 1:RESEARCH UNDER AN INTEGRATED SCHEME REGARDING THE NEEDS OF THE SHOREBIRDS IN THE SHRIMP FARMS AND SURROUNDING HABITATS											
Identify critical nesting sites in salt flats, shrimp farms and beaches.	●	●			●	●		●	●	●	
Study the body condition of shorebirds.	●		●	●	●	●		●			
Improve knowledge on the use and distribution patterns in habitats and map out the wetland ecosystem complex.	●	●	●			●					
Investigate the quality of food available for shorebirds			●	●	●						
Improve the knowledge of the ecological use and functionality of the salt flats and other wetlands for shorebirds.			●	●	●			●			
Identify and map the roosting areas of shorebirds inside and outside of the shrimp farms that are most likely to be affected by disturbance.		●	●	●	●	●	●	●	●	●	
Develop new techniques to scare away shrimp-eating water-birds that limit disturbances to shorebirds			●		●	●		●			
Identify and map the roosting areas of shorebirds inside and outside of the shrimp farms that are most likely to be affected by disturbance		●		●	●						
STRATEGY 2: MANAGEMENT AND PROTECTION OF NATURAL HABITATS INSIDE AND OUTSIDE THE PRODUCTIVE AREAS											
Management and protection of critical areas inside and outside the shrimp farms	●	●		●	●	●	●	●	●	●	
Implementation of good practices for the benefit of shorebirds by the producers	●	●	●		●						
Management of specific areas with humidity control by members of the community.	●	●			●	●	●				
Development of new alternatives for livelihoods among producers.	●			●	●		●				
Implementation of corporate responsibility programs that in-volve joint actions with the communities.	●	●	●	●	●	●	●	●	●	●	●
Promote integrated programs (improved market prices, impro-ved production) that help to reduce land use change.	●	●	●	●	●	●	●	●			

STRATEGIES	Threat			Habitat							
	Habitat Loss	Disturbance	Degradation	Mudflats	Shrimp Farm	Salt Flats	Mangrove	Wetland	Sand-Gravel	Salt Pan	Breending Areas
Create a system of economic incentives to protect salt flats as a threatened habitat.	●					●					
Humidity management in the nearby wetlands for the use of waterfowl in the summer to reduce the incidence of waterfowl in shrimp farm.	●		●					●			
STRATEGY 3: AWARENESS AND TRAINING FOR PRODUCERS, LOCAL COMMUNITIES AND AUTHORITIES											
Increase the knowledge of business leaders, communities and governments on the needs to conserve and manage the habitats of shorebirds.	●	●	●	●	●	●		●			●
Develop awareness campaigns for shrimp consumers to promote a "shorebird-friendly production".	●	●	●		●						●
Develop awareness campaigns on the specific needs of shorebirds among producers, community members and officials.	●	●	●	●	●	●	●	●	●	●	●
Producers trained in shorebird and waterfowl identification.	●	●				●			●		
STRATEGY 4: CERTIFICATION DEVELOPMENT AND/OR UPDATE											
Create a handbook of shorebird friendly practices in shrimp farms.	●	●	●		●						
Develop a standard for Shorebird Friendly Shrimp.	●	●	●		●						●
Carry out workshops with various stakeholders to consult and create standards that meet international requirements and complement other existing certifications.	●	●	●		●						
Implement a process of "Best Practices" as a pilot program.	●	●	●		●						
Present to the governments the potential regulations identified that should be integrated as part of the local or national policies.	●	●	●		●	●	●	●	●	●	●

ANNEX 5: CONCEPTUAL MODEL SHRIMP AND SHOREBIRD