POPULATION DECLINE AND BREEDING DISTRIBUTION CHANGES OF MAGNIFICENT FRIGATEBIRDS *FREGATA MAGNIFICENS* IN BAJA CALIFORNIA SUR

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ABSTRACT

MARRÓN, G., HERNÁNDEZ-ALVAREZ, A., CARMONA, R., & ÁGUILA, S. 2021. Population decline and breeding distribution changes of Magnificent Frigatebirds *Fregata magnificens* in Baja California Sur. *Marine Ornithology* 49: 19–24.

The Magnificent Frigatebird *Fregata magnificens* (MaFr) is a tropical seabird species that is widely distributed along the mid-latitude coasts of the Americas. Historically, its most important breeding location has been Estero Las Tijeras in the Magdalena Lagoon complex (MLC), Baja California Sur, Mexico. Our recent data indicate a severe (~96%) population decline at this location. In 2002–2003, 33 535 MaFr were counted in all of the MLC, and historical data (1985–1986) support the maintenance of consistently high numbers of MaFr in this region over time. Yet, MaFr abundance dropped severely—to ~1 200 individuals—in 2015. This low abundance persisted into 2017, when we recorded 1 712 individuals; however, we also discovered two new breeding colonies in Baja California Sur. Thus, from 2015–2017, we estimated a total breeding population of ~1 300 pairs in all of Baja California Sur. The reasons for this apparent severe decline, however, remain unclear. Based on satellite images, we discovered a large decline of living mangrove (~70% loss of apparent surface area) in Estero Las Tijeras from 2003 to 2017. Given these apparent changes in breeding effort, local population size, and observed shifts in nesting substrate, and considering other factors such as human disturbance and food-supply changes that may affect MaFr populations, it is evident that more extensive and detailed monitoring and ecological study of MaFr populations is needed. This will make it possible to further define factors affecting this species' status and will support science-based management strategies.

Key words: breeding pairs, nesting population size, habitat transformation, census, Magnificent Frigatebird, Baja California

INTRODUCTION

The Magnificent Frigatebird *Fregata magnificens* (MaFr) is a tropical seabird distributed mainly in the Caribbean, Gulf of Mexico, and the Mexican Pacific (Diamond & Schreiber 2002). It feeds primarily on fish that it catches at the sea surface or steals from other birds (Diamond 1975, Gibbs 1987). Nests are built atop shrubs or small trees in coastal areas in Mexico, especially in the mangrove canopies (Diamond 1973, 1975).

The world population of MaFr, on the basis of available historical data, was estimated to range from 59 000 to 71 000 breeding pairs (Diamond & Schreiber 2002), most of which occur in the Mexican northwest (Moreno-Matiella & Carmona-Piña 1988). In most areas for which information is available, populations are declining, apparently due to loss of habitat, disturbance, and tourist and urban development (Diamond & Schreiber 2002).

Breeding colonies in Mexico are found on islands in most of the coastal states (López-Ornat & Ramo 1992, Howell & Webb 1995, Diamond & Schreiber 2002). Within this wide distribution, there are three main nesting areas: (1) Estero Las Tijeras in the Magdalena Lagoon complex (MLC), Baja California Sur, where 20 117 pairs were reported in 1986–1987 (Moreno-Matiella & Carmona-Piña 1988); (2) Ensenada Pabellones, Sinaloa, with 10 000–20 000 pairs; and (3) Bahía Santa María, Sinaloa, with 18 000 pairs (Everett & Anderson 1991).

On the Baja California peninsula, after Estero Las Tijeras, the area with the most MaFr was La Paz Bay, with 1 600 individuals reported in 1986–1987 (Moreno-Matiella & Carmona-Piña 1988). Nesting was not confirmed until 2012, when a colony with about 1 300 individuals, including chicks, was found in Bahía San Gabriel, Espíritu Santo Island (Marrón *et al*. 2014).

Because of recently detected changes and global trends of MaFr populations (Diamond & Schreiber 2002), it is expected that Baja California Sur populations are shifting; however, the detailed status of populations is currently unknown. Here, we explore the sites of greatest historical relevance for the species in Baja California Sur, estimate the local population size, and analyze changes among breeding colonies.

METHODS

Study area

The MLC is located in southwestern Baja California Sur (Fig. 1; 24°30′N–25°80′N, 111°50′W–112°20′W). It is composed of three areas—Santo Domingo channel, Magdalena Bay, and Almejas Bay—and is 1 875 km^2 in total (Saad & Palacios 2004). The climate of the MLC is hot semi-arid, with an annual rainfall that fluctuates between 48 and 153 mm and, consequently, the lagoon complex does not receive freshwater most of the year (Funes-Rodríguez *et al*. 2007). The largest mangrove forest on the Baja

California peninsula is located in the MLC and consists of about 25 000 ha of red mangrove *Rhizophora mangle*, white mangrove *Laguncularia racemosa*, and black mangrove *Avicennia germinans* (López-Medellín *et al*. 2011, Rebman & Roberts 2012).

La Paz Bay is located on the southeast coast of the Baja California peninsula. It has an area of approximately 2 000 km^2 (Jiménez-Illesca *et al*. 1997). The climate of this region is semi-arid, with an average rainfall of 200 mm, mainly concentrated in the summer months (García & Mosiño 1968). The Espíritu Santo archipelago is located to the east of the bay, and San Gabriel Bay is located to the southwest of those islands (Fig. 1D). La Paz Bay is an open cove with sandy, silty, and rocky substrate, and the beach slope is smooth and covered with mangrove forest, with red mangrove predominating (Bojórquez 1997).

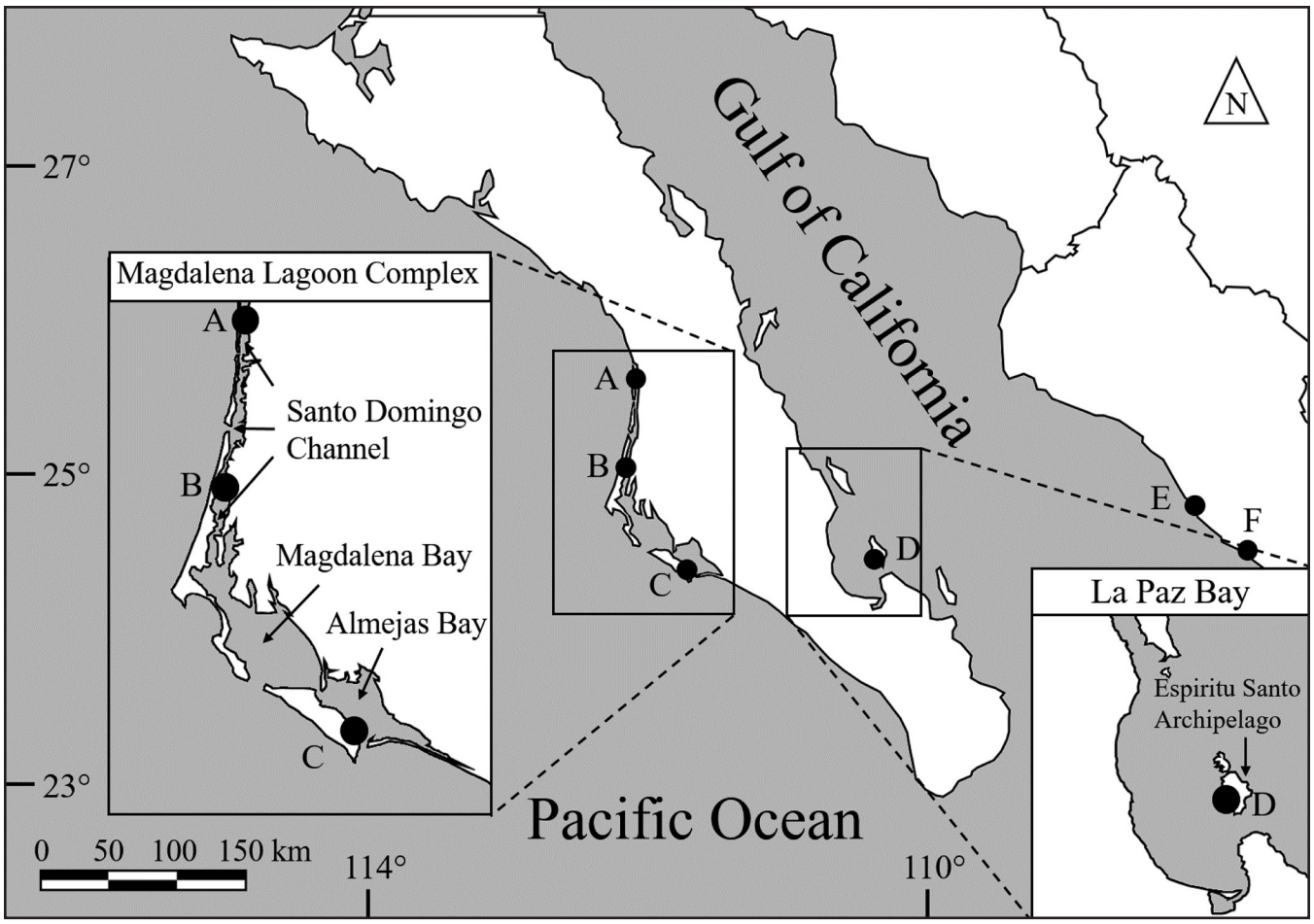

Fig. 1. Magnificent Frigatebird *Fregata magnificens* breeding sites in the Magdelena Lagoon complex, Baja California Sur, Mexico. A: Las Ánimas, B: Magdalena Island channel, C: Estero Las Tijeras, D: San Gabriel Bay, E: Santa María Bay, F: Ensenada Pabellones.

TABLE 1
Magnificent Frigatebird *Fregata magnificens* abundance, including number of nesting pairs (parentheses) at key sites in Baja California Sur

Site	1985–1986[a]	2002–2003[b]	2012[c]	2015[d]	2017[d]
Magdalena Lagoon complex		33 535		150[e]	824 (126)[e]
Estero Las Tijeras	40 234 (20 000)			1 061	888 (296)
La Paz Bay	1 600				
Espíritu Santo Island				191[f]	
San Gabriel Bay			1 300	2 189 (912)	

[a] Moreno-Matiella & Carmona-Piña 1988
[b] Zárate-Ovando *et al*. 2006
[c] Marrón *et al.* 2014
[d] This study
[e] Not including Estero Las Tijeras
[f] Not including San Gabriel Bay

Fieldwork

During 05–07 December 2015 and 21–23 May 2017, we visited the three major areas of the MLC. On 23 November 2015, we visited the Espíritu Santo archipelago and traveled along the perimeter of the islands.

Counts were made by two teams of three people each: two observers and one note-taker. During each survey, we identified and counted all birds that we observed. We made counts from 7-m long boats moving at a constant speed, from no farther than 100 m offshore, making stops at nesting sites for better counts. We counted individual-by-individual in flocks of *ca*. 300 birds or less, and we estimated the number of birds in larger flocks using the block method (Howes & Bakewell 1989), which involves counting the number of individuals in a part of the flock, and using that count as a standardized measure to estimate the number of birds in the remainder of the flock. The block size varied from 10 to 250 individuals depending on the total size of each flock.

Satellite images

To analyze changes in the status of mangroves at Estero Las Tijeras, we obtained satellite images for the site from Google Earth in 2003 and 2009, and from Google Maps in 2017.

RESULTS

Counts from the MLC in 2015 reached 1 211 MaFr, of which 88% were at Estero Las Tijeras (Table 1). For the same year, at Espíritu Santo Island, 2 380 individuals were counted, of which 92% were at San Gabriel Bay, with 912 pairs nesting (Table 1).

In 2017, 1 712 individuals were found in the MLC, of which 52% were at Estero Las Tijeras, where we detected 296 pairs (Table 1). Two new breeding colonies were located in the bay in the Santo Domingo channel, one to the north near Las Ánimas (colony A, Fig. 1) and another to the south of Puerto López Mateos (colony B, Fig. 1), with 90 and 36 pairs, respectively (Table 1).

Considering the counts of pairs found in each breeding colony, the total number of breeding pairs of MaFr in Baja California Sur is currently 1 334.

Satellite images indicate a loss of live mangrove cover in Estero Las Tijeras. In 2003, mangrove appeared to cover almost the entire site, but in 2009 some areas around the main channel had dried up, and by 2017 the majority of the mangroves had died (Fig. 2). The total loss of mangrove coverage between 2003 and 2017 was about 70%.

DISCUSSION

Although the MLC and La Paz Bay (including Espíritu Santo archipelago) are not the only places in Baja California Sur where MaFr can be found, those sites support the largest numbers of MaFr and are the only sites where nesting has been recorded. Thus, describing changes occurring in those areas can reflect the total population trend of this species (Moreno-Matiella & Carmona-Piña 1988, Marrón *et al*. 2014). In this context, the MaFr population decreased from 41 834 birds in 1985–1986 (Moreno-Matiella & Carmona-Piña 1988) to 4 092 individuals in 2015–2017, representing roughly a 90% decline.

Considering the number of pairs of MaFr recorded at Estero Las Tijeras, San Gabriel Bay, and several small, new colonies found north of the MLC, we estimate that > 18 000 pairs are no longer present. This represents a decrease in the total world population of 26%–32% (Moreno-Matiella & Carmona-Piña 1988, Diamond & Schreiber 2002, Marrón *et al.* 2014), mostly in the last 15 years in our study area, given that in 2002–2003, 33 535 individuals were still present in the MLC (Zárate-Ovando *et al*. 2006). Another possibility is that the MaFr population size has not decreased, but instead, birds have moved to other breeding sites, most likely out of the state. Currently, however, there is no evidence to support this explanation.

Colony fragmentation could create additional ecological vulnerabilities (e.g., increased predation, increased human disturbance, further habitat deterioration) because one of the main benefits of colonial nesting is to reduce the chances of predation on eggs and chicks (Götmark & Anderson 1984). In contrast, segregation of nesting sites could decrease the likelihood that the entire population will be affected by localized environmental changes (Anderson & Keith 1980), such as climate change effects.

Modifications in the amount of mangrove cover at Estero Las Tijeras indicate that this factor (habitat loss and fragmentation, regardless of the cause) may have contributed to the aforementioned changes in the abundance and distribution of MaFr. Because of the demonstrated connectivity of reproductive colonies in the Mexican Pacific (Moreno-Matiella & Carmona-Piña 1988, González-Jaramillo & Rocha-Olivares 2011), Estero Las Tijeras could again host a large colony if conditions conducive to nesting are re-established through ecologically-based conservation and management. Other factors that could have contributed to the decrease in the MaFr population include the presence of exotic fauna or disturbance, and it should be noted that these factors are not mutually exclusive.

Other factors that could have contributed to mangrove death in the MLC include sedimentation in channels that carry water to the system, or sea-level rise (López-Medellín *et al.* 2011), since it was evident from satellite images that the channels in the system took on different shapes each year. Sedimentation can cause decreases in the flow of nutrients and the development of anoxic or other harmful conditions, effects that can be exacerbated by increases in temperature and other consequences of climate change (Gilman *et al*. 2008).

Another factor that could explain the decrease in abundance of MaFr is food availability, since the breeding success of other ichtyophagous birds has been observed to decline with a decrease in the biomass of small pelagic fishes that has occurred in response to thermal anomalies or other factors (Velarde *et al*. 2004). In this regard, in recent decades there has been a decrease in small pelagic fish abundance on the west coast of North America (Cavole *et al*. 2016), such as the Pacific sardine *Sardinops sagax*. Despite an overall trend towards declining biomass (Zwolinski *et al*. 2012), sardine catches on the west coast of Baja California Sur increased in the same period until 2015, when the catches fell to more than half compared to the previous year, coinciding with the El Niño event (Grijalva 2017).

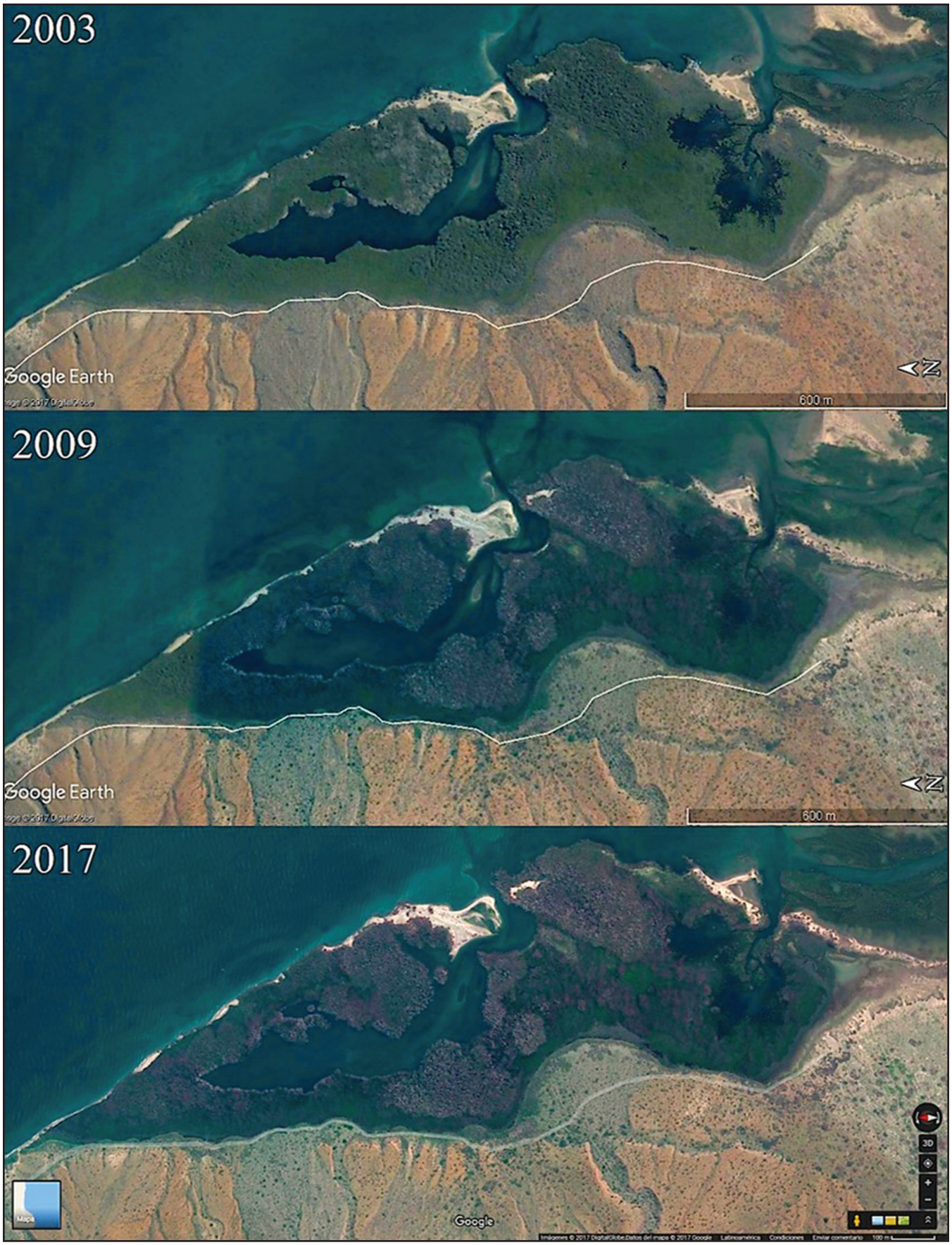

Fig. 2. Satellite view from Estero Las Tijeras in the Magdalena Lagoon complex, Baja California Sur, Mexico, in 2003, 2009, and 2017 (Google Earth and Google Maps images).

The relative concentration of trace elements in the MaFr food supply may also have influenced MaFr abundance, since a high concentration of heavy metals and other elements in the food of seabirds can cause direct and indirect mortality, as well as a decrease in breeding success (Burger & Gochfeld 2000). In the study area, elevated concentrations of trace elements have been reported, with levels of lead, cadmium, and arsenic reported in fish at higher levels than those recommended for human consumption (Sujitha *et al*. 2018). Therefore, this potential cause of MaFr decline cannot be ruled out.

Based on our findings, it is critical that MaFr be listed as a threatened species by the Mexican government (SEMARNAT 2010). By doing so, conservation authorities in the region will be encouraged to develop detailed studies 1) to elucidate the causes of MaFr decline, with a goal of focusing conservation efforts to mitigate identified threats; and 2) to contribute to a current evaluation of the world MaFr population.

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