Chapter 10. Breeding Waterbirds of the Mexican Portion of the Colorado River Delta

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Introduction

Once a mighty and wild river with abundant wetlands, the section of the Colorado River flowing through Mexico has become a trickle … whenever it flows. Most of the time since the 1960s, until recently, it did not and was completely dry. This brought tremendous changes in the "original" constitution and biological processes of the region, although they have not been fully investigated.

Although any fine-scale reconstruction of the historic characteristics of the Colorado River Delta is impossible, wetlands were widespread over an area of 500,000 ha in what in part is today the Mexicali Valley in Baja California and Sonora. Luxurious riparian forests existed in dozens of braided channels in the deltaic alluvial floodplain and the influence of the river extended 65 km into the Gulf of California (Felger 2000; Leopold 1953; Rodriguez et al. 2001; Sykes 1937).

However, this image must be seen with a note of caution. What is usually considered the natural conditions of the Lower Colorado River is not accurate, as the picture of large amounts of sediment flowing into the sea through the Colorado River documented by Sykes (1937) was flawed. These large sediment loads were atypical, because they resulted from extensive loss of beaver (*Castor canadensis*) dams from the river's tributaries due to trapping and from overgrazed watersheds. This began with the arrival of the Spaniards during the 18th century (Dobyns 1978, 1981). These increased sediments must have changed the physiognomy of the lower delta, although the details and consequences remain unknown.

In addition, in the last 100 years, the reduction of freshwater flows and other hydrological changes in the basin have caused biotic degradation of the delta, to the point where wetlands now encompass only about 10 percent of the previous area (Glenn et al. 2001; Zamora-Arroyo et al. 2005). Although some diversions and dams were constructed in the early 1900s, the major changes in the delta began with the construction of Hoover Dam in 1936 and Glen Canyon Dam in 1963 (Zamora-Arroyo et al. 2005). These reservoirs were filling up until 1979, capturing flows that would otherwise reach the delta, driving the habitat degradation of the region (Glenn et al. 2001).

However, even in their current reduced and altered state, these wetlands continue to provide critical habitat for endangered species and for thousands of migratory waterbirds (Gomez-Sapiens et al. 2013; Hinojosa-Huerta et al. 2007). The area has been recognized as a Wetland of International Importance by the Ramsar Convention and a Site of Hemispheric Importance by the Western Hemisphere Shorebird Reserve Network (Hinojosa-Huerta and Carrillo-Guerrero 2010). This biological richness has been maintained by the persistence of a diversity of habitat types in the area, ranging from riparian forest and freshwater streams to brackish marshes, tidal mudflats, and the estuarine/marine environment of the Upper Gulf of California (Hinojosa-Huerta et al. 2007).

Since the late 1970s, periodic river releases, agricultural return flows, and treated effluent of wastewater plants have revitalized portions of the delta, and the populations of some waterbird species have responded accordingly (Glenn et al. 2001; Hinojosa-Huerta et al. 2004). This resiliency in the delta has been attributed to a number of key elements, including (1) the maintenance of undeveloped land in the river corridor and lower delta, (2) the conservation of a geomorphologically active floodplain, (3) the influence of the large tides of the Upper Gulf of California, and (4) the maintenance of some flows of water as river releases, agricultural drainage, and groundwater flows (Glenn et al. 2013; Nagler et al. 2005; Nelson et al. 2013).

In this chapter, we present information on the current status of breeding waterbirds in the Colorado River Delta in each of the habitat types in the region, including information on historical changes, current threats, and conservation recommendations.

Fresh Water, Riparian, and Marsh Habitat

Riparian and riverine habitats have been affected the most in the lower Colorado Delta, as they depend on freshwater flows. Nevertheless, approximately 1,200 hectares of cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*) forests, with about 47 km of wet channel, remain in the riparian corridor between Morelos Dam and the Hardy River, maintained by groundwater flows and sporadic releases from the dam (Glenn et al. 2013).

The brackish marshes, dominated by southern cattail (*Typha domingensis*), are in better condition because they benefit from agricultural return flows and can tolerate some influence of tidal seawater. Major brackish marshes include the Ciénega de Santa Clara, with 5,800 ha of emergent vegetation and shallow lagoons, the Hardy River, the El Doctor wetlands, and Laguna del Indio (Zamora-Arroyo et al. 2005). In addition, a 100-ha open water and marsh habitat in the northern portion of the Hardy River sub-basin was recently re-created with treated effluents from Las Arenitas Wastewater Plant, 30 km south of Mexicali.

Freshwater, riparian, and marsh habitats in the delta support four groups of waterbirds: waterfowl (mostly wintering and migrating), divers (mostly grebes), waders, and marshbirds (Patten et al. 2001). Waterbirds were particularly conspicuous before the 1930s, when major reductions in water flow in the river began (Bancroft 1922; Kramer and Migoya 1989; A. Leopold 1949, 1953; A.S. Leopold 1959; Payne et al. 1991; Price 1899). From the descriptions by Aldo Leopold (1949, 1953) and others it seems that the current numbers of between 20,000 and 50,000 ducks and geese, especially in the Ciénega de Santa Clara and the Rio Hardy region (Hinojosa-Huerta et al. 2013a), are just a pale reminiscence of what the area used to harbor. Four waterfowl species breed here: cinnamon teal, redhead, mallard, and ruddy duck, while the fulvous whistling-duck was a common breeder before the habitat changes in the delta (Hinojosa-Huerta et al. 2007; Patten et al. 2001; scientific names are in table 10).

Three species of shorebirds, black-necked stilt, American avocet, and killdeer, and seven species of waders breed along waterways and marshlands in the Colorado Delta: great blue heron, snowy egret, great egret, tricolored heron, cattle egret, green heron,

Table 10—Waterbirds that breed, or have bred recently, in the Mexican portion of the Colorado River Delta. The list follows the taxonomic nomenclature and order of the seventh edition of the Checklist of North American Birds (American Ornithologists' Union 1998), including the changes made in the 56th supplement to the checklist. Risk categories are: Endangered (E, En peligro de extinción), Threatened (T, Amenazado) and under special protection (Pr, sujetos a protección especial), according to the Mexican list of species at risk (NOM-059-SEMARNAT-2010).

Species	Freshwater /marsh	Upper estuary	Montague Island	Risk category
Anseriformes				
Anatidae: ducks and geese				
Mallard (*Anas platyrhynchos*)	x			
Cinnamon teal (*Anas cyanoptera*)	x			
Redhead (*Aythya americana*)	x			
Ruddy duck (*Oxyura jamaicensis*)	x			
Podicipediformes				
Podicipedidae: grebes				
Pied-billed grebe (*Podilymbus podiceps*)	x			
Eared grebe (*Podiceps nigricollis*)	x			
Pelecaniformes				
Phalacrocoracidae: cormorants				
Double-crested cormorant (*Phalacrocorax auritus*)		x		
Ciconiiformes				
Ardeidae: herons, egrets, and bitterns				
American bittern (*Botaurus lentiginosus*)	x			T
Least bittern (*Ixobrychus exilis*)	x	x		Pr
Great blue heron (*Ardea herodias*)	x	x	x	
Great egret (*Ardea alba*)	x	x		
Snowy egret (*Egretta thula*)	x	x	x	
Tricolored heron (*Egretta tricolor*)	x			
Reddish egret (*Egretta rufescens*)			x	Pr
Cattle egret (*Bubulcus ibis*)	x			
Green heron (*Butorides virescens*)	x	x		
Black-crowned night-heron (*Nycticorax nycticorax*)	x	x	x	
Threskiornithidae: ibises				
White-faced ibis (*Plegadis chihi*)	x			
Gruiformes				
Rallidae: rails and coots				
Black rail (*Laterallus jamaicensis coturniculus*)	x			E
Yuma Ridgeway rail (*Rallus obsoletus yumanensis*)	x	x		T
Virginia rail (*Rallus limicola*)	x			Pr
Common gallinule (*Gallinula galeata*)	x			
American coot (*Fulica americana*)	x			

Table 10—*Continued.*

Species	Freshwater /marsh	Upper estuary	Montague Island	Risk category
Charadriiformes				
Recurvirostridae: stilts and avocets				
Black-necked stilt (*Himantopus mexicanus*)	x	x		
American avocet (*Recurvirostra americana*)	x	x		
Haematopodidae: oystercatchers				
American oystercatcher (*Haematopus palliatus*)			x	E
Charadriidae: plovers				
Snowy plover *(Charadrius alexandrinus)*	x	x		
Wilson's plover *(Charadrius wilsonia)*		x	x	
Killdeer *(Charadrius vociferus)*	x	x		
Laridae: gulls and terns				
Laughing gull *(Leucophaeus atricilla)*	x		x	
Least tern *(Sternula antillarum)*		x	x	Pr
Gull-billed tern *(Gelochelidon nilotica)*	x		x	
Caspian tern *(Hydroprogne caspia)*	x			
Forster's tern *(Sterna forsteri)*	x			
Royal tern (*Thalasseus maximus*)			x	
Elegant tern (*Thalasseus elegans*)			x	Pr
Black skimmer (*Rynchops niger*)	x		x	

and black-crowned night-heron, while little blue heron might do so too (Mellink et al. 2002; Patten et al. 2001). After a rebound from early 20th century hunting for their nuptial plumes (Funcke in Mellink 2000), most breeding species are presumed to have reduced their colonies and their numbers, while some wintering species also have reduced their numbers, although recently some new colonies have formed (Mellink et al. 2002). Conversely, the white-faced ibis has increased its numbers as a result of agriculture (Anderson and Ohmart 1982; Mellink et al. 1997), and the cattle egret, which has bred in the Mexicali Valley since the early 1970s, is increasing in numbers in the region (Garret and Dunn 1981; Rosenberg et al. 1991).

Pied-billed grebes nest in the marshes of the delta, especially in the Ciénega de Santa Clara and the Hardy River, where they are abundant (Hinojosa-Huerta et al. 2013a). Eared grebes are common winter visitors and were documented nesting in the delta for the first time in 2010, at Las Arenitas wetlands, when 75 adults and at least seven nests were observed (Erickson et al. 2011). Since then, pairs, nests with eggs, and adults feeding juveniles have been recorded every year (Edith Santiago, Sonoran Institute, and Eduardo Soto-Montoya, Reserva de la Biosfera Alto Golfo de California y *Delta del Río Colorado*, personal communication).

Western and Clark's grebes breed in nearby regions in California and Arizona, and they were common breeding visitors in the delta during the 1980s (Patten et al. 2001) but have not been recorded breeding in the delta since then.

Seven species of marshbirds breed among the emergent vegetation of the wetlands in the area, and some of them have large populations in the Ciénega de Santa Clara (Hinojosa-Huerta et al. 2013b). One of the species of major interest is the Yuma Ridgeway rail, protected both in the United States and Mexico, and whose population in the Ciénega de Santa Clara is almost 75 percent of the known population of the subspecies, with estimates ranging between 6,000 and 8,000 individuals (Hinojosa-Huerta et al. 2001, 2013b). Some minor populations of this rail occur along the marshes of the Colorado and the Hardy Rivers and in vegetated agricultural drains throughout the valley (Hinojosa-Huerta et al. 2013b).

The most sensitive marshbird in the delta is the California black rail, which is protected as Endangered in Mexico and has fewer than 200 individuals in the region. The largest populations of this species in the delta are located at El Doctor wetlands and the Ciénega de Santa Clara (Hinojosa-Huerta et al. 2013b). The same Ciénega de Santa Clara holds important populations of other marshbirds, including Virginia rail, least bittern, and American bittern, as well as common gallinule and American coot.

The habitat changes in the delta and Lower Colorado reduced the populations of marshbirds in this region (Eddleman et al. 1988), but a modest contribution of agricultural return flows (about 140 million m3 per year, or less than 1 percent of the average annual flow of the Colorado) has created and maintained nearly 10,000 ha of marsh habitat for these birds, sustaining the largest population of these species in Northwestern Mexico and the Sonoran Desert ecoregion (Hinojosa-Huerta et al. 2008).

As a product of the Cerro Prieto Geothermal facility, several ponds were created. These have small islets on which at least 11 species of waterbirds nest: great blue heron, great egret, snowy egret, black-crowned night-heron, laughing gull, gull-billed, Caspian and Forster's terns, black skimmer, snowy plover, American avocet and, possibly, black-necked stilt (Mellink et al. 2002; Molina and Garret 2001). The nearby 100 ha wetland of Las Arenitas, associated with the wastewater treatment plant, also provides habitat for several breeding waterbirds, including redhead, Yuma Ridgeway rail, Virginia rail, American coot, common gallinule, and eared grebe.

Upper Estuary

The tides of the Upper Gulf have one of the largest amplitudes in the world and extend 44 km upstream from the river mouth during the highest tides of the year, connecting with the flows of the Hardy River and other agricultural drains (Nelson et al. 2013). This area, known as the Upper Estuary, covers nearly 12,000 ha and is dominated by mudflats, tidal channels, Palmer's salt grass (*Distichlis palmeri*) patches, saltcedar (*Tamarix* spp.) trees, and few patches of emergent vegetation. The mudflats have been traditionally used for nesting by at least five species: American avocet, black-necked stilt, snowy plover, killdeer, and least tern (Mellink et al. 1996).

This area has experienced large-scale changes recently. Most of it was above the highest tidal line, but coseismic subsidence caused by the April 4, 2010, earthquake dropped the elevation of the area by up to 1.5 m (Nelson et al. 2013), creating this large area of mudflats. The decrease in elevation also facilitated the interaction between tides and drains, especially in sites like Laguna del Indio, where the surface of open water increased. These recently formed habitats are being used by a diversity of waterbirds, in particular migratory shorebirds. Prior to the 2010 earthquake, the area had very few birds (Hinojosa-Huerta et al. 2004), and recent aerial counts estimate between 13,000 and 20,000 shorebirds in the area (Gomez-Sapiens et al. 2013).

The increase of open water and flooding of pre-existing saltcedar thickets favored the establishment of new colonies of waterbirds, especially at Laguna del Indio, where a colony started forming in 2012, and, in 2014, had nesting and juveniles of great blue heron (21 nests), black-crowned night-heron (12 nests), snowy egret (9 nests), great egret (3 nests), green heron (2 nests), and double-crested cormorant (7 nests) (Hinojosa-Huerta et al. 2015). We have also detected vocalizing pairs of Yuma Ridgeway rail, Virginia rail, and least bittern during the breeding season.

Montague Island

Montague Island (22 km long and 7 km in maximum width, surface area = 47 km^2), is a low lying, silt island at the mouth of the Colorado River (31° 43’ 45” N and 114° 45’ 05” W). The island is nearly featureless, but in its southeastern end there are a series of tidal channels, with banks supporting Palmer’s salt grass, the only vascular vegetation of the island, and several sub-fossil shell banks of a nearly-extinct clam (*Mulinia coloradoensis*; Karl Flessa, University of Arizona, personal communication).

Montague Island existed early in the 20th century, but its existence before the 19th century has not been ascertained. It may have been formed by increased sediment supplies produced by the removal of beavers and by cattle grazing in the Colorado River watershed. Its birds, as well as its other biota, have been studied scantly. Of all known early visitors to the Colorado River Delta, only L.J. Goldman is known to have visited Montague Island. He failed to find any nesting birds there, but considered that “... some of the smaller species might have had nests in the grass,” possibly referring to the large-billed savannah sparrows (*Passerculus sandwichensis rostratus*), which he found to be abundant on the island (Smithsonian Institution Archives, Record Unit 7176).

Montague Island remained marginal to biological reconnaissance for nearly eight decades, until 1991, when we began limited and intermittent research work (Mellink 2003; Mellink et al. 2002; Palacios and Mellink 1992, 1993; Peresbarbosa-Rojas and Mellink 1994, 2001). At least 12 species of waterbirds have been documented to nest on Montague Island (table 10). Additionally, one landbird, the large-billed savannah sparrow, also nests there. The data suggest that Montague Island has been used by nesting birds for no more than a century, as we elaborate below.

At the turn of the 20th century the Colorado River carried large, albeit variable, volumes of water all the way to the Gulf of California. At this time, even under conditions of an “unusually low river,” as in 1902, Montague and Gore Islands were “frequently submerged at periods of high tide and river ... [and] at high tide a semi-submerged fringe of salt grass is all that is visible” (Sykes 1937). Similar conditions were recorded in 1915 (L.J. Goldman in 1915, Smithsonian Institution Archives, Record Unit 7176), also a relatively dry year (U.S. Claims Court 1988). Conditions in “normal” or wet years could only be less suitable. Hence, no successful nesting seems to have been possible at that time.

By 1935, water storing and diversion projects, including Boulder Dam, had been profusely established on the Colorado River and caused a reduction in water flow in the lower delta (Sykes 1937; U.S. Claims Court 1988). In addition to several biological impacts (Mellink and Ferreira-Bartrina 2000), the reduction in flow might have allowed for extended periods of dry ground and the development of channels with vegetated banks on Montague Island, making it suitable for nesting by waterbirds for the first time.

The ardeids nested widely in the region and would have easily colonized Montague Island when nesting habitat became available. The larids present a more intriguing question. On his 1915 trip to Montague Island, Goldman collected 12 specimens (held in the National Museum of Natural History), among them two gull-billed terns (James Dean, National Museum of Natural History, personal communication). This was the first documentation of this species in the delta of the Colorado River, although it was overlooked by both Nelson (1921) and Grinnell (1928). In the Salton Sea, there were at least 500 pairs of gull-billed terns nesting by 1927 (Pemberton 1927). For such a colony to have formed since the creation of the Sea, or in 6 years as Pemberton thought, the founding group must have been large, or gull-billed terns must have been already nesting somewhere in the delta. The two specimens during the breeding season from Montague Island before conditions were adequate suggest this later possibility, in which case gull-billed terns might have nested in some southern, but unsurveyed, sections of the delta.

Not only were laughing gulls and black skimmers not nesting on Montague Island at the time, but they had not been recorded in the delta in the early 20th century at all (Dawson 1923; Grinnell 1928; Murphy 1917). Laughing gulls began to nest in the Salton Sea in the late 1920s (Miller and van Rossem 1929). This species is highly visible, and individuals can feed several kilometers from their breeding sites. They would not have been overlooked by ornithologists visiting the delta if they had nested in the area. This species is now found in the area even in the non-breeding season (Patten et al. 2001). Its scarcity in the Salton Sea in 1928 (Miller and van Rossem 1929) suggest that it might have been a newcomer to the area, perhaps from the southern Sonora-northern Sinaloa colonies.

Black skimmers are seemingly recent arrivals to the delta, as they were recorded for the first time in the Salton Sea in 1968 (Collins and Garrett 1996; McCaskie et al. 1974). Given the species' post-Salton Sea history, it is possible that black skimmers used Montague Island as a stepping stone to reach it (Peresbarbosa-Rojas and Mellink 2001), as is suggested by banding records. A likely source for the Montague Island colony would have been the southern Sonora-northern Sinaloa wetlands.

Wilson's plovers were detected to nest there only recently (Eduardo Soto, the head of monitoring, Upper Gulf of California and Delta del Río Colorado Biosphere Reserve, personal communication). These would have colonized from nearby colonies in Sonora, where they nest along the entire northern coast (Mellink and Palacios 1993).

One of the most striking characteristics of Montague Island is frequent tidal inundations (Peresbarbosa-Rojas and Mellink 2001). Such inundations result in very low reproductive output of birds in many, or perhaps most, years. However, in some years there is a good crop of chicks. For example, on 28 June 2001, there were abundant

Table 11—Number of nesting pairs of waterbirds recorded on Montague Island. El Niño conditions prevailed during the breeding seasons of 1992 and 1998.

Species	1991	1992	1993	1994	1998	1999	2001
Great blue heron	?	-	1	2	-	-	1?
Snowy egret	>100	+	87	23	129	+	+
Black-crowned night-heron	20?	2?	-	10	-	5	-
American oystercatcher	n.r.	-	?	-	1	2	-
Laughing gull	60	+	170	127	102	+	+
Caspian tern	-	-	-	def.	-	-	-
Least tern	n.r.	20	<10	27	±110	8	-
Gull-billed tern	-	±175	92	94	>77	+	few
Elegant tern	n.r	±275	-	-	160	2	1
Royal tern	n.r.	±275	-	-	135	16	12
Black skimmer	-	?	14	21	±178	20	low 100s

? = possibly nesting
- = not found nesting
n.r. = not reviewed
def. = nest defense behavior, but nest not searched for or not found;
+ = the species was nesting in numbers comparable to previous years
few = that there were notably fewer pairs nesting than in previous years.

chicks of snowy egret and laughing gull that were old enough to prove that the colonies had not been completely inundated, and giving the prospect of a season with many fledglings of these two species for that year. These inundations also cause within-year dynamics as colonies totally or partially move between the Estero and the Lighthouse or from lower tidal channels of the Estero to higher ones (Peresbarbosa-Rojas and Mellink 2001).

There are also inter-year differences, as exhibited during 1993 and 1994. In these two non-El Niño years there were some differences, at least in the number of snowy egrets, laughing gulls, and least terns (table 11). Not only were there fewer nests of snowy egrets and laughing gulls in 1994, but these species did not begin nesting until June, much later than in 1993 (Peresbarbosa-Rojas and Mellink 2001). During 1993 there was much runoff of fresh water through the Colorado River, and although difference in flow was the only evident difference, it was not clear how it could cause the observed differences in nest numbers.

At a larger scale, during El Niño (Southern Oscillation) years the colonies on Montague Island exhibit remarkable changes (table 11; Mellink 2003). In 1992 and 1998, both El Niño years, there was an influx of nesting elegant and royal terns, and in 1992 there were many more gull-billed tern nests than in 1993 and, in 1998, many more least tern and black skimmer nests. Such increases in Montague Island bird populations do likely not reflect a major increase in available food or favorable breeding conditions. Rather, it might reflect poor conditions at other breeding grounds (Mellink 2003), at least for those species that nest far away and depend on marine resources. However, our knowledge is inadequate to speculate on the particular origin of individuals reaching Montague Island.

Conservation Problems

As in other delta ecosystems worldwide, insufficient and unreliable water supplies and poor water quality are the ultimate causes of environmental degradation in the Colorado River Delta, intensified in this particular case by its location in an arid region. The remnant wetlands in the delta have survived with accidental releases or unintentional flows, and until very recently, there was no water secured for environmental purposes. This is a major challenge for all the different wetland areas, including the Ciénega de Santa Clara, that rely almost completely on agricultural return flows coming from the United States. Such flows have been planned to be diverted for desalinization and further consumptive uses, which will likely cause the degradation of these wetlands.

Most of the present delta vegetation has been enhanced and maintained by flood releases during the 1980s and 1990s (Glenn et al. 2001), restoring in part the cottonwood-willow forests. However, lack of a proper flow regime increases the depth to groundwater, reduces the recruitment of native trees, and increases soil salinity, which favors the establishment of exotic plants, and thereby decreases habitat value. This is coupled with a generalized increase of groundwater extractions, which causes drastic declines of the water table in certain sections of the river corridor, drying up remaining wetlands and stressing riparian vegetation (Ramirez et al. 2013).

Pollution is a concern in the delta that has been prevalent for several decades (see García-Hernández et al. 2000, 2013; Mora 1991; Mora and Anderson 1995). The farming areas in Baja California, Sonora, and Arizona that drain toward the delta are under intense, highly mechanized cultivation. This type of farming involves large quantities of agrochemicals, some of which drain into the wetlands of the delta and flow to the sea in the areas with tidal exchange (Daesslé et al. 2008). Major pollutants of concern in these wetlands and their biota include metals such as mercury, copper, arsenic, and selenium, as well as residue of DDT, PCBs and other organic agrochemicals, especially in the Ciénega de Santa Clara, Hardy River, and the Upper Estuary (García-Hernández et al. 2006, 2013; Guardado-Puentes 1975; Mora 1991).

Human disturbance to the colonies has not been a problem yet. However, as extractive activities become more restricted due to the protected status of the area, larger numbers of tourists, especially at the seashore, may have negative impacts on bird communities. Indeed, some fishermen already have taken tourists to Montague Island during the breeding season. If this activity increases without controls to prevent disturbance, the impacts might aggravate natural impacts (inundating tides, for example), and eventually discourage birds from nesting here.

Predation can impact waterbird colonies (e.g., Pratt and Winkler 1985) but has not been documented on the lower Colorado Delta in general. However, on Montague Island nesting waterbirds are subject to predation by coyotes, which sometimes take a heavy toll on the colonies (Peresbarbosa-Rojas and Mellink 2001). It is not possible to determine the real effect of such predation, especially in the presence of other events that destroy eggs such as high tides or possibly ants (Peresbarbosa-Rojas and Mellink 2001). However, prevention of coyote predation might be of benefit and would be easily accomplished, if desired.

Two other potential threats, indicated for seabirds in Baja California (Everett and Anderson, 1991), seem not to be a problem for Montague Island nesting waterbirds:

(1) human exploitation of birds or eggs, and (2) impacts of fisheries. In the delta, fisheries have been greatly restricted, involve artisanal gill-nets that do not entangle birds, and extract only fish that are much larger than those consumed by the nesting birds.

Restoration and Conservation Actions

One of the key strategies to restore waterbird habitat has included securing water sources for the different wetland areas in the delta. This has involved securing the effluent of wastewater plants as instream flows, maintaining the agricultural return flows to the wetlands, and the dedication of irrigation water rights to restore key areas (Hinojosa-Huerta and Carrillo-Guerrero 2010; Zamora-Arroyo et al. 2008). The Colorado River corridor has recently received allocated flows for ecological restoration under Minute 319 of the International Water Treaty, securing 195 million cubic meters of water on a 5-year period (2012–2017), with one-third of the water provided by Mexico, one-third by the United States, and one-third by a binational coalition of environmental organizations (Gerlak 2015). Part of this water (130 million cubic meters) was delivered as a "pulse flow" during 2014, to revitalize the delta ecosystem, to promote the greening-up of the existing vegetation and the germination of new native plants, and to learn more about the hydrological and biological response of the system (Flessa et al. 2013). Since then, and until 2017, the rest of the water (65 million cubic meters) is being delivered as "base flows" at critical areas of the corridor, to maintain the habitat that has been restored (Flessa et al. 2013).

These efforts have been coupled with intensive restoration actions in specific locations along the riparian corridor, where the intervention includes clearing exotic vegetation, grading the land, establishing native plants, and adding water to sustain the new vegetation and create open water zones (Hinojosa-Huerta et al. 2005). Between 2008 and 2014, a total of 337 ha has been restored and maintained.

Part of the efforts in the delta also includes the implementation of land conservation strategies. One of the earliest achievements was the establishment of the Upper Gulf of California and Colorado River Delta Biosphere Reserve, which protects the Ciénega de Santa Clara, El Doctor Wetlands, Laguna del Indio, and the mudflats near the mouth of the river. To complement the public conservation efforts implemented by the Mexican government with the Biosphere Reserve, environmental organizations have established conservation easement agreements with landowners in key wetlands (Ciénega de Santa Clara and El Doctor) to protect priority habitat for endangered and migratory species. A total of 1,200 ha has been protected under this mechanism in the delta.

Concluding Remarks

Amazingly, despite the intensive and extensive modification of the wetlands of the Mexican portion of the Colorado River Delta, 37 species of waterbirds nest here. Most of those that nested here in the early 20th century, before the large-scale environmental changes, do so still today, albeit perhaps in much lower numbers. Only one species has ceased breeding in the delta (fulvous whistling-duck), but several have been gained, mostly thanks to the creation of new habitat, including Montague Island (as a nesting locale), the Cerro Prieto islets and, on the U.S. side but interconnected, the Salton Sea.

At the same time, the rise of public and government environmental awareness, public pressure, and careful negotiation by NGOs have opened unprecedented opportunities for the conservation of wetlands and their associated biota in this area. Fulfillment of such opportunities with serious, knowledgeable, science-based wetland restoration and creation will increase the role of the Mexican portion of the Colorado River Delta as an important area for the conservation of regional biodiversity.

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