

Transboundary seabird conservation in an important North American marine ecoregion

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Date submitted: 2 September 2005 Date accepted: 31 July 2006 First Published online: 1 November 2006

SUMMARY

Many seabird species of conservation concern have large geographic ranges that span political borders, forcing conservation planners to facilitate their protection in multiple countries. Seabird conservation planning within the seabird-diverse California Current System (CCS) marine ecoregion presents an important opportunity for transboundary collaborations to better protect seabirds across the USA/México border. While seabird populations in the USA are relatively well-studied and well-protected, the status of seabird populations in the Mexican region of the CCS is not well known and seabird colonies have been virtually unprotected. This study synthesizes and supplements information on breeding seabird diversity and distribution, identifies and ranks threats to seabirds and evaluates conservation capacity in the Mexican CCS to provide a framework for transboundary seabird conservation throughout the CCS ecoregion. Island-breeding seabirds in México support 43–57% of CCS breeding individuals, 59% of CCS breeding taxa and a high level of endemism. Connectivity between populations in México and the USA is high. At least 17 of the 22 extant Mexican CCS breeding seabirds are USA/México transboundary breeders or foragers, 13 of which are federally listed in the USA or México. Introduced predators and human disturbance have caused multiple seabird population extirpations in the Mexican CCS because breeding colonies lack legal protection or enforcement. However, conservation capacity in this region has increased rapidly in recent years through the establishment of new protected areas, growth of local conservation non-governmental organizations, and increase in local community support, all of which will allow for more effective use of conservation funds. Transboundary conservation coordination would better protect CCS seabirds by facilitating restoration of seabird colonies in the Mexican CCS and enabling an ecoregion-wide

prioritization of seabird conservation targets to direct funding bodies to the most cost-effective investments.

Keywords: California Current System, conservation, international, México, seabird, transboundary

INTRODUCTION

Seabirds pose an international conservation challenge because most seabirds have large ranges that span international borders (Kushlan *et al.* 2002) and require protection at both their terrestrial breeding and roosting sites and marine foraging grounds. Effective conservation strategies for wide-ranging species often necessitate collaborations across political borders to ensure population persistence and to conserve genetic and ecological diversity across species' ranges (Roca *et al.* 1996; Abbitt *et al.* 2000). Transboundary cooperation can facilitate more effective research and prioritization, better protect large contiguous areas, provide better control of cross-border threats such as spread of invasive species, poaching and pollution, and provide economic benefits to local and national economies (Weber & Rabinowitz 1996; Sanderson *et al.* 2002).

Increasingly, seabirds are being recognized as an ecologically important and threatened component of marine and terrestrial ecosystems. As top predators with high metabolic rates, seabirds remove an estimated 7% of global aquatic primary production annually, which is roughly equivalent to that taken by all fisheries worldwide (Brooke 2004). Additionally, seabirds transport nutrient subsidies from their marine foraging grounds to their terrestrial breeding colonies which can alter the structure of terrestrial food webs and community diversity (Anderson & Polis 1999; Croll *et al.* 2005). Seabirds have life history characteristics that make them particularly vulnerable to population declines and, in some cases, extinctions. They are typically long-lived and have delayed reproductive maturity and low annual fecundity, which limits their ability to recover quickly from disturbances (Russell 1999). Furthermore, seabirds often nest in concentrated colonies in coastal areas and islands which are particularly vulnerable to human impacts (Boersma *et al.* 2002). As a result of multiple threats, more than 30% of the world's seabirds are at risk of global extinction (IUCN [World Conservation Union] 2006).

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Here we examine the opportunities for transboundary seabird conservation planning in an important marine ecoregion, the California Current System. The California Current System (CCS), spanning 26° latitude along the west coast of the USA and northern México, is a highly productive coastal upwelling ecoregion that supports a diverse assemblage of breeding seabirds and millions of migratory seabirds (Tyler *et al.* 1993). CCS seabird populations in the USA have been well-studied at many colonies, well-censused at sea and on land, and relatively well-protected at their breeding colonies during the past three decades (Varoujean 1979; Hunt *et al.* 1980; SOWLS *et al.* 1980; Briggs *et al.* 1987; Speich & Wahl 1989; Ainley & Boekelheide 1990; Ainley & Hunt 1991; Brueggeman 1992; Carter *et al.* 1992; Tyler *et al.* 1993; Ralph *et al.* 1995; Lafferty 2000; Wahl & Tweit 2000; Hyrenbach & Veit 2003). The most important breeding colonies in the USA are legally protected and extensively managed (Wolf 2002).

In contrast, the status of seabird populations in the southernmost region of the CCS in México is not well-known (Everett & Anderson 1991; Hatch *et al.* 1994). Although ornithologists have visited this region since the late 1800s, historical data are largely anecdotal and lack sufficient detail for diagnosing population trends. Grinnell (1928) was the first to summarize historic distributional information for the birds of this region. Everett and Anderson (1991) provided the only comprehensive update on seabird distribution and partial estimates of population sizes. However, complete data on seabird population sizes, population status, threats to seabirds and conservation capacity in the Mexican region of the CCS are largely unavailable and have never been compiled. Here we (1) supplement and synthesize the most recent information on breeding seabird distribution and diversity on islands in the Mexican region of the CCS; (2) identify and rank the relative impacts of terrestrial and marine threats to existing populations; (3) evaluate seabird conservation capacity in north-west México; and (4) examine the potential for transboundary seabird collaboration across the USA/México border to better protect seabirds in this marine ecoregion.

METHODS

To determine current and historic seabird distributions and population sizes, we reviewed published material, government reports and unpublished data. For all species, we selected the most recent and reliable population estimates. We supplemented existing information with our own population censuses conducted between 1999 and 2003. For ground-nesting species, we conducted direct counts of active nests sites (incubating birds and/or nests with chicks) from land and boat-based vantage points that allowed viewing of the entire colony. To increase count accuracy, we mapped and divided colony areas into smaller sub-colony units based on vegetative and topographic features. We conducted counts once during peak incubation for synchronously nesting species or on multiple days spread throughout the nesting season for asynchronously nesting species. For burrow-nesting

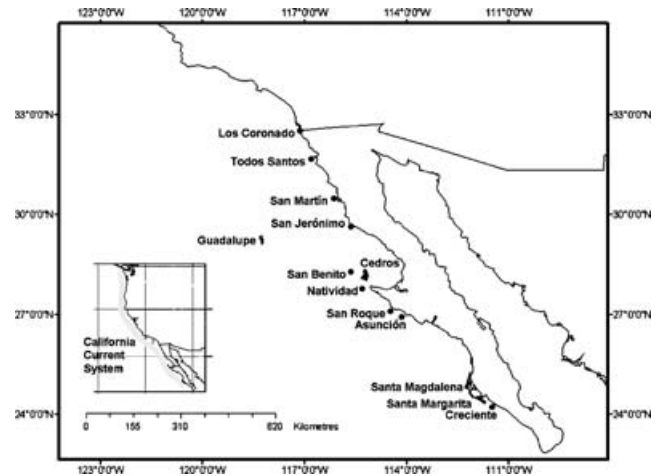


Figure 1 Location of the California Current System.

species, we used sampling methods described in Keitt *et al.* (2003). Briefly, we mapped colony areas using a handheld GPS unit, estimated burrow densities within the colony by counting burrows within randomly placed circular plots, and determined burrow occupancy rates by examining a subset of burrows for incubating adults or eggs using an infrared camera probe. Population estimates equal total colony area multiplied by burrow density and occupancy rate. We limited this review to seabirds that forage in neritic and pelagic waters and excluded shorebirds (Charadriiformes) and wading birds (Ciconiiformes). We gathered information on threats to seabird populations and conservation capacity from the literature, visits to islands, and interviews with researchers, island managers and island residents.

Study area

Our study area is the seabird island-breeding habitat and marine foraging area within the CCS starting at the USA/México political border and ending at the southern limit of Bahía Magdalena, Baja California Sur, where California Current waters merge with southern water masses (Roden 1971). The primary seabird nesting habitat consists of thirteen islands and island groups, referred to as the Mexican CCS islands (Fig. 1). The island groups range in size from 37 874 ha (Cedros) to 67 ha (San Jerónimo) and all, except Guadalupe (an oceanic island 252 km offshore), lie on the continental shelf within 66 km of the coast (Junak & Philbrick 1999a). No data are available for seabird occupancy on near-shore rocks and coastal cliffs, and they have been excluded from this analysis. We also excluded coastal wetland habitat, which supports a small percentage (1% by abundance) of seabirds in the region (see Massey & Palacios 1994; Castellanos *et al.* 2001).

SEABIRD DIVERSITY AND CONNECTIVITY

The breeding seabird assemblage of the Mexican CCS islands consists of 22 species and subspecies (see Supplementary

Table 1 Total number of breeding seabirds and seabird species/subspecies in the CCS. Sources: (1) Massey & Palacios (1994); (2) Castellanos *et al.* (2001); (3) Carter *et al.* (1992); (4) Briggs *et al.* (1987); (5) Tyler *et al.* (1993); and (6) Speich & Wahl (1989).

<i>Region</i>	<i>Breeding birds</i>	<i>% total</i>	<i>Breeding sp./ssp.</i>	<i>% total</i>	<i>Sources</i>
Mexican CCS islands	2 432 749	57	22	59	This study
Western Baja California coastal	26 590	1	9	24	1, 2
California islands/coastal	629 471	15	22	59	3
Oregon islands/coastal	949 276	22	12	32	4, 5
Washington islands/coastal	232 324	5	13	35	4, 5, 6
Total CCS breeding population	4 270 410		37		

Table 2 Known causes of seabird population extirpations from the Mexican CCS islands. Populations have subsequently recolonized some islands. Pred = introduced predators; Dist = human disturbance; Poll = pollution; Unkn = unknown cause. Sources: (1) McChesney & Tershy (1998); (2) Everett & Anderson (1991); (3) Jehl (1973); (4) Palacios *et al.* (2003); (5) Wolf (2002); (6) Carter *et al.* (1995); (7) Jehl & Bond (1975); and (8) Drost & Lewis (1995).

<i>Species</i>	<i>Todos Santos</i>	<i>San Martín</i>	<i>San Jerónimo</i>	<i>Guadalupe</i>	<i>Cedros</i>	<i>Natividad</i>	<i>San Roque</i>	<i>Asunción</i>	<i>Sources</i>
Guadalupe storm-petrel				Pred					1,2
Brown pelican	Dist, Poll	Dist, Poll						Dist	2,3,4
Brandt's cormorant		Dist	Dist						2,4,5
Double-crested cormorant		Dist, Poll					Dist		2,4,6
Elegant tern							Unkn	Unkn	2
Royal tern							Unkn		2
Xantus's murrelet	Pred	Pred	Pred						1,8
Cassin's auklet					Pred	Pred	Pred	Pred	1,2

material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 1) and represents 59% of CCS breeding taxa (Table 1). We estimate that 2 433 000 individuals breed on the Mexican CCS islands (see Supplementary material at http://www.ncl.ac.uk/icef/EC_Supplement.htm, Appendix 1), comprising 57% of CCS breeding seabird abundance (Table 1). Storm-petrels are the most abundant seabird group with Leach's storm-petrel (*Oceanodroma leucorhoa*), black storm-petrel (*Oceanodroma melania*), and least storm-petrel (*Oceanodroma microsoma*), principally from the San Benito Islands, comprising 85% of the Mexican CCS islands' breeding population. Although population estimates for storm-petrels on the San Benito Islands are based on approximations of nocturnal bird densities, we believe these estimates are conservative (S. Howell & S. Webb, personal communication 1999). Nonetheless, even if these estimates are reduced by half, Mexican CCS seabirds still comprise 43% of the CCS breeding seabird abundance. The Mexican CCS islands support all 10 taxa endemic to the CCS, six of which breed only on the Mexican CCS islands at three or fewer confirmed colonies: black-vented shearwater, three Leach's storm-petrel subspecies (*Oceanodroma leucorhoa chapmani*, *O. l. socorroensis*, *O. l. cheimomnestes*), Xantus's murrelet subspecies *Synthliboramphus hypoleucus hypoleucus* and Cassin's auklet subspecies *Ptychoramphus aleuticus australe*.

The Mexican CCS still retains much of its historic species richness, although elegant and royal terns have been

lost from Mexican CCS island breeding locations, and the island endemic Guadalupe storm-petrel is presumed extinct (Ceballos & Márquez-Valdelamar 2000). However, historic seabird data indicate that many Mexican seabird populations have been greatly reduced from their former abundances (Wolf 2002) and that at least 18 seabird populations were extirpated from their colony sites (Table 2). For example, San Martín Island was historically the largest double-crested cormorant colony in North America estimated at 348 480 nests in 1912 by Wright (1913). It was abandoned in the 1980s owing largely to human disturbance, and reoccupied in 1999 by 1200 nesting birds (Palacios & Mellink 2000).

Seabird connectivity throughout the CCS ecoregion is high. In total, at least 17 of the 22 Mexican CCS seabirds are USA/México transboundary breeders or foragers, 13 of which are federally listed in the USA or México and six of which are IUCN listed (Table 3). All but one of the IUCN-listed seabirds in the CCS (marbled murrelet *Brachyramphus marmoratus*) use breeding or foraging sites in both the USA and México.

THREATS TO MEXICAN CCS SEABIRDS

Historic threats to CCS seabirds in the 1800s to mid-1900s were principally colony-based over-harvesting, disturbance, habitat alteration and introduced mammals (Ainley & Lewis 1974; Ainley & Hunt 1991; Everett & Anderson 1991). Current threats are both terrestrial and marine-based, including (1) the

Table 3 Listing and transboundary status of extant Mexican CCS island seabirds. EXT = extinct; END = endangered; THR = threatened; SP = special protection; SCC = species of special concern; CAN = candidate for listing; EN = endangered; VU = vulnerable; and NT = near threatened.

<i>Species</i>	<i>México listing status</i>	<i>US federal listing status</i>	<i>US state listing status</i>	<i>IUCN status</i>	<i>Transboundary status</i>
Laysan albatross	THR			VU	forager
Black-vented shearwater	END			NT	forager
Leach's storm-petrel (<i>O. l. chapmani</i>)	THR				forager
Leach's storm-petrel (<i>O. l. socorroensis</i>)	END				
Leach's storm-petrel (<i>O. l. cheimomnestes</i>)	THR				
Ashy storm-petrel	THR		SSC	EN	breeder
Black storm-petrel	THR		SSC		breeder
Least storm-petrel	THR				forager
Magnificent frigatebird					
California brown pelican		END	END		breeder
Double-crested cormorant			SSC		breeder
Neotropic cormorant					
Brandt's cormorant			CAN		breeder
Pelagic cormorant					breeder
Heermann's gull	SP			NT	forager
Western gull					breeder
California least tern	END	END	END		breeder
Xantus's murrelet (<i>S. h. scrippsi</i>)	END	CAN	THR	VU	breeder
Xantus's murrelet (<i>S. h. hypoleucus</i>)	END			VU	forager
Craveri's murrelet	THR			VU	forager
Cassin's auklet (<i>P. a. aleuticus</i>)	THR		SSC		breeder
Cassin's auklet (<i>P. a. australe</i>)					

presence or potential introduction of non-native mammals; (2) habitat conversion; (3) exploitation; (4) direct disturbance; (5) pollution; and (6) fisheries impacts.

Introduced mammalian predators

Predators have been accidentally or intentionally introduced to every island group in the Mexican CCS islands (Table 4). Cats (*Felis catus*) and rats (*Rattus* spp.) are particularly effective predators of small-bodied burrow and crevice-nesting species such as shearwaters, storm-petrels, auklets and murrelets (Moors & Atkinson 1984), but they also depredate large-bodied species. Feral cats extirpated Cassin's auklet populations from four Mexican CCS islands, contributed to the apparent extinction of the Guadalupe storm-petrel (Table 2), and likely extirpated breeding populations of five alcids and procellariids from mainland Guadalupe Island (Jehl & Everett 1985; McChesney & Tershy 1998; Keitt *et al.* 2005). Feral cats have likely reduced seabird populations on all islands on which they occurred. Cats on Natividad Island killed over 1000 black-vented shearwaters per month during the 10 months that shearwaters attended the island (Keitt *et al.* 2003). Cats on mainland Guadalupe Island depredated more than 35 adult Laysan albatross in 2003 (Keitt *et al.* 2005). On Santa Margarita Island, cats depredated chicks of magnificent frigatebirds, brown pelicans and western gulls (Anderson *et al.* 1989). Between 1994 and 2002, cats were eradicated from all the Mexican CCS islands under 2000 ha (Wood *et al.* 2002), but cats are still present on the four largest colonies (Table 4).

Black rats (*Rattus rattus*) were successfully eradicated from San Roque Island in 1994 (Tershy *et al.* 2002), but rats remain on Cedros, Santa Margarita and Santa Magdalena Islands (Table 4).

Introduced mammalian herbivores

Ten herbivore species have been introduced to the Mexican CCS islands (Table 4). Introduced herbivores destroy and degrade nesting habitat by trampling nests, browsing native vegetation and increasing erosion of top soil (Donlan 2000). For example, goats (*Capra hircus*) introduced to Guadalupe Island in the 1800s intensively trampled and browsed the nesting habitat of the Guadalupe storm-petrel and contributed to the apparent extinction of this species (Jehl & Everett 1985). Rabbits (*Oryctolagus cuniculus*) were transported to island groups by fishers as recently as the 1990s (Donlan 2000). Rabbits not only destroy nesting habitat, but also compete with burrow-nesting seabirds for limited nest sites by ejecting eggs, chicks and adults from nests. Introduced herbivores remain on five island groups (Table 4).

Habitat conversion

Human-mediated habitat conversion displaces breeding seabirds from nesting and roosting habitat and often causes reproductive failure. Permanent populations have been established on Cedros (1940 residents), Natividad (500 residents), Santa Magdalena (259 residents) and Santa

Margarita Islands (333 residents) (Instituto Nacional de Estadística, Geografía, y Informática 2000), and nine of the Mexican CCS islands support seasonal or permanent fishing camps (Table 4). Expansion of towns and camps contributes to the degradation of nesting habitat through road and house construction and contamination from garbage and sewage disposal. Keitt *et al.* (2003) estimated that 38 ha of the black-vented shearwater colony on Natividad Island were destroyed by town and road construction, representing a loss of *c.* 26 500 nests, or 15% of the colony. On Santa Margarita Island, local fishers harvest white mangrove (*Laguncularia racemosa*) from the large magnificent frigatebird colony (E. Palacios, personal observation 2002).

Guano mining on San Jerónimo Island was first noted in 1897 by Brandege (1900) and later reported by Banks (1963) at 300 tons of guano mined annually. In 1999, guano mining on San Jerónimo caused abandonment of the Brandt's cormorant colony and destruction of thousands of Cassin's auklet burrows across 30% of the island (Keitt 2000). Algal harvesting operations were permitted to dry algae on the San Benito Islands until 2001, and trampled hundreds of seabird burrows in dense seabird habitat (S. Wolf, personal observation 2001).

Exploitation

Egg harvesting, especially from gull and brown pelican nests, still occurs on some Mexican CCS islands (Everett & Anderson 1991; Keitt *et al.* 2000). Egg collection in brown pelican colonies can cause the failure of the entire colony when adults flush from their nests and leave eggs exposed to gull predation (Anderson 1988).

Direct disturbance

The Mexican CCS islands are moderately used by tourists for surfing, recreational boating, fishing and ecotourism. None of the Mexican CCS islands has any ranger presence or regulation of tourist activities. In the absence of enforcement, direct seabird disturbance can be significant. For example, in 2002, local fishers began daily visits to San Roque Island to stop abalone poaching. This visitation apparently caused the Brandt's cormorant colony to decline from an estimated 2000 breeding individuals to fewer than 200 individuals (B. Keitt, unpublished data 1999, 2000, 2001). Tourist visits to islands in Northwest México increased by about 5% per year 1986–1993 (Tershy *et al.* 1997). Tourism could increase dramatically in the next decade owing to a proposed tourism infrastructure project sponsored by the Mexican government, which has been challenged because of its potentially wide environmental impacts (Aguirre-Muñoz 2002).

Light pollution

Nocturnal seabirds are attracted to artificial light sources at night and can become disoriented, injured, separated from young at sea, or made vulnerable to predators (Carter *et al.*

1999; Longcore & Rich 2004; Black 2005). Light from towns and fishing camps on islands injures nocturnal seabirds when they crash into human structures, and exposes seabirds to higher levels of predation when lights directly illuminate breeding colonies (Keitt 1998). Nocturnal seabirds have been observed stranding and dying on lighted vessels at night off the Mexican CCS islands (S. Wolf, personal observation 2001, 2002, 2003, 2005). In 2003, Chevron Corporation proposed construction of a liquid natural gas receiving and re-gasification terminal 600 m offshore of South Coronado Island (ChevronTexaco de México 2003; Aguirre-Muñoz 2005). Light pollution from the proposed 300 m platform and docking supertankers would likely impact five nocturnal seabirds at this colony, all of which are listed as threatened or endangered in México.

Pollution

Seabirds are exposed to a wide range of pollutants in the marine environment from local point sources and from non-point agricultural and urban run-off (Sheehan & Tasto 2001). DDT discharged into Southern California coastal waters in the 1960s and early 1970s led to eggshell thinning and associated reproductive failure of brown pelicans and double-crested cormorants on Los Coronado and San Martín Islands (Gress 1973). Use of DDT derivatives in México provides a current source of contaminants to coastal ecosystems from agricultural run-off. Both the Todos Santos and San Martín Islands lie within six kilometres of intensive agricultural areas, which are thought to be the principal sources for high DDT values measured in Western gull eggs collected from Todos Santos (Jimenez-Castro *et al.* 1995) and in sediment sampled near San Martín Island (Gutierrez-Galindo *et al.* 1996). Regional marine fuel reception facilities are potential oil spill hazards, and the port of Ensenada near Todos Santos Island contains high levels of mercury (Carreón-Martínez *et al.* 2001) and organotoxins (Macias-Carranza *et al.* 1997) which can bioaccumulate in seabirds. México has laws regulating oil spill mitigation, but spill detection and cleanup, documentation of seabird mortality and oiled seabird rehabilitation are not well funded.

Fisheries impacts

Since the mid-1980s, coastal gillnet and long-line fisheries have developed and expanded along the western coast of Baja California (Everett & Anderson 1991; DeGange *et al.* 1993; Berdegué-Aznar 2002). Seabird by-catch in gillnets is poorly documented in Baja California and, therefore, the extent of mortality is difficult to estimate. However, Brandt's and double-crested cormorant, brown pelican, common loon (*Gavia immer*), Pacific loon (*Gavia pacifica*) and western grebe (*Aechmophorus occidentalis*) mortality from the gillnet fishery has been recorded (DeGange *et al.* 1993). Depletion of seabird prey species via competition with fisheries is a potential problem in Mexican CCS waters that has not been assessed.

Ranking threats to Mexican CCS seabirds

Of the known causes of seabird extirpations from Mexican CCS islands since the 1900s, non-native predators and human disturbance outnumbered other threats and were the principal causes of 14 recorded extirpations and one likely extinction (Table 2). Although non-native predators have been eradicated from most Mexican CCS islands (Table 4), eradications are still needed on the four largest islands and the risk of re-introduction remains high. Threat detection programmes are needed to determine current impacts of pollution, habitat conversion and fisheries.

CONSERVATION CAPACITY

Conservation capacity in northwest México has increased rapidly in recent years through the creation of new environmental laws, protected areas, and organizational infrastructure. In 1994, México instituted the legal infrastructure to list at-risk species under the federal environmental law, Norma Oficial Mexicana NOM-059-ECOL, with specific protection provided by Article 87 of the General Law of the Ecological Balance and Environmental Protection and Article 85 of the General Wildlife Law. As of 2006, 16 of the 22 Mexican CCS island breeding seabird species and subspecies were federally listed as endangered, threatened, rare, or subject to special protection (Table 3) (Secretaría de Medio Ambiente y Recursos Naturales 2002).

The protected status of the Mexican CCS islands, which are under federal jurisdiction, is also rapidly changing. Prior to the early 2000s, these islands received little federal support or oversight in resources management and monitoring. Three islands were incorporated into the Vizcaino Biosphere Reserve in 1985, but lacked proper federal funding and capacity. More recently, in 2005, the Mexican Presidency designated Guadalupe Island and its surrounding islets and waters as a biosphere reserve. The Guadalupe Island Biosphere Reserve will soon have an active management plan in place and a suite of on-the-ground restoration activities (Aguirre-Muñoz *et al.* 2003) supported by funding and personnel from Mexican government agencies. In 2004–2005, close to 50% of the funding for restoration and conservation infrastructure for the Guadalupe Island Biosphere Reserve came from Mexican federal and Baja California state agencies, in addition to extensive in-kind logistical support from the Mexican Navy, with the remainder of the funding from conservation non-governmental organizations (NGOs) (A. Aguirre-Muñoz, unpublished data 2006). Another advance in conservation capacity was gaining local community support for new protected areas. Mexican conservation NGOs are working with local fishing cooperatives to guarantee them continued sustainable resource use within the biosphere reserve, and developing long-term environmental education programmes for local communities. In 2003, the Mexican Federal Congress requested a Natural Protected Area designation for six other Mexican CCS Island groups, inclusive of marine buffer zones

around each island. Active management, restoration and local community participation are also planned for this protected area.

The growth of Mexican conservation NGOs (including Grupo de Ecología y Conservación de Islas, Pro Esteros, Pronatura Noroeste-Mar de Cortés and Pro Peninsula), a large number of local Mexican universities and research institutions, and the Mexican government are providing organizational infrastructure, expertise in monitoring, research and restoration activities, and trained personnel for seabird conservation along the Baja California peninsula. International conservation organizations have prioritized the islands and waters of the Mexican CCS, based in part on their seabird diversity. BirdLife International recognized eight Mexican CCS islands as Important Bird Areas in 2000 based on their seabird populations (Arizmendi & Márquez-Valdelamar 2000). The North American Commission for Environmental Cooperation designated eight Mexican CCS islands and their surrounding waters as marine conservation priority areas, highlighting their seabird diversity (Morgan *et al.* 2005). While affording no legal protection, these designations help draw recognition and conservation funding.

DISCUSSION

Our review indicates that seabirds of the Mexican region of the CCS comprise a large, previously unrecognized portion of the seabird diversity of the CCS marine ecoregion. However, compared with seabirds in the USA, Mexican CCS seabirds face substantial on-going threats because of past lack of protection and restoration. A transboundary conservation approach that coordinates efforts across the USA/México border could enhance protection of CCS seabirds, because most seabirds of conservation concern breed or forage in both countries and northwest México has rapidly developing conservation capacity that can use increased conservation investment. Specifically, a transboundary conservation approach would facilitate the cross-border exchange of knowledge, technical expertise and funding, enabling managers and NGOs to (1) better plan and implement effective on-the-ground conservation action and (2) create an ecoregion-wide seabird conservation prioritization to direct funders to the most cost-effective investments.

One of the foremost and easily attainable benefits of transboundary coordination is the sharing of expertise and coordination in research, monitoring and on-the-ground conservation actions by managers and NGOs within and outside the region. On-the-ground conservation actions targeted at seabird breeding colonies can be particularly cost-effective because they protect large numbers of birds concentrated at geographically small hotspots. Mexican conservation NGOs have become leaders in the development and implementation of introduced species eradications at seabird colonies and have successfully used this technique to protect seabirds on both USA and Mexican CCS islands

(Aguirre-Muñoz *et al.* 2005). Other proven conservation techniques that could benefit seabirds in new protected areas in the Mexican CCS are measures to prevent non-native species introductions and reduce human disturbance and habitat conversion, as well as seabird reintroduction and threat detection programmes.

Specifically, Mexican CCS managers could implement plans to prevent future non-native species introductions by maintaining rodent bait stations in fishing camps and on vessels, prohibiting pets from islands and initiating rapid response to near-island shipwrecks. To reduce human disturbance, managers could enforce whole island closures at six Mexican CCS islands where there are no human user groups, and institute seasonal restrictions and light pollution mitigation measures on the remaining islands. Measures to prevent further habitat conversion include a moratorium on expanding the footprint of towns, roads, garbage dumps and other human-altered areas, the prohibition of destructive resource extraction projects, and the development of effective disposal methods for hazardous waste, garbage and sewage on islands. Reintroduction and social attraction methods that have successfully restored extirpated seabird populations (Kress *et al.* 1988) could be used to re-establish Xantus's murrelet and Cassin's auklet populations on Natividad, San Roque and Asunción Islands. Colony-based seabird monitoring programmes have been successful in detecting both land and sea-based threats, while fisheries observer programmes and stranded bird surveys can be effective means for detecting fisheries and pollutant-related seabird mortality (Salzman 1989; Forney *et al.* 2001). Finally, enforced closures or restrictions on fisheries that cause high seabird by-catch, and oil spill response and clean-up programmes, could complement at-sea threat detection programmes.

A transboundary approach should also be applied to the prioritization of imperilled seabird species and colonies across the CCS. Specifically, managers and NGOs in México and the USA could synthesize existing information on the diversity, distribution, status and threats to seabirds, set quantitative conservation goals, prioritize conservation targets throughout the CCS, and determine the most cost-effective conservation actions to meet those goals. Such transboundary prioritizations that bring together specialists from across species' ranges have proven useful in conservation planning for other wide-ranging species (Wikramanayake *et al.* 1998; Sanderson *et al.* 2002; Thorbjarnarson *et al.* 2006). The trilateral North American Commission for Environmental Cooperation is sponsoring two new initiatives, the Baja to Bering Priority Conservation Areas and the Marine Species of Common Conservation Concern programmes, to promote cooperative conservation action among institutions throughout the CCS.

Perhaps one of the biggest challenges for transboundary conservation coordination will be securing sustained sources of conservation funding to supplement government support for implementing seabird restoration projects, especially in the new Mexican CCS protected areas. Placing CCS

seabird conservation in a transboundary context should help to attract international conservation funding to the Mexican CCS because of the high benefit-to-cost ratio of investing in this region. Although conservation dollars are typically concentrated in developed countries, recent global cost-benefit analyses of conservation projects indicate that conservation is more economically efficient in less developed countries, such as México, where there are lower costs to implementing conservation plans (Balmford *et al.* 2003). In the CCS, investment in seabird conservation in the Mexican CCS islands between 2000 and 2002 was more than an order of magnitude lower than that invested in the CCS islands bordering California (S. Wolf, unpublished data 2002), which have a total island area roughly equal to that of the Mexican CCS islands. Therefore, funding organizations may make a more cost-effective investment in Mexican CCS seabird conservation where there is little current funding but many restoration opportunities, and avoid the diminishing returns of investing where protection is already high.

Seabird conservation in the Mexican CCS is already receiving an influx of international funding based in part on the increasing transboundary vision of funders. Two recent sources of seabird conservation funding in the CCS have been oil spill restoration funds mandated by the United States Oil Pollution Act of 1990 and litigation settlements to mitigate injury from other pollutants. These funds have supported restoration projects at seabird breeding colonies, often at great distances from the site of impact and across international borders, most recently in the Mexican CCS (Montrose Settlements Restoration Program 2005; Luckenbach Trustee Council 2006).

A collaborative transboundary approach to cataloguing seabird diversity, prioritizing targets and implementing on-the-ground conservation action should also prove useful for seabird conservation in other ecoregions. Our transboundary examination of seabird diversity in the CCS found that most species of conservation concern breed or forage across the international border, which is likely to be the case in other ecoregions based on the metapopulation dynamics of seabirds. Conservation prioritizations across the ranges of these at-risk species would best identify the most cost-effective conservation investments, especially in ecoregions that border countries with significant differences in conservation resources and levels of protection.

ACKNOWLEDGEMENTS

We thank Eric Mellink, Bill Henry, Harry Carter, Darrell Whitworth, Gerry McChesney and Frank Gress for providing data, and Jim Estes for reviewing an earlier version of this manuscript. Héctor Loubet-García and Enrique Zamora assisted in collecting field data. Field work was funded in part by the National Science Foundation Graduate Research Fellowship and the Switzer Environmental Fellowship. We thank the Mexican government for granting permits: Oficio Num/SGPA/DGVS/5283 from Secretaría

de Medio Ambiente y Recursos Naturales and Oficio No. DCPEFM/211/2608/02 from Secretaría de Gobernación.

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