

# The California Current Marine Bird Conservation Plan

## Chapter 7

### Other Human-Seabird Interactions



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# The California Current Marine Bird Conservation Plan Chapter 7

*Other Human-Seabird Interactions*

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## CHAPTER 7: OTHER HUMAN-SEABIRD INTERACTIONS

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As discussed in the previous chapter, fisheries are one human-seabird interaction that can have significant direct effects on seabird populations. There are also additional interactions that can have population-level consequences for seabirds in the CCS and, thus, need to be addressed. These include habitat alteration, both terrestrial and marine, species interactions, various pollutants, and direct human disturbance.

Oil pollution is a globally recognized issue; exposure to even small amounts can coat seabird feathers or be ingested, thereby compromising health or killing individuals outright. Garbage is ubiquitous, occurring throughout the world's oceans and coastlines. Plastics are especially problematic as they are often mistaken for food and fed to chicks, which in severe cases can cause starvation.

Human disturbance includes impacts such as the disruption of feeding flocks and injury of seabirds on the water by fishing vessels. Fishing vessels that approach too closely to breeding birds on their nests may cause them to flush, thereby leaving the eggs and/or chicks exposed to predation.

In this chapter, we highlight various human-seabird interactions, including loss of nesting or roosting habitat, modification of marine habitat, the impact of introduced and "overabundant" species on seabird populations, effects of pollution (organochlorine, metal, oil, and plastic), and direct human disturbance of seabirds.

### Loss of Nesting or Roosting Habitat

Loss of nesting or roosting habitat is a common problem faced by seabirds in the CCS. With the increase in the world's human population, there has been corresponding encroachment into seabird habitats. Other reasons for habitat degradation include habitat alteration, vegetation succession, sea level rise (from global warming), erosion, and periodic inundations.

Despite the protection of many important seabird habitats, historic loss and degradation of coastal habitat in the CCS region has been significant. In many areas of the CCS region, there has been a long history of human presence. For example, the Channel Islands, off the coast of southern California, have a long history of human habitation and support populations of native mammalian predators (e.g., mice, fox) in addition to introduced plants and animals that have greatly altered the natural habitats (see section 7.3).

Larger islands, such as Santa Catalina and San Clemente islands in the Channel Islands and Whidbey and Camano islands in Puget Sound (Washington), are more likely to be inhabited, or to have been inhabited in the past, by humans (some for thousands of years) and, thus, to support both native and introduced predators. Most of these larger islands have been significantly altered through development for residential, agricultural, commercial, or military purposes. Consequently, few of these large islands support large numbers of breeding seabirds.

Present sites of high seabird concentrations, such as the Farallon Islands and the Channel Islands in California, once had human settlements which decimated several species (1), although some populations subsequently have recovered.

Coastal development and logging of old growth forests have impacted seabirds along the west coast of North America; in particular, logging in the 1800s removed over 90% of Marbled Murrelet habitat (2). This loss of habitat resulted in the listing of this segment of the population as threatened under the Endangered Species Act.

However, not all species are equally vulnerable to habitat loss. Species such as Common Murres (*Uria aalge*), Pigeon Guillemots (*Cephus columba*), and Pelagic Cormorants (*Phalacrocorax pelagicus*) nest on steep cliffs and headlands, areas which are difficult for predators and humans to access; thus, levels of disturbance and predation are typically lower.

Wetland and estuary habitats, despite providing critical nesting and feeding opportunities to numerous species, both resident and migratory, are the most severely impacted by humans. Most of these impacts have been the result of conversion of these habitats for development and discharges of pollutants through agricultural practices and runoff. It is estimated that there has been a loss of approximately 54% of wetland habitat in the United States (87), impacting certain seabirds such as Caspian Terns (*Sterna caspia*), a species which seems to prefer to nest on isolated and sparsely vegetated islands (3).

Euro-Americans have significantly degraded low islands found in bays and estuaries through channelization, construction of hydroelectric dams, dredging, increased boat traffic and disturbance. On the other hand, islands created or enhanced by deposition of dredge spoils now provide some of the most important habitat for coastal seabirds. Many of the species that historically nested in coastal estuaries and marshes now nest on artificial habitats such as dredge-spoil islands and salt pond dikes. Several of these species are federally listed under the Endangered Species Act (California Least Tern), Birds of Conservation Concern (Gull-billed, Caspian, and Elegant Terns), and state threatened/endangered species lists.

With a growing human population, the loss of nesting or roosting habitat will likely become a more pressing issue in the future. It is therefore of great importance to protect those areas that are identified as important nesting and roosting habitat, if they are not already protected. With challenges such as these, it is essential to implement proactive conservation actions for long-term preservation of marine birds in the CCS.

## 7.2 MODIFICATION OF HABITAT

There are numerous indirect effects of fisheries on seabird populations in the CCS, including the reduction of seabird prey (discussed in Chapter 5), disturbance of seabirds at sea and at colonies (discussed in section 7.9), oil contamination from fishery vessels (discussed in section 7.7), and the introduction of debris into the marine environment (discussed in section 7.9).

Another indirect effect is the impact to the marine ecosystem caused by fisheries; the Gulf of California shrimp fishery is a good example. Among the problems associated with this particular fishery is the modification of marine habitats. Such habitat alteration can, in turn, change ecosystem structure by both removing large amounts of biomass and modifying the ocean floor.

Typically, the shrimp fishery uses medium-sized boats equipped with otter-trawl nets that are dragged over shallow soft-bottom areas. This dragging action, or trawling, has been widely recognized as one of the fishing methods with the most impacts on marine ecosystems.

There are two basic sources of these impacts. The first is related to the type of nets used in the shrimp fishery. These nets have very low selectivity and thus capture large quantities of non-target organisms in a ratio that has been estimated at 10:1 (10 kg of bycatch per kg of shrimp) and consists of up to 200 different species (88). For the shrimp fishing in the upper Gulf of California, Nava-Romo found that the diversity of the bycatch decreased as the fishing season progressed. Some species became more prevalent in the catch, and the size of individuals and total biomass captured decreased. In general, seabird bycatch is not a problem associated with shrimp trawl operations.

As mentioned above, the second way that marine habitats are impacted by this fishery is through alteration of benthic habitat (89). It has been calculated that in some heavily fished areas, each square meter of bottom is trawled between four to seven times per year (88). The impact of shrimp trawlers in heavily fished areas can be substantial in changing the biodiversity, complexity, and structure of communities in the ocean floor (89). These changes can have a ripple effect through the ecosystem, potentially producing changes in the composition of species that form the prey base for migrating or breeding seabird populations, especially those that rely on coastal prey species. No studies have been conducted to investigate these effects.

Shrimping is the most economically important fishery in Mexico and the third largest by catch volume. In 1997, the total catch in Mexico was 66,500 metric tons, of which 70% was harvested from the Pacific Ocean.

The shrimping areas off the west coast of the Baja California peninsula are located over the continental shelf off Bahía Magdalena and inside Bahía Vizcaíno. The rest of the habitat is too deep for the operation of the otter-trawl nets. Most boats in the fishing fleet, which numbers nearly 1,000 boats, use two nets, from 25 to 35 m wide.

In Washington, Oregon, and California, the shrimp fishery operates between April and October, with a fleet size of approximately 300 vessels.

In B.C., a prawn and shrimp fishery operates in nearshore waters. However, the trawling is mid-water, and therefore does not impact the ocean floor; also, bycatch of non-target species has been reduced to essentially zero because of a special net design.

### 7.3 INTRODUCED SPECIES

There has been a long history of both accidental or purposeful introduction of animal and plant species to areas that support seabird colonies. During the past 200 years in the Channel Islands, 15 herbivore species have been introduced. Rabbits were transported to four island groups by fishermen as pets and for hunting as recently as the 1990s (4).

Such introductions have resulted in both direct and indirect impacts on seabirds of the CCS, including decreases in population numbers and extinctions. In the CCS, 20 non-native vertebrates and 100+ plant species have been introduced to islands with breeding seabirds (Table 7.1 and 7.2). Non-native animals impact seabirds through predation, habitat alteration, and/or competition for food or habitat. Non-native plants may impact seabird populations by displacing native plants used by seabirds as nesting material or by covering the habitat of burrowing seabird species with a tough root system.

Non-native predators of seabird adults and nestlings include cats (*Felis catus*), black rats (*Rattus rattus*), brown rats (*Rattus norvegicus*), and dogs (*Canis familiaris*). Introduced vertebrate species may also significantly impact seabird colonies through habitat alteration.

On the Mexican islands, introduced cats are responsible for the extirpation of Cassin's Auklets (*Ptychoramphus aleuticus*) from four islands and for the extinction of the Guadalupe Storm-Petrel (*Oceanodroma macrodactyla*) (5, 6). Existing feral cat populations undoubtedly continue to reduce the breeding populations of small-bodied alcids and procellariiforms on Guadalupe Island (5, 6). Cats have been documented depredating large Magnificent Frigatebird (*Fregata magnificens*) and Brown Pelican (*Pelecanus occidentalis*) chicks and displacing Western Gulls (*Larus occidentalis*) from nests to depredate eggs and chicks on Santa Margarita Island (7) and Laysan Albatrosses (*Phoebastria immutabilis*) on Guadalupe Island (B. Keitt pers. comm.). Thus, cats are also capable of impacting large-bodied species.

A large feral dog population on Cedros Island is known to depredate the endemic mule deer and rabbit (8) and may be a significant predator of ground-nesting seabirds.

Introduced pigs (*Sus scrofa*) and ungulates (Family Artiodactyla and Perisodactyla) may damage seabird nesting habitat by trampling breeding burrows, consuming native vegetation, and increasing erosion (4). European rabbits (*Oryctolagus cuniculus*) browse foliar cover and compete with burrow-nesting seabirds for limited nest sites, ejecting eggs, chicks, and adults from nests (1). When rabbits are introduced along with exotic predators such as cats, they may impact seabird populations by sustaining predator populations when seabirds are not attending the colony (5).

Introduced mammals have had impacts on a range of other islands in the CCS. A combination of cat predation and burrow damage from goats (*Capra hircus*) caused the extinction of the Guadalupe Storm-Petrel on Guadalupe Island (5, 6). Cats were introduced to five of the Channel Islands, where they extirpated Cassin's Auklet (*Ptychoramphus aleuticus*) colonies from Santa Barbara Island and Leach's Storm-Petrel (*Oceanodroma leucorhoa*) from Coronado North (9, 10). Black rats significantly reduced the population of Xantus's Murrelet (*Synthliboramphus hypoleucus*) from Anacapa Island (11).

Seabird populations can also be impacted by non-native plants, which compete with native plants and may disrupt ecological processes of native floral communities. Non-natives may outcompete native plants during average environmental conditions and dominate floral communities on small islands with little habitat variation. However, during extremes in climatic and/or disturbance events, non-native plants may not have the genotypic variation to survive. Non-native plants common to CCS islands include iceplant (*Mesembryanthum* spp.), mallow (*Malva* spp.), New Zealand spinach (*Tetragonia expansa*), and various grasses (i.e. *Hordeum* spp.).

Non-native plant populations on Año Nuevo Island in central California were established during human occupation in the early-mid 1900s and dominated the floral community until 1998. In 1998, an unusually dry summer and wet winter, coupled with unusual levels of trampling by pinnipeds and Brown Pelicans likely led to a simultaneous rapid increase in non-native plant mortality and decrease in native plant recruitment. Consequently, Año Nuevo is now virtually devoid of plants, resulting in increased erosion and susceptibility of Rhinoceros Auklet (*Cerorhinca monocerata*) and Cassin's Auklet burrows to collapse. Efforts are currently underway to revegetate the island with native plants.

Eradication of non-native species is an effective management strategy, although it is often a difficult and costly task. Island size, variation in insular habitats, and natural history of non-native species all influence the difficulty of eradication. Public reaction also affects the likelihood of a successful eradication. Large islands and those with high habitat diversity pose a greater difficulty for eradication than small islands or islands with less habitat variability. Non-native species with relatively high fecundity and small body size are more difficult to eradicate than species with low fecundity and/or large body size. Eradication efforts should take into account impacts on native flora and fauna and public reaction.

A number of successful eradications of introduced mammals have been achieved on islands within the CCS. Cats have been successfully eradicated from islands under 1,000 hectares (Tables 7.1 and 7.2), including two of the Channel Islands, Anacapa and Santa Barbara, but they remain on Santa Catalina, San Nicolas, and San Clemente. Black rats have been removed from Anacapa (284 ha) and San Roque (79 ha) islands (12) but are still present on San Miguel, San Clemente, and Santa Catalina in the Channel Islands. Brown rats are present only on Santa Catalina. In Mexico, black rats remain on Cedros Island, and are suspected, but not confirmed, on San Martín, Santa Margarita, and Santa Magdalena islands (5). Sheep have been eradicated from all of the Channel Islands (284-26,134 ha) and from Natividad Island (1029 ha). Pigs were eradicated from Santa Rosa and San Clemente islands (14), and eradication is in progress on Santa Catalina Island (15) and is planned for Santa Cruz Island (S. Ortega, pers. com).

Introduced herbivores have successfully been removed from a number of islands. Feral rabbits have been removed from most islands less than 850 hectares. In the Channel Islands, eradication efforts have eliminated non-native herbivores from all but two islands: Santa Rosa with two non-native ungulate species and Santa Catalina with five non-native ungulate species (17, 18). Eradication efforts have eliminated introduced herbivores from all but six of the Mexican island groups (12). Eradications are more difficult on larger islands, and as a consequence, Guadalupe is still beset by a large feral goat population and Cedros by four ungulate species (8, 16) (Table 7.1).

Table 7.1 – Accounts of introduced species on islands off of Baja, Mexico.

	Area (ha)	Human Use	Cat ( <i>Felis catus</i> )	Black rat ( <i>Rattus rattus</i> )	Brown rat ( <i>Rattus norvegicus</i> )	House mouse ( <i>Mus musculus</i> )	Dog ( <i>Canis familiaris</i> )	Pig ( <i>Sus scrofa</i> )	Rabbit ( <i>Oryctolagus cuniculus</i> )	Sheep ( <i>Ovis aries</i> )	Cattle ( <i>Bos taurus</i> )	Donkey ( <i>Equus asinus</i> )	Horse ( <i>Equus caballus</i> )	Elk ( <i>Cervus elaphus</i> )	Mule deer ( <i>Odocoileus hemionus</i> )	Other herbivores	References
<b>Mexican Islands</b>																	
<b>Los Coronados:</b>																	
*North Coronados	80	REC	E														(98,115-118)
*Middle Coronados	32	REC															
*South Coronados	227	LH, MIL, REC, VIG	E				C					C					
<b>Todos Santos:</b>																	
*North Todos Santos	61	LH, MIL, REC	E				C		E				C				(98,115,116,119-121)
*South Todos Santos	127	FISH, LH	E				E		E								
San Martín	298	FISH, LH, REC	E	P			C			NE							(98, 116, 116, 119)
San Jerónimo	67	FISH, LH	E					C					E				(98,116, 116)
Guadalupe	26,470	FISH, LH, MIL	C			C	C		E			C	C			Mule	(98, 116, 116,122-126)
Cedros	37,874	FISH, IND, LH, MIL, REC, TOWN, VIG	C	C		C	C		C		C	C	C				(98, 122, 126)
<b>San Benitos:</b>																	
*East San Benito	195	REC	NE							E							(98, 116, 116, 122, 127,128)
*Middle San Benito	104	REC	NE							E							
*West San Benito	548	FISH, LH, REC, RES, VIG	NE							E			C				
Natividad	1,029	FISH, LH, IND, REC, RES, TOWN	E					IP	C		E					Antelope squirrel	(98, 116, 116, 122, 129-131)
San Roque	79	VIG	E	E													(98, 116, 116)
Asunción	68	VIG	E														(98, 116, 116)
Santa Magdalena	30,330	FISH, REC, RES, TOWN	C	P	P	P	C										(131)
Santa Margarita	23,892	FISH, REC, RES, TOWN	C	P	P	P	C										(105, 131)
Creiente	2,494																(131)

For each island, area in hectares, current human use, and the status of introduced species are indicated. Under human use, **RES**, research activity; **REC**, recreation/tourism; **MIL**, military base and/or lodging; **LH**, lighthouse; **FISH**, fishing camp; **TOWN**, permanent human habitation >250 residents; **IND**, industry; **VIG**, vigilante camp.

Under introduced species, **C**, current feral population (2002); **C boxed**, current domestic population (2002); **E**, feral population eradicated; **E boxed**, domestic population removed; **IP**, eradication in progress (2002); **P**, probable population, presence of non-native species suspected but not confirmed; **NE**, population naturally eradicated (i.e., population established, but died out naturally).

Table 7.2 – Accounts of introduced species on the Channel Islands, California.

	Area (ha)	Human Use	Cat ( <i>Felis catus</i> )	Black rat ( <i>Rattus rattus</i> )	Brown rat ( <i>Rattus norvegicus</i> )	House mouse ( <i>Mus musculus</i> )	Dog ( <i>Canis familiaris</i> )	Pig ( <i>Sus scrofa</i> )	Rabbit ( <i>Oryctolagus cuniculus</i> )	Sheep ( <i>Ovis aries</i> )	Cattle ( <i>Bos taurus</i> )	Donkey ( <i>Equus asinus</i> )	Horse ( <i>Equus caballus</i> )	Elk ( <i>Cervus elaphus</i> )	Mule deer ( <i>Odocoileus hemionus</i> )	Other herbivores	References
<b>Channel Islands</b>																	
San Miguel	4,342	REC, RES		C						E		E					(98, 99)
Santa Rosa	22,565	REC, RES						E		E			E	C	C		(98, 100)
Santa Cruz	26,137	REC, RES					C			E	E		E				(98, 99, 101, 102)
Anacapa:		REC, RES															(98, 103-105)
*East Anacapa	45	REC, RES			IP				E	E							
*Middle Anacapa	60	RES			IP					E							
*West Anacapa	179	RES	E		IP					E							
Santa Barbara	328	REC, RES	E						E	E							(98, 104, 105-109)
Santa Catalina	20,363	REC, RES	C	C	C	C		IP		E	E			C		American bison, Asian black buck	(98, 99, 104, 110-112)
San Nicolas	6,234	MIL, RES	C							E			E				(98, 113)
San Clemente	15,555	MIL, RES	C	C		C		E		E	E					California vole, Harvest mouse	(98-100, 104, 114)
<p>For each island, area in hectares, current human use, and the status of introduced species are indicated. Under human use, <b>RES</b>, research activity; <b>REC</b>, recreation/tourism; <b>MIL</b>, military base and/or testing; <b>LH</b>, lighthouse; <b>FISH</b>, fishing camp; <b>TOWN</b>, permanent human habitation &gt;250 residents; <b>IND</b>, industry; <b>VIG</b>, vigilante camp.</p> <p>Under introduced species, <b>C</b>, current feral population (2002); <b>C boxed</b>, current domestic population (2002); <b>E</b>, feral population eradicated; <b>E boxed</b>, domestic population removed; <b>IP</b>, eradication in progress (2002); <b>P</b>, probable population, presence of non-native species suspected but not confirmed; <b>NE</b>, population naturally eradicated (i.e. population established, but died out naturally).</p>																	

Ten herbivore species have been introduced to the Mexican islands, whose arid climate may have discouraged ranching ventures. Goats released on Guadalupe Island in the 1700s intensively trampled and browsed the nesting habitat of the Guadalupe Storm-Petrel in upland pine and cypress forests and contributed to its extinction (19, 20). Donkeys (*Equus asinus*) are still commonly used on various islands to transport diesel to lighthouses and are permitted to browse native vegetation (5).

Over many decades, introduced goats and donkeys on West San Benito Island collapsed the nesting burrows of storm-petrels, Cassin's Auklets, and Black-vented Shearwaters (*Puffinus opisthomelas*), either blocking entry to the nest or exposing individuals to Western Gull and Common Raven (*Corvus corax*) predators (B. Tershy and D. Croll, pers. comm.).

#### 7.4 NUISANCE SPECIES: THE PROBLEM OF OVERABUNDANCE

As described in the Predators section of this plan (Section 6.1), gulls (*Larus* spp.) are common predators of adults, eggs, and young of other seabirds at colonies in the CCS. Furthermore, gulls may compete for breeding sites with other ground-nesting species (21). Gulls are extremely adaptable to changing environments and have exploited several artificial food resources created by humans, namely landfills and discards from commercial fishing.

As populations of several gull species in North America have increased in recent decades, management concerns have arisen regarding the impact of inflated gull populations on other seabird species. Large concentrations of gulls in urban areas have occasionally been associated with fresh water contamination, damage to buildings, and increasing hazards to aircraft (22). A fair body of scientific research has examined these issues, primarily with Atlantic and Great Lakes populations, though there are similar issues in the CCS.

Sanitary landfills frequently attract large numbers of feeding gulls, at least seasonally, and create concentrations of gulls in urban areas (22). It has been suggested that food gathered by gulls at landfills is "lower quality" than natural food sources (i.e. fish). Long-term studies of Western Gulls on Alcatraz Island showed that individuals foraging primarily on garbage had shorter breeding lifespans and lower reproductive success than those which fed primarily on fish (23). Belant et al. (22) suggested that breeding Herring Gulls (*Larus argentatus*) in the Great Lakes rarely fed in landfills when higher quality food was available, but that these areas were extremely important for post-fledging birds and non-breeders.

Recent changes in landfill practices to reduce garbage availability to gulls might be contributing to recent declines in Western Gull populations at the Farallon Islands (PRBO unpublished data).

Another unnatural source of food for seabirds comes from fisheries practices. Fisheries discards and offal provide a large quantity of food for seabirds, particularly gulls. Furness et al. (24) detailed how fisheries discards are important food resources for four species of British gulls, and positive correlations between fishery landings and gull population numbers have been shown for several species (25, 26).

Where gull populations have grown, their impact as predators on other species has often increased. A number of studies (27, 28) have documented the complete abandonment of traditional nesting areas by terns in response to the encroachment of breeding gulls.

Further evidence comes from culling programs in which removing gulls from breeding colonies has increased recruitment and breeding performance of other seabird species (29-31). However, continued culling of gulls may be required to ensure the positive effects for other species (30). Non-lethal control methods to exclude gulls from nesting with the use of “above-ground wires” have been successful in some areas (32), although similar efforts to exclude Western Gulls from study plots on the Farallon Islands were unsuccessful (33).

Management decisions regarding the use of gull control to reduce negative impacts should be based on solid scientific data since population reduction from culling of gulls can threaten populations without reducing negative impacts, as seen in some instances of airport-based “gull control” to reduce air strikes (34).

Populations of Double-crested Cormorants (*Phalacrocorax auritus*) have been increasing rapidly in many parts of the U.S. since the mid-1970s. This abundance has led to increased conflicts, both real and perceived, with various biological and socio-economic resources, including other birds, recreational fisheries, and hatchery and commercial aquaculture.

The Double-crested Cormorant population breeding in the California Current System is a small fraction of the North American population, comprising only ~4% (USFWS 2003). Within the CCS, Carter et al. (35) documented recent population increases in California and Oregon, and declines in British Columbia, Washington, and Baja California. In the past 20 years, the largest increases in the region have taken place in the Columbia River estuary, where East Sand Island supports the largest active colony along the West Coast, with 6,390 pairs (~1/4 of the region’s breeding population) in 2000 (35, 36).

The primary concern with population increases of Double-crested Cormorants and other piscivorous marine birds, primarily Caspian Terns, is that they eat large numbers of migrating juvenile salmonids.

In 2003, the U.S. Fish and Wildlife Service produced an environmental impact statement for Double-crested Cormorant management, recommending a take of 160,000 cormorants from 24 U.S. states. However, no Pacific states are currently part of this plan, which seeks to reduce exponential growth of Double-crested Cormorant populations and their impact on human activities in eastern states. Current management of large cormorant and tern colonies in the Columbia River ecosystem is confined to non-lethal methods to discourage breeding in certain areas.

## 7.5 ORGANOCHLORINE POLLUTION

Organochlorines (OCs) encompass a large array of compounds that are highly toxic and remarkably persistent once released into the environment. Some of the more common and serious compounds are summarized below.

A large body of research has been conducted on effects of OC contamination on seabirds. Seabirds in the CCS may be contaminated by OCs introduced into the marine system from agricultural runoff, industrial effluents (37) from pollutants associated with pelagic dumpsites (e.g., radioactive waste and chemical munitions dumpsite near the Farallon Islands), and from marine dredge spoils (38).

Organochlorines are lethal to adult birds at high concentrations. Fortunately, the levels of OCs in the U.S. have declined considerably since the ban of DDT and PCBs. The primary impact of DDT on marine birds is its negative effect on eggshell thickness. As concentrations become higher, eggshells become correspondingly thinner. This can lead to a dramatic drop in productivity, through failure to hatch chicks. Several studies have investigated the degree to which OCs affect seabirds in the CCS by comparing OC concentrations and eggshell thickness between different species and different sites, and at different times (i.e., before, during, and after DDT) (37, 39-41).

It is important to consider bioaccumulation when assessing the effect of OCs on seabirds. Bioaccumulation is the tendency for certain substances, in this case OCs, to become increasingly concentrated in organisms at higher trophic levels. For instance, piscivores will have higher levels than planktivores within the same ecosystem. Likewise predatory birds that feed at an even higher trophic level (e.g., consume piscivores) will consequently have higher concentrations than piscivores (42).

OC levels not only vary between species, but they also differ intraspecifically as well; this is primarily due to habitat location (40, 41) but can also be a result of varying diet (43). Speich et al. (40) found that eggshell thickness of Glaucous-winged Gulls (*Larus glaucescens*) differed (but not significantly) and that DDT and PCB concentrations varied significantly between different breeding grounds along the Washington coastline. Their findings suggest that colonies nearer urban-industrial areas have higher concentrations of OCs. Bustnes et al. (43) found that Glaucous Gulls (*Larus hyperboreus*) that fed regularly on eggs of murrelets (*Uria* spp.) had higher levels of OCs than those that fed primarily on fish, providing evidence of bioaccumulation.

**The following are short descriptions of the most common organochlorines historically and/or currently found in the CCS:**

DDT is a pesticide that was once widely used but was banned in the U.S. in 1972 because of damage to wildlife ([www.epa.gov/history/topics/ddt/01.htm](http://www.epa.gov/history/topics/ddt/01.htm)); however, Mexico continues to allow the use of DDT. Recently, however, Mexico has successfully reduced use of this persistent organic pollutant by 80% under a side agreement of the North American Free Trade Agreement (NAFTA) (<http://www.ecoispc.com/goodnews12.asp>). DDE, a chemical similar to DDT, is the metabolic byproduct of DDT. Bioaccumulation is a serious problem with DDE. DDE build up in the fatty tissue of seabirds can cause eggshell thinning, which may significantly decrease reproductive success.

Polychlorinated biphenyls (PCBs) are mixtures of synthetic organic chemicals that were widely used for both industrial and commercial applications; their non-flammability, chemical stability, high boiling point, and electrical insulating properties made them highly versatile compounds. More than 1.5 billion pounds of PCBs were manufactured in the United States prior to the cessation of production in 1977 (<http://www.epa.gov/opptintr/pcb>).

Chlordane is a pesticide that was used in the United States from 1948 to 1978. It bioaccumulates and is a persistent toxic pollutant (<http://www.epa.gov/opptintr/pbt/chlordane.htm>).

Aldrin and Dieldrin (a product of Aldrin) are both insecticides that are now banned in the U.S. Both are persistent, toxic pollutants that bioaccumulate (<http://www.epa.gov/pbt/aldrin.htm>).

A study on Southeast Farallon Island and Año Nuevo Island in 1993 (41) found a trend suggesting that eggshell thickness was negatively correlated with six different organochlorines. However, only oxychlordane showed a significant correlation. The same study also reported that shell thickness was significantly thicker in the 1990s than the 70s, although eggs remained thinner than historic records from before 1947. Henny et al. (39) also found that eggshell thinning in Oregon seabirds appeared to be more severe during the 1950s than in 1979.

The current general opinion is that OCs have been a significant problem in the past but levels have declined to concentrations that no longer pose a great risk to seabirds in the CCS. Nonetheless, OCs persist in the environment and in seabird tissues.

## 7.6 METAL POLLUTION

The primary metals of concern to seabirds in the CCS are lead, mercury, cadmium, and selenium. These metals are present in trace quantities in the earth's crust and thus throughout the marine environment, but at levels which are not toxic to seabirds.

At higher concentrations, however, all metals are toxic. Such elevated concentrations of metals can occur in the marine or onshore coastal environment from anthropogenic sources. Because seabirds usually feed at high trophic levels, they are susceptible to bioamplification of metals.

### Following are descriptions of the metals of concern in the CCS, including documented effects on seabirds.

**Lead.** Potential sources of lead include waste from industrial sources, atmospheric lead from combustion of leaded gasoline, and lead paint. Sea ducks also occasionally ingest lead shot (44). Mortality from lead poisoning in seabirds is rare, but sublethal effects may be widespread. At high levels, lead causes neurological problems, including drooped wings, loss of appetite, lethargy, weakness, tremors, and impaired locomotion (91). On Midway Island, peeling lead paint on old military buildings has been found to cause lead poisoning in albatross chicks, sometimes leading to mortality. In the CCS, there are no reported incidents of lead poisoning in seabirds. Industrial lead sources probably pose the greatest threat of lead contact for seabirds in the CCS.

**Mercury.** Sources of mercury in the marine environment include runoff from terrestrial sources and atmospheric deposition, largely from coal-fired power plants (91). Although mercury occurs naturally in the earth's crust, considerably more mercury can enter the marine environment through contaminated watersheds. In the San Francisco Bay area, for example, runoff through mine tailings has led to significant contamination of marine sediments downstream from historic mines. Mercury poisoning can lead to reduced survival of embryos and chicks, behavioral effects, and other health-related issues. Sydeman and Jarman (45) studied trace metals in marine birds, mammals, and their prey in the central portion of the CCS, near the San Francisco Bay area. They found moderately elevated levels of mercury in eggs of Rhinoceros Auklet, Brandt's Cormorant (*Phalacrocorax penicillatus*), and Pigeon Guillemot.

**Cadmium.** Cadmium has been found in relatively high concentrations in marine organisms, and has been found to cause sublethal and behavioral effects at lower concentrations than other metals (91). Cadmium is a carcinogen and also causes behavioral and reproductive effects. Little information is available regarding effects of cadmium on seabirds, particularly in the CCS. Anthropogenic sources include smelters and the manufacture and disposal of batteries and paints.

**Selenium.** Selenium is an essential element for birds in small quantities, but in larger quantities can lead to deformities and mortality in aquatic birds. Selenium occurs naturally at low levels in the earth's crust, but can be concentrated in agricultural wastewater. High selenium in agricultural drainwater collected in California's Central Valley led to extreme embryonic deformities in several species of shorebirds and waterbirds (46).

Relatively little is known regarding the levels of these and other contaminants in seabirds within the CCS. Ohlendorf (92) posited that, based on available information, metal pollution is unlikely to lead to direct mortality in seabirds (with the exception of ingestion of lead paint chips at Midway, discussed above). Chronic metal contamination may, however, lead to sublethal effects, particularly reproductive failure (92). These sublethal effects have the potential to affect seabird populations in the CCS; thus, more research on this topic is warranted.

## 7.7 OIL POLLUTION

Oil pollution is one of the greatest threats to marine birds in the CCS, impacting birds in several different ways. Oil disrupts the waterproofing, and hence the insulation value, of birds' feathers, often leading to hypothermia in seabirds that have been oiled. Seabird mortality can also result from direct ingestion of oil, which occurs when birds preen oiled feathers. Even relatively small amounts of oil can lead to rapid mortality (i.e., a few days) through either of these pathways (47).

Oil spills in the CCS have occurred as a result of ship collisions and groundings, accidents while loading or unloading, and accidents at offshore oil rigs and pipelines.

Considerable oil also enters the marine environment through "non-point" sources, including runoff from terrestrial sources. Some oil can also enter the marine environment via natural seeps, most famously in the Southern California Bight. Seeps actually contribute the majority of oil in the marine environment in North America, and non-point sources also exceed the amount of oil from accidental spills (48).

Although these ongoing sources of oil represent a threat to seabirds, they contribute a small amount of oil over a long time period, as opposed to a large amount in a small time period typical of anthropogenic causes, and thus do not pose the same threat as large oil spills. Large spills can cover an extensive area of ocean with oil and persist for weeks or longer. Serious oil spills such as the Exxon Valdez spill in Alaska in 1989 can kill hundreds of thousands of seabirds (49).

In the CCS, there have been at least five major spills of over 1,000,000 gallons (Table 7.3). The 1969 spill from a Union Oil rig off Santa Barbara oiled hundreds of birds (probably thousands, although reliable estimates of mortality are unavailable), and helped to spur the environmental movement in the U.S. in the 1970s.

Between 1970 and the 1990s numerous federal and state regulations have been passed, including legislation requiring oil tankers to have double hulls. These regulations appear to have helped, as there has not been a spill of greater than 1,000,000 gallons in the CCS since 1984 (Table 7.3). It should be noted that although many of these spills in the CCS have heavily impacted seabirds, the largest spills here (a few million gallons) are considerably smaller than those that have occurred in other regions of the world.

Worldwide, there have been several spills of over 10 million gallons, including the Exxon Valdez spill in Alaska. The largest spill, the Amoco Cadiz spill off the coast of France in 1978, was approximately 60 million gallons. A spill of this scale in the CCS, where seabird densities at sea are among the highest in the world, would be truly devastating.

Although there have been no recent major spills, spill volume is not always directly proportionate to number of birds killed (50). As Table 7.3 shows, devastating impacts can result from moderate-size spills if they occur in areas of high seabird abundance.

Most oil spills in the CCS have occurred during winter months, probably as a result of severe weather. During this time both resident seabirds and wintering seabirds are found throughout the coastal waters. These visitor species include loons, grebes, and sea ducks, all of which have been heavily impacted by spills. Because Common Murres are the most abundant breeding species in the CCS and are resident year-round, they are usually the species most heavily impacted (in total numbers, if not proportion of population) during spills.

Areas most susceptible to population-level impacts from oil spills are those with the greatest densities of birds at sea, including the Puget Sound area, the Columbia River area, the Gulf of the Farallones and Monterey Bay (central CA), the Southern California Bight, and the Punta Eugenia area. Unfortunately, these are also areas of shipping traffic.

Location and timing of spills not only affect the total number of birds killed, but also affect which species are hardest hit. For example, although less than 2,400 birds were killed in the New Carissa spill in Oregon, 262 Marbled Murrelets were estimated to have been killed, a significant impact to their limited population in the CCS (51).

In addition to direct loss of individual birds during spills, populations can be negatively affected for years after a spill as a result of impacts to the entire marine ecosystem. In Prince William Sound, Alaska, populations of several species of seabird have failed to recover more than a decade after the Exxon Valdez spill. In addition, loss of breeding adult birds has cascading population-level effects; not only is an individual bird lost, but its potential offspring are also lost from the population. Rehabilitation of oiled birds may save individuals, but rehabilitated birds may be permanently affected and fail to breed, thereby contributing nothing to the population (52, 53).

Unfortunately, reliable estimates of damage to seabirds from several major oil spills in the CCS are unavailable (Table 7.3). Although most spills in the CCS receive considerable response, including analyses of both numbers of oiled birds recovered on beaches and of birds at risk at sea, a significant gap occurs off Baja California.

California has developed an efficient response program through the California Department of Fish and Game's Office of Spill Prevention and Response (OSPR); however, there is no mechanism for standardized scientific response to spills south of the border. In many areas, most notably in Mexico, there is also little in the way of ongoing research of baseline conditions.

Baseline data of seabird distribution at sea throughout the year could aid in developing damage assessment models, and ongoing monitoring of breeding colonies is important in determining long-term effects of spills on seabird populations in the CCS. In addition, ongoing monitoring of beaches for beach-cast birds can be useful for baseline mortality levels and detecting oil spill events (54, 55).

In B.C., one of the largest threats is illegal discharge of oil by ship operators, due to low fines and poor enforcement. However, a good system of aerial surveillance is now in place. The Canadian Coast Guard surveys the coast of B.C. for pollution and fisheries enforcement patrols between 65 and 70 days per year. In addition, the Department of National Defence also conducts pollution surveillance flights. Even though the spill reporting system in B.C. is good, it primarily reports and responds to large spills, disregarding the smaller spills (56), which can take a heavy toll on seabirds.

Although shipping traffic is less off Baja California than off southern California, there are no active programs to monitor and respond to oil spills off the Pacific coast of Baja; thus, spills usually go unreported. Pleasure craft use in this area is expected to rise dramatically in the next 12 years, in response to development of marina facilities. At Ensenada in 1997 there were 1240 arrivals and departures, more than double the number in 1993, and at Cabo San Lucas there were 1434 arrivals and departures, up from 1000 in 1993 (Fondo Nacional de Fomento al Turismo). Current plans to develop northwest Mexico with greater infrastructure for pleasure boats is expected to increase the current level of use more than eight-fold by 2014.

In addition, a large development project called the Escalera Nautica will create six new marinas and greatly expand one other along the Pacific coast of Baja California (Fig. 7.1). Considered as a whole, all of northwest Mexico will gain 23,000 new boat slips, of which 55% are marine and 45% are dry dock facilities. Total numbers of arrivals and departures are projected to reach 50,000 by 2014. The majority of this traffic will involve boats in the 30 to 55 foot size range.

It is unknown how the proposed Baja California Pacific Islands Biosphere Reserve will affect the threat of oil pollution in this region. It is highly unlikely that the creation of the reserve will lead to any changes in the current use of the waters surrounding the islands, and thus they will likely be at the same risk from an oil spill. However, in the case of an oil spill the reserve will provide the infrastructure to monitor and report the situation. Additionally, reserve status will hopefully provide increased awareness of these islands and make funds available for cleanup in the aftermath of a spill.

**Table 7.3** – Significant oil spills (including various petroleum products) in the California Current System (Vancouver Island to Punta Baja, Mexico). Question marks indicate lack of data; in some cases no data exist, in others (e.g., recent spills in California), mortality estimates are in preparation.

Year	Month	Name	Location	Volume (x1000 gal.)	Estimated Seabird Mortality	Refs
1937	Mar.	Frank Buck	Central CA	3900	10000	(50)
1956	Sep.	Seagate	Washington	?	>3000	(50)
1957	Mar.	Tampico Maru	Baja CA, Mex.	2500	?	-
1964	Mar.	United Transportation Barge	Washington	1200	?	(132)
1969	Jan.	Santa Barbara Oil Well	Southern CA	4200	?	(133)
1971	Jan.	OR Standard/AZ Standard	Central CA	810	20000	(50, 133, 134)
1971	Apr.	United Transportation Barge	Washington	230	?	(132)
1972	Jan.	General M.C. Meiggs	Washington	2300	?	(132)
1976	Dec.	Sansinena	Southern CA	1260	?	(133)
1983	Nov.	Blue Magpie	Oregon	69	?	(134)
1984	Mar.	Mobiloil	Washington	165	?	(50, 133)
1984	Oct.	Puerto Rican	Central CA	1470	4815	(133, 134)
1984	Dec.	Whidbey Island	Washington	5	?	(133)
1984	Dec.	Unknown Puget Sound	Washington	>406	>1500	(50)
1985	Dec.	ARCO Anchorage	Washington	239	4000	(50, 133)
1986	Feb.	Apex Houston	Central CA	26	10577	(135)
1987	Sep.	Pacific Baroness	Southern CA	386	?	(133)
1988	Jan.	MCN-5	Washington	67	?	(50, 133)
1988	Dec.	Nestucca	Washington	231	56000	(50, 133)
1990	Feb.	American Trader	Southern CA	417	3400	(135)
1991	Jul.	Tenyo Maru	Washington	100	?	(132, 133)
1991	Feb.	Texaco	Washington	210	?	(132, 134)
1992	Aug.	Avila Beach	Central CA	17	?	(134)
1993	Dec.	McGrath	Southern CA	87 (on beach)	?	(135)
1994	Dec.	Crowley Barge	Washington	27	?	(132)
1996	Oct.	Cape Mohican	Central CA	40	593	(135)
1997	Nov.	Kure	Northern CA	2+	?	(135)
1997	Sep.	Torch/Platform Irene	Central CA	>12	700	(135)
1998	Sep.	Command	Central CA	3	1500	(135)
1999	Sep.	Dredge Stuyvesant	Northern CA	2	?	(135)
1999	Feb.	New Carissa	Oregon	70?	2358	(136)
1999	May	Chevron	Baja CA, Mex.	110?	?	-
<2003	Winter	Jacob Luckenbach	Central CA	?	>20000	(55, 135, 137)

## 7.8 PLASTIC POLLUTION

Few studies have been conducted on ecosystem-wide effects of plastic pollution, yet plastic pollution in the marine environment is ubiquitous and can cause significant seabird mortality. There are several ways that plastic can affect seabirds and the marine environment in which they live: through ingestion or entanglement; by absorption and concentration of toxins (including DDT, PCBs, and organochlorines from seawater) (57); and through alteration of ecosystem function by reducing the exchange of gases between sediment and seawater, changing the chemical makeup of the benthos (58). Drifting plastic is also a vector for alien species. Plastics encrusted with marine organisms may travel long distances, introducing alien species and adversely affecting native flora and fauna (58).

Plastic debris is concentrated by currents along the same fronts and convergences as seabird prey items, thereby facilitating ingestion. In many cases, plastic debris also resembles prey items. The 0.5 – 1.0 cm plastic pellets used as raw material for the plastics industry are often mistaken for prey items by seabirds and fish, and can be passed on to young through regurgitation (58). Sievert and Sileo (59) found large volumes of plastic pellets in Laysan and Black-footed albatross chicks.

Spear et al. (60) have shown that in seabirds, body condition and plastics ingestion have a strong negative correlation, meaning that body condition declines as the amount of plastic ingested increases. Plastic ingestion may lead to false feelings of satiation, reducing foraging effort and perhaps hindering digestive processes (58). Drift plastics can be used as substrate by encrusting prey organisms, which are then eaten by seabirds along with the plastic substrate. Ingestion of plastic which has concentrated toxins can lead to reproductive disorders, increased risk of disease, altered hormone levels, and death (58).

Entanglement of marine organisms in plastic debris is well documented for several species of pinnipeds and several species of sea turtles, but the evidence is mainly anecdotal for seabirds, fish, and other animals. Natural behaviors such as curiosity or a need to find protection or food can increase the likelihood of entanglement. Animals can also become entangled when they attempt to haul out on debris, or when pursuing prey already caught in debris. Entanglement can cause decreased mobility, injury (which may lead to death from wounds or through decreased foraging efficiency), and death.

Monofilament fishing line is cited as most likely the greatest danger for entanglement for seabirds. The long life of plastic means that even after the entangled organism is gone, the plastic is available again to entangle another.

Distribution of plastic debris in the marine environment is uneven and dependent on currents, eddies, and weather patterns. Plastic debris is generally buoyant, which facilitates its long-distance dispersal. Drift plastic in the open ocean tends to be concentrated across fronts, at convergences, or held in gyres. In nearshore areas, plastic debris accumulation is typically denser following storms, which provide an influx of terrestrial debris (61).

There is evidence that the abundance of plastic debris in the ocean has declined slightly since 1987, when plastic dumping at sea was banned (60). However, illegal dumping still takes place, and the international authority responsible for enforcement, Annex V of MARPOL, does not have resources for complete enforcement (58). With the continually increasing human population and a corresponding increase in plastic usage, the threat of increased plastic in the marine environment is likely. Thus, stricter measures need to be developed to prevent plastic from polluting the marine environment and negatively affecting seabirds.

## 7.9 HUMAN DISTURBANCE

As the importance of human disturbance impacts to seabirds has been more widely acknowledged during the past two decades, it has become a more popular topic in the published literature. Many studies, however, have failed to deliver information which is reliable or appropriate to the practical challenges faced by conservation managers (62).

Only in the last several years have studies started to tackle the complex and interrelated factors influencing disturbance effects (63, 64), and experimentally test seabird limits for disturbance (65). The continued growth of human populations and their increasing mobility, concurrent with decreasing available quality habitat for seabirds, effectively increases potential for human-seabird interactions. Therefore, it has become imperative to understand the consequences of disturbance on seabirds for effective conservation and management.

Human activities can affect seabirds' ability to feed, rest, and breed; consequently, seabird breeding colonies, roosting sites, and foraging areas are all sensitive to human disturbance. Seabird responses to disturbance can vary depending on species, breeding status, group or community size and structure, environmental conditions, and type, severity and proximity of the disturbance. Effects may be direct or indirect, clearly observable (e.g., alarm calling, flushing, predation) or difficult to detect (e.g., physiological changes, cumulative effects of disturbance), or may impact an individual or an entire population. Effects of repeated or long-term disturbance are especially difficult to study and quantify.

Therefore, in long-lived species such as seabirds, the cumulative effects that disturbance can have on the individual (survival, lifetime reproductive success) or population level remain unknown. Furthermore, additional factors such as modification of species interactions and environmental change can either mask or intensify the effects of human activity (63, 66, 67). Although difficult, it is important to consider these factors in concert with breeding and/or feeding biology when assessing the impacts of human disturbance on seabirds (63, 64).

Finally, some researchers have begun studies of disturbance effects based on stimulus-response experiments with the scientific understanding that these quantitative assessments are more useful than anecdotal observations of wildlife responses to human activities (65).

### Disturbance to Seabird Colonies and Roost Sites

For roosting and successful breeding, many seabirds are dependent on islands free from both mammalian predators and high levels of human disturbance. Yet human use of and influence on the coastline and small islands appear to be increasing in many parts of the world, especially along the coasts of California and Baja California. Seabird responses to human disturbance at colonies or roost sites include alarm behaviors and temporary or permanent site abandonment; these effects can result in reduced nesting success or reproductive failure, or even death of adult birds due to predation (66, 68-70). Human disturbance to seabird colonies can result from recreational and commercial boating activities, aircraft overflights, ecotourism, and investigator disturbance.

Boats or aircraft that approach too closely to breeding seabirds on their nests may cause birds to flush, thereby leaving the eggs and/or chicks open to predation or overexposure to harsh elements. Recreational kayakers, jetskis (or personal watercraft), sailboats, fishing boats, and tourist helicopters or airplanes too close to breeding colonies on Alcatraz Island in San Francisco Bay are a common cause of disturbance to breeding Brandt's Cormorants, Pelagic Cormorants, and Western Gulls, resulting in stress responses of adults as well as some egg and chick loss (J. Thayer, pers. obs.).

Investigator disturbance in seabird colonies is known to reduce survival and growth rate of chicks of several species, thereby reducing overall breeding success (71, 72). Many researchers have altered methodologies to reduce disturbance in seabird colonies as much as possible, including erecting blinds from which to observe birds and reducing or eliminating the need to enter areas with colonially-nesting birds.

There are also several fisheries operating in the CCS that cause disturbance to seabird colonies (Table 7.4). The live rockfish fishery in central California, in which fishing activity is in close proximity to land, has been known to cause egg and chick loss at

Common Murre colonies, yet there are no regulations in place to prevent this from happening (M. Parker, pers. comm.). Negative effects of disturbance from bright lights used at night by the squid fishery are of great concern to seabirds that breed in the Channel Islands, California. This practice has resulted in nest abandonment and low reproductive success for Brown Pelicans (F. Gress, pers. comm.) and may have affected other species as well, including Xantus's Murrelets and Ashy Storm-Petrels (*Oceanodroma homochroa*) that breed on Santa Barbara Island.

The bright lights used in this fishery illuminate parts of the islands and make seabirds more vulnerable to predators such as gulls or owls. In addition, bright lights from boats can also attract birds to the lights and disorient seabirds as they fly to and from the islands, resulting in disruption of their foraging trips and/or collisions with the boat (70).

**Table 7.4** - Fisheries that operate in the CCS that indirectly affect seabirds as a result of disturbance (ASSP = Ashy Storm-Petrel, BRPE = Brown Pelican, COMU = Common Murre, XAMU = Xantus's Murrelet).

FISHERY	SPECIES AFFECTED	DISTURBANCE
CA squid purse seine	BRPE, XAMU, ASSP	light disturbance
CA finfish live trap/hook-and-line	COMU	vessel proximity to nesting colonies

Disturbances do not always have visible negative effects. Slight stress reactions, for example, may not be noticeable to observers. Physiological studies have found that humans approaching Adélie Penguins (*Pygoscelis adeliae*) resulted in significant increases in penguin heart rates, even when no evidence of stress was behaviorally manifested (73, 74).

Regular or repeated disturbances can in some cases devastate seabird colonies, but in other instances not have much visible effect. Explanations for the latter may stem from habituation of seabirds that are regularly disturbed (75-77). Laysan Albatrosses that were frequently exposed to humans responded more slowly and less severely than those that had experienced very little prior human contact (77). The researchers caution, however, that although these experiments suggest that albatross can habituate to the presence of humans, human activity should be limited to confined areas rather than distributed throughout the colony (78).

A cautionary consideration is the potential that regularly disturbed colonies are likely to persist only if the advantages for seabirds to stay at a colony outweigh the disadvantages. For instance, prey availability near Alcatraz Island may be high or predictable, prompting cormorants to breed there, but environmental conditions negatively affecting feeding conditions may intensify the effects of disturbance felt by the birds, resulting in colony abandonment (J. Thayer, pers. obs.).

With habitat for seabirds decreasing and becoming further degraded, such examples of other advantages outweighing human disturbance to a colony may be increasingly rare.

### Disturbance to Foraging Seabirds

There are both direct and indirect human threats to seabirds foraging at sea. Direct disturbances include boats disrupting seabird feeding flocks and injuring seabirds on the water, either through direct collision or entanglement in fishing gear. Indirect human threats can involve reduction of prey as a result of competition with fisheries for shared prey resources. While this section deals only with direct human threats to seabirds, please also see the fisheries-related sections in this document (in Chapters 5 and 6).

Flushing in response to boat traffic is frequently observed in many seabird species (68, 79-81, 93). Aside from direct injury, at-sea disturbance effects may be more severe during times of poor feeding conditions for seabirds, such as El Niño events or even seasonally during the winter when food is scarcer in the CCS. Belanger and Bedard (82) found that human activities resulting in flushing and alertness increased energy expenditure by Snow Geese (*Chen caerulescens*) and reduced their energy intake due to lower feeding rates. Extra energy expended during disturbances or missed feeding opportunities could act to reduce both reproductive success and survival of seabirds, potentially having negative population-level consequences.

Seabird response to disturbance can vary depending on a myriad of factors. Despite its close association with and known habituation to boating activities along the coast of Florida, the Brown Pelican exhibited one of the larger average flush distances of waterbirds studied by Rodgers and Schwikert (65), probably due to the fact that pelicans require more time to take flight. While larger species generally exhibited greater average flush distances to approaching watercraft, considerable variation in flush distances was detected both among individuals within the same species and among species (65). Ronconi and St. Clair (64) found that flushing behavior of Black Guillemots (*Cepphus grylle*) was related to the size, speed, and approach distance of boats as well as foraging distance from the colony, a variable which changes in both a diel (influenced by tides) and seasonal pattern.

### Reducing or Mitigating Disturbance

Rigorous studies that carefully measure disturbance responses are the first step towards establishing effective measures to reduce disturbance. Alert distance (the distance between an animal and an approaching human at which point the animal begins to exhibit alert behaviors to the human) or flush distance have been proposed as indicators of tolerance for birds (82-85). The largest flush distances should be used when buffer zones are implemented for mixed-species groups of birds at foraging, roosting, or breeding sites (86).

Although management options may be specific to a particular type of disturbance or location where a study is conducted, the analytical approach used to identify appropriate buffer zones may be relevant to other locations and seabird species. Once recommendations are proposed, however, reducing or mitigating disturbance at fixed locations such as seabird colonies or roosting areas may be somewhat easier than managing disturbance to seabirds at sea where distributions often depend on ephemeral oceanographic processes that concentrate prey.

A 1999 review by Carney and Sydeman (94) provides a useful summary of literature on human disturbance to seabirds, although more research has subsequently been conducted. Other useful endeavors such as conference workshops and ongoing field projects have been undertaken by various government agencies around the world to identify and suggest solutions for seabird disturbance. Several important documents have resulted from these efforts, including Guidelines for Managing Visitation to Seabird Breeding Islands, developed for the Great Barrier Reef Marine Park Authority, Australia, and websites such as Canadian Arctic Profiles' Arctic Environmental Sailing Directions.

### Source:

<http://collections.ic.gc.ca/arctic/envsens/environm.htm>

Australia's Great Barrier Reef guidelines contain information on the vulnerability of seabirds to disturbance, priorities to establish values for seabird breeding aggregations, the impacts of a range of human activities on breeding seabirds, and ways of mitigating these impacts. Techniques for implementing the guidelines include developing codes of conduct/practice, island closure, signage, publicity, permits, ranger patrols, and scientific monitoring.

Canadian Arctic Profiles has made widely available maps of sensitive wildlife areas along the Canadian coast, integrating seven different components: sensitivity, vulnerability, relative density, harvesting, endangered species index value, travel routes, and season. These efforts can serve as models for products from workshops focusing on seabird disturbance in the CCS.

## 7.10 RESEARCH AND MONITORING RECOMMENDATIONS

1. Investigate and model short-term and long-term effects of oil spills (chronic and catastrophic) on seabird prey, habitats, and population dynamics.
3. When an oil spill occurs, model the mortality of all species affected to determine appropriate mitigation and restoration efforts.
4. Assess oil pollution threats along the coast and identify areas most at risk (based on frequency of vessel traffic, time of year, and seabird numbers and diversity, etc.).
5. Implement regular monitoring of contaminant levels in seabird eggs, feathers, and tissues and of the effects of contaminants on seabird demography (survival and fecundity). Use bycaught seabirds to monitor contaminant levels.
6. Evaluate sublethal effects of contaminants.
7. Determine whether environmental contaminants are affecting breeding hormone concentrations and reproductive success.
8. Identify sources of contaminants and garbage in marine systems.
9. Examine levels of ingestion of plastics and other garbage in live and dead seabirds; determine the magnitude of this problem at the population level.
10. Map all sunken vessels in the CCS, with information on oil quantity and type aboard each vessel, date of sinking, depth, etc.
11. Identify which seabird species and colonies are most at risk from freshwater runoff (non point contaminant sources), especially from urban and agricultural centers.
12. Create a database that contains the results of seabird contaminant analyses and distribute this information to agencies with mandates to maintain water quality.
13. Investigate more thoroughly the interactions between terrestrial and marine environments regarding contaminant introductions to the ocean.
14. Consider removing fuel/oil from large-volume sunken vessels near colonies or near important seabird foraging habitats.
15. Conduct float/sink dispersal studies on small seabirds (nearshore and near island) to evaluate beach deposition rates.
16. Further investigate and document the effects of human disturbance on seabirds.

## 7.11 CONSERVATION AND MANAGEMENT RECOMMENDATIONS

1. Ensure that all oil transportation vessels have a double hull.
2. Change routes of major oil transportation vessels and barges based on studies of main current and wind patterns (by season) and potential impacts on important seabird colonies. Conduct studies to identify the level of “threat” in case of major oil spill at important colonies and where changes need to be recommended.
3. Enforce current bilge pumping regulations and work with appropriate agencies to increase strictness of regulations.
4. Use California oil spill response and documentation protocols as a model and make them available to other states in the CCS that lack comparable response protocols.
5. Create a database that includes a list of sensitive seabird areas, sensitive times of year, and a list of contact people for each of these areas. This database should be made available in the case of oil spills or other contaminant emergencies.
6. Require bilge tank cleaning to occur further offshore than current regulations mandate.
7. Work with waste removal and sanitation departments to decrease exposure of seabirds to garbage.
8. Evaluate and monitor the effects of light-intensive fishing activities on offshore, nearshore, and island colonies.
9. Include fisheries effects in management plans. Priority topics to include are: bycatch; light effects on seabirds; and disturbance of seabird colonies or roost sites by fishing vessels.

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