Volume III, Chapter 12
Caspian Tern

TABLE OF CONTENTS

12.0 Caspian Tern *(Sterna caspia)*

12.1 Introduction

Despite recent population increases, the Caspian tern (*Sterna caspia*) is of conservation concern in the Pacific Northwest because of the concentration of breeding terns at relatively few sites and fisheries conflicts at the Columbia River estuary, where 2/3 of the Pacific Coast and 1/4 of the North American population occurs. Although not listed at the national level, the species currently is listed as threatened or endangered in three states or provinces and is considered of special concern in ten more. The Caspian tern still occupies most of its historic range and has expanded slightly into new areas.

Historically, the Caspian tern suffered from harvest for the millinery trade, egging, human disturbance, habitat loss at interior wetlands, and, more recently, from contaminants. Historic population numbers are unknown but appear to have been substantially reduced early in the century. Relatively accurate population data for the Caspian tern in North America were unavailable until the late 1970s, when concerns over coastal habitat modification and offshore oil development prompted national multi-species surveys of colonial nesting waterbirds. Estimates of the US breeding population were roughly 9,454 pairs in the mid-1970s to early 1980s and 20,948 pairs in the late 1980s to late 1990s. Since the late 1970s, the population has increased in four of five major breeding regions in North America, and the continental population is estimated to be a minimum of 32,000 to 34,000 pairs, distributed differentially among regions: Pacific Coast/Western (interior) (45%), Central Canada (28%), Great Lakes (19%), Gulf Coast (7%), and Atlantic Coast (<1%).

Continent-wide population increases were fueled initially by the reduction or elimination of some historic pressures (e.g., hunting for millinery trade) but more recently by changes in breeding habitat and prey resources. Occupation of relatively stable artificial habitats (e.g., dredge spoil islands) has greatly concentrated the tern population leaving it more vulnerable to stochastic events, such as disease outbreaks, severe storms, disruption by predators or human disturbance, and oil spills. Caspian tern population increases in the Pacific region from the mid-1980s to 2001, primarily in the Columbia River estuary, may largely reflect the crucial juxtaposition of stable human-created habitats in conjunction with a predictable food supply. Human exploitation of native fish communities leading to dominance of small fish species favored by foraging terns appears to be a significant factor in tern increases in the Great Lakes and central Canada.

Conservation efforts will be most effective if focused on multiple fronts, including monitoring tern populations, resolving management conflicts with other species by addressing root causes, reducing risks to the tern population by distributing breeding colonies among a greater number of sites, filling gaps in knowledge of biology and threats on migration and the wintering grounds, and educating the public about the value of colonial waterbirds and possible effects of human actions on Caspian terns.

12.2 Life History & Habitat Requirements

12.2.1 Life History

12.2.1.1 Diet

Caspian terns are piscivorous in nature (Harrison 1984), requiring about 0.4 lbs (165 grams, 1/3 of their body weight) of fish per day during the nesting season. Diet analyses in 1997 showed that juvenile salmonids constituted 75% of the food consumed by the Rice Island colony (Roby *et al.* 1998). During the peak of the smolt migration, which coincides with the peak of nesting activity in May, the diet of Caspian terns on Rice Island was 98% salmonid smolts. Roby *et al.* (1998) estimated that the Caspian tern colony nesting on Rice Island consumed 6.6 to 24.7 million salmonid smolts in the estuary. Salmonid consumption rates are unknown for Threemile Canyon and Crescent Island, but they may be similar to rates found at Rice Island.

Roby *et al.* (1998) estimated that avian predators consumed 10-30% of the total estuarine salmonid smolt population in 1997; this means that between 100,000 and 600,000 listed smolts are being consumed. The large majority of salmonids being consumed by Caspian terns are hatchery fish (Independent Multidisciplinary Science Team 1998); many are from hatcheries constructed to mitigate the impacts of dam construction.

Breeding Caspian terns eat almost exclusively fish and rarely take crayfish, insects, and earthworms (Parkin 1998, Cuthbert and Wires 1999, P. Spiering pers. obs.). Globally, Caspian terns catch a variety of fish species with shallow plunge dives (Cuthbert and Wires 1999). The sizes of fish caught and diet composition are largely determined by geography and annual and seasonal prey availability, but most fish are between 2-10 in (5-25 cm) (Cuthbert and Wires 1999, Thompson *et al.* 2002, Roby *et al.* 2002).

In Oregon, concern over salmon conservation has motivated an intensive study of Caspian tern diets in the region (USACE 2001; Collis *et al.* 2001a, 2002; Roby *et al.* 2002). During 1999 and 2000, the diet of terns nesting on Rice Island in the Columbia River estuary was 77-90% juvenile salmonids, including coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), and steelhead (O. *mykiss*) (Roby *et al.* 2002). From 1999-2001, diet on East Sand Island, closer to the mouth of the Columbia River than Rice Island, was primarily non-salmonids, including anchovy (*Engraulis mordax*), herring (*Clupea pallasii*), shiner perch (*Cymatogaster aggregata*), sand lance (*Ammodytes hexapterus*), sculpins (*Cottidae*), smelt (*Osmeridae*), and flatfish; the yearly proportion of salmonids in the diet ranged from 33-47% (Roby *et al.* 2002). In 2000, diet on Threemile Canyon Island in the mid-Columbia River was 81% salmonids, with the remainder bass (*Micropterus spp*.), yellow perch (*Perca flavesceens*), and suckers (*Catostomus spp*.) (Collis *et al.* 2002). While salmonids comprised 65% of the diet of terns nesting on an experimental barge in Commencement Bay in May 2001 (Collis *et al.* in press), on the other hand, salmon were very uncommon diet items farther west on the outer coast in Grays Harbor, Washington (Smith and Mudd 1978, Penland 1981).

12.2.1.2 Reproduction

Most individuals do not breed until at least 3 years old, and usually wait until 4-5 years old. Pacific coast birds averaged 8.6 years. The average number of Caspian tern eggs per clutch is 2-3. The number of clutches per year is one or less. Caspian terns are seasonally monogamous. Caspian terns nest on bare open ground, on islands, on flat sand, or gravel or shell beaches.

12.2.1.3 Nesting

The terns arrive in April and nesting starts at the end of the month (Roby *et al.* 1998). Caspian terns form nesting colonies of a few hundred to thousands of pairs. To avoid predators, terns construct their nests on islands (Harrison 1984), and prefer barren sand. Clutch size is usually two eggs (Harrison 1984). First-time breeders often (58%) breed away from the natal colony. Caspian terns fledge at 30-35 days, but are partially dependent on the parents for 5-8 months.

Caspian terns forage 6.2-7.5 miles (10-12 km) from the colony and may forage up to 30 km from the colony. They defend a small territory around the nest site, about 1.6-4.9 ft (0.5-1.5m) in diameter. Caspian terns have high site fidelity to their summer range (IBIS 2003).

12.2.1.4 Nests & Nest Spacing

Caspian terns nest either in single-species colonies or in multi-species assemblages with other ground nesting waterbirds (gulls, skimmers, other terns, cormorants, and pelicans) (Cuthbert and Wires 1999). Colony sizes, varying widely among locations and years, typically range from tens to hundreds of pairs. Terns rarely breed as single pairs or small groups (2-3 pairs) or in colonies >1,000 pairs (Cuthbert and Wires 1999, Wires and Cuthbert 2000). Nests typically are densely packed at distances of 0.4-1.5 m as determined by territorial defense of a breeding pair (Cuthbert and Wires 1999). At large colonies in the Columbia River estuary, nesting density has varied from 0.25- 0.78 nest/m^2 depending on local habitat availability (Roby *et al.* 2002).

Nest sites often are on the highest point of low-lying islands, presumably for unobstructed views and to avoid flooding. Proximity to other terns, though, may override elevation in the selection process (Cuthbert and Wires 1999), and tern nests often extend to near the water's edge in single-species colonies or often cluster on the edge of colonies of gulls or pelicans that initiated nesting prior to the terns (D. Shuford pers. obs.).

Nest substrates vary from sand, sand-gravel, spongy marshy soil, or dead or decaying vegetation to hard soil, shell banks, limestone, or bedrock. Of experimental nest substrates in Ontario, terns preferred sand over pea-gravel and crushed stone and all of these over pre-existing hard packed ground (Quinn and Sirdevan 1998). Nests range from simple depressions or hollows in a bare substrate to nests lined (or built up elaborately) with debris, such as shells, crayfish chelipeds, dried grasses and weed stems, wood, chips of salt crust, or pebbles (Bent 1921, Cuthbert and Wires 1999). Adult terns may raise rim heights of nests by >1 in (3 cm) in areas subject to immediate flooding and may move small chicks >100 m to alternate scrapes if the original nest is disturbed (Cuthbert and Wires 1999).

12.2.1.5 Migration

Spring migrants first arrive at breeding sites between mid-March to mid-May depending on latitude, elevation, and coastal or interior location (Cuthbert and Wires 1999). Migratory terns regularly move along major water features, such as the Columbia River (Cuthbert and Wires 1999). On the coast, Caspian terns first appear in March with a peak in April, later inland.

The timing of southward migration varies with region (Cuthbert and Wires 1999), but fall movement has been noted as early as late June along the Pacific Coast (Gilligan *et al.* 1994). More typically, the peak of fall migration occurs between mid-July and mid-September (Cuthbert and Wires 1999) with stragglers leaving by the end of November (Gilligan *et al.* 1994, Peterjohn 2001). Oregon breeders depart colonies in late June and July.

Most Caspian terns congregate for migration at traditional foraging locations along marine coasts and major rivers or freshwater lakes about a month after young have fledged (Cuthbert and Wires 1999). Terns migrate singly or in groups that range from only a parent and young to rare flocks of thousands (Gilligan *et al.* 1994, Stevenson and Anderson 1994).

Caspian terns winter in southern California, Gulf Coast and southeastern US coast, Mexico, and the West Indies. Washington birds migrate 1,584 miles (2,550 km) to Mexico.

12.2.1.6 Mortality

Caspian terns in the West Coast population are reported to live up to 27 years, over half of the fledglings reach their fourth year, and individual birds have a breeding life expectancy of nearly 9 years (Gills and Mewaldt 1983). Maximum life span is greater than 20 years. The oldest known wild bird is 29 years and 6 months. The greatest mortality occurs during the first 6 months of life. Once a bird reached maturity, it will likely survive a long time.

12.2.2 Habitat Requirements

12.2.2.1 Breeding

Caspian terns typically locate their colonies close to a source of abundant fish in relatively shallow estuarine or inshore marine habitats or in inland freshwater lakes, rivers, marshes, sloughs, reservoirs, irrigation canals, and (low-salinity) saline lakes (Cuthbert and Wires 1999).

Aerial surveys of terns breeding on Rice Island in 1998 determined that 50% of all terns seen off the colony were within 5 miles (8 km) of the island, 75% within 9.3 miles (15 km), and 90% within 13 miles (21 km) (Collis *et al.* 1999). Monitoring the movements of Caspian terns breeding at East Sand Island in 2001 found 76% of all off-colony detections were within the estuary; the remainder were in the vicinity of the nearshore Oregon coast (6%), Willapa Bay (16%), or Grays Harbor (2%, Collis *et al.* 2001b).

12.2.2.2 Nesting

Caspian tern colonies typically form at sites isolated from ground predators and human disturbance and within reach of abundant prey resources. Nesting sites typically are on sandy, earthen, or rocky islands or reefs, sandy beaches, and inland on floating tule-mat islands (formerly in Klamath Basin) or, rarely, peninsulas in lakes (Bent 1921, Cuthbert and Wires 1999). Although coastal birds may breed on natural estuarine, salt marsh, or barrier islands, they increasingly nest on human-created habitats, such as dredge spoil islands, salt pond levees, islands created for salt marsh restoration, or islands created to enhance nesting sites for endangered species such as the California Least tern (*Sterna antillarum browni*). In South San Francisco Bay, Caspian terns prefer to nest on long continuous or interrupted levees or long islands free of vegetation, large rubble, or debris (Rigney and Rigney 1981). Caspian terns have also been attracted to nest on experimental sand-covered barges in Commencement Bay, Washington (Collis *et al.* in press) and on rafts in the Great Lakes (Lampman *et al.* 1996); the latter were used as transitional nesting sites before attracting the terns to artificial islands designed for use by multiple species of colonial nesters (Quinn *et al.* 1996, Pekarik *et al.* 1997). Terns in Puget Sound have also nested on the roof of a flat-topped building, among the metallic rust debris of a floating barge, and on broken sand bags securing black plastic covering contaminated soil in the Commencement Bay area (Collis *et al.* in press, Thompson *et al.* 2002). In 2002, a new colony formed in San Francisco Bay on an insular portion of a dilapidated pier along the waterfront of the city of San Francisco (D. Singer, J. Yakich in lit.). Nesting islands in interior wetlands are usually in large freshwater or saline lakes, reservoirs, or rivers, and sometimes on islands created for nesting waterfowl or colonial waterbirds at refuge impoundments. In California, Caspian tern colonies have formed on intact or broken levees of agricultural evaporation ponds, sewage ponds, floodwater storage basins, and flooded agricultural fields.

12.2.2.3 Foraging

Where they co-occurred in a California estuary, Caspian terns fed mostly over main channels and the Forster's tern in shallow water covering mudflats (Baltz *et al.* 1979). Although prey resources typically are close at hand, some terns at a San Francisco Bay colony regularly flew 18 miles (29 km), and occasionally up to 38 miles (62 km), to forage at freshwater reservoirs (Gill 1976); birds at the small colony at hypersaline Mono Lake (devoid of fish) likewise must fly at least 9.3-12.4 miles (15-20 km) to forage at freshwater reservoirs (D. Shuford pers. obs.). In central Washington, Caspian terns may fly 28-37 miles (45-60 km) from the nesting colony to forage in the Columbia River, as evidenced by the recovery at the Potholes colony of passive integrated transponder tags from salmonids released or reared in that river (Ryan *et al.* 2001, 2002). Caspian terns breeding in the Columbia River estuary appear to feed primarily in the estuary (Collis *et al.* 1999, Collis *et al.* 2001b).

12.3 Population & Distribution

12.3.1 Population

Estimates of the size of the breeding population of the Caspian tern in the United States were roughly 9,454 pairs (18,908 adults) in the mid-1970s to early 1980s and 20,948 pairs in the late1980s to late 1990s (Spendelow and Patton 1988, Wires and Cuthbert 2000) (Table 12-1). During both periods, numbers of breeding Caspian terns were highest in the Pacific states and substantially smaller in the Great Lakes and Gulf Coast; numbers on the Atlantic Coast have always been very small (Table 12-1). Wires and Cuthbert (2000) also estimated during the latter period there were 32,000 to 34,000 breeding pairs in North America split among five more-or-less disjunct regions: Pacific Coast/Western (interior) (45%), Central Canada (28%), Great Lakes (19%), Gulf Coast (7%), and Atlantic Coast (<1%). The proportion of the continental population in various regions should be interpreted cautiously given that (1) totals are summed from surveys taken in multiple years and with varying methods and (2) regional and local populations can change greatly over short time periods, as described below. Kushlan *et al.* (2002) estimated the North America breeding population to be about 66,000 to 70,000 adults (not pairs) but did not document the source of this estimate or the reason for the difference between their estimate and that of Wires and Cuthbert (2000). Both of these are likely minimum estimates given the great uncertainty in the size of the large nesting population in Manitoba and hence Central Canada.

Table 12-1. Estimates of the Caspian Tern breeding population in the United States, by region, from 1976-1982 and 1996-1998.

	1976–82 [a]		1996–98[b]	
	Estimated Pairs	**% Population**	**Estimated Pairs**	**% Population**
Pacific Coast	6,218	65.8	14,534	6.4
Great Lakes	1,682	17.8	3,979	19.0
Gulf Coast	1,513	16.0	2,303	11.0
Atlantic Coast	41	0.4	122	0.6
Total	*9,454*		*2,038*	

[a] Data from Spendelow and Patton (1988) with numbers of adults divided by two to roughly estimate 2038 pairs. As some of the original data were raw counts of adults, these likely underestimated numbers of pairs given some adults usually are away from the colony at any given time.
[b] Data from Wires and Cuthbert (2000) with slight modifications. Numbers of pairs for each region were derived by separately adding the low and high estimates for each state to obtain range for the region then taking the mid-point of the range as the best estimate.

By comparison to other North American terns, the size of the Caspian tern population is not especially large. Of nine other temperate or arctic species of Sterna tern breeding in North America (exclusive of Hawaii) for which continental population estimates are available (none available for Arctic tern [*S. paradisaea*]), five have smaller and four have larger populations than the Caspian tern (Kushlan *et al.* 2002) (Table 12-2). Of those species with a relatively widespread coastal and interior breeding distribution in North America, only the Forster's tern (*S. forsteri*) has a smaller population than the Caspian tern.

Table 12-2. Population size and conservation status categories, from the *North American Waterbird Conservation Plan* (Kushlan *et al.* 2002), of 11 species of terns of the genus *Stern*a breeding in temperate and arctic regions of North America (exclusive of Hawaii).

Common Name	Scientific Name	Population Size (adult breeders *not* pairs)	Conservation Status Category
Gull-billed tern	*S. nilotia*	6,000 -8,000	High
Caspian tern	*S. aspia*	66,000 -70,000	Low
Royal tern	*S. maxima*	100,000 -150,000	Moderate
Elegant tern	*S. elegans*	34,000 -60,000	Moderate
Sandwich tern	*S. sandvicensis*	75,000-100,000	Not currently at risk
Roseae tern	*S. dougalli*	16,000	High
Common tern	*S. hirundo*	30,000	Low
Arctic tern	*S. paradisaea*	Insufficient information	High
Forster's tern	*S. forsteri*	47,000 -51,500	Moderate
Least tern	*S. antillarum*	60,000 -10,000	High
Aleutian tern	*S. aleutia*	14,594	High

12.3.2 Distribution

Caspian terns are highly migratory and exhibit cosmopolitan distribution (Harrison 1983; Harrison 1984). Caspian terns world-wide are expanding in range and numbers. Nesting has been reported from Baja California to the Bering Sea, from the Gulf Coast of Texas to Lake Athabaska and from the Florida panhandle to Labrador as well as in Australia, New Zealand, South Africa, Asia and Europe. The West Coast population winters in Southern California and Baja California and returns north to nest (Harrison 1983; Harrison 1984).

Dredging the navigational channel created several estuary islands on which piscivorous birds are now nesting. There were no terns in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds moved to Rice Island in 1987. The combined total of the reestablished East Sand Island colony and the Rice Island colony has since expanded to approximately 10,000 pairs (the largest colony in North America) (Caspian Tern Working Group 1999).

Roby *et al.* (1998) report that two colonies have become established in the Columbia River above Bonneville Dam at ThreeMile Canyon and Crescent Island. Impounding the Columbia River behind John Day and McNary Dams created these islands. Populations have fluctuated in the past at these two sites with up to 1,000 pairs in residence at each. Populations estimated from aerial photographs in 1997 were 571 at ThreeMile Canyon and 990 pairs at Crescent Island (Roby *et al.* 1998).

12.3.3 Breeding

In North America, the Caspian tern breeds at widely scattered sites across the continent (Figure 12-1). In outlining patterns of regional distribution, this report follows Wires and Cuthbert's (2000) descriptions of five more-or-less disjunct breeding regions (see Figure 12-2), recognizing that future advances in knowledge may warrant adjustment of regional boundaries, as greater clarity is needed. For additional details see Cuthbert and Wires (1999), Wires and Cuthbert (2000), and pertinent sections of this report, on which the following summaries are based:

- Pacific Coast/Western (interior) Region—a very rare and recent breeder in coastal Alaska and southwestern British Columbia; a locally uncommon to abundant breeder along the coast of Washington, Oregon, and California; a locally uncommon to common breeder on the west coast of Baja California, Sinaloa, Mexico, and in the interior of Washington, Oregon, California, southern Idaho, Montana, Wyoming, western Nevada, and northern Utah.
- Central Canada—a locally rare to uncommon breeder in the Northwest Territories, Alberta, central Saskatchewan, and a locally uncommon to abundant breeder in south-central Manitoba.
- Great Lakes—an uncommon to abundant breeder on Lake Michigan, Lake Ontario, and Lake Huron.
- Atlantic Coast—a locally rare to uncommon breeder in Labrador, Newfoundland, southeastern Québec, Virginia, North Carolina and formerly, New Jersey, South Carolina, and Florida.
- Gulf Coast—a locally fairly common breeder at scattered sites from coastal Texas to Tampa Bay.

Figure 12-1. Seasonal distribution of the Caspian tern in North, Central, and South America. The species winters locally within the dashed line. Adapted with permission from Figure 1 in Cuthbert and Wires (1999).

Figure 12-2. Outlines of five more-or-less distinct breeding regions of the Caspian tern in North America, after Wires and Cuthbert (2000). Regional boundaries may need refinement after further study.

Although recorded year-round in breeding areas on the southern Pacific Coast, Gulf Coast, and southern Atlantic Coast, it is unclear if individuals remain in these areas all year or if there is replacement by, or mixing with, birds from other breeding populations. Still, most Caspian terns in North America are highly migratory. Juveniles in fall migrate to wintering areas where they remain through their first full year; subadult (second year) birds may remain to summer on the winter grounds or return to breeding areas, whereas almost all third year and older birds migrate to and from breeding and wintering areas seasonally (Ludwig 1965, Gill and Mewaldt 1983, L'Arrivée and Blokpoel 1988). Migration generally occurs from August through October in fall and in April and May in spring. Despite the protracted period of migration in fall, individual birds may migrate fairly rapidly (L'Arrivée and Blokpoel 1988).

Caspian terns breeding on the Pacific Coast of Washington and California appear to migrate along the coast to reach wintering areas on the west coast of Mexico and Guatemala (Gill and Mewaldt 1983). Average distances traveled to the wintering grounds from major colonies at Grays Harbor, Washington, were 1,585 miles (2,550 km). On average, terns from Grays Harbor wintered farthest north and those from San Diego farthest south, suggesting there may be some segregation on the wintering grounds dependent on natal origin. Gill and Mewaldt (1983) reported that some newly fledged birds disperse north in late summer before migrating south; in two cases, hatching year birds were recovered 497 and 932 miles (800 and 1,500 km) north of their natal colonies two months following banding (Gill and Mewaldt 1979). Most resightings during the post-breeding period of Caspian terns banded at colonies in the Columbia River estuary are from the coasts of Oregon, Washington, and British Columbia and east to up-river tern colonies in the mid-Columbia River (Collis *et al.* 2000, 2001b). Later resightings have been from along the Pacific Coast south to Manzanillo, Mexico. Collectively, these data suggest that terns may disperse northward along the coast before heading south to overwinter.

Although migrants from some colonies in the interior of Oregon apparently follow the Columbia River to the Pacific (Gilligan *et al.* 1994), it is unclear if all or even most birds in the western interior pursue such a trajectory. Of four recoveries on the wintering grounds from birds banded in the interior of California, Idaho, and Nevada, two were from the west coast of Mexico along the Gulf of California and two from the central interior of Mexico (Gill and Mewaldt 1983), suggesting that terns from the interior of the western United States may take a direct overland route to reach wintering areas rather than moving diagonally to the Pacific Coast of the United States before continuing south.

12.3.4 Winter

In the Americas, the Caspian tern winters primarily on the Pacific Coast from southern California south through west Mexico and (locally) Central America; inland in the Central Volcanic Belt and Atlantic (Gulf) Slope of Mexico; along the southern Atlantic Coast of the United States, the Gulf Coast of the United States and Mexico, (locally) along the Caribbean/Atlantic coast of Central America and northern South America; and locally in the West Indies (Figure 12-1). Details of regional distribution are provided below.

12.3.4.1 Pacific Coast

Along and near the Pacific Coast, the Caspian tern winters mainly from southern California south through Baja California, the Gulf of California, and west Mexico to Guatemala (Howell and Webb 1995, BirdSource 2001). Data for Pacific Coast terns suggests there is some segregation on the wintering grounds dependent on natal origin, but sample sizes are too small to quantify how much mixing occurs (Gill and Mewaldt 1983).

Recent Christmas Bird Count (CBC) data (1991-2000) (BirdSource 2001) show the northern limit of the regular winter range in California to be at Morro Bay, San Luis Obispo County, on the southern coast (range = 3-23 birds/year, median = 9), though a few individuals now winter disjunctly on the northern coast at Humboldt Bay (range = 1-8, median = 3.5; combined data for two CBCs). The Caspian tern formerly wintered regularly on the California coast only as far north as Pt. Migu, Ventura County (Garrett and Dunn 1981). In winter, the species is casual inland in central and southern California away from the immediate coast (e.g., San Joaquin Valley) except at the Salton Sea, where numbers of wintering birds (range = 18-413, median = 27; combined data for two CBCs) may in some years rival or exceed those at sites on the southern California coast (range = 55-221, median = 139; combined data for various CBCs). Highest winter numbers at the Salton Sea from 1995-1997 (413, 197, 109) preceded peak breeding numbers there in 1996-1998 (Molina 2001).

12.3.5 Summer (Nonbreeding)

Small numbers of Caspian terns oversummer throughout most of the wintering range (Ludwig 1965, Gill and Mewaldt 1983, Hilty and Brown 1986, L'Arrivée and Blokpoel 1988, Stiles and Skutch 1989, Howell and Webb 1995, Raffaele *et al.* 1998). Others may occur in mid-summer within the general breeding range, but away from known colonies (Gill and Mewaldt 1983, Bayer 1984), or at areas along migratory pathways outside the breeding range (Zeranski and Baptist 1990, Sibley 1993). Although some birds at known migrant areas in summer may be failed adult breeders or wandering subadults, most birds on the wintering grounds at that season are young birds. Immature Caspian terns (age 6-18 months) apparently spend all four seasons in the adult wintering range, as do some sub-adults (age 18-30 months) (Gill and Mewaldt 1983, L'Arrivée and Blokpoel 1988).

Table 12-3. Counts of Caspian terns on Christmas Bird Counts in Canada and the continental United States, 1991-2000.[a]

State	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ontario	1	1	0	0	0	0	0	0	0	0
Washington	0	0	1	0	0	0	1	0	0	0
California	161	154	83	108	508	297	265	265	245	184
Arizona	37	26	3	41	22	4	9	0	2	2
Indiana	0	0	0	0	0	0	0	1	0	0
Ohio	0	0	1	0	0	0	0	0	0	0
Texas	926	913	1,013	1,096	834	925	1,411	1,685	1,647	686
Louisiana	638	422	523	319	201	364	577	408	313	257
Mississippi	128	59	83	100	88	106	147	94	86	75
Alabama	83	38	98	19	112	20	70	89	48	73
Florida	585	590	645	532	543	629	635	906	1135	715
North Carolina	14	15	17	11	3	2	4	1	1	0
South Carolina	119	47	63	106	109	16	120	16	27	2
Georgia	27	40	29	16	14	4	35	8	13	6
Total	*2,719*	*2,305*	*2,676*	*2,348*	*2,434*	*2,367*	*3,274*	*3,473*	*3,517*	*2,018*[b]

[a] Numbers are raw counts summed over all CBCs on which the species was recorded in a particular state in a given year. Numbers are not adjusted to account for the number of count s conducted or for party hours or party miles. Data from BirdSource (2001).
[b] One Caspian Tern was also recorded on a CBC in Hawaii in 2000.

12.4 Status & Abundance Trends

12.4.1 Status

Caspian terns are currently protected throughout their breeding range by the Migratory Bird Treaty Act (1918) in the United States, the Migratory Bird Convention Act (1916) in Canada, and the Convention for the Protection of Migratory Birds and Game Mammals (1936) in Mexico.

Some wetland breeding habitat used by Caspian terns in the United States is provided limited protection by the Clean Water Act (Section 404) and the Food Security Act (Swampbuster Provision, 1985). These measures as historically enforced are insufficient to prevent net losses of wetland habitat. Despite permit requirements, a review of wetlands lost to dredge and fill materials found almost 500,000 hectares lost in the conterminous United States between 1985–95 (Dahl *et al.* 1997). Although many Caspian tern colonies are located on public lands, future ownership and management of the largest breeding concentration in the Columbia River (East Sand Island) is uncertain. Most countries in the wintering range have no legal mechanism to protect Caspian terns or their habitats, and enforcement and effectiveness of existing regulations are variable.

Early colony size estimates in the Pacific Northwest were of 500 pairs mixed with gulls and cormorants as far north as Klamath Lakes in Oregon (Harrison 1984). Since the early 1900s, the population has shifted from small colonies nesting in interior California and Southern Oregon to large colonies nesting on human-created habitats along the coast (Gill and Mewaldt 1983). The current population in the Columbia River Basin is part of a dramatic northward and coast-wide expansion in the range and overall increase in the numbers of terns in western North America. Table 12-4 lists current known nesting sites.

Table 12-4. A summary of available data on Caspian Tern numbers at breeding colonies in Washington, 1997-1999 (from Caspian Tern Working Group 1999).

Location	1997	1998	1999	Supplemental Information	Source
Commencement Bay	~100	—	80-100	1995—“hundreds”	Pers. Comm. M. Tirhi
Banks Lake	—	—	—	~15/year, limited habitat	Pers. Comm. R. Friesz
Sprague Lake	—	—	—	~20/year, limited habitat	Pers. Comm. R. Friesz
Potholes Reservoir	259	—	—	150-270 pairs/year	Pers. Comm. R. Friesz
Crescent Island	990 ad	575 ad	890 ad	—	Pers. Comm. D. Roby

Several estuary islands on which piscivorous birds now nest were created by dredging in the navigational channel. There were no terns nesting in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island. Those birds moved to Rice Island in 1987. The combined total of the re-established East Sand Island colony and the Rice Island colony has since expanded to approximately 10,000 pairs (the largest colony in North America).

Roby *et al.* (1998) report that two colonies have become established in the Columbia River above Bonneville Dam at Threemile Canyon and Crescent Island. These islands were created by impounding the Columbia River behind John Day and McNary Dams. Populations have fluctuated in the past at these two sites with up to 1,000 pairs in residence at each. Populations estimated from aerial photographs in 1997 were 571 at Threemile Canyon and 990 pairs at Crescent Island (Roby *et al.* 1998). These colonies have not been studied as extensively as the colonies in the estuary, but limited food habitats studies and PIT tag collections indicate a diet similar to the diet of the terns in the estuary.

12.4.2 Trends

Data available for assessing population trends of the Caspian tern are from regional surveys and monitoring, Breeding Bird Surveys (BBS), CBCs, and anecdotal accounts. The latter dominated in most regions until the 1960s or later, after which broad-scale, quantitative surveys became more prevalent.

12.4.2.1 Trends from Regional Surveys

Although efforts to monitor and protect waterbirds at the regional level began in the early 1900s, national multi-species surveys of colonial nesting waterbirds were not conducted until 1976-1982 in response to concerns over coastal habitat modification and offshore oil development (Spendelow and Patton 1988). These surveys provide the first reliable estimates of the size and distribution of the Caspian tern's breeding population in the United States and thus form the baseline for assessing trends in ensuing decades.

Wires and Cuthbert (2000) reviewed trends in numbers and distribution of the Caspian tern in North America based mainly on a combination of anecdotal information and regional survey data. Their analysis provides the primary basis for the discussion below of population trends within the five more-or-less disjunct regions in which the species breeds in North America. This account will concentrate on the Pacific Coast/Western Region only.

12.4.2.2 Pacific Coast/Western (Interior) Region

The current regional population of about 13,000 pairs of breeding terns is the largest in North America, having more than doubled since 1980 (Wires and Cuthbert 2000). From 1992-2001, Caspian terns bred at a minimum of 44 sites in the region (Figure 12-3). In 2001, 84% of the regional population was on the coast and 16% in the interior (Table 12-5), nearly identical proportions to those in the late 1970s to early 1980s (Gill and Mewaldt 1983). The dynamic nature of this population is evidenced by dramatic shifts in its distribution and abundance over short periods of time (Gill and Mewaldt 1983, Wires and Cuthbert 2000). Since at least the late 1970s, about 99% of the regional population has been in Washington, Oregon, and California (Table 12-5), but the proportions in those respective states shifted from 50%, 4%, and 45% in 1979-1981 to 11%, 70%, and 18% in 2001.

Gill and Mewaldt (1983) reviewed trends in the Caspian tern population of the Pacific states through about 1981. The species was first documented breeding in the region at Lower Klamath Lake, Oregon, in the early 1900s (Finley 1907, Chapman 1908). The subsequent period of limited ornithological exploration coincided with great wetland loss, making it very difficult to establish a baseline on the terns' population size and distribution, let alone track population trends. Although Gill and Mewaldt (1983) reported that by 1930 no large colonies existed away from the Pacific Coast, historical data are so sparse it is unclear if interior colonies were few or many, small or large. For example, prior to 1945 only six breeding sites were known for California (five interior and San Francisco Bay), and data on population size of reported colonies was either limited or non-existent. It is clear, though, that with wetland loss and human habitat modification the Caspian tern increasingly concentrated on artificial habitats (e.g., salt ponds) on the coast and (secondarily) at reservoirs in the interior. By the 1950s, the species had expanded northward along the coast to Washington, and since the 1970s, small numbers have continued to expand north to Alaska and south to Baja California and Sinaloa in west Mexico.

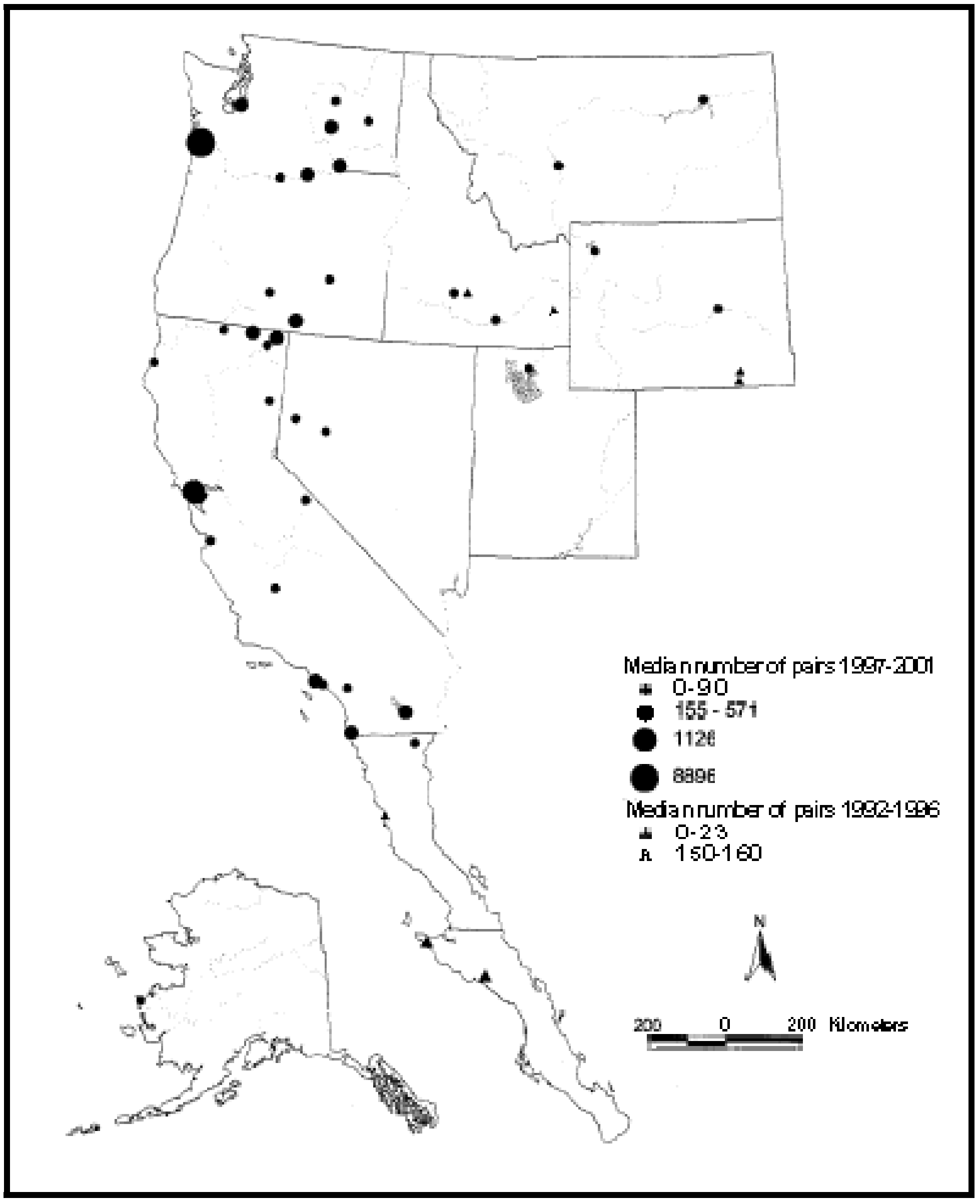

Figure 12-3. Distribution and relative size of Caspian tern colonies in the Pacific Region of western North America. Sites were mapped for 1992-1996 only if data were lacking for 1997-2001. The species has also bred at a number of other sites prior to 1992 and at some new sites in 2002.

The population of the Caspian terns in the Pacific states in the late 1970s to early 1980s was estimated to be about 5,780 pairs (84% coastal, 16% inland) (Table 12-5). Gill and Mewaldt (1983) indicated this represented an almost 74% increase since the early 1960s, but they did not report colony data or totals for the 1960s to compare to subsequent data or substantiate whether coverage was equal in both periods. Even if the size of this purported increase is valid, it might represent a rebound to, or below, the levels before the great loss of wetland habitat in the interior. Additional estimates for the Pacific region were about 14,900 pairs in the late 1990s (Wires and Cuthbert 2000) and 12,800-13,700 pairs in 2000–01 (see Table 12-5 for breeding pair estimates for individual colonies). Overall increases in the Pacific population since the 1960s appear to be in response to the terns' colonization of human-created nesting sites on the coast in close proximity to abundant fish resources (Gill and Mewaldt 1983, Wires and Cuthbert 2000), perhaps initially catalyzed by birds shifting coastward, as habitat was lost in the interior.

The regional increase since the early 1980s largely represents the great increase of the colony at the Columbia River estuary from 1984 to 2001 (Wires and Cuthbert 2000, Roby *et al.* 2002). Numerous anthropogenic and natural factors are thought to have contributed to this increase in tern numbers but the interactions among them are not well understood. Wires and Cuthbert (2000) conjectured that the increase might have been aided by the terns' exploitation of abundant and vulnerable hatchery-reared salmon. Collis *et al.* (2001a) speculated that the tern increase in the estuary was caused by the availability of hatchery-raised salmonids in combination with creation of dredge spoil islands, loss of breeding habitat elsewhere, and a build up of predators at former colonies outside the estuary. Clearly, the creation of Rice Island in 1963 substantially changed the characteristics and suitability of tern habitat in the upper estuary. Rice Island provided long-term stable nesting habitat, whereas historic habitat was ephemeral as spring river flows and tidal action created and eroded sand and gravel bars.

The magnitude and characteristics of Columbia River salmon outmigrations have also changed significantly from historic times, largely from over-harvest, hydroelectric development, mitigation measures to offset salmonid losses to dams, and various other factors. Taking into account the magnitude of current hatchery propagation and the transport of smolts (by barge or truck) to the lower river, the number of smolts in the estuary today is but a fraction of the number that occurred in the first half of this century (NMFS 2000, NWPPCC 2000). Since about the mid-1970s, the out-migration has predominately comprised hatchery-reared rather than wild smolts. Hatchery-reared yearling chinook salmon and steelhead, in some years, are more vulnerable to tern predation than their wild counterparts (Collis 2000a).

Table 12-5. Numbers of breeding pairs of Caspian terns at colonies in the Pacific Region (Washington, Oregon, California, Mexico, Idaho, Nevada, Montana, Wyoming), 1997 to 2001 and circa 1979-1981.[a]

	~1979[b]	1997	1998	1999	2000	2001
Washington						
Coastal Bays						
Commencement Bay, Pierce Co.	0	—	—	423	620[c]	388
Grays Harbor, Grays Harbor Co.	2,157	0	0	0	0	0
Willapa Bay, Pacific Co.	650	0	0	0	0	0
Mid-Columbia River						
Miller Rocks, Klickitat Co.	0	—	—	—	—	15
Crescent Island, Walla Walla Co.	0	614[c]	357[c]	552[c]	571	720
Columbia Basin Plateau						
Banks Lake, Grant Co.	—	—	—	—	10	23
Potholes Reservoir, Grant Co.	100	259	—	—	150	~250
Sprague Lake, Adams Co.	—0	—	—	~50	20	20
Oregon						
Columbia River Estuary						
East Sand Island, Clatsop Co.	0	0	0	1,400	8,513	8,896
Rice Island, Clatsop Co.	0	7,151	8,691	8,328	588	0
Miller Sands Spit, Clatsop Co.	0	0	17	0	0	0
Mid-Columbia River						
Threemile Canyon Island, Morrow Co.	210	354[c]	210[c]	238[c]	260	2

	~1979[b]	1997	1998	1999	2000	2001
Great Basin						
Malheur Lake, Harney Co.	—	65	25	30	192[c]	51[c]
Crump Lake, Warner Valley, Lake Co.	—	—	—	—	155[c]	—
Summer Lake, Lake Co.	—	—	—	38	16	0
California (Coast)						
Humboldt Bay	20[b]	—	—	—	—	~17[c]
San Francisco Bay	(1,500)[d]					
Little Island, Napa Co.	300	—	—	—	—	—
Knights Island, Solano Co.	0	400	~200	—	121[c]	43[c]
Brooks Island, Contra Costa Co.	0	~500	582	active	806[c]	512[c]
Hayward Regional Shoreline, Alameda Co.	0	1	1	1	1	1
Bair Island, San Mateo Co.	825	0	0	0	0	0
Ravenswood (Pond Rl), San Mateo Co.	0	0	(4 ad.)	0	1	1
Alameda NAS, Alameda Co.	0	285	267	1	0	0
Coyote Hills, Alameda Co.	0	30	22	0	0	—
Baumberg Tract, Alameda Co.	75	0	33	26	79	116
Turk Island, Alameda Co.	150	0	0	0	0	0
Drawbridge, Alameda Co.	150	0	0	0	0	0
Alviso (Pond A7), Santa Clara Co.	0	104	30	122	118	155
Central & Southern Coast						
Moss Landing salt ponds	105[c]	0	0	0	0	0
Elkhorn Slough, Monterey Co.	0	0	0	~30	~80	~65
Bolsa Chica, Orange Co.[e]	0	175	40	58	51	92
Los Angeles Harbor, Los Angeles Co.	0	25	146	250	336	160
South San Diego Bay NWR, San Diego Co.	409	320	198	261	380	350
California (Interior)						
Modoc Plateau/Great Basin						
Meiss Lake, Butte Valley WA, Siskiyou Co.	50	25[c]	16	27	19	0
Lower Klamath NWR	20	0	0	0	0	0
Clear Lake NWR, Modoc Co.	200	180[c]	68[c]	118	242c	201
Goose Lake, Modoc Co.	200	143[c]	—	310c	4	~240
Big Sage Reservoir, Modoc Co.	75	62[c]	—	0	48	0
Honey Lake WA, Lassen Co.	15	152	—	87	82	92
Mono Lake, Mono Co.	12	0	0	0	8	6
San Joaquin Valley, Tulare Basin, (All Kings Co.)						
Lemoore NAS sewer ponds	—	—	20[c]	0	—	—
Westlake Farms South Evaporation Basin, Kings Co.	—	0	3	0	0	0
Tulare Lakebed	—	0	20[c]	0	0	0
South Wilbur Flood Area		0	70	27	0	0
Tulare Lake Drainage District, North Evaporation Basin	—	0	0	0	0	1
Tulare Lake Drainage District, South Evaporation Basin	—	0	40	0	0	0
Coastal Slope, Southern California						
Lake Elsinore, Riverside Co.	—	—	—	14	—	—
Colorado Desert						

	~1979[b]	1997	1998	1999	2000	2001
Salton Sea, Imperial Co.	0	1,200	800	211	207	327
Mexico						
Baja California						
Cerro Prieto geothermal ponds, Mexicali Vy.	—	30	34	—	0	0
Idaho						
Snake River Plateau						
Morman Reservoir, Camas Co.	—	—	—	—	—	~2
Magic Reservoir, Camas and Blane Cos.	20	—	—	—	—	0
Blackfoot Reservoir, Caribou Co.	5	—	—	—	—	0
Minidoka NWR, Cassia Co.	—	—	—	—	1	0
Deer Flat NWR (Snake River Is.),		—	—	—	—	0
Owyhee Co.						
Bear Lake NWR, Bear Lake Co.	—	—	—	—	—	0
Nevada						
Great Basin						
Carson Sink, Churchill Co.	—	0	—	685	0	0
Anaho Island NWR, Pyramid Lake	6	1	5	0	0	0
Stillwater Point Reservoir,	5	0	0	0	0	0
Stillwater NWR						
Montana						
Canyon Lake Ferry Reservoir,	—	5	0	2	7	35
Lewis and Clark Co.						
Fort Peck Reservoir, Charles M.	—	?	?	?	?	~25
Russell NWR, Valley Co.						
Wyoming						
Molly Island, Yellowstone Lake,	21	4	5	4	0	3
Yellowstone National Park						
Soda Lake Islands, Natrona Co.	—	0	0	0	7	12
Pacific Region Totals[f]	*5,780*	*12,085*	*11,900*	*13,293*	*13,693*	*12,821*

[a] To enable estimation of the total numbers of breeding pairs in the entire region, we adjusted some raw counts or estimates. When a range was given for numbers of nests or pairs we report the mid-point (e.g., 800-850 pairs reported as 825 pairs) and for breeding adults we use the mid-point as the basis for estimating numbers of pairs. Counts or estimates of breeding adults were multiplied by 0.62 to approximately estimate numbers of breeding pairs on the basis of the average ratio of nests to adults at sites on the California coast (0.625, Carter et al. 1992, p. 1-45) and the California interior (0.61, D. Shufordun publ. data). Dashes (--) indicate that no survey was conducted or no data were available, zeroes (0) that a survey was conducted but no evidence of nesting was observed, and question marks (?) that nesting was strongly suspected but no solid data were available. All data presented are from published sources, unpublished reports, unpublished data, and personal and written communications as cited in regional accounts.

[b] Data for 1979-1981 from Gill and Mewaldt (1983) with the following modifications: (1) Humboldt Bay - numbers for this site for 1979 included although S. Harris (pers. comm.) knew of no breeding there after 1969, (2) Moss Landing –the report of 160-180 pairs is actually 160-180 breeding adults (Sowls et al. 1980, Harvey 1982), which we adjusted to 105 pairs (see above), (3) Mono Lake -we substituted 12 pairs as the mid-point of 10-15 pairs reported bJdehl(1986), (4) Pyramid Lake -excluded data for 1951-1965 as 6 pairs estimated in 1979 (W. Henry pers, comm.), (5) Columbia River (Threemile Canyon Is.) -instead of 200 pairs we used the 210 in 1978 reported by Thompson and Tabor (1981; also 184 pairs in 1977), (6) Molly Island, Yellowstone Lake - we added 21 pairs for 1979 (A. Cerovski pers. comn.), and (7) for consistency with treatment of recent data, we took the mid-point of the ranges for Hartson Reservoir (Honey Lake, WA) and Willapa Bay (see above).

[c] Counts of adults were converted to an estimate of breeding pairs by multiplying raw adults by the 0.62 described above.

[d] The number 1,500 is a total for San Francisco Bay in 1981 reported by Gill and Mewaldt (1983). A lack of data for all individual colonies required estimation of breeding pairs at Little Island.

[e] All counts from Bolsa Chica are of total nest attempts (on the basis of marked nests), which likely overestimates nesting pairs because of pairs that renest after initial failures.

[f] Totals are likely underestimates because of a lack of surveys at some sites in particular years or during the whole time period (e.g., most sites in Mexico).

In 1986, Caspian terns established the colony on Rice Island, which experienced rapid growth through the 1990s. Its initial growth appears to have been fueled by movement of terns from the large colonies at Grays Harbor and Willapa Bay, Washington. Thereafter, its continued growth and success can be attributed to the stability of the human-created nesting habitat, the reliable food supply of hatchery-reared salmon, the vulnerability of some hatchery smolts to tern predation, and the apparent immigration of terns hazed from other colonies (e.g. Everett Navel Base in 1996). These factors underscore the significance of human alterations of the environment to the growth of the Pacific population, especially in the Columbia River estuary. The success of the terns (e.g., 1.40 young/pair in 2001) following their relocation to East Sand Island, where salmonids represented only 33% of the diet (Roby *et al.* 2002), suggests that, at least in some years, the estuary could support a large and productive tern colony independent of significant alterations of nesting habitat or the attendant prey base.

12.4.2.3 Breeding Bird Survey Trends

Wires and Cuthbert (2000) cited Price *et al.* (1995) for large increases in Caspian tern numbers on BBS routes since the mid-1960s. Up-to-date and revised analyses of BBS data by Sauer *et al.* (2001), though, found a significant positive trend survey-wide only for the period 1966–79 but not for 1980–2000 or 1966–2000.

12.4.2.4 Christmas Bird Count Trends

Although rigorous analyses of CBC data for Caspian terns apparently have not been conducted, there does not appear to have been a unidirectional trend in wintering numbers in the United States over the last decade (Table 12-3). Raw CBC data suggest relatively stable numbers of wintering Caspian terns in the United States from 1991–96, substantially higher numbers from 1997–99, then a decline to the lowest numbers of the decade in 2000.

12.4.3 Productivity

Productivity levels for various North American colonies range from 0.6-1.6 young fledged per nest (Cuthbert and Wires 1999). Productivity of Caspian terns breeding at the large colonies in the Columbia River estuary has been closely monitored from 1997–2001 (Roby *et al.* 2002). Young fledged per nesting pair at Rice Island was 0.06 in 1997, 0.45 in 1998, 0.55 in 1999, and 0.15 in 2000. The proximate cause of most nest failure was predation on eggs or chicks by Glaucous-winged Gulls (*Larus glaucescens*), Western Gulls *(L. occidentalis*), and their hybrids. Disturbance from research activities in 1997 and management actions implemented to relocate the Rice Island tern colony in 1999 and 2000 may have also affected productivity levels at this site. Young fledged per nesting pair at East Sand Island has been consistently higher than at Rice Island: 1.20 in 1999, 0.57 in 2000, and 1.40 in 2001 (Roby *et al.* 2002).

Estimates of productivity at other Caspian tern colonies in the Pacific Coast region are limited. Kirven (1969) calculated an average of 1.1 young fledged per nesting pair at San Diego Bay, California, in 1967. Additional measures of colony breeding success were made in San Francisco by Ohlendorf *et al.* (1985). Two subcolonies ranged from about 0.69-0.82 young per nest and in Puget Sound by Shugart and Tirhi (2001) (0.40 chicks per pair). Anecdotal accounts and personal observations (C. Collins, K. Molina, D. Bell, G. Ivey, D. Shuford, C. Trost, and J. Parkin) suggest that most other colonies in the region in most years have experienced “good” productivity of about one young fledged per breeding pair. There are, however, accounts of colonies suffering total reproductive failure in a given year because of mammalian predators (Tulare, Elkhorn Slough, Threemile Canyon Island) or weather-related phenomena (Malheur, Bolsa Chica); reproductive success has also been greatly reduced by contaminants (Elkhorn Slough).

On the basis of a survivorship analysis of banded terns, Gill and Mewaldt (1983) estimated that the Pacific Coast population of Caspian terns needed to produce at least 0.64 young per pair per year to sustain the annual intrinsic growth rate of 2.7% observed between 1960 and 1980. Their analysis was limited, however, by the model assumption of no immigration or emigration from natal colonies, when in fact 58% of their breeders did not return to their natal colony.

12.5 Environmental Conditions

12.5.1 Habitat Distribution

Caspian terns are highly migratory and exhibit cosmopolitan distribution (Harrison 1983; Harrison 1984). Caspian terns world-wide are expanding in range and numbers. The West Coast population winters in Southern California and Baja California and returns north to nest (Harrison 1983; Harrison 1984).

Breeding populations are adaptable and able to exploit new habitats when bare sand and abundant prey are found in areas of low disturbance. Dredging the navigational channel created several estuary islands on which piscivorous birds are now nesting. There were no terns in the estuary before 1984 when about 1,000 pairs apparently moved from Willapa Bay to nest on East Sand Island and then moved to Rice Island in 1987. The combined total of the reestablished East Sand Island colony and the Rice Island colony has since expanded to approximately 10,000 pairs (the largest colony in North America) (Caspian Tern Working Group 1999) on about 10 acres of sand.

Roby *et al.* (1998) report that two colonies have become established in the Columbia River above Bonneville Dam at Threemile Canyon and Crescent Island. Populations have fluctuated at these two sites with up to 1,000 pairs in residence at each. Populations estimated from aerial photographs in 1997 were 571 at Threemile Canyon and 990 pairs at Crescent Island (Roby *et al.* 1998).

12.5.2 Habitat Status

Through the Interactive Biodiversity Information System (IBIS), the Northwest Habitat Institute (NHI) (2003) identified key habitat types (Table 12-6) and habitat elements (Table 12-7) with which Caspian tern is associated.

The most serious long-term threat to Caspian terns is the loss or deterioration of quality breeding habitat (i.e., insular, sparsely-vegetated islands). Although Cuthbert and Wires (1999) did not cite habitat loss as an important threat to Caspian terns in North America, it is estimated that 54% of wetland habitat has been lost in the conterminous United States (Dahl *et al*. 1997), including specific wetland losses impacting Caspian terns (e.g., Klamath Basin, Oregon-California; Bent 1921). Still, the species’ breeding range and population size have increased in the face of wetland losses.

Although the reasons for population growth are complex and multifaceted, the creation of artificial breeding sites and alteration of fisheries by humans appear to be two important factors influencing the tern’s population growth (Wires and Cuthbert 2000). Caspian terns clearly have the capacity to opportunistically respond to shifts in habitat and prey resources.

Table 12-6. Habitat types with which Caspian tern is associated (NHI 2003).

Habitat type	Association	Activities	Confidence	Comments
Open water (lakes, rivers, & streams)	Closely associated	Feeds & breeds	High	Nests on sandbars and dredge spoil islands within rivers.
Herbaceous wetlands	Closely associated	Feeds	High	None noted
Coastaldunes & beaches	Closely associated	Other (see comments)	High	Roosting/resting.
Coastal headlands & islets	Generally associated	Other (see comments)	High	Roosting/resting.
Bays and estuaries	Closely associated	Feeds	High	None noted
Marine nearshore	Closely associated	Feeds	High	None noted

Table 12-7. Habitat elements with which Caspian tern is associated (NHI 2003).

Habitat Element	Description	Comments
4.3	Ephemeral pools	Feeding.
4.4	Sand bars	Nesting and loafing.
4.5	Gravel bars	Nesting and loafing.
4.8	Islands	Nesting and loafing.
8.28	Hatchery facilities and fish	Good as a food source, but terns may be killed at aquaculture facilities.

Despite the persistence of large colonies for decades on dredge spoil islands, islands created by water impoundments, and salt dikes (McNair 2000, Wires and Cuthbert 2000, Collis *et al.* 2002), vegetation succession has and may continue to render many sites unsuitable for breeding terns.

Caspian terns are less tolerant of vegetation succession than the longer-legged, shorter-winged gulls that frequently share their breeding islands. Encroachment of vegetation and/or displacement by gulls were considered factors contributing to the decline of some large tern colonies, among them Sand Island and East Sand Island (Penland 1981, Neuman and Blokpoel 1997, J. Albertson pers. comm., S. Harris pers. comm.).

In the short term, vegetation succession may pose the greatest threat to colonies, particularly in the Pacific Region; in the long term, coastal colonies across the continent may be severely affected by sea level rises from global warming (Titus 1991). High water levels (not associated with global warming) have inundated nesting islands in the Great Lakes (Neuman and Blokpoel 1997), and tidal action has eroded and flooded breeding sites on salt pond levees in San Francisco Bay (Ryan 2000) and on islands in Grays Harbor and Willapa Bay. Overall, at least five historic nesting sites on the Pacific Coast have been lost to natural processes, such as vegetative succession, erosion, or inundation.

In Oregon and Washington, management actions have destroyed habitat or discouraged nesting at the largest and most recent coastal colonies, resulting in the loss of three additional breeding sites (Bird 1994, Collis *et al.* 2001a). Habitat modification (wooden stakes and monofilament lines) and hazing (e.g., walking through potential breeding sites to discourage colony establishment) were used to prevent nesting at Everett Naval Station, Washington, to reduce bird strike hazards to aircraft. These actions eliminated a nesting site that had 2,600 breeding adults the previous year (Smith *et al.* 1997, J. Flavin in lit.). In 2001, hazing and habitat modification were implemented to prevent nesting at the contaminated ASARCO Superfund clean-up site in Ruston, Washington. This site had at least 423 pairs in 2000 (Collis *et al.* 2001b, Shugart and Tirhi 2001). In 2001, as many as 388 breeding pairs moved to a barge provided as experimental nesting habitat. However, the barge was removed because of a breakdown of interagency coordination (Collis *et al.* in press). From 1999–2001, habitat modification (i.e., fencing, flagging, and winter wheat planting) and early season hazing (in 1999) were implemented on Rice Island to reduce fisheries conflicts in the Columbia River estuary (USACE 2001). These actions occurred concurrently with efforts to attract terns to nest at East Sand Island. Rice Island had previously been the largest colony in North America (Wires and Cuthbert 2000).

Future losses or degradation of habitat may also occur, such as increasing salinity, changing water priorities, and drought.

12.6 Factors Affecting Population Status

The factors limiting Caspian tern population growth are unknown or poorly understood. As with other seabirds, Caspian terns are long-lived, exhibit delayed maturation before breeding, and have low fecundity (clutch size, breeding frequency, and breeding success) (Weimerskirch 2002). This suggests that adult survival is likely one of the more important demographic parameters of Caspian terns. Both Gill and Mewaldt (1983) and Ludwig (1965), though, found that annual survivorship was lowest for terns in the interval between fledging and first breeding. The evolution of extended post-fledging parental care suggests that post-fledging survival may also be a factor in population regulation. Given that the North American population is currently increasing, it does not appear the number of Caspian terns is being unduly limited by any factor or combination of factors.

12.6.1 Overutilization

Historically, humans severely harmed Caspian tern colonies by collecting hundreds of eggs and adults for food and feathers (Finley 1907, Bent 1921, Ludwig 1965, and Lock 1993). In addition to the mortality and direct loss of eggs, it is likely that these activities resulted in undocumented colony failures and abandonment. Caspian terns are also vulnerable to direct persecution by people killing adults and young on the wing or at the colony (Penland 1976, Koonz 1982).

12.6.2 Disease & Predation

Caspian terns sometimes die in outbreaks of Newcastle disease and botulism, but these diseases do not appear to be a threat to the survival of the species (Campbell and Key 1996, Klinger 1997, K. Molina pers. comm.). The internal and external parasites known to infect Caspian terns are also not perceived as threats (Cuthbert and Wires 1999). Disease, though, may pose a threat to highly concentrated tern populations (see Concentration Risk below).

Caspian tern colonies are always vulnerable to predators, but there are no specific predator threats to the species at large. Persistent bald eagle activity at the Caspian tern colony on Rice Island in the Columbia River estuary caused significant egg and chick losses when gulls capitalized on the eagle-induced panic flights (see Burger and Gochfeld 1991, Collis *et al.* 2000). Bald eagle activity and gull nest predation have been suggested as factors in the abandonment of some coastal Washington colonies late in their history (e.g., Sand Island, Grays Harbor; Everett, Puget Sound; Penland 1976, Bird 1994).

Caspian tern colonies can also suffer from the introduction of predators by people that perceive a conflict between fish-eating birds and commercial or sport fisheries (Buchal 1998). In the Columbia River, researchers have removed raccoons and opossums (*Didelphis viginianus*) that were thought to be released by someone intent on destroying Caspian tern nests at Rice Island (Collis *et al.* 1999). Large Caspian tern colonies maintained by management of near-shore islands are perhaps the most likely to be threatened by predators in the long run. Long-established colonies may be most vulnerable to loss if there are no alternative sites nearby to relocate to when predation forces a colony move. Some colonies may need persistent predator monitoring and control to maintain them as long-term colony sites (Kress 2000).

12.6.3 Availability of Suitable Nesting Habitat

To be suitable, nesting habitat must be bare ground or in the earliest stages of vegetative succession, high enough above river or tide levels to avoid flooding of nests, eggs and young; large enough to accommodate a colony (critical mass of birds); and free of disturbance from predators (including humans). This combination of conditions is somewhat uncommon; therefore, available nesting habitat is limited.

Nesting habitat must consist of either bare or sparsely vegetated ground: In the short-term, vegetation succession may pose the greatest threat to colonies. The most serious long-term threat to Caspian terns is the loss or deterioration of quality breeding habitat (i.e., sparsely-vegetated islands). With reduction of flooding and peak flows in the Lower Columbia River subbasin, nesting sites have become less likely to be scoured by floods. In the absence of flooding, dredge spoil islands provide secure, stable nesting locations in the estuary, but nesting habitats are more susceptible to rapid vegetation succession, and need to be managed (scarified to set back succession) to allow continued tern nesting over time.

A number of known, historically active tern colonies have been lost in the Pacific Northwest along coasts and in interior marshes. The dense tule marsh at Lower Klamath, for example, where terns and other colonial water birds nested on matted sedges, was destroyed by the Klamath Basin water development project for agriculture, lack of water for wildlife, and by refuge management practices that open up marsh to make it more attractive for waterfowl; at the Everett Naval Base, the Defense Department, apparently without a permit, destroyed a nesting site used by a large colony of approximately 3,000 terns; and the relatively large colonies (1500-3590 pairs) on natural islands in Willapa Bay and Gray's Harbor were abandoned as sites became susceptible to flooding due to natural erosion, and disturbance and predation caused by Bald Eagles increased.

Potential nesting sites and methods of managing colonies along the Oregon and Washington coast, as well as elsewhere in the western region, are detailed in Seto et al. (2003). Gray's Harbor and an "unnamed island" in Umpqua estuary were among the better possibilities for re-establishing colonies. However, these and most other sites where colonies might be established are relatively small. Few good sites were identified; the capacity (numbers of terns that can be accommodated) was low at most sites, and those potential sites that were identified would require continual management, i.e., retardation of vegetative succession. Throughout North America, many if not most of the now-existing tern colonies nest at man-made sites, on dredge spoil islands or on islands in reservoirs.

Since nesting habitat was historically ephemeral, Caspian Terns have evolved a flexibility in their choice of nesting sites, and are able to occupy or move from a site when conditions change, such as through vegetative succession, erosion, and flooding probability.

Regulation of the hydro-system has made island habitat in the river, including dredge spoil islands, less erodible, less prone to flooding, and more secure as nesting habitat for colonial birds.

A nesting location must be large enough to accommodate a colony, as Caspian Terns are colonial.

A nesting site must be free from disturbance by predators, including humans. Access by mink, coyotes, etc. is sufficient to cause abandonment of a nesting site. Terns derive a degree of protection against avian predators by their colonial nature, and reproductive success tends to be higher at larger colonies, because of defense of the colony against gull predation. Therefore a colony must achieve some critical mass, i.e., be at least moderately sized, to be successful. Intentional human harassment, including management, at nesting sites is a potential limiting factor at any colony, and especially so at East Sand Island, the largest colony in North America.

12.6.4 Food Supply

Without a large predictable food suppy Caspian terns cannot nest successfully. The diet of Caspian Terns consists wholly of small fish. Salmonid smolts, in the Columbia River predominantly hatchery fish, provide a significant part (1/3) of their energy needs. At the mouth of the estuary, at East Sand Island, marine fish species comprise a larger portion of the diet. Hatchery salmonid smolts are more vulnerable to tern predation than wild smolts . Collis et al.2001, shows that hatchery yearling Chinook appear to be three times more vulnerable to predation than wild stock in 1998 – the only year for which they have data. Hatchery Steelhead appeared to be nearly twice as vulnerable to predation in 1997, but were not more vulnerable in 1998. At East Sand Island, which is close to the mouth of the Columbia River, the terns forage both in the mouth of the estuary as well as along the outer coast. This may affect the abundance and availability of marine fish, and therefore the proportion of marine fish in the diet.

12.6.5 Pesticides & Other Contaminants

In general, levels of organochlorines are declining, and current levels are not likely to threaten most Caspian tern colonies in North America though individual colonies may be affected or threatened (Henny *et al.* 1982, Cuthbert and Wires 1999, J. Buck pers. comm.). The effects of pesticides and other environmentally toxic compounds on Caspian terns have best been evaluated in the Great Lakes region, especially at the industrially-impacted colonies of Green Bay, Lake Michigan, and Saginaw Bay, Lake Huron (Cuthbert and Wires 1999). Eggs from Green Bay and Saginaw Bay had the highest polychlorinated biphenyls (PCBs) levels of eggs analyzed in the Great Lakes (Ewins *et al.* 1994). Grasman *et al.* (1996, 1998) found organochlorine compounds, especially PCBs, associated with the suppression of the immune system in prefledging Caspian tern chicks. This is coincident with the findings of low natal philopatry in areas of high PCB contamination (Struger and Wesloh 1985). These high PCB concentrations are thought to be lowering the reproductive success and juvenile survivorship of Caspian terns (Grasman *et al.* 1998).

Impacts of organochlorine pollutants, especially DDE (a breakdown product of DDT), have been documented on the Pacific Coast. Ohlendorf *et al.* (1985) found high chick mortality in San Diego associated with high DDE levels in eggshells. High DDE levels were also found in egg shells in the San Francisco Bay area (Ohlendorf *et al.* 1985, 1988). In 1995, residual DDE and other pollutants re-suspended by record flooding were also considered to be responsible for a reproductive collapse of a Caspian tern colony in Elkhorn Slough, California (Parkin 1998).

Ludwig *et al.* (1993) described a similar failure in the Great Lakes also caused by re-suspension of contaminants by floodwaters.

These accounts underscore that despite pollutants such as DDE and PCBs being better regulated today, individual Caspian tern colonies continue to be threatened by them long after they have been banned. Caspian terns are well suited as sentinel species (Grasman 1998), and hence their colonies should be monitored on a regular basis if they are associated with sources of contaminants, such as manufacturing in the Great Lakes or channel deepening on the Columbia River. In general there are ongoing concerns for the potential risk to waterbirds of reproductive impairment or immunotoxicity from selenium, boron, mercury, DDE, PCBs, and trans-nonachlor (Ohlendorf 1985, 1988; Setmire *et al.* 1990, 1993; Grasman 1996, 1998; Bruehler and de Peyster 1999).

12.6.6 Human Disturbance

Human disturbance is a well-known cause of reproductive failure in a wide range of seabirds (Carney and Sydeman 1999, Nisbet 2000, Carney and Sydeman 2000). Caspian tern colonies are especially vulnerable during the early courtship and incubation stages (Cuthbert and Wires 1999). Human visitors that approach Caspian terns during these stages typically cause panic flights of the entire colony. Such human disturbances can lead to permanent nest or colony abandonment (Cuthbert and Wires 1999). Most of the well-documented cases of human impact are from research activities, underscoring the vulnerability of Caspian terns.

The impacts of human disturbance are often magnified by the response of predators or the terns themselves. Egg losses may result from adults damaging or kicking their eggs out of the nest when abruptly fleeing human disturbance (Cuthbert and Wires 1999). Similarly, chicks may flee nest sites by swimming and get lost, drown, or die of exposure (Quinn *et al.* 1996). Fleeing chicks may also be attacked and often killed by neighboring adults (G. Shugart in lit.). The impact of a colony disturbance can be greatly increased when nearby gulls act as egg and chick predators (Penland 1982, Quinn 1984). Although a panic flight of a colony reacting to disturbance may last only a few seconds, gulls at Rice Island stole hundreds of eggs and young chicks per day during these brief disturbances (Collis *et al.* 2000). The Rice Island colony appeared most vulnerable to gull predation during the early chick stage, when small chicks (5-10 days old) ran from the nest but were still easily consumed in a single bite by gulls on the wing (D. Craig pers. obs.). Chicks are also particularly vulnerable to humans entering a colony at this stage as evidenced by chick mortality (about 30% died) following a 1-hour banding effort in Grays Harbor (Penland 1981). In subsequent years, chick mortality due to researcher disturbance was avoided by selecting the banding date to be at a stage when most chicks had just hatched and by restricting banding to 20-minute periods (WDFW pers. comm.). In 1998, 72 chicks died at Rice Island from heat exhaustion when too many chicks became crowded together in a holding pen during a midday banding effort (D. Craig pers. obs.). Since 2000, banding activities on the Columbia River have been conducted at either dawn or dusk, and groups of about eight nearly fledged chicks have been held in pheasant crates to minimize crowding (D. Craig pers. obs.). Although researchers often document their impact, the majority of human intrusions and disturbances by the general public are undocumented and their effects unmeasured.

12.6.7 Introduced Species

There are no apparent threats to Caspian terns directly associated with introduced species. Introduced plants such as tansy ragwort (*Senecio jacobaea*), common evening primrose (*Oenothera biennis*), and European beach grass (*Ammophila arenaria*) may be accelerating the degradation of quality breeding habitat by advancing vegetation succession at a rate faster than that of native plants of the Columbia River (D. Craig pers. obs.). The introduction of non-native mammalian predators has been documented at several colonies, particularly those in conflict with human interests.

12.6.8 Population Size & Isolation

Although limited information is available on the size of historic populations, numbers of Caspian terns have increased markedly in North America in the last 30 years, when relatively good population data have been gathered (Wires and Cuthbert 2000). The species still occupies most of its former range and has expanded into new areas. The continent-wide breeding population numbers at least 32,000 to 34,000 pairs. The current population size itself does not warrant conservation concern. Although there are insufficient data regarding the mixing of Caspian terns among regions in the breeding or non-breeding seasons, isolation of populations is not an apparent conservation threat.

12.6.9 Concentration Risk

Natural and human-caused events have reduced or eliminated habitat at many colonies. In the Pacific Coast region, eight of 15 historic colonies have been lost or abandoned in the last 20 years. This has apparently led to terns concentrating on few remaining suitable sites (e.g., Rice Island, Oregon) or colonizing new sites in conflict with human interests (e.g., ASARCO, Ruston, Washington). Shipping traffic on the Columbia River leaves large breeding aggregations of terns, such as those at East Sand Island, especially vulnerable to oil spills or other spilling or shipping accidents. The large breeding concentration in the Columbia River estuary is also more vulnerable to stochastic events (e.g., storms, predators, and human disturbance) and disease (e.g., Newcastle and botulism) than a comparable population dispersed among many smaller colonies (Klinger 1997, Roby *et al.* 2002, K. Molina pers. comm.). Natural and human disturbances that cause panic flights at larger colonies may result in significant chick mortalities, as the probability of chicks becoming lost and then killed by adults increases with colony size (Penland 1976, D. Craig pers. obs.). Roby *et al.* (2002) suggested that in years with poor ocean conditions near large concentrations like East Sand Island there is an increased likelihood of terns being reliant on juvenile salmon. Large concentrations of Caspian terns are also more likely to engender conflict with fisheries interests and hence may be subjected to organized eradication efforts through introduced predators (e.g., pigs) (Buchal 1998).

12.7 Inventory & Assessment of Existing Management Plans

Seto, N., J. Dillon, W.D. Shuford, and T. Zimmerman. 2003. A Review of Caspian tern (*Sterna caspia*) Nesting Habitat: A Feasibility Assessment of Management Opportunities in the US Fish and Wildlife Service Pacific Region. US Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

This document is a comprehensive review of management options and strategies that will direct Caspian tern management in Oregon and Washington. It describes the conflicts of Caspian tern management and helps to direct solutions in Washington and Oregon.

Shuford, W.D., and D.P Craig 2002. Status Assessment and Conservation Recommendation for the Caspian tern in North America. US Department of the Interior, fish and Wildlife Service, Portland Oregon.

This document is a comprehensive review of management options and strategies that will direct Caspian tern management in Oregon and Washington. It describes the conflicts of Caspian tern management and helps to direct solutions in Washington and Oregon.

Collis, K., D.D. Roby, C.W. Thompson, D.E. Lyons, and M. Tirhi. 2002. Barges as temporary breeding sites for Caspian terns: Assessing potential sites for colony restoration. Wildlife Society Bulletin 30: 1140-1149.

This document describes a unique treatment of a management solution, the use of temporary barges for nesting. It could be valuable in helping to direct innovative solutions for providing nesting area for Caspian terns to draw them into areas where nesting can be tolerated in Washington and Oregon.

Roby, D.D., K. Collis, and D.E. Lyons. 2003. Conservation and management for fish-eating birds and endangered salmon. Proceedings of the Third International Partners in Flight Conference, Asilomar, California.

This is a report on managing Caspian terns in Oregon and Washington. It describes the many conflicts of Caspian tern management and helps to direct solutions in Washington and Oregon.

Caspian tern Interim Management Plan FY 2003-2004 and Pile Dike Excluder Maintenance to Discourage Cormorant Use Lower Columbia River Oregon Interim Environmental Assessment: March 26, 2003.

This is the governing document for current tern management on the Lower Columbia River.

12.8 Inventory & Assessment of Existing Restoration & Conservation Plans

The USFWS anticipates releasing the final Caspian Tern EIS by January 2005 and issuing a signed Record of Decision by February 2005. This is a comprehensive review of management options and strategies that will direct Caspian tern management in Oregon and Washington. If respected and implemented, it will be instrumental in ensuring the secure future of Caspian terns in Washington and Oregon.

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