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Trends in Caspian Tern Numbers and Distribution in North America: A Review

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Abstract.—The breeding range of the Caspian Tern (*Sterna caspia*) covers large parts of six geographic regions in North America. We obtained data from individuals who monitor colonial waterbirds to determine current status and distribution of the Caspian Tern in the U.S., Canada and Mexico and to report regional population trends. We estimate 32,000–34,000 pairs nested in North America from the late 1980s to 1998. The species' breeding range is expanding along the Pacific coast and in central Canada. Over the last three decades numbers of breeding pairs have significantly increased in the Great Lakes, central Canada, and along the Gulf and Pacific coasts; the Atlantic coast is the only region where significant decline has occurred. On the Pacific and Gulf coasts, large numbers of Caspians utilize artificial habitat (e.g., dredge spoil islands, salt dikes and levees, landfills, artificial lakes). Changes in food supply may be at least partly responsible for population increases in the Great Lakes, on the Pacific coast, and in central Canada in Manitoba. Other factors that may contribute to increases include creation of artificial habitat that Caspian Terns find attractive for nesting, and legislation that protects Caspian Terns and their habitat. *Received 15 Mar 1999, accepted 19 July 1999.*

Key words.—Caspian Tern, distribution, North America, population trends, *Sterna caspia*.

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The distribution and abundance of the Caspian Tern (*Sterna caspia*) is characterized by change in several parts of its cosmopolitan range (Bergman 1953, 1980; Blokpoel and Fetterolf 1978; Staav 1979; Penland 1982). Though it occurs on all continents, with the exception of Antarctica, it is uncommon everywhere except for a few locations where large numbers (>1,000 pairs) nest. In Europe and Africa, the species declined during the last half century and is now rare or absent in many areas of former occupation (Brooke 1984; Cramp 1985). In North America, concern over low or declining numbers or limited habitat led to special management status in several states and provinces; some status designations afford legal protection additional to the Migratory Bird Treaty Act, and all help prioritize the need for greater conservation efforts.

Over the last three decades, numbers of Caspian Terns increased in many areas in North America, and the population appears to be expanding along the Pacific coast and in central Canada (Campbell *et al.* 1990; Gibson and Kessel 1992; Bennett 1995; Sherrington 1996). In some areas where numbers

are increasing (Pacific and Gulf coasts), large numbers of Caspians utilize artificial habitats (e.g., dredge spoil, other human-created islands). In this paper, we describe the continental abundance and distribution of the Caspian Tern and discuss factors that may be related to population increases.

METHODS

We contacted academic, federal, state and provincial biologists across North America who monitor colonial waterbirds to request the following information on breeding status: number of pairs, breeding location, origin of breeding site (natural vs. human created), earliest population estimates and current population trends. We also requested information on special management status designations (e.g., Endangered, Threatened). Published and unpublished reports and state colonial waterbird atlases were used when available.

Numbers of breeding pairs were estimated through a diversity of methods (e.g., aerial surveys, aerial photography, nest counts by boat, direct ground nest counts). For estimates of breeding birds in the U.S. Great Lakes, we conducted our own field surveys by total direct nest counts on foot (Cuthbert 1981). Latitude/longitude were obtained for most breeding sites. For sites where this information was not provided, we determined approximate locations by determining nearest town, lake, etc., to a breeding site that could be mapped. Here, "breeding site" refers to locations for single pair, semi-colonial and colonially-nesting birds. Breeding locations from 1987-1998 were entered into

an ArcView Geographic Information System (Environmental Systems Research Institute, Redlands, CA) to create a map of current distribution.

To estimate regional population sizes in the late 1990s, we combined the most recent data available for each location. To estimate proportion of each regional population using human-created breeding sites in the 1990s, we counted number of pairs breeding in such habitats in the last year each location was surveyed and summed these numbers.

RESULTS

Continental Distribution and Abundance

During 1987-1998, the Caspian Tern bred at scattered localities across North America. Banding data suggest that birds nesting west of the continental divide, along the Gulf Coast and in the Great Lakes, form three separate populations (Ludwig 1965, 1968; Shugart *et al.* 1978; Gill and Mewaldt 1983). It is not known if immigration/emigration occurs between these populations and breeding populations in central Canada and along the Atlantic coast; however, the latter form geographically distinct units. Therefore, we recognized five distinct breeding populations based on banding data and apparent geographic segregation: 1) Pacific coast/Western Region, where breeding occurs locally along the coast from Neragon Island, w. Alaska, to Baja California Sur, and at inland localities in Washington, Oregon, California, Nevada, Idaho, Wyoming and Utah (this region has been expanded from Gill and Mewaldt [1983] to include Utah and Wyoming); 2) Central Canada, in the Northwest Territories, Alberta, Saskatchewan and Manitoba; 3) Gulf coast, from coastal Texas to Florida; 4) Atlantic coast, in the northeast in Quebec and Newfoundland, and in the southeast in North Carolina and Virginia; and 5) Great Lakes, on lakes Huron, Michigan and Ontario (Fig. 1).

Major breeding areas include portions of the Pacific and Gulf coasts, the Great Lakes, and southern Manitoba (mostly lakes Winnipeg and Winnipegosis) (Fig. 2). Over the last three decades, numbers have increased substantially in all four of these areas (Fig. 3 a, b, c and d). Breeding Bird Survey results show an 86% from 1966-1993, and a 55% increase from 1984-1993 (Price *et al.* 1995).

We estimate between 32,000-34,000 pairs nested in North America in the late 1980s-1998 (Table 1), making this the largest of the global populations. The majority of breeding sites were surveyed in 1996 and 1997. Cuthbert and Wires (1999) previously reported 33,000-35,000 pairs during the same time period, but more accurate data are now available. In the U.S. we estimate 21,000 breeding pairs, approximately double the last estimate reported during the late 1970s and early 1980s (Spendelov and Patton 1988). We estimate that in the late 1990s the Canadian population was between 11,500-13,000 pairs; James (1999) estimated this population was "approaching" 14,000 pairs in 1999.

The Caspian Tern is protected under the Migratory Bird Treaty Act of 1916, but is not on any federal lists in the U.S., Canada or Mexico. Despite recent increases in some regions, the species has been designated or proposed for special management status in nine states and provinces (Table 2).

Regional Distribution and Abundance Summaries

Pacific coast/Western Region. Along the coast, birds occur on coastal inshore waters, breeding on levees or islands with little vegetation along salt evaporation ponds and estuaries, lagoons, bays and harbors. In the interior, lakes, rivers, reservoirs and sinks are utilized. During the 1990s, 89% of pairs nested on artificial sites (e.g., levees, salt dikes, dredge spoil islands, reservoirs, artificial lakes, landfills); 54% of pairs were on one dredge spoil island alone, Rice Island, located in the estuary of the lower Columbia River (OR). Of 45 sites used in the 1990s, at least 51% were on artificial habitats (we report minimum numbers because persons conducting surveys or reporting survey data sometimes did not know the history of a site).

In general, this population has been characterized by change, with rapid shifts of breeding locations and range expansion (Penland 1982; Gill and Mewaldt 1983). In the early 1900s, most breeding sites and large colonies were inland. However, agricul-

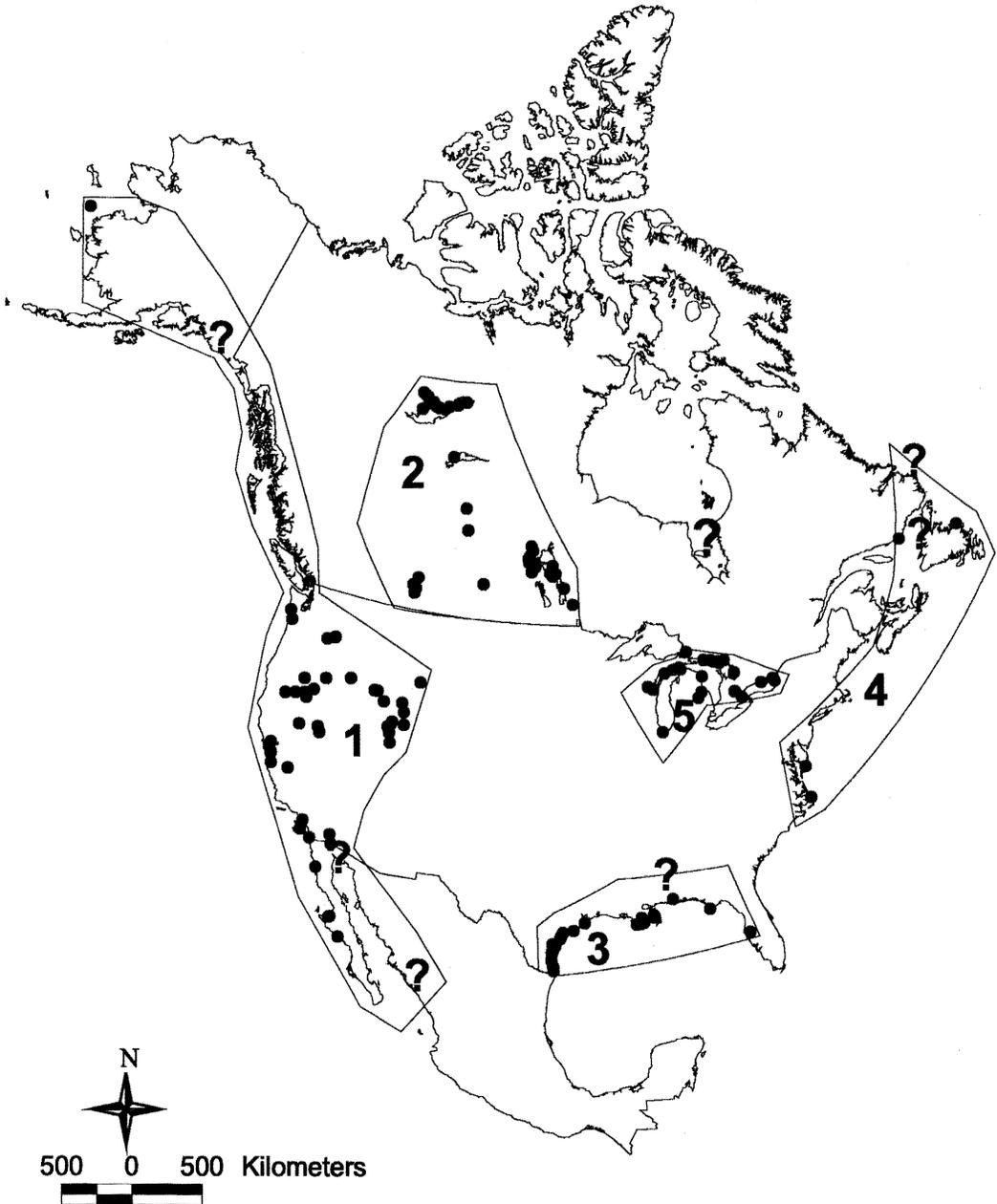


Figure 1. Distribution of Caspian Tern breeding sites in North America, 1987–1998. 1 = Pacific Coast / Western Region; 2 = Central Canada; 3 = Gulf Coast; 4 = Atlantic Coast; 5 = Great Lakes; ? = unconfirmed breeding site.

tural practices altered inland lakes and large tracts of marshes, and terns gradually shifted their nesting to coastal, human-created habitats, including the salt ponds in the San Francisco Bay area, and islands in recently created reservoirs and lakes. By 1930, only small colonies existed away from the coast (Gill and Mewaldt 1983). In the early 1940s,

a major period of expansion occurred, with new sites colonized in western Nevada and at the San Diego Bay Saltworks (Gill and Mewaldt 1983). In the late 1950s, Caspians began colonizing dredge spoil islands in western Washington (Alcorn 1958). In the mid-1960s, new colonies again formed in San Francisco Bay, and overall numbers in-

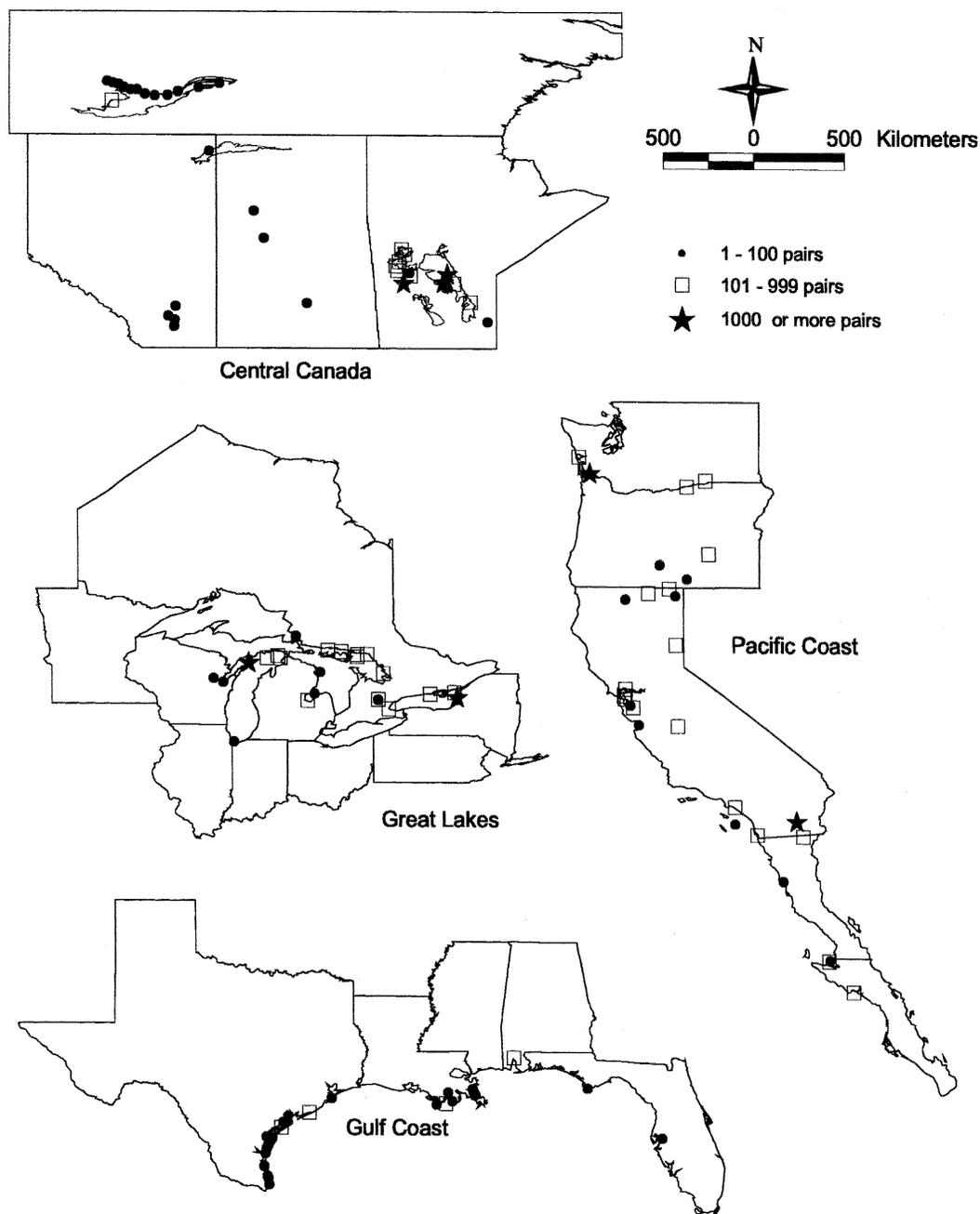


Figure 2. Distribution of Caspian Tern breeding sites and colony sizes in the four major breeding areas during most recent surveys. Central Canada, 1987-1996; Great Lakes, 1997-1998; Pacific Coast (excludes AK, BC, and western interior states), 1991-1998; Gulf Coast, 1996-1997.

creased in this area and in coastal Washington (Gill and Mewaldt 1983). During the 1970s expansion continued northward; summer observations in British Columbia gradually increased, and, in 1984, breeding was reported (Campbell *et al.* 1990) at Roberts

Banks, Fraser River Delta. Beginning in 1981, summer observations in Alaska were reported annually, and by 1989 breeding was suspected on the western Copper River Delta (Gibson and Kessel 1992). In 1996, breeding was confirmed and the northern and west-

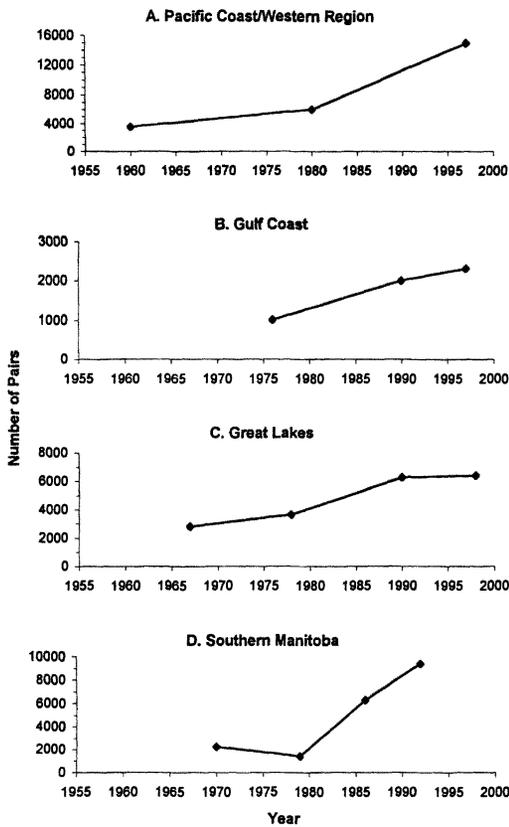


Figure 3. Caspian Tern population trends in the four major breeding areas, 1960-1997.

ern most breeding location for the continent was obtained when three nests were documented on Neragon Island in the Bering Sea (McCaffery 1997).

In the southern portion of the range, new sites have recently been colonized in Baja California Norte at Laguna Figueroa in 1991 (Palacios and Alfaro 1992) and at Baja California Sur at San Ignacio Lagoon, Ballena Island in 1988 (Danemann and Guzman Poo 1992), the southernmost colony on the coast and possibly on the continent. The colony at Scammons Lagoon has remained stable (Massey and Palacios 1994). Though the species is reported to breed on the west coast of Sinaloa (Howell and Webb 1995; E. Palacios and E. Mellink, pers. comm.), present status for this site could not be obtained. Breeding may also occur in the Gulf of California on Montague Island (Delta del Rio Colorado) (E. Palacios, pers. comm.).

While the majority of breeding sites in this region are coastal, significant numbers also breed inland on lakes and rivers. In the 1990s, large colonies (≥ 500 pairs) occurred along the lower Columbia River (OR) and at Salton Sea (CA). In the western interior states breeding numbers are small (< 500 pairs in each state). In Idaho, small numbers nest across the entire southern portion of the state, and the species has become more common in the north; however, formal surveys have not been conducted on a regular basis, and trends are not known (Taylor 1990; C. Trost, pers. comm.). In Nevada, Utah and Wyoming, breeding appears to be erratic or opportunistic; numbers fluctuate greatly with water levels (A. Cerovski, L. Neel and D. Paul, pers. comm.). At the Stillwater Wildlife Management Area at the Carson Sink (NV), as many as 475 nests have been reported during wet years (Alcorn 1988); in drier years, however, breeding is sporadic. In Mexico, breeding occurs inland near Mexicali at Cerro Prieto, but these colonies are very small (≤ 25 pairs; K. Molina, pers. comm.).

The breeding population in the Pacific coast/Western Region is the largest of the North American populations. In the late 1990s this population was close to 15,000 pairs and has increased at an average annual rate of 5.4% since 1980 (Fig. 3a). Most colonies were counted in 1997. Colonies in Mexico, Utah, Wyoming and Idaho were surveyed in earlier years (1992-1996) or not surveyed at all (British Columbia). However, in these locations numbers are small (750-860 pairs), and represent only 5-6% of the Pacific coast/Western Region population. Thus we assume our estimate is within $\pm 10\%$ of the actual population size.

Growth in this region has been due mostly to large increases at the Rice Island colony. Caspian Terns began colonizing the Columbia River area in 1986, about the same time Grays Harbor, WA, was abandoned. Grays Harbor was formerly the largest known Caspian colony on the Pacific coast. This colony peaked at about 4,000 pairs in the mid-1980s, and then birds gradually abandoned it. Based on recovery of 3 birds at Rice Island, banded

Table 1. First and current estimates for Caspian Terns breeding in North America, and current population trends¹ (+ = increase, - = decrease, 0 = no change, na = not available).

Breeding Location	Census Date	Number of Pairs	Source ²	Trend
GREAT LAKES				
<i>Lake Michigan</i>				
Indiana	1997	>40	J. Castrale (IN Dept. Natural Resources)	na
Michigan	Late 1930s	600-800	Ludwig 1962	
	1997	2340	F. Cuthbert (Univ. MN)	+
Wisconsin	1989	9	Scharf and Shugart 1998	
	1997	6	F. Cuthbert	+
<i>Lake Ontario</i>				
New York	1987	35	Blokpoel and Scharf 1991	
	1997	1204	F. Cuthbert	+
Ontario	1976	44	Blokpoel and Scharf 1991	
	1998	1008	D. V. C. Weseloh (Canadian Wildlife Service)	+
<i>Lake Huron</i>				
Michigan	1962	75	Ludwig 1962	
	1997	389	F. Cuthbert	+
Ontario	1963	870	Ludwig 1979	
	1998	1429	D. V. C. Weseloh	+
Regional total	1967	2800	Ludwig 1979	+
" "	1976-80	3631	Scharf 1978; Blokpoel and Tessier 1996; 1997	+
" "	1989-90	6285	Scharf and Shugart 1998; Blokpoel and Tessier 1996, 1997	+
" "	1997-98	6416	F. Cuthbert; D. V. C. Weseloh	0
ATLANTIC COAST				
Newfoundland	1986	28	J. Chardine (Canadian Wildlife Service)	
	1997	75-100	D. Ballam (Parks and Natural Areas Div.)	+
Quebec	1884	200	Todd 1963	
	1990-96	0-14	Chapdelaine 1996; M. Robert (Canadian Wildlife Service)	-
Virginia	1975-88	1-4	Williams <i>et al.</i> 1990	
	1989-97	1-3	Williams <i>et al.</i> 1990; B. Truitt (The Nature Conservancy)	
N. Carolina	1972	2	Parnell and Soots 1976	
	1990-97	15-37	D. Allen (NC Wildlife Resources Commission)	+

Table 1. (Continued) First and current estimates for Caspian Terns breeding in North America, and current population trends¹ (+ = increase, - = decrease, 0 = no change, na = not available).

Breeding Location	Census Date	Number of Pairs	Source ²	Trend
Regional total	1995-97	142-44	Chapdelaine 1996; D. Allen; D. Ballam	na
GULF COAST				
Texas	1973	900	M. Lange (US Fish and Wildlife Service)	0
	1996	855	W. Roach (US Fish and Wildlife Service)	
Louisiana	1967	500	Clapp 1983; S. Shively (LA Dept. Wildlife and Fisheries)	
	1997	820	G. Lester and W. Vermillion (LA Dept. Wildlife and Fisheries)	+
Alabama	1976	66	Portnoy 1977	
	1997	522	R. Clay (AL Dept. Fish and Game)	+
Mississippi	1976	2	Portnoy 1977	na
Florida	1962	1	Woolfenden and Meyerricks 1963	
	1997	106	McNair 2000	+
Regional total	1976	1023	Dunstan <i>et al.</i> 1975; Portnoy 1977; M. Lange	+
" "	1990	2003	Martin and Lester 1990; R. Clay; G. Lester; M. Lange	
" "	1996-7	2303	McNair 2000; R. Clay; G. Lester; W. Vermillion; M. Lange	+
CENTRAL CANADA				
Northwest Territories, GSL	1989	115-129 ³	Sirois <i>et al.</i> 1991, 1995	na
Alberta (n.)	1952	20	Salt and Wilk 1966	
	1994	86	D. Moore (Fish and Wildlife, Env. Protection Natural Resources Service)	+
Alberta (s.)	1991	2	Bennett 1995	
	1994-96	≤34-45	Bennett 1995; Sherrington 1996	+
Saskatchewan	1956	"small"	Houston 1956	
	1989	≥5	Smith 1996	0
	1970	>2245	Vermeer 1970	
Manitoba	1989-92	8780-9980	B. Koonz (Manitoba Dept. Natural Resources)	+
Regional total (so. Manitoba)	1970	2245	Vermeer 1970	
" "	1979	1393	Koonz and Rakowski 1985	-
" "	1986	6283	B. Koonz	+
" "	1989-92	8780-9980	B. Koonz	+
PACIFIC COAST/ WESTERN REGION				
Alaska		na ⁴		na
British Columbia		na ⁴		na
Washington	1975	1329	Penland 1982	

Table 1. (Continued) First and current estimates for Caspian Terns breeding in North America, and current population trends¹ (+ = increase, - = decrease, 0 = no change, na = not available).

Breeding Location	Census Date	Number of Pairs	Source ²	Trend
Oregon	1997	1000	Roby <i>et al.</i> 1998; T. Owens (WA Dept. Fish and Wildlife)	—
	1978	200	Thompson and Tabor 1981	
	1997-98	8680	Roby <i>et al.</i> 1998; M. St. Louis (OR Dept. Fish and Wildlife); G. Ivey (US Fish and Wildlife Service); W. DeVours (Bureau of Land Management)	+
California	1979-81	2654-2684	Gill and Mewaldt 1983	
	1997	4350	Shuford 1998; Parkin 1998; C. Collins (CA State Univ.), J. Konecny (US Fish and Wildlife Service), K. Keane (Keane Biological Consulting), K. Molina (Natural History Museum of LA County), T. Ryan (San Francisco Bay Bird Obs.), and J. Seay (H.T. Harvey and Associates)	+
Nevada	1990-97	Avg. = 20/year ⁵	G. Chisholm (Great Basin Bird Observatory), L. Neel (NV Div. Wildlife), B. Henry (Stillwater NWR)	na
Idaho	1993	100	C. Trost (ID State Univ.), K. Ryan (Deerflats NWR)	na
Wyoming	1984	16-21	A. Cerovski (WY Game and Fish)	
	1995	17	A. Cerovski	0/-
Utah	1997	345-390	D. Paul (UT Div. Wildlife Resources)	na
<i>Mexico</i>				
Laguna Figueroa, BCN	1991	10	Palacios and Alfaro 1992; Massey and Palacios 1994	
Cerro Prieto, BCN	1990s	25	K. Molina	
Isla Conchas, BCS	1992	120	Massey and Palacios 1994; E. Palacios (Afegua, A. C.)	
Saltworks, BCS	1992	40	Massey and Palacios 1994; E. Palacios	
Ballena Island, BCS	1992	150	Danemann and Guzman Poo 1992; Massey and Palacios 1994	
Regional total	1960	3500	Gill and Mewaldt 1983	
“ “	1980	6000	Gill and Mewaldt 1983	
“ “	1991-98	14846-14982	See sources for WA, OR, CA, NV, ID, UT, WY and MX, above.	

¹Trends based on review of all available census data, magnitude of change and opinions of biologists familiar with individual state/provincial populations.

²Sources given with Name and Year are listed in Literature Cited; other listings give name and organization.

³Surveys conducted 1986-1994, but entire area or all known breeding sites not surveyed in same year due to size of area. Estimate given is highest number of nests found in any survey year.

⁴No state or province-wide surveys have been conducted.

⁵Numbers can widely fluctuate and in wet years population size can increase greatly. In 1986 and 1987, 475 and 110 pairs, respectively, were counted at the Carson Sink in the Lahontan Valley.

Table 2. Special Status of Caspian Terns in North America.

Location	Status	Status Definition	Reason for Status
Ontario	Rare, 1988	Species monitored	Limited number of breeding sites.
Quebec	Endangered, 1988 ¹	Occurs regularly; likely to become extinct in near future.	Small number of breeding pairs; one known breeding site.
Wisconsin	Endangered, 1989	Threatened with extinction throughout all or a significant portion of its range.	Small number of breeding pairs; two known breeding sites.
Michigan	Threatened, 1980	Likely to become "endangered" in foreseeable future throughout all or most of range.	Contaminants, small number of breeding pairs and breeding sites.
Virginia	Species of Special Concern, 1992	Uncommon or highly specific in habitat requirements; requires monitoring.	Small number of breeding pairs and breeding sites.
Florida	Species of Special Concern ¹	See above.	Small number of breeding pairs; limited breeding sites and suitable habitat.
Louisiana	Species of Special Concern, 1988	See above.	Decline in breeding numbers in 1970s; limited number of breeding sites.
Wyoming	Species of Special Concern, 1996 ²	See above.	Low, possibly declining numbers; limited breeding sites; fluctuating water levels.
Utah	Species of Special Concern	See above.	Low, possibly declining numbers; limited breeding sites; fluctuating water levels; potential predation and human disturbance.

¹Unofficial or recommended status.

²Formerly "Priority species" since 1987; current designation equivalent, just different nomenclature.

as juveniles at Grays Harbor, the Grays Harbor colony is thought to have relocated at Rice Island. During 1987- 1997, numbers at Rice Island increased by >600% (Roby *et al.* 1998). In 1997 8,000 pairs were estimated (Table 1); in 1998 >10,000 pairs were estimated (D. Roby, pers. comm.), making Rice Island the largest colony on the continent and probably in the world (Cuthbert and Wires 1999). However, productivity at this site was poor through 1997, and much of the growth in the 1980s-1990s appears to have been due to shifting of breeding pairs from Grays Harbor, Willapa Bay and East Sand Island near the Columbia River mouth (Roby *et al.* 1998).

While the Pacific coast/Western population has dramatically increased overall, many local declines have occurred along the coast and inland. Large colonies existed in the 1980s in western coastal Washington but these were abandoned. In California, numbers at the San Diego Bay Salt Works, Bolsa Chica Ecological Reserve, Huntington Beach,

and the southern portion of San Francisco Bay have recently decreased. Declines were attributed to a variety of factors (e.g., predation, food shortage, human disturbance, unsuitable nesting habitat and emigration), especially to larger colonies (Stadtlander *et al.* 1993; T. P. Ryan and C. Collins, pers. comm.). Inland, declines occurred at Moss Landing in Central California, and at Mono Lake, California. In 1997, there was no successful breeding at the former site (Parkin 1998; C. Collins, pers. comm.), and the small colony at the latter site disappeared (J. Jehl, pers. comm.). In Utah and Wyoming, numbers are low and may be declining (F. Howe and A. Cerovski, pers. comm.).

Gulf coast. Caspian Terns nest along the Gulf coast on mainland and barrier island beaches and dredge spoil islands from Texas to Florida. Similar to Pacific coast/Western Region Caspians, these birds also tend to change breeding sites fairly often. In Texas, 48 sites were documented between 1980-

1996, but most were not used yearly. During this period, breeding occurred on average at about 17 sites per year; each site was used on average for about six years (not always consecutively). During roughly the same time period in Louisiana, colony locations frequently changed and former breeding islands sometimes disappeared (G. Lester and J. Harris, pers. comm.). During 1987-1997, at least 44% of the confirmed 63 colony sites used were on dredge spoil islands; in 1996-1997, at least one third of breeding sites and 35% of pairs were on dredge spoil islands.

In Louisiana, numbers of breeding pairs declined in the 1970s and only four sites were known (S. Shively, pers. comm.). However, in the 1990s numbers of breeding pairs increased, and, in 1997, 820 pairs were recorded at eight sites, a growth of 64% since 1967 (Table 1).

In Florida, numbers increased consistently since breeding was first reported in 1962 (Woolfenden and Meyerriecks 1963; Table 1). Colonies are currently established at Tampa Bay and at the Apalachicola River mouth (Rodgers *et al.* 1996; Pranty 1997).

In Alabama, the species was first recorded breeding in 1976 (Portnoy 1977). Currently, Caspian Terns nest at one location, Galliard Island, a dredge spoil island in Mobile Bay, where nesting has occurred since 1983. Nest counts have been conducted yearly since 1988, and numbers have increased at an average annual rate of 15%. Average colony size between 1988-1992 was 187 pairs (range = 150-255 pairs; excludes 1991), and between 1993-1997 average colony size was 448 pairs (range = 245-606 pairs; excludes 1994), an increase of 140% (R. Clay, pers. comm.). Number of pairs increased by nearly seven-fold since the species was first recorded breeding in the state (Table 1).

Along the Texas coast, the Caspian Tern has nested since at least the late 1800s (Baird *et al.* 1884). Numbers have been fairly stable since the early 1970s, fluctuating between 900-1200 pairs (Clapp *et al.* 1983; W. Roach, unpubl. data). In 1996, 855 pairs were counted at 18 sites (Table 1).

In Mississippi, the Caspian Tern was confirmed to be nesting on the coast at Horn Is-

land in 1966, and at Petit Bois Island in 1967 and 1968 (Portnoy 1977). A few birds may nest at single pair sites along the coast, but breeding has not been confirmed since 1976 (Portnoy 1977; J. Jackson, pers. comm.).

The Gulf coast population has more than doubled since the mid-1970s (Fig. 3b). Most increases occurred in Louisiana, Alabama and Florida (Table 1). With the exception of Texas, all known colonies were counted in 1997; Texas colonies were counted in 1996. Because numbers in Texas have been fairly stable since the early 1970s, we assume our estimate is accurate to within 9% of the actual population size, erring on the side of an underestimate.

Great Lakes. In the Great Lakes, Caspian Terns nest mostly on remote, natural islands; limited nesting occurs at a few sites on the mainland. During 1997-1998, six of 24 sites used were artificial (e.g., human created islands, dredge spoil islands, steel plant). Thirty seven percent of nesting pairs occurred on Lake Michigan, 34% on Lake Ontario, and the remaining 28% were on Lake Huron. Compared to the Pacific and Gulf coasts, there are fewer but relatively large colonies, and sites appear more stable, despite fluctuating water levels. Most sites have been used regularly since breeding was first recorded; a few have been used for a century or more, and consistently provide breeding habitat for large numbers of terns. For example, in 1896, "fully a thousand terns" were reported nesting on Hat Island, Lake Michigan (Reed 1965), and over 600 nests were counted at this site in 1997.

Since the late 1960s, the Great Lakes population has nearly tripled (Fig. 3). On Lake Ontario, numbers have consistently increased, and numbers have more than doubled since the late 1970s. On this lake, there was an average annual increase of 22% between 1963 and 1990 (Neuman and Blokpoel 1997). Between 1994 and 1997, numbers increased overall by 15%, but growth slowed to an annual rate of increase of about five percent (D. Weseloh, pers. comm.). On lakes Huron and Michigan, increases occurred in the 1970s and 1980s; however, in the late 1990s, declines oc-

curred. The most significant decreases occurred on Lake Huron, where eight of 11 colonies declined, and number of pairs dropped 22% between 1989/90 and 1997/98. On Lake Michigan, only two of 10 colonies declined between 1989 and 1997. These were two large colonies that completely disappeared, causing an overall decline on the lake of 11% during this period. Nevertheless, increases on Lake Ontario appear to have countered the decreases on lakes Michigan and Huron, and the Great Lakes population has essentially remained stable during the last decade.

Central Canada. In Central Canada, Caspian Terns breed on natural sandy islands and reefs in lakes in Manitoba, Saskatchewan, Alberta and the Northwest Territories. The majority of the population breeds in Manitoba (50-70%; James 1999), and large increases have been reported on and around lakes Winnipeg and Winnipegosis. Surveys of these lakes conducted in 1979 suggest numbers were declining, as only 1,393 nests were estimated, about 62% of the number recorded in 1970 by Vermeer (1970). However, just prior to the surveys, Manitoba's largest colony was abandoned, due in part to road construction activity, and large concentrations of nonbreeding terns were observed in the area (Koonz and Rakowski 1985). Surveys conducted between 1989 and 1992 estimated the largest numbers of breeding terns ever recorded on lakes Winnipeg and Winnipegosis, three times that estimated in 1970 (Table 1).

In Alberta and Saskatchewan, numbers are marginal, with <400 pairs estimated for both provinces combined. In Alberta, Caspians historically bred in the northern portion of the province at Egg Island, Lake Athabasca. Here, nesting was first documented in 1952 when 20 pairs were observed (Salt and Wilk 1966); however, nesting is thought to have occurred since at least the early 1900s (Seton 1911). By the late 1970s, the number of nests doubled. Counts made between 1987 and 1994 showed further increases, with numbers fluctuating between >60 and 100 nests (D. Moore, pers. comm.). In 1991, first nesting was documented for the south-

ern portion of the province at Lost Lake near Enchant (Bennett 1995). New sites continue to be discovered and increases observed in this area, with small numbers (<100 pairs) recorded at Lake Newell (Semenchuk 1992) and at Fincastle and Scope lakes, near Taber (Sherrington 1996). In Saskatchewan the species is an uncommon visitor over much of the central portion of the province, and is described as "a rare and local summer resident;" two to three hundred pairs are thought to nest at 2 main sites, but systematic surveys have not been conducted (R. James and K. Roney, pers. comm.). A small colony was discovered at Churchill Lake in 1989 (Smith 1996), bringing the total number of known breeding sites to three.

In the Northwest Territories, Caspian Terns breed at Great Slave Lake and possibly at Akimiski Island in James Bay. At the latter site, several hundred pairs may nest (James 1999) but current counts are not available. At Great Slave Lake, 82% of breeding sites are occupied by single pairs, and 94% are occupied by ≤ 5 pairs. Only one site has >100 pairs. Surveys have not been regularly conducted in this province, and no trend information is available.

Atlantic coast. In this region, the species has a disjunct distribution, occurring on remote islands and lakes along the northeast coast in Labrador, Newfoundland and Quebec, and on barrier islands and inlets along the southeast coast from Virginia to South Carolina. In North Carolina, dredge spoil islands are frequently used (4 of 6 known sites; D. Allen, pers. comm.). Twelve breeding sites are known, with most (83%) occurring in North Carolina and Newfoundland; during the most recent counts conducted between 1995 and 1997, only 4 sites were active. Colonies >100 pairs have not been observed. The largest colony is in Newfoundland at the eastern extreme of the breeding range. It was last estimated at 100 pairs and has tripled since 1986 (Table 1).

In Quebec, the only confirmed breeding site is at the Ile a la Brume Migratory Bird Sanctuary, along the lower North Shore. In the late 1800s, approximately 200 breeding pairs occupied this area, but by 1925 the

population declined to about 60 adults (Chapdelaine 1996). Human disturbance (e.g., "traditional" egg harvesting) may have caused near extirpation of this colony (Nettleship and Lock 1973). Between 1925 and 1988 numbers fluctuated, but declined overall; in 1988 only 15 adults were found, and by 1993 the species was no longer breeding there. However, a census in 1995 revealed that Caspians were again present at the sanctuary in very small numbers (Chapdelaine 1996) (Table 1). Breeding may also occur on the Magdalen Islands, but this has not been confirmed (Lock 1983).

In Labrador, Audubon (1844) recorded breeding of the "cayenne" tern, probably the Caspian (Bent 1921), on the southern coast in 1833. In 1887, Frazar (1887) recorded a colony of 200 pairs about 20 miles west of Cape Whittle. However, in 1979 only four adults and one chick were recorded in Labrador at Lake Melville (Lock 1983). Current breeding status is unavailable.

Along the Virginia coast, the species was fairly abundant in the late 1800s, but declined from harvest for the millinery trade and eggging (Weske *et al.* 1977). Caspians disappeared entirely from the state during the late 1880s-1890s. Nesting was documented again between 1912 and 1915, but breeding islands were eroded, and no nests were found again until 1974 (Weske *et al.* 1977). Though Caspians currently nest on the barrier islands off the Virginia coast or on insular marshes, only a few pairs are known to regularly do so and numbers have not rebounded.

In the Carolinas, very small numbers (<5 pairs) were documented in the 1970s (McDaniel and Beckett 1971; Parnell and Soots 1976). In South Carolina, the only confirmed nesting occurred between 1970 and 1974 at Cape Island, Cape Romain NWR, though earlier, but questionable, records exist (McNair 1994). In North Carolina, Caspians nest on dredge spoil islands at inlets along the coast. Though the number of pairs has increased steadily since the species was first discovered nesting in the state in 1972 (Parnell and Soots 1976), colony sizes have remained <50 pairs (Table 1).

DISCUSSION

For many avian species a review of population trends is difficult because baseline data are often too vague or incomplete to accurately determine long term or large scale population changes (Jehl and Johnson 1994). Additionally, differences in survey methods and gaps in monitoring limit ability to describe population changes in detail. Nevertheless, extensive and systematic data have been recorded on the Caspian Tern throughout most parts of its range for at least 20-30 years, and in some areas for much longer. These data suggest the following changes have occurred in the North American breeding population: 1) the range has expanded over the last 60 years; 2) the current breeding distribution is broader than when first described a century ago (e.g., Baird *et al.* 1884; Ridgway 1919; Bent 1921); 3) and the number of breeding pairs has significantly increased over the last two to three decades.

Reasons for Range Expansion and Population Increase

Reasons for range expansion and increased numbers are complex and likely due to multiple factors that are region or site specific. However, increasing populations in several parts of the North American range (Central Canada, Pacific coast, Great Lakes and Gulf coast) have some specific factors in common.

More Intensive Monitoring

In 1966 the Breeding Bird Survey was initiated to encourage states and provinces to begin systematically monitoring colonial waterbird populations; in 1980 the Fish and Wildlife Conservation Act was passed (DiSilvestro *et al.* 1987) and led to establishment of state nongame programs. In addition, several states and provinces initiated colonial waterbird surveys prior to 1980 (Table 1). Monitoring breeding bird population trends is now a common goal of federal, state and provincial agencies. Documentation of breeding site locations has become a priority

and has accelerated discovery of more water-bird colonies over time. Increased numbers of field workers and more intensive field surveys may have resulted in higher numbers of birds seen and counted (Taylor 1990; C. Trost, pers. comm.). However, in areas where populations have been monitored over long periods of time or where colonies have been closely followed (e.g., Pacific coast, Great Lakes), real changes in distribution and or numbers appear to be occurring.

Food Supply

Alterations in fishery practices over the last half century have resulted in fish species composition changes and higher abundances of forage fishes on the Pacific coast, in the Great Lakes and in Manitoba at Lake Winnipegosis, three of the four major Caspian Tern breeding areas. On the Pacific coast, the very large colony at Rice Island in the Columbia River estuary is near a salmon (*Oncorhynchus* spp.) hatchery release point, where yearly hatchery production of millions of salmonid smolts provides an abundant food source (Roby *et al.* 1998). Rice Island was colonized in 1986 and Caspians quickly specialized on juvenile salmonids (an estimated 6-25 million smolts were consumed in 1997) (Roby *et al.* 1998). Declines in alternative forage fish resources and greater vulnerability of hatchery-raised compared to wild smolts may have facilitated this diet specialization. Human efforts to reduce smolt mortality in-river may cause hatchery-raised juveniles to reach the estuary prematurely; in turn, smolts reaching the estuary prematurely may avoid seawater and remain in the freshwater lens at the surface, where they are more vulnerable to tern predation (Roby *et al.* 1998).

In the Great Lakes, fish populations have undergone many changes in the last 60 years. From the late 1930s to the 1950s, dramatic declines occurred in large predatory fish populations, primarily Lake Trout (*Salvelinus namaycush*) and, to a lesser extent, Burbot (*Lota lota*). These declines were precipitated by years of heavy fishing, invasion of the Sea Lamprey (*Petromyzon marinus*), loss of spawning areas, and possibly

increased levels of contaminants. With these declines, smaller fish species, mainly Alewife (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*), underwent unprecedented population explosions (Weseloh and Collier 1995). By 1955 these smaller species provided a steady and abundant food supply for Caspian Terns (Ludwig 1965, 1991).

In Manitoba, changes in fishery practices on Lake Winnipegosis since the 1940s led to major fish species composition changes (Lysack 1988). Heavy human exploitation of Walleye (*Stizostedion vitreum*) and Northern Pike (*Esox lucius*) reduced predation on smaller species such as White Sucker (*Catostomus commersoni*), Yellow Perch (*Perca flavescens*) and Tullibee (*Coregonus artedii*). These fish tend to occur in large schools and inhabit shallower areas in the lake, which makes them vulnerable to certain avian predators. With reduced predation from Walleye and Pike, these species have become more abundant. Hobson *et al.* (1989) suggested that increased abundance of Double-crested Cormorants (*Phalacrocorax auritus*) on the lake is due partly to the increased abundance of forage fish caused by excessive commercial exploitation of large predatory fish. Though the diet of Caspian Terns has not been examined on Lake Winnipegosis, they are opportunistic feeders and have likely exploited changes in forage fish abundance. Increased numbers therefore are probably related, at least in part, to these changes in fish populations.

Artificial Habitat

Caspian Terns currently nest in large numbers on artificial habitats, especially human-created islands (e.g., impoundments, dredge deposits). Since the early 1980s, large persistent colonies established on a few dredge spoil islands, salt dikes and artificial lakes and reservoirs in the southeastern U.S. and along the Pacific coast, while colonies on natural islands in these regions have been and remain small (McNair 2000; this study). Human-created habitat may appeal to Caspian Terns for several reasons. In some locales, these habitats are closer to food resources (e.g., Rice Island).

Many of these habitats also provide safe breeding sites. Because artificial islands often have no mammalian predators, and are frequently maintained and kept free of vegetation, they provide attractive and reliable habitat.

Along the Pacific coast, there is not much high quality natural habitat remaining for nesting. In 1997, 64% of the population nested on three artificial islands in the lower Columbia River and Estuary. In this area, constantly expanding dredge spoil islands and mainstream dam impoundments created abundant nesting habitat. The combination of newly created nest habitat and an abundant food source may account for recent large increases in number of birds.

Along the Gulf coast, dredging operations also created nesting habitat. In relatively recently colonized Alabama and Florida, all pairs nest on dredge spoil islands. In Alabama, all Caspian Terns nest on one spoil island; in Florida, Caspians are using two spoil islands. The last known nesting in Mississippi also occurred on a spoil island. In Texas and Louisiana both natural and spoil islands are utilized, though Caspian Terns are becoming increasingly restricted to dredge-material islands (McNair 2000). In the southeastern U.S. (Alabama, Florida and North Carolina), the species may favor artificial sites (McNair 2000).

Legislation

In 1916, passage of the Migratory Bird Treaty Act halted egg harvesting and collection of adults for the millinery trade and probably protected many tern populations from local extirpation. More recently, increased attention to nongame species undoubtedly benefited Caspian Terns in a number of ways that may have contributed indirectly to recent population increases. For example, in northern Lake Michigan, Hat Island, one of the largest and oldest colonies in the region, was purchased by the Michigan Chapter of The Nature Conservancy, specifically for the purpose of protecting the Caspian Tern colony (D. Ewert, pers. comm). Land ownership was subsequently transferred to the National Wildlife Refuge system. Additionally, at Hamilton Harbor, Ont., Mobile Bay, AL, and coastal NC,

management activities have been recommended or undertaken to maintain dredge spoil islands with little vegetation (Quinn *et al.* 1996; Clay 1992; Parnell and Shields 1990), to control Ring-billed Gull (*Larus delawarensis*) nesting, to provide appropriate substrates, and to attract Caspians to nest (Quinn *et al.* 1996; Quinn and Sirdevan 1998).

In some areas where Caspian Terns have special status, numbers of breeding birds and/or breeding sites have increased substantially since listings were first designated. While these changes suggest that Caspian Terns are doing well in these areas, appropriateness of status designations and de-listings should be carefully considered. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recently reviewed the status of the Caspian Tern across Canada and determined the species was "not at risk." (COSEWIC 1999). Formerly the species had been assigned "vulnerable" status, signifying "a species of special concern because of characteristics that make it particularly sensitive to human activities or natural events" (COSEWIC 1999). Recent increases and large breeding pair estimates across the country led to this status designation change; however, James (1999) recommended that the "vulnerable" status be retained, due to the small number of colony sites nationwide and the vulnerability of the species to disturbance and vandalism at its major breeding areas in Manitoba.

CONCLUSION

Unlike most other tern species that breed in North America, the Caspian Tern has benefited from recent anthropogenic environmental changes. This species appears able to exploit human modified habitats and respond quickly to habitat changes (Gill and Mewaldt 1983). The ability to shift colony sites and rapidly colonize dredge spoil islands and other artificial habitats probably contributed to population increases and range expansions. As natural habitat disappears across many parts of the range, the number of birds breeding on artificial habitat will likely increase.

Nevertheless, the Caspian Tern has never been abundant anywhere in its range, and large colonies are uncommon; only seven North American colonies have $\geq 1,000$ pairs. Because of the recent trend for large numbers of birds to aggregate at a small number of colonies, populations may be highly vulnerable to local environmental changes. If most of the population nests in only one or two colonies (e.g., Pacific coast), site-specific changes in human activities could have significant effects for an entire region. For example, habitat modifications that result in large numbers aggregating at single sites render the population vulnerable to stochastic events and conflicts with fishery resources. Therefore, we recommend that large colonies be monitored and management actions that affect them be carefully evaluated.

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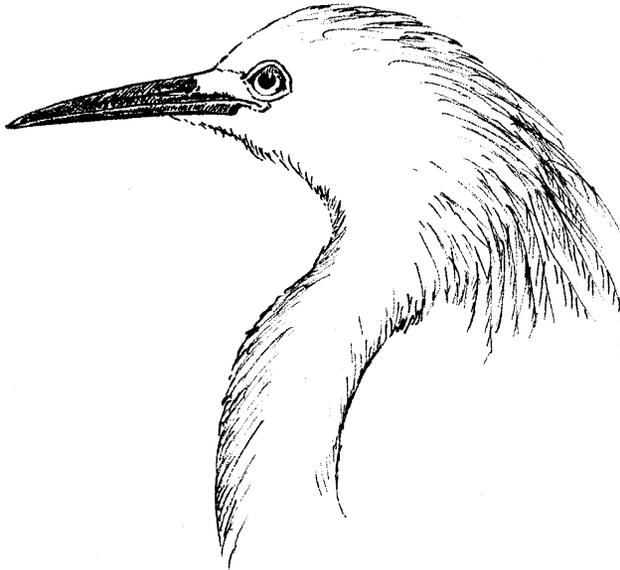
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