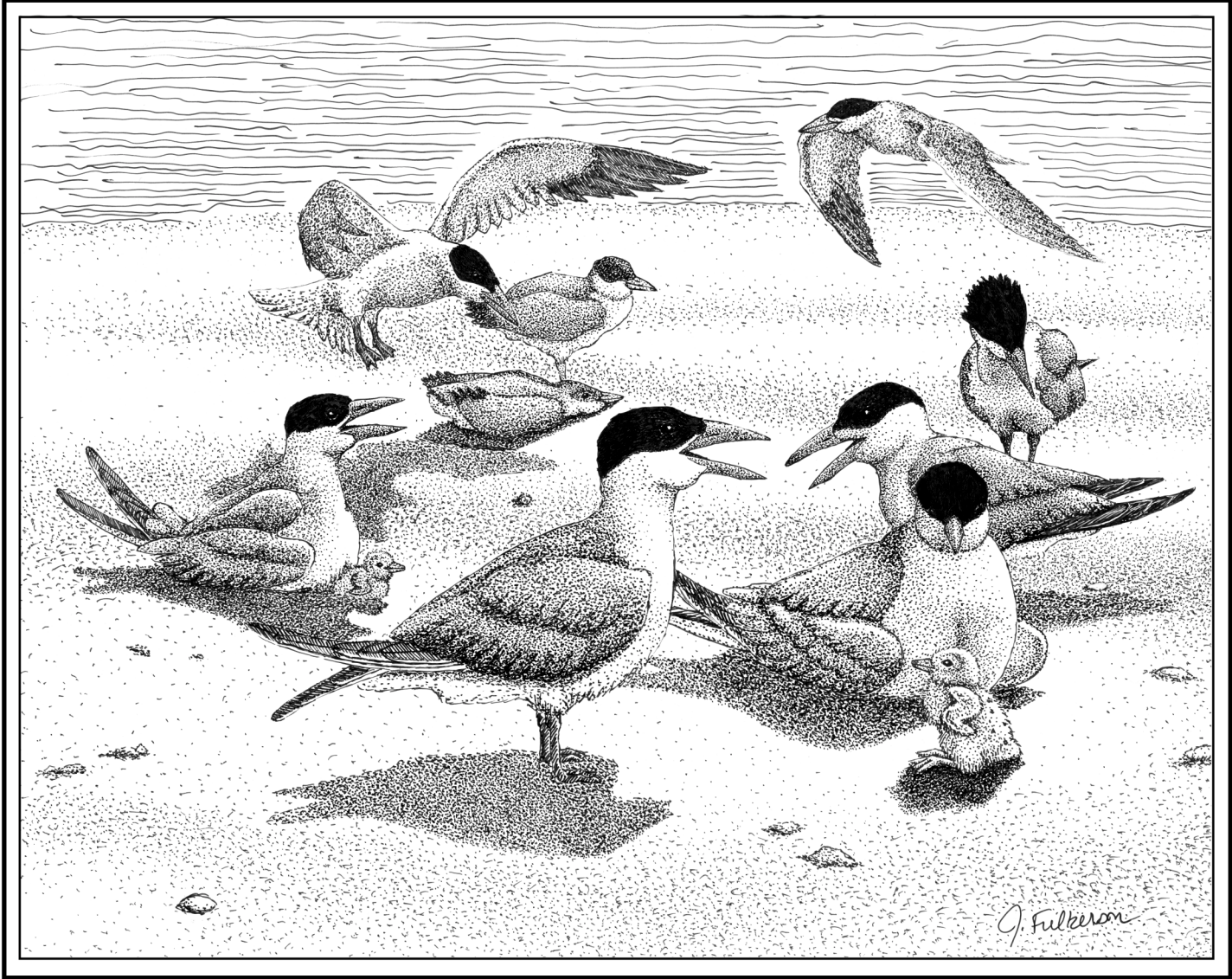


Status Assessment and Conservation Recommendations for the Caspian Tern in North America

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**Status Assessment and
Conservation Recommendations for the
Caspian Tern (*Sterna Caspia*) in North America**

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TABLE OF CONTENTS

Acknowledgments	viii
Summary	1
Taxonomy	2
Legal and Conservation Status	2
United States	2
Canada	2
Mexico	4
Central and South Americas	4
Description	4
Geographic Distribution	4
Breeding	4
Migration	7
Winter	8
Pacific Coast	9
Atlantic, Gulf, and Caribbean Coasts	9
Summer Nonbreeding	10
Natural History	11
Breeding	11
Nests and Nest Spacing	11
Reproductive Phenology	11
Breeding Site Fidelity	12
Demography and Limiting Factors	13
Predators	14
Diet	15
Migration	15
Habitat Requirements	16
Breeding Season	16
Migration	17
Winter and Summer Nonbreeding Seasons	17
Population Estimates and Trends	17
Estimates	17
Trends	19
Trends from Regional Surveys	19
Pacific Coast/Western (interior) Region	19
Central Canada	25
Great Lakes	26
Gulf Coast	26
Atlantic Coast	31
Breeding Bird Survey Trends	31
Christmas Bird Count Trends	31
Threats	32
Overutilization	32
Adequacy of Existing Regulatory Mechanisms	32
Habitat Loss and Degradation	32
Disease and Predation	34

Pesticides and Other Contaminants	34
Human Disturbance	35
Introduced Species	36
Population Size and Isolation	36
Concentration Risk	36
Monitoring Activities	37
Regional Surveys	37
Breeding Bird Survey	37
Christmas Bird Count	38
Management Activities	38
Management Activities in the Columbia River Estuary	38
Habitat and Vegetation Management	39
Artificial Nest Platforms	40
Social Attraction	41
Predator Management	42
Minimizing Disturbance	42
Outreach and Education	43
Status Recommendations	43
Conservation Recommendations	44
Monitoring Recommendations	44
Habitat Management and Protection Recommendations	45
Research Recommendations	46
Outreach and Education Recommendations	47
References	49
Appendix 1. Summaries for States, Provinces, and Territories within the Breeding Range Of Caspian Tern in Canada, the United States, and Mexico	1-1
Pacific Coast/Western (interior) Region	1-1
Alaska	1-1
British Columbia	1-2
Washington	1-2
Oregon	1-8
California	1-12
Mexico	1-22
Idaho	1-24
Nevada	1-26
Utah	1-28
Montana	1-30
Wyoming	1-31
Central Canada Region	1-32
Northwest Territories	1-32
Alberta	1-33
Saskatchewan	1-35
Manitoba	1-36
Great Lakes Region	1-39
Ontario	1-39
Minnesota	1-40
Wisconsin	1-41

Michigan	1-41
Indiana	1-43
New York	1-44
Gulf Coast Region	1-45
Texas	1-45
Louisiana	1-48
Alabama	1-50
Mississippi	1-51
Florida	1-52
Atlantic Coast Region	1-54
Newfoundland and Labrador	1-54
Québec	1-55
New Jersey	1-55
Virginia	1-56
North Carolina	1-57
South Carolina	1-58
Georgia	1-58
Florida (Atlantic Coast)	1-58
Outlying Populations	1-59
North Dakota	1-59
Appendix 2. Regional, State, Provincial, and Territorial Contacts and Contributors	2-1

LIST OF TABLES AND FIGURES

Table 1. Government and Natural Heritage conservation status rankings for the Caspian Tern in 30 states, provinces, and territories in North America by five distinct breeding populations (after Wires and Cuthbert 2000).	3
Table 2. Counts of Caspian Terns on Christmas Bird Counts in Canada and the continental United States, 1991-2000.	10
Table 3. Estimates of the Caspian Tern breeding population in the United States, by region, from 1976-1982 and 1996-1998.	18
Table 4. 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 <i>Sterna</i> breeding in temperate and arctic regions of North America (exclusive of Hawaii).	19
Table 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.	21
Table 6. Numbers of breeding pairs of Caspian Terns from four comprehensive surveys of colonies on the Great Lakes of Canada and the United States.	27
Table 7. Numbers of breeding pairs of Caspian Terns from two comprehensive surveys of colonies on the Gulf Coast of the United States.	29
Figure 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).	5
Figure 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 (see text).	6
Figure 3. Distribution and relative size of Caspian Tern colonies in the Pacific Region of western North America (see Appendix 1 for raw data, 1997-2001). 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 (see text).	20

CONVENTIONS USED IN THE TEXT

NATURAL HERITAGE STATUS RANKS

In Table 1 and in each state, provincial, or territorial account (Appendix 1), the standardized subnational (state/provincial) S-rank priority categories (codes) for breeding (B), developed by NatureServe, The Nature Conservancy, and the Natural Heritage Network to ensure uniform conservation rankings across regions, are expressed as their verbal equivalents (NatureServe 2001). The S-rank codes, verbal equivalents, and definitions are as follows (for additional details see <http://www.natureserve.org/explorer/ranking.htm>):

SX = Presumed Extirpated Element is believed to be extirpated at the state or provincial level; not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SH = Possibly Extirpated (Historical) Element occurred historically in the state or province, and there is some expectation that it may be rediscovered; its presence may not have been verified in the past 20 years.

S1 = Critically Imperiled Critically imperiled in the state or province because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state or province; typically five or fewer occurrences or very few (<1000) remaining individuals.

S2 = Imperiled Imperiled in the state or province because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state or province; typically 6 to 20 occurrences or few (1000-3000) remaining individuals.

S3 = Vulnerable Vulnerable in the state or province either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation; typically 21 to 100 occurrences or between 3000 and 10,000 individuals.

S4 = Apparently Secure Uncommon but not rare, and usually widespread in the state or province; usually more than 100 occurrences and more than 10,000 individuals. Possible cause of long-term concern.

S5 = Secure Common, widespread, and abundant in the state or province. Essentially ineradicable under present conditions; typically with considerably more than 100 occurrences and more than 10,000 individuals.

S? = *Unranked* State or provincial rank not yet assessed.

S#S# = *Range Rank* A numeric range rank (e.g., S2S3 = Critically Imperiled-Imperiled) is used to indicate a range of uncertainty about the exact status of an element; ranges cannot skip more than one rank.

SA = Accidental Accidental or casual in the state or province, i.e., infrequent and outside usual range. Includes species recorded once or only a few times, a few of which may have bred on the one or two occasions they were recorded.

For purposes of this report, the Caspian Tern is considered of “conservation concern” in the states and provinces that list the species as Critically Imperiled, Imperiled, or Vulnerable.

ACRONYMS USED

AB = American Birds

AFN = Audubon Field Notes

BBS = Breeding Bird Survey

CBC = Christmas Bird Count

NASFN = National Audubon Society Field Notes

NWR = National Wildlife Refuge

USFWS = U.S. Fish and Wildlife Service

WA = Wildlife Area

DESCRIPTIVE STATISTICS

Depending on completeness of the data source, the central tendency of data is usually expressed as an average (range, Standard Deviation [SD], Standard Error [SE], sample size [n]).

ACKNOWLEDGMENTS

We are extremely grateful to the many people who took time from their busy professional and private lives to provide us with reports, reprints, unpublished data, and insight about the status and biology of the Caspian Tern in North America, without which this report would not have been possible. These contributions were supported by a host of state, provincial, territorial, federal, and private organizations to which we are indebted. Most of the individuals and institutions are cited in the text or tables (particularly Table 5) or are listed in Appendix 3. We were also greatly helped in our search for literature on the Caspian Tern by various research librarians, particularly Gareth Penn. Frances Cuthbert and Linda Wires greatly smoothed the road by their recent reviews of the biology and populations trends of the Caspian Tern in North America, which were invaluable resources. The map of the seasonal status of the Caspian Tern in North America is used with permission, courtesy of Christine Bush of Birds of North America, Inc., and Frances Cuthbert, the author with Linda Wires of the BNA account for this species. We thank Lars Pomaro and Diana Stralberg for modification, formatting, or production of that figure and others in the report. Dan Roby and Ken Collis have been praise worthy for their courage and endurance in leading the pursuit of research on the Caspian Terns of Oregon and Washington. In 5 years of intense professional pressures they have discovered notable new scientific facts, helped develop new management techniques, and been extremely generous with their unpublished data. We want to particularly thank Tara Zimmerman for her unswerving dedication to conservation of the Caspian Tern on the Pacific Coast in the search of reasonable solutions to tern-fisheries conflicts at the Columbia River estuary. Earlier drafts of this document greatly benefited from comments by David Ainley, Joy Albertson, Range Bayer, Rocky Beach, Brad Bortner, Charles R. Bruce, Ken Collis and the Columbia Bird Research Team, Jeff Dillon, John Grettenberger, Craig Harrison, Gregg Mauser, Marie Morin, Rex Sallabanks, Nanette Seto, Gary Shugart, Chris Thompson, Dave Wesley, Robert E. Willis, Linda Wires, Roger A. Woodruff, and Tara Zimmerman. U.S. Fish and Wildlife Nongame staff in Portland contributed greatly to editing and formatting this document while under pressure to meet a tight deadline. Funding for this status assessment and compilation of much of the population data for the Pacific Coast was provided by the Division of Migratory Birds and Habitat Programs, U.S. Fish and Wildlife Service, Pacific Region, Portland, Oregon. This is Contribution 1,012 of PRBO Conservation Science.

SUMMARY

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 currently two-thirds of the Pacific Coast and one-quarter 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, eggng, 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 U.S. 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%).

Continentwide 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.

TAXONOMY

Common name: Caspian Tern
Scientific name: *Sterna caspia*
Order: Charadriiformes
Family: Laridae
Subfamily: Sterninae

This widespread species, with disjunct breeding populations on all continents but South America and Antarctica, is considered by most authorities to be monotypic (Cramp 1985; AOU 1957, 1998; Olsen and Larsson 1995).

LEGAL AND CONSERVATION STATUS

UNITED STATES

The Caspian Tern is designated a nongame migratory bird in the United States and was initially protected under the Convention for the Protection of Migratory Birds (1916) between the United States and Great Britain (acting on behalf of Canada). The Migratory Bird Treaty Act of 1918 established Federal responsibility for the conservation of this and other species of migratory birds. The Caspian Tern is not included on USFWS's list of Migratory Nongame Birds of Management Concern (USFWS 1995), National Audubon Society's Blue List from 1978 to 1986 (Tate 1981, Tate and Tate 1982, Tate 1986), or Partners in Flight's 1996 Watchlist (Carter et al. 1996). A conservation ranking of colonial waterbirds in the North American Waterbird Conservation Plan (NAWCP) places the Caspian Tern in a list of species of "Low Concern" (Kushlan et al. 2002). As of 1997, the Association for Biological Diversity ranked the Caspian Tern globally (rangewide) as Secure (G5) and for its U.S. range as Apparently Secure to Secure as a breeder (N4N5B) (NatureServe 2001). At the state level, the Caspian Tern is considered Endangered in Wisconsin, Threatened in Michigan, and a Species of Special Concern in Montana, New Jersey, Utah, Virginia, and Wyoming (Table 1). The USFWS's Birds of Conservation Concern 2002 (USFWS in prep) includes the Caspian Tern as a species of concern only in the North Pacific Coast Bird Conservation Region (BCR 5), which extends from coastal southern Alaska to coastal northern California (U.S. North American Bird Conservation Initiative Committee 2000). Bird Conservation Regions (BCRs) encompass landscapes having similar bird communities, habitats, and resource issues.

CANADA

In 1978, the Committee on the Status of Endangered Wildlife in Canada designated the Caspian Tern as "Rare" (synonymous with "Vulnerable" 1990-1999, "Special Concern" 2000 to present) (COSEWIC 2001). Reexamination in 1999 led to delisting it to "Not at Risk," despite a recommendation for retention of "Vulnerable" status (James 1999). The NAWCP status applies to Canada as well as the United States. As of 1997, the Association for Biological Diversity ranked the Caspian Tern in Canada as Vulnerable to Apparently Secure as a breeder (N3N4B) (NatureServe 2001). At the provincial/territorial level, the Caspian Tern is listed as Endangered in Québec and a Species of Special Concern (or equivalent) in Northwest Territories, Alberta, British Columbia, Ontario, and Manitoba (Table 1).

TABLE 1. Government and Natural Heritage conservation status rankings for the Caspian Tern in 30 states, provinces, and territories in North America by five distinct breeding populations (after Wires and Cuthbert 2000).

REGION - STATE, PROVINCE, OR TERRITORY	GOVERNMENT	NATURAL HERITAGE STATUS ^a
PACIFIC COAST/WESTERN		
Alaska	no status ^b	Vulnerable
British Columbia	Blue List (vulnerable) ^c	Vulnerable
Washington	no status ^b	Apparently Secure – Secure
Oregon	no status ^b	Apparently Secure?
California	no status ^b	Apparently Secure
Idaho	no status ^b	Critically Imperiled
Montana	Species of Special Concern	Imperiled
Wyoming	Species of Special Concern	Critically Imperiled
Nevada	no status ^b	Vulnerable – Apparently Secure
Utah	Species of Special Concern	Critically Imperiled
CENTRAL CANADA		
Northwest Territories	Sensitive	unranked
Alberta	Sensitive	Imperiled
Saskatchewan	no status ^b	Imperiled
Manitoba	Species of Special Concern	Vulnerable
GREAT LAKES		
Indiana	no status ^b	accidental breeder
Michigan	STATE THREATENED	Imperiled
Wisconsin	STATE ENDANGERED	Critically Imperiled
New York	no status ^b	Critically Imperiled
Ontario	Vulnerable (Species of Special Concern)	Vulnerable
Minnesota	no status ^b	unranked
ATLANTIC COAST		
Newfoundland and Labrador	no status ^b	Critically Imperiled
Quebec	PROVINCIALY ENDANGERED	Critically Imperiled
New Jersey	Species of Special Concern	no status assigned
Virginia	Species of Special Concern	Critically Imperiled
North Carolina	no status ^b	Critically Imperiled
GULF COAST		
Texas	no status ^b	Apparently Secure
Louisiana	no status ^b	Critically Imperiled – Imperiled
Alabama	no status ^b	Imperiled
Mississippi	no status ^b	accidental breeder
Florida	no status ^b	Imperiled

^a These are the verbal definitions of the Association of Biodiversity Information’s standardized Subnational (state or provincial level) Heritage Status Ranks signifying a numeric rank of relative imperilment (see the section on Conventions Used in the Text for additional details).

^b “No status” indicates that for a particular state or province the species is not listed as threatened or endangered nor is it given a specific conservation status designation such as “species of special concern” (or equivalent). It varies by state or province, though, whether the species is considered “protected” by a statute or rule as it is federally under the Migratory Bird Treaty Act.

^c Blue List are indigenous species or subspecies considered to be Vulnerable (at risk), i.e. are of special concern because of characteristics that make them particularly sensitive to human activities or natural events.

MEXICO

The Caspian Tern was included in the Convention between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Mammals in 1936, but the species is not protected under any specific legal status in Mexico and is not listed by the IUCN or CITES (InfoNatura 2001). The NAWCP status applies to Mexico as well as to Canada and the United States.

CENTRAL AND SOUTH AMERICAS

The Caspian Tern has no legal status in Central or South America and is not listed by the IUCN or CITES (InfoNatura 2001). The NAWCP status applies to Central America and the Caribbean (exclusive of islands associated with South American nations) as well as to Canada, the United States, and Mexico.

DESCRIPTION

The Caspian Tern is the largest tern, and its heavy build, broad-wings with bold black wedge on underside of outer primaries, and stout, conspicuous red bill render it unmistakable. In alternate plumage, adults have a black cap and short crest but otherwise white head, neck, and underparts; upperparts are pale gray with a white rump and tail (some tail feathers may be pale gray and outer primaries slightly darker); and underwings are white with a bold blackish patch on outer primaries (Howell and Webb 1995, Olsen and Larsson 1995). The bill is bright red to orange-red with a black subterminal ring and fine pale tip, legs and feet are black (orange to pink soles) and eye dark (set within dark cap). Adult basic plumage (from mid-summer) is much like alternate but with forecrown streaked or freckled white, bill duller than in summer (with broader black ring around tip), and outer primaries often darker (through wear). In juveniles, the black cap is streaked whitish to buff, narrow pale eye-ring present, upperparts have brown chevrons and spots, secondaries dusky terminally, tertials dark (edged white), and tail is pale gray with a darker subterminal band. Juvenile bill is reddish orange to orange with a dark tip, and legs are dull orange, soon becoming black. First summer plumage is much like adult basic but often shows dark carpal bar, bar on secondaries, dark outer primaries, and incomplete tail band; in second summer, may show white flecks in black cap and darker outer primaries than in adult.

GEOGRAPHIC DISTRIBUTION

BREEDING

In North America, the Caspian Tern breeds at widely scattered sites across the continent (Figure 1). In outlining patterns of regional distribution, we follow Wires and Cuthbert's (2000) descriptions of five more-or-less disjunct breeding regions (Figure 2). We recognize, though, that future advances in knowledge may warrant adjustment of regional boundaries, as greater clarity is needed, particularly with respect to small interior colonies in Idaho, Utah, Montana, Wyoming, and North Dakota. 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:



Fig. 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).



Fig. 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 (see text).

- (1) 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.
- (2) Central Canada – a locally rare to uncommon breeder in the Northwest Territories (Great Slave Lake), Alberta, central Saskatchewan, and a locally uncommon to abundant breeder in south-central Manitoba (mainly lakes Winnipeg and Winnipegosis).
- (3) Great Lakes – an uncommon to abundant breeder on Lake Michigan (Indiana [rare], Michigan, Wisconsin [rare]), Lake Ontario (Ontario, New York), and Lake Huron (Ontario, Michigan).
- (4) Atlantic Coast – a locally rare to uncommon breeder in Labrador, Newfoundland, southeastern Québec, Virginia, North Carolina and formerly, New Jersey, South Carolina, and Florida.
- (5) Gulf Coast – a locally fairly common breeder at scattered sites from coastal Texas to Tampa Bay, Florida (very rare in Mississippi).

MIGRATION

Although recorded year round in breeding areas on the southern Pacific Coast (southern California, west coast of Baja California, and Sinaloa), Gulf Coast, and southern Atlantic Coast (North Carolina southward), 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, as indicated by recoveries of a Great Lakes banded juvenile in the Dominican Republic in August (date unknown) and an adult in Columbia on 3 September (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, and San Francisco Bay and San Diego Bay, California, were 2,550 km, 1,930 km, and 1,640 km, respectively. Still, 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 800 and 1,500 km north of their natal colonies 2 months following banding. These may be the terns from San Francisco Bay that dispersed northward as far as interior Washington and Alberta (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 (north to Vancouver) 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. From the extreme outlying breeding colony in the Bering Sea at Neragon Island, Alaska, the potential migration distances are 4,300 km to the nearest Asian wintering area in Japan and nearly 5,000 km to the main wintering area in western North America in west Mexico (McCaffery et al. 1997).

Although migrants from some colonies in the interior of Oregon apparently follow the Columbia River to the Pacific Ocean (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). Although this sample size is very small, it suggests 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.

Band recoveries indicate Great Lakes' terns migrate to and from wintering areas on the Gulf and Atlantic coasts, the Caribbean, and northern South America via the Atlantic Coast and the Mississippi Flyway. At both seasons, birds apparently move between the Great Lakes and the mid-Atlantic region via lakes Erie and Ontario and traversal of New York and Pennsylvania (Ludwig 1965, L'Arrivée and Blokpoel 1988). The average distance banded birds traveled from the Great Lakes to areas where recovered in winter (Nov-Feb, $n = 46$ birds) was 2000 km (Ludwig 1942). Banded birds from the Great Lakes have dispersed well out of range to reach Manitoba, Nova Scotia, Newfoundland, the Pacific Coast of Columbia, and even England; evidence of some birds from Atlantic Canada suggest they were storm-driven (Ludwig 1965, L'Arrivée and Blokpoel 1988).

Very little appears to be known about the migration pathways of populations breeding in central Canada, the Atlantic Coast, and the Gulf Coast. On geographic grounds, it seems likely that Atlantic Coast birds follow the coastline south to winter in areas similar to those occupied by Great Lakes birds and return by the same route. Likewise, many Gulf Coast terns likely migrate along the coast to winter on the east coast of Mexico and perhaps Central America and the Caribbean Basin. Geography does not suggest whether terns from central Canada pass southward down the center of the continent, cross the Rockies to the Pacific Coast, move to the Atlantic Coast via the Great Lakes, or follow a combination of these depending on the colony of origin.

Also unknown are the sources of birds representing outlying records from areas such as the Hawaiian Islands (Oahu, Maui, and Hawaii) or the interior of western North America north to east-central Alaska and west-central Yukon (AOU 1998).

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 1). Details of regional distribution are provided below.

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). Band recoveries are concentrated on the central coast of west Mexico (Gill and Mewaldt 1983). Although unrecorded from El Salvador (Howell and Webb 1995), the species occurs on the Pacific Coast of Nicaragua (single inland record), Costa Rica (small numbers Golfo de Nicoya), and Panama (rare) (L'Arrivée and Blokpoel 1988, Ridgely and Gwynne 1989, Stiles and Skutch 1989). Single extralimital records are known for the Pacific Coast/slope of Columbia and Ecuador (L'Arrivée and Blokpoel 1988, Ridgely and Greenfield 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).

Atlantic, Gulf, and Caribbean Coasts

On the Atlantic and Gulf Coasts, the species winters regularly from southern North Carolina south around Florida to south Texas and south along Mexico to Honduras (Howell and Webb 1995, Bird Source 2001). On the Caribbean Coast/slope, the species is unrecorded in Nicaragua and Costa Rica (L'Arrivée and Blokpoel 1988, Stiles and Skutch 1989) but winters in small numbers in Panama (especially Canal area), Columbia (most from Cartagena to Santa Marta; inland along lower Magdalena River), and northwestern Venezuela (Hilty and Brown 1986, L'Arrivée and Blokpoel 1988, Ridgely and Gwynne 1989). Extralimital winter records to the north are from Michigan, Nova Scotia, and New Jersey (L'Arrivée and Blokpoel 1988, Sibley 1993) and to the south from Trinidad and French Guiana (Ffrench 1991, AOU 1998).

The Caspian Tern also winters inland in the United States, usually in smaller numbers, on large lakes and rivers of the coastal plain of Georgia, Alabama, Louisiana, Texas, and, most widely, on the Florida Peninsula (Lowery 1974, Oberholser 1974, Imhof 1976, Root 1988, Stevenson and Anderson 1994) and in Mexico, bridging the Pacific and Gulf coasts, in the Central Volcanic Belt and on the Atlantic Slope from Tamaulipas to Tabasco (Howell and Webb 1995).

In the West Indies, the Caspian Tern is rare and local in winter in the southern Bahamas, Cuba, Jamaica, Hispaniola, and Barbados; very rare on Puerto Rico and the Cayman Islands; and a vagrant in the northern Bahamas, St. Croix in the Virgin Islands, and the Lesser Antilles (St. Christopher, Antigua, Dominica, Martinique, and St. Lucia) (Raffaele et al. 1998).

Other than anecdotal observations, CBC data for the United States appear to be the only quantitative information available on the winter abundance of the Caspian Tern. Recent (1991-2000) counts show the bulk of the U.S. wintering population occurs in the Gulf Coast states and the Atlantic Coast of Florida (Table 2). Within that region, Root (1988) reported highest numbers on the Gulf Coast of Texas, from a bit north of Houston to south of Corpus Christi, and the east coast of Florida, just south of Cocoa Beach.

SUMMER NONBREEDING

Small numbers of Caspian Terns overwinter 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 2. Counts of Caspian Terns on Christmas Bird Counts in Canada and the continental United States, 1991-2000.^a

	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	1,130	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	1,135	715
North Carolina	14	15	17	11	3	2	4	1	1	0
South Carolina	119	47	63	106	109	16	120	16	27	20
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 counts 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.

NATURAL HISTORY

BREEDING

Nests and 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/m² 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.).

Caspian Terns typically nest in open, barren to sparsely vegetated areas, but also among or adjacent to driftwood, partly buried logs, rocks, or tall annual weeds (Bent 1921, Cuthbert and Wires 1999, Appendix 1). 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, Appendix 1). Adult terns may raise rim heights of nests by >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).

Reproductive Phenology

Nest site selection and scrape creation can occur within a few days following the terns' arrival at a colony (Collis et al. 1999, Cuthbert and Wires 1999). The earliest breeding pairs often arrive at colony locations 2 to 3 weeks before laying eggs somewhat synchronously with later arrivals. Earliest egg-laying dates vary annually and by latitude. Initiation of egg laying may range from the first week of April along the Gulf of Mexico and the southern California coast to the first week of June in central Canada (Vermeer 1972, Mitchel and Custer 1986, Cuthbert and Wires 1999). Egg laying at Oregon and Washington colonies has been detected as early as the third week in April (Collis et al. 2001a). Caspian Terns raise only one brood a year and lay most clutches within a 4 to 5 week period (Cuthbert and Wires 1999). Pairs that lose eggs or 1 to 2 week-old chicks will commonly renest within 2 to 3 weeks (Cuthbert and Wires 1999, Collis et al. 2001a). Renesting occurs through July in the Great Lakes and into at least mid-August on the coast of Oregon and Washington (Penland 1981, Cuthbert and Wires 1999, Collis et al. 2000). Clutch size is usually one

to three eggs (Cuthbert and Wires 1999). Eggs require 24-30 days to hatch with colony averages ranging from 25-27 days (Cuthbert and Wires 1999). Earliest hatch dates for Oregon and Washington are in the second week of May, but the peak is typically in the first week of June (Penland 1981, Roby et al. unpubl. data). The latest hatching date for replacement nests in Puget Sound was 1 September 2000 (C. Thompson unpubl. data). Given they fledge at approximately 5 weeks, most young have left colonies in coastal Washington and Oregon by mid- to late July. Young at some colonies (i.e., ASARCO, Commencement Bay, WA) that have fledged as late as early October (C. Thompson unpubl. data) presumably reflect late reneesting attempts. Parental care and feeding typically continues for several months, the longest period of parental care for any tern species (Cuthbert and Wires 1999). During this period of extended parental care juvenile Caspian Terns may learn migratory routes and scout potential future breeding locations.

It is unknown if Caspian Terns time reproduction on the basis of forage fish availability near their colony. Suggestions that Caspian Tern reproduction in the Columbia River estuary is timed to correspond with salmon smolt outmigration is confounded by the fact that Caspian Terns in non-salmon-bearing waters, such as southern California, may initiate breeding at the same time as those at the Columbia River (Keane 1998, Collis et al. 1999). By contrast, there can be considerable variation in the timing of egg laying at the local scale, as evidenced by a three- to four-week spread in the timing of peak egg laying among colonies in San Francisco Bay in 2002 (T. Adelsbach pers. comm.). An analysis of egg laying dates by latitude, climatic conditions, or ocean surface temperature is unavailable but needed.

Breeding Site Fidelity

Fidelity of Caspian Terns to breeding sites in successive years likely varies as a function of habitat stability. Many sites are ephemeral, and their suitability for nesting may vary with water levels, vegetation density, and forage fish populations as effected by droughts, floods, erosion, or other factors. Predators and human activity are also likely sources of disturbance that reduce colony site fidelity (Roby et al. 1998, Quinn and Sirdevan 1998, Cuthbert and Wires 1999). Cuthbert (1988) reported that adults at colonies in the Great Lakes show high fidelity to breeding sites used the previous year. However, comparable data are unavailable for other North American colonies.

Data on philopatry (adults returning to their natal colony) of Caspian Terns in the Pacific Coast population are minimal. Efforts to relocate banded terns have been strongly biased to colonies of the Columbia River. Only 39% (16 of 41) of the returns of breeding-age adults banded as nestlings at the Columbia River were from their natal colony (D. Craig et al. unpubl. data). Most (71%) of the non-natal-colony returns were of adults collected at Rice Island (1997-2000) that had been banded as young chicks on the Sand Island colony in Grays Harbor during the late 1970s or early 1980s. Although at first these data suggest fairly low philopatry, they are of very limited value, as the natal colonies in Grays Harbor were no longer available at the time of the Rice Island recoveries. Caspian Terns banded as chicks and adults in the Columbia River estuary in 1997-2000 have been collected during the breeding season in 2000 or 2001 at dams in the mid-Columbia River (i.e., Priest Rapids, Wanapum, and Rock Island dams) as part of an avian predator control program (C. Thompson unpubl. data). Although these may represent birds on foraging trips from Columbia River estuary colonies, these data suggest that some former Rice Island birds may have moved east to nest in upriver colonies.

Additional banding data that suggest low philopatry are from four adult terns originally banded as nestlings in Grays Harbor. These birds were recovered during the breeding season on or near an active colony in Malheur Basin (1), San Francisco Bay (1), and Salton Sea (2) (D. Craig unpubl. data). An additional banded adult tern was recovered at the Salton Sea after the breeding season (September), but the age of the carcass suggested the bird had died late in the breeding season (K. Molina pers. comm.).

There are few recent recoveries of banded terns north of their natal colony. Two birds banded as chicks in San Diego Bay were recovered in later years during the breeding season at colonies in San Francisco Bay (D. Craig unpubl. data). In 1999 and 2000, an adult tern was sighted on East Sand Island that had been color-banded as a chick at the Salton Sea in 1995 (D. Craig pers. obs.). In 2000, another tern banded in 1995 at the Salton Sea was observed on the breeding colony in Commencement Bay, Washington (D. Lyons pers. obs.). One Caspian Tern banded as a nestling in Grays Harbor was recovered in Alaska near the Copper River Delta (Orcas), where Caspian Terns have been suspected of breeding for 10 years (Gibson and Kessel 1992).

Demography and Limiting Factors

Band encounters for the last 20 years provide information on the longevity of Caspian Terns in the Pacific Coast population (D. Craig unpubl. analysis of U.S. Geological Survey Patuxent Wildlife Research Center Bird Banding Laboratory data). Encounters included Caspian Tern band numbers (of both live and dead birds) from the Western United States that were reported to the Bird Banding Lab. The average age of terns encountered throughout the Pacific Coast region that were of breeding age (after third year) was 10.4 years (SD = 5.3, range = 4–25 yrs, $n = 96$). More than half of these records were from birds banded in Grays Harbor (mean = 11.57 yrs, SD = 5.1, range = 4–25 yrs, $n = 54$). The average age for breeding terns banded at all other colonies was 8.98 years (SD = 5.3, range = 4–20 yrs, $n = 42$). One of these terns was 25 years old; the previous longevity record for a tern from the Pacific Coast population was 17 years (Gill and Mewaldt 1983). These high average ages are most likely an artifact of a change in banding effort through the years. The numbers of young Caspian Terns banded decreased after the early 1980s, while the Pacific Coast population size was increasing. Specific banding efforts include: 1981–1985 (2,978 banded), 1986–1990 (314), 1991–1995 (831), 1996–1999 (1,279). Seventy percent of the terns banded from 1981–1985 were banded as chicks in Grays Harbor; none were banded in Grays Harbor after 1984. Seventy-five percent of recent banding (1996–1999) in North America has been at Rice Island, Oregon (D. Craig unpubl. data).

Caspian Terns had an annual survival rate of 0.82 ± 0.01 (SE) for the pooled sample of all encounters in the Western United States from 1955–2000 (D. Roby unpubl. data). Annual survival rate was estimated by using Seber's (1970) parameterization of recovery model in program MARK (White and Burnham 1999); there was no significant difference in reporting rate between the non-breeding and breeding seasons. It is important to emphasize that the data set used to calculate this survival rate was relatively small (D. Roby unpubl. data).

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) (see Appendix 1).

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.

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.

Predators

Known avian predators of Caspian Tern eggs or chicks include the Herring Gull (*L. argentatus*), Western Gull, Glaucous-winged Gull, Western x Glaucous-winged Gull hybrids, California Gull (*L. californicus*), Ring-billed Gull (*L. delawarensis*), Common Raven (*Corvus corax*), and American Crow (*C. brachyrhynchos*) (Chanot 1970, Penland 1976, Roby et al. 1998). In 1987, Black-crowned Night-Herons (*Nycticorax nycticorax*) made nightly raids on Caspian Tern and California Gull colonies at Potholes Reservoir, Washington (G. Shugart pers. comm.). In 2000 and 2001, a mink (*Mustela vison*) made nocturnal attacks on incubating Caspian Terns at Threemile Canyon Island, Oregon (Collis et al. 2001b). The colony failed in both years and was abandoned in 2002 (M. Antolos pers. comm.). Other documented or suspected egg or chick predators include raccoon

(*Procyon lotor*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), western diamondback rattlesnake (*Crotalus atrox*), northern pike (*Esox lucius*), and marine fishes (Cuthbert and Wires 1999).

Predators known to have killed adult Caspian Tern include the Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Great Horned Owl (*Bubo virginianus*), red fox, and coyote (Roby et al. 1998, Cuthbert and Wires 1999). A pair of Common Ravens was also observed attacking an incubating adult, presumably to get at the nest contents (D. Craig pers. obs.). Predators may also cause considerable indirect mortality by inducing adults to abandon eggs and chicks on cold nights (G. Shugart pers. comm.).

Diet

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 wide 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 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 flavescens*), and suckers (*Catostomus* spp., Collis et al. 2002). Diet in Commencement Bay, Washington, in 2000 included 52% salmonids and a variety of other marine fish (Thompson et al. 2002). 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). The primary fishes in the diet of breeding Caspian Terns of coastal California, from San Francisco to San Diego, include shiner perch, sardine (*Sardinops sagax*), anchovy, and a couple of smelt species. In the Great Lakes, the tern diet consists primarily of alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), yellow perch, rock bass (*Ambloplites rupestris*), and other centrarchids (Shugart et al. 1978, Ewins et al. 1994, Cuthbert and Wires 1999).

MIGRATION

Although some occur year round along the Gulf of Mexico and southern California coast, 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). The timing of 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). 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, Mississippi River, Lake Erie, Lake Ontario, and both continental coasts (Cuthbert and Wires 1999).

HABITAT REQUIREMENTS

BREEDING SEASON

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, Appendix 1). 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 1997). Terns in Puget Sound, Washington, 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 litt.). 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 (Appendix 1). In the southern San Joaquin Valley of California, Caspian Tern colonies have formed on intact or broken levees of agricultural evaporation ponds, sewage ponds, floodwater storage basins, and flooded agricultural fields.

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, Appendix 1). Where they co-occurred in a California estuary, the Caspian Tern 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 29 km, and occasionally up to 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 15-20

km to forage at freshwater reservoirs (D. Shuford pers. obs.). In central Washington, Caspian Terns may fly 45-60 km from the nesting colony at Potholes Reservoir 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. 1998, Collis et al. 2001b). Aerial surveys of terns breeding on Rice Island in 1998 determined that 50% of all terns seen off the colony were within 8 km of the island, 75% within 15 km, and 90% within 21 km (Collis et al. 1998). 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).

MIGRATION

On migration, and during post-breeding dispersal, Caspian Terns frequent the same suite of habitats used while breeding: shallow estuarine or inshore marine habitats and freshwater lakes, marshes, refuge impoundments, sloughs, reservoirs, irrigation canals, and (low-salinity) saline lakes (Cuthbert and Wires 1999, Appendix 1). An abundance of fish prey and secure roosting sites appear to be characteristics of favored stopover sites, which often are the larger water bodies. These may be widely spaced, such as estuaries on the Pacific Coast or inland lakes in the arid West, or continuous, such as the chain of Great Lakes and the Mississippi River and its tributaries. Along the coast, Caspian Terns clearly favor estuarine habitats and secondarily inshore marine waters. Most migrants along the Pacific Coast appear to pass close to shore as evidenced by the rarity of sightings at the Farallon Islands 42 km off central California (Pyle and Henderson 1991) and at the Channel Islands off southern California (P. Collins pers. comm.). However, Caspian Terns that migrate to Caribbean Islands, and those reaching northern South America presumably via this route, must pass over long stretches of open ocean.

WINTER AND SUMMER NONBREEDING SEASONS

Habitats used in wintering areas, where non-breeders also oversummer, are similar to those used during migration and breeding, although concentrated more in coastal and near-coastal areas. In addition to the more coastal wintering distribution, the species' greater reliance on estuarine habitats on the wintering grounds is evidenced by the smaller size of tern populations on fresh water in winter compared to those breeding on the Great Lakes or on lakes Winnipeg and Winnipegosis in Manitoba. The northern limits of wintering on the Pacific and Atlantic coasts indicates the species avoids regions where the mean average ocean-surface temperature falls below 13°C (55° F) (Root 1988). Birds oversummering within the general breeding range but away from known colonies, or at areas along migratory pathways outside the breeding range, use the same suite of foraging and roosting habitats used near breeding colonies.

POPULATION ESTIMATES AND TRENDS

ESTIMATES

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 late 1980s to late 1990s (Spendelow and Patton 1988, Wires and Cuthbert 2000; Table 3). 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 3). 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 (see Appendix 1).

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 4). 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 3. Estimates of the Caspian Tern breeding population in the United States, by region, from 1976-1982 and 1996-1998.

	1976-1982 ^a		1996-1998 ^b	
	Estimated Pairs	% Population	Estimated Pairs	% Population
Pacific Coast	6,218	65.8%	14,534	69.4%
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		20,938	

^a Data from Spendelow and Patton (1988) with numbers of adults divided by two to roughly estimate 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 a range for the region then taking the mid-point of the range as the best estimate.

TABLE 4. 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 *Sterna* breeding in temperate and arctic regions of North America (exclusive of Hawaii).

Species	Population Size (adult breeders <i>not</i> pairs)	Conservation Status Category
Gull-billed Tern (<i>S. nilotica</i>)	6,000-8,000	High
Caspian Tern (<i>S. caspia</i>)	66,000-70,000	Low
Royal Tern (<i>S. maxima</i>)	100,000-150,000	Moderate
Elegant Tern (<i>S. elegans</i>)	34,000-60,000	Moderate
Sandwich Tern (<i>S. sandvicensis</i>)	75,000-100,000	Not currently at risk
Roseate Tern (<i>S. dougallii</i>)	16,000	High
Common Tern (<i>S. hirundo</i>)	300,000	Low
Arctic Tern (<i>S. paradisaea</i>)	Insufficient information	High
Forster's Tern (<i>S. forsteri</i>)	47,000-51,500	Moderate
Least Tern (<i>S. antillarum</i>)	60,000-100,000	High
Aleutian Tern (<i>S. aleutica</i>)	14,594	High

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.

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 (Spendelov 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. We do, however, provide additional perspectives and updated information as needed; details can be found in the relevant state and provincial accounts in Appendix 1.

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 3). In 2001, 84% of the regional population was on the coast and 16% in the interior (Table 5), nearly identical proportions to those in the late 1970s to early 1980s (Gill and Mewaldt 1983). The

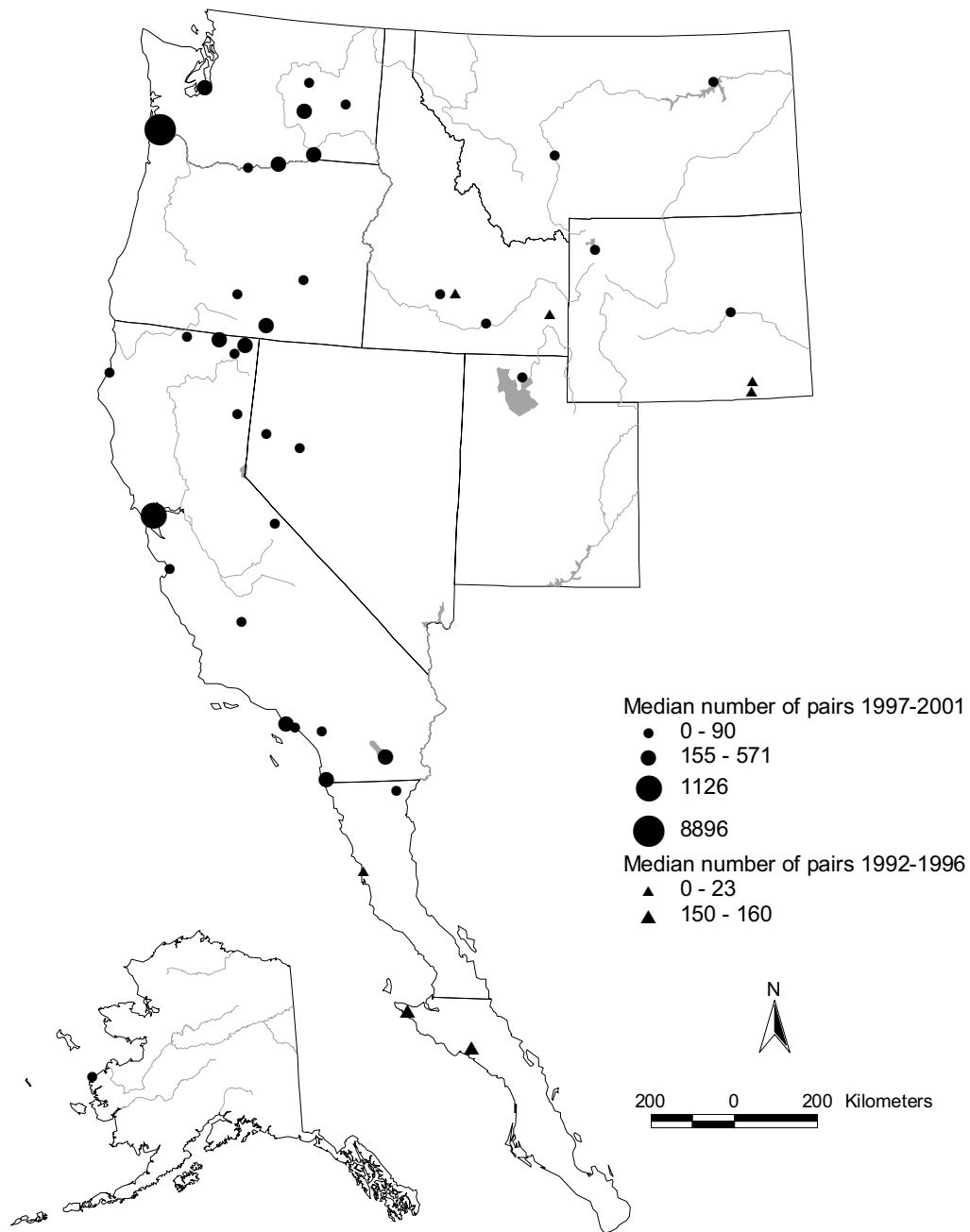


Fig. 3. Distribution and relative size of Caspian Tern colonies in the Pacific Region of western North America (see Table 5 for raw data, 1997-2001). Sites were mapped for 1992-1996 only if data were lacking for 1997-2001. The species has also bred at a number of other sites prior to 1992 and at some new sites in 2002 (see text).

TABLE 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						
<i>COASTAL BAYS</i>						
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
<i>MID-COLUMBIA RIVER</i>						
Miller Rocks, Klickitat Co.	0	—	—	—	—	15
Crescent Island, Walla Walla Co.	0	614 ^c	357 ^c	552 ^c	571	720
<i>COLUMBIA BASIN/PLATEAU</i>						
Banks Lake, Grant Co.	—	—	—	—	10	23
Potholes Reservoir, Grant Co.	100	259	—	—	150	~250
Sprague Lake, Adams Co.	—	—	—	~50	20	20
OREGON						
<i>COLUMBIA RIVER ESTUARY</i>						
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
<i>MID-COLUMBIA RIVER</i>						
Threemile Canyon Island, Morrow Co.	210	354 ^c	210 ^c	238 ^c	260	2
<i>GREAT BASIN</i>						
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
<i>SAN FRANCISCO BAY</i>						
Little Island, Napa Co.	(1,500) ^d	—	—	—	—	—
Knights Island, Solano Co.	300?	—	—	—	—	—
Brooks Island, Contra Costa 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 R1), 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
<i>CENTRAL AND SOUTHERN COAST</i>						
Moss Landing salt ponds	105 ^c	0	0	0	0	0

TABLE 5. (cont.) 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
Elkhorn Slough, Monterey Co.	0	0	0	~30	~80	~65
Bolsa Chica, Orange Co. ^c	0	175	40	58	51	92
Pier 400, Terminal Island, 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)						
<i>MODOC PLATEAU/GREAT BASIN</i>						
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	242 ^c	201
Goose Lake, Modoc Co.	200	143 ^c	—	310 ^c	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
<i>SAN JOAQUIN VALLEY, TULARE BASIN, (ALL KINGS CO.)</i>						
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
<i>COASTAL SLOPE, SERN CALIFORNIA</i>						
Lake Elsinore, Riverside Co.	—	—	—	14	—	—
<i>COLORADO DESERT</i>						
Salton Sea, Imperial Co.	0	1,200	800	211	207	327
MEXICO						
<i>BAJA CALIFORNIA</i>						
Cerro Prieto geothermal ponds, Mexicali Valley	—	30	34	—	0	0
IDAHO						
<i>SNAKE RIVER PLATEAU</i>						
Morman Reservoir, Camas Co.	—	—	—	—	—	~2
Magic Reservoir, Camas and Blaine cos.	20	—	—	—	—	0
Blackfoot Reservoir, Caribou Co.	5	—	—	—	—	0
Minidoka NWR, Cassia Co.	—	—	—	—	1	0

TABLE 5. (cont.) 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
Deer Flat NWR (Snake River Is.), Owyhee Co.	—	—	—	—	—	0
Bear Lake NWR, Bear Lake Co.	—	—	—	—	—	0
NEVADA						
<i>GREAT BASIN</i>						
Carson Sink, Churchill Co.	—	0	—	685	0	0
Anaho Island NWR, Pyramid Lake	6	1	5	0	0	0
Stillwater Point Reservoir, Stillwater NWR	5	0	0	0	0	0
MONTANA						
Canyon Lake Ferry Reservoir, Lewis and Clark Co.	—	5	0	2	7	35
Fort Peck Reservoir, Charles M. Russell NWR, Valley Co.	—	?	?	?	?	~25
WYOMING						
Molly Island, Yellowstone Lake, Yellowstone National Park	21	4	5	4	0	3
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. I-45) and the California interior (0.61, D. Shuford unpubl. 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 (Appendix 1).

^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 by Lehl (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. comm.), 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 correction factor 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 re-nest 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).

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, Appendix 1). Since at least the late 1970s about 99% of the regional population has been in Washington, Oregon, and California (Table 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 (Appendix 1). 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.

The population of the Caspian Tern in the Pacific states in the late 1970s to early 1980s was estimated to be about 5,780 pairs (84% coastal, 16% inland; Table 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 2000-2001 (see Table 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, Appendix 1). 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 may 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 overharvest, 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 (National Marine Fisheries Service 2000, Northwest Power Planning Council 2000). Since about the mid 1970s, the outmigration has been predominately comprised of 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).

In 1986, Caspian Terns established the colony on Rice Island, which experienced rapid growth through the 1990s. The initial growth of this colony appears to have been fueled by movement of terns from the large colonies at Grays Harbor and Willapa Bay, Washington. Thereafter, the continued growth and success of this colony 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 Naval 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.

Central Canada. Caspian Terns breed in the Northwest Territories, Alberta, Saskatchewan, and, particularly, Manitoba, which currently holds roughly 90% of the regional population (James 1999, Wires and Cuthbert 2000). Although Manitoba alone hosts one of the largest populations of Caspian Terns in North America, the data available for estimating breeding pairs are the poorest of any area because of the logistical difficulties of surveying the province's vast prairie lake complexes.

Trends have largely been driven by the fate of Manitoba's large populations at (and near) lakes Winnipeg and Winnipegosis. Vermeer (1970a) estimated a minimum of 2,245 pairs on these lakes from surveys of the largest colonies. A lower estimate of 1,393 pairs in 1979 apparently was an artifact of abandonment of the province's largest colony (near Long Point, Lake Winnipeg), due in part to disturbance just prior to the survey (Koonz and Rakowski 1985). An estimate of about 8,780-9,980 pairs in Manitoba in 1989-1992 (B. Koonz in Wires and Cuthbert 2000) was formed by summing counts from lakes Winnipeg (in 1992) and Winnipegosis (in 1989) with counts or gross estimates of numbers at other sites known or thought to hold small to moderate numbers. Counts seem to have been most consistent at Lake Winnipegosis: at least 710 pairs at 2 islands in 1970 (Vermeer 1970a), 2,763 at 5 islands in 1989 (McMahon and Koonz 1991), and 5,868 at 8 islands in 1999 (Koonz 1999). Although numbers increased in the 1970s and 1980s, the magnitude of change is unknown because of the lack of comprehensive surveys during that or any other period. Given the great annual fluctuations in numbers of breeding pairs, the lack of concurrent counts on the province's largest lakes, and the lack of any surveys at all on some lakes with known or suspected colonies, it is not yet possible to accurately estimate the size of the province's Caspian Tern population (B. Koonz pers. comm.). Given this uncertainty, B. Koonz (in litt.) in 2002 estimated the Manitoba population probably to be a minimum of 11,000 pairs with a maximum of perhaps double that.

The Caspian Tern population in the remainder of the region is relatively small, probably totaling 500-700 pairs (Wires and Cuthbert 2000). Numbers appear to be increasing in Alberta, but systematic surveys are lacking for Saskatchewan and unsuitable for trend assessment in the Northwest Territories.

Several factors may have lead to population increases of Caspian Terns in central Canada. Although diet studies of terns are lacking at Lake Winnipegosis, their prey base may have been greatly increased by human overexploitation of the lake's large predatory fish leading to "predator release" of now more abundant smaller species. These species occur in larger schools and shallower water than the previously dominant fish (Wires and Cuthbert 2000, B. Koonz pers. comm.). Other factors that may have aided tern population increases in Manitoba are restrictions on use of toxic chemicals, power dams that provide open water for feeding early and late in the season, reduced human disturbance, changing human attitudes, and the increased number of large power boats that cannot negotiate reefs near nesting colonies (Koonz 1999).

Great Lakes. The regional breeding population, currently about 6,416 pairs (on lakes Michigan, Ontario, and Huron), has nearly tripled since the 1960s, and, despite water level fluctuations, breeding habitat appears to be more stable than on the Pacific and Gulf coasts (Wires and Cuthbert 2000; Table 6, Appendix 1). Prior estimates of the breeding population of the Great Lakes were 1,995 pairs in 1963, 2,800 in 1967, 3,772 in 1977, 3,597 in 1978, 5,693 in 1987, and 6,335 in 1989-1990 (Ludwig 1979, Table 6). Numbers on Lake Ontario have increased geometrically from 47 pairs in the late 1970s to 2,212 pairs in the late 1990s (Table 6). On lakes Huron and Michigan, numbers increased in the 1970s and 1980s then declined in the late 1990s, particularly on Lake Huron (29% decline in 1990s). The increases on Lake Ontario generally have offset the losses on lakes Michigan and Huron to maintain a relatively stable regional population in the 1990s. The lake shares of the Great Lakes population in 1997-1998 were: lakes Michigan (37%), Ontario (34%), and Huron (28%); and the state/provincial shares were: Michigan (42%), Ontario (38%), New York (19%), and Indiana and Wisconsin (0.7%).

Wires and Cuthbert (2000) suggested that increases in the Great Lakes tern population may have been enabled by human alteration of native fish communities. From the late 1930s to the 1950s, large predatory fish populations, primarily lake trout (*Salvelinus namaycush*) and secondarily bubot (*Lota lota*), declined dramatically from long-term overfishing, invasion of the sea lamprey (*Petromyzon marinus*), loss of spawning areas, and perhaps increased contaminant levels. These declines lead to unprecedented population explosions of smaller fish species, mainly alewife and rainbow smelt, which by 1955 served as abundant prey for the terns (Ludwig 1965, 1991). The causes of tern population increases may be more complex than suggested, though, as indicated by the patterns of change in fish stocks and tern populations in Lake Ontario. Alewives were already abundant in Lake Ontario by at least the early 1930s (Ludwig 1965), but tern populations did not increase dramatically on this lake until the 1980s and 1990s, when populations on lakes Huron and Michigan were declining (Table 6).

Gulf Coast. Breeding on the coast from Texas to Florida, Caspian Terns in this region also tend to shift colony sites frequently (Wires and Cuthbert 2000, Appendix 1). The regional population, currently at about 2,700 breeding pairs (Table 7), has roughly doubled since the mid-1970s driven largely by trends in Louisiana (500 pairs in 1967, 170 in 1976, 820 in 1997), Alabama (66 in 1976,

TABLE 6. Numbers of breeding pairs of Caspian Terns from four comprehensive surveys of colonies on the Great Lakes of Canada and the United States.

COLONY SITE	1976-1980 ^a	1987 ^b	1989/1990 ^c	1997/1998 ^d
LAKE ONTARIO				
<i>ONTARIO</i>				
Pigeon I.	40	458	479	130
Gull Island, Presqui'le Provincial Park	0	36	102	442
Leslie Spit/Tommy Thompson Park (aka Eastern Headland)	7	45	0	3
Hamilton Harbour, North Island	nh ^e	nh ^e	nh ^e	303
Hamilton Harbour, Middle Island	nh ^e	nh ^e	nh ^e	130
Hamilton Harbour, Eastport	0	134	184	0
<i>NEW YORK</i>				
Little Galloo Island	0	35	320	1204
<i>Lake Ontario subtotal</i>	47	708	1085	2212
LAKE HURON				
<i>ONTARIO</i>				
Georgian Bay, South Watcher Island	523	764	747	571
Georgian Bay, North Watcher Island	139	0	38	0
Georgian Bay, North Island of South Limestone Islands	334	321	433	279
Georgian Bay, Halfmoon Island	259	98	207	0
Georgian Bay, largest island of the Gull Rocks	0	0	47	107
Georgian Bay, Papoose Island	202	35	220	134
Georgian Bay, Gull Island	134	282	0	–
North Channel, Elm Island	152	243	224	206
North Channel, East Island of the Cousins Islands	395	543	379	130
North Channel, Ironsides Reef	0	0	0	2
<i>MICHIGAN</i>				
Thunder Bay Island	0	0	39	9
Little Charity Island	0	0	29	56
Saginaw Confined Disposal Facility	nh ^e	277	206	324
<i>Lake Huron subtotal</i>	2,138	2,563	2,569	1,818

TABLE 6. (cont.) Numbers of breeding pairs of Caspian Terns from four comprehensive surveys of colonies on the Great Lakes of Canada and the United States.

COLONY SITE	1976-1980 ^a	1987 ^b	1989/1990 ^c	1997/1998 ^d
LAKE MICHIGAN				
<i>INDIANA</i>				
LTV Steel Plant	0	0	0	>40
<i>MICHIGAN</i> ^f				
Gravelly Island	550 (537)	584	612	1,027
High Island	63 (30)	430	939	0
Gull Island	0	0	0	566
Big Gull Island	0 (0)	301	540	0
Little Gull Island	0 (22)	0	0	0
Hat Island	730 (686)	955	437	604
Ile aux Galets	316 (312)	152	144	143
<i>WISCONSIN</i>				
Kidney Island	0	0	9	4
Kewaunee Confined Disposal Facility	0	0	0	2
Lake Michigan subtotal	1,659 (1,587)	2,422	2,681	2,386
Canadian subtotal	2,185	2,959	3,060	2,437
United States subtotal	1,659 (1,587)	2,734	3,275	3,979
GREAT LAKES TOTAL	3,844 (3,772)	5,693	6,335	6,416

^a Data for Canada for 1976-1980 from Blokpoel and Tessier (1996, 1997) and for the United States for 1976 and 1977 from Scharf et al. (1978).

^b Data for 1987 from Blokpoel and Scharf (1991).

^c Data for 1989 and 1990 for Canada from Blokpoel and Tessier (1996, 1997) and for the United States from Scharf and Shugart (1998).

^d Data of the United States for 1997 from F. Cuthbert in litt. and for Canada for 1998 from Canadian Wildlife Service unpublished data (C. Pekarik and D. V. C. Weseloh in litt.).

^e nh = no nesting habitat available at these sites at the time of surveys.

^f Surveys for Caspian Terns were conducted on the U.S. Great Lakes in both 1976 and 1977 (Scharf et al. 1978).

Although data for these years are presented here outside and inside parentheses, respectively, the 1977 survey was considered a complete count and the one subsequently used for assessing population trends in the Great Lakes (L. Wires in litt.).

TABLE 7. Numbers of breeding pairs of Caspian Terns from two comprehensive surveys of colonies on the Gulf Coast of the United States.

Colony Site	1976 ^a	1997 ^b
TEXAS^c	139	0
Marker 91 Spoil Island	–	80
Marker 69 Spoil Island	–	16
South Bird Island	66	0
North of Bird Island Marker 43	–	2
Marker 37-38 Spoil	–	1
Pita Island	–	63
Kennedy Causeway Islands	25	30
Naval Air Station Islands	0	40
Marker 63-65 Spoil Island	–	15
Turnstake Island	51	0
Seadrift Island	0	2
Laguna Vista Spoil	–	50
Four Islands	0	25
South Land Cut	0	39
Green Island Spoils	35	70
Lavaca Bay Spoil Marker 63-77	197	253
South Deer Island	50	75
Dressing Point	0	65
Shamrock Island	0	60
West Nueces Bay	96	8
East Nueces Bay	40	39
Pelican Island Spoil	20	0
South Baffin Bay Island	7	120
Marker 103-117 Spoil	7	0
Aransas Channel Spoil	25	0
Long Reef-Deadman Island	126	0
Causeway Island Platforms	60	2
Second Chain of Islands	28	186
<i>Texas subtotal</i>	972	1,241

TABLE 7. (cont.) Numbers of breeding pairs of Caspian Terns from two comprehensive surveys of colonies on the Gulf Coast of the United States.

Colony Site	1976 ^a	1997 ^b
LOUISIANA^d		
Curlew Island	25	B
Isla au Pitre	27	B
Mitchell Key	93	B
Wine Island	25	0
<i>Louisiana subtotal</i>	170	820
MISSISSIPPI		
Horn Island Pass, spoil island	2	0
ALABAMA^e		
Dauphin I., north spoil island	66	0
Gaillard Island	0	522
<i>Alabama subtotal</i>	66	522
FLORIDA^f		
Apalachicola Bay, 1995 Dredge Island	nh ^g	39
Alafia Banks	0	67
<i>Florida subtotal</i>	0	106
GULF COAST TOTAL	1,210	2,689

^a Data for 1976 for Texas are from the Texas Colonial Waterbird Survey (W. Roach and P. Glass unpubl. data). The data for other states originally reported in Portnoy (1977) as adults birds at colonies are converted here to estimated breeding pairs (see Table 5 for conversion factor). Dashes (–) indicate area not surveyed.

^b Data for 1997 are from a variety of sources noted at the state level.

^c Data for 1997 for Texas are from W. Roach and P. Glass (unpubl. data).

^d Data for total breeding pairs in Louisiana in 1997 are from G. Lester and B. Vermillion (in Wires and Cuthbert 2000). B indicates breeding according to Visser and Peterson's (1999) observations of 1012 adults at 10 colonies in 1997. Original 1997 data for Louisiana was unavailable to resolve apparent differences between the two data sets at this time.

^e Data for 1997 for Alabama from R. Clay (unpubl. data).

^f Data for 1997 for Florida from Pranty (1997) and R. Paul (unpubl. data). Data for the periods reported here are all from the Gulf Coast of Florida though the species has bred on the Atlantic coast of this state.

^g nh = no nesting habitat available at these sites at the time of surveys.

522 in 1997), and Florida (1 in 1962, 57 in 1976-1978, 84-122 in 1995-1997) (Clapp et al. 1983, McNair 2000, Wires and Cuthbert 2000, Table 7). Numbers in Texas have been relatively stable overall since the 1970s, but sometimes fluctuating greatly annually, i.e., from 549-2,700 pairs (median = 925, mean = 1028; Table 7, Appendix 1). Reflecting the increases in other states, the proportion of the Gulf Coast population found in Texas decreased from about 80-86% in 1976-1980 (Spendelov and Patton 1988, Table 7) to 37-46% in 1997-1996 (Wires and Cuthbert 2000, Table 7). The small numbers (up to 15 pairs) documented breeding in Mississippi from 1966-1976 (McNair 2000) are inconsequential relative to regional trends.

Atlantic Coast. Caspian Terns breed in the region in three disjunct areas: Canada, New Jersey (intermittently), and the southern Atlantic states (Wires and Cuthbert 2000, Appendix 1). Although always relatively small, this population has declined, and in 1995-1997 only four colonies were known to be active (one each in Newfoundland, Québec, Virginia, and North Carolina). In Canada, declines in Québec (200 pairs in the 1880s, 60 in 1925, 0-14 in 1990-1996, 0 in 1997-2001) and Labrador (200 pairs in 1887, ~2 in 1979) have been offset to a limited degree by a recent increase in Newfoundland (28 pairs in 1986, 75-125 in 1997-2001). In the southern Atlantic states, early-century breeding records are known only from Virginia prior to 1916; accounts of actual nest records (1879-1915) range from 1-12 pairs, but other active observers (1888-1895) indicated the species formerly bred “abundantly” (Weske et al. 1977, McNair 2000). Recolonization of the southern Atlantic coast beginning in 1970 led to establishment of short-term breeding colonies at single sites in South Carolina (1-2 pairs, 1970-1974) and central Florida (1-10 pairs, 1973-1980), small numbers locally in Virginia (1-4 pairs, 1974-1997), and increasing numbers at one to four sites in North Carolina (1-5 pairs in 1972-1975, 26-37 pairs in 1995-1997) (Parnell and Soots 1976, McNair 2000, Wires and Cuthbert 2000). Harvest for the millinery trade and eggging (Nettleship and Locke 1973, Weske et al. 1977) seem sufficient to explain early declines but not the lack of a rebound after release of these pressures. Bailey (1913), though, cited changing conditions on the islands, rather than harvest, as the main cause suspected for the early-century decline in Virginia.

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 1966-1979 but not for 1980-2000 or 1966-2000. Moreover, data had a deficiency survey-wide and an important deficiency for most states, provinces, strata, and regions that were analyzed. Given the limitations imposed by a methodology designed to survey birds via driving routes scattered randomly over the continent (see discussion under Monitoring Activities below), it is not surprising that the BBS would have difficulty tracking trends of the Caspian Tern, as most of its continental population is concentrated at a couple of key estuaries, several very large inland lakes, and scattered islands along the Gulf Coast.

Christmas Bird Count Trends

Although rigorous analyses of CBC data for Caspian Terns apparently have not been conducted (see Monitoring Activities section below), there does not appear to have been a unidirectional trend in wintering numbers in the United States over the last decade (Table 2). Raw CBC data suggest

relatively stable numbers of wintering Caspian Terns in the United States from 1991-1996, substantially higher numbers from 1997-1999, then a decline to the lowest numbers of the decade in 2000.

THREATS

OVERUTILIZATION

Historically, humans severely harmed Caspian Tern colonies by collecting hundreds of eggs and adults for food and feathers, most notably on the Atlantic Coast, Great Lakes, and Klamath Basin (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). Ludwig (1965) reported that shooting was the cause of death for 21% (77 of 37) of the recoveries of Caspian Terns banded in the Great Lakes; in regions beyond the southern United States where terns are taken for food, 57% (28 of 49) of the recoveries were of birds shot.

ADEQUACY OF EXISTING REGULATORY MECHANISMS

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. Table 1 contains a summary of the legal status of the species in the states and provinces throughout the Caspian Tern breeding range.

Some of the wetland breeding habitat used by Caspian Terns in the United States is provided limited protection by the Cleanwater 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 1985-1995 (Dahl et al. 1997). Although many Caspian Tern colonies are located on public lands, which provides some protection through access regulations and management, future ownership and management of the largest breeding concentration in the Columbia River (East Sand Island) is uncertain (see Management Activities).

Most countries in the wintering range have no legal mechanism to protect Caspian Terns or their habitats. In countries that do have some provisions for protection, enforcement and effectiveness are variable.

HABITAT LOSS AND DEGRADATION

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.

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. Before dams, dikes, jetties, and draining reduced the processes that generated early seral stage habitats, the use of ephemeral sand and gravel bars on islands was likely an important part of the tern's breeding strategy. 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 on the Pacific Coast (Sand Island, Grays Harbor, Washington; Sand Island, north Humboldt Bay, California; East Sand Island, Columbia River estuary, Oregon; Alameda Naval Air Station, San Francisco Bay, California) and in Ontario, Canada (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 (see Appendix 1). Overall at least five historic nesting sites on the Pacific Coast have been lost to natural processes, such as vegetative succession, erosion, or inundation (Appendix 1).

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 litt.). 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, Oregon, 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 at the Salton Sea, California, where increasing salinity may within one to two decades severely affect fish populations and by extension

key piscivores such as the Caspian Tern (Appendix 1). Likewise, changing water priorities and drought in the Klamath Basin may possibly reduce both foraging and nesting habitat for Caspian Terns.

DISEASE AND 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. Still, there are multiple accounts from around North America of individual colonies being rapidly destroyed or severely impacted by mammalian predators, especially foxes, coyotes, raccoons, feral cats (*Felis catus*), and mink (see Appendix 1). Individual eagles, falcons, or owls can also pose serious threats to a Caspian Tern colony. 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 (i.e., synchronous flight of adults that usually last less than half a minute; 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 1978, 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 virginianus*) that were thought to be released by someone intent on destroying Caspian Tern nests at Rice Island (Collis et al. 1998).

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).

PESTICIDES AND 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 pre-fledging 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 resuspended 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 resuspension 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 (Grassman 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; Grassman 1996, 1998; Bruehler and de Peyster 1999).

HUMAN DISTURBANCE

Human disturbance is a well known cause of reproductive failure in a wide range of seabirds (Carney and Sydeman 1999, but also see Nisbet 2000 and 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. In a Lake Michigan study, Cuthbert (1981) attributed 22% of reproductive failure to researcher visits that resulted in nest desertion. Shugart et al. (1978) attributed abandonment of nests and eggs by 445 pairs of terns (66% of colony) to a single day of cannon-netting efforts in the first two weeks of incubation. At Rice Island, Oregon, use of a cannon net to capture adults prospecting a traditional breeding location resulted in less than 5% of marked birds returning to that colony site following capture (D. Roby et al. unpubl. data). This low percentage may have also been influenced by the social attraction effort implemented concurrently on East Sand Island.

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 litt.). 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 mid-day 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.

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 (see Disease and Predation and Concentration Risk).

POPULATION SIZE AND 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. On the other hand, the smallest and most isolated Caspian Tern colonies, such as those in Québec, are in theory vulnerable to not being recolonized after displacement by stochastic events such as catastrophic storms, habitat loss, or disturbance (Martins 1997).

CONCENTRATION RISK

Natural and human-caused events have reduced or eliminated habitat at many colonies. In the Pacific Coast region, 8 of 15 historic colonies have been lost or abandoned in the last 20 years (Appendix 1). 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).

MONITORING ACTIVITIES

REGIONAL SURVEYS

Currently, censuses of Caspian Terns in most states, provinces, and territories are conducted as part of periodic, multi-species surveys for various colonial waterbirds. In cases where the colonial waterbird fauna is dominated by larids (gulls, terns, and skimmers) and ciconiiformes (herons, egrets, ibis, and storks), Caspian Terns are usually well surveyed (Texas Colonial Waterbird Society 1982, Blokpoel and Tessier 1996). In other cases where the colonial waterbird fauna is dominated by seabirds (storm-petrels, cormorants, and murres) breeding primarily on offshore rocks and islands, Caspian Terns may not be surveyed directly but ancillary data (often incomplete) may be included in seabird catalogues (Sowls et al. 1980, Carter et al. 1992). In some cases, surveys are conducted annually for a number of years (e.g., Texas, 1973-1980; Texas Colonial Waterbird Society 1982); in others, surveys are at longer intervals (e.g., Great Lakes, about every 10 years; F. Cuthbert in litt.). Some of these broadscale surveys have been funded in response to environmental concerns over disposal of dredge spoils or offshore oil drilling (Chaney et al. 1978, Carter et al. 1992).

Rapid shifts in the distribution and abundance of terns makes it difficult to assess state or local trends over short time periods. For example, the apparent increase of the California population from the early 1980s to late 1990s (Wires and Cuthbert 2000, Table 5, Appendix 1) was largely an artifact of a short-lived increase at the Salton Sea. After 30 pairs recolonized that site in 1992, breeding numbers increased to 1,500 pairs in 1996 then declined to about 200-325 pairs in 1999-2001 (Molina 2001). When accurate data are needed to inform management decisions, more frequent surveys are usually required. This has been the case in the Pacific states, where in response to tern-fisheries conflicts since the late 1990s USFWS and PRBO Conservation Science have coordinated regionwide colony surveys annually since 2000 (see Appendix 1, Table 5).

BREEDING BIRD SURVEY

The BBS has been run annually since 1966 and is the only survey that provides trend estimates for the Caspian Tern throughout the United States and Canada (Sauer et al. 2001). BBS methodology, though, is known to be deficient in surveying wetland birds, colonial nesters, and certain other species (Bystrak 1981, Robbins et al. 1986). Peterjohn and Sauer (1997) reported that the BBS provides imprecise trend estimates for the Black Tern (*Chlidonias niger*) resulting from their semicolonial nesting habits, considerable annual fluctuations in population size, and, perhaps, because roadside sampling of wetlands may not be a representative subset of all habitats used by the

species. These drawbacks are probably even greater for the Caspian Tern given its highly colonial nesting habits, the relatively few colonies in any given region, and the disjunct nature of the regional breeding populations in North America. Sauer et al. (2001) calculated BBS trends for the Caspian Tern for 34 regions in the United States and Canada and concluded that the data had an “important deficiency” in 30 regions and a “deficiency” in 4 regions.

CHRISTMAS BIRD COUNT

The CBC provides a continentwide perspective on the early winter distribution and abundance of birds in North America. The number of count circles has grown exponentially from 25 in 1900 to 1,823 in 2000 (BirdSource 2001). Analyses of trends are available for some species (through 1988) but not for the Caspian Tern (Sauer et al. 1996).

MANAGEMENT ACTIVITIES

Management strategies for seabirds generally fall into two broad categories: (1) protection at the ecosystem level and (2) active management at the species or colony level (Kress 1998). Management for the Caspian Tern has largely been targeted at the species and colony level via these general measures (often used in combination): habitat and vegetation management, use of artificial nest substrates, social attraction, predator management, and minimization of disturbance. A current management plan to resolve fisheries conflicts in the lower Columbia River estuary seeks to manage Caspian Terns on a regional level by a multi-faceted, step-wise approach (Interagency Caspian Tern Working Group 2000). The goal is to reduce predation rates on at-risk salmonid populations by dispersing the Columbia River’s highly concentrated terns to a number of smaller colonies over a wider area, thereby minimizing the impacts of the terns on any one fishery. These efforts will be part of a long-range comprehensive plan in support of recovery efforts for salmonids in the Columbia River Basin, which includes habitat enhancement and management of harvest, hatchery production, and hydroelectric operations.

Whether management is focused at the colony, regional, or ecosystem level, effective techniques and strategies will vary among sites or at the same site over time. Hence, management and selection of restoration sites must be fine tuned to local conditions and constraints, both biological and political, and adaptively modified as new information is gained, particularly as novel methods are tried and perfected (Kress 1998). Given seabirds are long-lived, management and restoration projects must of necessity be long-term in nature (measured by the decade rather than year), and, thus, to be effective require extraordinary commitment of individuals and administrative and financial support.

MANAGEMENT ACTIVITIES IN THE COLUMBIA RIVER ESTUARY

Under the Endangered Species Act, the National Marine Fisheries Service (NMFS) and USFWS are responsible for assessing the potential impacts of federal actions on species listed as federally threatened or endangered. Where potential adverse effects may result from a federal action, NMFS and/or USFWS issues Biological Opinions (BO) to the federal action agency with mandatory terms and conditions and discretionary conservation recommendations to reduce impacts.

In 1995, NMFS issued a BO for listed salmonids on the Operation of the Federal Columbia River Power System to the Corps of Engineers (Corps). NMFS required the Corps to “...conduct studies to identify (a) Caspian tern predation of juvenile salmonids, and (b) methods to discourage tern nesting...” Research was initiated in 1997 to estimate the number of smolts consumed by Caspian Terns in the Columbia River estuary. Research results from 1997 and 1998 indicated that Caspian Terns nesting on Rice Island consumed more juvenile salmonids than any other prey type (Roby et al. 1998). In response to these findings, NMFS requested immediate remedial action to reduce impacts to threatened salmon.

In 1999, NMFS issued a second BO to the Corps with direction to manage the magnitude of Caspian Tern predation in the estuary. This BO on the Columbia River Channel Operation and Maintenance Program required the Corps to “...modify the habitat on Rice Island by April 1, 2000, so that it is no longer suitable as a nesting site for Caspian terns or provide for the hazing of terns off the island in a manner that will preclude their nesting...” The requirement was designed to reduce levels of tern predation on out-migrating smolts.

In 1999 and 2000, the Corps attempted to relocate the Rice Island Caspian Tern colony to East Sand Island, an island closer to the mouth of the Columbia River than Rice Island. This action was designed to meet the stipulations in the 1999 NMFS BO to eliminate tern nesting on Rice Island, reduce tern predation on salmon smolts, and provide appropriate habitat for the Caspian Tern population displaced by the project.

In 2000, Seattle Audubon, National Audubon, American Bird Conservancy, and Defenders of Wildlife filed a lawsuit against the Corps and USFWS on the basis that compliance with the National Environmental Policy Act for the proposed action was insufficient and in objection to the potential take of eggs as a means to prevent nesting on Rice Island. In 2002, all parties reached a settlement agreement. Terms of the agreement require the provision of approximately six acres of habitat for Caspian Terns on East Sand Island and the prohibition of lethal take of adults or eggs on Rice Island. The settlement agreement also stipulates federal agencies will complete three technical reports. These include an avian predation analysis to assess the significance and effect of Caspian Tern predation on salmon recovery in the Columbia River estuary, a Caspian Tern status assessment (this document) to review the distribution, abundance, and conservation needs of Caspian Terns in North America, and a feasibility analysis of establishing alternate nesting sites for some of the terns in the Columbia River estuary. Additionally, USFWS, NMFS, and Corps will prepare an Environmental Impact Statement to address salmon smolt predation and Caspian Tern management in the Columbia River estuary.

HABITAT AND VEGETATION MANAGEMENT

Habitat has been altered or created in various ways to enhance (or sometimes decrease) its suitability for nesting Caspian Terns. Creation of suitable habitat may involve construction of artificial islands designed for use by multiple species, as was done in Hamilton Harbour, Ontario (Quinn et al. 1996). Important overall design features of these islands were (1) the ability to withstand 25 to 50 year flood events (base of coarse rocks, the largest placed on windward side), (2) an area of calm water on the lee side allowing growth of submerged vegetation and fish spawning habitat to increase the number of species and population sizes of fish, and (3) the preparation of various areas with

substrates, vegetation, or artificial structures suitable for individual nesting species (Pekarik et al. 1997). It may be important to create multiple suitable nesting sites, even if not all are used at any one time, to offset changes, such as vegetative succession, drought, flood regimes, and build ups of predator populations, that influence the selection of nesting sites by terns.

Prior to construction of the artificial islands at Hamilton Harbor, Quinn and Sirdevan (1998) tested three substrate types for tern nesting preferences to facilitate placement of an appropriate nesting substrate for Caspian Terns. On the basis of their results of a preference of sand over pea gravel and crushed stone, and indirect evidence of preference of experimental substrates over pre-existing hard-packed ground, the proposed tern nesting area was surfaced with sand (and some gravel for nest lining), and the terns successfully colonized (Pekarik et al. 1997, Quinn and Sirdevan 1998). Suitability of the tern designated areas was maintained early in the season by covering them with heavy gauge plastic sheeting (to prevent gull nesting), which was removed shortly after the arrival of the terns. Recognizing the need to manage so that vegetation succession did not reduce suitability of colonial waterbird nesting habitat, Quinn et al. (1996) proposed planting a low-lying xerophytic plant on artificial islands in Hamilton Harbour, presumably to preclude establishment of plants taller in stature.

In some instances, Caspian Terns have colonized islands designed and constructed for another (single) species. In 1986, Caspian Terns colonized sandy islands first created in 1978 for the endangered California Least Tern at Bolsa Chica Ecological Reserve on the southern California coast (Collins et al. 1991). In other cases, Caspian Terns have colonized islands or levees created as disposal sites for dredge spoils, which only later were managed for colonial nesting terns or other waterbirds (Landin and Soots 1977, Clay 1992, Collis et al. 2001b).

Sometimes the suitability of existing islands for nesting terns has been enhanced (or reduced) by substrate and vegetation management. Efforts initiated in 1999 to lessen the impact of tern predation on salmon in the lower Columbia River focused on reducing the suitability of tern nesting habitat on Rice Island (up river), where the tern diet is dominated by salmonids, and enhancing nesting habitat on East Sand Island (closer to the ocean), where the tern diet includes more marine and estuarine species of fish (Roby et al. 2002). Efforts to discourage tern nesting at Rice Island included winter wheat plantings, placement of streamers and silt fencing, and hazing using eagle decoys and human harassment. Management on Rice Island was coupled with efforts to attract terns at East Sand Island, which included vegetation removal to restore bare-sand nesting habitat and provide a buffer zone from gulls, use of decoys and audio playback, and limited gull removal (Roby et al. 2002). By 2000 and 2001, respectively, these efforts were successful in relocating about 94% and 100% of the Rice Island tern colony to East Sand Island (Roby et al. 2002). On the California coast, vegetation has been clipped or uprooted annually at Elkhorn Slough and Bolsa Chica to maintain suitable habitat for nesting terns (Parkin 1998, C. Collins in litt.).

ARTIFICIAL NEST PLATFORMS

Since at least 1970, artificial structures have been successfully used to attract various species of nesting terns (Dunlop et al. 1991 and references therein). To date, nesting rafts for Caspian Terns (in the Great Lakes and Commencement Bay, Washington) have been used only as interim management solutions until more permanent nesting sites could be identified or constructed (Lampman et al. 1996, Pekarik et al. 1997, Collis et al. in press).

To determine the feasibility of relocating Caspian Terns from a colony threatened by development, Lampman et al. (1996) built and installed an artificial platform in Hamilton Harbour, Ontario, which was occupied by 2 pairs in 1993, 6 pairs in 1994, and 50 pairs in 1995. The raft was used to encourage Caspian Terns to nest at a “transition” location before attempting to attract them to islands soon to be built for multiple species (Pekarik et al. 1997). The Caspian Tern raft was made of 12 units (each 1.2 m x 2.4 m) covered with sand, gravel, and scattered pieces of driftwood and other debris, and it was located close to known Caspian Tern colony sites (Lampman et al. 1996). To increase the chances for colony establishment, biologists set out decoys and played tern vocalizations. To discourage early-nesting Ring-billed Gulls, they covered the raft with a tarpaulin until large numbers of terns had returned to the area. Tapes were played only in 1993 and 1994, and terns colonized the raft in 1994 after playing of tapes was terminated. The high reproductive success (about 97 fledglings from 50 nests) in 1995 was encouraging, but limited conclusions can be drawn from comparisons of success on natural or artificial islands to that of this single raft study.

Similarly, in 2001 researchers deployed a small sand-covered barge (with decoys and a tape playback system), in Commencement Bay, Washington. This effort was implemented to test the feasibility of using barges as temporary colony sites for assessing the suitability of alternative sites for permanent colony restoration (Collis et al. in press). This provided an opportunity to examine tern diet composition, particularly salmon consumption, as an important gauge of whether or not permanent colony relocation might reduce impacts on salmon populations in the Columbia River estuary or just shift the impacts to another area. The barge was set in place in mid-April, to coincide with the arrival of terns in the area, and it was anchored 100 m offshore, 7 km east of the ASARCO colony. The latter colony was active in 2000, but nesting in 2001 was precluded by covering the colony site with tarpaulins and hazing. The barge site was chosen to minimize navigational hazards and disturbance from commercial and recreational watercraft. Terns began nesting on the barge within one month of deployment, and they established about 388 nests. The barge was removed and the eggs collected prior to hatching, thus no data on reproductive success are available (Collis et al. in press).

Other features installed to enhance the suitability of rafts are drainage holes; chick shelters; low walls to protect nests from wind and spray, prevent chicks from falling in the water, and reduce erosion of sand; plastic snow fencing attached to the sides to prevent chicks from swimming underneath; ramps to allow chicks that might fall in the water to return to the rafts; and tethered floating driftwood for loafing areas (Dunlop et al. 1991, Lampman et al. 1996). More elaborate “reefrafts” not only provide nesting sites for terns but also habitat for fish in the form of artificial structures suspended below the raft (Jarvie and Blokpoel 1996).

SOCIAL ATTRACTION

Kress (1983, 1998) pioneered the use of social attraction techniques to encourage Common (*Sterna hirundo*), Arctic, and Roseate (*S. dougallii*) terns to recolonize their historic nesting site at Eastern Egg Rock on the coast of Maine. After eliminating nesting gulls from the island, biologists placed life-sized tern decoys (in alert and incubation postures) in suitable nesting habitat, where they also played recordings (endless tape loops) of non-aggressive tern vocalizations. In the third year of using these measures, terns nested in the immediate vicinity of the decoys and playback speaker.

Subsequently, social attraction techniques have been used to establish or reestablish colonies of various terns, including the Caspian Tern. As noted above, Lampman et al. (1996) and Collis et al. (in press) used decoys and taped playbacks of vocalizations to aid in attracting Caspian Terns to breed on artificial nest platforms. Decoys and taped playbacks also were among a suite of techniques used to attract Caspian Terns to nest on East Sand Island in the Columbia River (Roby et al. 2002).

PREDATOR MANAGEMENT

Predator management is used to protect tern colonies from increasing populations of introduced predators and, in some cases, natural predators such as gulls. Control of gull populations was deemed essential prior to efforts to reestablish colonies of three species of terns on Eastern Egg Rock, Maine (Kress 1983, 1998). Limited gull control also was one of several techniques used to attract Caspian Terns to nest on artificial islands in Hamilton Harbour, Ontario (Pekarik et al. 1997), and East Sand Island in the Columbia River estuary (Roby et al. 2002).

Predator management is conducted at or in the vicinity of most Caspian Tern colonies on the California coast (J. Albertson, J. Hansen, J. Parkin, B. Collins pers. comm.). In some cases (e.g., Elkhorn Slough and San Francisco Bay), Caspians benefit from predator management directed at protecting their colony, at other sites (e.g., Los Angeles Harbor and San Diego Bay) indirectly from efforts to reduce or eliminate predators that impact endangered species (e.g., California Least Tern). Predator management may include hazing, trapping and relocation, fencing to limit entry to colonies, or the lethal take of individual predators known to prey on the target species.

In many cases, predator management needs to be ongoing to provide sustained protection to colonies of Caspian Terns or other colonial nesting waterbirds (Kress 1983, 1998). In other cases, management of avian predators has been necessary only during the initial efforts to re-establish a historic nesting site for Caspian Terns (e.g., East Sand Island; Roby et al. 2002).

MINIMIZING DISTURBANCE

Human disturbance may reduce nesting success or cause colony abandonment as terns leave their nests, exposing eggs and chicks to gull predation or the adverse effects of extreme air temperatures or precipitation. Efforts to manage (eliminate or reduce) the impacts of human disturbance from research activities include the use of tunnels to access observation blinds without disturbing terns (Shugart et al. 1981, Collis et al. 1999) and careful placement of covers over nests to reduce gull predation when biologists enter tern colonies; the latter measure may be less effective at large colonies, where predation may continue outside the area at which nest covers are used (Quinn 1984). Disturbance to nesting terns by the general public can be limited by restricting public access to active colony sites, creating or enhancing nesting habitat in areas of limited human use, posting signs describing the sensitive nature of colony sites, and educating groups and individuals. Signs, however, may unnecessarily draw attention to tern colonies and may be ineffective, or even detrimental, when enforcement is not possible (Novak 1992).

OUTREACH AND EDUCATION

The large size and conspicuous flocks of Caspian Terns and other waterbirds capture people's attention and engender strong sentiment for their preservation (Parnell et al. 1988). By contrast, others consider terns to be a nuisance or problem species because of real or perceived conflicts with fisheries. Still, conservation education for the Caspian Tern has made substantial strides forward in recent years.

Environment Canada has published a "fact sheet" on the four species of terns, including the Caspian, that breed in the Canadian Great Lakes (Neuman and Blokpoel 1997). This document provides the lay reader with information on the biology, status and distribution, populations trends, known threats, and conservation approaches and associated research for these species. Although conservation and education in the Great Lakes have focused on the Common Tern, the species most impacted by humans, some of the methods used have been, or could be, applied to other terns. The "fact sheet" also promotes the availability of a video demonstrating "reefrafts" (tern nesting platforms with fish habitat) and a manual with step-by step instructions for building and guidelines for operation and maintenance (Jarvie and Blokpoel 1996). Signage at colonies to inform people that trespassing and disturbing terns is prohibited by law has had mixed success (Neuman and Blokpoel 1997).

The internet is increasingly useful for facilitating communication, sharing information, and generating public support for policy change (Boersma and Parrish 1998). The Columbia Bird Research website (<http://www.colmubiabirdresearch.org>) provides a wealth of information regarding collaborative research and management efforts to address conflicts surrounding the predation of Caspian Terns on endangered salmonids in the Columbia River estuary. This site hosts research reports and updates, videos and photos of research and management activities, environmental documents, links to organizations participating in Caspian Tern management, etc.

STATUS RECOMMENDATIONS

Conservation concern for the species varies by geographic region and scale. We recommend no change in the Caspian Tern's status at the national, regional, or BCR scales. Since the late 1970s, the population has increased in four of five major breeding regions in North America. The species still occupies most of its former range and has expanded slightly into new areas.

The USFWS Bird of Conservation Concern designation for the North Pacific Coast (BCR 5) is intended to stimulate coordinated and collaborative proactive conservation actions among public and private land managers and partners. We concur with this designation and recommend a collaborative approach to conservation considering (1) the significance of the high number of terns in this region to the Pacific Coast and continental populations, (2) threats from ongoing habitat loss and hazing to prevent tern nesting on several of the remaining nesting sites, (3) the vulnerability of terns in this region to stochastic events from the unprecedented concentration of breeding birds at few colonies, and (4) conflicts with management of endangered fisheries in this region.

Although continental populations have increased and no special status is warranted at the national or regional scale, habitat loss is ongoing, and occupation of relatively stable artificial habitats may

continue to concentrate the tern population leaving it more vulnerable to stochastic events, such as disease outbreaks or oil spills. Hence, efforts should be made to monitor Caspian Tern populations, protect and restore habitat, resolve management conflicts with other species, and reduce threats to the population.

CONSERVATION RECOMMENDATIONS

Recommended conservation actions for the Caspian Tern are prioritized below within each of four main categories: monitoring, research, habitat management and protection, and education. Priorities may vary among regions, and implementation of recommended actions may occur on an opportunistic basis. Priorities should be reevaluated periodically. It is important to emphasize that the success of protection and habitat enhancement efforts will require the collaboration of many individuals, groups, and disciplines on the multiple aspects of Caspian Tern conservation.

MONITORING RECOMMENDATIONS

Monitoring is crucial for effective conservation and management. Because Caspian Terns are vulnerable to habitat loss and degradation, they should be monitored to detect early warning signs of population declines, the impacts of contaminants, and, in some cases, to assess factors limiting reproductive success. Monitoring should also be used to evaluate the success of conservation and management actions and, if needed, to modify them to enhance their effectiveness. Specific recommendations are:

- As a foundation for a continental monitoring program, prepare a catalog of all current and historic breeding sites of the Caspian Tern in North America from regional seabird catalogs, regional and local monitoring efforts, and other published or unpublished sources. Prepare digital catalog maps in a standard, widely-used format that enables overlay of other data layers (e.g., habitat types, human development, etc.) and easy sharing and transfer of data.
- Monitor the continental population once every 10 years. As needed, track population trends in regions holding a large percentage of the North American population of Caspian Terns, ones threatened with population reduction, or those for which accurate population and distribution data are crucial to management decisions (e.g., North Pacific BCR). To better track population trends, devise a sampling design for regularly surveying a selected subset of breeding sites every 2 to 3 years, a frequency sufficient under most circumstances (Anonymous 2000). Any such design should produce statistically valid data and detect a particular magnitude of change over a specified time period; availability of resources may in effect dictate survey effort and, hence, the magnitude of change that can be detected.
- In concert with development of the North American Waterbird Conservation Plan, adopt a standardized monitoring protocol. Guidelines for surveying terns and other colonial waterbirds are currently being developed (Anonymous 2000). Standardize monitoring procedures and coordinate regional censuses in the same year and with multi-species surveys. Monitoring protocols must be flexible enough to allow for some variation in survey methods among sites necessitated by logistical (e.g., size, distribution, nesting habitat) or financial constraints. As the timing of surveys is crucial to ensure comparability and repeatability among sites and years

(Johnson and Krohn 2001), determine the best time to conduct population surveys, taking into account regional differences in the phenology of breeding and asynchrony of breeding among sites; the most effective time to count generally is during the mid- to late incubation period (Anonymous 2000). Surveys should be carefully designed to avoid or minimize disturbance to nesting terns.

- Monitor the effectiveness of restoration and management actions to evaluate their success and make mid-course changes in procedures as necessary (Kress 1998). For example, study whether reductions in Caspian Tern predation on juvenile salmonids in the Columbia River estuary will increase adult salmonid populations (Collis et al. 2001b).
- Monitor reproductive success (number of fledged young/nest) at selected colonies for which accurate reproductive data are crucial for determining limiting factors and making management decisions.
- Assess habitat during annual or periodic population surveys, both at current and historic colony sites, to monitor the quality of available habitat and to determine if availability of nesting sites is a limiting factor locally or regionally.
- Integrate Caspian Tern monitoring data with other multi-species databases, such as that of the Pacific Seabird Group (www.pacificseabirdgroup.org/committees.html) or the developing database for the USGS “comprehensive monitoring program for colonial waterbirds” that will be incorporated into the National Bird Population Data Center (<http://www.pwrc.usgs.gov/research/sis2000/steink01.htm>). Such databases can further coordination and standardization of monitoring, the timely dissemination of results, and use of seabirds as indicators of local and large-scale change in aquatic environments.

HABITAT MANAGEMENT AND PROTECTION RECOMMENDATIONS

Because nesting habitat is often a limiting factor for Caspian Terns at the local and regional scale, it will be important to work with all groups involved in wetland habitat restoration, enhancement, and protection to ensure that strategies to maintain or increase tern habitat are incorporated into these efforts. Such efforts should strive for multi-species benefits. For example, providing nesting habitat for Caspian Terns, typically aggressive mobbers of predators, can help other species of terns that otherwise might not colonize without the protective umbrella of the Caspians (Schaffner 1985, Collins et al. 1991). Conversely, groups should work to see that nesting habitat is not created where larger tern numbers could cause conflicts with other wildlife resources, such as sensitive fish populations. It will be important to maintain water quality in all foraging habitats (breeding and non-breeding) by discouraging use of pesticides to prevent contamination of wetlands. In all aspects of management and protection, it will be especially valuable to work with the various Joint Ventures or Regional Working Groups of the North American Waterfowl Management Plan, North American Waterbird Conservation Plan, U.S. Shorebird Conservation Plan, North American Bird Conservation Initiative, and Partners in Flight. Specific recommendations for management and site protection are to:

- Thoroughly investigate potential alternative sites suitable to support part of the Caspian Tern breeding colony at the Columbia River as a means to lessen impacts on endangered salmonids and to reduce the risks of stochastic events (disease, storms, predators, human disturbance, oil

spills, etc.) on the tern population (Roby et al. 2002). Shifting the Columbia River terns from the current single site to multiple dispersed sites, particularly ones distant from threatened or endangered fish populations, would greatly lessen the likelihood of further resource conflicts. Kress (1998) recommended that selection of sites for tern restoration should include knowledge of factors such as prior history as a productive breeding site, food base, vulnerability to predators and human disturbance, and practicality of staffing for long-term management, follow-up monitoring, and research.

- Initiate or maintain predator management where necessary to establish new colonies or maintain existing ones.
- Provide multiple suitable nesting sites within the coastal and interior breeding ranges. All sites may not be used at any one time, recognizing that loss and creation of nesting sites often is a dynamic process that fluctuates with environmental conditions, vegetation succession, and other factors that alter site suitability through time. As needed, remove vegetation on nesting islands. If done on a rotational basis this may also minimize predator build up. Protect nest sites in salt ponds, or create new ones, to compensate for Caspian Tern breeding colonies lost to habitat restoration for other purposes (e.g., conversion to salt marsh) or to future development.
- Protect important breeding habitats for the Caspian Tern via conservation easements, management agreements, legislative incentives, land acquisition, and enforcement of wetland protection regulations (references in Shuford 1999).
- Protect and restore wetlands at migratory staging areas and wintering grounds.

RESEARCH RECOMMENDATIONS

Although many aspects of the biology of the Caspian Tern are poorly known or unstudied (Cuthbert and Wires 1999), the following list focuses on research topics that seem most likely to lead to advances in conservation and management of this species, particularly where these terns are at risk or face conflicts with other wildlife resources.

- Assess the fish assemblage at potential restoration sites to avoid establishment of new tern colonies where potential fisheries conflicts exist. If necessary, use barges as temporary colony sites for Caspian Terns as a means to assess tern diets at potential restoration sites (Collis et al. 2001b).
- Study the diet and foraging ecology at breeding colonies to ascertain the relationships between changing prey resources and other aspects of Caspian Tern biology (e.g., breeding colony size, reproductive success, limiting factors).
- Identify and prepare a catalog of key migratory (or post-breeding) staging areas, molting areas, and wintering grounds. Assess the potential for effectively monitoring regional or continental populations at these sites.

- Study metapopulation dynamics and demography, focusing on parameters such as survival, age at first breeding, recruitment, lifetime reproductive success, dispersal, and population expansion or contraction (and factors that affect them) using marked or radio-tagged birds.
- Determine to what extent the relocation of Caspian Tern colonies affects their distribution, abundance, and reproductive success at both local and regional scales.
- Periodically assess the levels of contaminants in Caspian Terns and their eggs as a measure of both tern and ecosystem health. Study the possible effects of contaminants on eggshell thinning, behavioral modification, chick development, nesting success, and adult and juvenile survival.
- Use marked or radio-tagged birds to identify and map the migration routes of Caspian Terns.

OUTREACH AND EDUCATION RECOMMENDATIONS

Education is a valuable tool for providing the public, decision makers, resource managers, and conservationists with information on colonial waterbirds to illuminate their conservation problems, produce solutions, and foster change (Parnell et al. 1988, Boersma and Parrish 1998, Kushlan et al. 2002). Such information must be effectively communicated by providing it in a form useful for incorporating waterbird needs in planning, implementation, and management activities. It is also important that the best conservation practices are known, accepted, and widely used by managers and users of wetland habitats. Effective education efforts will need to accurately communicate ecological nuances and promote win-win resolutions to resource conflicts that pit one species or group of wildlife against another.

It will be valuable to partner with educators at all levels and in various programs – via public outreach, student training, and volunteer programs – to increase awareness and appreciation of colonial waterbirds and the conservation strategies needed to protect them. Although much future education about terns may be coordinated via the outreach initiative of the North American Waterbird Conservation Plan (Kushlan et al. 2002), it will be important to coordinate with local and regional groups, other continental conservation planning efforts (North American Waterfowl Management Plan, U.S. Shorebird Conservation Plan, North American Bird Conservation Initiative, Partners in Flight, Important Bird Areas Program), and various international and global programs to educate the public and resource managers regarding the status and role of Caspian Terns and other colonial waterbirds in the context of healthy ecosystem management. Some specific recommendations are:

- Model new education initiatives for terns after the multi-faceted approach promoted by the National Shorebird Education and Outreach Plan of the U.S. Shorebird Conservation Plan (Johnson-Shultz et al. 2000).
- Prepare and widely distribute a fact sheet about the Caspian Tern’s life history and role in the environment, including details about perceived fisheries conflicts.

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