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Caspian Tern Nesting Ecology and Diet in San Francisco Bay and Interior Oregon

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Final 2003 Annual Report

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EXECUTIVE SUMMARY

The goal of this study was to develop a better understanding of Caspian tern (*Sterna caspia*) colony status and diet composition at representative colonies in coastal and interior habitats of northern California and interior Oregon. Information from this study will be used in the development of a Caspian Tern Management Plan and Environmental Impact Statement (EIS) by the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA Fisheries. The Caspian Tern Management Plan and EIS are mandated by a court-mediated settlement agreement with the goal of reducing predation on salmonids by Caspian terns nesting on East Sand Island.

This annual report summarizes data collected on nesting Caspian terns during the 2003 breeding season at five different colonies in the San Francisco Bay area (Brooks Island, Knight Island, Baumberg Pond, A-7 Pond, and Agua Vista Park) and two colonies in interior Oregon (Summer Lake and Crump Lake). The purpose of this report is to present results to the funding agency, resource management agencies, and other stakeholders. This report addresses diet composition, colony size, nesting success, and factors limiting colony size and nesting success at these seven colonies. The findings presented in this report may change with further review and analysis; results have not yet undergone peer-review. Consequently, these data are not for citation or publication without prior permission from the authors.

There were five known breeding colonies of Caspian terns in the San Francisco Bay area in 2003, where a total of approximately 1,190 breeding pairs nested. Most breeding pairs in the San Francisco Bay area (72%) nested at the Brooks Island colony, by far the largest tern colony in the Bay area. Marine forage fishes, in particular anchovies (Engraulidae), surfperch (Embiotocidae), herring (Clupeidae), and silversides (Atherinidae), were the predominant component of Caspian tern diets at all five colonies. Small numbers of juvenile salmonids (chinook salmon smolts, *O. tshawytscha*) were identified in the diet of terns nesting at four of the five colonies; salmon comprised less than 10% of the diet at Knight Island, less than 2% of the diet at Brooks Island, and much less than 1% of the diet at Baumberg Pond, A7 Pond, and Agua Vista Park. Nesting success at each colony ranged from 0.08 to 0.70 young fledged/breeding pair; this is fair to poor productivity compared to other well-studied Caspian tern colonies in the region. Nesting success tended to be higher at the larger tern colonies in the Bay area. All five colonies appeared to be primarily limited both in size and productivity by the availability of suitable nesting habitat and/or the quality of nesting substrate. Other factors limiting nesting success for at least some of the colonies were mammalian nest predators, displacement by other colonial waterbirds, and human disturbance. Food availability may be a limiting factor for nesting success in some years, but it did not appear to be a significant constraint on productivity in 2003.

We studied Caspian tern nesting ecology at two sites in interior Oregon: Summer Lake Wildlife Area and Crump Lake in the Warner Valley. Both these sites have a recent history of Caspian tern nesting activity, but neither site apparently supported successful Caspian tern nesting in the last two years. Colony failure at both sites was evidently the result of fluctuating water levels that either flooded the available nesting habitat or

connected nesting islands to the mainland, allowing access by mammalian nest predators. To evaluate factors that limit nesting success at these two sites, we built an elevated nesting platform on Keister Island in Crump Lake (where the former colony site was flooded) and attempted to attract terns to nest on a small island in an impoundment in Summer Lake Wildlife Area (where the former colony site was connected to the mainland). Caspian terns nested successfully at both managed sites, and at no other sites in the respective areas, suggesting that suitable nesting sites for Caspian terns were very limited in these areas. The diet of terns nesting at both sites consisted mostly of Tui chubs (*Siphateles bicolor*) an unlisted species; no anadromous salmonids were detected in tern diets at either site. One Warner sucker (*Catostomus warnerensis*), a federally-listed threatened species, was identified in the diet of terns nesting on Crump Lake, but this species comprised less than 0.1% of tern diets. Nesting success at the two sites was only fair and was limited by the availability of suitable nesting habitat at Crump Lake and the quality of nesting substrate at Summer Lake Wildlife Area.

The preliminary conclusions from this Caspian tern study in 2003 are (1) breeding Caspian terns at all seven study sites preyed mostly on forage fishes that are neither listed under the ESA nor of significant economic value for commercial, recreational, or subsistence fisheries, (2) availability of suitable sites for breeding colonies was the main factor limiting the number and size of tern colonies in both the San Francisco Bay area and interior Oregon, and (3) nesting success at existing colonies was limited by attributes of those colony sites as they influence (a) quality of nesting substrate, (b) vulnerability to mammalian nest predators, (c) displacement by other colonial waterbirds, and (d) human disturbance.

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INTRODUCTION

Caspian terns (*Sterna caspia*) nesting at the colony on East Sand Island in the Columbia River estuary continue to consume about 4 - 6 million juvenile salmonids from the Columbia Basin annually. This despite the reduction in smolt consumption associated with relocation of the tern colony from Rice Island to East Sand Island (Roby et al. 2002, CBR 2003). Approximately two-thirds of all breeding age adults from the Pacific Coast population of Caspian terns are now nesting at East Sand Island (Wires and Cuthbert 2000), the sole remaining Caspian tern colony along the coast of Oregon and Washington (Shuford and Craig 2002). The U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA Fisheries are preparing an EIS for management of Caspian terns in the Columbia River estuary. The EIS will explore options to reduce the level of tern predation on Columbia River salmon while ensuring the protection and conservation of Caspian terns in the Pacific Coast/Western region. Some of these management options include the potential for relocating some of the East Sand Island colony to a number of smaller tern colonies outside the Columbia River estuary.

In 2000, Seattle Audubon, National Audubon, American Bird Conservancy, and Defenders of Wildlife filed a lawsuit against the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service on the basis that compliance with NEPA for the proposed management actions to relocate terns from Rice Island to East Sand Island was insufficient, and in objection to the potential take of eggs as a means to prevent tern nesting on Rice Island. In April 2002, all parties reached a settlement agreement mediated through the Ninth Circuit Court of Appeals. Terms of the settlement agreement stipulate federal agencies will (1) complete specific management actions in the estuary in 2002-2004, (2) prepare three technical reports addressing tern and salmon conservation, and (3) comply with a court stipulated timeline for completing an Environmental Impact Statement and Caspian Tern Management Plan to address smolt predation and tern management in the Columbia River estuary. The diet studies included in this report are a critical component in the development of management options for the EIS. Results of diet and food habits studies at potential alternative colony sites will be a major factor in determining which sites along the Pacific coast are selected for potential new, restored, or enhanced Caspian tern colonies.

Management of island sites for nesting terns has proven to be an effective method to assure adequate distribution of nesting colonies for several tern species, as well as restore colonies that have been abandoned (Kress 2000). Food habits studies of terns at sites outside of the Columbia River estuary are especially crucial because these data are necessary to assess the potential impacts of larger, permanent tern colonies in a variety of interior and coastal areas. This study was also designed to investigate whether low food availability or locally abundant nest predators may render some former or prospective tern colony sites as population sinks (Penland 1982). Studies at historical nesting locations in the San Francisco Bay area and in interior Oregon were conducted in 2003 as part of a comprehensive effort to evaluate the suitability of alternative colony sites along the west coast of the U.S.

The objectives of this study were to determine the diet composition, colony size, and nesting success of Caspian terns nesting at colonies in the San Francisco Bay area and in interior Oregon. The primary objective of these studies was to determine the fish species comprising the primary prey for terns nesting at selected colonies outside of the Columbia River estuary. Specific objectives related to diet studies were to determine (1) the taxonomic composition of the diet of terns nesting at each study colony, (2) the proportion of the diet that consists of juvenile salmonids, (3) the total number of juvenile salmonids consumed based on calculations using a bioenergetics model, and (4) predation rates on various species of smolts, where feasible, based on estimates of the numbers of juvenile salmonids available as potential prey in each migration year. Secondary objectives were to determine (1) the size of each tern colony (number of breeding pairs), (2) nesting success at each colony (average number of young fledged per breeding pair), and (3) those factors limiting the size and productivity of each colony, to the extent possible. In this study we evaluated the following potential factors limiting size and productivity of tern colonies in the San Francisco Bay area and in interior Oregon: (1) availability of suitable bare-sand nesting habitat, (2) competition for available nesting habitat with other colonial waterbirds (i.e., gulls, cormorants), (3) nest predation, (4) disturbance to nesting adults by potential predators (including humans), (5) forage fish availability, and (6) severe weather.

STUDY AREAS

In the San Francisco Bay area, the study sites were four existing colonies: Brooks Island, Knight Island, Baumberg Pond, and A7 Pond (Figure 1). The primary study site was on



Observation blind on Brooks Island, 2003

Brooks Island in central San Francisco Bay, where over 800 pairs of terns nested in 2002. The other study colonies are smaller (Knight Island in the northern San Francisco Bay area and Baumberg Pond and A7 Pond in the southern San Francisco Bay area). A new tern colony on a collapsing pier on the San Francisco waterfront adjacent to Agua Vista Park was discovered late in the 2002 breeding season (Figure 1); this colony was also monitored to estimate diet composition, colony size, and productivity in 2003.

Colonies at two historical sites in interior Oregon were studied during the 2003 breeding season: Summer Lake Wildlife Area and Crump Lake (Figure 2). The interior Oregon study sites were selected from among the following three historical colony sites: (1) Summer Lake Wildlife Area, (2) Warner Valley (i.e., Crump and Pelican lakes), and (3) Malheur National Wildlife Refuge (i.e., Malheur Lake; Figure 2). All three of these sites have a recent history of use by nesting Caspian terns (Shuford and Craig 2002, Roby et al. 2003a). Selection of the two study sites in 2003 was based on the relative prospects for tern nesting at each site, as determined by pre-season inspection visits during early March to ascertain water levels and resultant nesting conditions.



Crump Lake, Warner Valley, Oregon, 2003

All three of the potential study sites in interior Oregon have histories of intermittent nesting by terns (Roby et al. 2003a), reflecting annual variation in water levels and resultant changes in the availability of suitable nesting habitat and an adequate food supply. In drought years, islands formerly used by nesting terns can become connected to the mainland, providing mammalian predators with easy access to the colony site (e.g., Tern Island in Malheur Lake), and forage fish can become scarce. Conversely, during high water years, islands used by nesting terns can become inundated (e.g., Keister Island in Crump Lake), eliminating all suitable nesting habitat.

METHODS

We constructed observation blinds at the periphery of most tern colonies (Shovel Island, Keister Island, Brooks Island, and Baumberg Pond) to facilitate colony observations without disturbing nesting terns; other colonies (Knight Island, A7 Pond, and Agua Vista Park) were observed from a mainland vantage point that was sufficiently distant from the colony so as not to have a noticeable effect on tern nesting behavior. Data on number of terns on the colony, diet composition, and causes of tern nesting failure were collected on a weekly basis at each colony.

The number of Caspian terns breeding at colonies in San Francisco Bay and interior Oregon was estimated by ground counts of nests or incubating terns near the end of the incubation period. Nesting success (number of young raised per breeding pair) was estimated using ground counts of young at the colony just prior to the fledging period. Diet composition at all study colonies was determined by visually identifying fish brought back to the colonies in the bills of nesting adults with the aid of binoculars and spotting scopes. Forage fishes were identified to the lowest taxonomic grouping possible from visual observation. Visual identifications were verified using voucher specimens whenever possible. Tern chicks near fledging age were banded at several colonies to measure subsequent survival rates and movements among colonies. Each tern was banded with a federal metal numbered leg band and a unique color combination of plastic leg bands that allows for the identification of individual terns at a distance (i.e., at roosts or on colonies). Colony monitoring methodology followed standardized observational and data collection protocols described in Collis et al. (2002), Roby et al. (2002), and Roby et al. (2003b). Use of these protocols ensures that results are comparable and will provide managers with specific information necessary for decision-making and selection of sites to manage as permanent tern colony sites beginning in the 2005 nesting season.

Due to the high year-to-year variation in water levels at the two study sites in interior Oregon, successful accomplishment of study objectives required limited habitat enhancement at both sites in order to ensure availability of suitable nesting habitat for Caspian terns. Testing the feasibility of these habitat enhancement techniques also provided useful information on methods to encourage the regular use by breeding Caspian terns of interior sites that are subject to fluctuating water levels. If interior sites are eventually selected for management as tern colony sites, these feasibility studies may prove invaluable.

The habitat management techniques that were tested as part of this study were (1) an artificial nesting platform where no suitable island existed, (2) enhancement of a small push-up in an impoundment where water level control was feasible to protect nesting terns from mammalian nest predators, and (3) social attraction (tern decoys and audio playback systems) to increase use of newly restored or enhanced colony sites. Detailed descriptions of these various techniques for tern habitat management are presented in Kress and Hall (2002).

RESULTS AND DISCUSSION

San Francisco Bay Area

Brooks Island

Background: Brooks Island is in Central San Francisco Bay near the city of Richmond, and is owned and managed by the East Bay Regional Park District. Brooks Island has been the site of the largest nesting colony of Caspian terns in the Bay area during the last decade. The tern colony is located on a sandy, low-lying spit that extends to the northwest of the main part of the island, and was estimated at over 825 breeding pairs in 2002 (S. Bobzien, pers. comm.). Caspian terns nest on the upper part of the beach on the leeward (northeast) shore of the spit. The terns nest in close proximity to gull colonies that also use the spit: a colony of western gulls (*Larus occidentalis*) that has traditionally used Brooks Island, and a newly-formed colony of California gulls (*L. californicus*) that is evidently still expanding. Brooks Island is a popular destination for recreational boaters, and is located beneath the flight path of recreational and commercial aircraft. Previously, rats were inadvertently introduced to Brooks Island, and at least one raccoon was found on the island in 2003.

Colony Size and Nesting Success: Brooks Island was the first site in the San Francisco Bay area where Caspian tern nesting activity was recorded in 2003. The first Caspian tern egg was laid on the Brooks Island colony on April 17, and chicks began hatching on May 13 (Table 1). The first fledgling (young capable of flight) was observed on June 20. Nesting habitat near the observation blind was occupied first (Main Sub-colony), and later a separate satellite sub-colony was formed further down the beach to the northwest (NW Satellite). Most of the Main Sub-colony could be observed and numbers of adult terns counted from the observation blind, but some nesting adults were obscured by vegetation or topography. The NW



Young tern chick on Brooks Island, 2003

Satellite could not be observed from the observation blind, and numbers of nesting pairs could only be estimated by observers in a skiff offshore. Consequently, counts of adult terns on-colony are minimums and generally less than the number of active nests in the Main and NW Satellite sub-colonies combined (Table 8).

We estimated the size of the Main Sub-colony at 444 breeding pairs and the size of the NW Satellite at 415 breeding pairs, or a total of approximately 860 pairs of Caspian terns nesting on Brooks Island. This represents over 72% of the estimated total number of pairs nesting in San Francisco Bay during 2003 (1,190 pairs). This estimate of the size of the Brooks Island colony was obtained by counting all nests with eggs or nestlings and all young terns capable of leaving the nest scrape during a walk-through of both sub-colonies on June 5. The main objective of this walk-through was to record the fate of nests where eggs had been collected for contaminants analysis as part of a study conducted by the Sacramento Field Office, USFWS. The aerial photo census of the Brooks Island colony, conducted on May 29, failed due to poor weather conditions and incomplete photography coverage of the colony.

The estimated number of active tern nests on Brooks Island in 2003 was similar to estimates in 2000 (806 nesting pairs) and in 2002 (825 nesting pairs), but greater than the estimate in 2001 (512 nesting pairs; S. Bobzien, unpubl. data). As in previous years (S. Bobzien, pers comm.), the Brooks Island tern colony in 2003 was fragmented into two separate sub-colonies with about 50 m of unoccupied space between the Main Subcolony and NW Satellite.

We estimated that approximately 535 young terns fledged from the Brooks Island colony in 2003, or 309 and 226 young terns fledged from the Main and NW Satellite sub-colonies, respectively. Productivity was 0.70 and 0.54 young raised per breeding pair for the Main and NW Satellite sub-colonies, respectively, or 0.62 fledglings per breeding pair for the entire Brooks Island tern colony (Table 17). Productivity at the Main Sub-colony on Brooks Island was the highest of all known colonies of Caspian terns in San Francisco Bay during 2003. This level of productivity, however, is only considered fair compared to other well-studied colonies in the Pacific Region, and is well below recently measured levels of productivity at the East Sand Island tern colony in the Columbia River estuary (Roby et al. 2002).



Chick Banding and Resightings of Banded Adults: On June 30, 41 Caspian tern chicks near fledging age were banded with USGS numbered metal bands and a unique color combination of plastic leg bands; an additional 41 tern chicks that were younger were banded with numbered metal bands only.

Banding on fledgling tern on
Brooks Island 2003

During late March and early April, there were 10 different sightings of banded adult terns at the Brooks Island colony site. These birds presumably stopped at Brooks Island briefly while in route to other breeding colonies, most likely north of San Francisco Bay. Three of the banded individuals were identified: one tern was banded in 2000 as an adult on Rice Island in the Columbia River estuary, one tern was banded as a chick in 1981 in Grays Harbor, Washington, and one tern was recently banded as either a chick or adult at a colony in the Pacific Northwest (colony location unknown).

Diet Composition: A large number of Caspian tern bill loads were identified at the Brooks Island colony (N = 5,579). The diet of Caspian terns nesting at Brooks Island consisted primarily of schooling marine forage fishes, in particular anchovies (Engraulidae), surfperch (Embiotocidae), herring (Clupeidae), and silversides (Atherinidae), in that order (Table 9). These four taxa each made up greater than 10% of identified prey items. Additional fish taxa that represented more than 1% but less than 10% of the diet included toadfish (Batrachoididae), sculpins (Cottidae), gobies (Gobiidae), salmon (Salmonidae), and trout (Salmonidae), in that order. Eight other prey taxa represented less than 1% of the diet.

The salmon portion of the diet (1.9% of identified prey items) consisted of juvenile chinook salmon (*Oncorhynchus tshawytscha*), a listed species. The trout portion of the diet (1.6% of identified prey items) consisted of rainbow trout (*Salmo gairdneri*), evidently caught at nearby reservoirs where trout are stocked for recreational fisheries.

Factors Limiting Colony Size and Nesting Success: The primary factors limiting the size and productivity of the Brooks Island Caspian tern colony appeared to be (1) availability of suitable nesting habitat and (2) human disturbance (Table 16). Nesting habitat for terns



Shipping traffic near Brooks Island tern colony, 2003

on Brooks Island is restricted to a narrow band of bare sand habitat between the vegetated areas that dominate the spit and the high tide line. The area of suitable habitat for tern nesting appears to vary from year to year based on expansion and contraction of the beaches and vegetation (primarily native pickleweed, exotic ice plant, and a

non-native aster) depending on the number and intensity of winter and spring storms. Shoreline erosion removes nesting substrate from the seaward direction and annual dredging of the commercial shipping channel on the leeward side of the sand spit contributes to beach loss on the leeward side, where Caspian terns nest. These two processes appear to be responsible for the fragmentation of the Brooks Island tern colony into two sub-colonies in 2003. Although the mean high tide for this part of the bay is 5.4 feet, monthly high tides can reach 7.1 feet, further limiting the available beach area suitable for tern nesting and likely causing some tern nests in low-lying areas to fail. Thus the size of the Caspian tern colony on Brooks Island appeared to be largely limited by availability of suitable nesting habitat.

The California gull colony on Brooks Island was in close proximity to the Caspian tern colony, and the gull colony continued to expand. The California gulls, however, preferred vegetated habitat for nesting, and sparsely vegetated habitat that might be used by terns was mostly occupied later in the breeding season, after most terns had initiated nesting. Although competition for available nest sites may have occurred later in the breeding season, we observed little evidence of direct competition for nest sites during the peak of nest initiation for the two species. This may change in the future as the California gull colony continues to grow and gull pairs are forced to use nesting habitat suitable for Caspian terns.

Another constraint on nesting success of Caspian terns at Brooks Island appeared to be human disturbance. Gull predation on Caspian tern eggs and chicks was observed at the Brooks Island colony, but these events were uncommon except during disturbance events, especially human disturbance. We repeatedly observed that kayakers, other recreational boaters, and low-altitude aircraft flights caused nesting terns to flush from the NW Satellite.

Knight Island

Background: Knight Island is in San Pablo Bay (northern San Francisco Bay area), near the mouth of the Napa River and the city of Vallejo. Knight Island is a low-lying island of inter-tidal marsh that was converted into a salt pond. The area is owned and managed by the California Department of Fish and Game. In recent years Caspian terns have nested on small islands in the Knight Island salt pond. In particular, one island in the northeast portion of the salt pond (Northeast Colony) and another island near the levee on the south side of the salt pond (South Colony) have together supported over 200 nesting pairs of Caspian terns. In September 2002, the levee surrounding the Knight Island salt pond was intentionally and illegally breached, converting the former salt pond into a tidal pond (I. Woo, pers. comm.). This change has raised concern among local resource managers that the numbers of nesting Caspian terns and other colonial waterbirds at Knight Island will be adversely affected by fluctuating water levels. Foxes, raccoons, and other mammalian predators are known to frequent the levee surrounding the former salt pond on Knight Island. Human disturbance is evidently infrequent, although there is daily use of the slough surrounding Knight Island by recreational fishers and boaters. There is

also evidence of recreational use of the levee. During the 2003 breeding season, boaters were seen on several occasions using the levee to stretch their legs and walk dogs.

Colony Size and Nesting Success: Although Caspian terns were observed in the Knight Island area as early as April 3, no terns were seen roosting on the nesting islands until April 15, when 53 terns were counted on the South Colony (Table 2; Table 8). The first egg was not laid at the South Colony until about May 3, two weeks after the first egg was laid at Brooks Island. By May 11, however, the seven nests that had been initiated at the South Colony had been destroyed, presumably by a mammalian predator, and no adult terns were present on the South Colony (Table 8). Caspian terns returned to the South Colony by May 15, and re-laying commenced on May 24. Chicks began hatching on June 17 and the first fledgling was observed on July 27. The size of the South Colony was estimated at 203 breeding pairs. The size of the Northeast Colony on Knight Island was about half the size of the South Colony (T. Adelsbach, pers. comm.). These colonies together represented the second largest breeding colony of Caspian terns in the San Francisco Bay area during 2003.

We estimated that approximately 125 young terns fledged from the South Colony at Knight Island, or 0.62 young raised per breeding pair (Table 17). The Northeast Colony at Knight Island nearly failed (only 14 chicks observed at the colony site on June 24) likely due to a combination of encroachment by double-crested cormorants



Fledglings captured on Knight Island for banding, 2003

(*Phalacrocorax auritus*) that displaced nesting terns and attracted nest predators (i.e., gulls) and rising water levels that caused flooding of Caspian tern nests in low lying areas of the colony (T. Adelsbach, unpublished data). The productivity of the South Colony was similar to that of the Brooks Island colony this year, and is only considered fair compared to other well-studied colonies

in the Pacific Region. The productivity of the South Colony on Knight Island was well below recently measured levels of productivity at the East Sand Island tern colony in the Columbia River estuary (CBR 2003).

Chick Banding and Resightings of Banded Adults: On July 28, 62 tern chicks near fledging age were banded with USGS numbered metal bands and a unique color combination of plastic leg bands, and an additional 37 tern chicks that were younger were banded with a numbered metal leg band only.

During early April, we sighted one banded adult tern at the Knight Island colony. This tern was only banded with a numbered metal band that could not be read, and apparently only stopped briefly at Knight Island in route to another breeding colony, as it was not seen later in the season.

Diet Composition: A total of 835 bill load fish were identified at the South Colony on Knight Island. The diet of Caspian terns nesting at Knight Island was dominated by silversides (Atherinidae), followed by surfperch (Embiotocidae), sunfish (Centrarchidae), and gobies (Gobiidae), in that order (Table 10). Each of these four prey types represented greater than 10% of identified prey items. Additional fish taxa that represented more than 1% but less than 10% of identified prey items included salmon (Salmonidae), herring (Clupeidae), anchovies (Engraulidae), toadfish (Batrachoididae), sculpins (Cottidae), and trout (Salmonidae), in that order. Three other prey taxa each represented less than 1% of the diet. Salmon represented 8.7% of identified prey items and consisted of juvenile chinook salmon, a listed species. The Knight Island Caspian tern colony had the highest proportion of salmon in the diet of the five tern colonies studied in the San Francisco Bay area during 2003.



Adult tern with herring in bill

Factors Limiting Colony Size and Nesting Success: The primary factors limiting the size and productivity of the South Colony at Knight Island appeared to be (1) availability of suitable nesting habitat, (2) nest predation, and (3) encroachment by other colonial waterbirds (Table 16). At the South Colony, all active Caspian tern nests were destroyed early in the breeding season by an unidentified mammalian predator. Four days later, terns returned to the South Colony and began re-nesting, and soon all available suitable habitat for nesting terns on Knight Island appeared to have been occupied. The breaching of the salt pond levee at Knight Island does not appear to have caused an immediate decline in the numbers of Caspian terns nesting there compared to previous years; however, periodic low water levels due to low low tides make Caspian terns more

vulnerable to mammalian nest predators, and high high tides occasionally cause flooding of tern nests on low ground. Also, increasing numbers of double-crested cormorants used the small islands in the Knight Island salt pond for nesting sites (particularly the North Colony), and this factor appears to be directly limiting the numbers of Caspian terns nesting there (T. Adelsbach, pers. comm.). Competition for nest sites with cormorants appears to cause terns to nest in low lying areas, nests that are susceptible to flooding during high high tides. Cormorant nesting colonies also attract avian predators, primarily western and California gulls, which also prey on tern eggs and chicks.

Baumberg Pond

Background: Baumberg Pond is a former salt pond in South San Francisco Bay near the east end of the San Mateo Bridge. Baumberg Pond was created by building a levee around low-lying inter-tidal marsh, and is owned and managed by the California Department of Fish and Game. In recent years, several dozen pairs of Caspian terns have nested on a very small island in Baumberg Pond near the west levee. Foxes, raccoons, and other mammalian predators (e.g., long-tailed weasels and black rats) are known to frequent the levee surrounding Baumberg Pond. Human disturbance is evidently infrequent, and the area is closed to the public.

Colony Size and Nesting Success: Caspian terns were observed on the island in Baumberg Pond as early as April 10 (42 terns counted), but the first tern egg was not laid on the island until about May 1 (Table 3; Table 8), two weeks after the first egg was laid at Brooks Island. The first tern chick was observed on May 27, a day or two after it hatched. The first fledgling was observed on July 5. The size of the Baumberg Pond colony was estimated at 35 breeding pairs, the smallest of the known Caspian tern colonies in the San Francisco Bay area during 2003.

We estimated that approximately 15 young terns fledged from the Baumberg Pond colony, or 0.43 young raised per breeding pair (Table 17). This level of productivity is considered low compared to other well-studied colonies in the Pacific Region, and similar to levels observed at the Rice Island tern colony in the Columbia River estuary prior to relocation of the colony to East Sand Island.



Adult tern with chick

Chick Banding and Resightings of Banded Adults: Tern chicks were not banded at the Baumberg Pond colony due to relatively small colony size and the potential impact to colony productivity associated with disturbance during banding activities.

No banded adult terns were observed at the Baumberg Pond tern colony in 2003.

Diet Composition: A total of 603 bill load fish were identified at the Baumberg Pond colony. The diet of Caspian terns nesting at Baumberg Pond was dominated by surfperch (Embiotocidae), followed by silversides (Atherinidae), and juvenile sharks (Carcharhinidae), in that order (Table 11). Each of these prey types represented more than 10% of the diet. Additional fish taxa that represented more than 1% but less than 10% of the identified diet included anchovies (Engraulidae), herring (Clupeidae), toadfish (Batrachoididae), flatfish (Pleuronectidae), gobies (Gobiidae), sculpins (Cottidae), and sunfish (Centrarchidae), in that order. Two other prey taxa each represented less than 1% of the diet.

One juvenile chinook salmon, a listed species, was identified among the 603 identifiable prey items, or 0.17% of all prey items identified at the Baumberg Pond colony.

Factors Limiting Colony Size and Nesting Success: The primary factors limiting the size and productivity of the Baumberg Pond Caspian tern colony appeared to be (1) availability of suitable nesting habitat, (2) quality of nesting substrate, (3) encroachment



American white pelicans roosting on the Baumberg Pond tern colony, 2003

by other colonial waterbirds, and (4) human disturbance (Table 16). The nesting island is very small and much of it consists of fine-grained material that turns mucky after rain. Many of the active Caspian tern nests on the Baumberg Pond colony were destroyed this past season by American white pelicans (*Pelecanus erythrorhynchos*) and double-crested cormorants that used the small island as a

roosting site. Major construction of a new road and channel as part of the Baumberg Salt Pond Restoration Project began in late July 2003 and will continue for the next several years; it is unknown how these activities might impact the tern colony in the future.

Other researcher visits to the Baumberg Pond tern colony, the smallest colony studied in the San Francisco Bay area, appeared to cause terns to leave the colony and their nests for longer periods of time, as compared to researcher visits to larger colonies (i.e., Brooks and Knight islands). We observed that most nesting terns flushed by researchers at the Baumberg Pond colony did not return to their nests until the researchers completely left the area (i.e., the levees adjacent to the pond), while similar disturbances to larger colonies caused terns to leave their nests unattended for much shorter periods of time. Unattended nests are more vulnerable to exposure and nest predation than attended nests, both important factors affecting nesting success in Caspian terns (Kress and Hall 2002). To minimize the potential negative effects on tern nesting success of important research activities at smaller colonies, it may be important to limit the number of visits to the colony to the extent possible and minimize the number of people and time spent on colony during each visit.

A-7 Pond

Background: A-7 Pond is a former salt pond in South San Francisco Bay near the southern tip of the Bay. A-7 Pond was created by a levee surrounding low-lying intertidal marsh, and is owned and managed by the U.S. Fish and Wildlife Service as part of San Francisco Bay National Wildlife Refuge. In recent years several dozen pairs of Caspian terns have nested on several very small islands near the middle of A-7 Pond. Foxes, raccoons, and other mammalian predators are known to frequent the levee surrounding A-7 Pond. Human disturbance is evidently infrequent, and the area is closed to the public.

Colony Size and Nesting Success: Caspian terns were not observed in the vicinity of A-7 Pond until April 19, and adult terns (18) were first observed on the nesting islands in A-7 Pond on April 22 (Table 4; Table 8). The first tern egg was laid at the A-7 colony on about May 18; one month after the first tern egg was laid at the Brooks Island colony. Consequently, nesting chronology at the A-7 Pond colony was later than at any other known Caspian tern colony in the San Francisco Bay area. Two recently-hatched tern chicks were observed at the A-7 Pond colony on June 14. A total of 4 pre-fledged chicks were observed at the A-7 Pond colony during our last visit to the colony on July 30. The size of the A-7 Pond colony was estimated at 50 breeding pairs in 2003.

We estimated that 4 young terns fledged from the A-7 Pond colony, or 0.08 young raised per breeding pair (Table 17). This level of productivity was the lowest observed among the Caspian tern colonies studied in the San Francisco Bay area during 2003, and is considered very low compared to other well-studied colonies in the Pacific Region.

Chick Banding and Resightings of Banded Adults: Tern chicks were not banded at the A-7 Pond colony due to the relatively small colony size and concern over the potential impact of disturbance during banding activities on the already low productivity of this colony.

No banded adult terns were observed at the A-7 Pond tern colony in 2003.

Diet Composition: A small number of Caspian tern bill loads were identified at the A-7 Pond colony (N = 90), due to the small size of the colony and the distance between the levee and the colony (> 300 m). Based on this small sample size, the diet of Caspian terns nesting at A-7 Pond included toadfish (Batrachoididae), sculpins (Cottidae), gobies (Gobiidae), silversides (Atherinidae), surfperch (Embiotocidae), and anchovies (Engraulidae), in that order (Table 12). Each of these prey types represented greater than 10% of the diet. Additional fish taxa that represented more than 1% but less than 10% of the identified diet included flatfish (Pleuronectidae), sunfish (Centrarchidae), and juvenile sharks (Carcharhinidae). There were no salmonids observed among the identified bill loads at A-7 Pond in 2003.



Adult tern with anchovy in bill

Factors Limiting Colony Size and Nesting Success: The primary factors limiting the size and productivity of the A-7 Pond Caspian tern colony appeared to be (1) availability of suitable nesting habitat, (2) quality of nesting substrate, and (3) researcher disturbance (Table 16). The islands in A-7 Pond are very small and mostly consist of fine-grained material that turns mucky after rain.

Visits by other researchers to the A-7 Pond tern colony appeared to cause terns to leave the colony and their nests for longer periods of time, as compared to researcher visits to larger colonies (i.e., Brooks and Knight islands). We observed that most nesting terns flushed by researchers at the A-7 Pond colony did not return to their nests until the researchers completely left the area (i.e., the levees adjacent to the pond), while similar disturbances to larger colonies caused terns to leave their nests unattended for much shorter periods of time. Unattended nests are more vulnerable to exposure and nest predation than attended nests, both important factors affecting nesting success in Caspian terns (Kress and Hall 2002). To minimize the potential negative effects of important research activities on tern nesting success at this colony, it may be important to limit the number of visits to the colony and minimize the number of people and time spent on colony during each visit.

Agua Vista Park

Background: The small Caspian tern colony just offshore of Agua Vista Park in San Francisco was first noted during the 2002 nesting season, but no previous data on colony size or nesting success were available (C. Strong, pers. comm.). The colony has formed on two fragments of a wooden pier on the San Francisco waterfront, just south of Pacific Bell Park (home of the SF Giants). The colony got its name from a very small park of that name on the waterfront adjacent to the tern colony. The section of the pier nearest the shore has completely rotted away, leaving the outer sections unconnected to the mainland and thus free of mammalian predators. Caspian terns are nesting on the decaying wooden pier, digging nest scrapes in the dirt and debris on the surface. Several pairs of western gulls nest in the vicinity, including on the pier fragments where the terns are nesting. The two sections of pier that support the tern colony appear in imminent danger of collapsing. The owner of the property is the Port of San Francisco.

Colony Size and Nesting Success: The field crew did not learn of this colony until late in April, and they first visited the site on May 2. On that date, 54 Caspian terns were counted on the colony site and some tern eggs had evidently been laid (Table 5; Table 8). The first tern chick hatched about May 25, suggesting that egg laying at the Agua Vista colony began about April 29. The first fledgling was observed on July 16. The size of the Agua Vista Park tern colony was estimated at 43 breeding pairs in 2003.

The minimum estimate of number of young fledged from the Agua Vista colony was 18, or 0.42 young raised per breeding pair (Table 17). This is the minimum productivity for this colony in 2003 because not all fledglings on the colony could be seen from shore, and the colony is not accessible for closer inspection. This minimum level of productivity is considered low compared to other well-studied colonies in the Pacific Region, and similar to levels observed at Rice Island in the Columbia River estuary.

Chick Banding and Resightings of Banded Adults: Tern chicks were not banded at the Agua Vista Park colony due to the inaccessibility of the colony and the danger associated with attempting to access the colony on the decaying pier structure.

We were unable to determine if any banded adult terns frequented the Agua Vista Park tern colony in 2003 due to the great distance between the colony and our observation site (> 300 m).

Diet Composition: A small number of Caspian tern bill loads were successfully identified at the Agua Vista colony (N = 190), due to the small size of the colony and the distance between our observation site and the colony. Based on this small sample size, which was biased toward later in the breeding season, the diet of Caspian terns nesting at the Agua Vista colony included surfperch (Embiotocidae), anchovies (Engraulidae), silversides (Atherinidae), and herring (Clupeidae), in that order (Table 13). Each of these prey types represented greater than 10% of the diet. Additional fish taxa that represented more than 1% but less than 10% of the identified diet included toadfish (Batrachoididae). Five additional prey taxa each represented less than 1% of the diet.

One juvenile chinook salmon, a listed species, was identified among the 190 identifiable prey items, or 0.53% of all prey items identified at the Agua Vista Park colony.

Factors Limiting Colony Size and Nesting Success: The primary factors limiting the size and productivity of the Agua Vista Caspian tern colony appeared to be (1) the quality of nesting substrate and (2) the availability of suitable nesting habitat (Table 16). Suitable nesting substrate was certainly the proximate factor limiting the size of the tern colony on the pier fragments. Most nests appeared to be along the edges of broken asphalt, where



there was more loose material in which a nest scrap could be made. Because Caspian terns nested at the site, availability of suitable tern nesting habitat is evidently extremely limited in that part of San Francisco Bay. By mid-July several dilapidated boats were moored adjacent to the colony. It is not known if this had any impact on tern nesting success.

Dilapidated pier with nesting terns near Agua Vista Park, 2003

Interior Oregon

Shovel Island, Summer Lake Wildlife Area

Background: Shovel Island is a small push-up, less than 100 m² in area, which is located in East Link Impoundment on the Summer Lake Wildlife Area. The Wildlife Area is owned and managed by the Oregon Department of Fish and Wildlife, and consists of an extensive area of wetlands, moist soil units, and freshwater impoundments associated with the Ana River, just north of Summer Lake. The former colony of Caspian terns at Summer Lake was small (< 50 breeding pairs) and was associated with a much larger colony of California and ring-billed gulls (*L. delawarensis*) on an island at the north end of Summer Lake, immediately adjacent to the Wildlife Area. This colony has apparently failed during the last two breeding seasons because the water level in Summer Lake has been low, and remains so low that the former nesting island is virtually connected to the mainland. This provides access to the island for mammalian predators (e.g., coyotes, raccoons, skunks). Summer Lake itself is too alkaline to support fish life, so all potential foraging sites for Caspian terns in the area are in the Wildlife Area or adjacent water bodies (e.g., Ana Reservoir).

During the 2002 breeding season, one pair of Caspian terns attempted to nest on a small push-up in East Link Impoundment, but the nesting attempt failed. This was the only known nesting attempt by Caspian terns in the Summer Lake area during 2002. Prior to the arrival of Caspian terns to the Summer Lake area in spring of 2003, East Link Impoundment was nearly dry. After improvements were made to Shovel Island with hand tools and straw bails were placed around the island to protect it from wave erosion, ODFW staff diverted water to East Link Impoundment, creating the island. An observation blind was built on a nearby push-up, and 60 Caspian tern decoys and 2 audio playback systems were deployed on Shovel Island. Following a severe rainstorm on May 29, we discovered that the substrate on Shovel Island had become mucky and unsuitable for tern nesting. On June 12, we placed 10 small piles of crushed gravel on the island (see below).



Construction of Shovel Island, 2003

Colony Size and Nesting Success: The first Caspian tern was sighted in the Summer Lake area on April 28. This is the latest date for first arrival of Caspian terns at the Summer Lake Wildlife Area since the staff began keeping records of arrival dates 10 years ago. Two days later (April 30), a pair of Caspian terns was observed on Shovel Island. The first Caspian tern egg was laid on Shovel Island on May 22 (Table 6). During the night of May 29, a weather front and associated severe thunderstorms passed over this part of south-central Oregon. At the time of this storm, three pairs of Caspian terns had laid clutches of two eggs each on Shovel Island. In the two weeks following the storm, no additional nests were initiated on Shovel Island. Prior to the storm as many as 31 Caspian terns were counted on Shovel Island; following the storm the numbers of terns on the

island did not exceed 20 (Table 8). Two of the three active Caspian tern nests on the island prior to the storm failed, presumably due to the poor substrate conditions on the island (i.e., eggs stuck in mud such that terns could not roll their eggs). The two eggs laid in the third nest both hatched, the first on June 23. Two new tern nests were initiated after placing gravel substrate on the island on June 12, one on June 14 and the other on June 15. Both of these nests subsequently failed. The first fledgling was observed on August 13; however, fledging likely occurred about two weeks earlier. The size of the Shovel Island tern colony was 5 breeding pairs in 2003.

Two young terns fledged from the Shovel Island colony in 2003, or an average of 0.40 young raised per breeding pair (Table 17). This level of productivity is considered low compared to other well-studied colonies in the Pacific Region, and similar to levels observed at Rice Island in the Columbia River estuary, prior to the relocation of the colony to East Sand Island.



Two chicks that were successfully raised on Shovel Island, 2003

Chick Banding and Resightings of Banded Adults: On July 25, two tern chicks near fledging age were banded with USGS numbered metal bands and a unique color combination of plastic leg bands.

On July 7, an adult tern wearing a numbered metal leg band was observed on the colony and the number was read; the tern was banded as a chick in 1999 at Stillwater NWR in Nevada.

Diet Composition: Based on the limited diet data collected (N = 141 identified bill loads) the diet consisted almost entirely of Tui chubs (*Siphateles bicolor*) (at least 74% of identified prey items), which are abundant in the streams, ponds, and impoundments of the Wildlife Area. Additional fish taxa that represented more than 1% but less than 10% of the identified diet included trout (Salmonidae). Bass (Centrarchidae) comprised less than 1% of the diet (Table 14). The trout were likely captured at Ana Reservoir or Jack's Lakes, where trout are stocked for recreational fisheries and Caspian terns were observed foraging.

Factors Limiting Colony Size and Nesting Success:

The most apparent factors limiting colony size and nesting success of Caspian terns on Shovel Island were the (1) quality of nesting substrate and (2) availability of nesting habitat (Table 16). Capillary action by the fine-grained materials comprising Shovel Island, coupled with the heavy rainfall on May 29, saturated the substrate on Shovel Island, which consisted of muck from the bottom of the impoundment.



Tern eggs stuck in mud on Shovel Island, 2003

Despite no measurable rainfall in the two weeks following the May 29 storm, the substrate on Shovel Island failed to dry out, except for a thin crust. Two of the three nests initiated prior to the storm failed due to the eggs in each of those nests being stuck in the mud (see above). In order to test the hypothesis that the mucky condition of the substrate was preventing the initiation of new tern nests on Shovel Island, we placed 10 small piles of crushed gravel on the island on June 12. The same day, Caspian terns were observed digging nest scrapes in the piles of gravel. On June 14 a new tern nest was initiated in a footprint left by the field crew and on June 15 another new tern nest was initiated, this time on one of the new piles of gravel placed on the island three days earlier; both of these nests ultimately failed. The timing of nest initiation after the placement of substrate on the island provides further evidence that the existing nesting substrate on the island was a major limiting factor for both the size and the nesting success of the Caspian tern colony.

No other Caspian tern nesting colonies were located anywhere else in the Summer Lake area, so it appears that suitable nesting habitat other than Shovel Island was lacking in the area.

Keister Island, Crump Lake (Warner Valley)

Background: Keister Island is a small, low-lying, rocky island, less than 0.5 acres in area, located in Crump Lake in the Warner Valley. The island is owned and managed by the Oregon Division of State Lands, and is about 1.5 km from shore in the northern part of Crump Lake. The island is named for George Keister, a biologist with the Oregon Department of Fish and Wildlife, who led the effort to reconstruct the island in 1990, when a severe drought caused Crump Lake to dry up. An island had existed at the location of Keister Island prior to European settlement and had served as a nesting site

for several species of colonial waterbirds during the early part of the 20th century. The island was destroyed, however, when it was looted for Native American artifacts, and no colonial waterbirds used the site until after 1990. The breeding colony of Caspian terns on Keister Island was last confirmed in 2000, when approximately 150 breeding pairs nested on the island in association with a larger colony of California gulls. No Caspian terns apparently nested on Keister Island in the last two breeding seasons because the water level in Crump Lake was so high that the island was completely submerged when terns normally initiate their nests.

Prior to the arrival of Caspian terns in the Crump Lake area this year, Keister Island had emerged from Crump Lake, exposing about 200 m² of suitable sand and gravel nesting habitat for Caspian terns. After improvements were made to the tern nesting habitat with



Construction of Keister Island nesting platform with flooded island in background

hand tools, an observation blind was built in shallow water just to the south of the tern colony site on Keister Island, and 141 Caspian tern decoys and 2 audio playback systems were deployed on the tern colony site. After rising water levels in Crump Lake eliminated nearly all the available tern nesting habitat

on Keister Island before terns initiated nesting in 2003, we constructed a wooden platform on the submerged island to accommodate nesting terns (see above photo).

Colony Size and Nesting Success: The first Caspian terns were sighted in the Crump Lake area on April 25, much later than anticipated. On the same day, three Caspian terns were observed on Keister Island among the tern decoys (Table 7). Due to unseasonably low temperatures and high precipitation (rain and snow) during March, April, and the first half of May, the water level in Crump Lake gradually rose until very little of the original tern nesting area remained above water. On May 17, we constructed a wooden platform on Keister Island measuring 16' by 24' (384 ft²) and placed about 2-3 inches of sand on the platform as substrate for nesting Caspian terns. The platform was elevated four feet above Keister Island in order to assure that rising water levels and wave action would not

inundate the sand on the platform. The tern decoys were removed from Keister Island and 30 decoys were placed on the nesting platform.

The next day (May 18), 14 Caspian terns were observed on the nesting platform (Table 8); the first Caspian tern egg was laid on the platform five days later on May 23. Soon thereafter, the continued rise in lake level completely submerged all tern nesting habitat on Keister Island and waves lapped at the underside of the nesting platform. By June 8, there were 49 active Caspian tern nests on the platform, 38 with two-egg clutches and 11 with one-egg clutches. The available nesting habitat on the platform appeared to be



Tern eggs laid on Keister Island Platform, 2003

completely occupied, and the nesting density on the platform was about 1.3 nests/m². The first tern chick hatched on the platform on June 19, and the first fledgling was observed on July 31, likely about a week after fledging from the platform commenced. The total number of breeding pairs that nested on the platform was estimated at 49 pairs.

During the first week in June the level of Crump Lake stabilized and during the second week in June the lake level began receding. By June 11 the tern nesting habitat on Keister Island began to re-emerge and on June 12 several Caspian terns were observed roosting on the old colony site for the first time in several weeks (Table 8). The first Caspian tern egg was laid on Keister Island on June 17, 25 days after the first egg was laid on the nesting platform. Chicks began hatching on the island by July 12. The size of the Keister Island colony was estimated at 22 breeding pairs. In total, about 69 breeding pairs used either the nesting platform or Keister Island itself in 2003.

We estimated that approximately 31 young terns fledged from the nesting platform and 14 young terns fledged from Keister Island, for a total of about 45 young fledged. Productivity was similar for the nesting platform (0.63 young raised per breeding pair) and for the island (0.64 young per breeding pair; Table 17). This level of productivity, however, is only considered fair compared to other well-studied colonies in the Pacific Region and is well below recently measured levels of productivity at the East Sand Island tern colony in the Columbia River estuary.

Chick Banding and Resightings of Banded Adults: On July 24, 31 tern chicks near fledging age were banded with USGS numbered metal leg bands and a unique color combination of plastic leg bands, and an additional 14 younger chicks were banded with numbered metal leg bands only. These marked individuals will allow us to measure survival rates and movements among colonies.



Chick
banding at
Keister
Island, 2003

On June 18, a color-banded adult was observed on the colony and was identified as a tern recently banded as either a chick or adult at a colony in the Pacific Northwest (colony location unknown).

Diet Composition: A large number of Caspian tern bill loads were successfully identified at the Keister Island nesting platform (N = 1,378). The diet of Caspian terns nesting at Keister Island consisted primarily of Tui chub (Cyprinidae), followed by sunfish



Tui chub collected from tern colony

(Centrarchidae) and catfish (Ictaluridae), in that order (Table 15). These three taxa each made up greater than 10% of identified prey items. Additional fish taxa that represented more than 1% but less than 10% of the diet included trout (Salmonidae) and goldfish (Cyprinidae), in that order. One other prey taxon (suckers) represented less than 1% of the diet.

We suspect that the trout portion of the tern diet consisted mostly, if not entirely, of native Great Basin redband trout; a sensitive species in the State of Oregon.

Stocked non-native trout are available to terns; however, they are located in lakes and reservoirs that are greater than 30 km from Keister Island (C. Edwards, pers. comm.).

One Warner sucker (*Catostomus warnerensis*; Catostomidae) was positively identified among the tern bill loads identified early in the nesting season. Warner suckers, a species listed as threatened under the ESA, represented 0.07% of identified tern prey at Keister Island in 2003.

Factors Limiting Colony Size and Nesting Success: The most apparent factor limiting colony size and nesting success of Caspian terns on Keister Island was the availability of suitable nesting habitat (Table 16). Despite the submergence of all tern nesting habitat on Keister Island by late May, no Caspian tern nesting colonies were initiated elsewhere in the Warner Valley. Also, the rapid colonization and onset of nesting on the artificial nest platform, plus the high nesting density on the platform, supports the hypothesis that suitable tern nesting habitat is severely limiting in this area of interior Oregon.

We observed California gulls removing Caspian tern eggs from the nesting platform on several occasions, but at least some of these eggs appeared to have been unattended and may have been laid on the platform by a female tern without a nest scrape.

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Figure 1. Map of the San Francisco Bay area, showing the locations of known active breeding colonies of Caspian terns during 2003.

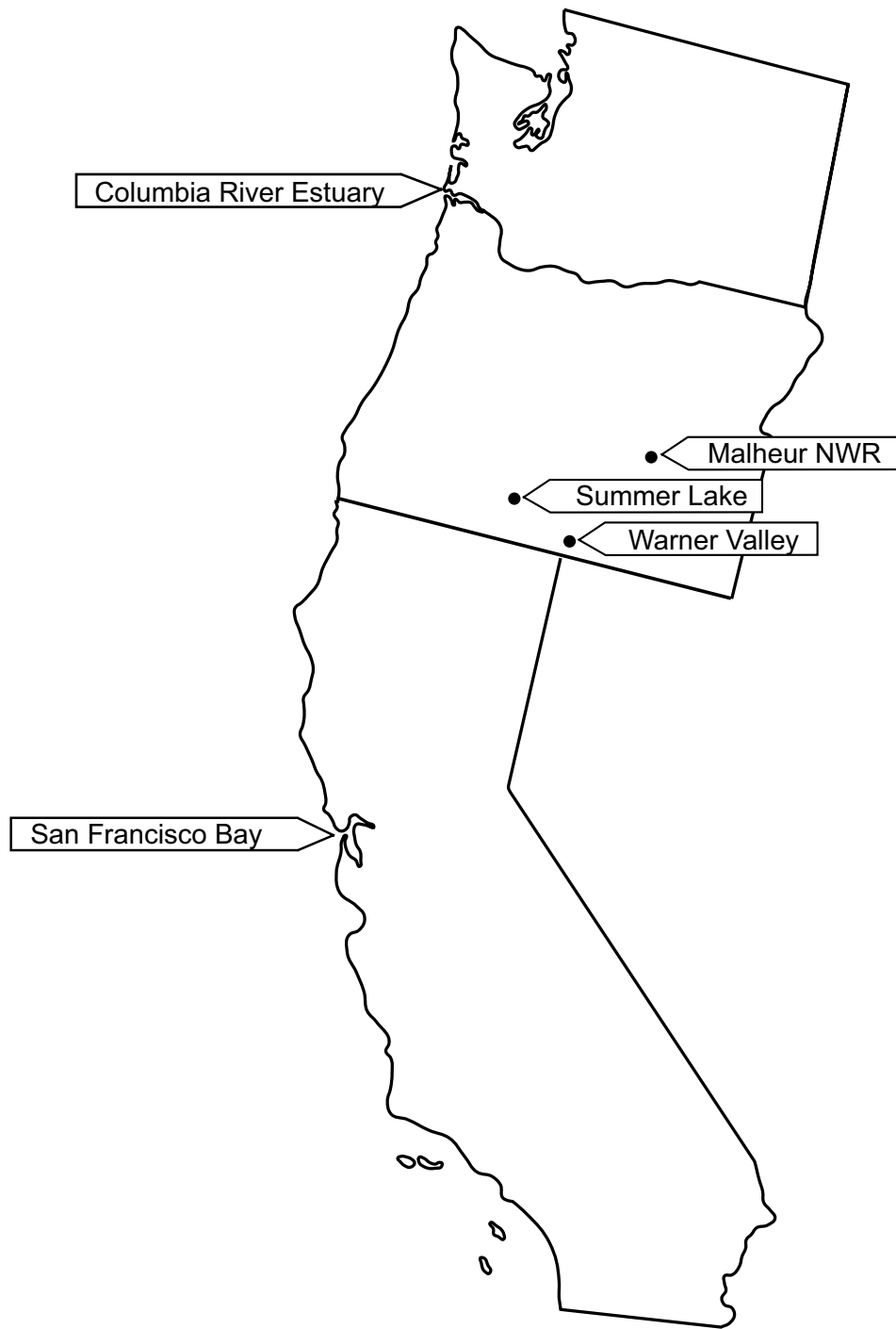


Figure 2. Caspian tern nesting areas mentioned in this report.

Table 1. Timeline for research activities and Caspian tern nesting chronology at Brooks Island, San Francisco Bay, California in 2003.

Date	Colony	Note
03/10/03	Brooks Is.	First adult tern (n = 1) observed near colony
03/25/03	Brooks Is.	First crew visit to colony site; 20 terns on-colony; observation blind constructed
04/01/03	Brooks Is.	Diet data collection begins
04/17/03	Brooks Is.	First tern egg laid
05/13/03	Brooks Is.	First tern chick hatched
05/23/03	Brooks Is.	First count of NW colony
05/29/03	Brooks Is.	Aerial photo census of colony attempted
06/05/03	Brooks Is.	Colony size estimated during walk-through of the Main and NW Satellite sub-colonies
06/20/03	Brooks Is.	First fledgling observed
06/30/03	Brooks Is.	Tern fledglings banded; colony productivity estimated
08/01/03	Brooks Is.	Final visit to colony; blind winterized

Table 2. Timeline for research activities and Caspian tern nesting chronology at Knight Island, San Francisco Bay, California in 2003.

Date	Colony	Note
04/03/03	Knight Is.	First crew visit to colony site; 10 terns observed nearby
04/15/03	South Colony, Knight Is.	First adult terns (n = 53) observed on-colony
04/15/03	South Colony, Knight Is.	Diet data collection begins
05/03/03	South Colony, Knight Is.	First tern egg laid
05/11/03	South Colony, Knight Is.	No adult terns on colony; all nests with eggs (n = 7) depredated
05/15/03	South Colony, Knight Is.	Number of terns on-colony returned to levels observed before 5/11
05/24/03	South Colony, Knight Is.	Re-laying by terns begins
06/17/03	South Colony, Knight Is.	First tern chick hatched
07/27/03	South Colony, Knight Is.	First fledgling observed
07/28/03	South Colony, Knight Is.	Tern fledglings banded; colony productivity estimated
07/29/03	South Colony, Knight Is.	Final visit to colony

Table 3. Timeline for research activities and Caspian tern nesting chronology at Baumberg Pond, San Francisco Bay, California in 2003.

Date	Colony	Note
04/10/03	Baumberg	First crew visit to colony site; 42 terns observed on-colony
04/19/03	Baumberg	Diet data collection begins
05/01/03	Baumberg	First tern egg laid (date approximate)
05/26/03	Baumberg	Observation blind constructed
05/27/03	Baumberg	First tern chick observed
07/05/03	Baumberg	First fledgling observed
07/26/03	Baumberg	Blind removed
07/30/03	Baumberg	Final visit to colony

Table 4. Timeline for research activities and Caspian tern nesting chronology at A7 Pond, San Francisco Bay, California in 2003.

Date	Colony	Note
04/10/03	A7 Pond	First crew visit to the colony site
04/19/03	A7 Pond	First adult terns (n = 8) observed near A7; diet data collection begins
04/22/03	A7 Pond	First adult terns (n = 18) observed on colony
05/18/03	A7 Pond	First tern egg laid
06/14/03	A7 Pond	First tern chick observed
07/30/03	A7 Pond	Final visit to colony; 4 pre-fledging chicks observed

Table 5. Timeline for research activities and Caspian tern nesting chronology at Agua Vista Park, San Francisco Bay, California in 2003.

Date	Colony	Note
05/02/03	Agua Vista	First crew visit to colony site; 54 terns observed on-colony; tern eggs present
05/18/03	Agua Vista	Diet data collection begins
05/25/03	Agua Vista	First tern chick hatched
07/16/03	Agua Vista	First fledgling tern observed
07/30/03	Agua Vista	Final visit to colony

Table 6. Timeline for research activities and Caspian tern nesting chronology at Shovel Island, Summer Lake Wildlife Area, Oregon in 2003.

Date	Colony	Note
03/26/03	Shovel Is.	First crew visit to colony site (small push-up island in East Link Impoundment)
03/26/03	Shovel Is.	Floodgates to East Link Impoundment opened; observation blind constructed
03/28/03	Shovel Is.	Tern decoys (60) and sound systems (2) deployed
03/29/03	Shovel Is.	Habitat enhancement (work on push-up island with hand tools) completed
04/08/03	Shovel Is.	East Link Impoundment filled; Shovel Is. becomes an island
04/15/03	Shovel Is.	Flood gates closed to East Link Impoundment
04/28/03	Shovel Is.	First adult tern observed near Shovel Island
04/30/03	Shovel Is.	First adult terns (n = 2) observed on Shovel Island
05/15/03	Shovel Is.	Diet data collection begins
05/22/03	Shovel Is.	First tern egg laid on Shovel Island
06/12/03	Shovel Is.	Suitable nesting substrate (10 small piles of gravel) added to island
06/13/03	Shovel Is.	Adult terns observed digging nest scrapes in new nesting substrate
06/15/03	Shovel Is.	First tern egg laid on new substrate placed on island
06/23/03	Shovel Is.	First tern chick hatched on Shovel Island
07/07/03	Shovel Is.	Banded adult tern observed roosting on colony
07/25/03	Shovel Is.	Tern fledglings banded
08/13/03	Shovel Is.	First fledgling tern observed
08/13/03	Shovel Is.	Final visit to colony; blind removed

Table 7. Timeline for research activities and Caspian tern nesting chronology at Keister Island and nesting platform, Crump Lake, Warner Valley, Oregon in 2003.

Date	Colony	Note
03/30/03	Keister Is.	First crew visit to colony site
03/31/03	Keister Is.	Observation blind constructed
04/01/03	Keister Is.	Tern decoys (141) and sound systems (2) deployed
04/25/03	Keister Is.	First adult terns observed near Keister Island; first terns observed on-colony (n = 3)
05/16/03	Keister Is.	Rising lake levels submerge most (80-90%) of tern nesting habitat
05/17/03	Keister Is.	Nesting platform (16' x 24') constructed; sand and 30 tern decoys placed on platform
05/18/03	Keister Is. Platform	First adult terns (n = 14) observed on nesting platform
05/23/03	Keister Is. Platform	First tern egg laid on nesting platform
05/26/03	Keister Is. Platform	Diet data collection begins; Keister Is. completely submerged
06/11/03	Keister Is.	Tern nesting habitat on island re-emerged (ca. 2 sq. ft.)
06/12/03	Keister Is.	First terns (n = 6) observed on re-emerged tern nesting habitat on island
06/17/03	Keister Is.	First tern egg laid on Keister Island
06/18/03	Keister Is.	Color-banded adult tern observed roosting on colony
06/19/03	Keister Is. Platform	First tern chick hatched on nesting platform; colony size on platform estimated
07/12/03	Keister Is.	First tern chick hatched on Keister Island
07/24/03	Keister Is. Platform	Tern fledglings banded; colony productivity estimated
07/31/03	Keister Is. Platform	First fledged young from nesting platform observed
08/14/03	Keister Is. Platform	Final visit to colony; blind and nesting platform removed from the island

Table 8. Average number of adult Caspian terns counted each week at five nesting colonies in San Francisco Bay (Brooks Island main sub-colony, Brooks Island satellite sub-colony, Kr Baumberg Pond, A-7 Pond, Agua Vista Park) and two colonies in interior Oregon (Keister Island and Keister Island nesting platform in Crump Lake, Shovel Island in Summer Lake Wildlii

Week ending	Brooks Is.(main colony)	Brooks Is.(NW satellite)	Knight Is.	Baumberg Pond	A-7 Pond	Agua Vista	Keister Is.	Keister Is. Platform
30-Mar	26	no data	no data	no data	no data	no data	0	-
6-Apr	74	no data	0	no data	no data	no data	0	-
13-Apr	96	no data	no data	42	0	no data	0	-
20-Apr	153	no data	73	44	0	no data	0	-
27-Apr	168	66	58	21	no data	no data	3	-
4-May	275	422	80	35	no data	54	6	-
11-May	299	250	73	38	17	54	22	-
18-May	358	362	80	49	41	78	12	14
25-May	384	246	118	45	54	68	8	13
1-Jun	385	336	129	40	42	79	0	28
8-Jun	373	303	207	33	47	38	0	44
15-Jun	355	319	203	35	45	41	1	49
22-Jun	299	289	220	27	44	65	23	44
29-Jun	282	278	214	26	38	81	54	57
6-Jul	225	195	203	20	27	70	57	46
13-Jul	183	233	184	20	9	59	64	32
20-Jul	130	170	161	29	32	73	67	16
27-Jul	91	99	51	11	no data	35	53	4
3-Aug	55	no data	75	9	20	25	45	1
10-Aug	no data	no data	no data	no data	no data	no data	23	0
17-Aug	no data	no data	no data	no data	no data	no data	9	0

NOTE: Numbers of terns reported for Knight Island are only for the South Colony (does not include Northeast Colony); about the same number of terns are nesting at Northeast Colony (

Table 9. Caspian tern diet composition at the Brooks Island colony (Main Sub-colony), San Francisco Bay, California, based on percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Anchovy	Butterfish	Centrarchid	Clupeid	Croaker	Flatfish	Goby	Lamprey	Trout	Salmon	Sandlance	Sculpin	Shark	Silverside	Surfperch	Toadfish	Tomcod	Other
6-Apr	35	17.1	0	0	0	0	0	2.9	0	2.9	0	0	0	0	57.1	20	0	0	0
13-Apr	32	31.3	0	0	0	0	0	3.1	0	6.3	0	0	0	0	37.5	21.9	0	0	0
20-Apr	174	52.3	0	0	0	0	0	5.2	0	0.6	0	0	8.6	0	8	25.3	0	0	0
27-Apr	242	22.7	0	0.4	1.2	0	0	3.3	0	7.9	0	0	5.4	0.8	30.2	26	2.1	0	0
4-May	227	53.3	0	0	3.5	0	0	1.8	0	2.6	0	0	2.6	0	11.9	22.5	1.3	0	0.4
11-May	234	20.9	0	0.9	14.1	0	0.4	7.7	0	1.7	0	0	5.1	0	19.2	25.6	2.6	0	1.7
18-May	496	12.5	0	0.4	22.6	0.6	0.4	1.2	0	0.4	0.6	0	1.6	0	9.7	48.2	1.2	0.4	0.2
25-May	504	15.9	0	0.2	18.3	0	0	3.4	0	0	1.8	0	5.5	0	5	49	0.4	0.4	0.2
1-Jun	466	27.7	0	0.2	12.9	0.2	0.2	0.8	0	0.2	7.3	0	2.8	0	5.8	40.8	0.6	0	0.4
8-Jun	441	12.7	0	0	10.4	0	0	1.8	0	0	6.8	0	1.8	0	7.7	56	2.3	0	0.5
15-Jun	628	24.7	0	0.6	22.9	0	0	2.6	0	1	2.5	0	1.9	0	3.8	36.8	2.7	0.5	0
22-Jun	477	23.1	0.6	0.4	35	0	0	3.4	0	0.6	1.9	0	4.6	0	4.5	16.1	7.1	0	2.5
29-Jun	325	29.5	0.3	0.9	27.1	0	0	1.2	0	0	1.5	0	6.8	0.3	4.3	10.8	12.3	0	4.9
6-Jul	479	19.8	3.5	0.4	11.9	0	0	1.4	0	0.8	0.8	0	5.2	0	8.9	29.4	14.6	0	2.9
13-Jul	328	21.6	1.8	2.4	27.4	0	0	2.1	0	1.2	4.3	1.2	6.7	0	4.9	11.3	13.1	0	1.8
20-Jul	326	26.7	0.6	1.2	18.7	0.3	0.3	3.1	0.3	0.6	3.7	1.8	5.8	0	6.7	12.2	14.7	0	3.1
27-Jul	165	51.5	2.4	0.6	10.3	0.6	0.6	4.8	0	0	1.2	0	8.5	0	1.2	7.3	7.3	0	3.6
TOTAL	5579	27.3	0.5	0.5	13.9	0.1	0.1	2.9	0.0	1.6	1.9	0.2	4.3	0.1	13.3	27.0	4.8	0.1	1.3

NOTE: The "Salmon" category consisted of juvenile chinook salmon.

NOTE: The "Trout" category consisted of stocked rainbow trout from nearby reservoirs.

Table 10. Caspian tern diet composition at the Knight Island colony (South Colony), San Francisco Bay, California, based on percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Anchovy	Centrarchid	Clupeid	Croaker	Flatfish	Goby	Trout	Salmon	Sculpin	Silverside	Sucker	Surfperch	Toadfish	Other
20-Apr	8	12.5	25	12.5	0	0	37.5	0	0	0	12.5	0	0	0	0
27-Apr	45	8.9	4.4	0	0	0	22.2	0	0	4.4	44.4	0	15.6	0	0
4-May	21	4.8	14.3	0	0	0	33.3	4.8	0	4.8	28.6	0	9.5	0	0
11-May	43	7	7	0	0	0	4.7	0	0	0	41.9	0	37.2	2.3	0
18-May	49	2	4.1	65.3	2	0	2	0	0	0	22.4	0	2.1	0	0
25-May	48	8.3	4.2	22.9	0	2.1	4.2	0	2.1	2.1	20.8	0	33.3	0	0
1-Jun	79	1.3	1.3	2.5	0	0	1.3	0	2.5	0	86.1	0	5.1	0	0
8-Jun	114	0.9	0.9	0.9	0	0	0.9	0	5.3	1.8	80.7	0	6.1	0	2.6
15-Jun	22	4.6	0	0	0	0	9.1	4.5	31.9	0	18.2	0	27.3	4.6	0
22-Jun	42	7.1	7.1	7.1	0	0	9.5	0	21.4	2.4	14.3	0	19.1	7.1	4.8
29-Jun	12	0	8.3	0	0	0	0	0	0	0	8.3	0	66.7	0	16.7
6-Jul	51	19.6	5.9	5.9	0	0	5.9	3.9	0	7.8	13.7	0	21.6	11.8	3.9
13-Jul	128	8.6	12.5	10.9	0	0.8	7	1.6	21.1	2.3	13.3	0.8	9.4	9.4	2.3
20-Jul	109	6.4	8.3	9.2	0	0	11	0	42.2	0	3.7	0	6.4	11.9	0.9
27-Jul	14	0	64.3	0	0	0	7.1	7.1	0	7.1	0	0	0	7.1	7.1
3-Aug	50	6	24	0	0	0	24	0	12	6	8	0	0	14	6
TOTAL	835	6.1	12.0	8.6	0.1	0.2	11.2	1.4	8.7	2.4	26.1	0.1	16.2	4.3	2.8

NOTE: The "Salmonid" category consisted of juvenile chinook salmon.

NOTE: The "Trout" category consisted of stocked rainbow trout from nearby reservoirs.

Table 11. Caspian tern diet composition at the Baumberg Pond colony, San Francisco Bay, California, based on percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Anchovy	Butterfish	Centrarchid	Clupeid	Flatfish	Goby	Salmon	Sculpin	Shark	Silverside	Surfperch	Toadfish	Other
20-Apr	33	3	0	0	0	0	0	0	6.1	12.1	18.2	60.6	0	0
27-Apr	30	0	0	0	0	10	0	0	0	46.7	3.3	40	0	0
4-May	7	28.6	0	0	0	0	0	0	0	0	57.1	14.3	0	0
11-May	71	0	0	0	2.8	4.2	0	0	0	28.2	28.2	31	1.4	4.2
18-May	54	0	0	0	0	18.5	0	0	5.6	18.5	3.7	50	3.7	0
25-May	58	1.7	0	0	0	8.6	3.4	0	1.7	38	0	44.8	1.7	0
1-Jun	58	13.8	0	0	3.4	1.7	0	0	0	3.4	5.2	72.4	0	0
8-Jun	34	23.5	0	0	0	0	5.9	0	2.9	0	11.8	47	5.9	2.9
15-Jun	37	8.1	0	0	0	0	8.1	0	0	0	40.54	43.2	0	0
22-Jun	96	9.4	0	0	18.8	0	7.3	1	4.2	0	36.5	19.8	2.1	1
29-Jun	26	30.8	0	7.7	26.9	0	11.5	0	0	0	7.7	11.5	3.8	0
6-Jul	81	6.2	0	0	12.3	4.9	1.2	0	0	3.7	46.9	3.7	16	5
13-Jul	16	0	6.3	6.3	18.8	0	0	0	0	0	12.5	0	43.8	12.5
20-Jul	2	0	0	0	0	0	0	0	0	0	0	0	0	100
TOTAL	603	8.9	0.5	1.0	5.9	3.4	2.7	0.1	1.5	10.8	19.4	31.3	5.6	9.0

NOTE: The "Salmonid" category consisted of one juvenile chinook salmon.

Table 12. Caspian tern diet composition at the A-7 Pond colony, San Francisco Bay, California, based on percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Anchovy	Centrarchid	Flatfish	Goby	Sculpin	Shark	Silverside	Surfperch	Toadfish	Other
20-Apr	1	0	0	0	0	0	0	100	0	0	0
27-Apr	0										
4-May	0										
11-May	6	0	0	0	16.7	16.7	16.7	16.7	33.3	0	0
18-May	5	0	20	0	0	0	0	20	20	40	0
25-May	11	18.2	0	0	27.3	54.5	0	0	0	0	0
1-Jun	4	0	0	25	0	0	0	0	50	0	25
8-Jun	5	20	0	0	40	0	0	0	0	40	0
15-Jun	6	50	0	0	16.7	16.7	0	0	16.7	0	0
22-Jun	10	30	0	0	30	0	0	0	0	0	40
29-Jun	4	0	0	0	0	50	0	0	0	50	0
6-Jul	13	0	0	0	7.7	7.7	0	0	0	84.6	0
13-Jul	0										
20-Jul	25	0	0		0	0	0	0	0	100	0
TOTAL	90	10.7	1.8	2.5	12.6	13.2	1.5	12.4	10.9	28.6	5.9

Table 13. Caspian tern diet composition at the Agua Vista Park colony, San Francisco Bay, California, based on percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Anchovy	Clupeid	Flatfish	Goby	Salmon	Sandlance	Sculpin	Silverside	Surfperch	Toadfish	Other
18-May	3	0	0	0	0	0	0	0	66.7	33.3	0	0
25-May	1	100	0	0	0	0	0	0	0	0	0	0
1-Jun	0											
8-Jun	5	0	0	0	0	0	0	0	20	80	0	0
15-Jun	0											
22-Jun	8	0	37.5	0	0	0	0	0	0	62.5	0	0
29-Jun	6	16.7	83.3	0	0	0	0	0	0	0	0	0
6-Jul	27	33.3	11.1	0	0	0	0	3.7	18.5	25.9	7.4	0
13-Jul	16	6.3	6.3	0	0	0	0	0	43.8	12.5	18.8	12.5
20-Jul	104	23.1	24	1	1	1	1.9	4.8	13.5	9.7	17.3	2.9
27-Jul	20	30	0	0	0	0	0	0	25	25	0	20
TOTAL	190	23.3	18.0	0.1	0.1	0.1	0.2	0.9	20.8	27.7	4.8	3.9

NOTE: The "Salmonid" category consisted of one juvenile chinook salmon.

Table 14. Caspian tern diet composition at the Shovel Island colony, Summer Lake Wildlife Area, Oregon, based on the percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Week ending	N	Catfish	Centrarchid	Chub	Cyprinid	Non-Salmonid	Trout	Sucker	Other
18-May	3	0	0	33.3	0	66.7	0	0	0
25-May	47	0	2.1	68.1	0	29.8	0	0	0
1-Jun	27	0	0	74.1	0	18.5	7.4	0	0
8-Jun	16	0	0	87.5	0	12.5	0	0	0
15-Jun	9	0	0	88.9	0	0	11.1	0	0
22-Jun	3	0	0	100	0	0	0	0	0
29-Jun	14	0	0	71.4	0	0	28.6	0	0
6-Jul	6	0	0	66.7	0	16.7	16.7	0	0
13-Jul	16	0	0	75	0	0	25	0	0
TOTAL	141	0.0	0.2	73.9	0.0	16.0	9.9	0.0	0.0

NOTE: The "Trout" category consisted solely of stocked rainbow trout.

NOTE: The "Non-Salmonid" category consisted of fish that could not be identified to family, but were definitely not salmonids (i.e., trout).

Table 15. Caspian tern diet composition at the Keister Island colony, Crump Lake, Oregon, based on the percent of identifiable prey items delivered as bill loads to the colony in 2003. TOTAL percentages are means of the weekly percentages.

Date	N	Catfish	Centrarchid	Chub	Goldfish	Non-Salmonid	Trout	Sucker	Other
1-Jun	27	11.1	22.2	44.4	0	14.8	3.7	3.7	0
8-Jun	52	9.6	26.9	59.6	0	0	1.9	0	1.9
15-Jun	71	28.2	16.9	50.7	0	0	4.2	0	0
22-Jun	34	17.6	5.9	58.8	0	0	17.6	0	0
29-Jun	113	14.2	29.2	52.2	3.5	0	0.9	0	0
6-Jul	128	16.4	14.1	65.6	1.6	0	2.3	0	0
13-Jul	192	20.3	21.9	56.8	1	0	0	0	0
20-Jul	216	18.5	27.3	51.9	1.9	0	0.5	0	0
27-Jul	167	15	33.5	47.3	4.2	0	0	0	0
3-Aug	225	8.9	42.7	47.6	0.4	0	0.4	0	0
10-Aug	132	18.2	31.1	50.8	0	0	0	0	0
17-Aug	21	4.8	47.6	47.6	0	0	0	0	0
TOTAL	1378	15.2	26.6	52.8	1.1	1.2	2.6	0.3	0.2

NOTE: The "Sucker" category consisted solely of the Warner sucker, a species listed as threatened under the ESA.

NOTE: The "Trout" category consisted mostly or entirely of native Great Basin redband trout, a sensitive species in the State of Oregon. Stocked trout are available to terns; however, they are stocked in lakes and reservoirs greater than 30 km from Keister Island (C. Edwards, pers. comm.).

NOTE: The "Non-Salmonid" category consisted of fish that could not be identified to family, but were definitely not salmonids (i.e., trout).

Table 16. Potential limiting factors for colony size and nesting success at Caspian tern colonies in San Francisco Bay area and Interior Oregon in 2003. "X" denotes an observed factor of significance, "x" denotes an observed factor of minor importance, and "?" denotes a suspected factor. Contaminants are also a possible limiting factor at some colonies in San Francisco Bay, but this study does not address that issue directly.

	San Francisco Bay					Summer Lake	Crump Lake
	Brooks Is.	Knight Is.	Baumberg Pond	A7 Pond	Agua Vista	Shovel Is.	Keister Is. / Platform
Availability of nesting habitat	X ¹	X ⁴	X ⁸	X ⁸	?	x	X ¹⁵
Quality of nesting substrate		x	X ⁹	X ⁹	X ¹²	X ⁹	
Prey fish availability						? ¹³	? ¹³
Mammalian predators	? ²	X ⁵	x ¹⁰			? ¹⁴	
Displacement by other colonial waterbirds	? ³	X ⁶	X ¹¹				?
Avian predators (other than gulls)	x	x					
Gull kleptoparasitism	x	? ⁷			?		?
Gull nest predation	x	? ⁷		? ¹⁶	?		x
Human disturbance	X ¹⁷	?	X ¹⁸	X ¹⁸	?		
Commercial aircraft	x						
Recreational aircraft	x						

¹ encroaching pickleweed; high spring tides associated with extreme weather

² one raccoon present on the island; rats present on the island

³ expanding California gull colony

⁴ tidally influenced since dike was breached in 2002/2003

⁵ unknown mammalian predator caused nest failure (7 nests) and colony abandonment on May 11

⁶ expanding double-crested cormorant colony (North Colony)

⁷ expanding double-crested cormorant colony (North Colony) may attract gulls to island

⁸ changing water levels due to mitigation for hyper-saline conditions in adjacent salt ponds

⁹ sticky when wet and terns have difficulty digging scrapes

¹⁰ two red foxes, a long-tailed weasel, and a domestic cat are using adjacent dikes

¹¹ tern eggs and nests trampled by roosting white pelicans and double-crested cormorants

¹² nesting on pier deck where there is little or no nesting substrate

¹³ due to fluctuating water levels

¹⁴ raccoon with wet fur observed on dike nearby

¹⁵ rising water levels inundated entire island on May 26

¹⁶ regular nest, egg, and/or chick loss at colony, possibly due to California gull depredation

¹⁷ disturbance mostly from recreational kayakers and boaters

¹⁸ disturbance from other researchers

Table 17. Size and productivity of Caspian tern nesting colonies in San Francisco Bay area and south-central Oregon during the 2003 breeding season.

	Colony Size (# breeding pairs)	# Fledglings Produced	Productivity (fledglings/pair)
San Francisco Bay			
Brooks Island	859	535	0.62
Main Sub-colony	444	309	0.70
NW Satellite Sub-colony	415	226 ^a	0.54 ^c
Knight Island	203	125 ^b	0.62 ^d
Baumberg Pond	35	15	0.43
A-7 Pond	50	4 ^b	0.08 ^d
Agua Vista Park	43	18 ^a	0.42 ^c
South-central Oregon			
Keister Island (Crump Lake)	22	14 ^b	0.64 ^d
Keister Island Platform (Crump Lake)	49	31	0.63
Shovel Island (Summer Lake WA)	5	2	0.40

^a Minimum number of fledglings due to observation distance and visual obstructions.

^b Maximum number of fledglings; includes smaller chicks that may not have survived to fledging.

^c Minimum productivity due to potential underestimation of number of fledglings.

^d Maximum productivity due to potential overestimation of number of fledglings.