U.S Fish & Wildlife Service

Caspian Tern Nesting Ecology and Diet at Colony Sites on the Olympic Peninsula, Washington

---

November 2005

Caspian Tern Nesting Ecology and Diet on the Olympic Peninsula, Washington

2005 Final Annual Report

[Not for citation or publication without prior permission from the authors]

Submitted to:

U.S. Fish and Wildlife Service, Region 1
Migratory Birds and Habitat Programs
911 NE 11th Avenue
Portland, Oregon 97232

by

Daniel D. Roby, Principal Investigator
USGS - Oregon Cooperative Fish and Wildlife Research Unit
104 Nash Hall
Oregon State University
Corvallis, Oregon 97331-3803
Internet: daniel.roby@orst.edu
Telephone: 541-737-1955

Ken Collis and Allen Evans
Real Time Research, Inc.
61434 Linton Loop
Bend, Oregon 97702
Internet: kcollis@realtimeresearch.org
Telephone: 541-382-3836

S. Kim Nelson, Kirsten Bixler, and Don Lyons
Department of Fisheries and Wildlife
104 Nash Hall
Oregon State University
Corvallis, Oregon 97331-3803

November 16, 2005

EXECUTIVE SUMMARY

This 2005 final annual report presents results from the second year of a study investigating colony status and diet composition of Caspian terns (*Sterna caspia*) nesting on Dungeness Spit in Dungeness National Wildlife Refuge, Washington. We also present data for an incipient Caspian tern colony on warehouse rooftops in the Puget Sound Naval Shipyard, Bremerton, Washington. 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 two colony sites. 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 Consequently, these data are not for citation or publication without prior permission from the authors.

The Caspian tern colony on Dungeness Spit in Dungeness National Wildlife Refuge evidently formed for the first time during the 2003 nesting season, and was located on sandy substrate amongst driftwood approximately one kilometer southwest of the Dungeness Lighthouse National Historic Site. In 2005, this tern colony consisted of about 680 breeding pairs, and 417-754 young were fledged (0.61-1.11 fledglings/breeding pair). This represents an increase of about 150% in colony size and similar nesting success, compared to 2004. The Dungeness Spit colony had the highest nesting success of any Caspian tern colony that we monitored during the 2005 nesting season. Unlike 2004, when most early season nesting attempts failed due to frequent visits to the tern colony by a coyote, mammalian predation was not a major factor limiting nesting success at the Dungeness tern colony in 2005. In 2005, gull predation and human disturbance were the primary factors limiting colony size and nesting success at Dungeness Spit; there was no indication that nesting habitat or food availability were limiting factors. The diet of terns nesting at Dungeness NWR consisted mostly of surfperch (Embiotocidae; 31%), salmonids (Salmonidae; 17%), sculpins (Cottidae; 15%), herring and sardines (Clupeidae; 13%), and smelt (Osmeridae; 12%). Salmonid smolts were 45% less prevalent in the diet in 2005 compared to 2004. Presumably, some (most?) of the salmonid smolts consumed by terns nesting at this colony were outmigrants from the nearby Dungeness River, where the Dungeness Hatchery is located approximately 15 km upstream from the mouth.

The Caspian tern colony at the Puget Sound Naval Shipyard in Bremerton, estimated to consist of 130 breeding pairs, had low nesting success (49 young were fledged or 0.38 fledglings/breeding pair) compared to the Dungeness Spit colony and other colonies in the region. The primary factors limiting colony size and nesting success were human disturbance and the quality and availability of suitable nesting habitat. The diet of Caspian terns at the Bremerton Naval Shipyard consisted primarily of salmonids (Salmonidae; 34%), surfperch (Embiotocidae; 32%), and herring and sardines (Clupeidae; 19%).

We conclude from these studies of Caspian terns nesting on the Olympic Peninsula that (1) terns nesting at Dungeness Spit will continue to be vulnerable to mammalian nest predators without some form of protection (e.g., predator fencing, predator control), (2) in the absence of mammalian nest predators, nesting success at Dungeness Spit will probably be limited by predation by gulls and human disturbance, and (3) the incipient tern colony on warehouse rooftops at the Bremerton Naval Shipyard, as well as documented tern nesting on other rooftops in the Puget Sound area in previous years, provides strong evidence that the availability of suitable nesting habitat for Caspian terns in the Puget Sound region is very limited. Food availability for Caspian terns nesting at Dungeness Spit was good in 2005, despite poor ocean conditions along the coast of the Pacific Northwest, which resulted in widespread nesting failure among piscivorous seabirds. This suggests that, barring disturbance by mammalian nest predators, the Dungeness Spit colony may continue to increase in size in future years.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Caspian terns (*Sterna caspia*) nesting at the colony on East Sand Island in the Columbia River estuary consume about 3 - 6 million juvenile salmonids from the Columbia Basin annually. This magnitude of smolt losses to terns continues 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 2005). 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, Suryan et al. 2004), the sole remaining Caspian tern colony along the outer coast of Oregon and Washington (Shuford and Craig 2002, Suryan et al. 2004). The U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA Fisheries prepared an Environmental Impact Statement (EIS) for management of Caspian terns in the Columbia River estuary. The EIS explored 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. The Final EIS for Caspian tern management lists the redistribution of approximately two-thirds of the East Sand Island colony to alternative colony sites outside the Columbia Basin as the selected alternative (USFWS 2005).

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, if any, 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 habit 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 (in 2003 - 2005), interior Oregon (in 2003), and coastal Washington (in 2004 and 2005) were conducted as part of a comprehensive effort

to evaluate the suitability of alternative colony sites along the west coast of the U.S. (Roby et al. 2003b, Roby et al. 2004).

The objectives of this study were to determine the diet composition, colony size, and nesting success of Caspian terns nesting at colonies on the Olympic Peninsula, Washington, specifically at Dungeness National Wildlife Refuge and at the Puget Sound Naval Shipyard, Bremerton. Our primary objective was to determine the fish species comprising the primary prey for terns nesting at these colonies. 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) 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: (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. Presented here are the results from our studies of the Dungeness Spit and Bremerton Shipyard tern colonies in 2005.

STUDY AREAS

The Caspian tern colony on Dungeness Spit was studied from early April through late July, 2005. Dungeness Spit is a natural sand spit approximately 8 km in length, located on the Olympic Peninsula in the Strait of Juan De Fuca near the city of Sequim, Washington (Figures 1 and 2). Dungeness Spit is a low-lying peninsula that is connected to the mainland, and is owned and managed by the U.S. Fish and Wildlife Service as part of Dungeness National Wildlife Refuge. The Caspian tern colony evidently formed on Dungeness Spit for the first time during the 2003 nesting season, and was located on sandy substrate amongst driftwood approximately one km southwest of the Dungeness Lighthouse National Historic Site (Figure 2).

A Caspian Tern colony at Puget Sound Naval Shipyard, Bremerton was observed from late June through mid August, 2005. Bremerton, Washington is located on the Olympic Peninsula, about 40 km west of Seattle, Washington. The colony was situated on the rooftops of three waterfront warehouses in the shipyard and adjacent to Sinclair Inlet. Caspian tern nests scrapes were confined to the small amount of shells, sand, bone, and other debris accumulated along the ridgelines of each of the rooftops (one aluminum and two covered with asphalt shingles). Terns were present at the colony site beginning in 2003, but may not have nested until 2004.

With the exception of some small ephemeral tern colonies located on other waterfront rooftops, these were the only known Caspian tern breeding colonies on the coast of Washington during the last two years.

METHODS

We constructed an observation blind on the periphery of the Dungeness Spit tern colony to facilitate colony observations without disturbing nesting terns; the rooftop colony in Bremerton was observed from an adjacent rooftop. Data on number of terns on the colony (adult and juvenile), diet composition, and causes of tern nesting failure were collected on a daily basis at Dungeness Spit and on a weekly basis at the Bremerton colony.

The number of Caspian tern breeding pairs nesting at each colony was estimated using aerial photos taken from fixed-wing aircraft. At the Dungeness Spit colony site, counts of all adult terns in aerial photos were corrected to estimate the number of breeding pairs at the colony using ground counts of incubating and non-incubating terns on several study plots within the colony area. Counts of adult terns in aerial photographs at the Bremerton Naval Shipyard were not corrected using ground counts. Nesting success (number of young fledged per breeding pair) was estimated just prior to the peak of fledging using aerial photographs and ground counts at the Dungeness Spit colony, and ground counts only at the Bremerton Shipyard colony.

Diet composition at all study colonies was determined by visually identifying fish brought back to the colonies in the bills of nesting adults ("bill-loads") with the aid of binoculars, spotting scopes, and digital photography. 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 Dungeness NWR to measure subsequent survival rates and movements among colonies. Each tern was banded with a federal numbered metal 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). Before banded chicks were released they were each weighed using Pesola spring scales and the length of their wing was measured. These measurements were used to assess the condition of fledglings and how well their parents had provisioned them during the chick-rearing period.

Colony monitoring methodology followed standardized observational and data collection protocols described in Collis et al. (2002), Roby et al. (2002), and Roby et al. (2003a). 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.

RESULTS AND DISCUSSION

Dungeness Spit, Dungeness National Wildlife Refuge

Background: The Caspian tern colony on Dungeness Spit, initially formed during the 2003 nesting season, is located on sandy substrate amongst driftwood approximately one km southwest of the Dungeness Lighthouse National Historic Site. It was estimated to consist of between 233 and 293 breeding pairs in 2004, despite the failure of the majority of the first nesting attempts due to repeated visits to the colony by a coyote. Skunks, opossums, raccoons, river otters, foxes, coyotes, and other mammalian predators are known to frequent the spit. Although located in an area that is closed to the public, human disturbance may potentially affect the colony because an adjacent beach is open to the public and is commonly used by hikers and recreational boaters.

Colony Size and Nesting Success: In 2005, Caspian terns were first observed in the vicinity of the Dungeness Spit nesting colony on 14 April and were observed on-colony 3 days later. The first tern egg was laid on 8 May (2 days earlier than in 2004). The first chick hatched on 2 June (13 days earlier than in 2004). See Table 1 for a complete timeline of research activities and Caspian tern nesting chronology at Dungeness Spit in 2005.

The colony was highly asynchronous (as was the case in 2004), with terns continuing to initiate new nests through mid-June (Table 3), more than a month after the first egg was laid. The core colony (i.e., colony area used in 2004) was occupied first, with later nesting terns occupying areas not previously used for nesting to the northeast and southwest of the core colony area. A substantial portion of the colony could not be observed from the blind due to the topography of the site and the accumulation of driftwood. In order to estimate the number of breeding pairs, aerial photographs of the colony were taken on 7 June and again on 3 July. In 2005, the size of the Dungeness Spit tern colony was estimated to be 680 breeding pairs (Table 7), an increase of ca. 150% in colony size compared to the previous year. The productivity of the colony was assessed using aerial photographs taken on 16 July. The estimate of number of young fledged was 417-754, or 0.61-1.11 young fledged per breeding pair (Table 7). The best estimate of the number of young fledged and colony productivity was 558 and 0.82, respectively. Estimated productivity at the Dungeness Spit colony was similar to last year (0.80-1.12 young fledged per breeding pair) and is considered good compared to other well-studied colonies in the Pacific Region.

Chick Banding and Resightings of Banded Adults: On 19 July 2005, 73 tern chicks near fledging age were banded with USGS numbered metal leg bands and a unique color combination of plastic leg bands. An additional 36 tern chicks that were too young to hold plastic leg bands were banded with numbered metal bands only.

Chick body mass corrected for size (wing length) indicated that chicks had been well-provisioned throughout the chick-rearing period. Size-adjusted body mass of fledglings at the Dungeness Spit colony was higher than at the East Sand Island (OR), Crescent Island

(WA), or Brooks Island (CA) colonies in 2005. The body mass of Dungeness Spit tern chicks in 2005 was similar to that of chicks raised at East Sand Island during the best years, and to chicks raised in captivity on ad libitum diets.

Between mid April and late August, there were 188 different sightings of banded adult terns on the Dungeness Spit colony site. Some of the banded birds probably passed through the site early in the season on their way to small colonies farther north (e.g., rooftop colonies near Puget Sound). Later in the season, it is likely that banded terns stopped at the colony after experiencing nest failure at these sites or in the Columbia River estuary. There were 8 color-banded terns that were confirmed nesting at the Dungeness Spit colony site. Of the 188 resightings of banded terns at the Dungeness Spit colony site, 18 banded birds were identified such that the banding year, age class (i.e., adult or chick), and location were known. One of these birds was banded as an adult at East Sand Island, in the Columbia River estuary in 2004. Seventeen of the banded birds were banded as chicks; five were banded in Commencement Bay, Washington at the ASARCO Industrial Site (2000), 11 were banded at East Sand Island (1 in 2000, 2 in 2001, 7 in 2002, and 1 in 2003), and one was banded at Solstice Island in Potholes Reservoir, eastern Washington (2001).

Diet Composition: A large number of Caspian tern bill-loads were successfully identified at the Dungeness Spit colony (N = 6,897; Table 4). The diet of Caspian terns was dominated by surfperch (Embiotocidae), salmonids (*Oncorhynchus* spp.), sculpins (Cottidae), herring and sardines (Clupeidae), and smelt (Osmeridae) in that order (Table 4). This year, compared to 2004, the prevalence of surfperch and salmonids decreased in the diet, while sculpin, clupeids, and smelt increased. These five prey types represented more than 85% of the identified prey items. Additional fish taxa that represented more than 1% but less than 10% of the identified prey items included pricklebacks (Stichaeidae), anchovies (Engraulidae), and sand lance (Ammodytidae) in that order (Table 4). Five additional prey taxa each represented less than 1% of the diet (Table 4).

A variety of salmonid species and evolutionarily significant units (ESUs) are potentially susceptible to predation by Caspian terns nesting at Dungeness Spit. At least nine different salmonid ESUs have been documented in Dungeness Bay or in the nearby Strait of Juan de Fuca (Beamish et al. 1998; Sweeting et al. 2003): (1) Puget Sound chinook salmon *(O. tshawytscha*), (2) Even-year pink salmon (*O. gorbuscha*), (3) Odd-year pink salmon, (4) Hood Canal chum salmon (*O. keta*), (5) Puget Sound/Strait of Georgia chum salmon, (6) Puget Sound/Strait of Georgia coho salmon (*O. kisutch*), (7) Puget Sound steelhead (*O. mykiss*), (8) Puget Sound bull trout/dolly varden (*Salvelinus* spp.), and (9) Puget Sound sea-run cutthroat trout (*O. clarki*). Sockeye salmon (*O. nerka*) are also present in the Strait of Juan de Fuca, but are not currently identified with a particular ESU. Three of these nine ESUs are currently listed under the U.S. Endangered Species Act: (1) Puget Sound spring/summer-run chinook salmon (threatened), (2) Hood Canal summer-run chum salmon (threatened), and (3) Puget Sound bull trout/dolly varden (threatened) (NOAA Fisheries 2004).

The proportion of juvenile salmonids in the diet averaged 17% of all identified prey items (this percentage is the average of the weekly percentages; Table 4), down from 31% in

2004. The salmonid portion of the diet consisted of 83% chinook, coho, chum, or pink salmon, 7% steelhead, and 10% unidentified salmonid (either steelhead or salmon). The salmonid portion of the diet of Dungeness Spit Caspian terns likely included smolts released from the Dungeness Hatchery, located on the Dungeness River approximately 14 km upstream from the mouth. Each spring (mid-April to late May) the Dungeness Hatchery releases chinook salmon, coho salmon, and winter-run steelhead trout into the Dungeness River. We observed Caspian terns foraging at the river mouth on multiple occasions, at variable tide levels, and at various times of day. Chinook salmon, coho salmon, and steelhead are the most likely salmonid prey types for Caspian terns foraging at the mouth of the Dungeness River due to the large size of these smolts during out-migration (range ~100 to 200 mm fork length). The Dungeness River supports a relatively large number of ESA-listed bull trout, but these fish primarily reside in the deep pools of the upper Dungeness River (WDFW 2000), presumably outside the foraging range of the Dungeness Spit Caspian tern colony. Terns foraging within the Strait of Juan de Fuca, however, are likely to encounter a more diverse assemblage of salmonid species, including large numbers of chum and pink salmon that are known to rear in the near-shore habitat of Puget Sound before migrating to the open North Pacific (Groot and Margolis 1991, Beamish et al. 1998).

We do not know the reason for the 14 percentage-point (45%) decrease in proportion of salmonids in the tern diet in 2005 compared to 2004. One possible explanation is the reduction in number of juvenile salmonids out-migrating from the Dungeness River in 2005 compared to 2004. For example, the Dungeness Hatchery released ~150,000 fewer spring/summer chinook smolts in 2005 compared to the previous year (Dungeness River Hatchery, personal communication). In addition, very few pink salmon smolts were produced in the Dungeness River in 2005, but a large juvenile run was observed in 2004 (Pete Topping, WDFW personal communication). Although pink salmon (and to lesser extent chum salmon) are relatively abundant in the Dungeness River in some years, these species migrate to the bay immediately following emergence in the spring and may be too small (i.e., range = ca. 20 - 40 mm fork length) to attract foraging Caspian terns. It is possible, however, that these pink and chum salmon remain in the bay and sound to rear and eventually become large enough to attract foraging terns during the summer months.

In 2005, the Washington Department of Fish and Wildlife (WDFW) installed a fish trap near the mouth of the Dungeness River to monitoring the migration timing and relative abundance of juvenile salmonids from the Dungeness River (Pete Topping, WDFW personal communication). Data from this monitoring effort will be available during the winter of 2006, and may provide clues to tern foraging behavior in 2005. The WDFW is planning to continue this fish monitoring effort in 2006.

Factors Limiting Colony Size and Nesting Success: The main factors limiting the colony size and nesting success of Caspian terns on Dungeness Spit are mammalian nest predators and, to a much lesser degree, avian predators and human disturbance (Table 6). In 2004, most of the early nesting attempts by terns at Dungeness Spit failed due to frequent visits to the colony by a coyote. Following the hazing of the coyote by USDA-Wildlife Services, terns re-nested with no further evidence of nest predation by coyotes.

In 2005, no evidence was detected of nest predation by mammals, although coyote scat and tracks were found 5 km southwest of the colony. In addition, river otter, river otter tracks and scat, as well as raccoon tracks were seen in the vicinity of the tern colony. We suspect that without protection (i.e., predator fence, predator control) the nesting colony of Caspian terns on Dungeness Spit will be highly vulnerable to partial or complete nesting failure caused by mammalian nest predators.

Gulls were observed depredating 15 nests (9 eggs and 6 chicks) in 2004. In 2005, gulls were known to have depredated 10 chicks. Direct interactions between bald eagles and terns were seen for the first time in 2005. Although no bald eagles depredated adult terns, chases resulted in kleptoparasitism of two bill-loads, plus two tern chicks were taken by eagles. Bald eagles caused 80% of all disturbances to the tern colony, flushing all or part of the colony 0.65 times/hour on average.

In 2004 and 2005, the level of human disturbance was lower than reported in 2003, perhaps as a result of (1) posting of area closure signs in the vicinity of the colony, (2) frequent presence of researchers in a blind located near the colony, and (3) relatively low numbers of visitors to the spit through June due to inclement weather. We observed four human disturbance events during 2005: kayakers flushed a portion of the colony on two occasions; hikers approached the colony resulting in a colony flush; and three people digging for clams walked onto the colony, potentially trampling nests and causing nest abandonment. In the last instance, gulls depredated at least one chick that left the colony as a result of the disturbance.

The high size-adjusted body mass of fledglings at the Dungeness Spit colony indicates that food availability for nesting adult terns was good in 2005. This despite the generally poor ocean conditions along the coast of the Pacific Northwest, due to the late onset of spring upwelling. The area within foraging range of Caspian terns nesting at Dungeness Spit was apparently rich in forage fishes in both 2004 and 2005, and suggests that, barring repeated nesting failure due to mammalian nest predators, Caspian terns will continue to be attracted to nest at this site. There was no evidence that the size of the colony or its productivity was limited by the availability of suitable nesting substrate at the colony site. The location of the colony on a spit connected to the mainland, as opposed to an island, suggests that the Dungeness Spit colony is in a precarious site and its future is problematic because of eventual incursions into the colony by mammalian nest predators.

Puget Sound Naval Shipyard, Bremerton

Background: Caspian terns (60-70) were first observed on warehouse rooftops at the Bremerton Naval Shipyard in 2003 (personal communication, Steve Holtom and Matt Cleland, USDA-Wildlife Services). In 2004, nesting was confirmed, with a maximum of 174 Caspian terns counted on rooftops at the naval base (personal communication, Steve Holtom and Matt Cleland, USDA-Wildlife Services). In 2005, Wildlife Services hazed the incipient colony intensely for 5 nights beginning 2 June until eggs were discovered, at which time the hazing was discontinued. In 2006, Wildlife Services will attempt to

prevent all Caspian terns from nesting on the Naval Base Kitsap Bremerton (personal communication, Steve Holtom and Matt Cleland, Wildlife Services).

Colony Size and Nesting Success: In 2005, Caspian terns were first observed in the vicinity of the naval shipyard during the last week of April (personal communication, Steve Holtom and Matt Cleland, USDA-Wildlife Services). We conducted observations of the Caspian tern colony from late June through mid August (Table 3). See Table 2 for a complete timeline of research activities and Caspian tern nesting chronology at Naval Base Kitsap Bremerton in 2005.

The size of the Bremerton colony was estimated to be approximately 130 breeding pairs in 2005 (Table 7). The estimate of number of young fledged from the colony was 49, or 0.38 young fledged per breeding pair (Table 7). Productivity of the Bremerton colony is considered low compared to the Dungeness Spit colony and other well-studied Caspian tern colonies in the Pacific Region.

Chick Banding and Resightings of Banded Adults: Tern chicks were not banded at the Bremerton colony.

Between late June and mid August, there were 13 different sightings of banded terns on the Bremerton colony site. During this time of year, it is likely that banded terns stopped at the colony after experiencing nest failure at other sites, such as the Dungeness Spit and East Sand Island colonies. There was one banded tern that was confirmed nesting at the Bremerton colony site. Of the 13 sightings of banded terns, 5 were identified such that the banding year, age class (i.e., adult or chick), and location were known. One of these terns was banded as a chick at ASARCO in 2000 and four were banded at East Sand Island; one as a chick in 2001, two as chicks in 2002, and one as an adult in 2004.

Diet Composition: A small number of Caspian tern bill-loads were successfully identified at the Bremerton colony (N = 296; Table 5). The diet of Caspian terns nesting at the naval base was dominated by salmonids (*Oncorhynchus* spp.), surfperch (Embiotocidae), and herring/sardines (Clupeidae), in that order (Table 5). These prey types represented more than 80% of the identified prey items. Additional fish taxa that represented more than 1% but less than 10% of the identified prey items included sculpins (Cottidae), smelt (Osmeridae), pricklebacks (Stichaeidae), and anchovies (Engraulidae) (Table 5). Gunnels (Pholidae) represented less than 1% of the diet (Table 5).

The proportion of juvenile salmonids in the diet averaged 33.7% of identified prey items (this percentage is the average of the weekly percentages; Table 5). Within the salmonid portion of the diet, 100% were salmon (chinook, coho, chum, or pink salmon smolts). We observed Caspian terns foraging at the mouths of Clear, Chico, Gorst, Dogfish, and Cowling creeks, all within foraging distance of terns nesting at the Bremerton Naval Shipyard and all salmon-bearing streams.

Factors Limiting Colony Size and Nesting Success: The main factors limiting colony size and nesting success of Caspian terns at the Bremerton rooftop colony are (1) human

disturbance, (2) quality and availability of suitable nesting habitat, and, potentially, (3) avian and mammalian predation (Table 6).

Human disturbance to the Bremerton colony was intentional; USDA-Wildlife Services, charged with removing the terns from the Naval Shipyard due to safety concerns, tried to discourage tern nesting. The colony was hazed using lasers for 5 nights. All hazing was terminated when tern eggs were first discovered. USDA-Wildlife Services will attempt to prevent tern nest initiation during the 2006 breeding season by removing debris on the rooftops that serves as nesting substrate and potentially installing some form of nest exclusionary device.

The quality of nesting habitat and availability of suitable nesting substrate limited the colony at Bremerton Shipyard. The nesting substrate was either corrugated tin or asphalt shingles. With few exceptions, nests were scraped into a thin layer of shells, sand, bone, and other material confined to thin drifts along the ridgeline of each roof. The presence of this colony and its persistence despite severe human disturbance is indicative of the lack of suitable nesting habitat available for Caspian terns in the Puget Sound area.

Although no sign of predation was seen at the Bremerton colony, potential sources of predation and disturbance included bald eagles, peregrine falcons, American crows, glaucous-winged/western gulls, raccoons, rats, opossums, and feral cats; all were seen in the vicinity of the roof top colony.

ACKNOWLEDGMENTS

This study was funded by the U.S. Fish and Wildlife Service, Pacific Region, Migratory Birds and Habitat Programs; we thank Nanette Seto, Tara Zimmerman, Brad Bortner, and Dave Wesley, without whose support and assistance this project would not have been possible. We also thank the Dungeness National Wildlife Refuge; Puget Sound Naval Shipyard, Bremerton; and USDA-Wildlife Services in Poulsbo, Washington for allowing access to the study sites. We appreciate the hard work and dedication of the field technicians, interns, and volunteers whose contribution to this research was invaluable: Jessica Adkins, Lindsay Adrean, Janet Bruening, Chris Couch, Brendan Courtot, Deborah Cox, Dave Craig, Jim Fedderly, Clare Hatler, Verbie Ketzebeck, Rachel Lord, Dacey Mercer, Sarah Moculeski, Travis Poitras, Paul Runyan, Risha Sparhawk, Sarah Stieg, Yasuko Suzuki, Ali Theuer, Barbara Vanderwerf, Bill Vanderwerf, Carmelinda Wiley, and Leonard Wiley. Mike Hawbecker provided important technical assistance at critical times during this project. Assistance with aerial photographs of the Caspian Tern colony at Dungeness NWR was provided by Paul Runyan. Naval Base Kitsap Bremerton aerial photographs were taken by Jessica Adkins. Aerial survey flights were piloted by Brad Goldman and Kenneth Plute.

We are very grateful for the assistance, advice, and in-kind support from the following individuals: Trish House and Jan Cyrus, Department of Fisheries and Wildlife, Oregon State University; Dave Craig, Willamette University; Kevin Ryan, Pam Sanguinetti,

Annette de Knijf, and staff, U.S. Fish and Wildlife Service, Washington Maritime National Wildlife Refuge Complex; Kolleen Irvine and Kathy Wagoner, Dungeness National Wildlife Refuge Rangers; Natalie and Scott Erickson, resident caretakers on Dungeness National Wildlife Refuge; John Pease, Manager of Dungeness Recreation Area; Pete Topping, Washington Department of Fish and Wildlife; Brian Russell, Dungeness River Hatchery; members of the Friends of Dungeness National Wildlife Refuge; and Roy Lowe, U.S. Fish and Wildlife Service, Oregon Coast National Wildlife Refuge.

LITERATURE CITED

Beamish, R.M. M. Folkes, R. Sweeting, and C. Mahnken. 1998. Intra-annual changes in the abundance of coho, chinook and chum salmon in Puget Sound in 1997. Puget Sound Research Proceeding

CBR (Columbia Bird Research). 2005. Caspian Tern Research on the Lower Columbia River: 2004 Final Season Summary. Real Time Research, Bend, Oregon. Available through the Internet at *http://www.columbiabirdresearch.org* (accessed 2 November 2005).

Collis, K., D.D. Roby, D.P. Craig, S. Adamany, J.Y. Adkins, and D.E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the lower Columbia River: Implications for losses of juvenile salmonids to avian predators. Transactions of the American Fisheries Society 131:537-550.

Groot, C., and L. Margolis. 1991. Pacific Salmon Life Histories. UBC Press, Vancouver.

Kress, S.W. 2000. Colony site management techniques. Issue Report in the Managers Toolbox, North American Waterbird Conservation Plan. Available through the Internet at http//www.nawcp.org/plan/toolbox.html

Penland, S. 1982. Distribution and status of the Caspian tern in Washington State. Murrelet 63: 73–79.

NOAA (National Oceanic and Atmospheric Administration) Fisheries. 2004. Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin. Available through the internet at http://www.salmonrecovery.gov/R_biop_final.shtml (accessed December 2004).

Roby, D.D., K. Collis, D.E. Lyons, D.P. Craig, J.Y. Adkins, A.M. Myers, and R.M. Suryan. 2002. Effects of colony relocation on diet and productivity of Caspian terns. Journal of Wildlife Management 66:662-673.

Roby, D.D., D.E. Lyons, D.P. Craig, K. Collis, and G.H. Visser. 2003a. Quantifying the effect of predators on endangered species using a bioenergetics approach: Caspian terns

and juvenile salmonids in the Columbia River estuary. Canadian Journal of Zoology 81:250-265.

Roby, D.D., K. Collis, S.K. Nelson, K. Larson, and K. Bixler. 2003b. Caspian tern nesting ecology and diet in San Francisco Bay and Interior Oregon. 2003 Annual Report submitted to the U.S. Fish and Wildlife Service, Region 1, Migratory Birds and Habitat Programs, Portland, OR.

Roby, D.D., K. Collis, S.K. Nelson, K. Larson, and K. Bixler. 2004. Caspian tern nesting ecology and diet in San Francisco Bay and Dungeness National Wildlife Refuge. 2004 Annual Report submitted to the U.S. Fish and Wildlife Service, Region 1, Migratory Birds and Habitat Programs, Portland, OR.

Shuford, W.D., and D.P. Craig. 2002. Status assessment and conservation recommendations for the Caspian tern (*Sterna caspia*) in North America. U.S. Department of the Interior, Fish and Wildlife Service, Portland, OR.

Suryan, R.M., D.P. Craig, D.D. Roby, N.D. Chelgren, K. Collis, W.D. Shuford, and D.E. Lyons. 2004. Redistribution and growth of the Caspian tern population in the Pacific Coast region of North America, 1981-2000. Condor 106:777-790.

Sweeting, R.M., R.J. Beamish, and C.M. Neville. 2003. Juvenile Salmon in Puget Sound and the Strait of Georgia. Proceedings of the Puget Sound Conference. Available on the World Wide Web:
http://www.psat.wa.gov/Publications/03_proceedings/PAPERS/ORAL/4c_sweet.pdf

USFWS (U.S. Fish and Wildlife Service). 2005. Caspian tern management to reduce predation of juvenile salmonids in the Columbia River estuary: Final Environmental Impact Statement, January 2005. Migratory Birds and Habitat Program, Portland OR.

WDFW (Washington Department of Fish and Wildlife). 2000. Bull Trout and Dolly Varden Management Plan. Available on the World Wide Web:
http://wdfw.wa.gov/fish/bulltrt/bulldollyfinal.pdf

Wires, L. R., and F. J. Cuthbert. 2000. Trends in Caspian tern numbers and distribution in North America: A review. Waterbirds 23:388–404.

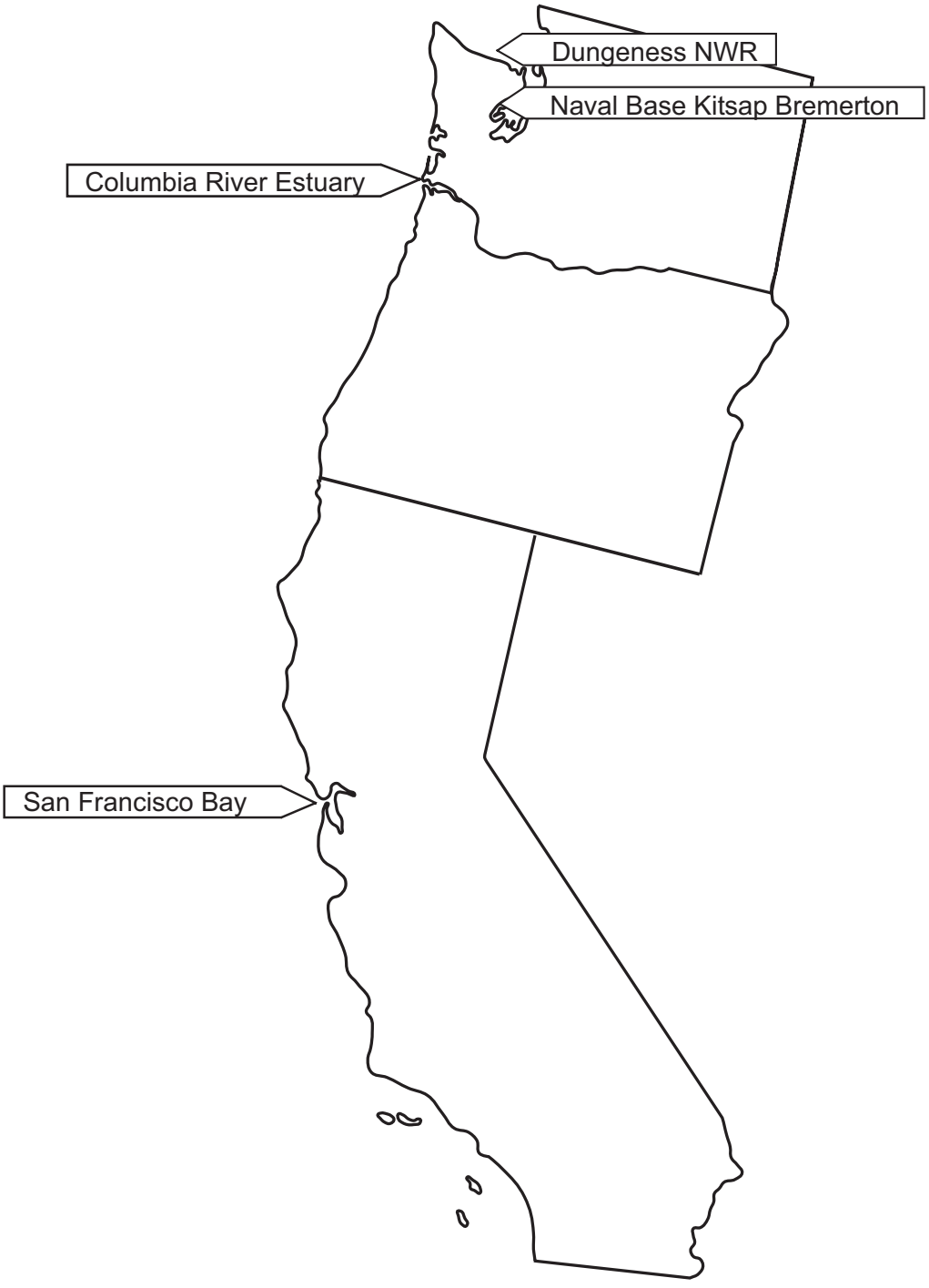

Figure 1. Caspian tern nesting areas mentioned in this report.

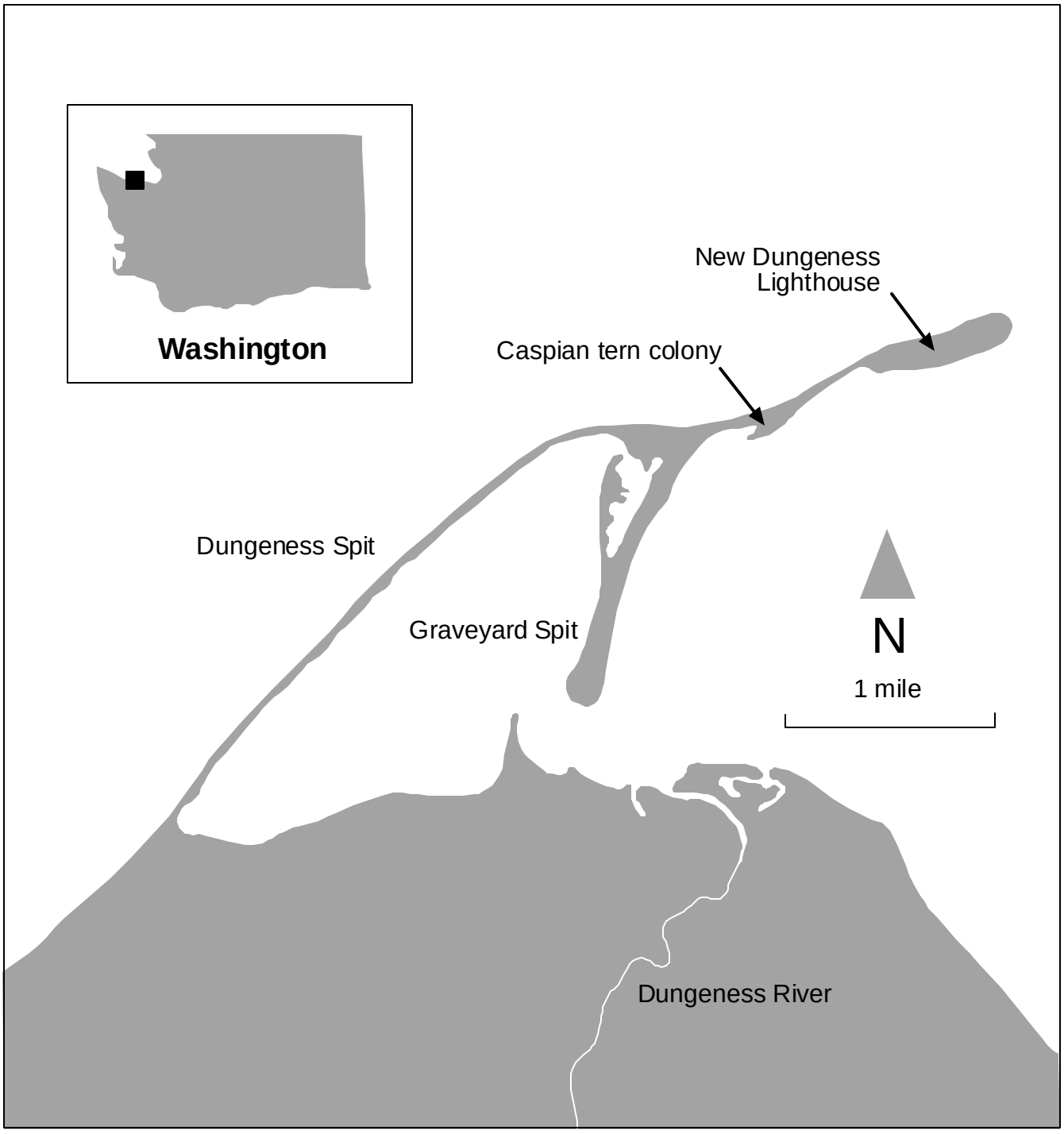

Figure 2. Map of Dungeness National Wildlife Refuge showing the location of the active breeding colony of Caspian terns in 2005.

Table 1. Timeline for research activities and Caspian tern nesting chronology at Dungeness NWR, Washington in 2005.

Date	Colony	Note
04/07/05	Dungeness Spit	First crew visit to colony site
04/08/05	Dungeness Spit	Observation blind constructed
04/14/05	Dungeness Spit	First adult terns (8) observed near colony
04/17/05	Dungeness Spit	First adult terns (6) observed on-colony
04/20/05	Dungeness Spit	Diet data collection begins
05/08/05	Dungeness Spit	First tern egg observed
06/02/05	Dungeness Spit	First tern chick observed on colony
06/07/05	Dungeness Spit	Aerial photo census of colony conducted
07/03/05	Dungeness Spit	Aerial photo census of colony conducted
07/11/05	Dungeness Spit	First fledgling seen
07/16/05	Dungeness Spit	Aerial photo census of colony conducted
07/30/05	Dungeness Spit	Last day of colony observation
07/30/05	Dungeness Spit	Observation blind removed

Table 2. Timeline for research activities and Caspian tern nesting chronology at Puget Sound Naval Shipyard, Bremerton, Washingtc

Date	Colony	Note
4/24/05-4/30/05	Bremerton Naval Shipyard	First tern seen on colony (USDA-Wildlife Services)
06/02/05	Bremerton Naval Shipyard	USDA-Wildlife Services begins five nights of hazing tern colony with lazers
06/13/05	Bremerton Naval Shipyard	Aerial photo census of colony taken
06/23/05	Bremerton Naval Shipyard	First crew visit to colony site
06/23/05	Bremerton Naval Shipyard	Diet data collection begins
07/13/05	Bremerton Naval Shipyard	First fledgling seen
08/18/05	Bremerton Naval Shipyard	Last day of colony observation

Table 3. Average number of adult Caspian terns counted each week at colonies on the Olympic Peninsula (Dungeness NWR and Bremerton Naval Shipyard), Washington in 2005.

	Olympic Peninsula	
Week ending	Dungeness Spit NWR	Bremerton Shipyard
10-Apr	0	-
17-Apr	0	-
24-Apr	16	-
1-May	36	-
8-May	180	-
15-May	258	-
22-May	369	-
29-May	521	-
5-Jun	555	-
12-Jun	569	-
19-Jun	629	-
26-Jun	574	189
3-Jul	580	-
10-Jul	546	-
17-Jul	532	329
24-Jul	514	116
31-Jul	398	250
7-Aug	309	61
14-Aug	204	-
21-Aug	149	50
28-Aug	116	-
4-Sep	49	-

Table 4. Caspian tern diet composition at the Dungeness National Wildlife Refuge colony, Washington, based on percent of identifiable prey items delivered as bill-loads to the colony in 2005. TOTAL percentages ar
of the weekly percentages.

Week ending	N	Anchovy	Clupeid	Cod	Flatfish	Goby	Gunnel	Prickleback	Rockfish	Salmon	Salmonid UNID	Sand lance	Sculpin	Smelt	Steelhead	Surfperch	UNID
3-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-Apr	35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	0.0	0.0	62.8	0.0	25.8	0.0
1-May	107	0.0	3.8	0.0	0.9	0.0	0.0	1.9	0.0	0.0	13.1	8.4	3.7	17.8	0.0	50.4	0.0
8-May	353	0.0	11.9	0.0	0.0	0.0	0.0	0.3	0.0	28.3	4.0	0.8	1.1	6.8	5.9	38.5	2.3
15-May	415	0.0	1.9	0.0	0.0	0.0	0.0	1.4	0.0	36.9	1.0	2.2	2.7	6.5	6.7	40.0	0.7
22-May	428	0.0	9.6	0.0	0.0	0.0	0.0	1.2	0.0	30.1	0.7	1.6	2.8	11.7	6.8	34.1	1.4
29-May	415	0.0	7.0	0.0	0.0	0.0	0.7	12.3	0.0	15.7	0.5	1.4	4.1	14.7	3.6	39.3	0.7
5-Jun	452	9.5	13.1	0.0	0.0	0.0	0.0	6.2	0.0	9.3	0.7	1.1	5.8	8.0	0.9	43.8	1.8
12-Jun	420	0.5	6.9	0.0	0.5	0.0	0.0	10.7	0.0	16.2	0.0	1.7	9.8	7.1	0.0	46.7	0.0
19-Jun	411	2.7	9.7	0.0	0.0	0.2	0.0	2.7	0.2	29.2	0.0	2.2	4.4	3.9	0.0	44.3	0.2
26-Jun	402	7.2	7.2	0.0	0.2	0.2	1.0	20.6	0.0	10.9	0.0	2.0	10.0	10.4	0.0	29.6	0.5
3-Jul	413	11.6	9.4	0.0	0.2	0.0	0.5	5.1	0.0	8.7	0.2	0.5	8.7	3.4	0.0	51.4	0.2
10-Jul	406	3.4	12.1	0.0	1.2	0.0	0.5	16.7	0.0	9.4	0.0	1.0	13.8	6.2	0.0	35.7	0.0
17-Jul	407	0.0	16.2	0.0	0.7	0.0	0.0	6.4	0.0	23.8	0.0	0.0	8.8	5.9	0.0	38.1	0.0
24-Jul	399	0.5	13.5	0.5	2.0	0.0	0.8	16.0	0.0	11.0	0.0	0.8	25.6	9.3	0.0	20.1	0.0
31-Jul	407	3.2	21.4	0.0	0.7	0.0	1.2	7.1	0.0	21.6	0.0	0.0	23.3	8.3	0.0	13.0	0.0
7-Aug	416	1.2	14.9	0.0	0.7	0.0	1.9	11.5	0.0	12.7	0.0	0.2	28.6	18.5	0.0	9.6	0.0
14-Aug	355	1.1	23.1	0.0	1.4	0.0	0.0	4.2	0.0	9.3	0.0	0.3	41.4	12.4	0.0	6.8	0.0
21-Aug	171	1.8	29.8	0.0	0.6	0.0	7.0	11.7	0.0	2.9	0.0	0.6	29.8	8.2	0.0	7.6	0.0
28-Aug	336	1.2	22.3	0.0	0.6	0.0	0.3	9.2	0.0	3.0	0.0	1.8	34.8	12.5	0.0	14.3	0.0
31-Aug	149	2.7	22.8	0.0	0.0	0.0	0.0	5.4	0.0	1.3	0.0	0.0	30.9	14.1	0.0	22.8	0.0
TOTAL	6897	2.3	12.8	0.0	0.5	0.0	0.7	7.5	0.0	14.0	1.6	1.3	14.5	12.4	1.2	30.6	0.4

NOTE: The "Salmon" category consisted of chinook, coho, chum, or pink salmon.

NOTE: The "Salmonid UNID" category consisted of unidentified salmonids (either steelhead or salmon).

NOTE: The "UNID" category consisted of unidentified non-salmonids.

Table 5. Caspian tern diet composition at the Puget Sound Naval Shipyard, Bremerton colony, Washington, based on percent of identifiable prey items de the colony in 2005. TOTAL percentages are averages of the weekly percentages.

Week ending	N	Anchovy	Clupeid	Gunnel	Prickleback	Salmon	Sculpin	Smelt	Surfperch	UNID
3-Apr	-	-	-	-	-	-	-	-	-	-
10-Apr	-	-	-	-	-	-	-	-	-	-
17-Apr	-	-	-	-	-	-	-	-	-	-
24-Apr	-	-	-	-	-	-	-	-	-	-
1-May	-	-	-	-	-	-	-	-	-	-
8-May	-	-	-	-	-	-	-	-	-	-
15-May	-	-	-	-	-	-	-	-	-	-
22-May	-	-	-	-	-	-	-	-	-	-
29-May	-	-	-	-	-	-	-	-	-	-
5-Jun	-	-	-	-	-	-	-	-	-	-
12-Jun	-	-	-	-	-	-	-	-	-	-
19-Jun	-	-	-	-	-	-	-	-	-	-
26-Jun	50	4.0	10.0	0.0	0.0	20.0	6.0	8.0	52.0	0.0
3-Jul	-	-	-	-	-	-	-	-	-	-
10-Jul	-	-	-	-	-	-	-	-	-	-
17-Jul	49	2.0	24.5	0.0	0.0	24.5	6.1	4.1	38.8	0.0
24-Jul	48	0.0	39.6	2.1	8.3	16.7	8.3	4.2	20.8	0.0
31-Jul	51	0.0	17.6	0.0	0.0	51.0	0.0	7.8	21.6	2.0
7-Aug	49	0.0	8.2	0.0	0.0	44.9	8.2	6.1	32.7	0.0
14-Aug	-	-	-	-	-	-	-	-	-	-
21-Aug	49	0.0	14.3	0.0	2.0	44.9	14.3	0.0	24.5	0.0
28-Aug	-	-	-	-	-	-	-	-	-	-
31-Aug	-	-	-	-	-	-	-	-	-	-
TOTAL	296	1.0	19.0	0.4	1.7	33.7	7.2	5.0	31.7	0.3

NOTE: The "Salmon" category consisted of chinook, coho, chum, or pink salmon.

NOTE: The "UNID" category consisted of unidentified non-salmonids.

Table 6. Potential limiting factors for colony size and nesting success at Caspian tern colonies on the Olympic Peninsula (Dungeness NWR and BremertonNaval Shipyard) in 2005. "**X**" denotes an observed factor of significance, "x" an observed factor of minor importance, and "?" denotes a suspected factor.

	Olympic Peninsula	
	Dungeness Spit	Naval Base Kitsap Bremerton
Availability of nesting habitat		**X**[6]
Quality of nesting substrate		**X**[7]
Prey fish availability		
Mammalian predators	**X**[1]	?[8]
Encroachment by other colonial waterbirds		
Avian predators (other than gulls)	x[2]	?[9]
Avian disturbances (other than gulls)	x[2]	?[9]
Gull kleptoparasitism		?[10]
Gull nest predation	x3	?[10]
Human disturbance	?[4]	**X**[11]
Recreational boats (including canoes and kayaks)	?[5]	
Commerical shipping (including dredges)		
Commercial, military, or enforcement aircraft		?
Recreational aircraft		

[1] repeated visits to the colony by a coyote resulted in an almost complete failure of the first nesting attempt in 2004, evidence of other mammalian predators in the vicinity of the colony in 2004 and 2005

[2] bald eagles caused frequent disturbance to the tern colony, predation of chicks seen by subadult bald eagles

[3] gull predation of chicks was an increasing factor as the season progressed

[4] public access beach adjacent to the colony site; human disturbance to the colony has been reported in previous years and four times in 2005

[5] boaters and kayakers use bay heavily, attempts were made to travel in to the lagoon and land in the vicinity of the colony

[6] shells, bone, and other debris limited to ridge line of the rooftops

[7] little nesting substrate, rooftops composed of metal or asphalt shingles

[8] mammals on the naval base with potential access to the colony include raccoons, rats, oppossum, and feral cats

[9] Glaucous x western gull hybrids nest adjacent to and within the tern colony

[10] American crows seen in colony ingesting fish, bald eagles seen depredating gull chicks in previous years, peregrine falcons nesting in vicinity

[11] Wildlife Services hazed the colony intensively for one week in 2005

Table 7. Size and productivity of Caspian tern nesting colonies on the Olympic Peninsula (Dungeness NWR and Naval Base Kitsap Bremerton) in 2005.

	Colony Size (# of breeding pairs)	# Fledglings Produced	Productivity (fledglings/breeding pair)
Olympic Peninsula			
Dungeness National Wildlife Refuge	680	415 - 754[2]	0.61 - 1.11[2]
Naval Base Kitsap Bremerton	130[1]	49[3]	0.38

[1] Estimated number of breeding pairs based on aerial photo census not corrected by simultaneous ground counts.

[2] Uncertainty in the number of fledglings due to obstructed view of the colony in aerial photographs and from blind. The best estimate is 558 and 0.82 feldglings produced and fledglings/breeding pair, resepectively.

[3] Minimum estimate of the number of fledglings (based on ground counts) due to observation distance and visual obstructions.