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Observations of Caspian Terns Nesting at Dungeness National Wildlife Refuge and Distribution of Gull Colonies in Puget Sound, Washington

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Final Annual Report

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2006 Final Annual Report

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EXECUTIVE SUMMARY

This 2006 draft annual report presents observations from the third year of an ongoing study investigating colony status of Caspian terns (*Hydroprogne caspia*) at Dungeness National Wildlife Refuge. In addition, we present data collected during a visit to the Naval Base Kitsap Bremerton, where another colony of Caspian terns exists, as well as results from an aerial survey of the Puget Sound area to document the distribution of nesting gulls (*Larus* spp.). This report includes observations on colony size, nesting success, factors limiting colony size and nesting success, and diet composition of Caspian terns nesting at Dungeness NWR, but due to budget constraints the quantity and frequency of data collected at this colony in 2006 is much less than in 2004 and 2005. Consequently, interpretations of the results from 2006 are more prone to error. For the first time in 2006, we flew an aerial survey of much of the Puget Sound coastline, searching for colonies of gulls, especially colonies on the roofs of warehouses and other anthropogenic structures. The purpose of this report is to present results to the funding agency for review. 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 Consequently, these data are not for citation or publication without prior permission from the authors.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 in 2006 was located close to the colony site used in 2003-2005. Our best estimate of the peak number of breeding pairs of Caspian terns at the Dungeness Spit colony in 2006 was 795, but this estimate is approximate because the colony was highly asynchronous. This represents a 17% increase in colony size compared to 2005 and a 202% increase in colony size from 2004. We estimate that in 2006 149-301 young fledged or 0.19-0.38 young were fledged/breeding pair. Nesting success in 2006 was much lower than that of the previous two years (0.80-1.12 and 0.61-1.11 fledglings/breeding pair in 2004 and 2005, respectively), and is considered low compared to other colonies in the region. In 2006, we observed nest predation by coyotes, resulting in a complete failure of the first nesting attempt at the colony. The diet of terns nesting at Dungeness NWR in 2006 consisted mostly of surfperch (Embiotocidae; 33%), sculpin (Cottidae; 24%) and salmonids (Salmonidae; 22%), but these percentages are based on limited sample sizes of visually identifiable prey fish (n = 552). Relatively low food availability may have contributed to the lower nesting success in 2006. The Caspian tern colony at the Naval Base Kitsap in Bremerton was observed on only one occasion during the breeding season. The colony was estimated to consist of as many as 500 breeding pairs; no estimate of nesting success was possible.

A total of 9,882 gulls and 3,640 gull nests were counted in aerial photographs of gull colonies taken in the Puget Sound area. Of the gull colonies photographed, about 1,550 gull nests were counted on Protection Island (42%), about 300 on Graveyard Spit in Dungeness NWR (8%), about 300 on Smith Island (8%), about 300 at Pier 90 in Seattle (8%), about 250 on Padilla Bay dredge spoil islands (7%), about 250 at the Naval Base in Bremerton (7%), and about 200 in the Port of Tacoma (5%). The counts of gull nests at Protection Island and Bremerton are likely underestimates. At least 71% of all gull nests at the surveyed colonies were in natural habitat and at most 29% were located on rooftops in urban areas.

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INTRODUCTION

Caspian terns (*Hydroprogne caspia*) nesting at the colony on East Sand Island in the Columbia River estuary continue to consume about 3 - 6 million juvenile salmonids (*Oncorhynchus* spp.) 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 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 half 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 reported in the last two years of this ongoing study were a critical component in the development of management options for the EIS. Results of diet and food habits studies at potential alternative colony sites were a major factor in determining which sites along the Pacific coast would be 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 were especially crucial because these data were 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 rendered 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, Roby et al. 2005). The Dungeness Spit Caspian tern colony is a major nesting site for the species in the Pacific Northwest, second only to East Sand Island in the Columbia River estuary. The future size and productivity of the Dungeness Spit Caspian tern colony has implications not only for the survival of juvenile salmonids near the Spit, but also for the population status of Caspian terns in the Pacific Northwest and throughout the Pacific coast of North America.

Large gull (*Larus* spp.) colonies located in natural habitat have reportedly been in decline over the past few years. However, gull use of rooftop nesting habitat has increased over the last few decades. The decline observed in colonies located in natural nesting habitat could be indicative of a Sound-wide population decline or the redistribution of gulls to anthropogenic colony sites, such as warehouse rooftops.

The objectives of this study were to determine the colony size and nesting success of Caspian terns breeding at Dungeness National Wildlife Refuge. Secondarily, we checked Naval Base Kitsap Bremerton in order to obtain a rough estimate of colony size and nesting success at a Caspian tern colony that uses roof-top nesting habitat at this site. We also sought to determine the distribution of breeding colonies of gulls along the shores of Puget Sound, with emphasis on gulls that were nesting on roof-tops and other anthropogenic habitat. Presented here are the results from our studies on the Olympic Peninsula and in the Puget Sound area in 2006.

STUDY AREAS

Two existing tern colony sites on the Olympic Peninsula were visited in 2006: Dungeness Spit in the Dungeness National Wildlife Refuge and several warehouse roof-tops in Naval Base Kitsap Bremerton. 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. 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. The Caspian tern colony evidently formed on the spit for the first time during the 2003 nesting season, and was located on sandy substrate amongst driftwood approximately 1.5 km southwest of the Dungeness Lighthouse National Historic Site. The Caspian tern colony remained at this site in 2004, 2005, and 2006.

A second Caspian tern colony is located on the Olympic Peninsula, at Naval Base Kitsap Bremerton, about 40 km west of Seattle in the city Bremerton, Washington. In 2005, the colony was spread over the roofs of three adjacent waterfront buildings within the naval shipyard, on Sinclair Inlet. Caspian terns have been present at the colony site beginning in 2003, but may not have nested there until 2004.

With the possible exception of some small, ephemeral tern colonies located on other waterfront rooftops, these two were the only known Caspian tern breeding colonies along the coast of Washington during 2003-2006.

We flew an aerial survey covering much of the Puget Sound area, searching for nesting colonies of large gulls (*Larus glaucescens* X *L. occidentalis*). We searched both natural habitat (islands and spits) as well as artificial habitat (man-made structures in urban areas) along the shoreline of Puget Sound and the Strait of Juan de Fuca. The aerial survey included Admiralty Inlet, Rosario Strait, and southern Georgia Strait to the north of Puget Sound, and the Strait of Juan de Fuca from Port Angeles eastward. We specifically searched for gull colonies in urban areas, where colonies have been increasingly reported on rooftops, particularly on warehouses near ports and harbors. We searched the waterfronts of the following cities on Puget Sound or adjacent water bodies for gull colonies: Olympia, Tacoma, Seattle, Everett, Anacortes, Bellingham, Bremerton, Port Townsend, and Port Angeles. We did not search the waterfront buildings at Oak Harbor, Blaine, Friday Harbor, or other smaller cities scattered around the shores of Puget Sound.

We also searched islands, spits, and other potential natural habitat within the study area for nesting gulls. The natural gull nesting habitat searched included Graveyard Spit (in Dungeness NWR, approximately 10 km north of Sequim), Protection Island (11 km west of Port Townsend), and Smith Island (15 km west of Oak Harbor), dredge spoil islands in Padilla Bay (6 km east of Anacortes), islands in Rosario Strait, islands in Bellingham Bay, islands in Skagit Bay, and Viti Rocks (10 km north of Anacortes). We did not conduct surveys of the San Juan Islands as part of this project, nor did we attempt to cover all potential sites where gull colonies might exist in the Puget Sound and Strait of Juan de Fuca region.

METHODS

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

The number of breeding pairs of Caspian terns and gulls nesting at each colony was estimated using aerial photos taken using a Canon Rebel XT digital camera from a fixed-wing aircraft (Cessna 205) flying at an altitude of 500 - 700 feet. 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 Naval Base Kitsap Bremerton were not corrected with ground counts. Breeding pairs of gulls were identified by the presence of nest structures attended by adults. At locations where nest structures were not visible due to photograph quality, vegetation, or obstructions, the number of nests was corrected using counts from other locations within the same site or the Puget Sound-wide count from this study. Nesting

success (number of young fledged per breeding pair) of terns was estimated using ground counts at Dungeness NWR.

Diet composition of terns at the colony on Dungeness Spit was determined by visually identifying fish brought back to the colony in the bills of nesting adults ("bill-loads") with the aid of binoculars, spotting scopes, and digital photography. Forage fish were identified to the lowest taxonomic grouping possible from visual observation. Visual identifications were verified using voucher specimens whenever possible. 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 in the management of these tern and gull colonies and their nesting habitat in future seasons.

RESULTS AND DISCUSSION

Dungeness Spit, Dungeness National Wildlife Refuge

Background: Dungeness Spit is a natural sand spit located on the Olympic Peninsula in the Strait of Juan de Fuca near the city of Sequim, Washington. Approximately 8 km in length, Dungeness Spit, is a low-lying peninsula connected to the mainland. It is owned and managed by the U.S. Fish and Wildlife Service as part of Dungeness National Wildlife Refuge. The Caspian tern colony, initially formed in the 2003 nesting season, is located on sandy substrate amongst driftwood approximately 1.5 km southwest of the Dungeness Lighthouse National Historic Site. In 2004, this colony was estimated to consist of between 233 and 293 breeding pairs. In 2005, the colony increased to an estimated 680 pairs. Skunks, opossums, raccoons, 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 also potentially affect nesting success at this 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 2006, Caspian terns were first observed in the vicinity of the Dungeness Spit nesting colony on 31 March. Thirty terns were observed on-colony during the first visit to the colony site by the field crew on 17 April. The first tern egg was laid at the Dungeness Spit colony between 30 April and 16 May. By comparison, the first egg was observed on 8 May in 2005 and on 10 May in 2004. The first nesting attempts at the Dungeness Spit colony in 2006 failed, wholly or partially due to nest predation by coyotes. Coyotes were observed eating tern eggs on 27 May, approximately two weeks before the first chicks were due to hatch. A second wave of nest initiations occurred during the first week of June, and the first chick hatched between 29 June and 5 July. By comparison, the first chick observed in 2005 was on 2 June, and the first chick observed in 2004 was on 15 June. See Table 1 for a complete timeline of research activities and Caspian tern nesting chronology at Dungeness Spit in 2006.

The colony was extremely asynchronous in 2006 (as was the case in 2004 and 2005), with terns apparently continuing to initiate new nests through early July, two months after the first egg was laid. After the coyote nest predation event that was observed on 27 May, the nesting area shifted southwest toward the tip of the small spit on which the colony is located, adjacent to the area used by the terns in 2004 and 2005. As a result, a significant portion of the colony could not be observed from the blind due to the topography of the site and the accumulation of driftwood. In addition, the new colony location was farther from the observation blind, making all observations more challenging. To estimate the number of breeding pairs, aerial photographs of the colony were taken on 21 June and again on 8 July. For 2006, the maximum number of simultaneously active Caspian tern nests at Dungeness Spit was detected in the 21 June photography. Between 730 and 861 breeding pairs were counted on that date, with a best estimate of 795 pairs. The data suggest that the colony size had decreased by the second survey on 8 July, to 551 to 759 breeding pairs (Table 5), presumably due to nest failures caused by factors other than coyote predation.

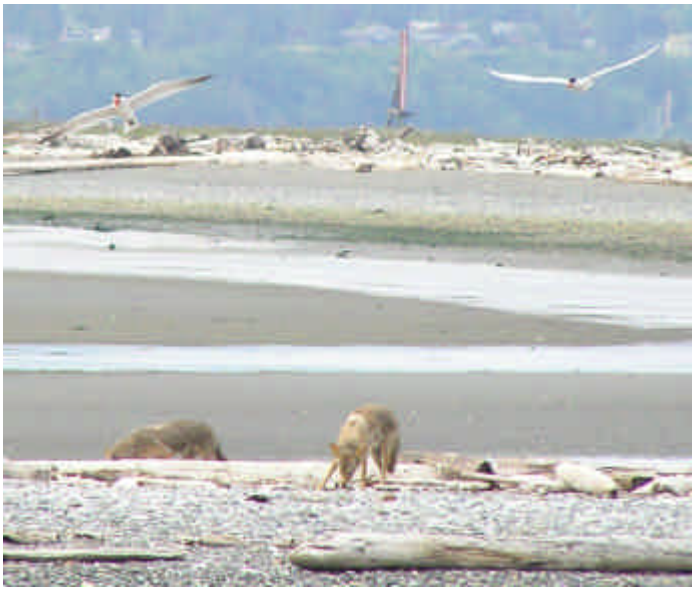
The estimate of number of young fledged from the Dungeness Spit colony was between 149 and 301, or 0.19-0.38 young fledged per breeding pair (Table 5). Estimated productivity at the Dungeness Spit colony in 2006 was much lower than in 2004 and 2005 (0.80-1.12 and 0.61-1.11 fledglings/breeding pair, respectively) and was considered low compared to other well-studied colonies in the Pacific Region.

Chick Banding and Resightings of Banded Adults: Tern chicks were not banded at Dungeness Spit in 2006. Between late April and mid-August, there were 21 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. No color-banded terns were confirmed to nest at the Dungeness Spit colony site. Of the 21 re-sightings of banded terns in 2006, 12 birds were identified such that the banding year, age class (i.e., adult or chick), and location were known. Three of these birds were banded as adults; 1 in Commencement Bay at the ASARCO Industrial Site (2000), 1 at East Sand Island (2004) and 1 at Crescent Island on the mid-Columbia River (2005). Nine of 12 identifiable banded birds that were sighted at the Dungeness Spit tern colony were banded as chicks at East Sand Island, 3 in 2001 and 6 in 2002.

Diet Composition: A small number of Caspian tern bill-loads were successfully identified at the Dungeness Spit colony in 2006 (N = 552; Table 3). The diet of Caspian terns was dominated by surfperch (*Embiotocidae*), sculpins (*Cottidae*) and salmonids (*Salmonidae*), in that order (Table 3). These three prey types represented more than 78% of the

identified prey items. Additional fish taxa that represented more than 1% but less than 10% of the identified prey items included herring and sardines (*Clupeidae*), pricklebacks (*Stichaeidae*), smelt (*Osmeridae*), sand lance (*Ammodytidae*) and gunnels (*Pholidae*), in that order (Table 3). Two additional prey taxa each represented less than 1% of the diet (Table 3). In 2006, compared to 2005, The prevalence of sculpins, surfperch, and salmonids in the diet during 2006 was greater than in 2005, while the prevalence of herring and/or sardine, smelt, and anchovy (all schooling marine forage fishes) was less. The proportion of juvenile salmonids in the diet averaged 21.8% of all identified prey items (this percentage is the average of the weekly percentages; Table 3). Salmonids comprised 17% of the tern diet in 2005 and 31% in 2004. The higher proportion of salmonids in the tern diet during 2004 and 2006 may have been related to the higher availability of pink salmon smolts (*Oncorhynchus gorbuscha*) from the Dungeness River in those two years, compared to 2005.

Factors Limiting Colony Size and Nesting Success: The main factor limiting colony size and nesting success of Caspian terns on Dungeness Spit in 2006 was nest predation from mammalian predators. Avian nest predators, especially gulls, and possibly human disturbance may also have contributed to the low nesting success observed at the Dungeness Spit colony in 2006. In 2006, the entire first set of nesting attempts failed, wholly or partly as a result of nest predation. The majority of the first nesting attempt was destroyed between 21 May and the end of the observation period on 27 May 2006, when two coyotes were seen entering the colony and eating eggs. In 2004, most of the early nesting attempts by terns at Dungeness Spit also failed due to frequent visits to the colony by a coyote. Following the hazing of the coyote in 2004, terns re-nested with no further signs of nest failure due to coyote predation. In 2005, there was no evidence of mammalian predation, although coyote scat was found within a kilometer of the colony and tracks were reported 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 colony. We suspect that without protection (e.g., predator fence, predator control) nesting terns on Dungeness Spit will continue to be vulnerable to partial or complete nest failure caused by mammalian predators.



Gulls were observed depredating 15 nests (9 eggs and 6 chicks) in 2004 and 10 nests (10 chicks) in 2005. In 2006, gulls were again continually present in the colony and nest predation was likely, especially during the frequent colony disturbances caused by bald

eagles. Direct interactions between bald eagles and Caspian terns were not observed in 2006, presumably because far less time was spent conducting observations from the blind in 2006 compared to 2004 and 2005. Bald eagles caused 63% of all disturbances, flushing all or part of the colony on average 0.68 times/hour of observation.

During 2004 - 2006, the level of human disturbance observed at the Caspian tern colony was lower than reported in 2003, perhaps as a result of (1) posting of area closure signs in the vicinity of the colony, (2) periodic presence of researchers in a blind located near the colony, and (3) relatively low numbers of visitors to the spit through May due to inclement weather. We observed one human disturbance event during 2006: hikers approached the colony resulting in a partial colony flush.

A potential contributing factor to the unexpectedly low nesting success at the Dungeness Spit Caspian tern colony in 2006 was food availability. Although we were unable to collect direct evidence of a food shortage in 2006 (due to the infrequency of visits to the colony and lack of data on chick growth rates and chick provisioning rates), the taxonomic composition of identified bill-loads in 2006 suggests that Caspian terns were forced to switch to prey of lower availability and quality. The lower prevalence of herring/sardines, smelt, and anchovies and the higher prevalence of sculpins in the 2006 diet suggests less than optimal foraging conditions for Caspian terns nesting at Dungeness Spit.

Naval Base Kitsap Bremerton

The Caspian tern colony at Naval Base Kitsap Bremerton was located on three adjacent waterfront buildings within the naval shipyard on Sinclair Inlet during 2006, as it was in 2005. Caspian tern nest scrapes consisted of a 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). Caspian terns (60-70) were first observed on the Naval Base Kitsap Bremerton in 2003 (Steve Holtom and Matt Cleland, USDA-Wildlife Services, personal communication). In 2004, nesting was confirmed, with a maximum of 174 Caspian terns counted on rooftops at the naval base (Steve Holtom and Matt Cleland, USDA-Wildlife Services, personal communication). In 2005, Wildlife Services hazed the colony intensively during five nights beginning on 2 June until eggs were discovered, at which time the hazing was discontinued. In 2006, no hazing was conducted at the colony.

In 2006, we observed the colony on one day, 13 July, during which time we counted a maximum of 723 adult terns. This suggests that the size of the Caspian tern colony in 2006 may have been as large as 500 nesting pairs. Although this number is a very rough estimate based on limited data, it is evident that the Bremerton colony was larger in 2006 than in 2005, when short-term intensive hazing was conducted at night at the colony. The productivity of the Bremerton colony could not be estimated in 2006 due to the absence of data.

In 2006, tern chicks were not banded at the Bremerton colony. Six banded Caspian terns were re-sighted during our brief observation period. No banded terns were confirmed nesting at the Bremerton colony site. Of the 6 sightings of banded terns, four were identified such that the banding year, age class (i.e., adult or chick), and location were known. Each was banded at East Sand Island as a chick: one in 2003, one in 2002, and two in 2001.

A very small number of Caspian tern bill-loads were successfully identified at the Bremerton colony in 2006 during our observation period (N=10). The prey types included surfperch (*Embiotocidae*; n = 6), salmonids (*Salmonidae*.; n = 3) and sculpin (*Cottidae*; n = 1).

The main factors limiting colony size and nesting success of Caspian terns at the Bremerton rooftop colony in 2006, to the extent that we could determine from our very limited observations, were (1) quality and availability of suitable nesting habitat, and (2) possible avian predation (gulls).

The quality of nesting habitat and availability of suitable nesting substrate limited the colony at Naval Base Kitsap Bremerton. 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 in 2005 is

indicative of the lack of suitable nesting habitat available for Caspian terns in the Puget Sound area.

There was no human disturbance to the tern colony in 2006. Wildlife Services will likely prevent nest initiation during the 2007 breeding season by removing debris on the roof-tops that serves as nesting substrate for terns and potentially installing some form of nest exclusionary device.

Distribution of Gulls in the Puget Sound Area

Background: Rooftops along the shoreline of Puget Sound, particularly warehouses located within ports, provide important artificial nesting "islands" for gulls. The Puget Sound area includes several port cities utilized by breeding gulls, including Olympia on the southern shore of Puget Sound; Tacoma, Seattle, Everett, and Bellingham on the eastern shore (mainland Washington); and Bremerton, Port Townsend, and Port Angeles on the western shore (east and north coast of Olympic Peninsula).

Gulls nested in considerable numbers within natural habitat on six islands that were surveyed in the Puget Sound area. Sites in the eastern Strait of Juan de Fuca where nesting gulls were found included Graveyard Spit, Protection Island, and Smith Island. Islands used by gulls in Rosario Strait included dredge spoil islands in Padilla Bay, Viti Rocks, and Bird Rocks.

Distribution of Gulls: A total of 9,882 gulls and 3,640 gull nests were counted within colonies surveyed in the Puget Sound area, based on aerial photographs taken on 21 June 2006. The numbers of gull nests were highest on Protection Island (42%), Graveyard Spit (8%), Smith Island (8%), Seattle Pier 90 (8%), Padilla Bay Dredge Spoil Islands (7%), Naval Base Kitsap Bremerton (6%), and the Port of Tacoma (5%) (Table 6). These eight sites included 85% of the total number of gull nests counted in this survey of Puget Sound gull colonies. Counts of gull nests in natural nesting habitat were biased low because nests were sometimes concealed in vegetation. Also, the count of gull nests at Bremerton Shipyard was a minimum estimate because of poor photograph quality.

Additional colony locations that each comprised less than 5% of the total number of gull nests counted included the Naval Base in Everett, the Port of Olympia, Bird Rock, Viti Rocks, and the harbor in Bellingham. No roof-top nesting by gulls was detected in Anacortes, Port Townsend, and Port Angeles. The absence of gulls nesting on roof-tops in Port Angeles was surprising, because we had been told by Wildlife Services that gulls nested on roofs there (M. Cleland, USDA-Wildlife Services, pers. comm.).

A minimum of 71% of all gull nests in colonies photographed during this survey were in natural areas and a maximum of 29% were located on rooftops in urban areas. Within urban areas that were surveyed, 27% of gulls nested in Seattle, 20% in Bremerton (mimium percentage), 18% in Tacoma, 14% in Everett, 12% in Olympia, and 9% in Bellingham. Among the gull colonies in natural habitat that were surveyed, 59% of gull

nests were on Protection Island, 12% were on Graveyard Spit, 11% on Smith Island, 10% on islands in Padilla Bay, and 4% each on Viti Rocks and Bird Rocks.

The aerial survey for gull colonies along the coastline of Puget Sound and eastern Strait of Juan de Fuca (exclusive of Canadian shoreline) required about 6 hours of flight time in the Cessna 205, plus a ½-hour commute each way from the airport in Kelso, WA to the study area. Survey efficiency and the quality of the photography are dependent on good flying conditions with little turbulence and good visibility. A flight crew of four people is important so that, in addition to the pilot, there can be a designated spotter, a designated photographer (on the same side of the aircraft as the spotter), and a designated recorder (who also spots out the other side of the aircraft). Once the general areas where gulls nest are known, it should be possible to add additional areas where colonies could be searched for without increasing the duration of the survey. Adding the San Juan Island to the survey route would substantially increase the duration of the survey due to the large number of small islands, and would likely require extending the survey into a second day.

We are confident that we located and photographed most rooftop colonies of any size (> 30 pairs) along the shoreline of Puget Sound. Gull colonies on rooftops were easily spotted if there were more than a few gull nests and if the buildings they were nesting on were adjacent to the shoreline. In most parts of Puget Sound, suitable rooftop nesting habitat for gulls is restricted to large metropolitan areas, reducing the area that requires searching. Gull nests generally were evident from the air as collections of debris scattered over rooftops (see photograph below). However, some rooftop gull colonies may have been missed. For example, we had heard from birders in the Seattle area that Caspian terns and gulls nested on rooftops at Pier 90 on the Seattle waterfront. We searched Pier 90 from the air and saw no evidence of nesting gulls until we searched further inland, across a major highway, and found gulls nesting on warehouses at some distance from the shore. If other “inland” rooftop gull colonies exist in the Puget Sound area, they could easily be missed.

Some digital photographs were poor quality, making it difficult or impossible to count active gull nests. Photo quality was influenced by flight altitude, flight speed, turbulence, lighting conditions, and obstructions/air space closures that restricted where the aircraft could fly. In general, photo quality can be enhanced by zooming in with a telephoto lens of the appropriate length (70-200 mm), avoiding back-lit conditions, using a high shutter speed, avoiding camera movement during shooting, and taking care to use the auto-focus effectively. Taking consistently quality aerial photographs of bird colonies, even with fully automatic digital cameras of 8.0 megapixels or greater, requires practice and experience. Novice photographers and inexpensive digital cameras should be avoided.

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Table 1. Timeline for research activities and Caspian tern nesting chronology at Dungeness NWR, Washington in 2006.

Date	Colony	Note
03/31/06	Dungeness Spit	First adult terns observed at Dungeness Spit (Audubon Society BirdFest)
04/17/06	Dungeness Spit	First crew visit to the colony site
04/17/06	Dungeness Spit	Observation blind constructed
04/17/06	Dungeness Spit	First adult terns (30) observed on-colony
04/30/06	Dungeness Spit	Diet data collection begins
05/16/06	Dungeness Spit	First tern egg observed[1]
05/27/06	Dungeness Spit	Approximately 50% of colony nests predated. Two coyotes observed eating tern eggs[2]
06/21/06	Dungeness Spit	Aerial photo census of colony conducted
07/05/06	Dungeness Spit	First tern chick observed on colony[3]
07/08/05	Dungeness Spit	Aerial photo census of colony conducted
08/14/05	Dungeness Spit	First fledgling seen
08/14/06	Dungeness Spit	Last day of colony observation

[1] First egg produced between 30 April and 16 May 2006.

[2] No chicks observed from first nesting attempt.

[3] Chicks less than one week in age.

Table 2. Average number of adult Caspian terns counted during visits to the colony at Dungeness NWR in 2006.

Week ending	Colony count
2-Apr	no data
9-Apr	no data
16-Apr	no data
23-Apr	no data
30-Apr	158
7-May	no data
14-May	no data
21-May	753
28-May	389*
4-Jun	no data
11-Jun	788
18-Jun	no data
25-Jun	625
2-Jul	1779
9-Jun	689
16-Jul	825
23-Jul	no data
30-Jul	no data
6-Aug	511
13-Aug	no data
20-Aug	646

*Count likely low due to predation events by coyotes.

Table 3. Caspian tern diet composition at the Dungeness National Wildlife Refuge colony based on percent of identifiable prey items delivered as bill-loads to the colony in 2006. TOTAL percentages are averages of the weekly percentages.

Week ending	N	Anchovy	Clupeid	Flatfish	Goby	Gunnel	Prickleback	Salmon	Salmonid UNID	Sand lance	Sculpin	Smelt	Steelhead	Surfperch	UNID
2-Apr															
9-Apr															
16-Apr															
23-Apr															
30-Apr	57	0.0	10.5	1.8	0.0	1.8	0.0	17.5	1.8	26.3	15.8	8.8	0.0	15.8	0.0
7-May															
14-May															
21-May	149	0.0	14.1	0.7	0.0	3.4	4.7	11.4	1.3	6.7	3.4	8.1	8.1	37.6	0.0
28-May	20	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	85.0	0.0
4-Jun															
11-Jun	75	4.0	2.7	0.0	0.0	0.0	0.0	37.3	4.0	0.0	10.7	2.7	1.3	37.3	0.0
18-Jun															
25-Jun	51	0.0	0.0	2.0	0.0	0.0	9.8	19.6	0.0	0.0	41.2	0.0	0.0	25.5	2.0
2-Jul	50	2.0	0.0	0.0	0.0	2.0	18.0	16.0	0.0	0.0	14.0	2.0	0.0	46.0	0.0
9-Jul															
16-Jul	50	0.0	4.0	2.0	0.0	0.0	8.0	14.0	2.0	2.0	24.0	2.0	0.0	42.0	0.0
23-Jul															
30-Jul															
6-Aug	50	0.0	0.0	0.0	0.0	6.0	4.0	18.0	0.0	0.0	66.0	4.0	0.0	2.0	0.0
13-Aug															
20-Aug	50	0.0	4.0	2.0	0.0	0.0	0.0	44.0	0.0	0.0	38.0	10.0	0.0	2.0	0.0
YTD	552	0.7	5.0	0.9	0.0	1.5	4.9	19.8	1.0	3.9	23.7	4.7	1.0	32.6	0.2

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

NOTE: The "Salmonid UNID" category consisted of unidentified salmonids.

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

Table 4. Distribution of gull colonies in the Puget Sound Area in 2006.

Location	Number Gulls	Percent	Number Nests	Percent of Nests
Protection Island	4483	45.37	1531	42.05
Graveyard Spit	626	6.33	309	8.49
Smith Island	984	9.96	288	7.91
Seattle	737	7.46	284	7.80
Padilla Bay	1085	10.98	268	7.37
Bremerton	308	3.12	213	5.84
Tacoma	370	3.74	189	5.19
Everett	326	3.30	147	4.04
Olympia	165	1.67	124	3.41
Bird Rocks	267	2.70	97	2.66
Viti Rocks	265	2.68	96	2.64
Bellingham	266	2.69	94	2.58
Total	9882	100.00	3640	100.00