



MONITORING AND PREDATOR CONTROL AT THE CORPS-CONSTRUCTED CASPIAN TERN ISLANDS IN SOUTHEASTERN OREGON AND NORTHEASTERN CALIFORNIA, 2015

Annual Report

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BACKGROUND

Beginning in 2008, the U.S. Army Corps of Engineers – Portland District implemented management described in the January 2005 Final Environmental Impact Statement (FEIS) and November 2006 Records of Decision (RODs) for *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary* (USFWS 2005, 2006). This management plan, which was developed jointly by the U.S. Fish and Wildlife Service (USFWS; lead), the USACE, and NOAA Fisheries, sought to redistribute the majority of Caspian terns (*Hydroprogne caspia*) nesting at the colony on East Sand Island in the Columbia River estuary to alternative colony sites (artificial islands) outside the Columbia River basin by 2015. The goal of the plan was to reduce Caspian tern predation on out-migrating juvenile salmonids (salmon and steelhead; *Oncorhynchus* spp.) in the Columbia River estuary, and thereby enhance recovery of Endangered Species Act (ESA)-listed salmonid stocks from throughout the Columbia River basin, without negatively affecting the Pacific Coast population of Caspian terns. Thirteen evolutionarily significant units (ESUs) or distinct population segments (DPSs) of Columbia Basin anadromous salmonids are currently listed as either threatened or endangered under the ESA.

The Caspian Tern Management Plan for the Columbia River estuary called for the creation of approximately 7 – 8 acres of new or restored Caspian tern nesting habitat (islands) and to actively attract Caspian terns to nest at these sites. As alternative tern nesting habitat was created or restored outside the Columbia Basin, the available nesting habitat for Caspian terns on East Sand Island would be reduced from its initial area (approximately 5 acres) to 1.0 – 1.5 acres.

The objective of the Plan was to reduce the size of the East Sand Island Caspian tern colony to 3,150 – 4,175 nesting pairs by limiting the availability of suitable nesting habitat, while providing new nesting habitat for Caspian terns at alternative colony sites outside the Columbia River estuary. These objectives were identified as the preferred alternative in the Final Environmental Impact Statement (EIS) released in early 2005 (USFWS 2005). Caspian terns displaced by habitat reduction on East Sand Island were expected to relocate to alternative colony sites, including the nine¹ Corps-constructed tern islands in southeastern Oregon and northeastern California (i.e., Fern Ridge Reservoir, Crump Lake, Summer Lake Wildlife Area [3 separate islands], Tule Lake National Wildlife Refuge (NWR), Lower Klamath NWR [2 separate islands], and Malheur NWR; *Map 1*). Construction of additional Caspian tern colony sites in the southern portion of San Francisco Bay at Don Edwards National Wildlife Refuge was completed prior to the 2015 breeding season, and was available to nesting Caspian terns for the first time this season. The results of monitoring and evaluation of the tern islands constructed before the 2015 breeding season in Don Edwards NWR will be reported elsewhere.

Success of the Caspian tern management plan depends on (1) being able to attract Caspian terns from East Sand Island to the Corps-constructed tern islands, and (2) maintaining the Corps-constructed tern

¹ Prior to the 2013 breeding season the floating island built for Caspian terns at Dutchy Lake in the Summer Lake Wildlife Area was decommissioned and removed from the lake, leaving eight Corps-constructed tern islands available for tern nesting in southeastern Oregon and northeastern California during 2013-2015.

islands as suitable nesting habitat such that Caspian terns attracted to the site remain and do not return to East Sand Island or other colony sites in the Columbia River Basin. Caspian terns prefer to nest on islands with patches of open, sparsely-vegetated substrate (Quinn and Sirdevan 1998), at a safe elevation above the high water line, in the presence of inter-specific allies (i.e. gulls; *Larus* spp.), and devoid of terrestrial mammalian predators (Cuthbert and Wires 1999). Social attraction using tern decoys and audio playback of vocalizations has been used to entice Caspian terns to initiate nesting at historical and new colony sites (Kress 1983; Roby et al. 2002), presumably because the presence of conspecifics, in this case decoys, and/or other ground-nesting colonial waterbirds (e.g., gulls) identifies the site as safe from terrestrial predators. To maximize the likelihood of successfully establishing nesting colonies of Caspian terns at the Corps-constructed islands, a combination of habitat enhancement, social attraction, intensive colony monitoring, and predator control (when warranted) are required (Kress 1983, 2000; Kress and Hall 2002).

Once a colony is established, on-going (annual or periodic) management of nesting substrate (e.g., vegetation control and erosion abatement) and other factors limiting tern colony size and nesting success (e.g., predators) are needed to ensure the long-term sustainability of the site as nesting habitat for Caspian terns. A primary reason that Caspian terns select islands as nesting sites is because islands tend to be free of terrestrial mammalian predators, which are proficient predators on the eggs and young of ground-nesting birds. When terrestrial mammalian predators (e.g., fox [*Vulpes* sp.], raccoon [*Procyon lotor*], coyote [*Canis latrans*], mink [*Neovison vison*]) access or are introduced to an island that supports a ground-nesting waterbird breeding colony, the colony generally fails and the breeding adults disperse to alternative colony sites. Predatory birds can also, under some circumstances, cause waterbird nesting failure and subsequent colony abandonment. Based on our experience monitoring Caspian tern colonies in the interior regions of western North America, the four most significant and prevalent avian predators on Caspian tern eggs and chicks are California gulls (*L. californicus*), ring-billed gulls (*L. delawarensis*), great horned owls (*Bubo virginianus*), bald eagles (*Haliaeetus leucocephalus*), and black-crowned night-herons (*Nycticorax nycticorax*; BRNW 2015). In addition, great horned owls and bald eagles can cause colony abandonment by preying on breeding adult terns at the colony. Depending on the Caspian tern colony and year, any of the above avian predators can cause active tern colonies to fail, and result in breeding adult terns abandoning the colony site.

Predation on Caspian tern eggs and young by great horned owls and raccoons, as well as by California and ring-billed gulls nesting sympatrically with Caspian terns, has been observed on the Corps-constructed tern islands in previous years. Together with depredation of breeding adult Caspian terns by great horned owls and raccoons, these predation pressures have been identified as major limiting factors for the successful establishment and persistence of Caspian tern colonies at some of these alternative nesting islands (BRNW 2015a). California and ring-billed gulls arrive at the Corps-constructed islands and initiate nesting earlier than Caspian terns, and can interfere with the formation of a cohesive Caspian tern colony. Additionally, both species of gulls may turn to predation on Caspian tern eggs and chicks to provision their own young. Lethal take of predatory gulls during the nesting season may remove individual gulls that habitually depredate Caspian tern nests, but is a reactionary approach that usually occurs after the gull has depredated one or more Caspian tern nests. Fortunately, early season hazing and dissuasion of pre-nesting gulls can delay the onset of nesting, potentially lowering their impact on Caspian terns attempting to nest at that site later in the season.

Great horned owls not only negatively affect Caspian tern colonies through direct predation on Caspian tern adults and young, but may also cause adults to abandon the colony at night. If this occurs when their chicks are young and susceptible to exposure, nocturnal abandonment due to owl disturbance can

cause widespread chick mortality (BRNW 2015a). Great horned owls typically hunt from a perch, and placement of “bird-be-gone” spike strips and “bird netting” on observation blinds and other elevated surfaces can reduce the availability of owl perches. However, the removal of great horned owls through live-trapping or lethal take may become necessary to ensure the success of a Caspian tern colony if they repeatedly disturb the tern colony at night. Similarly, raccoons and other mammalian predators (e.g., mink, foxes, coyotes) can also cause Caspian tern colonies to fail by swimming out to their nesting site to take Caspian tern eggs, young, and incubating adults during the night (Antolos et al. 2004; Adkins et al. 2014; BRNW 2015a). Like great horned owls, raccoons can also cause nocturnal abandonment of the colony by adult Caspian terns, leaving young chicks vulnerable to the elements and potentially causing colony failure. Preemptive, targeted trapping around certain artificial tern islands may lower the density of the nearby raccoon population, and thereby potentially reduce the chance of raccoon visits to the island during the breeding season. Placing live traps for raccoons around the edge of tern colonies has proven ineffective at reducing raccoon predation at the Corps-constructed tern island in Tule Lake Sump 1B; however, lethal control using firearms at this site has proven successful in the past, and may be necessary at this tern colony and others in the future (BRNW 2015a). In summary, for effective conservation of Caspian tern breeding colonies, nesting islands must be maintained free of avian and terrestrial mammalian predators using targeted predator control measures (Kress 1983, 2000; Kress and Hall 2002).

PROJECT OBJECTIVES

The primary goal of this study was to monitor and evaluate the efficacy of providing alternative Caspian tern nesting habitat in southeastern Oregon and northeastern California as part of the Caspian Tern Management Plan for the Columbia River estuary (USFWS 2005, 2006), and to actively manage those factors (e.g., predators) that might limit Caspian tern colony size and nesting success at four of the tern islands constructed by the Corps as alternative nesting habitat in these regions.

We monitored and evaluated the effects of Caspian tern management actions at the four Corps-constructed tern islands that were deemed suitable for Caspian tern nesting in southeastern Oregon and northeastern California during the 2015 breeding season (see *below*). In general, colony preparations (e.g., removal of emergent vegetation) and social attraction techniques (i.e., Caspian tern decoys and audio playback of vocalizations) were used to entice Caspian terns to initiate nesting at each site. Predators, both avian and mammalian, were actively managed under permit to help ensure the success of Caspian terns attempting to nest at these sites. Also, Caspian tern nesting ecology and factors limiting colony size and nesting success were investigated. Furthermore, predation rates by Caspian terns on fishes of conservation concern were evaluated at each of the colonies monitored as part of this study. Specifically, there were three project objectives in 2015, which are outlined below.

Objective 1. Implement predator control measures and evaluate their effectiveness at the Corps-constructed Caspian tern islands: Major limiting factors on Caspian tern colony size and nesting success at the Corps-constructed islands are (1) colony disturbance and depredation of Caspian tern eggs, chicks, and adults by terrestrial mammalian predators (i.e. raccoons, coyotes, mink), (2) colony disturbance and depredation of Caspian tern adults and chicks by avian predators (i.e. great horned owls), and (3) inter-specific competition for nest sites and depredation of Caspian tern eggs and chicks by California and ring-billed gulls (Collis et al. 2002, BRNW 2015a) Impacts from these predators can not only reduce colony size and nesting success, but may also cause entire Caspian tern colonies to be

abandoned. We implemented various measures (see [below](#)) at the Corps-constructed tern islands to reduce or eliminate these limiting factors and carefully monitored their effectiveness.

Objective 2. Attract, monitor, and evaluate Caspian terns nesting at Corps-constructed islands: Habitat enhancement and social attraction techniques were used to attract Caspian terns to nest at the Corps-constructed tern islands. Once a colony was established, we monitored colony occupancy/attendance, nesting chronology, and factors limiting colony size and nesting success.

Objective 3. Evaluate predation rates on fish populations of conservation concern by Caspian terns nesting at Corps-constructed tern islands: To identify potential conflicts with fish species of conservation concern from Caspian terns nesting at the Corps-constructed tern islands, we recovered (electronically detected) PIT tags placed in juvenile fishes that were consumed by Caspian terns and later deposited at their nesting colonies. These data were used to estimate predation rates by Caspian terns on ESA-listed suckers (Warner sucker [*Catostomus warnerensis*], Lost River sucker [*Deltistes luxatus*], and shortnose sucker [*Chasmistes brevirostris*]) by terns nesting on a Corps-constructed island in the Upper Klamath Basin, and on redband trout (*O. mykiss gairdneri*) by terns nesting on a Corps-constructed island in Malheur Lake.

METHODS

Of the eight Corps-constructed tern islands in southeastern Oregon and northeastern California, only four were deemed suitable for Caspian tern nesting in 2015 (i.e. Tule Lake Sump 1B in Tule Lake NWR, East Link Impoundment in Summer Lake Wildlife Area, Gold Dike Impoundment in Summer Lake Wildlife Area, and Malheur Lake in Malheur NWR; see [Map 1](#)). In 2015, colony monitoring and predator control activities were carried out at these four sites regularly (i.e., 3-5 days/week) throughout the breeding season (late April – August) by dedicated 2-person field crews.

Colony preparation, colony monitoring, and predator control activities were carried-out as outlined in the Performance Work Statement using established protocols (BRNW 2015a). In general, colony preparations on the Corps-constructed tern islands were carried-out prior to or soon after the terns' arrival at these nesting sites. Colony monitoring entailed visits to each colony by trained field technicians throughout the breeding season. Using diurnal colony monitoring at each colony, combined with nocturnal colony monitoring as needed, we assessed the presence and impacts of avian and mammalian predators on Caspian tern colony size and productivity. Predator control was carried out at each colony as needed. Predation rates by Caspian terns on fish species of conservation concern were measured by recovering PIT tags implanted in juvenile fishes and subsequently consumed and deposited by Caspian terns on their breeding colony. All the necessary permits to complete the monitoring and management objectives were acquired prior to commencement of this work. See below for a detailed description of the methods used as part of this study.

Colony Preparation

The first visit to each of the four Corps-constructed islands occurred on 14 April (Tule Lake tern island), 15 April (East Link and Gold Dike tern islands), and 16 April (Malheur Lake tern island; see [Map 1](#)). During these visits, pioneer vegetation was removed from the tern colony area on each island; Gold Dike tern island was the only site of the four that required extensive vegetation removal in 2015. Second,

ropes were laid out on the ground across each tern colony area to form a grid to enhance our ability to monitor and map the locations of breeding birds on the colony. Third, observation blinds used for colony monitoring at each site were repaired and readied for use in 2015. Fourth, shade structures (n = 2 - 6) and chick shelters (n = 4 - 5) were placed at the periphery of the rope grid on each island to provide terns with on-colony cover from heat and avian predators. Fifth, Caspian tern decoys (n = 212 - 235) and two audio playback systems were deployed on each island to enhance the prospects of tern nesting at the four sites. Sixth, silt fencing or plywood sheets were erected in a “V” configuration (i.e. “bat wings”) at the boat landing on the shore of each island in order to conceal researchers from terns on-colony when accessing the observation blinds. Lastly, elevated structures (i.e. shade structures, chick shelters, and observation blinds) were covered with spike strips (i.e. bird-be-gone) to prevent avian predators from using them as perches.

Finally, a few additional measures were implemented at the Corps-constructed tern island at Tule Lake Sump 1B. To help address the anticipated mammalian predation issues at this site, walk-in traps (n = 3 - 4) and coon cuff traps (n = 4 - 8) were set and maintained on the island throughout the breeding season. Also, two Reconyx time-lapse cameras were installed on the observation blind on 25 May, one camera on the north side of the blind that was set to photograph the tern colony area every 5 minutes, and the second camera on the east side of the blind that was set to photograph when motion was detected because it was believed that raccoons were using the riprap that bisects the island to access the tern colony. Both cameras were operational 24 hours/day throughout the 2015 breeding season.

Colony Monitoring

We used observation blinds situated at the periphery of the Caspian tern colony area on each of the four Corps-constructed islands in southeastern Oregon and northeastern California to monitor Caspian tern nesting activity and the activities of both mammalian and avian predators at each site. Trained field technicians visited each site during 3 - 6 days/week throughout the breeding season (late April – August). Each visit by the colony monitors to each site lasted at least 4 hours to permit collection of comprehensive data on Caspian tern nesting activities and to observe or collect evidence of predator activities on each island.

At each of the four Corps-constructed tern islands, we measured (1) seasonal colony attendance (i.e., number of Caspian tern adults on colony), (2) nesting chronology and behavior, (3) nesting habitat types used, (4) nesting area occupied, (5) peak colony size (i.e. number of breeding pairs), and (6) number of nests initiated and young fledged (i.e., nesting success). The numbers of Caspian tern pairs breeding at colonies on the four Corps-constructed islands were estimated from ground counts of incubating adult terns near the end of the incubation period during peak nesting activity. Nesting success (average number of young raised per breeding pair) at each colony was estimated from ground counts of young at the colony at the beginning of the fledging period. Measurement uncertainty in colony size and nesting success was not expressly estimated; however, repeatability of ground-based counts was generally < 5%.

During each site visit, data were also collected to assess factors that might be limiting colony size and nesting success, and more specifically, direct observations and/or signs of avian or mammalian predation on terns or tern nests. Signs of predation at a tern colony included, but were not limited to, observations of: (1) dead birds or broken eggs; (2) mammal tracks or scat; (3) owl pellets; (4) large colony disturbances; (5) nervous behavior of nesting birds; (6) large reductions in the number of

breeding adults, attended nests, eggs, or chicks since the last visit; and (7) presence of nocturnal predators on colony in video footage (in the case of the Tule Lake tern island).

As part of a greater regional effort to evaluate the Caspian Tern Management Plan for the Columbia River Estuary (USFWS 2005, 2006) and the Inland Avian Predation Management Plan (IAPMP; USACE 2014), efforts supported by the Bonneville Power Administration, the U.S. Fish and Wildlife Service, the Grant County Public Utility District, the Priest Rapids Coordinating Committee, and the USACE – Walla Walla District, Caspian tern nesting activity and inter-colony movements were investigated at all eight Corps-constructed tern islands in southeastern Oregon and northeastern California. Caspian tern nesting activity at all eight Corps-constructed tern islands are presented in brief here. A more in depth presentation of these results, as well as the inter-colony movements of banded Caspian terns, will be provided in a subsequent report.

Predator Control

As has been done in previous years, efforts were made to identify and control nocturnal avian predators (e.g., great horned owls) and mammalian predators (e.g., raccoons) at the four monitored Corps-constructed tern islands in 2015. We used regular nighttime colony monitoring in conjunction with on-colony trapping and/or lethal take (i.e. shooting) of confirmed nuisance predators to help ensure colony establishment and nesting success by Caspian terns at each site. In 2015, we also implemented efforts to selectively remove predatory California gulls and ring-billed gulls to protect Caspian tern eggs and chicks from gull depredation. Removal of avian and mammalian predators was carried out by authorized project personnel under pertinent State, Federal, and landowner permits.

Pre-season predator control: Prior to nest initiation, attempts were made to remove mammalian predators from sites where mammals have been observed to depredate Caspian tern nests in previous nesting seasons (e.g., raccoons at the Tule Lake tern island) and at sites that had signs of recent mammal activity (e.g., fresh tracks or scat). During visits to the colonies prior to nest initiation (March-April), there were no signs of recent mammal activity at any of the Corps-constructed tern islands visited, with the exception of the Tule Lake tern island. In mid-March, Refuge personnel observed fresh raccoon scat in the revetment that bisects the island and, as a result, 3 Havahart walk-in live traps were set prior to tern nest initiation and maintained throughout the breeding season at the Tule Lake tern island. Additionally, as was mentioned above, all elevated structures (i.e. observation blinds, shade structures, and chick shelters) on each of the four Corps-constructed islands were fitted with bird-be-gone to prevent them from being used as hunting perches by great horned owls and other raptors.

In-season predator control: During the breeding season, colony monitors visited the Corps-constructed tern islands up to 5 days/week. If nest predation or predatory behavior (e.g., gulls engaged in searching flight over the tern nesting area) was observed during daytime visits to the colony, attempts were made to lethally remove the predator (i.e. California gull, ring-billed gull, or raccoon) under permit using a high-powered .22 caliber rifle operated by trained marksmen. We used .22 caliber Conical Ball Cap ammunition in order to reduce noise and disturbance to the tern colony. The total number of predators removed at each site was documented and reported to the funding agency on a weekly basis throughout the breeding season.

If signs of nocturnal predation were observed (see [above](#)), colony monitors would initiate night-time visits to the colony to identify the predator. Night-time visits to a site were carried out on consecutive nights until (1) the predator was identified and removed or (2) nocturnal predation activity was no

longer suspected. Using night vision binoculars, trained technicians observed the colony from the observation blind. If a mammalian predator (e.g., raccoon) was spotted on or near the colony, attempts were made to shoot the predator, under permit, with a .22 caliber rifle equipped with a night vision scope. If a great horned owl was detected, padded leg-hold traps were set to capture the owl alive for banding (i.e. federal numbered metal leg-band), transport, and release at a designated site at a distance from the colony and approved by federal and state resource management agencies. As directed by the Manager at the Summer Lake Wildlife Area, no attempts were made to remove adult owls at the East Link tern island in 2015. As mentioned above, the removal of nocturnal predators at Corps-constructed tern islands was carried out under permit and was closely coordinated with the funding agency and the appropriate federal and state resource managers.

Predation on Fish of Conservation Concern

Warner suckers, Lost River suckers, shortnose suckers, and redband trout are PIT-tagged (Prentice et al. 1990) to evaluate their behavior and survival following release in areas of southeastern Oregon and northeastern California. Some proportion of these tagged fish are consumed by colonial waterbirds and the tags subsequently deposited on the birds' nesting colony. The recovery (electronic detection) of PIT tags on bird colonies by researchers following the nesting season can then be used to provide data on predation rates on tagged fish of conservation concern (Collis et al. 2001; Antolos et al. 2005; Evans et al. 2012).

We scanned for PIT tags implanted in ESA-listed suckers by researchers from the USGS Klamath Field Station (POC, David Hewitt) or ODFW (POC, Paul Sheerer) at the Tule Lake tern island, and for PIT tags implanted in redband trout by researchers from ODFW (POC, Shaun Clements) at the Malheur Lake tern island (see [Map 1](#)). We used the scanning methods outlined in Evans et al. (2012). In brief, PIT tags deposited by birds on nesting colonies were recovered *in situ* after birds dispersed from their breeding colonies following the nesting season (August-September). Colony sites were scanned using pole-mounted PIT tag antennas and portable transceivers capable of detecting both full- and half-duplex PIT tags. PIT tags were detected by scanning the entire area occupied by birds during the nesting season using two passes (or complete sweeps) of the nesting area.

RESULTS

Colony Monitoring & Predator Control

Caspian terns were observed during the 2015 breeding season at 6 of the 8 Corps-constructed tern islands in southeastern Oregon and northeastern California ([Figure 1](#)); however, Caspian terns only attempted to nest at five of the islands: Crump Lake, East Link, Sheepy Lake, Tule Lake, and Malheur Lake tern islands ([Figure 2](#), [Table 1](#)). Caspian terns were observed loafing on the tern island in Gold Dike Impoundment, but no nesting attempts by Caspian terns were detected at this site.

In total, 45 predators were removed from the four Corps-constructed islands deemed suitable for nesting in 2015 ([Table 2](#)). Most of these were predatory California and ring-billed gulls (33 or 73.3%), followed by raccoons (11 or 24.4%). One great horned owl was trapped at Tule Lake tern Island in 2015 and relocated outside of the Upper Klamath Basin.

Tule Lake: In 2015, average weekly colony attendance by Caspian terns on the Tule Lake tern island was considerably higher, especially during May – July, compared to colony attendance during the 2011-2014 nesting seasons (*Figure 3*). The Tule Lake Caspian tern colony consisted of 545 breeding pairs in 2015; more than five times larger than the average colony size observed during 2011-2014 (107 breeding pairs; *Figure 4*). Depredation rates by gulls on Caspian tern eggs and chicks at the Tule Lake tern island were low, necessitating the removal of only one California gull and 6 ring-billed gulls (under permit) at the colony in 2015 (*Table 2*). Nevertheless, other predators were frequently observed causing disturbance and nest failure of Caspian terns at the colony on Tule Lake tern island, necessitating the removal of six raccoons and one great horned owl (under permit) from the island during the 2015 breeding season (*Table 2*). Despite the record large size of the Caspian tern colony on Tule Lake tern island in 2015, nesting success was low (average of 0.16 young raised per breeding pair) compared to average nesting success during 2011-2014 (average of 0.31 young raised per breeding pair; *Figure 5*). Low Caspian tern nesting success in 2015 was due to a combination of repeated disturbance and nest depredation by raccoons and great horned owls, as well as severe weather during the week of 7-13 July. During this one week, over half of the Caspian tern chicks on the Tule Lake colony (> 190 chicks) died of exposure during intense thunderstorms, cloud bursts, and low colony attendance by breeding adults, apparently a reflection of low forage fish availability during the period of inclement weather.

Malheur Lake: Caspian terns nested on the Corps-constructed island at Malheur Lake in Malheur NWR in 2015; however, weekly colony attendance was markedly lower in 2015 compared to average colony attendance during 2012-2014 (*Figure 6*). Colony size was estimated at just 148 breeding pairs in 2015, half of the average colony size during 2012-2014 (299 breeding pairs; *Figure 7*). Eight ring-billed gulls and three California gulls that were observed depredating tern and/or other gull eggs at the Malheur Lake tern island were shot under permit in 2015 (*Table 2*). All but one nesting attempt by Caspian terns on the Malheur Lake new tern island failed during the 2015 breeding season. Gull depredation was the proximate cause of many of the Caspian tern nest failures, but low forage fish availability was clearly a major contributing factor to poor tern nesting success. Water levels in Malheur Lake were very low throughout the Caspian tern nesting season, and breeding terns were off-colony for longer periods of time to forage, leaving their eggs and chicks vulnerable to predation and exposure. Night-time visits to the island and nest predation by raccoons late in the breeding season (raccoon tracks and scat were found on the island in mid-July) also likely contributed to poor nesting success. Water levels in Malheur Lake had become so low by mid-July that mammalian predators (raccoons and coyotes) had easy access to the island, with signs of both predators being present on or near the island in July. Only one fledgling Caspian tern was observed at the Malheur Lake tern island in 2015 (an average of 0.01 young raised per breeding pair), which was markedly lower than the average nesting success at the island during 2012-2014 (0.36 young raised per breeding pair; *Figure 8*).

Summer Lake: In 2015, Caspian terns attempted to nest at one of the two Corps-constructed tern islands in the Summer Lake Wildlife Area, the island in East Link Impoundment. Only one Caspian tern was observed on the tern island in Gold Dike Impoundment during the 2015 nesting season, and there was no evidence that Caspian terns initiated nests at that site. At both of the Summer Lake tern islands, combined average weekly colony attendance by Caspian terns peaked at 35 adults on-colony in mid-June and declined thereafter (*Figure 9*). Twenty-seven Caspian tern breeding pairs attempted to nest at the East Link tern island in 2015, which was higher than the average colony size observed at the two tern islands in Summer Lake Wildlife Area during 2009-2014 (17 breeding pairs; *Figure 10*). Eleven ring-billed gulls and four California gulls that were observed depredating tern and/or other gull eggs at the East Link tern island were shot under permit during the 2015 nesting season (*Table 2*). Additionally, five raccoons were shot under permit at the Gold Dike tern island (*Table 2*). The 2015 season marked the

third year in a row with successful nesting by Caspian terns at the island in East Link Impoundment (0.14, 0.55, and 0.41 young raised per breeding pair in 2013, 2014, and 2015, respectively); no young Caspian terns were fledged from the East Link tern island during 2011-2012 (*Figure 11*).

Sheepy Lake: Caspian terns attempted to nest at the 0.8-acre Corps-constructed floating island at Sheepy Lake in Lower Klamath NWR during 2015, despite the fact that lake levels were low and the island became land-bridged before the end of the breeding season. Due to low lake levels that prevented boat access to the island, weekly colony attendance by Caspian terns at the Sheepy Lake tern island was not measured. A survey of the island conducted near the peak of incubation indicated that 336 breeding pairs of Caspian terns attempted to nest at the Sheepy Lake tern island in 2015, which was higher than the average colony size observed on the island during 2010-2014 (199 breeding pairs; BRNW 2015a). Because the colony could not be accessed by boat and regularly monitored, no predator control activities were conducted at or near the island. Although some young Caspian terns apparently fledged from the Sheepy Lake tern island in 2015, nesting success (average number of young raised per breeding pair) was not measured.

Crump Lake: As was the case in 2014, the Corps-constructed tern island at Crump Lake was land-bridged in 2015 due to severe drought conditions in the Warner Valley basin. Despite the lack of water surrounding the island throughout the breeding season, a small number of Caspian terns (ca. 8 individuals; *Figure 1*) attended the island and three to five breeding pairs of Caspian terns initiated nesting (laid eggs) on the island in 2015 (*Table 1*); however, all of these nesting attempts failed and no young Caspian terns were fledged from the island in 2015.

Orems Unit and Fern Ridge: Aerial surveys during the nesting season indicated that no Caspian terns attempted to nest on the Corps-constructed tern islands at Orems Unit in Lower Klamath NWR or at Fern Ridge Reservoir during the 2015 breeding season. The impoundment at Orems Unit was dry in 2015 because of on-going water shortages in the Upper Klamath Basin.

Predation on Fish of Conservation Concern

No sucker PIT tags were detected on the Tule Lake tern island after the 2015 nesting season. Over the past eight years, only one PIT tag from an ESA-listed sucker has been recovered on a Corps-constructed tern island in southeastern Oregon or northeastern California, a PIT tag recovered following the 2008 nesting season on the Crump Lake tern island in the Warner Valley. This PIT tag was from a 22-cm (fork-length) Warner sucker that was captured, tagged, and released by ODFW into Crump Lake in June 2008 (P. Sheerer, ODFW, pers. comm.). In 2013, a PIT tag from a juvenile sucker (species unknown) was found on the Sheepy Lake tern island in Lower Klamath NWR, but the tag was not found on a part of the island typically used by Caspian terns, but instead along the edge of the island where American white pelicans (*Pelecanus erythrorhynchos*) and double-crested cormorants (*Phalacrocorax auritus*) frequently roosted (BRNW 2014).

PIT tags from redband trout were recovered on the Corps-constructed tern island at Malheur Lake, Malheur NWR after the 2015 nesting season (n = 14 tags; number is preliminary pending confirmation by ODFW). PIT tags from redband trout were also recovered following the 2013 (n = 15) and 2014 (n = 53) breeding seasons. Analogous to the sucker PIT tag found on the Sheepy Lake tern island, redband trout tags found on the Malheur Lake new tern island were from areas of the island occupied by multiple species of piscivorous waterbirds during the breeding season, including Caspian terns, American white pelicans, double-crested cormorants, and several species of gulls. Consequently, the

fraction of recovered PIT tags that were from redband trout depredated by Caspian terns nesting on the island is not known. Based on diet composition data collected from Caspian terns nesting on the island in previous years – when rainbow trout have been observed in tern bill loads – some redband trout are likely consumed by Caspian terns nesting on the Malheur Lake tern island (BRNW 2015a). However, based on the size of some rainbow trout observed in tern bill loads, plus the timing of observations of some trout bill loads, some of the observed bill load trout were apparently hatchery rainbow trout stocked in nearby waterbodies. More detailed results, including data on the availability of PIT-tagged redband trout, are summarized and reported by ODFW (POC, Shaun Clements; see also Ramirez 2014).

CONCLUSIONS & MANAGEMENT CONSIDERATIONS

A combined total of 1,059 breeding pairs of Caspian terns attempted to nest at Corps-constructed tern islands in southeastern Oregon and northeastern California in 2015. This represents a 65% increase from the average number of breeding pairs that nested on Corp-constructed tern islands during 2008-2014 (642 breeding pairs), and the second highest combined total recorded since tern islands were first constructed by the Corps in 2008 (*Figure 12*). As was the case in 2014, severe drought in southeastern Oregon and northeastern California was a major limiting factor in Caspian tern colony size at some Corps-constructed tern islands, and a major limiting factor in Caspian tern nesting success at virtually all Corps-constructed tern islands in 2015. With the exception of the tern island at Tule Lake NWR, all of the Corps-constructed tern islands become land-bridged or nearly so by the end of the 2014 and 2015 breeding seasons, and mammalian predators were detected at least once on all Corps-constructed islands that were intensively monitored during the 2014 and 2015 Caspian tern breeding seasons. Therefore, despite our increased predator control efforts in recent years (*Table 3*), disturbance and predation by terrestrial predators was a limiting factor for Caspian tern nesting success at each of the Corps-constructed islands in 2014 and 2015, with the possible exception of the tern island at East Link Impoundment in Summer Lake Wildlife Area.

Disturbance and nest predation caused by avian and mammalian predators may be the most significant proximal factor limiting the size and productivity of Caspian tern colonies in southeastern Oregon and northeastern California, but low forage fish availability and reduced foraging habitat due to drought has also likely been a contributing factor to limiting Caspian tern colony size and nesting success at most Corps-constructed islands, especially Crump Lake tern island during 2013-2015, Malheur Lake tern island during 2014-2015, and Sheepy Lake tern island during 2014-2015. In addition to small colony sizes and low productivity, evidence that food availability is a limiting factor at some of the Corps-constructed islands is provided by (1) the low colony attendance of breeding adult terns with eggs and/or chicks on the islands, (2) the high degree of inter-annual variation in diet composition of terns nesting on the islands, and (3) the presence in the tern diet of non-local fishes (e.g., lamprey [*Petromyzontiformes*] at the Crump Lake tern island and yellow perch [*Perca flavescens*] at the Malheur Lake tern island; BRNW 2015a), suggesting that Caspian terns are commuting long distances from the breeding colony to forage. The high variability in diet composition of Caspian terns nesting at several of the Corps-constructed tern islands suggests there are fluctuations in the prey base and the availability of primary prey types for breeding Caspian terns, forcing terns to switch to less preferred prey in order to meet food requirements.

The small number of PIT tags from Warner suckers recovered on the Crump Lake Caspian tern colony to date (n = 1) and the low percentage of suckers identified in Caspian tern bill load fish (< 0.1%; BRNW

2015a) suggest that mortality of Warner suckers from predation by Caspian terns nesting at Crump Lake tern island has been extremely low since the island was built during the winter of 2007-08. With the exception of the lone PIT tag found at an off-colony, mixed-species loafing area on the Sheepy Lake tern island in 2013, no sucker PIT tags have been recovered to date at the Corps-constructed tern islands in the Upper Klamath Basin, which also suggests that mortality of shortnose and Lost River suckers due to predation by Caspian terns in the Upper Klamath Basin is rare (BRNW 2014, 2015a). Although no PIT-tagged suckers have been found on Caspian tern colonies in the Upper Klamath Basin, juvenile suckers have occasionally been observed in Caspian tern bill loads, indicating that Caspian terns do consume suckers, albeit rarely (< 0.1% of identified bill loads; BRNW 2015a). Because these observed bill load suckers were juveniles, however, it is not known whether they were ESA-listed suckers or non-listed suckers (i.e. Klamath largescale suckers [*Catostomus snyderi*]) because juvenile suckers in this region cannot be identified to the level of species based on morphology (Markle et al. 2005).

Rainbow trout have been observed in Caspian tern bill loads (range = 0.5 – 2.0% of prey items annually; BRNW 2015a) at the Corps-constructed tern island in Malheur Lake, and PIT tags from redband trout tagged and released by ODFW into the Donner and Blitzen rivers have been consistently detected on the island since redband trout were first tagged in 2013. However, some undetermined fraction of trout observed in Caspian tern bill loads are hatchery rainbow trout stocked in nearby lakes and reservoirs (BRNW 2015a). While all PIT tags from trout that have been recovered on the Corps-constructed island in Malheur Lake are known to have come from wild redband trout, it is not known what percentage of these redband trout were depredated by Caspian terns. Researchers from ODFW have been tasked with assessing the management implications of these data in relation to redband trout survival (POC, Shaun Clements; see also Ramirez 2014).

Appendix A provided task-specific recommendations that could be used to help guide future work at the Corps-constructed tern islands in southeastern Oregon and northeastern California.

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MAPS



Map 1. Corps-constructed tern islands in southeastern Oregon and northeastern California (East Sand Island and Don Edwards NWR are also shown for reference). Corps-constructed tern islands highlighted in yellow were used by nesting Caspian terns in 2015.

FIGURES

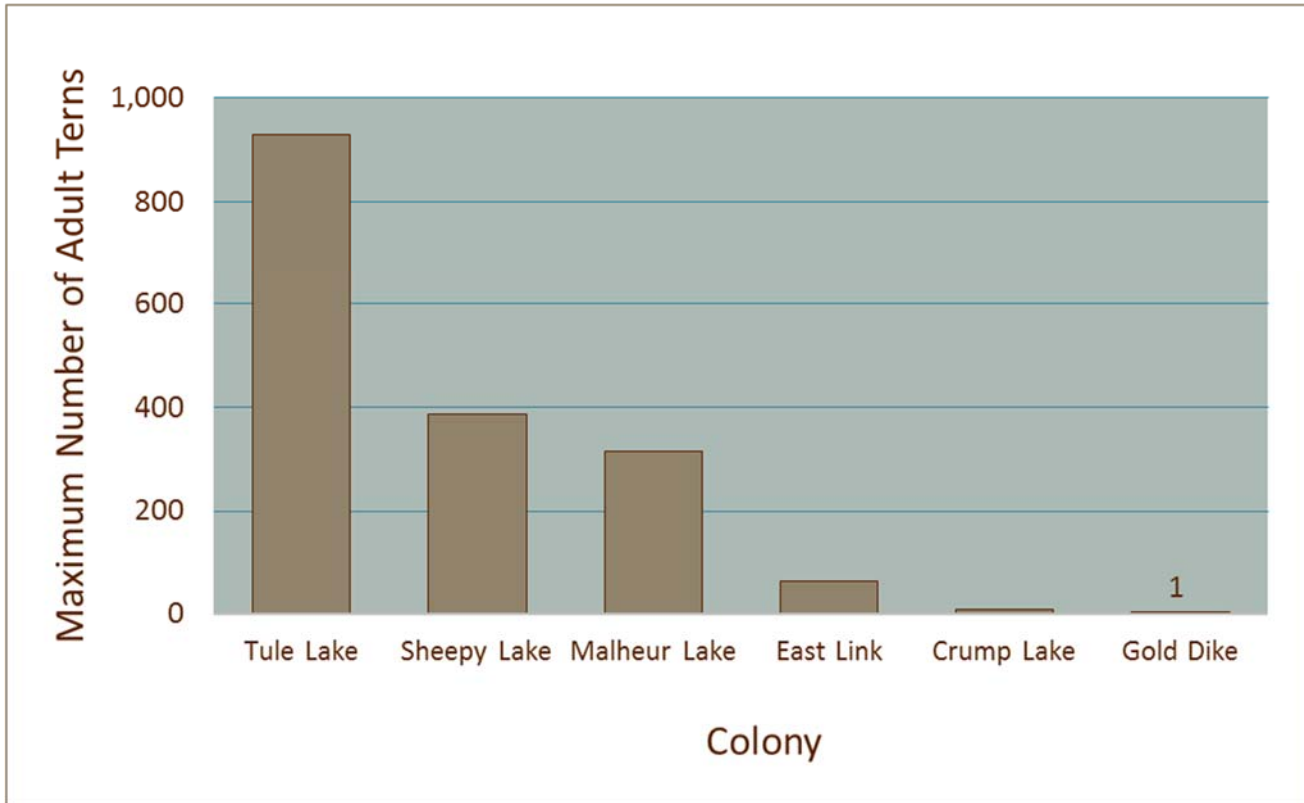


Figure 1. Maximum number of adult Caspian terns counted during the 2015 nesting season on Corps-constructed tern islands in southeastern Oregon and northeastern California. Caspian terns were not observed on the Corps-constructed tern islands at Fern Ridge Reservoir or at Orem's Unit in Lower Klamath National Wildlife Refuge in 2015. Data from the Fern Ridge, Orem's Unit, Sheepy Lake, and Crump Lake tern islands in 2015 were collected as part of a greater regional effort to evaluate ongoing Caspian tern management plans.

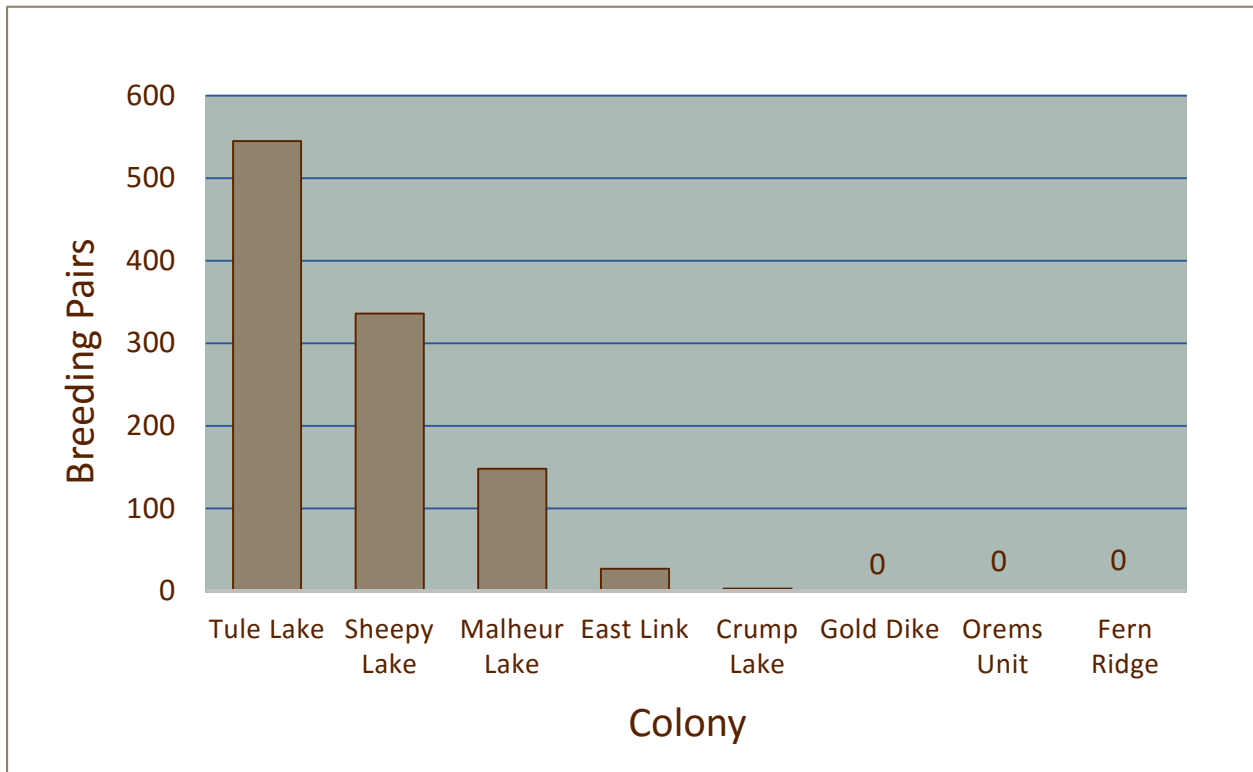


Figure 2. Sizes of Caspian tern breeding colonies (numbers of breeding pairs) on Corps-constructed tern islands in southeastern Oregon and northeastern California during the 2015 breeding season. Data from the Fern Ridge, Orem's Unit, Sheepy Lake, and Crump Lake tern islands were collected as part of a greater regional effort to evaluate ongoing Caspian tern management plans.

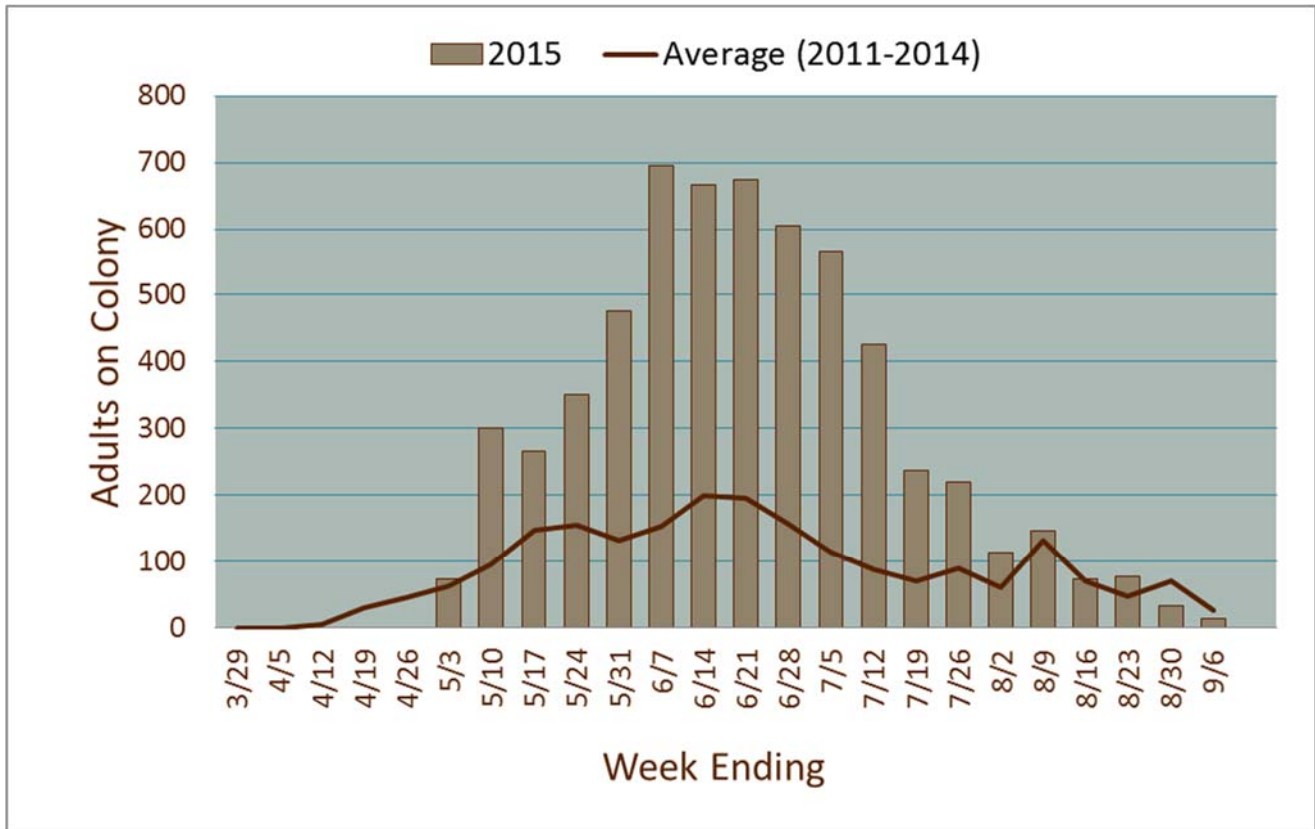


Figure 3. Estimates from the ground of the number of adult Caspian terns on the Corps-constructed tern island at Tule Lake Sump 1B in Tule Lake National Wildlife Refuge, California, by week during the 2015 breeding season.

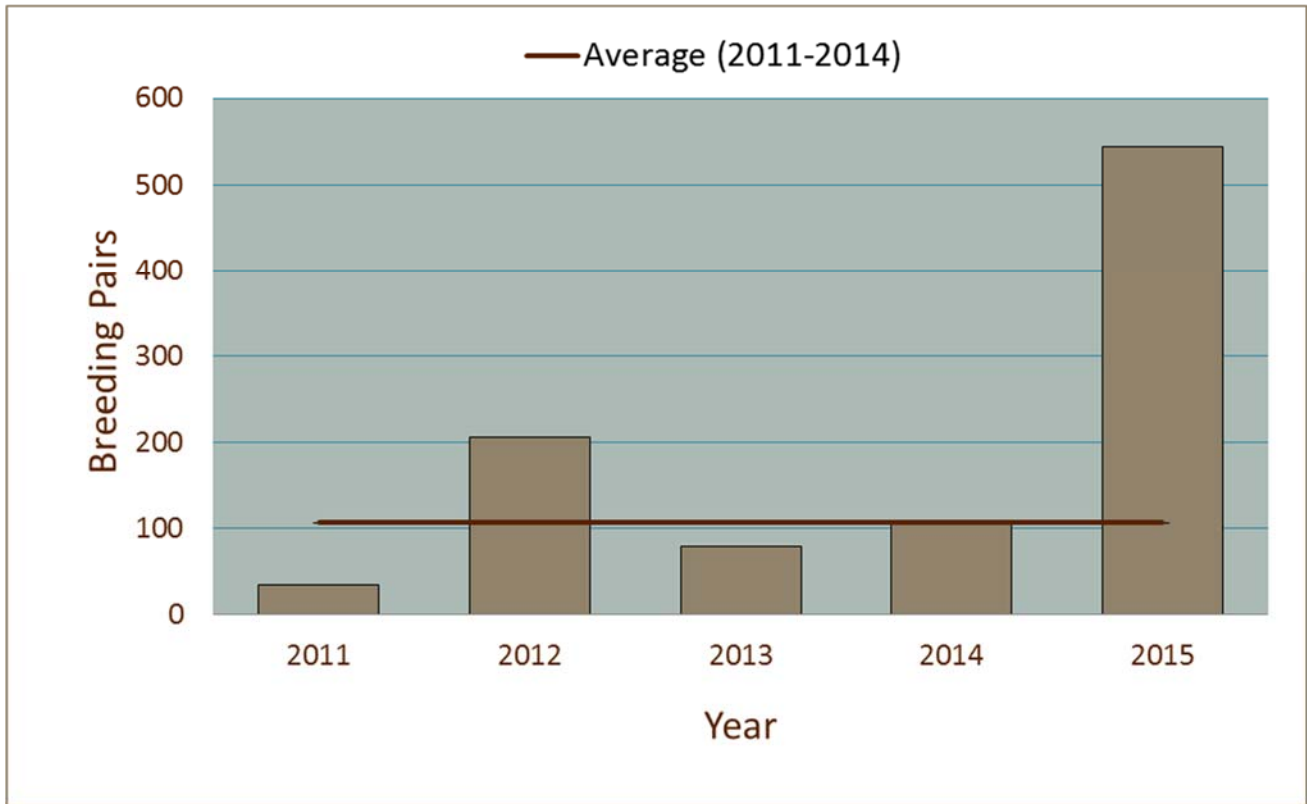


Figure 4. Size of the Caspian tern breeding colony (number of breeding pairs) on the Corps-constructed tern island at Tule Lake Sump 1B in Tule Lake National Wildlife Refuge, California, during the 2011-2015 breeding seasons.

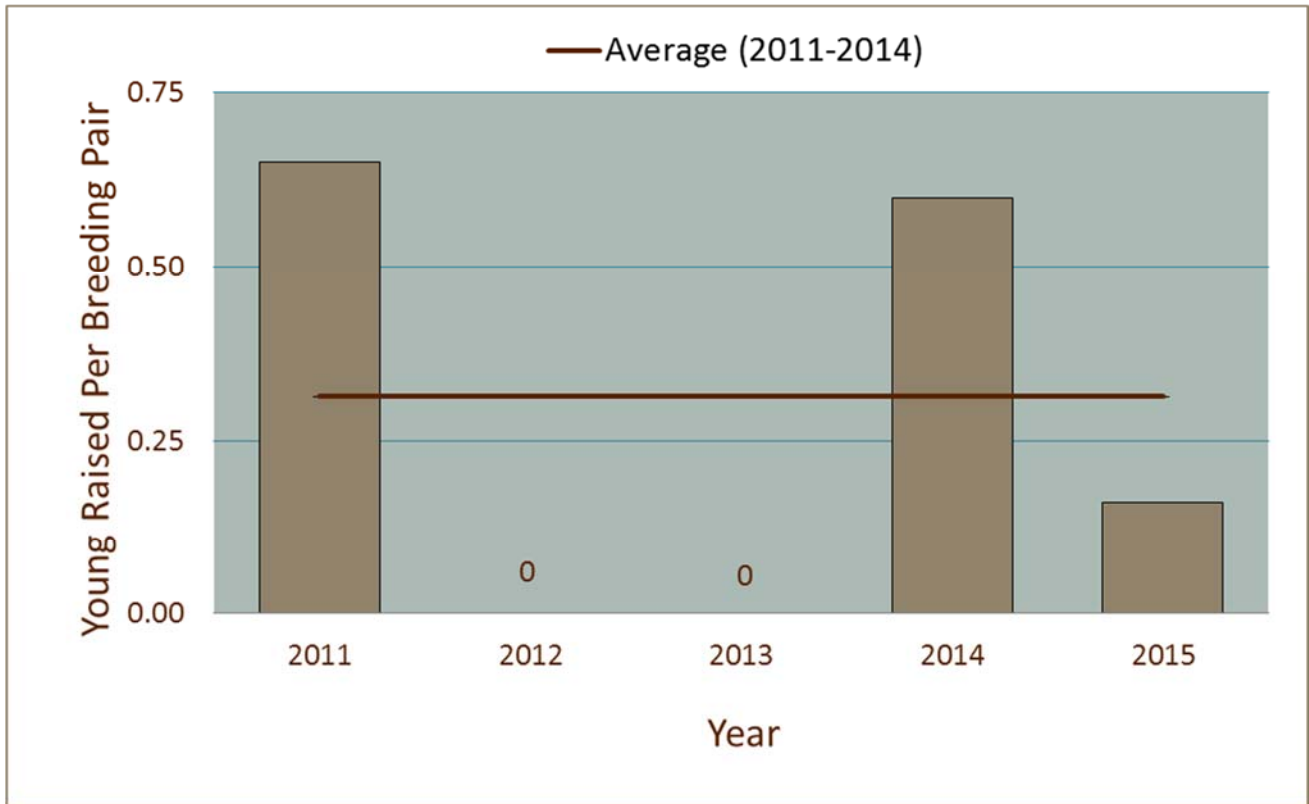


Figure 5. Caspian tern nesting success (average number of young raised per breeding pair) on the Corps-constructed tern island at Tule Lake Sump 1B in Tule Lake National Wildlife Refuge, California, during 2011-2015. No young terns were fledged from the Tule Lake tern island during 2012-2013.

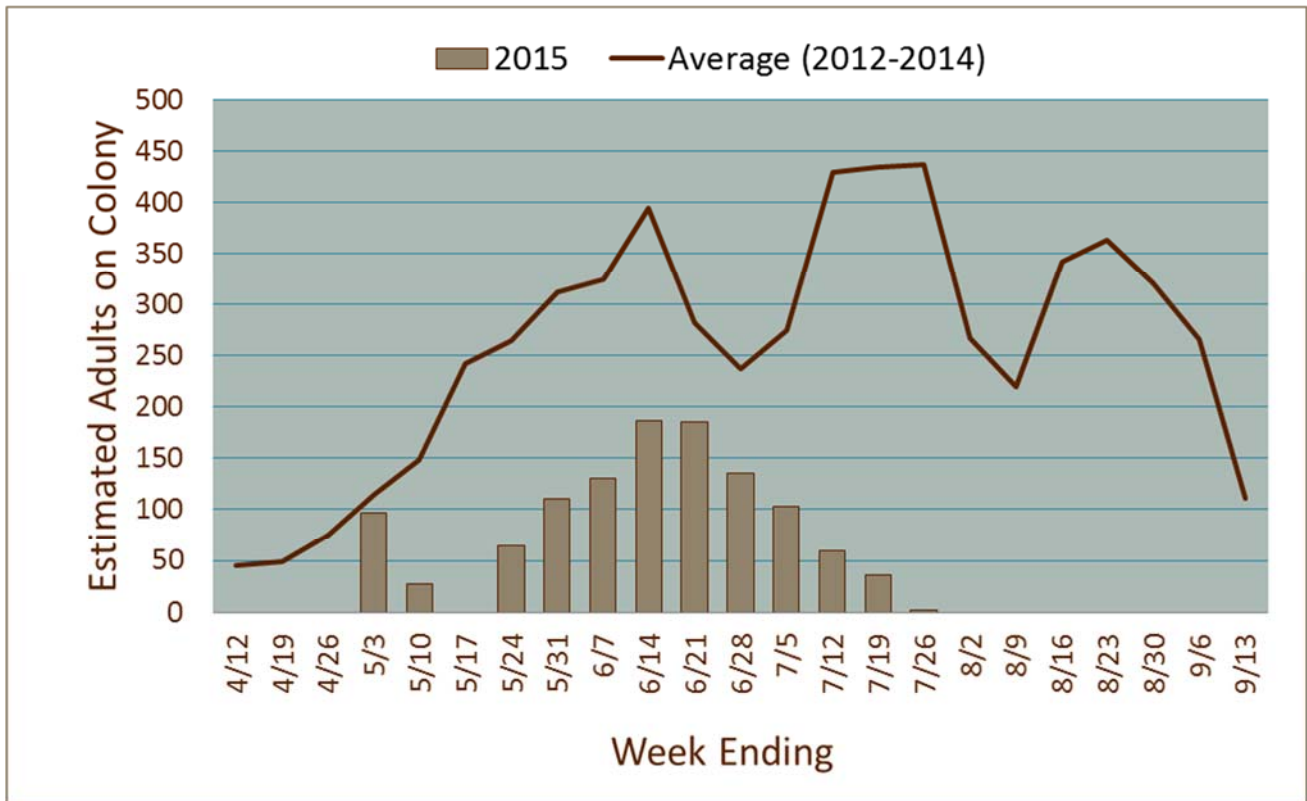


Figure 6. Estimates from the ground of the number of adult Caspian terns on the Corps-constructed tern island at Malheur Lake in Malheur National Wildlife Refuge, Oregon, by week during the 2015 breeding season.

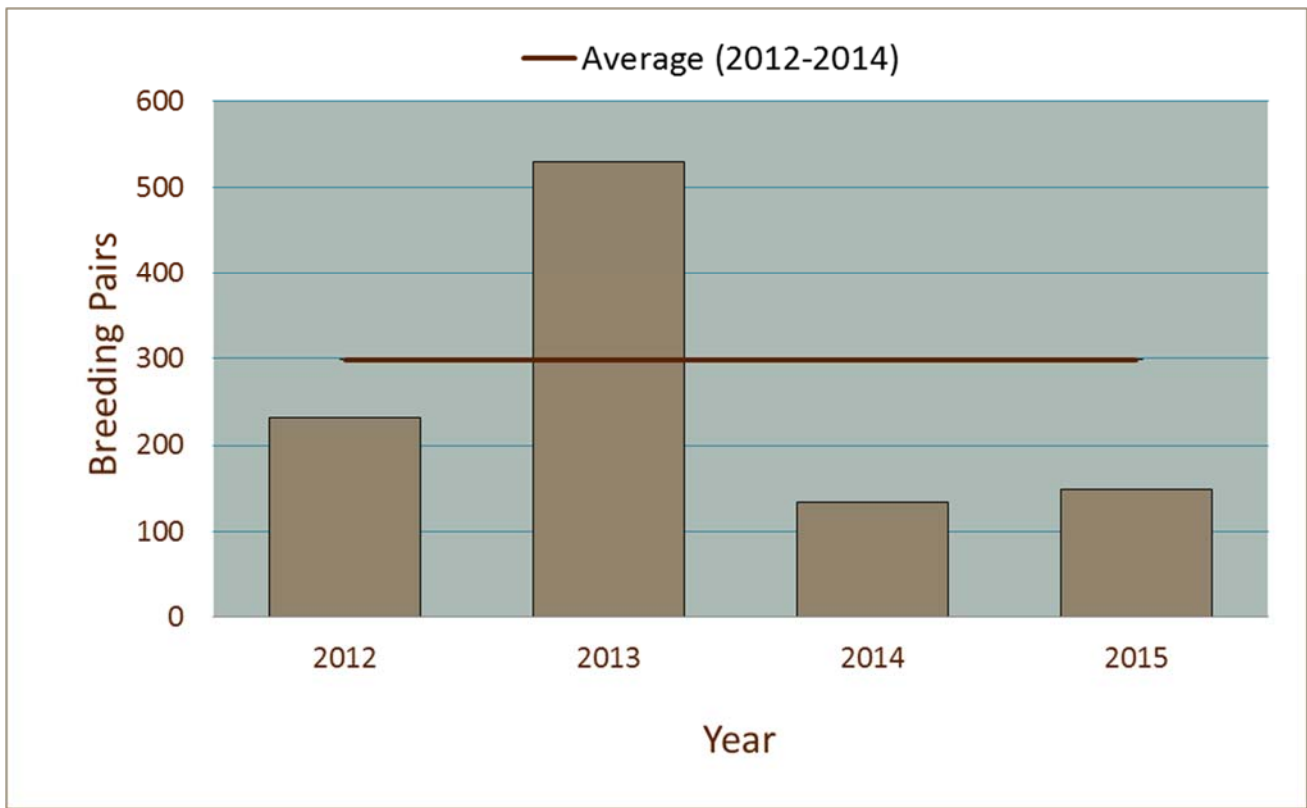


Figure 7. Size of the Caspian tern breeding colony (number of breeding pairs) on the Corps-constructed tern island at Malheur Lake in Malheur National Wildlife Refuge, Oregon, during the 2012-2015 breeding seasons.

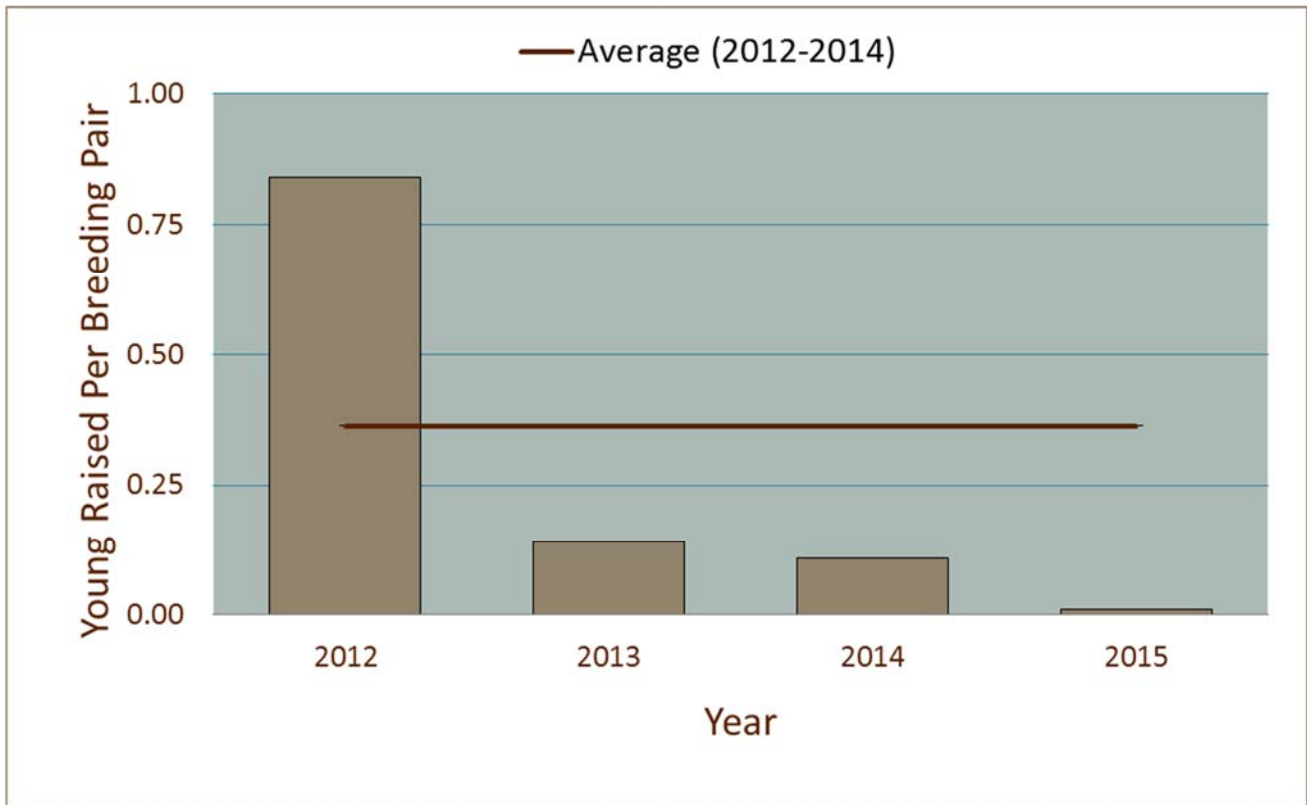


Figure 8. Caspian tern nesting success (average number of young raised per breeding pair) on the Corps-constructed tern island at Malheur Lake in Malheur National Wildlife Refuge, Oregon, during 2012-2015.

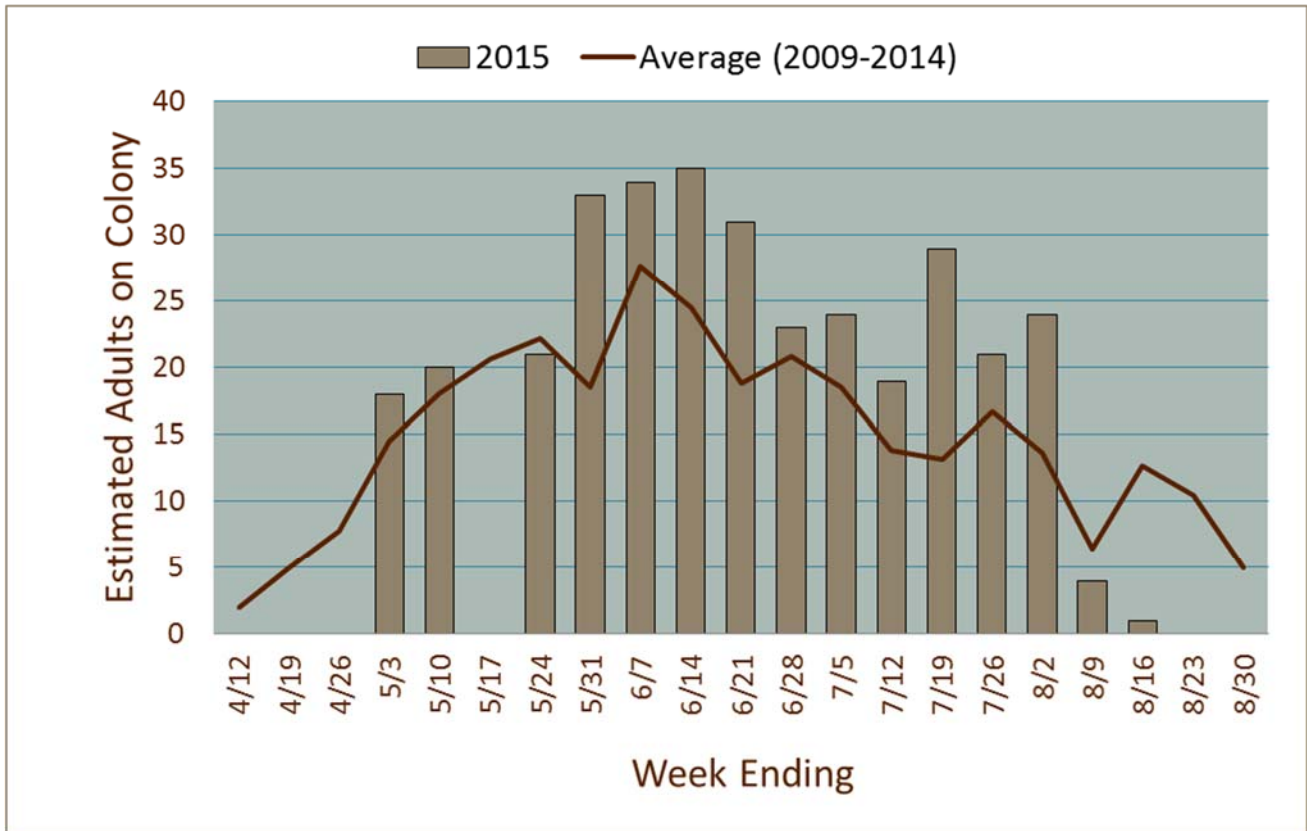


Figure 9. Estimates from the ground of the total number of adult Caspian terns on the Corps-constructed islands in East Link Impoundment and Gold Dike Impoundment at Summer Lake Wildlife Area, Oregon, by week during the 2015 breeding season.

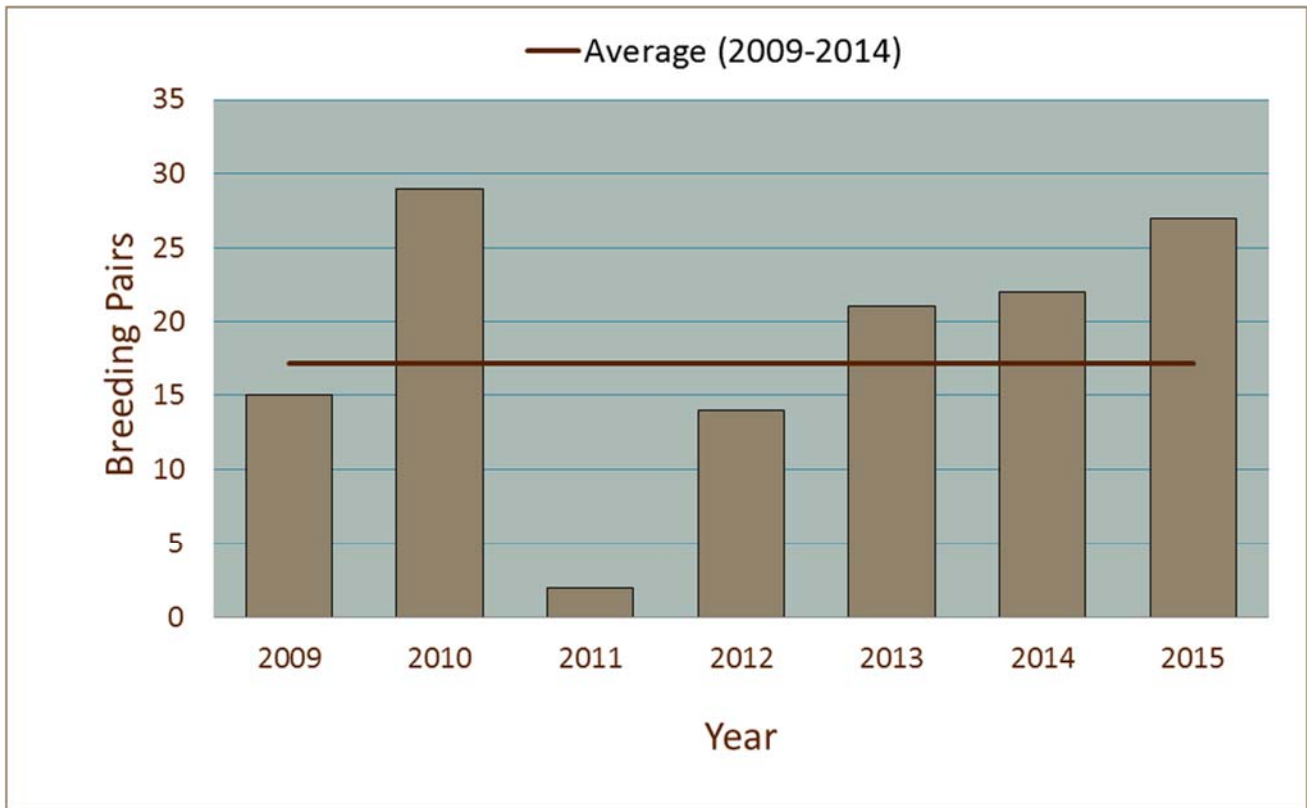


Figure 10. Total size of Caspian tern breeding colonies (number of breeding pairs) on Corps-constructed tern islands in East Link Impoundment, Gold Dike Impoundment, and Dutchy Lake at Summer Lake Wildlife Area, Oregon, during the 2009-2015 breeding seasons. Caspian terns did not nest on the Dutchy Lake tern island during 2010-2012, and the island was removed prior to the 2013 nesting season.

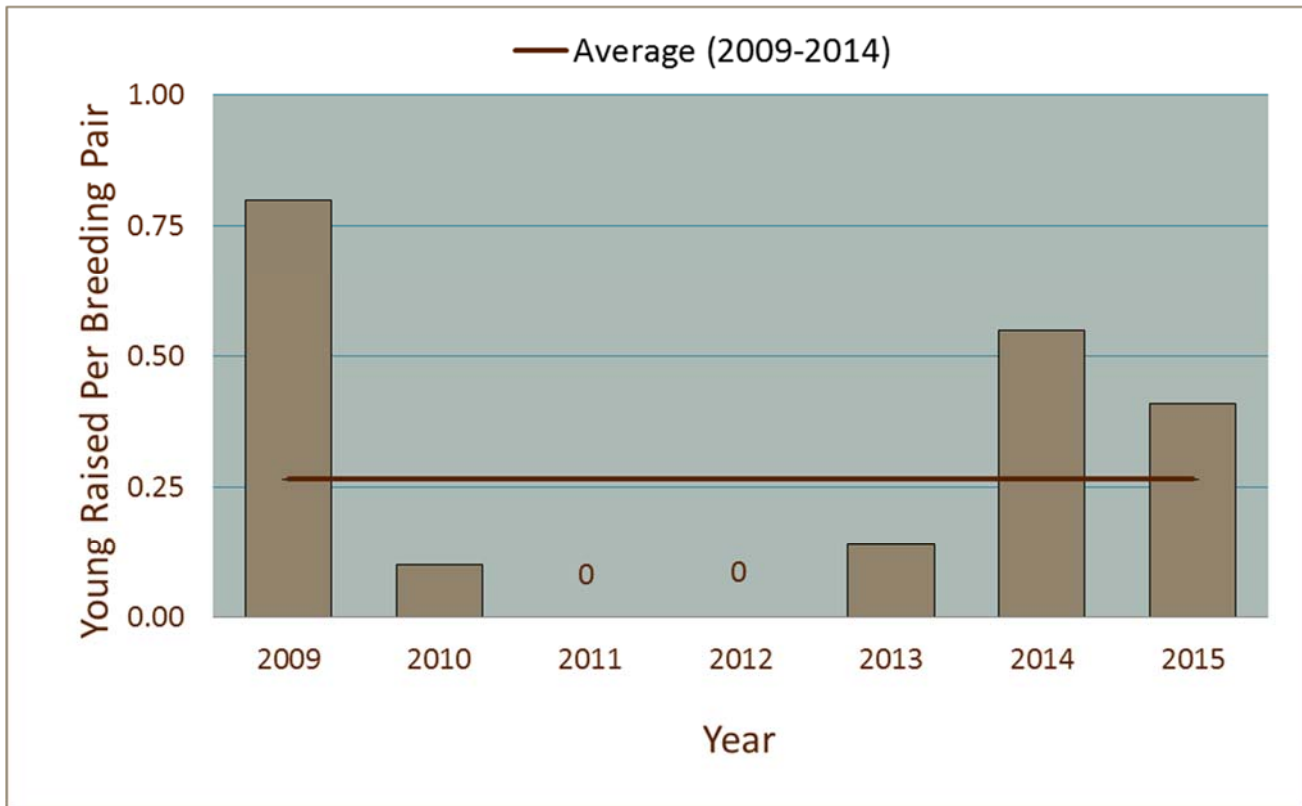


Figure 11. Caspian tern nesting success (average number of young raised per breeding pair) at Corps-constructed tern islands in Summer Lake Wildlife Area (i.e. tern islands in East Link Impoundment, Gold Dike Impoundment, and Dutchy Lake), Oregon, during 2009-2015. Caspian terns did not nest on the Dutchy Lake tern island during 2010-2012, and the island was removed prior to the 2013 nesting season. No young terns were fledged from the East Link tern island during 2011-2012 or the Gold Dike tern island during 2012-2015.

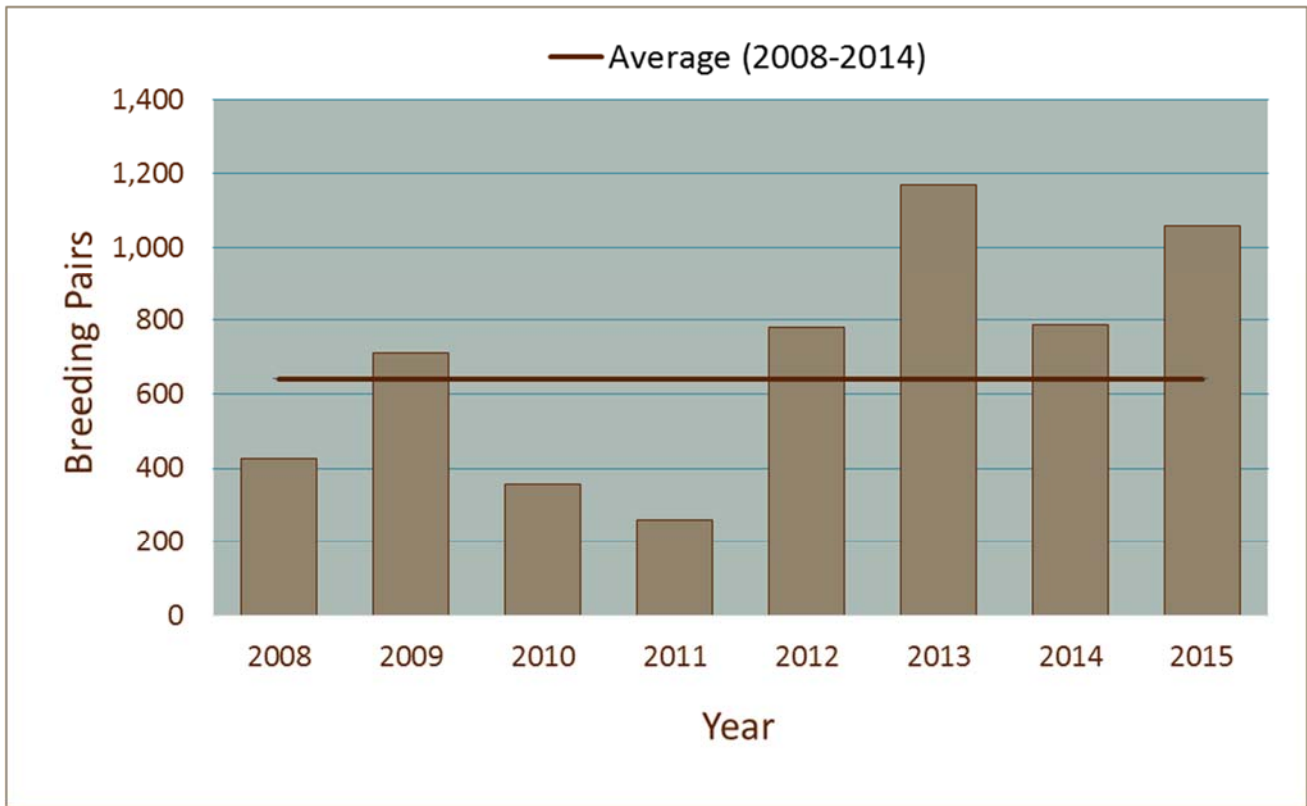


Figure 12. Total numbers of Caspian tern breeding pairs nesting on Corps-constructed tern islands in southeastern Oregon and northeastern California during 2008-2015. Data from the Fern Ridge, Orem Unit, Sheepy Lake, and Crump Lake tern islands in 2015 were collected as part of a greater regional effort to evaluate ongoing Caspian tern management plans.

TABLES

Table 1. Estimated colony size (number of breeding pairs) for Caspian terns nesting at nine Corps-constructed tern islands in southeastern Oregon and northeastern California during 2008-2015. A blank indicates that the island was not available/suitable for tern nesting (i.e. either the island had not yet been constructed, the island had been dismantled, the island was overgrown with vegetation, or the island was not surrounded by water) during that year. A zero indicates that the island was available but not used by nesting Caspian terns during that year. Data from the Fern Ridge, Orem's Unit, Sheepy Lake, and Crump Lake tern islands in 2015 were collected as part of a greater regional effort to evaluate ongoing Caspian tern management plans.

Year	Fern Ridge ¹	Crump Lake ²	East Link ³	Dutchy Lake ³	Gold Dike ³	Tule Lake ⁴	Orem's Unit ⁵	Sheepy Lake ⁵	Malheur Lake ⁶	TOTAL
2008	0	428								428
2009	0	697	7	8						712
2010	0	71	29	0				258		358
2011	0	35	2	0		34	2	188		261
2012	0	115	10		4	207		212	232	780
2013	0	223	21		0	79		316	530	1,169
2014	0	1	22		0	109		520	134	786
2015	0	3	27		0	545		336	148	1,059
Average	0	197	17	3	1	195	2	305	261	694

¹ In Fern Ridge Reservoir near Eugene, Oregon; data provided by separately funded NWP project (Fern Ridge Project)

² In the Warner Valley near Adel, Oregon

³ In the Summer Lake Wildlife Area near Summer Lake, Oregon

⁴ In Tule Lake National Wildlife Refuge near Tulelake, California

⁵ In Lower Klamath National Wildlife Refuge near Klamath Falls, Oregon

⁶ In Malheur National Wildlife Refuge near Burns, Oregon

Table 2. Pre- and in-season management strategies used to facilitate successful nesting by Caspian terns at Corps-constructed tern islands in southeastern Oregon and northeastern California during 2015.

	Tule Lake	East Link	Gold Dike	Malheur Lake
Pre-season Management Strategy				
Attempt to trap mammals (yes, no)	yes	no	no	no
Vegetation removal (yes, no)	no	no	yes	no
Install video surveillance system (yes, no)	yes	no	no	no
Provide chick shelters (yes, no)	yes	yes	yes	yes
In-season Management Strategy				
Nocturnal colony monitoring (yes, no)	yes	yes	yes	yes
Lethal removal of gulls (number)	7	15	0	11
Lethal removal of mammals (number, species)	6, raccoons	0	5, raccoons	0
Trap and relocate owls (number)	1	0	0	0

Table 3. Summary of predator control efforts at Corps-constructed tern islands in southeastern Oregon and northeastern California during 2011-2015. Blank cells represent no predator removal and N/A denotes islands that were not available as Caspian tern breeding habit during that year.

Colony	Species	2011	2012	2013	2014	2015
Tule Lake Sump 1B Tern Island	California Gull		1	1		1
	Ring-billed Gull		1	2	1	6
	Great Horned Owl	2		2	2	1
	Raccoon			1	8	6
Malheur Lake Tern Island	California Gull	N/A	4	8	6	3
	Ring-billed Gull	N/A	5	5	3	8
	Great Horned Owl	N/A				
	Raccoon	N/A				
East Link Tern Island	California Gull				4	4
	Ring-billed Gull				9	11
	Great Horned Owl					
	Raccoon					
Gold Dike Tern Island	California Gull	N/A				
	Ring-billed Gull	N/A				
	Great Horned Owl	N/A				
	Raccoon	N/A				5

APPENDIX A

Task Specific Recommendations

Task 1.1.1 – Mobilization and Demobilization

- 1) Obtain outside contract or coordinate with USACE for habitat inspection of all Corps-constructed tern islands, completion of vegetation control or surface repairs (as needed), and removal of any mammalian predators that have taken up residence on the island during the non-breeding season (as needed) by 25 March, before the spring arrival of prospecting Caspian terns.

Task 1.1.2 – Eliminate any potential elevated great horned owl perches

- 1) Continue to deploy bird-be-gone (spike strips) on observation blinds, shade structures, and other elevated surfaces on or near the tern colony.

Task 1.1.3 – Conduct pre-season mammalian removal

- 1) Deploy IR capable trail cameras pre-season to detect island use by potential mammalian nest predators
- 2) Deploy and monitor baited live traps by 20 April

Task 1.1.4 – Install social attraction

- 1) Install social attraction materials (decoys and audio playback systems) by 20 April
- 2) Replace aging batteries and sound box components

Task 1.1.5 – Prepare and/or repair observation blinds

- 1) Complete blind preparation and repairs by 20 April
- 2) Place second observation blind on east side of Sheepy Lake tern island to allow monitoring of all Caspian tern nests on the island

Task 1.1.6 – Monitor and conduct in-season predator removal

- 1) Begin regular colony monitoring no later than 01 May
- 2) Conduct pre-season gull dissuasion at all Corps-constructed islands with large gull colonies (i.e. East Link, Crump Lake, and Sheepy Lake tern islands)
- 3) Install and regularly monitor IR capable cameras at all sites to assist with detection and identification of any nocturnal predators on Corps-constructed tern islands
- 4) Continue using padded leg-hold traps on perches adjacent to tern colonies to remove and relocate great horned owls that repeatedly visit Corps-constructed tern islands.
- 5) Improve efficiency of live trapping methodologies
- 6) Extend monitoring and predator removal period through August, as needed (i.e. based on site-specific breeding chronology)

Task 1.1.7 – Conduct post-season scans for fish PIT tags

- 1) No recommendations

Task 1.1.8 – Provide weekly in-season reports and an annual report

- 1) No recommendations

APPENDIX B

System-level Monitoring: Aerial Surveys of Corps-constructed Tern Islands in Southeastern Oregon, Northeastern California, and at Don Edwards National Wildlife Refuge

I. Project Summary

As a result of implementation of the Caspian Tern Management Plan for the Columbia River Estuary (USFWS 2005) and the Inland Avian Predation Management Plan (IAPMP; USACE 2014), Caspian terns (*Hydroprogne caspia*) displaced from colonies on East Sand Island, Goose Island, and Crescent Island are expected to relocate to tern colony sites elsewhere within their breeding range in the Pacific Flyway, including the 14 Caspian tern nesting islands constructed by the U.S. Army Corps of Engineers (USACE) in southeastern Oregon (6 islands), northeastern California (3 islands), and in the southern portion of San Francisco Bay at Don Edwards National Wildlife Refuge (DENWR) (5 islands). Monitoring of these sites was conducted by aerial surveys (USACE Contract Number W912EF-14-D-004, Order No. 0002) in conjunction with frequent ground monitoring and active predator control by our research team at the SE Oregon and NE California sites (USACE Contract Number W912EF-14-D-004, Order No. DT01). On the ground monitoring and predator management efforts at the DENWR islands were conducted by USGS and USDA-APHIS-WS, respectively. Appendix B is focused on the aerial survey work conducted at the Corps-constructed tern islands in 2015.

II. Objectives

We conducted aerial surveys and took oblique aerial photography of the Corps-constructed tern islands in order to assist with system-level monitoring related to the implementation of ongoing management plans aimed at reducing the impacts of Caspian tern predation on ESA-listed juvenile salmonids from the Columbia River Basin (USFWS 2005, USACE 2014). The specific objectives of this work in 2015 were to (1) conduct aerial surveys and take oblique aerial photography to document tern colony formation, colony attendance (adults on colony), and presence of young (i.e., nesting success) at the Corps-constructed islands, and (2) conduct aerial surveys and take high-resolution, vertical aerial photography for estimating peak colony size (number of breeding pairs) and colony area (m²) at each of the active tern colonies on the Corps-constructed islands. The high-resolution, vertical aerial photography of the tern islands at Don Edwards NWR was provided to USGS staff for analysis; all other photography was analyzed by our research team and those results are provided herein.

III. Methods

The first visit to each Corps-constructed tern island in southeastern Oregon and northeastern California occurred on 14 April (Sheepy Lake), 27 April (Malheur Lake), 28 April (East Link), 29 April (Gold Dike), 30 April (Tule Lake), and 8 May (Crump Lake; see [Map 1](#) in main report). During these visits, aerial survey monuments were placed at all six sites so that aerial imagery taken during the 2015 breeding season could be ortho-rectified during post-flight image processing.

Periodic aerial surveys were conducted from a fixed-wing aircraft to determine the numbers and distribution of Caspian terns (both nesting and roosting) at the Corps-constructed tern islands in southeastern Oregon and northeastern California. Three aerial surveys of the Corps-constructed tern islands were conducted during the 2015 nesting season on the following schedule: (1) on 18 May, early in the incubation period; (2) on 8 June, late in the incubation period; and (3) on 1 August, during the fledging period. A fourth flight was originally planned to occur during the late incubation period, but was deemed unnecessary based on ground observations of the colonies. When Caspian terns were observed from the air at a site, oblique aerial photography was taken using a digital SLR camera with an image-stabilizing, zoom lens in order to count the number of birds visible in aerial photography at the three aforementioned discrete time periods during the breeding season. Additionally, geo-referenced high-resolution, vertical aerial photography (2-cm cell size at ground level) was taken of the Corps-constructed tern islands in southeastern Oregon and northeastern California on 10 June to more accurately estimate colony size and colony area at each site. Finally, geo-referenced high-resolution, vertical aerial photography (2-cm cell size at ground level) was taken of the Corps-constructed tern islands at Don Edwards NWR on 27 May to estimate colony size and colony area at those sites. See [Appendix B: Table 1](#) for a summary of the aerial surveys flown in 2015.

[Appendix B: Table 1](#). Targets of aerial surveys in SE Oregon and NE California in 2015.

Target	Number of oblique photo flights	Number of vertical photo flights	Location (UTM)
Crump Lake, Warner Valley	3	1	11N 265500 4685250
Sump 1B, Tule Lake NWR	3	1	10N 626400 4633400
East Link, Summer Lake Wildlife Area	3	1	10N 686350 4758488
Gold Dike, Summer Lake Wildlife Area	3	1	10N 681300 4753500
Sheepy Lake, Lower Klamath NWR	3	1	10N 600100 4646900
Malheur Lake, Malheur NWR	3	1	11N 352600 4794950
Don Edwards NWR, Pond A16 (2 islands)	0	1	10N 591025 4144900
Don Edwards NWR, Pond SF2 (3 islands)	0	1	10N 576750 4149700

A custom application, developed in ArcGIS, was used to count adults and fledglings from aerial photography to estimate colony size and nesting success at the Corps-constructed tern islands in southeastern Oregon and northeastern California.

IV. Results & Discussion

Caspian terns attempted to nest at five of the six Corps-constructed tern islands that were available for tern nesting in southeastern Oregon and northeastern California during the 2015 breeding season (Crump Lake, East Link, Sheepy Lake, Tule Lake, and Malheur Lake tern islands; [Appendix B: Table 2](#)). See main report for more details.

Appendix B: Table 2. Caspian tern colony attendance, number of breeding pairs, number of fledglings, productivity (average number of young raised per breeding pair), and colony area at the Corps-constructed tern islands in southeastern Oregon and northeastern California during the 2015 breeding season.

	Max Attendance	Breeding Pairs	Fledglings	Productivity	Area (m ²)	Area (ac)
Crump Lake	8	3	0	0	na	na
Tule Lake	929	545	89	0.16	551.4	0.136
East Link	62	27	11	0.41	51.6	0.013
Gold Dike	1	0	0	0	0	0
Sheepy Lake	388	336	unknown	unknown	226.3	0.056
Malheur Lake	315	148	1	0.01	273.3	0.068

Crump Lake – The northern side of Crump Lake was completely dry at the conclusion of the 2014 breeding season, but the Corps-constructed tern island was surrounded by shallow water at the beginning of the 2015 breeding season. A few Caspian terns were documented to be attending the island during the 18 May flight. The water level of the lake quickly receded and the island was land-bridged by mid-June, with just three active Caspian tern breeding pairs (peak colony size) identified from oblique aerial photographs taken on 08 June. Caspian terns abandoned nesting attempts by the 1 August flight, and likely did not hatch any young at the site during the 2015 breeding season. The colony area (m²) was not calculated for the very small, short-lived tern colony at the Crump Lake tern island ([Appendix B: Table 2](#)).

Tule Lake – Caspian terns had established a breeding colony within the social attraction area on the northern half of the Corps-constructed tern island at Tule Lake Sump 1B by the 18 May aerial survey flight. The Tule Lake Caspian tern colony was repeatedly disturbed by nocturnal predators, which delayed nesting chronology at the site (see main report). A peak colony size of 545 pairs was determined from ground counts conducted at this site on 26 June, about 2.5 weeks after the 8 June flight to take oblique photographs. Based on ground counts conducted at the time of the June aerial photography, colony size was approximately 450 breeding pairs and the area of the tern colony was 0.136 acres based on high-resolution, vertical imagery taken on 10 June ([Appendix B: Table 2](#)). Caspian tern chicks were still present on the colony during the 01 August aerial survey. Based on ground monitoring of the site, an estimated 89 Caspian tern chicks fledged from the Corps-constructed tern island in Tule Lake Sump 1B in 2015.

East Link – Caspian terns had established a breeding colony on the Corps-constructed tern island in the East Link Impoundment at the Summer Lake Wildlife Area by the 18 May aerial survey flight. A peak colony size of 27 pairs was determined by ground counts at this site on 14 June, about a week following the 08 June flight to take oblique photographs. The high-resolution, vertical imagery flight was conducted on 10 June, and the area of the colony at the East Link tern island was 0.013 acres based on these images ([Appendix B: Table 2](#)). By the 1 August flight nearly all of the 11 chicks produced at the East Link colony in 2015 had fledged, and were no longer present on the colony.

Gold Dike – No Caspian terns were observed on the Corps-constructed tern island in the Gold Dike Impoundment at the Summer Lake Wildlife Area during any of the aerial survey flights. A few ring-billed gulls (*Larus delawarensis*) attempted to nest on the Gold Dike tern island during the 2015 breeding season, but only a single Caspian tern was seen on the island during monitoring from the ground.

Sheepy Lake – Sheepy Lake was completely dry at the conclusion of the 2014 breeding season, but the Corps-constructed tern island located there was surrounded by shallow water at the beginning of the 2015 breeding season, and Caspian terns had established a breeding colony on the island prior to the 18 May aerial survey. Ground access to the colony was limited by low water levels, however, and the peak size of the Caspian tern colony on the Sheepy Lake island was estimated to be 336 breeding pairs (*Appendix B: Table 2*) based on oblique aerial imagery taken on 8 June. Colony area was 0.056 acres based on vertical imagery taken on 10 June. Caspian terns in incubating postures were apparent in both oblique and vertical photography taken in June, and field crews counted a total 145 tern chicks during their last ground visit to the island on 20 June. The Caspian tern colony site on the Sheepy Lake tern island was no longer occupied by Caspian terns during the oblique aerial photography survey on 1 August; consequently, it was not possible to estimate tern fledging success at this site, although some young Caspian terns apparently fledged from the colony in 2015.

Malheur Lake – Caspian terns had established a breeding colony within the social attraction area on the Corps-constructed tern island at Malheur Lake by the 18 May aerial survey flight. A peak colony size of 148 pairs was counted from the ground at this site on 17 June, about 1.5 weeks after the 8 June flight to take oblique photography. At the time that high-resolution, vertical imagery was taken on 10 June, ground counts indicated that colony size was about 88 breeding pairs. The area of the tern colony at the Corps-constructed tern island in Malheur Lake was 0.068 acres based on the 10 June photography (*Appendix B: Table 2*). Because of low water, the tern colony at Malheur Lake failed and no Caspian terns were present on the island by the 1 August aerial survey. Ground monitoring indicated that a single Caspian tern chick was fledged from the Malheur Lake tern island in 2015.

Don Edwards NWR – Flight timing was coordinated with personnel at the USGS Dixon Field Station, and high-resolution, vertical imagery of the Corps-constructed tern islands at the Don Edwards National Wildlife Refuge (DENWR) complex (see *Map 1* in main report) was taken on 27 May in an effort to capture the 2015 peak colony size at those sites. The imagery was georeferenced and delivered to DENWR staff for analysis.

V. Literature Cited

- 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, Oregon.
- USACE (U.S. Army Corps of Engineers). 2014. Inland Avian Predation Management Plan Environmental Assessment. U.S. Army Corps of Engineers, Walla Walla District, Northwestern Division. January 2014. Available online at <http://www.nww.usace.army.mil/Missions/Projects/InlandAvianPredationManagementPlan.aspx>.