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DISTRIBUTION AND DISSUASION OF CASPIAN TERNS (*Hydroprogne caspia*) AND DOUBLE-CRESTED CORMORANTS (*Nannopterum auritum*) ON EAST SAND ISLAND: 2023 SEASON SUMMARY REPORT

Fisheries Field Unit

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SUMMARY

From 7 March to 26 October 2023, the U.S. Army Corps of Engineers conducted colonial piscivorous water bird monitoring and dissuasion efforts on East Sand Island in the Columbia River estuary. Consistent with existing management plans, objectives included: 1) maintain the East Sand Island Caspian Tern (*Hydroprogne caspia*) colony at one acre to support the maximum target population of 3,125 – 4,375 breeding pairs, 2) prevent the formation of satellite tern colonies, and 3) monitor the abundance of Double-crested Cormorant (*Nannopterum auritum*) to ensure the maximum target population of 5,380–5,939 breeding pairs is not exceeded. All three objectives were successfully implemented in 2023. The one-acre colony of Caspian Terns had a peak abundance of 524 breeding pairs on 15 June. No Caspian Tern eggs hatched in 2023. The formation and failed dissuasion of a satellite colony on nearby Rice Island could be a factor limiting the East Sand Island colony. Double-crested Cormorants began nesting later than usual and their abundance peaked on 19 September with 3,100 individuals. A total of 241 Double-crested Cormorant active nests were enumerated, and chicks were documented, but the number of breeding pairs nor the success of the nests were monitored. The potential impacts of increased predator activity on the island may have contributed to the failed reproductive attempts of Caspian Terns and Double-crested Cormorants.

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BACKGROUND

Long term evaluation of Caspian Terns (CATE; *Hydroprogne caspia*) and Double-crested Cormorants (DCCO; *Nannopterum auritum*) in the Columbia River estuary has revealed that aggregations of these colonial waterbirds can negatively impact threatened and endangered salmonid stocks native to the Columbia River (Evans et al. 2012, Adkins et al. 2014). In response to an increased presence and abundance of CATE and DCCO in the Columbia River estuary, National Oceanic and Atmospheric Administration (NOAA) Fisheries issued a Biological Opinion (BiOp) in 1999 requiring the U.S. Army Corps of Engineers (USACE or Corps) to dissuade these species from nesting on Corps-owned and managed lands in the estuary. These specific requirements of the 1999 BiOp have been reissued in every BiOp since and have led to complex management efforts to balance the impacts of avian predators on Endangered Species Act (ESA) listed salmonids while preserving the integrity of the avian populations in the Pacific Flyway (NOAA 1999, 2005, 2012). Most recently, the Corps and fellow cooperative agencies, Bonneville Power Administration (BPA) and U.S. Bureau of Reclamation (hereafter collectively referred to as the Action Agencies), included a commitment to continue implementation of avian predation management and monitoring activities from the Proposed Action of the 2020 Columbia River System (CRS) Biological Assessment submitted to NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) (BPA et al. 2020). This suite of actions included continued implementation of Corps' CATE and DCCO management plans at East Sand Island (ESI), supported by NOAA Fisheries in their associated 2020 CRS BiOp (NOAA 2020).

East Sand Island is a 62-acre island owned and managed by the Corps with restricted public access. Situated close to the former location of a natural sandy island, ESI has been greatly modified by human activities. Historically ESI was a dredge material deposition site that served as infrastructure for wartime efforts; the island is now a passively managed dredge material placement site. Placement here helps maintain the Federal Navigation Channel and ancillary navigation channels like one south of ESI that serves Chinook, Washington. The island has served several nesting piscivorous waterbird colonies over the years including CATE and DCCO. The history and evolution of ESI management for associated bird habitat is briefly provided below.

CATE - Historically, CATE occupied the Pacific-Northwest (PNW) in small, disassociated groups of 200-300 individuals (Gill et al. 1983). By the early 1980s, colonies were forming in the estuary and in 1984, a CATE colony was identified on Rice Island, a USACE dredge material deposition site approximately 21 kilometers upstream from ESI (Figure 1). By the 1990s, this colony accounted for 54% of CATE pairs in the Pacific coast breeding population, making it the largest in the world (Wires & Cuthbert 2000, Roby 2003). It is thought that birds shifting northward from inland lakes, marshes, and impoundments was a result of habitat loss elsewhere in concurrence to the creation of islands in the estuary from dredge materials (Wires & Cuthbert 2000). After a period of intense colony growth during the late 80s and 90s, managers identified the need to relocate this colony away from the area of concentrated outmigration of juvenile salmonids. The 1999 BiOp called for the Corps to relocate the Rice Island colony to the downstream site of ESI where there is increased access to estuarine and marine fishes over freshwater or anadromous salmonid species, in turn reducing salmonid consumption (Figure 1). By 2001, the CATE colony on Rice Island was successfully moved to ESI and dietary monitoring showed that the intended dietary shift had occurred (Roby et al. 2021).

Following this action, a final Environmental Impact Statement (EIS) was developed in 2005 as part of a lawsuit settlement agreement of CATE management in the Columbia River estuary. The EIS evaluated a range of alternatives to reduce the CATE population in the Columbia River estuary. The preferred alternative selected as the Caspian Tern Management Plan (Tern Management Plan) establishes criteria for desired maximum CATE colony size and breeding bird abundance in the Columbia River estuary to minimize impacts to salmonids while maintaining the integrity of the CATE breeding population across the Pacific Flyway. Chief among the Tern Management Plan's objectives is to reduce the ESI breeding colony site to one acre of habitat which would reduce the number of breeding pairs of CATE to a range of 3,125–4,375 pairs, based on their breeding density (USACE 2015a, 2015b).

The Action Agencies involved in developing the EIS were the USFWS, USACE, and NOAA Fisheries; USFWS was the lead agency for the EIS and USACE and NOAA Fisheries were cooperating agencies. Implementation of the Tern Management Plan required Records of Decision (ROD) by the USFWS and USACE, wherein the Action Agencies detailed what the intended actions are to achieve the goals and objectives of the Tern Management Plan. These RODs are now referenced, in conjunction with the 2005 EIS and any subsequent decisions evaluated in National Environmental Policy Act (NEPA) Environmental Assessments, as the guiding documents of the Tern Management Plan.

In conjunction with fulfilling these actions, the Tern Management Plan directs that once habitat objectives (i.e., the prepared one-acre colony) have been met on ESI, the responsibility for the work would transition from a short-term monitoring and research mission to a long-term monitoring and management mission based on Operations and Maintenance requirements. Once initiated, long-term management activities would operate to ensure that: 1) CATE are not breeding outside of the one-acre colony at East Sand Island, and 2) estimates of colony size are generated at least every three years to inform the USFWS for population monitoring metrics.

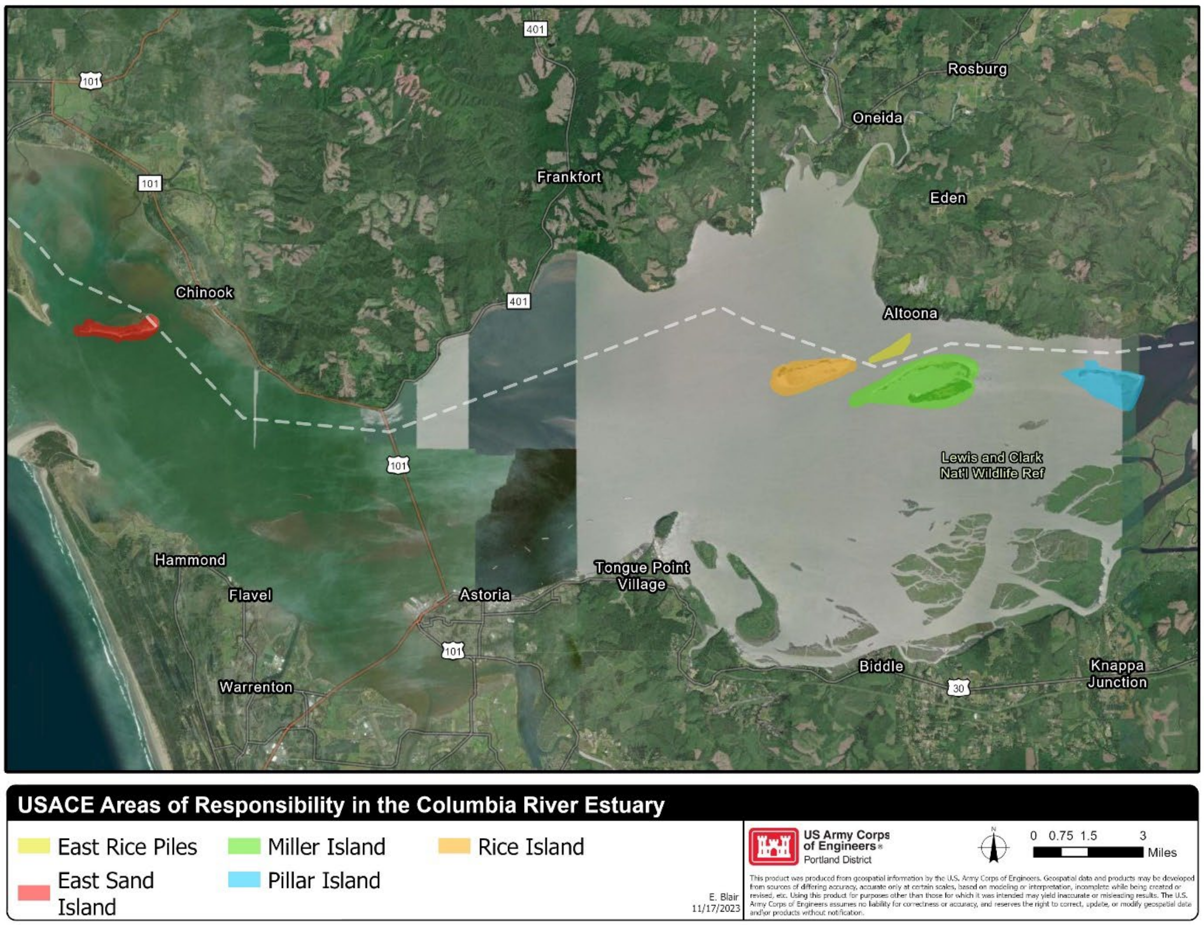

Figure 1. Dredge material islands managed by the U. S. Army Corps of Engineers in the Lower Columbia River estuary. 2023.

In 2018, the short-term monitoring objectives of the post construction habitat requirements were satisfied, and the one-acre colony was successfully established on ESI. From here, management of the ESI CATE colony was transitioned to the Operations Division of the USACE Portland District and in January 2019, the Fisheries Field Unit (FFU), a unit within the Portland District's Operations Division, began implementing the long-term monitoring of CATE on ESI. Since the change of management, FFU personnel have been on island each season, following long-term management protocols while monitoring and collecting data on ESI, both on-and off- colony.

Since the Corps assumed monitoring of the ESI colony, several factors have been observed that impact the success of the colony. The presence of avian predators such as Bald Eagles (BAEA; *Haliaeetus leucocephalus*), Pacific gull species (*Larus spp*.), and North American river otter (*Lontra canadensis*) on ESI have been known to fluctuate throughout the years but have documented impacts to CATE colony success. Since the ban of DDT in 1972, BAEA populations have rebounded; the return of this top predator has been associated with the decline of nesting success at some seabird colonies due to their ability to exploit a variety of prey using diverse foraging techniques (Collar 2013). BAEA also pose an indirect negative effect on nesting success by permitting smaller nest predators, such as gulls, to depredate the nest contents of CATE when they flush from their nest as a response to BAEA flying overhead. Roby et al. (1998) reported that disturbance by BAEA resulted in a high rates of egg predation by Pacific gulls in a CATE colony. This associative relationship between BAEA and gulls has led to the collapse of other seabird colonies and studies have identified a correlation between nest failure and intense BAEA activity (Collar 2013). Although not a common occurrence, predation by river otter on adult colonial water birds, such as Glaucous-winged Gulls (GWGU; *Larus glaucescens)*, Aleutian Terns (*Onychoprion aleuticus*), and Common Terns (*Sterna hirundo*), has been previously documented. Multiple studies identified that predation included both adult take as well as nest depredation that can also sequentially lead to colony flushes (Duffey 1995, Butler 1977, and Verbeek & Morgan 1978). Repeated colony flushes from predators like BAEA and otters could lead to colony abandonment (Roby et al. 1998). Another outside influence on the CATE colony is the positive relationship between Ring-billed Gulls (RBGU*: Larus delawarensis*) and CATE. Numbers of CATE will nest amidst a large colony of RBGU as these gulls rarely prey on CATE chicks nor are they highly kleptoparasitic to CATE (Roby 1998). CATE have been documented nesting in RBGU colonies at inland sites along the Columbia River dating back to 1997 (Roby et al. 1998). Increased numbers of RBGU in the Columbia River estuary have the potential to influence the nesting behavior of CATE in the estuary.

DCCO - While historical records of breeding DCCO in the Lower Columbia River (LCR) basin are scant, breeding colonies were formally recorded on ESI and on Rice Island in 1988 (Carter et al. 1995). Nesting colonies of DCCO formed upriver on Miller Sands and on the mid-river navigation aids; however, these colonies remained small, whereas the ESI colony has increased ~2% per year from 1990 to 2009 until it reached 15,000 breeding pairs in 2013, making it the largest known DCCO colony on the Pacific Coast of North America (Anderson et al. 2004, USACE 2015c). Dietary studies indicated that DCCO on Rice Island and ESI were consuming large quantities of out-migrating juvenile salmonids found in the Columbia River system, many being ESA-protected species or stocks (Roby et al. 2021). Although total consumption varies each year depending on an array of outside factors including El Niño Southern Oscillation and other climate events, DCCO in the Columbia River estuary have been known to eat around 11 million juvenile salmonids annually (NOAA 2014). The typical foraging range of DCCO is approximately 15 miles, meaning the diet of DCCO on ESI differs from those upriver since they have increased access to marine forage fish further out in the estuary and will rely less on out-migrating salmonids (USACE 2015c). DCCO on Rice Island consumed two to three times more juvenile salmonids per capita compared to DCCO on ESI (Collis et al. 2000). The average annual predation by DCCO on ESI was estimated to be 10.9 million juvenile salmonids between 1998–2013, with a high of 20.9 million smolt in 2011. This figure represents, an average of 10% of all smolt outmigration in the Columbia River (Roby & Collis 2021). Steelhead (*Onocorhynchus mykiss*) are the most susceptible to cormorants and an analysis by NOAA (2014) predicts that 6.7% of juvenile steelhead mortality is from DCCO predation. Consumption is highest in early May, which typically coincides with the peak nesting season.

In response to the impact that DCCO were having on ESA-listed salmonids in the LCR, the Corps adopted a plan to reduce predation on juvenile salmonids in the Columbia River estuary (hereafter referred to as the "Cormorant Management Plan"; USACE 2015c). The Corps acted as the lead agency but worked in conjunction with USFWS, U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) – Wildlife Services, ODFW, and WDFW as cooperating agencies to develop the Final EIS and Cormorant Management Plan.

The Cormorant Management Plan calls for a reduction to no more than 5,380–5,939 breeding pairs of DCCO on ESI. The breeding pair objective was set based on "base period" levels of DCCO from the years 1983 – 2002, which would restore juvenile steelhead survival to the environmental baseline or "base period" levels. The objective was drafted to specifically impact juvenile steelhead survival since they are the most affected. The plan was implemented in two phases. Phase one involved lethal take of adult DCCO and their nests over a four-year period. Phase one, initiated in 2015 and ending in 2017, called for authorized total take of 18,185 adult DCCO in addition to hazing and limited egg take at dredge material islands within 25 km of the ESI colony, however, the USDA Wildlife Services reported culling 5,576 adult DCOO and oiling 6,181 nests on ESI. Phase two was implemented according to the adaptive management framework from 2018 with habitat modification restricting available habitat to 1.7-acres by allowing tidal inundation of the historical breeding area and was completed in 2020 (USACE 2015c). Under the Cormorant Management Plan, the Corps is responsible for monitoring and reporting DCCO abundance and breeding attempts on ESI, and if necessary, dissuading DCCO to maintain breeding pair management objectives through continued hazing. Monitoring activity may fluctuate depending on information need but aligns with the Pacific Flyway Monitoring Strategy that calls for the minimum of monitoring and reporting selected sites every three years.

Outside of management actions, other factors have been observed at ESI that impact the success of the ESI DCCO colony. The presence of avian predators, such as BAEA, Western Gull (WEGU; *Larus occidentalis*), and Western x Glaucus-winged hybrid gulls (WGWH; *Larus occidentalis x L. glaucescens*), have known impacts on nesting DCCO. Turecek et al. (2019) reported an associative interaction between BAEA disturbance and gull egg depredation on ESI, suggesting that DCCO flushes in response to the presence or approach of BAEA may have facilitated predation by gulls on nest contents during the periods of disturbance. Previous studies suggest that disturbance periods over 15 minutes a day, or more than just two disturbance events a day is enough to delay or prevent cormorant nesting (BRNW 2013). The ESI colony could also be impacted by the DCCO colony on the Astoria-Megler Bridge; a previous study has shown existing connectivity between the ESI and bridge colonies as DCCO that were banded on ESI were observed nesting on the bridge in both 2017 and 2018 (Turecek et al. 2019).

METHODS

Avian abundance and occupancy monitoring follows pre-established protocols for ESI piscivorous bird monitoring (Roby et al. 2021). Consistent with existing management plans, objectives include: 1) maintain the East Sand Island CATE colony at one-acre to support the expected population of 3,125 –4,375 breeding pairs, 2) prevent the formation of CATE satellite colonies, and 3) monitor the abundance of Double-crested Cormorant (*Nannopterum auritum*) to ensure the maximum target population of 5,380–5,939 breeding pairs is not exceeded. To do so, the Corps conducted the following:

Biologists collected estimates of avian abundance on CATE and DCCO by boat and land-based observations using 8x42 binoculars. Spatial data were collected using mobile devices equipped with the ArcGIS Field Maps Application which allowed Corps biologists to document points, lines and polygons on scrapes, eggs, and management actions while in the field. All Corps biologists were trained as avian observers and count techniques were calibrated between observers through field practice and online resources such as the USFWS Estimating Flock Size Training and Testing Resources (Bowman 2015).

CATE – To ensure that the one-acre CATE colony met the requirements stipulated in the Tern Management Plan, the Corps undertook basic maintenance of the colony prior to the arrival of birds each season. Maintenance began with repairs to the t-posts and silt fencing that define the perimeter of the one-acre colony. One acre of bare sand was ensured by mechanically and chemically addressing the weed growth which has, in previous years, prohibited CATE from making full use of the one-acre colony. In recent years, weed growth was concentrated around the edge of the perimeter fencing and most developed on the southern edge of the colony. A disk harrow mounted on an ATV, supplemented with hand-removal, was employed to remove weeds mechanically. Chemical abatement was accomplished in the spring through the application of Imazapyr granules from an herbicide spreader and direct application of Glyphosate to individual plants as needed. Chemical weed abatement was conducted by a certified herbicide applicator.

Installation and maintenance of passive dissuasion materials outside of the colony followed the methods outlined by Harper (2018), with reinstallation of dissuasion flagging arrays south and west of the colony. Passive dissuasion flagging was composed of twisted polypropylene rope strung between 1.5-meter u-channel posts (or similar t-posts) in a three-meter by three-meter grid. Yellow strips of plastic dissuasion flagging made from industrial caution tape approximately 90 centimeters long were spaced approximately one meter apart and strung through the poly rope with enough slack to flutter in the wind. These grid arrays were established throughout areas of open ground outside of the appropriated one-acre colony that were historically used by CATE as nesting sites (Figure 2).

Corps biologists performed visual encounter surveys systematically, beginning with offshore enumeration from a Corps' research vessel. Corps biologists approached ESI slowly, opportunistically sampling CATE from the eastern tip of the island to the southwestern end of the dissuasion flagging. Sampling then continued in a counterclockwise manner, around the eastern tip of the island to the anchor point on the northeast side end of the island, taking care not to double count flocks of CATE previously enumerated. Land based surveys took place on the island along the south and east beaches and from two stilt blinds located on the northern edge of the colony. From the blind's elevated vantage point, Corps biologists enumerated CATE and CATE eggs on colony, and documented colony flushes and the presence of avian predators such as BAEA. Preliminary abundance was recorded from observer estimates of the colony as seen from the blind and observer estimates of birds seen off-colony along the south and east beaches. During land-based surveys, Corps biologists took caution to not disturb the colony by utilizing covered tunnels to travel around the colony and by maintaining a low sound-profile in and around the blinds.

Figure 2. Photo of the dissuasion flagging implemented south of the Caspian Tern colony in historical nesting areas on East Sand Island. Photo by Noah Strong 2023.

In conjunction with monitoring the colony, Corps biologists searched for and dissuaded nesting attempts off-colony. Nest detection transects were conducted on foot, between the wrack line and the dissuasion flagging on the south beach (Figure 3). While performing nest detection transects, Corps biologists maintained a safe operating distance from the perimeter of the colony and walked or crawled slowly to avoid disturbing the colony. Scrape enumeration was performed in a uni-directional pattern to minimize double counting of scrapes and eggs. When a CATE scrape was identified, it was assessed for the presence of an egg. If no egg was present, the scrape was recorded on Field Maps and filled in with sand to dissuade future nesting attempts and to enable accurate scrape enumeration. If an egg was observed, Corps biologists recorded information on the nest location and contents from a distance equal to or greater than 4.5 meters and continue with the sampling transect, leaving the nest undisturbed (per recommendation by personal communication with USFWS). Additional opportunisitic monitoring was implemented this season when Corps biologists deployed a game camera on the south beach to observe potential predator activity.

Figure 3. Map of Caspian Tern colony and the associated dissuasion flagging on East Sand Island.

In addition to land- and boat-based visual surveys, productivity plots were used to allow formal abundance enumeration. The productivity plots were six-meter by six-meter plots arranged in pairs, evenly spaced around the colony, and made by rope and rebar stakes. The Corps coordinated semi-regular flights over the island with the Civil Air Patrol (CAP) to provide aerial photographs of the birds to aid in breeding pair estimates enumeration. Corps biologists conducted visual observation from the blinds simultaneously with the CAP flights overhead to monitor CATE nest attendance on the colony productivity plots. Productivity plot enumeration was performed five times for each CAP flight, beginning 30 minutes before the CAP flight passes over head, with intervals spaced fifteen minutes apart. At each interval, Corps biologists recorded the number of birds attending versus not-attending an active nest/scrape in a paired plot, keeping the counts separate (each paired plot is numbered, and "Plot A" and "Plot B" refer to the plots in that pair). Birds on colony in each photo from these flights were then individually enumerated and validated by separate Corps biologists. Using these numbers in conjunction with the average ratio of attending versus not-attending birds recorded in all the productivity plots during each interval, total CATE abundance in the colony and the total estimate of CATE breeding pairs was calculated (i.e., number of individuals * average ratio of attending birds = number of breeding pairs). Typically, four to six CAP flights are scheduled throughout the season, one of them aligning with the estimated colony peak for the season. This year, productivity plot enumeration was only conducted for two out of four flights due to lack of colony presence.

Predation by piscivorous birds was assessed using Passive Integrated Transponders (PIT) tag technologies. Upriver, PIT tags are implanted into smolt by the Project fisheries team and management partners. When tagged smolt travel downstream, some of the smolt fall prey to CATE on ESI. To facilitate analysis, Corps biologists placed control tags on the colonies prior to bird arrival and post bird dispersal to determine detection efficiency of PIT tag collection. The percentage of pre- and post-sown PIT tags that are recovered at the end of the season are compared against those recovered from the bird dietary remains, enabling biologists to assess annual predation rates of smolt consumed by CATE on ESI. To detect tags, Corps biologists used an ATV equipped with a tag reader master controller attached to a PIT array with an eight-coil flat plate antenna, followed by a shallow harrow and large tow-behind sweep magnet that then recover the tags (Figure 4). Recovered tags were then rescanned by hand for redundancy, ensuring that every tag had been recorded. Recorded PIT tag data were shared with a contractor who conducted analysis and calculated predation impacts. Data were also uploaded to the PIT Tag Information System (PTAGIS), where regional partners have access to the data for further analysis.

Figure 4. A photo displaying PIT tag recovery equipment installed on an ATV and in-use at the East Sand Island Caspian Tern colony. Photo by Noah Strong 2023.

DCCO – During colony preparation, Corps biologists surveyed the available habitat at the western end of ESI to ensure habitat availability for DCCO nesting. Abundance of DCCO was documented during visits to ESI by Corps biologists following the same protocol as was utilized to enumerate off-colony CATE. Corps biologists performed visual encounter surveys, while approaching ESI slowly by boat, opportunistically sampling DCCO from the eastern tip of the island to the southwestern end of dissuasion flagging. Corps biologists then sampled systematically, in a clockwise manner, around the western tip of the island to the northeastern end of the island in a full circumnavigation. DCCO utilizing exposed pilings as roost sites between the survey vessel and the shoreline were enumerated. Flying DCCO and those in the water were not enumerated. As DCCO are sensitive to disturbance, care was taken to prevent flushing DCCO flocks when conducting counts by navigating the vessel slowly, maintaining distance, and limiting noise level.

Abundance estimates were supplemented by enumeration of birds in aerial photographs taken during CAP flights. Birds in each photo from these flights were individually enumerated and validated by separate Corps biologists. Analysis of photographs taken during CAP flights also provided assurance that DCCO nesting activity on ESI was restricted to the 1.7-acre area defined and managed for breeding (Figure 5). Breeding success for DCCO was calculated from CAP flight data by counting the number of DCCO nests in photographs captured near the maximum seasonal occupancy.

Figure 5. Estimation of the current nesting area being utilized by Double-crested Cormorant (DCCO) colony on East Sand Island.

During the pre-season colony site inspection, Corps biologists sowed control PIT tags, like those sown in the one-acre CATE colony. The percentage of pre- and post-sown PIT tags that were recovered at the end of the season are estimated against those recovered from the bird dietary remains, enabling biologists to assess annual predation rates of smolt consumed by DCCO on ESI. To detect tags, Corps biologists used handheld tag readers and antennas in lieu of the ATV PIT recovery set-up, as much of the DCCO nesting area is in the riprap, which is only conducive to tag reading efforts, not collection. Corps biologists passed over the colony twice to ensure all tags have been read. Recorded PIT tag data were shared with a contractor who conducted predation analysis of the data. Data were also uploaded to the PIT Tag Information System (PTAGIS), where regional partners have access to the data for further analysis.

RESULTS

CATE – ESI colony preparation, maintenance and monitoring began on 7 March and concluded 233 days later, with breakdown of the colony and full demobilization completed on 26 October. During this time, ESI was visited and monitoring data was collected on 32 days by Corps biologists. Installation of passive dissuasion measures began on 7 March with the deployment of the dissuasion flagging array and concluded on 20 September when the last of the dissuasion flagging was removed. Corps biologists deployed 0.48 acres of dissuasion flagging to the south of the CATE colony above the wrack line in areas historically utilized by nesting CATE. CAP flights occurred on 1 June, 15 June, 12 July, and 1 August, and were paired with visual observations of nest attendance for breeding pairs on 1 June and 15 June. Reported estimates of bird abundance across the season is based on visual (land- and boat-based) estimates. We report peak colony attendance by breeding pair with CAP flight data collected during the peak abundance times as informed by visual estimate data.

The first CATE at ESI was documented 13 April and the last CATE on colony was observed on 30 August (Table 1). The estimate of peak colony abundance was difficult to capture this year due to a partial colony abandonment event that occurred just prior to the historic and concurrent breeding period. Since management uses the number of breeding pair as the objective unit of measure and the breeding pair is estimated by measuring active nest attendance on colony, Corps biologists elected to split the reporting period into two sections, pre-breeding and active-breeding period, to give a more representative reflection of true colony activity during the reproductive period. Partial colony abandonment occurred on 25 May. Prior to that, little breeding activity had been recorded. Of the 15 observation days on ESI prior to abandonment, very few copulation attempts had been noted and only one CATE egg had been observed on- or off-colony. CATE returned to the colony by 7 June (i.e., $n > 1000$ individuals) and were observed actively scraping, copulating, and depositing eggs at that time. Thus, for reporting purposes we define the pre-breeding period as 13 April – 25 May and the active-breeding period as 26 May – 30 August.

During the pre-breeding period, the colony increased to a maximum of 2,000 CATE individuals, counted on 17 May (Table 1, Figure 6) and averaged 403.2 ± SD 670.1 CATE per sample day (Table 2). Counts of total CATE on ESI (on- and off-colony) averaged 613.4 ± SD 962.4 per sample day, with the maxima of 2,850 individuals also observed on 17 May (Figure 7).

During the active breeding period, the colony increased to a maximum of 1,300 CATE individuals on 15 June (Table 1, Figure 6) and had a daily average of 459.0 ± SD 457.4 individuals per sample day (Table 3). Counts of total CATE on ESI (on- and off-colony) during this period averaged 551.6 ± SD 585.4 individuals (Figure 7).

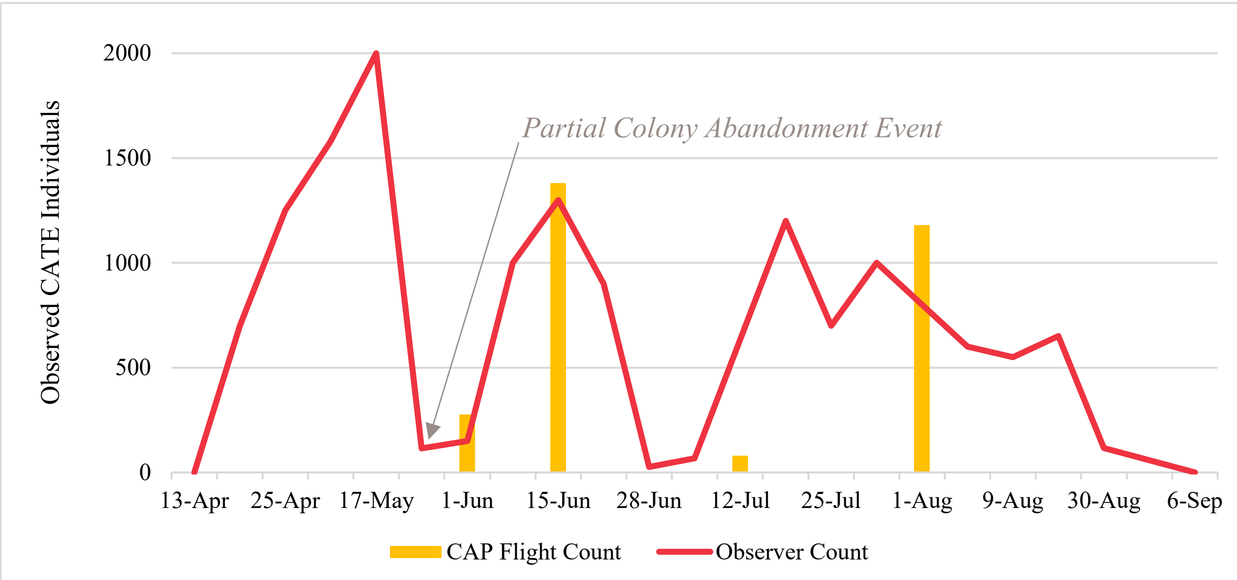

Figure 6. Caspian Tern (CATE) individual abundance on colony at East Sand Island (ESI) over time, in comparison with CAP flight imagery colony enumeration, using the adjusted monitoring period for analysis.

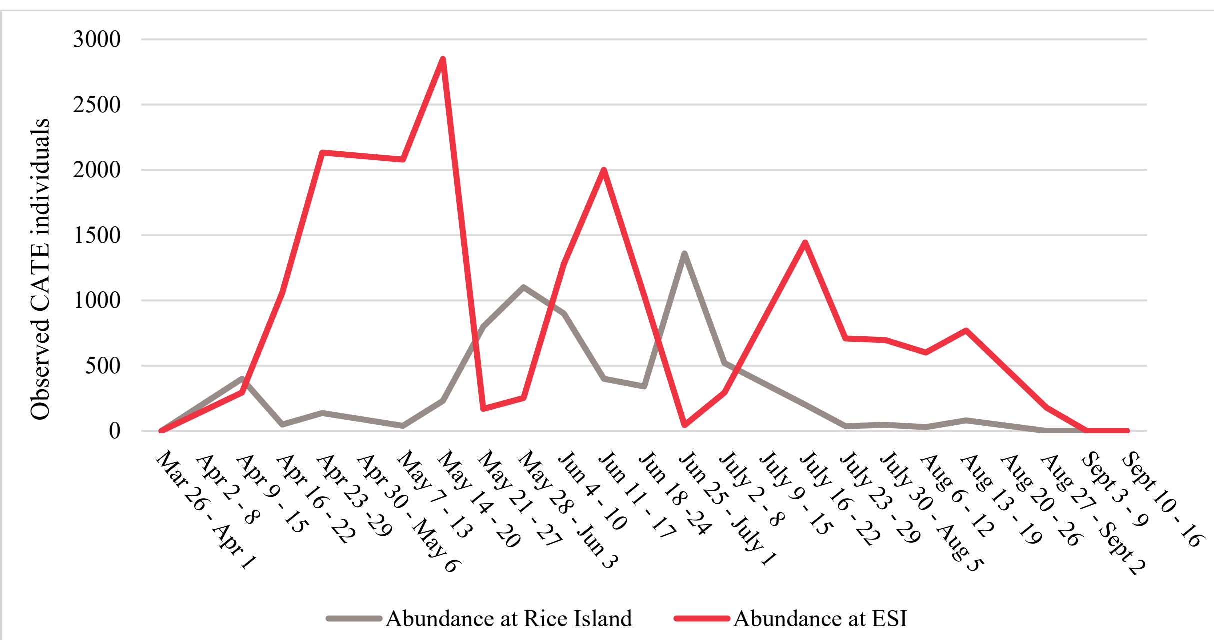

Figure 7. The weekly peak abundance of Caspian Terns (CATE) both on- and off-colony at East Sand Island (ESI) compared to peak weekly abundance of CATE at Rice Island.

The CAP flight photos reviewed for peak breeding pair were those on 1 June and 15 June which corresponds to the visual estimates of peak CATE abundance on ESI reported above (Table 4, Figure 6). On 1 June, Corps biologists reported an average of 103 breeding pairs, based on average colony observer counts of 280.5 ± SD 4.5 individuals and the average percent attending in the productivity plots of 0.37 attendance ratio. On 15 June, an average of 524 breeding pairs (1352 ± SD 52 individuals, 0.39 attendance ratio) was calculated. The second CAP flight captured the colony peak during the breeding period for both visual and CAP based CATE abundance, thus the peak number of breeding pair on ESI being reported this year is 524 pair.

Corps biologists observed two total eggs in the colony throughout the nesting season; the first egg was documented on 10 May, the second was documented on 27 July. Additional broken and consumed eggs were observed, however, these eggs could not be totaled as many were consumed by gulls immediately after colony flushes before enumeration was possible. No known CATE eggs hatched.

Off-colony nest detection transects were performed on 9 days between 10 May and 19 September. During these surveys Corps biologists enumerated 20 scrapes on the south shore between 10 May and 19 September. Nest detection transects found zero eggs off-colony. All documented scrapes were from two survey dates, 10 May and 17 May, and the creation of new scrapes off-colony immediately ceased following the colony abandonment event (Table 1). All scrapes enumerated outside of the colony were recorded south of the colony between the dissuasion flagging and the wrack line.

Observations of predators as well as colony flushes were documented throughout the nesting season. Out of the 19 days that predators were documented, the dominant predator observed was BAEA with a peak abundance recorded on 22 June with 22 BAEA (Figures 8 & 9). The average abundance of BAEA throughout the season was 2.7 ± 4.3 individuals. An average of 34.9 ± SD 16.5 WGWH gulls per day was calculated within the colony perimeter. One river otter was observed near the colony by Corps biologists on 25 May, coinciding with the first day Corps biologists observed depredated eggs on colony and the timing of the partial colony abandonment event. River otters were documented by the game camera situated near the colony on seven additional days (Figure 8). Corps biologists recorded as many as five colony flushes (i.e., occurrences when all [or most] birds at the colony flew simultaneously from their nests) occurring during a two-hour period (Figure 9). The total number of colony flushes observed throughout the nesting season was 29 with an average of 1.5 ± SD 1.7 flushes per observational period.

Corps biologists scanned 111,163 unique PIT tags during post-season CATE colony demobilization on 3-6 October. Of these, 3,239 were 2023 migration year fish directly attributed to CATE predation, the balance of the tags were remnant previous migration year PIT tags. Of the 2023 migration year tags detected, 2,301 were steelhead, 25 were sockeye, 115 were coho, and 786 were chinook; complete data is available on PTAGIS or in the Real Time Research 2024 Final Annual Report (Evans et al., 2024).

Figure 8. Photos of predators captured on game camera. (Left to right) 1) Bald eagle captured on camera by the Caspian Tern colony at East Sand Island on 11 July 2023. 2) River otter captured on camera by the Caspian Tern colony at East Sand Island on 29 June 2023. Photos by Erin Blair.

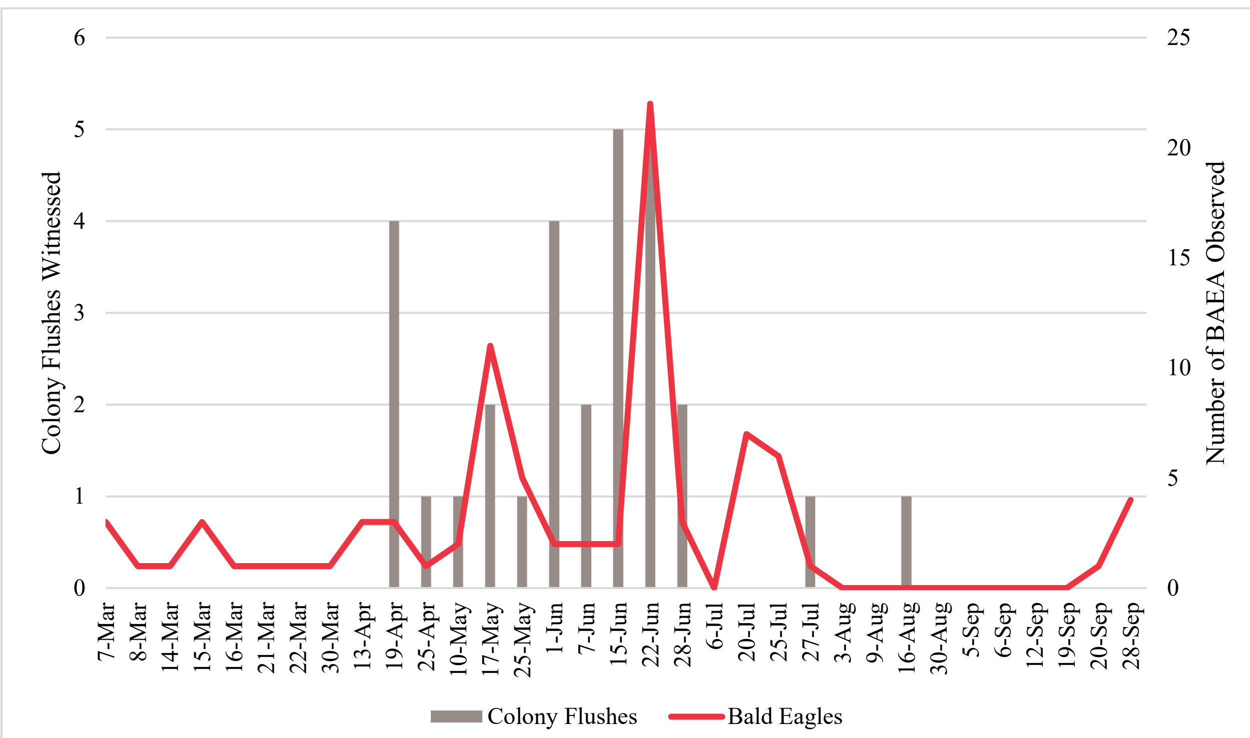

Figure 9. The number of colony flushes Corps biologists witnessed compared to the number of Bald Eagles (BAEA) observed in relation to the East Sand Island (ESI) Caspian Tern colony.

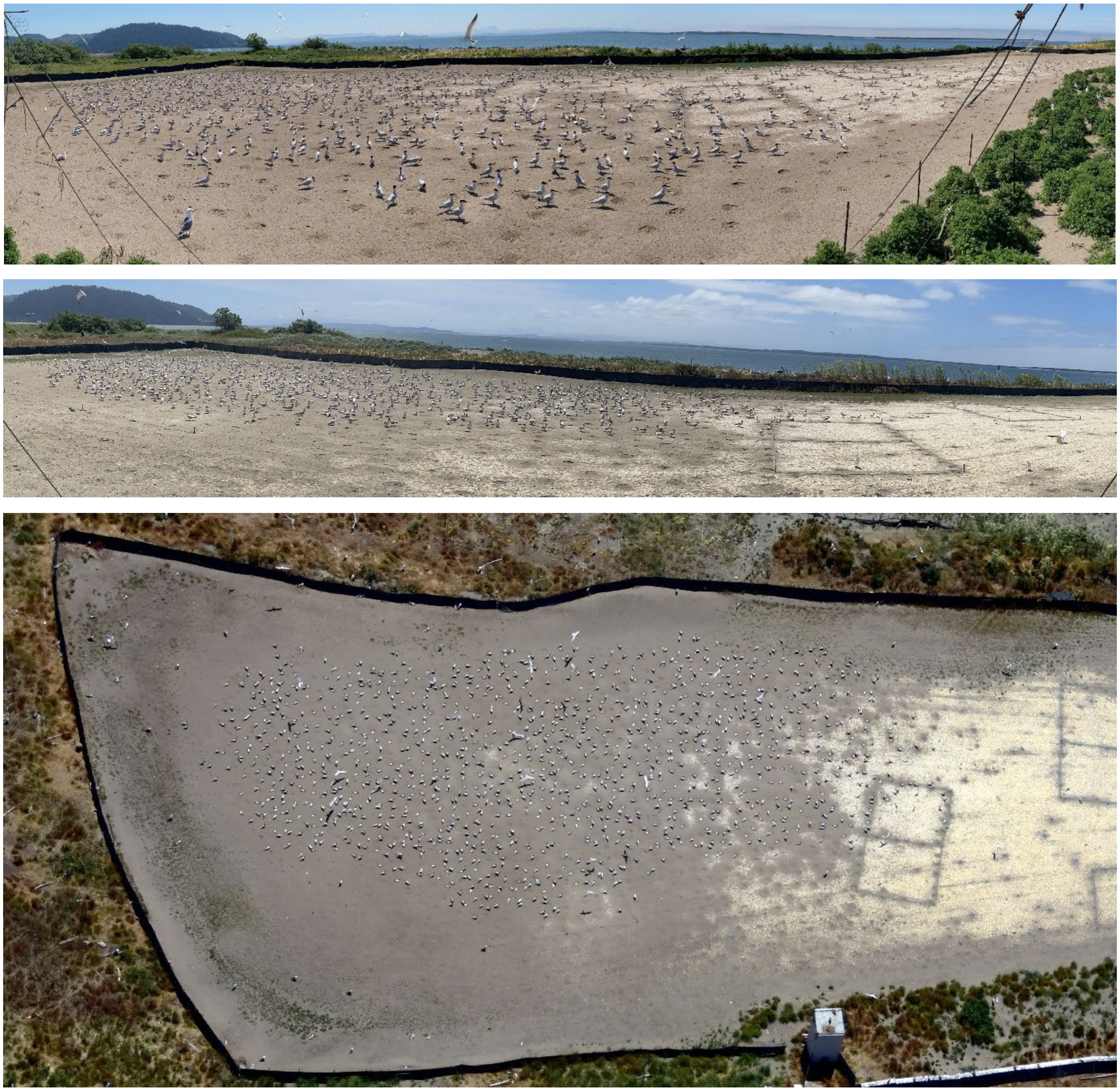

Figure 10. Colony photos of the Caspian Terns (CATE) at East Sand Island (ESI). (Top to bottom) 1) Panoramic photo of CATE colony at ESI near peak abundance, pre-colony abandonment event, 17 May 2023. Photo by Marcus Roberts. 2) Panoramic photo of CATE colony at ESI at or near peak abundance, post-colony abandonment event, 15 June 2023. Photo by Noah Strong. 3) Maximum colony abundance observed from CAP flight imagery, 15 June 2023. Photo by 1st Lt. Jonathan Ritchie.

DCCO – Monitoring of DCCO began on 7 March and concluded 233 days later with full demobilization completed on 26 October. During this time, ESI was visited and monitoring data was collected on 32 days by Corps biologists. Corps biologists conducted seven circumnavigation trips around

ESI throughout the season; the first complete circumnavigation was performed 17 May and the last circumnavigation survey was completed 19 September. CAP flights occurred on 1 June, 15 June, 12 July, and 1 August and number of nests on colony was analyzed using the flight on 1 August. Reported estimates of DCCO abundance across the season is based on visual (land- and boat-based) estimates. We report peak colony attendance by nest counts with CAP flight data collected during the peak abundance times as informed by visual estimate data.

DCCO were first observed on ESI by Corps biologists on 13 April and last observed on 28 September (Table 6). During the monitoring period, DCCO reached a maximum of 3,100 DCCO individuals on island on 19 September, 97 days later than the estimated maximum seasonal occupancy in 2022 (Figure 11). Corps biologists calculated a daily average of 350.8 ± SD 779.6 total DCCO individuals (on- and off-colony) per sample day.

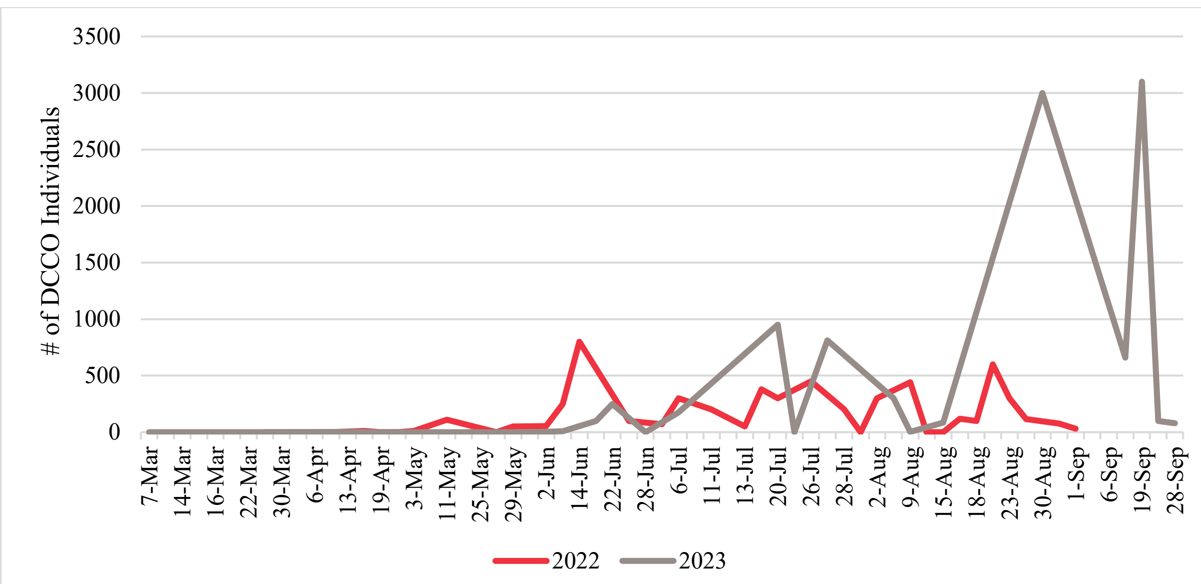

Figure 11. A comparison of the individual abundance of Double Crested Cormorant (DCCO) on East Sand Island between the 2022 and 2023 breeding seasons, based on observer estimates.

During all four CAP flights, DCCO were seen nesting in the 1.7-acres of nesting habitat located on the riprap at the far west end of ESI (Figure 12). No nests were documented anywhere on ESI beyond those enumerated on the DCCO colony. The CAP flight photos reviewed for peak nest counts were those on 1 August which corresponds to the visual estimates of peak DCCO abundance on ESI reported above.

From this flight, Corps biologists enumerated 241 DCCO nests within the colony footprint but activity and nest success from these nests could not be determined (Table 6).

Figure 12. Fledgling Double-crested Cormorants seen within the 1.7-acre colony in the riprap on 28 September 2023. Photo by Erin Blair.

Observations of predators were documented throughout the nesting season. Out of the 19 days that predators were documented, the dominant predator observed was BAEA with a peak abundance recorded on 22 June with 22 BAEA (Figures 13 & 14). The average abundance of BAEA throughout the season was 2.72 ± SD 4.32 individuals.

Corps biologists scanned 306 unique individual PIT tags during post-season colony demobilization on 25-26 October. Of these, 48 were 2023 migration year fish consumed by DCCO. Of those tags, two were steelhead, one was coho, and 45 were chinook; complete data is available on PTAGIS or in the Real Time Research 2024 Final Annual Report (Evans et al., 2024).

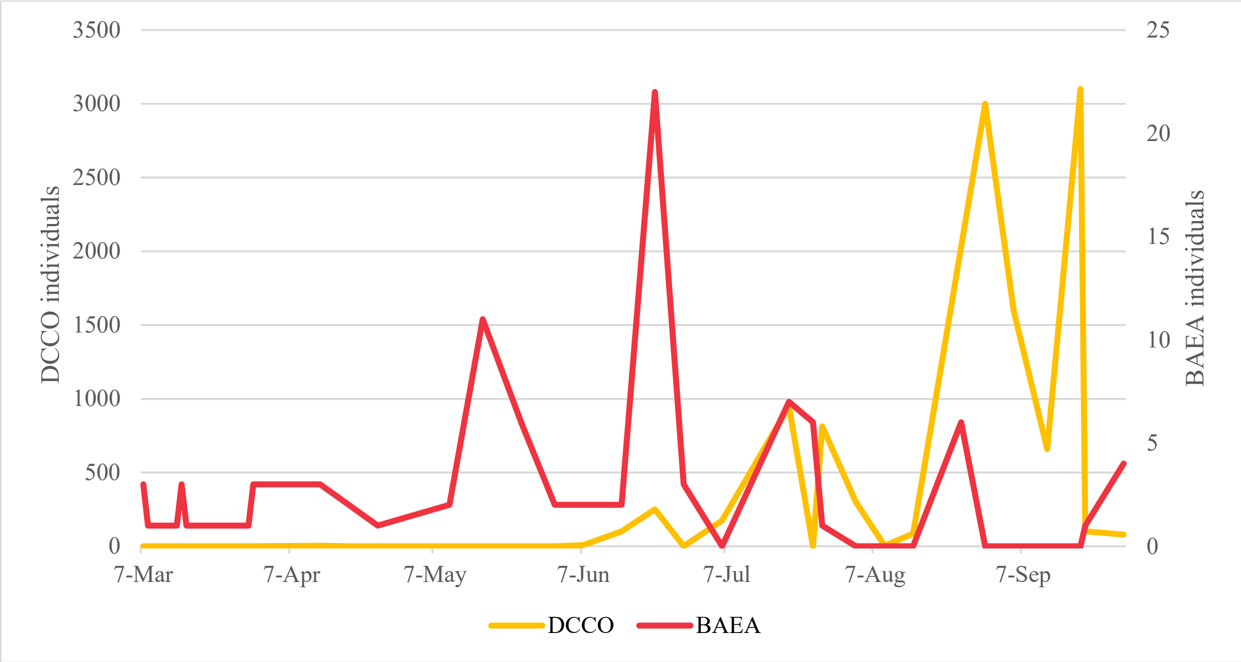

Figure 13. The individual abundance of Bald Eagles (BAEA) and Double-crested Cormorants (DCCO) on East Sand Island (ESI), based on observer estimates from 2023.

Figure 14. Two juvenile Bald Eagles captured on a game camera erected on the south beach of East Sand Island, captured 30 June 2023, prior to arrival of most Double-crested Cormorants. Photo by Erin Blair.

DISCUSSION

The Corps met the objectives established by the guiding documents and maintained compliance with both CATE and DCCO management plans. The abundance of both CATE and DCCO were below the maximum management objectives. Below we discuss the seasonal result of each species monitoring efforts respectively, but first we broadly discuss salient observations from this season that impacted both species monitoring efforts.

Based on the PIT data recovered and consistent with historical analysis, fewer salmonids were consumed by DCCO and CATE at ESI than at upriver sites like Rice Island. Roby et al. (2017) estimated that CATE consumption of smolts at ESI is 59% less than that at Rice Island and DCCO consumption rates are also documented to decrease further downstream in the estuary (NOAA 2020). Based on this year's recovered tags, there were 63% less salmonids consumed on ESI than at Rice Island.

Highly Pathogenic Avian Influenza (HPAI) was widespread in the Pacific Northwest this season and impacted colonial piscivorous waterbirds. The disease has been circulating in North American wild avian species since December 2021 with detections in Oregon waterfowl first documented in May 2022 (ODFW & Quillian 2023). The current H5N1 strain has caused increased mortality for waterfowl and wildlife managers have been monitoring it closely. Corps biologists were able to confirm positive cases of HPAI in CATE from mortalities recovered on Rice Island, upstream in the estuary, on 15 June. Corps biologists collected samples of CATE mortalities and delivered them to ODFW for testing; ODFW confirmed the birds were infected with HPAI. Although testing confirmation for birds on ESI was not conducted, Corps biologists observed many of the same symptoms and an increased number of mortalities in CATE and DCCO on ESI.

Discrepancy between observer counts and CAP flight counts for population abundance can be explained by several factors. The high BAEA activity on ESI would often cause colony flushes while biologists were actively counting, leading the final counts to be lower than what might have been observed in CAP flight imagery. Additionally, human error must always be taken into consideration when using visual observer counts, although this was mitigated for by calibrating observers' counts. We affirm that the observer-based counts have value as they economically capture day to day trends in a greater variability of weather, but CAP flight imagery is vital to accurately estimating peak colony abundance.

CATE - CATE nesting on ESI were restricted to the one-acre colony location and the peak estimate of 524 breeding pairs remained below the 3,125–4,375 breeding pair maximum in the Tern Management Plan. All CATE nesting activity outside of the colony boundaries on ESI was closely monitored and nesting efforts by CATE outside the one-acre colony were successfully dissuaded with the passive dissuasion flagging erected pre-colony arrival. While scraping outside of the one-acre colony did occur, there were no eggs or successful nests detected. This change from last year's observations is noteworthy, as off-colony activity has not been this low since the Corps assumed management of the 1-acre colony. This year we documented 21% fewer scrapes off-colony than in 2022 and a complete reduction of eggs.

Abundance of CATE on ESI may have been depressed by the formation of an incipient CATE and RBGU colony on Rice Island, a site upriver from ESI (Figure 1). Corps biologists confirmed the formation of this colony on 10 April and documentation from CAP flight photos confirmed there were no other incipient colonies elsewhere, including historically used sites like Willapa Bay. Corps biologists responded to the incipient colony by enacting an intensive dissuasion period lasting from 24 April through 15 June (See Roberts et al., 2024). CATE numbers on ESI initially rose in the wake of the dissuasion efforts that took place on Rice but fluctuated throughout the season at both sites (Figure 7). Dissuasion measures on Rice were not as effective as they have been in past years, possibly due to the formation of a RGBU colony that the CATE co-inhabited. The association between CATE and RGBU may have permitted additional protection for CATE from predators, active dissuasion, and egg take as the RBGU are less reactive and maintained their colony despite outside pressures (Figure 14).

Another factor that could have contributed to the ongoing partial CATE colony abandonment on ESI was the increased pressures of predation. Consistent with observations made in 2022, BAEA were a large source of disturbance near the colony. The peak abundance of BAEA on ESI more than doubled since 2022 (i.e., FY22 had 10 BAEA; FY23 had 22 BAEA). Corps biologists consistently observed BAEA activity result in partial- and total-colony flushes of nesting CATE from the colony. During many of these events, Corps biologists observed CATE eggs left exposed when the adult CATE flushed, only to be immediately depredated by WGWH gulls. These gulls typify the pattern of sit and wait egg specialists called "droolers" by Roby et al. (1998).

Another predator observed several times by Corps biologists was American river otters. Investigation of otter distribution on the island found many caches of CATE mortalities surrounded by otter sign (slides, tracks, etc.) in the vegetation surrounding the CATE colony (Figure 15). Two otters were documented several times by a camera trap situated near the CATE colony. In his 1995 paper, Duffey suggests that otters can be opportunistic killers; there is a possibility that the CATE colony was weakened by HPAI, giving the otters an increased opportunity at predation. However, there is no evidence confirming actual CATE take by otters; caches of carcasses could be collections of mortalities that had already succumbed to HPAI, other predators, or other pressures. A more common occurrence is the observation of otters feeding on eggs, which has been documented at night (Arnold et al. 2022). Repeated colony flushes overnight from otters feeding on eggs could have been an increased pressure that influenced the CATE abandonment of the ESI colony.

Figure 15. Photos documenting river otter activity on East Sand Island (ESI). 1) Otter tracks observed approaching and leaving the area surrounding the Caspian Tern (CATE) colony on ESI. 2) Otter slides observed on the beach south of the CATE colony on ESI. Photos by Erin Blair, 2023.

In previous years the CATE colony suffered from heavy vegetative growth around the perimeter, especially to the south and east edges. This issue was addressed by the Corps during the 2022 season by employing chemical and mechanical removal. These management actions proved beneficial as a less intensive treatment was needed this season. Future vegetation control efforts including herbicide application and mechanical removal will be required to maintain the one-acre colony.

Substantially less dissuasion flagging was erected compared to previous years; the flagging footprint only represented about 22% of the area flagged in 2020. This reduction in passive dissuasion was largely due to rapid secondary succession of Himalayan blackberry (*Rubus spp*.), Scotch broom *(Cytisus scoparius*), and European beach grass (*Ammophilia spp*.) on the south facing back shore between the colony and the wrack line. The dense overgrowth of these grass and woody shrubs has rendered that area inhospitable to nesting by CATE. Ongoing coastal erosion has also reduced backshore nesting habitat, as the south shore beaches of ESI are substantially reduced since 2022.

DCCO – All DCCO nesting on ESI were restricted to the 1.7-acre colony location. The peak estimate of 241 nests reflect that the colony is below the maximum of 5,380 – 5,939 breeding pair management objective, and lower than last year's estimate of 1,158 nests. However, the peak abundance estimate of 3,100 individuals is higher than the previous season's peak enumeration of 2,317 individuals (from CAP flight imagery) and occurred 97 days later into the season (FY22 occurred 23 June 2022; FY23 occurred 19 September 2023). Despite spring DCCO arrival to ESI being documented at the same time for both years (FY22 occurred 14 April; FY23 occurred 13 April), the DCCO nesting attempts occurred much later in the present season with fledglings still being present on nests through the end of September. Corps biologists had attempted to conduct PIT-tag recovery efforts on the DCCO colony during the last week of September, following a similar timeline used in previous years. However, Corps biologists estimated that around 50% of the fledglings still had down at this time and could be impacted by a disturbance event, delaying PIT recovery two additional weeks. Compared to observations by Bird Research Northwest from 2003 to 2013, this is a late fledging; fledging at this colony has historically been observed by mid-August (BRNW 2014).

The increased presence of avian predators such as BAEA is a factor that could have altered the nesting timeline. During 2018, researchers reported frequent predator interactions between BAEA and DCCO with as many as two disturbances per hour of the colony during the months of May-July, after which, BAEA numbers on ESI reportedly tapered off (Turecek et al. 2019). Similar observations were made in 2022 and 2023 with the DCCO colony peak occurring after the peak presence of BAEA. It is known that late breeding attempts and late departure from breeding colonies can create effects on the population that carry-over to the following season such as delayed arrival and reduced fitness which can greatly affect colony size and nesting success (Fayet et al. 2016).

Dispersal to the Astoria-Megler bridge is another possibility that may have impacted DCCO abundance and nesting activity at ESI. From 2011 to 2018, the cormorant colony on the bridge grew 66% (Turecek et al. 2019). The decrease in nests could be related to the recruitment of pairs to the bridge colony.

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Appendix I: Tables

*Table 1. Raw data from boat, land, and Civil Air Patrol (CAP) flight-based surveys documenting abundance of Caspian Tern (CATE) individuals and nesting data at East Sand Island (ESI) in 2023. Blank cells represent no data collected, *denotes observer estimates.*

	Date	CATE Off Colony*	CATE On Colony*	CAP Flight Count of CATE Colony	CATE Scrapes Off Colony	CATE Eggs Off Colony	CATE Eggs On Colony
Pre-breeding period	3/7/2023	0	0		0	0	0
	3/8/2023	0	0				0
	3/14/2023	0	0				0
	3/15/2023	0	0				0
	3/16/2023	0	0				0
	3/21/2023	0	0				0
	3/22/2023	0	0				0
	3/30/2023	0	0				0
	4/13/2023	295	0				
	4/19/2023	360	700				
	4/25/2023	882	1250				0
	5/10/2023	500	1580		5	0	1
	5/17/2023	850	2000		15	0	0
	5/25/2023	55	115		0	0	0
Breeding period	6/1/2023	102	150	276	0	0	0
	6/7/2023	280	1000			0	0
	6/15/2023	700	1300	1381			0
	6/22/2023	136	900				0
	6/28/2023	19	26				0
	7/6/2023	225	68		0	0	0
	7/12/2023			80			
	7/20/2023	245	1200				
	7/25/2023	9	700		0	0	0
	7/27/2023	170	1000		0	0	1
	8/1/2023			1181			
	8/3/2023	95	600		0	0	0
	8/9/2023	50	550				0
	8/15/2023	120	650				0
	8/30/2023	62	117				0
	9/5/2023	4					
	9/6/2023	0	0				0
	9/12/2023	0	0				
	9/19/2023	0	0				
	9/20/2023	0	0				
	9/28/2023	2	0				

Table 2. Monitoring data for Caspian Tern (CATE) individual abundance and reproductive activity on East Sand Island during the adjusted pre-breeding period 7 March – 25 May 2023), based on observer estimates.

Variable	*n* days monitored	$\bar{x} \pm$ S.D	Range
Average Total CATE Abundance	13	613.4 ± 962.4	0-2850
Average CATE on Colony	13	403.2 ± 670.1	0-1300
Average CATE off Colony	13	210.1 ± 310.7	0-882
CATE Scrapes off colony	2	10 ± 5	0-15
CATE Eggs off colony	2	0	N/A
CATE Eggs on Colony	13	1	0-1

Table 3. Monitoring data for Caspian Tern (CATE) individual abundance and reproductive activity on East Sand Island during the adjusted active breeding period (26 May – 30 August 2023), based on observer estimates.

Variable	*n* days monitored	$\bar{x} \pm$ S.D	Range
Average Total CATE Abundance	18	551.6 ± 585.4	0-2000
Average CATE on Colony	18	459.0 ± 457.4	0-2000
Average CATE off Colony	18	113.7 ± 159.9	0-700
CATE Scrapes off colony	9	0	N/A
CATE Eggs off colony	9	0	N/A
CATE Eggs on Colony	18	1	0-1

Table 4. Caspian Tern (CATE) breeding pair attendance calculated from Civil Air Patrol flights over East Sand Island from 6 June to 1 August 2023. Data was not captured for the last two flights due to lack of breeding activity in the colony.

	06 June	15 June	12 July	01 August
Plot 1 Attending	0.34	0.48	--	--
Plot 2 Attending		0.42	--	--
Plot 3 Attending	0.39	0.37	--	--
Plot 4 Attending		0.28	--	--
Colony Average Attending	0.36745	0.3875	--	--
Colony Average Observed	280.50	1352	--	--
Average Breeding Pairs Attending	103.07	523.90	--	--

*Table 5. Raw data from boat, land, and CAP flight-based surveys documenting abundance of Double-crested Cormorant (DCCO) individuals and nesting data at East Sand Island (ESI) in 2023. Blank cells represent no data collected, *denotes observer estimates.*

Date	DCCO Individuals*	CAP Flight Count of DCCO Colony	DCCO CAP Flight Nest Count
3/7/2023	0		
3/8/2023	0		
3/14/2023	0		
3/15/2023	0		
3/16/2023	0		
3/21/2023	0		
3/22/2023	0		
3/30/2023	0		
4/13/2023	3		
4/19/2023	0		
4/25/2023	0		
5/10/2023	0		
5/17/2023	0		
5/25/2023	0		
6/1/2023	0	26	0
6/7/2023	7		
6/15/2023	100	253	0
6/22/2023	250		
6/28/2023	0		
7/6/2023	175		
7/12/2023		278	0
7/20/2023	950		
7/25/2023	0		
7/27/2023	812		
8/1/2023		2204	241
8/3/2023	300		
8/9/2023	3		
8/15/2023	85		
8/30/2023	3000		
9/5/2023	1600		
9/6/2023			
9/12/2023	659		
9/19/2023	3100		
9/20/2023	100		
9/28/2023	80		

Appendix II: Definitions & Abbreviations

APHIS: Animal and Plant Health Inspection Service

BAEA: Bald Eagles, *Haliaeetus leucocephalus*

BiOp: Biological Opinion

BPA: Bonneville Power Administration

BRNW: Bird Research Northwest

CATE: Caspian Terns, *Hydroprogne caspia*

Cormorant Management Plan: Double-crested Cormorant Management Plan

CRS: Columbia River System

DCCO: Double-crested Cormorants, *Nannopterum auritum*

EIS: Environmental Impact Statement

ESA: Endangered Species Act

ESI: East Sand Island

FFU: Fisheries Field Unit

GWGU: Glaucous-winged Gull*, Larus glaucescens*

LCR: Lower Columbia River

Tern Management Plan: Caspian Tern Management Plan

NEPA: National Environmental Policy Act

NOAA: National Oceanic and Atmospheric Administration

ODFW: Oregon Department of Fish & Wildlife

PNW: Pacific Northwest

RBGU*:* Ring-billed Gull*, Larus delawarensis*

ROD: Records of Decision

USACE or "Corps": U.S. Army Corps of Engineers

USDA: U.S. Department of Agriculture

USFWS: U.S. Fish and Wildlife Service

WDFW: Washington Department of Fish & Wildlife

WEGU: Western Gull, *Larus occidentalis*

WGWH: Glaucus-winged x Western hybrid Gulls, *Larus occidentalis x L. glaucescens*