US Army Corps of Engineers®
Portland District

February 2023

DISTRIBUTION AND DISSUASION OF CASPIAN TERNS (*Hydroprogne caspia*) AND DOUBLE-CRESTED CORMORANTS (*Nannopterum auritum*) ON EAST SAND ISLAND: 2022 SEASON SUMMARY REPORT

Fisheries Field Unit

U.S. Army Corps of Engineers, Bonneville Lock and Dam, Cascade Locks, OR. 97014

Noah E. Strong & Kyle S. Tidwell

Correspondence: Kyle.S.Tidwell@usace.army.mil

US Army Corps of Engineers®
Portland District

February 2023

SUMMARY

From 29 March to 15 September 2022, 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 with an expected effect of a population of 3,125 – 4,375 breeding pairs, 2) prevent the formation of tern satellite colonies, and 3) monitor the abundance of Double-crested Cormorant (*Nannopterum auritum*). All three objectives were successfully implemented in 2022. The one-acre colony of Caspian Terns had a peak abundance of 1,725 breeding pairs on 20 July. Despite the formation of a temporary Caspian Tern colony on nearby Rice Island, nesting attempts were largely dissuaded at off-colony locations. Double-crested Cormorant abundance was sporadic and peaked on 23 June with 2,317 individuals. A total of 58 Double-crested Cormorant nesting attempts were documented from Civil Air Patrol flight photos. No Caspian Tern eggs hatched in 2022. The potential synergistic impact of Bald Eagle (*Haliaeetus leucocephalus*) presence and subsequent egg predation by Glaucus-winged x Western hybrid gulls (*Larus spp.*) may have contributed to the failed reproductive attempts of Caspian Terns and Double-crested Cormorants.

US Army Corps of Engineers®
Portland District

February 2023

Table of Contents

List of Figures

List of Tables

BACKGROUND

Long term evaluation of Caspian Terns (CATE; *Hydroprogne caspia,* formerly *Sterna caspia)* and Double-crested Cormorants (DCCO; *Nannopterum auritum* formerly *Phalacrocorax auritus*) in the Columbia River estuary has revealed that aggregations of these colonial waterbirds can impact endangered salmonid stocks native to the Columbia River (Evans et al., 2012, Adkins et al., 2014). In response to the increased presence and abundance of CATE and DCCO in the Columbia River estuary, NOAA Fisheries issued a Biological Opinion (BiOp) in 1999 requiring the U.S. Army Corps of Engineers (USACE) to dissuade these species from nesting on USACE 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 ESA listed salmonids while preserving the integrity of the avian populations in the Pacific Flyway (NOAA 1999, 2005, 2012). Most recently, USACE and fellow Action Agencies Bonneville Power Administration (BPA) and U.S. Bureau of Reclamation included a commitment to continue implementing various avian predation management and monitoring activities in 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 CATE and DCCO management plans at East Sand Island (described below); NOAA Fisheries supported this ongoing effort in their associated 2020 CRS BiOp (NOAA 2020).

Formed in 1984, the primary CATE colony was on Rice Island (Figure 1), a USACE dredge material deposition site owned by the state land management agencies of Oregon and Washington. The 1999 BiOp called for the USACE to relocate the Rice Island colony to the downstream site of East Sand Island (ESI) to minimize salmonid consumption by increasing the available level of estuarine and marine fishes in the CATE diet that would be anticipated to occur in the area closer to the Columbia River mouth (Figure 1). East Sand Island is owned and managed by USACE. The site has historically been used for dredge material deposition. In 2000, the CATE colony on Rice Island was successfully moved to East Sand Island and dietary monitoring showed that the intended dietary shift had occurred.

Figure 1. Islands managed by the United States Army Corps of Engineer in the Lower Columbia River.

Following this action, an Environmental Impact Statement (EIS) was developed in 2005 as part of a lawsuit settlement agreement of Tern management in the Columbia River estuary. The EIS evaluated a range of alternatives to reduce the Caspian Tern population in the Columbia River estuary. The preferred alternative selected as the Caspian Tern Management Plan (Management Plan) involved reducing the tern population by managing habitat on East Sand Island and redistributing a portion of the tern colony to created or enhanced sites outside of the Columbia River basin (USACE 2015a). 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. As a guidance document, the Management Plan establishes criteria for desired CATE colony size and breeding bird abundance in the Columbia River estuary; to minimize impacts to salmon while maintaining the integrity of the CATE breeding population across the Pacific Flyway.

Implementation of the Management Plan required Records of Decision (ROD) by the USFWS and USACE, wherein the Action Agencies spelled out what they intended to do to achieve the goals and objectives of the Management Plan. These RODs are now referenced, in conjunction with the 2005 EIS, as the guiding documents of the Management Plan, as well as subsequent decisions evaluated in National Environmental Policy Act (NEPA) Environmental Assessments which supplement and tier to the 2005 EIS. Chief among the Management Plans objectives is to reduce the ESI breeding colony site to a minimum of one acre of habitat which would theoretically reduce the number of breeding pairs of CATE to 3,125–4,375 pairs, and simultaneously mitigate for the loss of breeding sites by providing alternative inland avian breeding sites as stated in the 2015 EA and FONSI (USACE 2015a, 2015b).

Concomitant to fulfilling these actions, the management plan directs that: 1) an Adaptive Management Plan be developed for CATE management actions beyond those directed by the Management Plan, and 2) once habitat objectives (i.e., the prepared one-acre colony) had been met on ESI, the responsibility for the work would transition from a short-term monitoring and research mission to a long-term monitoring 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 every three years to the USFWS for population monitoring metrics.

In 2018, the short-term monitoring objectives of the post construction habitat requirements were satisfied, and the one-acre colony was established on ESI. Management of the East Sand Island CATE colony was transitioned to the Operations Division of the USACE Portland District. In January 2019, the Fisheries Field Unit, a unit within the Portland District's Operations Division, began implementing the long-term monitoring of CATE on ESI.

While historical records of breeding DCCO in the Lower Columbia River (LCR) basin are scant, a breeding colony was first recorded on ESI and on Rice Island in 1988 (Carter et al., 1995). Nesting colonies of DCCO formed upriver on Miller Sands, Pillar Rock and on the mid-river pilings; however, these colonies remained small, whereas the East Sand Island colony grew to 15,000 breeding pairs and was 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 extremely large quantities of out-migrating juvenile salmonids found in the Columbia River system, all of which are considered threatened or endangered species or stocks (Roby et al., 2021). Studies found that DCCO on Rice Island consumed two to three times more juvenile salmonids per capita compared to that of DCCO on ESI (Collis et al., 2000). The average annual predation by DCCO on ESI was estimated to be 10.9 million smolt between 1998–2013, with a high of 20.9 million smolt in 2011. This figure, represents, an average of 10% of all smolt in the Columbia River (Roby & Collis 2021).

In response to the impact that DCCO were having on ESA-listed salmonids in the LCR, the USACE 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 Cormorant Management Plan calls for a reduction to no more than 5,380–5,939 breeding pairs of DCCO on ESI. The plan was implemented in two phases. Phase one involved lethal take of adult DCCO and their nests over a four-year period and ended in 2017, and phase two was implemented according to the adaptive management framework in 2018 with habitat modification that restricted available habitat by allowing tidal inundation of the historical breeding area and was completed in 2020 (USACE 2015c). Under the management plan the USACE is responsible for monitoring and reporting DCCO abundance and breeding attempts on ESI, and if necessary, dissuading DCCO to maintain the no more than 5,380–5,939 breeding pair management objectives.

METHODS

CATE– To ensure that the one-acre CATE colony as established in 2020 met the requirements stipulated in the management plan, the USACE undertook basic repairs and maintenance of the colony prior to nesting by CATE during the 2022 season. Maintenance began on 29 March with repairs to the T post and silt fencing which demarks the perimeter of the one-acre colony. One acre of bare sand was ensured by addressing the weed growth which has, in previous years, prohibited CATE from making full use of the one-acre colony. In 2021 weed growth was concentrated around the edge of the perimeter fencing, and most developed on the southern edge of the colony (Figure 4). Weed abatement was accomplished by both mechanical and chemical means. A disk harrow mounted on an ATV, supplemented with hand-removal, was employed to remove weeds mechanically. Chemical abatement was accomplished through application of Imazapyr granules from an herbicide spreader and direct application of Glyphosate to individual plants. All weed management was conducted by a certified USACE herbicide specialist.

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 of the colony (Figure 2). Passive dissuasion relies primarily on a 3 m grid of bright yellow 90 cm strips of plastic dissuasion flagging spaced approximately 1 m apart, suspended from 4 ft aluminum T posts. These posts are driven throughout areas of open ground historically used by CATE as nesting sites.

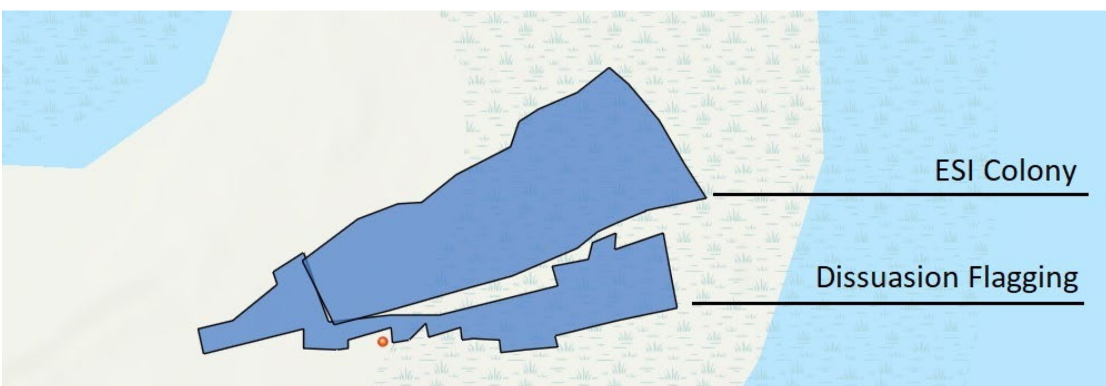

Figure 2. Colony and dissuasion flagging.

We planned to assess predation by piscivorous birds with Passive Integrated Transponders (PIT) tag technologies. Upriver, PIT tags are implanted into smolt. When tagged smolt travel downstream, some of the smolt fall prey to both CATE and DCCO on ESI. The percentage of pre- and post-sown PIT tags that are recovered at the end of the season, are estimated against those recovered from the bird guano and dietary remains enabling biologists to estimate and assess annual predation rates of smolt consumed by DCCO and CATE on ESI. To facilitate analysis, we placed control tags on the colonies and known areas of bird use prior to bird arrival to determine detection efficiency of PIT tag collection.

Avian abundance and occupancy monitoring commenced according to established protocols for ESI bird monitoring (Roby et al., 2021). Biologists collected estimates of avian abundance by boat- and land-based observations with 8x42 binoculars. Data were recorded on mobile devices utilizing the ArcGIS Survey123 Application®. GIS mapping was accomplished using mobile devices equipped with the ArcGIS Field Maps Application® which allowed USACE biologists to geospatially record polygons and GPS points of bird scrapes and eggs while in the field.

USACE biologists performed visual encounter surveys systematically, beginning with offshore enumeration from a USACE research vessel. USACE biologists approached ESI slowly, opportunistically sampling CATE and DCCO from the eastern tip of the island to the southwestern end of the dissuasion flagging. USACE biologists then sampled in a counterclockwise manner, around the eastern tip of the island to the anchor point on the north end of the island, taking care not to double count flocks of CATE or DCCO previously enumerated. USACE biologists on the island observed CATE from one of two stilt blinds located on the northern edge of the colony. From this elevated vantage point, they enumerated CATE on colony, CATE eggs, and recorded data on colony flushes and the presence of Bald Eagles (BAEA; *Haliaeetus leucocephalus*) and Peregrine Falcons (PEFA; *Falco peregrinus*).

Concomitant to monitoring the colony, USACE biologists searched for and dissuaded nesting attempts off-colony on the east and south beaches (Fig. 2). Nest detection transects were conducted on foot, between the wrack line and the dissuasion flagging. While performing nest detection transects, USACE biologists maintained a safe operating distance from the perimeter of the colony and walked or crawled slowly to avoid disturbing the colony. When a CATE scrape was identified, it was assessed for the presence of an egg. If no egg was present, the scrape was recorded and filled in with sand to dissuade future nesting attempts and to enable accurate scrape enumeration. If an egg was observed, USACE biologists recorded information on the nest location and contents from a distance greater than or equal to

4.5 m (USFW pers. comm.), and continued with the sampling transect, leaving the nest undisturbed. Scrape enumeration was performed in a uni-directional pattern, to minimize double counting of scrapes and eggs.

Between 23 June and 9 August, the USACE coordinated with Civil Air Patrol (CAP) to conduct regular flights over the island to provide aerial photographs of the birds and allow formal enumeration of the abundance of CATE at the colony. USACE biologists coordinated visual observation from the blinds with the CAP flights overhead to monitor CATE nest attendance on the colony in paired 6 m x 6 m productivity plots, set at even intervals throughout the colony. By applying standardized sampling methods described by the Bird Research Northwest field protocol, the number of breeding pairs in the colony was calculated (BRNW, 2018). Productivity plot enumeration was performed at 5 intervals, beginning 30 minutes before the CAP flight passed over head, with intervals spaced fifteen minutes apart. Photos from these flights were individually enumerated and validated by separate USACE biologists and total CATE abundance in the colony and the total reported CATE breeding pairs were calculated from these data.

DCCO– In 2018, the USACE restricted DCCO habitat to an area of 1.2 acres as part of an ongoing effort to limit the abundance of DCCO on ESI. During initial colony preparation, USACE biologists surveyed the available habitat at the western end of ESI to ensure habitat availability for DCCO nesting. During colony site inspection, USACE biologists sowed control PIT tags, like those sown in the one-acre CATE colony, to assess fish mortality in the Columbia River estuary.

Abundance of DCCO was documented during visits by USACE biologists to ESI following the same protocol as was utilized to enumerate CATE. USACE 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. USACE biologists then sampled systematically, in a counterclockwise manner, around the eastern tip of the island to the northeastern end of the island. Flying DCCO and those in the water were not enumerated. DCCO utilizing exposed pilings as roost sites between the survey vessel and the shoreline were enumerated. As DCCO are sensitive to disturbance, care was taken to prevent flushing DCCO flocks when conducting counts. Abundance estimates were supplemented by careful enumeration of aerial photos taken during CAP flight surveys. Analysis of photographs taken during CAP flights provided assurance that DCCO nesting activity on ESI was restricted to the DCCO 1.2-acre area defined and managed for breeding by the species, and permitted analysis of DCCO abundance in the colony and total DCCO abundance for ESI. Breeding success for DCCO was calculated from CAP flight data.

RESULTS

ESI colony preparation and maintenance began on 29 March and monitoring concluded with breakdown of the colony and full demobilization completed on 15 September. ESI was visited 44 days by USACE biologists, and monitoring data were collected on 36 of these days. Installation of active dissuasion measures began on 29 March with the deployment of the dissuasion flagging array and concluded on 9 September when the last of the dissuasion flagging was removed. USACE biologists deployed dissuasion flagging at 0.49 acres to the south of the CATE colony above the wrack line in areas historically utilized by nesting CATE (Figure 2).

CATE- USACE biologists enumerated an average of 303.6 ± SD 241.1 CATE per sample day on ESI outside the boundary of the one-acre colony. The average number of CATE recorded within the bounds of the one-acre colony was 1663.9 ± 1259.1 per sample day. Together, the average of both on- and off-colony CATE reported on ESI was 1,265.7 ± 1,303.1 per sample day. Nest detection transects were performed on 14 days, and USACE biologists enumerated 91 off-colony scrapes on the south shore between 26 May and 25 August. Nest detection transects resulted in detection of 8 eggs, enumerated off-colony on 7 July, between the colony perimeter and the wrack-line. USACE biologists recorded the first scrape off-colony on 2 June and the last scrape off-colony was recorded on 1 August. The average number of off-colony scrapes enumerated during nest detection transects was 6.5 ± 16.8 scrapes per sample day, with a single day peak of 58 scrapes reported on 13 July. All scrapes enumerated outside of the colony were recorded south of the colony between the dissuasion flagging and the wrack line. CATE eggs were first reported at the colony on 26 May. USACE biologists enumerated an average of 4.1 ± 12.0

eggs in the colony for 17 days that surveys reported eggs present. No known CATE eggs hatched, either on- or off-colony during the 2022 season.

Coordinated efforts by USACE biologists and CAP flights to count CATE utilizing the one-acre colony took place on four dates during the breeding season. During these flights the number of breeding pairs were estimated by observers using the productivity plot counts; the results of each are available in Table 4. On 23 June, enumeration of the first CAP flight photos of the season reported an average of 722 breeding pairs. On 8 July, an average of 1,345 breeding pairs was enumerated. Peak abundance of breeding pairs occurred twelve days later during the third CAP flight on 20 July, when an average of 3,468 individual CATE was enumerated (Figure 4). During this count we estimated 0.50 percent of the CATE on the productivity plots to be attending a nest and therein representing a breeding pair. Thus, at peak colony attendance we estimate an average of 1,725 breeding pairs (i.e. 3,468 individuals * 0.50 ratio of attending/not attending) of CATE on the ESI colony in 2022. Following the peak, we estimated an average of 295 breeding pair of CATE present at the colony on 9 August.

Figure 3. Caspian Tern colony at East Sand Island, at or near maximum seasonal occupancy, 19 July 2022.

DCCO - Abundance and occupancy data for DCCO were recorded by USACE biologists during 25 visits to ESI, as well as during the four separate CAP flights surveys that took place during the 2022 season. DCCO were first enumerated on ESI by USACE biologists on 14 April and last enumerated on 1 August. USACE biologists visiting ESI calculated an average abundance of 154.9 ± SD 195.4 individual DCCO. Enumeration of CAP flight photos provided a single day peak abundance estimate of 2,317 (1,158 pair) DCCO on 23 June (Table 3). No ground based DCCO nest surveys were conducted in 2022.

While no ground-based nest assessment surveys were performed on ESI, nesting by DCCO was confirmed by analysis of CAP photos. Photos from the 7 June CAP flight confirmed one DCCO nesting in the 1.2 acres of nesting habitat located on the riprap at the far west end of ESI. During the single day peak abundance estimate of DCCO on 23 June, CAP flight photo analysis produced a minimum of 58

DCCO nesting in the riprap and against the privacy fence that delineates the edge of nesting habitat. Only nine DCCO nests were noted in the photographs taken during CAP flight on 8 July. No DCCO nests were documented after 8 July, and no nests were documented anywhere on ESI beyond those enumerated on the DCCO colony.

PIT tags were recovered over a three-day period from the one-acre CATE colony and DCCO colony then scanned. PIT tag data were uploaded to the PIT Tag Information System (PTAGIS).

DISCUSSION

The USACE met the objectives established by the guiding documents and maintained compliance with both CATE and DCCO management plans. CATE nesting on ESI was restricted to the one-acre colony location, with 1,725 peak nesting pairs enumerated, less than the 3,125–4375 breeding pair projected in the management plan. All CATE nesting activity outside of the colony boundaries on ESI was closely monitored, and while egg laying outside of the one-acre colony did occur, no eggs were incubated. The peak estimate of 1,158 pair of DCCO was well below the maximum of 5,380 – 5,939 breeding pair management objective, and DCCO nesting was restricted to the DCCO colony.

During 2021, the CATE colony suffered from heavy vegetative growth around the perimeter, especially to the south and east edges. This issue was addressed by the USACE during the 2022 season by employing mechanical removal and the application of Imazapyr and glyphosate herbicide (Figure 4). Future vegetation control efforts including herbicide application and manual removal will be required to maintain the one-acre colony.

Figure 4: Left, 24 June 2021. Right, 23 June 2022, illustrating the impact of herbicide application and mechanical treatment at the East Sand Island Caspian Tern colony.

Nesting efforts by CATE outside the one-acre colony were successfully dissuaded with the deployment of flagging in regions wherein CATE had historically attempted to nest. In 2022, as in past seasons, approximately 50% less passive dissuasion was required compared with previous seasons (i.e., 0.48 acres in 2022, 0.90 acres in 2021, and 2.11 acres in 2020). This reduction in passive dissuasion was largely due to rapid secondary succession of Himalayan blackberry (*Rubus spp.*) and European beach grass (*Ammophilia spp.*) on the south facing back shore between the colony and the wrack line. The dense overgrowth of blackberry and beach grass rendered that area inhospitable to nesting by CATE in 2022.

Numbers of CATE on ESI early in the season may have been depressed by the movement and subsequent formation of an incipient CATE colony on Rice Island a site upriver from ESI. USACE biologists confirmed the formation of this colony on 23 May. During an intensive dissuasionary period lasting from 23 May to 6 June, a team of USACE biologists responded to CATE presence at the incipient colony location and succeeded in dissuading CATE from utilizing the site. CATE numbers on ESI rose in the wake of the dissuasion efforts that took place during the intensive dissuasion period (Figure 5).

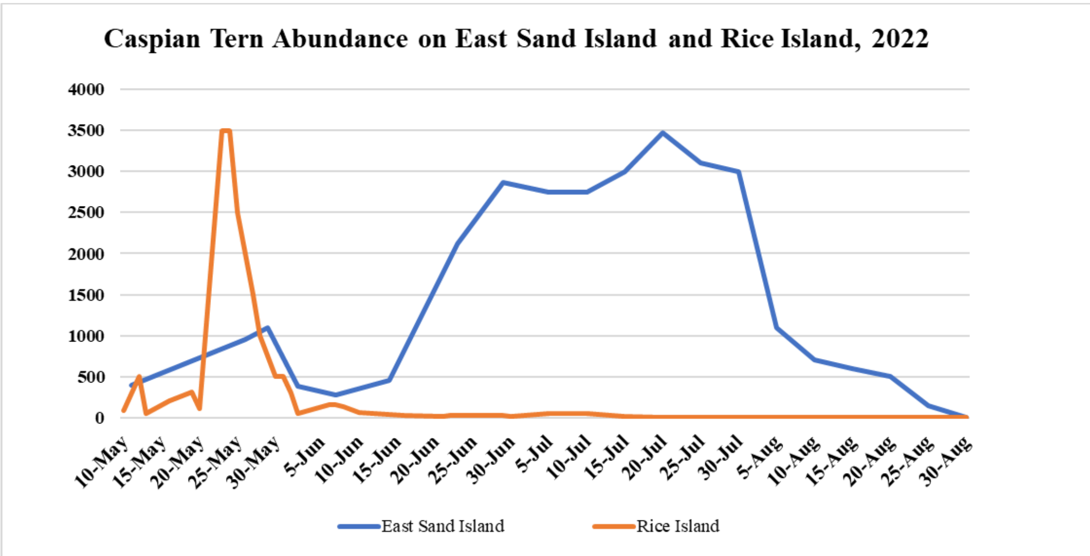

Figure 5. Caspian Tern numbers during the incipient colony formation period.

Consistent with observations made in 2021, Bald Eagles were a large source of disturbance near the colony. USACE biologist recorded as many as 5 colony flushes (flushes (i.e., occurrences when all [or most] birds at the colony flew simultaneously from their nests) occurring during a two-hour period, and as many as 10 BAEA were observed on ESI at one time. Roby et al., (1998) reported that disturbance by BAEA resulted in a high rates of egg predation by Glaucus-winged x Western Gulls in a CATE colony. USACE biologists in the 2022 season consistently observed BAEA activity result in partial- and total-colony flushes of nesting CATE from the colony. During many of these events, USACE biologists observed CATE eggs left exposed when the adult CATE flushed, only to be immediately depredated by Glaucus-winged x Western Gulls. These gulls typify the pattern of sit and wait egg specialists called "droolers" by Roby et al., (1998). An average of 47.1 ± 15.8 gulls per day were calculated within the colony perimeter, at least 10 gulls nests were recorded within the CATE colony. In addition to the synergistic impact of BAEA and gulls, Peregrine Falcons (*Falco peregrinus*) nesting on marine navigation day markers near the island contributed to flushes that likely led to unprotected CATE egg predation by Glaucus-winged x Western hybrid gulls. Crows (*Corvus spp.*) were also observed within the colony, periodically engaged in egg predation. During peak colony occupation on 20 July, only five eggs were observed in the colony. No eggs were observed after 20 July.

The number of DCCO on ESI fluctuated throughout the season. Early in the season, DCCO were largely absent until 10 May when 110 DCCO were present on the south and east-facing beaches on ESI. The peak abundance estimate of 2,317 DCCO, on 23 June on ESI was nearly the same as the estimates of 2,522 individuals one year before, on 8 June 2021. A second, smaller peak abundance was estimated 1,277 DCCO present on 9 August. During 2018, researchers reported seeing frequent predator interactions between BAEA and DCCO with as many as 2 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. For example, during surveys of the DCCO colony on 11 May, 10 BAEA were sighted at one time at or near the colony and 6 BAEA were present on 14 June, after which time BAEA sightings tapered off. Turecek et al., (2019) reported a synergistic 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 which may have magnified the influence of predator effects on the behavior and productivity of CATE at the colony.

ACKNOWLEDGMENTS

This work would not be possible without the support of the Civilian Air Patrol crew (Jonathan Ritchie) and the efforts of Real Time Research crew (Ken Collis and Allen Evans). Thanks to Kelcy McHarry USACE for the support of colony herbicide application. Field data were collected by USACE research staff thanks to: Christine Brandtner, Mark Braun, Sean Carrol, Jim Day, Steven Sachs, Bjorn van der Leeuw, and Robert Wertheimer for all your hard work.

REFERENCES

Anderson, C. D., Roby, D. D., & Collis, K. (2004). Conservation Implications of the Large Colony of Double-crested Cormorants on East Sand Island, Columbia River Estuary, Oregon, USA. *Waterbirds*, 27(2), 155-160.

Bird Research Northwest. (2018). Fish and Data Collections Protocols. East Sand Island. Stand Sit Protocols. Revised March 2018. 7-12 pp.

Bonneville Power Administration, Bureau of Reclamation, and U.S. Army Corps of Engineers. (2020). Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species. Portland, Oregon. January 2020.

Carter, H. R., Sowls, A. L., Rodway, M. S., Wilson, U. W., Lowe, R. W., McChesney, G. J., ... & Anderson, D. W. (1995). Population Size, Trends, and Conservation Problems of the Double-crested Cormorant on the Pacific Coast of North America. *Colonial Waterbirds*, 189-215

Collis, K., Adamany, S., Roby, D.D., Craig, D.P., & Lyons, D.E. (2000). Avian Predation on Juvenile Salmonids in the Lower Columbia River: 1998 Annual Report. Submitted to Bonneville Power Administration and U.S. Army Corps of Engineers, Portland, Oregon. 100 pp.

Evans, A. F., Hostetter, N. J., Roby, D. D., Collis, K., Lyons, D. E., Sandford, B. P., ... & Sebring, S. (2012). Systemwide Evaluation of Avian Predation on Juvenile Salmonids from the Columbia River Based on Recoveries of Passive Integrated Transponder Tags. *Transactions of the American Fisheries Society*, 141(4), 975-989.

Harper, J. & Collis, K. (2018). 2018 hazing and Dissuasion of Caspian Terns in the Lower Columbia Estuary: Season End Summary Report. 10 Pg.

NOAA Fisheries. (1999). Endangered Species Act – Section 7 Consultation Biological Opinion, Columbia River Navigation Channel Operation and Maintenance Dredging. NWR-1999-1150. Northwest Region. Seattle, Washington. September 15, 1999.

NOAA Fisheries. (2005). Endangered Species Act – Section 7 Consultation Biological Opinion and Conference Opinion & Magnuson-Stevens Act Essential Fish Habitat Consultation, Reinitiation of Columbia River Federal Navigation Channel Improvements Project. NMFS No. 2004/01612. Northwest Region. Seattle, Washington. February 16, 2005.

NOAA Fisheries. (2012). Reinitiation of Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Columbia River Navigation Channel Operations and Maintenance, Mouth of the Columbia River to Bonneville Dam, Oregon and Washington (HUCs 1708000605, 1708000307, 1708000108). NMFS No. 2011/02095. Northwest Region. Seattle, Washington. July 11, 2012.

NOAA Fisheries. (2020). Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Continued Operation and Maintenance of the Columbia River System. NMFS No. WCRO 2020-00113. West Coast Region. Portland, Oregon. July 24, 2020.

Roby, D. D., Craig, D. P., Collis, K., & Adamany, S. L. (1998). Avian Predation on Juvenile Salmonids in the Lower Columbia River. 1997 Annual Report Submitted to the Bonneville Power Administration and U.S. Army Corps of Engineers.

Roby D.D., Evans, A.F., & Collis, K. (editors). (2021). Avian Predation on Salmonids in the Columbia River Basin: A Synopsis of Ecology and Management. A Synthesis Report Submitted to the U.S Army Corps of Engineers, Walla Walla, Washington; the Bonneville Power Administration, Portland, Oregon; the Grant County Public Utility District/Priest Rapids Coordinating Committee, Ephrata, Washington; and the Oregon Department of Fish and Wildlife, Salem, Oregon. 788 pp.

Turecek, A., Tennyson, J., Collis, K., von Weller, P. & Cramer, B. (2019). Double-crested Cormorant Monitoring on East Sand Island, and in the Columbia River Estuary, 2018. Final Annual Report to the US Army Corps of Engineers, Portland District, Portland, Oregon, USA.

USACE (U.S. Army Corps of Engineers). (2015)a. Caspian Tern Nesting Habitat Management East Sand Island, Clatsop County, Oregon, Final Environmental Assessment, April 2015. U.S. Army Corps of Engineers, Portland District, Northwestern Division, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). (2015)b. Caspian Tern Nesting Habitat Management East Sand Island, Clatsop County, Oregon, Finding of No Significant Impact, April 2015. U.S. Army Corps of Engineers, Portland District, Northwestern Division, Portland, Oregon.

USACE (U.S. Army Corps of Engineers). (2015)c. Double-crested Cormorant Management Plan to Reduce Predation on Juvenile Salmonids in the Columbia River Estuary: Final Environmental Impact Statement, February 2015. U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Appendix

Table 1. Monitoring data for Caspian Tern (CATE) abundance and reproductive activity on East Sand Island between 29 March and 1 September 2022

Variable	*n* days monitored	$\bar{x} \pm$ S.D	Range	*n* days = 0
Total CATE Abundance ESI	36	1261.7 ± 1306.7	0-4035	1
Total CATE on Colony	20	1739.9 ± 1241.4	0-3500	1
Total CATE off Colony	34	303.6 ± 241.1	0-1100	1
CATE Scrapes off colony	14	6.5 ± 16.8	0-58	10
CATE Eggs off colony	14	0.6 ± 2.1	0-8	13
CATE Eggs on Colony	17	4.1 ± 12.0	0-50	10

Table 2. Monitoring data for Caspian Tern (CATE) abundance and reproductive activity on East Sand Island between 29 March and 1 September 2022

Date	CATE Off Colony	CATE on Colony	CATE Scrapes off Colony	CATE eggs off colony	CAP flight Average Count
22-03-29	1				
22-03-30	0				
22-03-31	2				
22-04-06	0				
22-04-07	55				
22-04-14	100				
22-04-19	300				
22-04-25	250				
22-05-03	600				
22-05-11	400				
22-05-26	950		0		
22-05-29	1100		0		
22-06-02	240	140	1		
22-06-07	130				
22-06-14	200	260	0		
22-06-23	310				1810.5
22-06-29	312		2		
22-07-06	130	2900			
22-07-08					2746
22-07-11	510				
22-07-13	350	2750	58	8	
22-07-19	350	3000			
22-07-20	450	3000			3467.5
22-07-26	245	3100	0		
22-07-28	535	3500			
22-08-01	580	3000	30		
22-08-02	90				
22-08-09	200	1700	0		1093
22-08-11	250	1100	0		
22-08-15	200	1500			
22-08-17	270	701	0		
22-08-18	188	680	0		
22-08-22	500				
22-08-23	600		0		
22-08-25	244		0		
22-08-31	133	158			
22-09-01	200	0			

Table 3. Monitoring data for Double Crested Cormorant (DCCO) abundance on East Sand Island between 14 April and 1 September 2022.

Date 2021	DCCO Boat Point Count	DCCO CAP Flight Count	DCCO CAP Flight Nest Counts
22-04-14	10		
22-05-03	10		
22-05-11	110		
22-05-29	50		
22-06-02	55		
22-06-07	250	137	1
22-06-14	800		
22-06-23	100	2317	58
22-06-29	70		
22-07-06	300		
22-07-08		195	9
22-07-11	200		
22-07-13	50		
22-07-19	380		
22-07-20	300	221	0
22-07-26	450		
22-07-28	205		
22-08-02	300		
22-08-09	440	1277	0
22-08-17	120		
22-08-18	100		
22-08-22	600		
22-08-23	300		
22-08-25	115		
22-08-31	75		
22-09-01	31		

Table 4. Caspian Tern (CATE) breeding pair attendance calculated from Civil Air Patrol flights over East Sand Island from 23 June to 9 August 2022.

	23 June	08 July	20 July	09 August
Plot 1 Attending	0.47	0.56	0.55	0.23
Plot 2 Attending	0.46	0.49	0.48	0.26
Plot 3 Attending	0.33	0.45	0.43	0.28
Plot 4 Attending	0.34	0.46	0.52	0.31
Colony Average Attending	0.40	0.49	0.50	0.27
Colony Average Observed	1810.5	2746	3467.5	1093
Average Breeding Pairs Attending	722.41	1345.31	1724.5175	294.82