2021 ACTIVITIES INVOLVING THE CALIFORNIA LEAST TERN AT VA ALAMEDA POINT

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This report was prepared for Robert J. Bezek, Alameda Program Manager, San Francisco VA Health Care System, Department of Veterans Affairs in San Francisco, CA, and U.S. Fish and Wildlife Service's Ecological Services Program, Bay Delta Fish and Wildlife Office in Sacramento, California. The information within satisfies the requirements mandated in the U.S. Fish and Wildlife Service Regional Blanket Permit TE-108507 and the San Francisco Bay National Wildlife Refuge Complex's Sub-permit SFBNWR-24.1.

INTRODUCTION

The endangered California Least Tern (*Sternula antillarum browni*) was first documented nesting in 1976 at Naval Air Station Alameda (Maps 1-3). After the base closure in 1997, the U.S. Department of the Navy (Navy) leased out a large portion of the former Naval Air Station property, east of the air field, to the City of Alameda. The Navy continued to oversee the property north and west of the City leased portion, which included the air field and California Least Tern colony. The entire property was then referred to as Alameda Point. From 2002 through mid-2014, the U.S. Fish and Wildlife Service monitored the Least Tern colony under an Economy Act agreement with the Navy.

On June, 27, 2014, the Navy transferred 624 acres of the Alameda Point property to the U.S. Department of Veterans Affairs (VA) in a Federal-to-Federal transfer. The transferred acreage included the air field and California Least Tern (hereafter referred to as Least Tern) colony and was renamed VA Alameda Point. Since 2014, the U.S. Fish and Wildlife Service (USFWS) has monitored the Least Tern colony under an Economy Act agreement with the Department of Veterans Affairs (IAA # 36C26119M0001-B00000: VA Project 612-115). For the purpose of this report, VA Alameda Point will refer only to the area outlined in red in Map 3.

Up to seven nesting colonies in northern California (north of San Luis Obispo and Kings Counties) provide data to California Department of Fish and Wildlife (CDFW) on Least Terns each year. VA Alameda Point continues to be the largest of these nesting colonies and is one of the most productive in the State.

The main objectives of this project are to manage and protect the Least Tern colony at VA Alameda Point, and to monitor the terns' reproductive success and fledgling production. Since 2002, USFWS has estimated the adult population size of this colony using breeding pair estimating methods promoted by CDFW. Frequent snapshot adult counts were taken to evaluate population trends during the breeding season, and nest/chick/fledgling surveys were conducted to determine reproductive success and fledgling production. Factors that could negatively affect the colony's reproductive success (e.g., predation, disturbance and health issues) were recorded. Comparisons of reproductive success and predation were made between 2021's data and previous years. These data were also shared annually with CDFW and will be included in its state-wide annual report on Least Tern breeding success and population estimates.

Dropped prey items and Least Tern fecal samples were collected with and for Meredith Elliott, senior scientist at Point Blue Conservation Science, hereafter, referred to as Point Blue, to study Least Tern prey composition and size selection (Elliott 2021).

Wildlife Services, a division of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, continued to conduct predator management at VA Alameda Point (Pyzik 2022).

Activities were conducted pursuant to Section 10(a)(1)(A) of the Endangered Species Act, the U.S. Fish and Wildlife Service Regional Blanket Permit TE-108507 and the San Francisco Bay National Wildlife Refuge Complex's Sub-permit SFBNWR-24.1.

Least Tern Study Area

Alameda Island is located in the central portion of San Francisco Bay in California, lying just south of the San Francisco-Oakland Bay Bridge, on the east side of the bay (Map 1). VA Alameda Point is located on the northwest end of Alameda Island (Map 2). Least Terns were first documented nesting on a small portion of tarmac between two long runways on the former Naval Air Station Alameda (Map 3) in 1976. Over time, this nesting site was enclosed by a fence and expanded to its current size and shape. The nesting site, hereafter, referred to as the colony, is a 3.9 hectare (9.7 acre) rectangle of reclaimed land, centrally located in VA Alameda Point. The perimeter of the colony is enclosed with four-foot high chain-link fencing material. The corners of the fence are rounded to prevent the chicks from crowding and becoming stuck in a tight corner while running to avoid predators or monitors. In 2019, 0.3 m (1 ft) high aluminum hardware fencing material with 0.25 inch-size mesh was attached at the bottom of the west-facing fence along the inside, not only to prevent chicks from slipping through the chain link, but to allow cool breezes to blow through, preventing small chicks lying next to it from overheating. Moreover, the north, east and south-facing chain link fences have boards (12 foot x 1 foot x 2 inches treated redwood) attached to the inside bottom foot of the chain-link to hold sand inside the enclosure during high-wind events and to prevent small

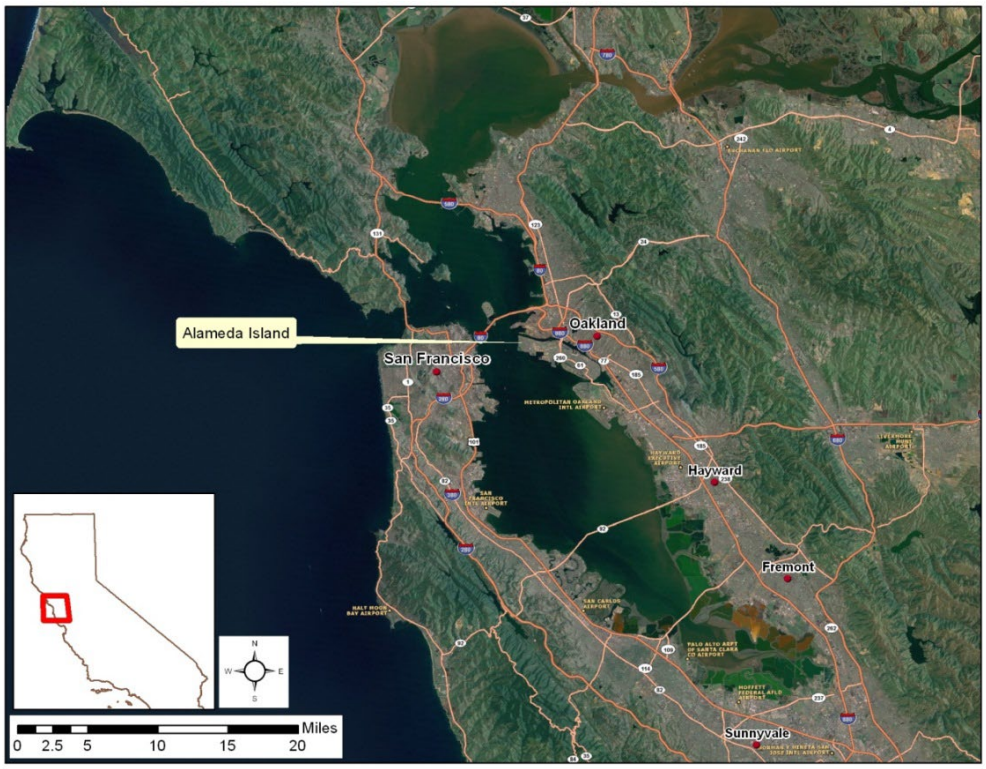
chicks from escaping. Small gaps (~2 inches) between the board ends were allowed to let rainwater flow out. However, small chicks could potentially escape through or get entrapped in these gaps, so plastic-coated wire mesh was stapled to the boards to close any gaps.

The original substrate of the colony is the underlying tarmac. The nesting substrate, added in 2005, 2009, 2010, 2014 and 2016, is called Angel Island coarse sand, which consists of fine and coarse sand, small pebbles and bits of mixed shells. This substrate was spread uniformly within the enclosure, at a depth of three to four inches, to provide an enhanced breeding habitat for the Least Terns (Collins 2000). Pea gravel lines the inside perimeter at the base of the fence to prevent chick escape and injury. Several hundred pounds of oyster shells, donated by Drake's Bay Oyster Company in Point Reyes, CA, were added to the colony between 2005 and 2010, to serve as chick shelters and cryptic camouflage for adult terns (Euing 2012). Terracotta half-round tiles with a height of approximately four inches, small wooden A-frames (Figure 1), and whole oyster shells were evenly distributed throughout the colony to provide additional shelter for chicks and fledglings. Any broken chick shelters were repaired or replaced as needed.

To assist staff and volunteers as a location reference, cinder block markers were used to form a lettered-numbered grid system within the colony. The grid system consisted of 99 uniquely identified grid cells (each cell measuring approximately 20 m [65.5 ft.] by 20 m) formed in rows (0-8), running west to east, and columns (A-K), running north to south, throughout the colony (Figure 2). In addition, plastic numbers were attached to the north-facing fence and plastic letters on the east and west-facing fences to indicate rows and columns, respectively. These references facilitated mapping of nests, Least Tern chicks and location of specific birds or predator takes (kills).

Figure 1. Wooden A-frame and terracotta cylinder chick shelters, Alameda, CA.

Map 1. Location of Alameda Island in the San Francisco Bay Area in California.



Map 2. VA Alameda Point in the NW section of Alameda Island, Alameda, CA.

Map 3. VA Alameda Point Features, including location of Least, Caspian and Elegant Tern Colonies, Alameda, CA.

METHODS

Data were collected to determine nest distribution, chronology of nesting, reproductive success and its components (clutch size, hatching success and fledgling success), population size, predation and mortality.

Least Tern Colony Monitoring

California Department of Fish and Wildlife recognizes three types of Least Tern monitoring methods: Types 1 and 2, and a combination of the two. Type 1 monitoring surveys are conducted on foot within the colony and Type 2 monitoring surveys are conducted from a blind, usually a vehicle, outside the colony. Throughout the State, methods used and monitoring frequency has varied from colony to colony because each colony has different aspects, such as topography, substrate, location, observational conditions, land ownership, number of monitors, vegetation and predators, to name a few.

Our survey methods at VA Alameda Point were consistent with those recommended and recognized by the CDFW's Least Tern monitoring protocols in their annual report (Sin 2021). Each year prior to 2020, monitors surveyed the colony up to six days per week between April and late August: one to two people conducting Type 2 and three to four people conducting Type 1. However, in 2020 and 2021, due to state, local, and USFWS COVID-19 human health and safety restrictions, we used modified methods with only

two experienced monitors for Type 1 surveys, and did not use volunteer or intern assistance. Type 2 surveys were conducted in April through August, 1-2 days/week only. Please refer to the 2019 and older tern reports for a description of the regular survey methods used.

As in past years, Wildlife Services (a division of the U.S. Department of Agriculture-Animal and Plant Health Inspection Service) monitored predator activities from April through August, 2021, and conducted predator management as necessary to protect terns.

Type 1 monitoring

Type 1 survey method at VA Alameda Point was originally established by Point Blue (formerly known as PRBO Conservation Science until 2013) in 2000 at the former Naval Air Station Alameda (Elliott and Sydeman 2002), and modified by USFWS since 2006. In addition, USFWS developed a standardized training that is required for all first-time monitors to take prior to and upon entering the Alameda colony during their first week. No new monitors were trained this year.

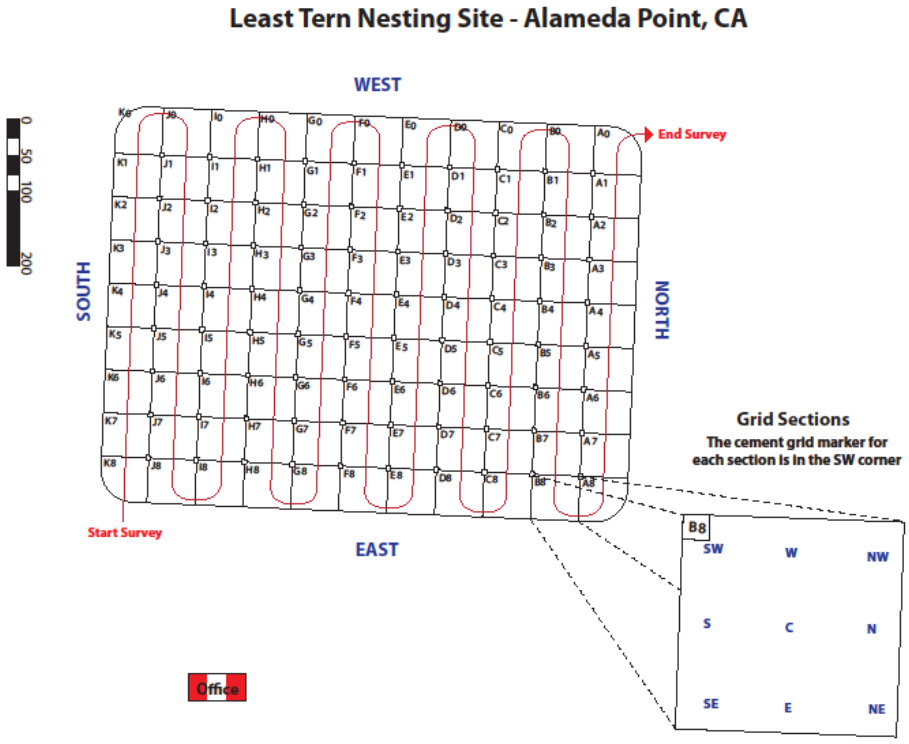
For the second year in a row, in response to continuing human health and safety issues posed by COVID-19, and potential State and county shelter-at-home orders (heretofore referred to as COVID-19 restrictions), the USFWS issued guidance on resuming limited high priority fieldwork. In spring of 2020, in order to resume fieldwork at VA Alameda Point, USFWS had to reassess our field methods and get regional approval of proposed mission essential field work activities, making sure that all personnel could accomplish their duties/goals using social distancing and other safety measures in place. Field biologists and supervisors completed COVID-19 Phased Recovery Operations Documentation (PROD) (Euing 2020). With the surge of the Delta variant, USFWS updated the PROD in spring of 2021 to again allow limited personnel to resume modified tern surveys and other fieldwork beginning in late April.

In 2021, Type 1 surveys were conducted by two monitors (USFWS and Point Blue) twice per week (Tuesdays and Fridays), between 0800 and 1600 hours, from May 21 to August 30. Type 1 surveys were weather-dependent to protect eggs and chicks from exposure. Surveys were conducted only during optimal temperature and wind conditions to prevent compromising any eggs or chicks that might become temporarily disturbed and exposed to the elements while monitors were present. If conditions were not safe for the birds (high-wind storm, rain, temperatures too high or low, etc.), a Type 1 survey would be replaced with a Type 2 survey to minimize disturbance to the birds. Fortunately, weather was agreeable for each of our Type 1 surveys this year.

Each column (A through K) contained nine grids. Each grid was marked with a cinder block grid marker at its SW corner, labelled with a unique Letter/Row designation. To conduct the survey, the two monitors stationed themselves laterally in a line at the west end of the first grid in the NW corner, spacing themselves socially and equidistant from one another. The monitors then walked forward in a sinusoidal pattern within the first column to locate all nests, eggs and chicks. The monitors walked from one fence line to the other in that column. This method was repeated in the opposite direction for the next column and so on, until all columns had been surveyed. Figure 2 shows a diagram of the

grid system.

Figure 2. Grid layout of VA Alameda Point Least Tern colony, Alameda, CA.



When a new nest was located, a sequentially numbered nest marker was placed approximately 0.6 m (2 ft.) southeast of the nest cup (Figure 3), and the new nest's location was recorded by grid and grid section. Status of each numbered nest was recorded on a datasheet, and status was checked and updated during each subsequent Type 1 survey. When a nest was deemed inactive (e.g. eggs or chicks no longer present), the nest marker was turned on its side and the nest was no longer monitored. On the few occasions that we found new eggs in an older, inactive nest cup, we simply added a new nest marker next to the old nest marker and recorded the new nest as a "shared cup" nest.

Nest markers were constructed out of 7.6 cm (3 in) diameter metal washers vertically cemented into small plaster of Paris mounds (Figure 3). The washers and bases were painted white and while still wet, the bases were coated with sand to help them blend with the substrate. A nest number was written on both sides of each painted washer with a black paint pen.

During each survey, Western Black Widow Spiders (*Latrodectus hesperus*), their egg sacs, and any webs found within the colony, were removed to reduce harm to chicks. Most spider activity was associated with the chick shelters, so all shelters were checked once per week during a Type 1 survey.

Figure 3. Nest Marker, close-up (left) and shown in use (right), Alameda, CA.

S. Euing 2009

Chick Marking

All observed chicks were categorized by age-class according to their size, proximity to nest, plumage and behavior during Type 1 surveys. The primary monitor (USFWS wildlife biologist) would train any new monitors how to visually distinguish chicks by age-class (Euing 2012). No training of new monitors was required in 2021, since only experienced monitors conducted surveys this year.

These four chick age categories were used as follows:
A = 0-2 days old (often found in the nest – all feathers downy, no pin feathers);
B = 3-13 days old (from new pin feathers emerging to fully feathered but no primary projection);
C = 14-plus days old; showing early primary projection (pre-fledge);
Fledgling = airborne; primaries full-length or nearly so; body shape tapered like adult

New chicks observed for the first time were temporarily marked to distinguish them from slightly older chicks to prevent double-counting and to insure an accurate number of hatches. In the past, even though the best efforts were made to obtain the correct number of new chicks, there was a degree of uncertainty due to active chicks moving within the colony during surveys. For example, a chick might have hatched right after monitors passed by its nest, or by the end of that day's survey, and therefore, it would not have been recorded as a new chick by monitors that day. During the subsequent Type 1 survey, this chick would be indistinguishable from chicks of the same age that were counted as new during the previous survey.

To solve this dilemma, the primary monitor found a temporary way to mark chicks safely and easily. New chicks seen for the first time were immediately marked on the crown of the head by hand with a medium-green, non-toxic, washable marker made by Crayola^{R} normally used by young children. At ground level, the monitor would block a chick to be marked with one hand and roll the marker a few strokes both forward and backward on the crown of the chick's head, until a clear mark could be seen (Figure 4).


This method was chosen for several reasons: 1) application was quick, easy, inexpensive and non-toxic; 2) very little to no handling of the chicks was required to mark, or view the mark afterward; 3) green color was chosen because, after drying a few minutes later, it blended well with the plants where the chicks sought shelter and the color did not strongly stand out against the chicks' plumage, but was detectable by the monitors; 4) the green color either faded or was covered by newer plumage within a week. The adult terns did not appear to behave any differently towards marked chicks than unmarked chicks in past years. This procedure was approved by USFWS Ecological Services and added to the current USFWS Endangered Species Recovery Permit in 2012.

Fledgling Counts and Type 2 Survey

After the first fledgling of the year was observed (July 12), we counted fledglings in the morning (between 0800-0900 hours) immediately preceding each Type 1 survey. We surveyed from outside the colony, using individual vehicles as a blind. Between two monitors, we divided the colony in half with each having designated rows and columns within which to count fledglings, using binoculars and hand-held tally counters. After searching the colony, we checked the surrounding tarmac and runways for fledglings in a similar manner, using designated sections. Throughout the breeding season, adult (and later, fledgling) Least Terns roosted on the tarmac in various locations of VA Alameda Point (Map 3). Roosting locations could change annually depending on vegetation coverage and Least Tern preferences. Feathering status was noted to discriminate between chicks and fledglings.

Type 2 surveys were conducted one to two times per week from April 26 through August 24, 2021. All but one were conducted by USFWS; one by Point Blue. Using binoculars and spotting scope, we were able to determine and record whether nests were being attended by an adult (active) or not attended (inactive).

Dropped fish collection

Dropped fish (prey that had been brought to the colony by adult Least Terns, and left uneaten on substrate), were collected and bagged during each Type 1 survey. Every week these fish were transferred to Point Blue for analysis.

Predation signs
Evidence of predation, such as feathers, body parts, broken eggs, and raptor pellets/tracks, was documented during surveys and removed from colony. Certain evidentiary items were shown to Wildlife Services to identify predator and/or prey. These items were either saved or photographed for training purposes and discarded.

Dead specimen collection for analysis
Dead Least Terns in fresh condition were counted, collected, bagged, labelled and frozen-stored at the USFWS VA Alameda Point office. These specimens will be donated to permitted institutions, such as California Academy of Sciences in San Francisco, California, if requested. Whenever a medical issue was suspected, a subset of dead Least Terns was taken to California Animal Health and Food Safety lab at University of California, Davis, for necropsy and disposition. Any carcasses unsuitable for analysis due to rapid decomposition were buried at VA Alameda Point away from the colony. Abandoned and failed-to-hatch eggs were collected during the nesting season and given to U.S. Geological Survey for future analysis. No specimens were donated in 2021.

Predator and Disturbance Monitoring
Predator activity was recorded by USFWS two days/week during surveys and on any extra, allowed visits to the colony between 0800 and 1700 hours. Wildlife Services also monitored for predators during their normal work activities. Same as in 2020, the regular crew of USFWS Tern Watch volunteers, who normally would report predator activity and their behavioral observations to the USFWS biologist, were not allowed to work at VA Alameda Point this year due to COVID-19 human health and safety restrictions

Indices of Population Size
Nesting Attempts
Total nesting attempts during the breeding season were obtained from the number of nest markers used.

Observations made during Type 1 and 2 surveys this year produced a comprehensive list of nest numbers, attendance and productivity. This list was used to estimate the number of breeding pairs, fledglings, hatched nests and nests that had been abandoned, non-viable (dead) or depredated (killed).

After the departure of the Least Terns, the location data of each nest was recorded using an iPad with the ArcCollector application for ArcGIS and partnered with a trademarked Arrow Series GNSS receiver with sub-meter accuracy and Eos Tools Pro software. These coordinates were downloaded to ArcGIS software to generate a coordinate list and a map (Map 4).

Breeding Pair Estimation
According to Massey and Atwood (1981), breeding pairs can be estimated from the nesting attempts in each surge or "wave" of nest initiation activity.
Typically, two waves occur during a Least Tern breeding season at most sites (including VA Alameda Point). The first wave (early May through mid-June) consists of older, more experienced breeders. Egg laying begins in early to mid-May, with most of the

chicks hatching by mid-June. The second wave (mid-June to early-August) is more prolonged than the first and consists of late breeders (breeding for the first time that season) and renesting pairs (laying a second nest after a failed first attempt). Egg laying starts in mid-June, with chicks hatching throughout July and possibly into August.

The number of California Least Tern breeding pairs at each colony is calculated using one of three methods described in the California Department of Fish and Wildlife report entitled "California Least Tern Breeding Survey 2017 Season" (Sin 2021). The descriptions are as follows:

"Three different calculations (Methods I, II, III) were used to determine the total number of breeding pairs at any one site. Adjustments to the total number of nests was required to estimate breeding pair totals due to pairs renesting after a failed attempt and young adults nesting later in the year (Massey and Atwood 1981).

Method I assumes the number of breeding pairs renesting is equal to half of the number of nests in the second wave, with the second wave defined as all nests initiated after 14 June (unless otherwise specified by the site monitor). If there is a period with an obvious lull in nest initiation, dates of nest initiation dictate the start of the second wave. For Method I, total breeding pairs of a site is calculated by adding the number of nests of the first wave (prior to 15 June) to half of the nests in the second wave.

Total Pairs (#nests prior to 15 June + [(#nests 15 June or after) / 2])

Method II calculates the total number of breeding pairs by subtracting the total number of nests and broods lost prior to 20 June from the total number of nests. This method assumes that renesting will not occur from a nest or brood lost after 20 June and the number of nests and broods lost before this date are equal to the number of pairs renesting at that same site.

Total Pairs (total nests - (#unsuccessful nests prior 20 June + #broods lost prior 20 June)

Method III is much more subjective, relying on the monitor to estimate of the number of renesting pairs in the first and second wave. This calculation subtracts the estimated number of renesting pairs for each wave from the total nests during each wave. The totals for waves one and two are then added to estimate the total number of breeding pairs. Adult banding can reduce the subjectivity of Method III by allowing the monitor to observe renesting pairs.

Pairs first wave (#nests prior to 15 June - estimated renesters prior to 15 June)
Pairs second wave (#nests 15 June or after - estimated renesters 15 June or after)
Total Pairs (pairs first wave + pairs second wave)

Pair estimation and total nest calculations included eggs that were laid and likely abandoned shortly thereafter, as the eggs were not observed to be incubated or attended by an adult."

In most years since 2006, USFWS estimated the number of breeding pairs at VA Alameda Point using Method I. Method I was used most frequently during relatively "normal years" where the nesting waves were clear and the renesting pairs were more defined, and to be consistent in our reporting across years. However, in years when the waves were not clearly defined, perhaps due to unusual biological events, such as those

that occurred in 2014, 2017, 2019 and 2020, Method I did not corroborate with that which was observed in the field, and more often would have resulted in an overestimation of pairs. Therefore, the biologist might use Method II or III, which are more subjective and depend on the experience of and data collection made by the biologists.

Egg and Nest Status Determination

Egg Fate

An attempt was made to record the status and contents of each nest daily. The fate of each egg was determined using the following criteria obtained from both Type 1 and Type 2 visits:

- Hatched: egg hatched, produced a chick.
- Depredated: egg was discovered broken or missing with the following evidence present prior to minimum incubation period of 19 days: the nest had not been active long enough for the egg to have hatched; there is presence of yolk or eggshell fragments with yolk in or near the scrape; and/or other animal tracks were near the scrape (Sin 2021).
- Failed-to-hatch/non-viable: egg was regularly attended by an adult within the 21-day average incubation period (Thompson *et al.* 1997), and appeared intact but did not hatch within a 35-day period after the nest initiation date. However, at least one other egg in the nest had hatched.
- Dead/non-viable: same as failed to hatch except no eggs in the nest hatched.
- Abandoned: egg was not attended by an adult for at least three consecutive Type 2 monitoring visits within the 21-day incubation period and did not hatch.
- Died while hatching: egg was discovered after hatching process began but fully-formed chick was dead inside. This is counted as an egg fate, not a chick fate.
- Probable Hatch: an egg that was incubated full term but no firm evidence of a hatch (chick, egg shells or sign of predation) was found; eggs in nearby nests have hatched and one can see marked chicks in vicinity; adult least terns are dive bombing/mobbing near the nest; and/or chick feces are present in nest cup. In these situations, the egg probably hatched and the chick was hidden somewhere (Sin 2021).
- Scavenged: egg was discovered broken or missing after maximum incubation period of 35 days and was already determined as abandoned or non-viable.

Nest Status and Fate

The status and fate of each nest was determined, using the following criteria:

- Active: a nest containing at least one egg being attended (incubated) by an adult through the expected 21-day incubation period. A nest was still considered active if an adult continued to incubate beyond the 21-day incubation period, regardless if the egg(s) were or were not viable.
- Not active: a nest containing at least one egg not being attended by an adult. Could be an abandoned nest or one in which all eggs hatched and chicks dispersed.

- 100% Hatched: all eggs in the nest were known to have hatched.
- Partially hatched: at least one egg in a two or more egg nest hatched and the remaining egg(s) did not hatch.
- Depredated: at least one egg within the nest was taken by a predator, and any remaining egg(s) were either non-viable, abandoned, or of unknown fate.
- Abandoned: no adult was attending nest for at least three consecutive Type 2 monitoring visits and thereafter, within the 21-day incubation period and no hatching occurred.
- Unknown: a nest once containing eggs that were later missing, but it could not be determined if nest had hatched, was depredated, abandoned or unviable. Unknown is only used for the final nest outcome, not interim status (Sin 2021).

Productivity and Mortality

In the majority of cases, the estimated number of fledglings was calculated by averaging the minimum and maximum fledgling numbers. The *minimum* number of fledglings produced was calculated by adding together the individual fledgling counts from each three-week period starting from the first fledgling until fledglings were no longer present, in accordance with the instructions for completing the California Department of Fish and Wildlife (CDFW) Final Report form (CDFW 2018; Sin 2021). The *maximum* number of fledglings produced was the highest possible number of fledglings mathematically. This was determined by taking the total number of hatched chicks and subtracting the dead (both depredated and non-depredated) chicks and fledglings. Fledgling production was then estimated as the average of the minimum and maximum (Elliot and Sydeman 2002). We conservatively did not include unknown fate eggs or probable hatches in the final counts of chicks. The average seemed reasonable when predator activity/predations were low and many fledglings were moving about the property, which made it challenging to count them at one time. In a few years of high predation, (2006, 2012, 2020, for example), the primary monitor determined that the average fledgling production was unreasonably high compared to the numbers of live fledglings and predators/predations actually seen in the field that year. In those cases, the minimum number of fledglings was used.

Dead chicks and fledglings were counted, recorded and collected to determine the rate of mortality and, if evident, cause of death was also noted. Chick mortality numbers were used in concert with live chick numbers to determine the hatch rate.

Management

Colony Preparation and Maintenance

Colony preparation occurred during the non-breeding months (September through April). Due to the COVID-19 restrictions, without help from volunteers, USFWS conducted all preparation work at the colony. Tasks accomplished included: making new nest markers, replacing broken grid markers with new, painted cinder blocks, weed removal, redistribution of chick shelters and shells from Pacific oysters (*Crassostrea gigas)*, enclosure security checks, removal of potential hazards to the Least Terns and realigning the grid markers. Thousands of shells and approximately 1000 chick shelters (wooden A-frames, terracotta half-round tiles) were spread throughout the colony to maximize protective cover for the chicks and fledglings. Any unsteady shelters were removed to

prevent them from collapsing on Least Terns. In the spring, the VA's contractor, Oneida Total Integrated Enterprises (OTIE) applied herbicide for weed management on the VA property, including the Least Tern colony.

Non-native vegetation, predominantly mustard species, sweet clover (*Melilotus albus*), filaree (*Erodeum spp*.) and plantain (*Plantago coronopus*) continued to invade the colony throughout the year. Any presence of Stinkwort (*Dittrichia graveolens*) and a newer species, Mare's tail (*Hippuris vulgaris*), within the colony perimeter was controlled immediately upon discovery. The presence of abundant vegetation might limit suitable nesting areas for Least Terns, which prefer open, sparsely-vegetated, sandy substrate. Vegetation provides habitat for hares, mice and other prey species, which might attract avian and mammalian predator species, as well as provide them cover. Chemical weed control was applied by qualified applicators in early April. An herbicide solution consisting of Polaris (imazapyr), Rodeo (glyphosate), and soap (bubbles used to track application) was applied with a 30-foot boom within the Least Tern colony to reduce/control invasive plants. In addition, OTIE, sprayed herbicide outside the colony's southern end from the fence to approximately 40 feet outward where Stinkwort tended to grow thickly. OTIE, under direction of the VA, also conducted vegetation removal activities on the tarmac portions of VA Alameda Point outside of the nesting colony, and selective removal of invasive plants in-field areas.

Predator Management

To reduce predation on Least Terns, the USFWS entered into an Inter-Agency Agreement with Wildlife Services to manage predator populations at the colony and surrounding VA Alameda Point property during the Least Tern breeding season. Communication methods used between USFWS and Wildlife Services included conversations in person, by phone, by two-way radio and/or written record in the site log. Wildlife Services was contacted immediately if: 1) a predator was found in the colony, 2) a predator was hunting in pursuit of Least Terns, or 3) a Peregrine Falcon (*Falco peregrinus*), American Kestrel (*Falco sparverius*) or any owl species was found within sight of the colony. Falcons and owls employ highly effective hunting methods and have a penchant for feeding upon Least Terns.

As part of Wildlife Services' predator management effort, cage traps were used for mammalian predator control outside the periphery of the colony fence and along the service road surrounding the property during the breeding season. Set traps were checked at least once per day. Mammalian predators were euthanized on site (Pyzik 2022).

Avian predator control methods included this year were nest material removal, egg removal, hazing, live trapping and relocation of avian predators, and shooting, as appropriate. Predator control efforts and results are reported to USFWS by Wildlife Services each year (Pyzik 2022).

Types of Predators

Predators and their take (killed least terns/eggs) in 2021 were reported in this document and to the California Department of Fish and Wildlife. Predators were characterized as

either “documented”, “suspected”, or “possible”, terminology used by the CDFW (Sin 2021). These predator classifications rely on the expertise of the monitors.

Documented predators required a direct observation of a predator killing a least tern/egg, or substantial evidence to indicate responsibility. This evidence could be characteristic kill technique, feeding patterns, tracks leading to a carcass, or carcass/shell remains.

Suspected predators were reported when the loss of a least tern/egg directly corresponded to the presence of a predator, but the predation was not witnessed and evidence was not substantial.

Possible predators were reported if predation of terns occurred and a potential predator was known to be on or near the site through direct observation or other signs such as tracks or scat (but their presence did not directly correspond to the predation).

RESULTS AND DISCUSSION

The following permit-required information can be found within Table 1:

- Estimated number of fledglings
- Estimated number of adults (breeding pairs)
- Fate of adults within colony
- Estimation of chick fates
- Estimation of nest fates
- Number and account of any Least Tern deaths associated with monitoring
- Number of color bands applied or observed on any Least Tern in 2021

Table 1: 2021 Summary of California Least Tern Nesting, Alameda, CA.

Date Least Terns first observed on site	08 Apr
Date Least Terns last observed on site	18 Aug
Date first nest discovered	17 May
Date last nest discovered	30 Jul
Date of first hatch	27 Jun
Date of last hatch	13 Aug
Date of first fledgling	12 July
Date of last fledgling sighting	13 Aug
Total number of nests	420
Number/ % of successfully hatching nests	325 (77.4%)
Number/% of 100% unsuccessful nests: Abandoned (35), Depredated (26), Non-Viable (26), 1DH (1), 1DH/1NV (1)	89 (21.2%)
Number/% of Nests: 100% probable hatch/unk. fate	6 (1.4%)
Estimated number of breeding pairs	357 (Method III)
Minimum number of fledglings	min=169 (max=363, avg=266)
Fledgling-per-pair ratio	min=0.47 (max=1.02, avg=0.75)
Total number of eggs	668
Clutch size: 1-egg nests	174 (41.4%)
Clutch size: 2-egg nests	244 (58.1%)
Clutch size: 3-egg nests	2 (0.5%)
Clutch size: 4-egg nests	0
Average clutch size	1.59 (± 0.50 s.d.)
Number of Eggs hatched	501 (75.0%)
Number of Eggs: probable hatch/unknown fate	18
Predation	
Eggs	31
Chicks	18
Fledglings	19
Adults	9
Unknown Age	2
Mortality (Non-predation)	
Abandoned eggs	40
Non-viable eggs* (failed-to-hatch/dead eggs)	71
Died while hatching eggs	7
Eggs unknown if attended, did not hatch	0
Dead chicks	100
Dead fledglings	4
Dead adults	2
Least Tern deaths associated with monitoring	0
Number of color bands applied or observed	0

*Non-viable eggs (NV): those that failed to hatch from a normal nest that was active full term.

Mortality

Non Predation

In 2021, there were 89 nests, representing 21.2% of the total that had fully failed. This included 35 abandoned, 26 depredated, 26 non-viable, one in which the chick had died while hatching and one of mixed cause (one chick died while hatching and second egg was non-viable). We recorded 223 Least Tern mortalities, which included 118 eggs, 100 chicks, four fledglings and two adults (Table 1). Of the 118 eggs, 40 had been abandoned, 71 were non-viable and seven died while hatching.

Out of the 501 hatches, nearly 20% died, compared to 5% in 2020. Seventy nine of the 100 chicks were under 3 days old, 20 were between 3-13 days old and fully feathered, and one was a larger pre-fledgling chick with its primary feathers projecting, which would have enabled it to fly within the week.

The loss of 100 chicks this year was similar in number to 2019, which had 102 dead chicks. Annually, we expect some chick loss due natural causes such as hyper/hypo-thermia, or malnutrition, for examples. A very young chick under 3 days of age is unable to thermoregulate for the first few days. If a parent is away for prolonged periods, then a young chick can get too hot or cold, and succumb. Some examples of prolonged periods might be a single parent leaving the nest to collect fish, parents flushing off the nest due to predator presence or other disturbance, a parent needing to fly farther distances for fish are examples of prolonged periods.

Predator birds, mainly Peregrine Falcons and Common Ravens, were seen at VAAP frequently throughout the breeding season. Peregrine Falcons were seen on 31 days between June 8 and August 24 by USFWS staff and/or WS. Often when falcons are present or hunting Least Terns, tern adults flush off their nests, sometimes up to 20 minutes at a time, leaving their eggs vulnerable. If predation pressure gets too high for the colony, we might see abandonment of some nests and chicks or, in the worst case scenario, the entire colony.

Further, the possibility of malnutrition causing death among this year's chicks might be explained by an excerpt from the 2021 Point Blue report "Dropped Prey Results and Diet Analysis", which reads:

"One notable observation about the 2021 breeding season is the late start to nesting, with an approximate one month delay (compared to most years) in the start of the chick-rearing period ... The late start to hatching was similar to 2019, although the chick-rearing period was more contracted compared to two years prior …, and the size of dropped prey collected during the chick-rearing period was smaller than prey collected in 2019 … Delayed breeding in least terns and other seabirds has been noted in periods of reduced ocean productivity (e.g., El Nino events; Massey *et al*. 1992, Ainley *et al*. 1986). While cold water conditions were noted in the tropical Pacific Ocean during the 2020-21 winter and 2021 spring prior to the 2021 least tern breeding season (Climate Prediction Center, November 2021), ocean nutrients and productivity (as measured by the North Pacific Gyre Oscillation) showed warm, less productive ocean conditions in the North Pacific during these same months (North Pacific Gyre Oscillation, November 2021).

Four fledglings were found dead in August. The first was discovered on August 3, hanging from the south fence. It appeared that something might have spooked it and it tried to fly over the fence, only to get a leg hopelessly stuck in the top of the fence. The second was found alive and well-fed on the runway on August 6 with an injured wing, which turned out to be dislocated. The wildlife biologist caught the fledgling and took it to International Bird Rescue (IBR) in Cordelia, where the bird expired on August 9. Two fledglings had been found dead, but intact (no puncture wounds or missing body parts) inside the colony on August 13.

On June 29, two intact adults were found dead inside the colony. One was lying face-down approximately 1 ft. away from a nest with two new chicks. The other was facing upward, not near any particular nest. Neither showed any obvious signs of trauma despite sightings of Peregrine Falcons in the area that week. All dead terns, except one chick that died at IBR, were buried on the property.

Predation

The number of Least Tern predations in 2021 increased by almost 44% from 2020. In 2021, there were at least 79 verified predations on Least Terns: 9 adults, 19 fledglings, 18 chicks and 31 eggs (Table 4), compared to 55 in 2020.

Peregrine Falcons were documented (direct observation and/or physical evidence) taking five adults, 19 fledglings, three chicks and two terns of unknown age. They were strongly suspected of taking three more adults and eight chicks because of frequent sightings near the time of the kills and the behavior of the Least Terns towards falcons (seen by observers). Peregrine Falcons were the probable predators of one adults and seven chicks. Common Ravens (*Corvus corax*) were suspected of taking five eggs and were the probable predators of 26 more eggs (Table 2). Ravens were observed in person and on camera, in the colony searching for eggs just prior to the discovery of the first five missing eggs, and ravens were seen over the property and colony around the time of the loss of 26 more eggs. Four cameras were deployed by Point Blue for one week, May 25 to June 1 (Elliott 2021). No mammalian predators have been seen in or near the colony during the breeding season.

Table 2. 2021 List of documented, suspected and probable Predators of Least Terns at VA Alameda Point, Alameda, CA.

Least Tern Age	Peregrine Falcon	Common Raven	Totals
Unknown Age	2D		2
Adult	5D, 3S, 1P		9
Fledgling	19D		19
Chick	3D, 8S, 7P		18
Egg		5S, 26P	31
Total depredations	48	31	79

*Note: depredations are separated out as D = documented; S = strongly suspected; P = probable predator

Fledgling to Breeding Pair Ratio

Estimation of fledglings

In 2021, the maximum and minimum number of fledglings were 360 and 169, respectively, with an average of 265. However, this year, we considered the minimum number of fledglings (169) as the most realistic number. Considering that USFWS and WS observed a high number of predators during Type 1 and 2 surveys and work shifts, it is highly likely that predations were also occurring when we were not present. The minimum number of fledglings, reflecting our actual observations, was a more credible estimate this year.

Estimation of Breeding Pairs

It was challenging determining the end of the first wave in 2021. California Department of Fish and Wildlife assumes June 15 to be the default division between nesting waves for most California Least Tern colonies, usually 1-2 weeks after the first hatches (Sin 2021). This year, between April 26 and May 24, an average of eight (range 0-45) Least Tern adults per day flew over and/or landed in the colony. In normal years, there would be a daily increase of arriving terns starting in April. By early May, over 100 terns would have arrived and begun courtship/breeding, with the earliest nests having been laid in first half of May.

In 2021, the first nests were discovered on 17 May, even though only two adults were observed that day. From outside the colony during a Type 2 survey, the wildlife biologist observed a nest with no adult nearby. She walked through part of the colony, and discovered seven nests in total and marked them. No new nests were discovered between May 17 and the end of May. One of the original seven had an adult incubating it beginning May 25, but the final outcome of the nest was non-viable. On June 1, there were approximately 50-60 adult terns around the colony, exhibiting normal breeding season activity. Ten new nests were found that day and were being incubated by adults. From that point on, adult tern numbers increased and the breeding season progressed through middle of August. The wildlife biologist estimated the date of the end of the first wave as July 6.

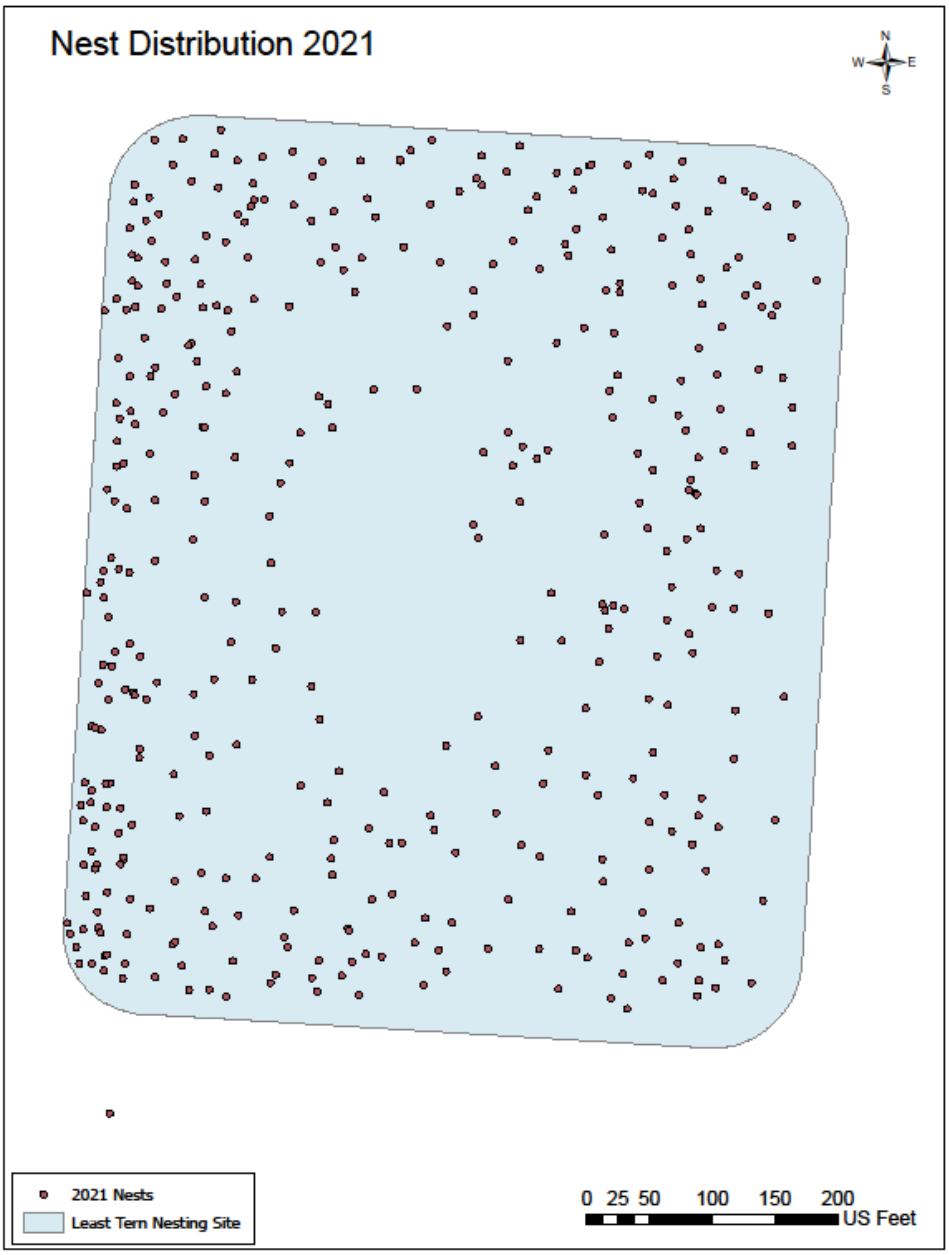
In 2021, Method III was used to determine estimated breeding pairs for three reasons: 1) the result most closely represented that which we observed in the field, 2) Method II's calculated result matched Method III's result and 3), Method I's result seemed unreasonably high compared to field observations.

According to Method III and using July 6 as end of first wave, estimated breeding pairs were calculated as follows:
(402 nests - 56 failed nests - 7 broods lost) + (18 nests - 0 failed nests - 0 broods lost) = 357 breeding pairs.

The fledgling to breeding pair ratio was calculated as 169 fledglings/357 pairs = 0.47.

Map 4 displays the distribution of nests within the colony in 2021. An open area in the center was unusual and notable. In prior years, nests were distributed more evenly throughout the colony.

Map 4. Least Tern Nest Distribution in 2021, Alameda, CA.



Personnel Hours 2021

Table 3 displays the number of hours spent by USFWS personnel and partners conducting surveys during the Least Tern breeding season, April 26 to August 30, 2021. Table 4 displays the number of hours spent by USFWS personnel and partners preparing the Least Tern and Caspian/Elegant Tern colony sites prior to the 2021 breeding seasons. Included in this latter category are weed removal by hand and chemical means, redistributing chick shelters and oyster shells, and calibrating/resetting grid markers. The combined total hours from Tables 3 and 4 are 566 hours.

Table 3. Staff and Partner Hours Spent Conducting Surveys, September 2020-August 2021: Types1 and 2, Gull nest removals and Monthly Bird, Alameda, CA.

Type 1 and 2 Surveys	
GS-9 USFWS Biologist	127 hours
USFWS Staff (Point Blue)	87 hours
Other USFWS staff	25 hours
USFWS Bio interns	8 hours
Data Input – 2 people	40 hours
	subtotal: 287 hours
Volunteer Monthly Bird Surveys	**subtotal: 70 hours**
California Gull nest removal	
GS-9 USFWS Biologist	5 hours
USFWS Staff	4 hours
	subtotal: 9 hours
Personnel Hours for 2021	**Total: 366 hours**

Table 4: Staff and Partner Hours Spent on Colony Maintenance and Repairs, September 2020-April 2021, Alameda, CA.

Colony Maintenance/ Repairs	
GS-9 USFWS Biologist LETE colony	96 hours
USFWS Staff	88 hours
OTIE contractor inside LETE colony	16 hours
Personnel Hours for 2021	**Total: 200 hours**

Prior to 2020, USFWS supervised monthly volunteer work parties to help prepare the Least Tern colony every second Sunday from September through April. However, for the second year, COVID-19 health and work restrictions shut down work from being done by volunteers at VA Alameda Point from March through mid-June, 2021. In 2021, USFWS staff completed the preparation work of the Least, Caspian and Elegant Tern colonies. Susan Euing and Meredith Elliott conducted all the Type 1 and 2 surveys.

Other Studies at VA Alameda Point

Point Blue Prey Diet Study

USFWS and Point Blue staff collected dropped fish found inside and immediately outside the Least Tern colony throughout the breeding season for analysis at Point Blue's lab in Petaluma, California. Point Blue prepared and categorized the fish by species, size, weight and condition, and comparisons were made across years. An annual report was presented to the USFWS Alameda office. Point Blue staff also collected Least Tern chick fecal material from plastic sheets placed below chick shelters in order to extract

otoliths (bone-like structure in inner ear of fish) and scales within the feces to determine the composition of fish that were consumed. Moreover, the Point Blue scientist, using a very keen eye, was able to find expelled pellets from adult Least Terns, in which fish parts could be extracted to determine fish species/families consumed. The aim was to test the null hypothesis that there were no differences in species composition and size of consumed prey between years 2008 to 2021. If the null hypothesis was proven wrong, then the aim would be to describe how the diet has differed inter-annually (M. Elliott, personal comment). These studies combined tell us what prey is being brought to the colony and what species are being consumed by different ages of Least Terns annually. These studies will be on-going as time, personnel and resources allow.

Other nesting species at VA Alameda Point

This year marked the third time that Elegant Terns (*Thalasseus elegans)* have nested in Northern California (San Francisco Bay Area). Before 2019, Elegant Terns were known to nest in Southern California and Mexico (Burness, et.al, 1999). According to Michael Horn, a biology professor at California State University, Fullerton, who has been studying Elegant Terns for several years, said it is fairly common for this species to nest alongside Caspian Terns (*Hydroprogne caspia*), probably because Caspian Terns are larger and more aggressive towards intruders to the colony (Horn personal comments).

In 2020, the VA funded a joint project with USFWS to remove invasive plants from the Caspian Tern (CATE) and Elegant Tern (ELTE) colony on site IR-2, in the western section of VA Alameda Point (Map 3). After USFWS flagged off the areas to be sprayed, OTIE applied herbicide in the winter to open up more sand for nesting. Several killed weeds were manually removed and the sand raked smooth by WS to finalize the preparation of the nesting colony. In 2021, much of the sand still remained open with dead iceplant (*Carpobrotus edulis*) along the edge. No spraying, weed removal or raking was necessary this year.

On March 16, 2021, S. Euing (USFWS), from outside the colony observed the first CATE adults at VA Alameda Point on the nesting beach in IR-2. First CATE nests were discovered from inside the colony on April 9. The first ELTE adults were observed on April 15, the same day that the first ELTE nests were discovered. First CATE chicks hatched on May 5; first ELTE chicks hatched on May 14 (Table 5).

The CATEs and ELTEs continued to benefit from the 2020 expansion of their nesting area, and were successful in producing fledglings at VA Alameda Point in 2021. For the third year, we counted at least 1500 Caspian and Elegant Terns, collectively, occupying the nesting beaches in the IR-2 this year.

Two USFWS biologists entered the CATE/ELTE colony 16 times between April 9 and May 28. Elegant terns nest very close to one another (~1-1.5ft between nests), and as the colony grew, nest counting took more time. As chicks became more mobile, our extended presence was increasing their stress levels; therefore we opted to photograph the ELTE nesting colony once and counted nests from photos taken on May 10. We stopped entering the colony on May 28. Despite lack of volunteer help and staff time, we were able to do infrequent surveys (snapshots) in June through August to count adults, chicks, and nests from outside the colony. Counting ELTEs was very challenging as they nested,

roosted and surrounded their chicks/fledglings in very tight groups in the colony; therefore, counts were most likely lower than actual. Table 5 displays ELTE highlights from 2021.

Table 5. 2021 Elegant Tern observations at IR-2, VA Alameda Point, Alameda, CA

Count	Date	Number	Observed by:	Comment
First ELTE nests observed	4/15/2021	7 adults 2 nests	S Euing & J Sellers	Viewed from within colony (ELTE adults not seen until this day)
ELTE nest counts	4/26/2021	138 nests	S Euing & J Sellers	Viewed from within colony
ELTE nest counts	4/28/2021	210 nests	S Euing & J Sellers	Viewed from within colony
ELTE nest counts	4/30/2021	292 nests	S Euing & J Sellers	Viewed from within colony
ELTE nest counts	5/3/2021	250 nests+	S Euing & J Sellers	Partial count of ELTE nests
Peak # of ELTE nests during first wave	5/10/2021	412*	S Euing & J Sellers	Estimated from photos taken from within colony. Ocular counts too difficult at this time.
CATE nest counts	5/12/2021	452	S Euing & J Sellers	ELTEs no longer counted (CATE nests only counted on this day)
First ELTE chicks observed	5/14/2021	30-40*	S Euing & J Sellers	Viewed from within colony
Snapshot count of adults/chicks	6/4/2021	409 adults 8 chicks*	S. Euing/M. Elliott	Viewed using binoculars outside colony from berm (250-400' away)
Snapshot count of adults/fledglings	7/10/2021	1,005 adults 271 fledglings*	J. Luther/L. Feeney	Viewed using binoculars outside colony from berm (250-400' away)
Snapshot count of adults/fledglings	8/18/2021	40 all ages	S. Euing	Viewed using binoculars outside colony from berm (250-400' away)

*estimated

CONCLUSIONS

In conclusion, the VA Alameda Point Least Tern colony had a less successful year of reproductive success in 2021, demonstrated by minimum 0.47 fledgling-to-breeding-pair ratio, compared to 2020's ratio of 0.81. Looking at Table 6, from 2017-2021, with the exception of 2019, nesting started within the first three weeks of May, and last nests were laid between July 13 and 30. First hatch dates were more spread apart (May 26 to June 28) between those five years.

Predator birds, mainly Peregrine Falcons and Common Ravens, were seen at VAAP frequently throughout the breeding season, during which 79 Least Tern losses by predation were recorded. Least Tern adults flushed from nests when predators were detected, leaving nests and chicks vulnerable.

This year's nesting season duration (from first incubated nests to last least tern to depart VAAP) was three weeks shorter than the average of 14 weeks. Adults were not present and incubating during May, when normally we'd see Least Terns bringing back Chinook salmon (*Oncorhynchus tshawytscha*) to the colony in that month. High Omega-3 fish, such as salmon, may be important for incubating seabirds and their eggs. According to Bond and Diamond, Arctic Terns (*Sterna paradisaea*) and Common Terns (*Sterna hirundo*) use locally derived nutrients for egg production. This might be true for Least Terns as well. Furthermore, according to Elliott 2021, "delayed breeding in least terns and other seabirds has been noted in periods of reduced ocean productivity". Reduced forage (fish availability or frequency of delivery to chicks) might help explain the high percentage of dead chicks in 2021

There were aspects of the 2021 breeding season that had negatively affected productivity and breeding success (Tables 6-8):

- Decreased hatching success rate: eggs 75.0% and nests 77.4%, compared to 82.3% and nests 86.2%, respectively, in 2020.
- Average clutch size decreased by 16.3% in 2020.
- Number of nests that completely failed (abandoned/depredated/dead/died hatching) increased by 50.8% from 2020 to 2021.
- Higher percentage of one-egg nests, and lower percentage of two-egg nests, compared to 2020.
- Number of non-viable eggs (failed-to-hatch and dead) and died-hatching increased by 20.3% and 600%, respectively.
- Chick mortality increased in 2021 (20.0%), compared to 2020 (4.6%)
- Collective number of predations of Least Tern eggs, chicks, fledglings and adults increased by 43.6% from 2020.
- Adult Least Terns produced an estimated minimum 169 fledglings, compared to estimated minimum 289 fledglings in 2020, a 41.5% decrease.

However, despite the challenges presented, there were positive aspects leading to

continued success of the VA Alameda Point colony (Tables 6-8):

- Estimated number of breeding pairs decreased only slightly by 0.6%.
- The number of probable hatches decreased by 33.3%, from 2020.
- Number of abandoned eggs decreased by 28.6% in 2021, from 2019.
- Experienced management and oversight by USFWS and VA was continued.
- Experienced predator management by Wildlife Services was continued.

In 2021, VA Alameda Point Least Tern colony has shown an overall trend towards growth (approx. 6.83% per year). Growth has declined slightly from last year's 6.84% annual growth rate and appears to have flattened (M. Elliott, pers. comm).

VA Alameda Point's overall success is due, in part, to the management strategy, which includes monitoring, protection, and predator management provided by the VA, USFWS, and USDA Wildlife Services.

Table 6: Rolling Five-Year Comparison of California Least Tern Nesting Parameters, Alameda, CA.

Least Tern Breeding Season	**2017**	**2018**	**2019**	**2020**	**2021**
Date Least Terns first observed on site	13 Apr	18 Apr	17 Apr	22 Apr	8 Apr
Date Least Terns last observed on site	17 Aug	28 Aug	29 Aug	10 Aug	18 Aug
Date first nest discovered	4 May	12 May	04 Jun	13 May	17 May
Date last nest discovered	13 Jul	24 Jul	16 Jul	13 Jul	30 Jul
Date of first hatch	26 May	5 Jun	28 Jun	5 Jun	27 Jun
Date of last hatch	24 Jul	6 Aug	6 Aug	3 Aug	13 Aug
Date of first fledgling	16 Jun	21 Jun	19 Jul	23 Jun	12 Jul
Total number of nests	447	375	345	435	420
Number of successfully hatching nests	322	282	266	375	325
Number of Nests: 100% unsuccessful	125	93	79	59	89
Number of Nests: 100% probable hatch/unk. fate				1	6
Estimated number of breeding pairs	318	321	311	359	357
Minimum number of fledglings	182	190	182	289	169
Fledgling-per-pair ratio	0.79	0.76	0.73	0.81	0.47
Total number of eggs	697	595	544	827	668
Clutch size: 1-egg nests	206	156	148	68	174
Clutch size: 2-egg nests	232	232	196	342	244
Clutch size: 3-egg nests	9	1	0	25	2
Clutch size: 4-egg nests	0	0	1	0	0
Average clutch size	1.56	1.57	1.58	1.90	1.59
Number of Eggs hatched	504	439	424	681	501
Number of Eggs: probable hatch/unknown fate	9	6	3	27	18
Predation					
Eggs	4	7	4	3	31
Chicks	3	21	1	13	18
Fledglings	6	19	8	31	19
Adults	5	17	12	8	9
Unknown Age	0	0	0	0	2
Mortality (Non-predation)					
Abandoned eggs	95	60	56	56	40
Non-viable eggs (failed-to-hatch/dead eggs)	72	82	49	59	71
Died while hatching eggs	13	1	8	1	7
Dead chicks	175	95	141	31	100
Dead fledglings	1	4	1	8	4
Dead adults	5	0	0	1	2
Least Tern deaths associated with monitoring	0	0	0	0	0
Number of color bands applied or observed	0	0	0	0	0

Table 7. California Least Tern Nests, Pairs and Fledglings at VA Alameda Point: 2002-2021, Alameda, CA.

Year	Number of Nesting Attempts	Breeding Pairs*	Minimum # of Fledglings observed	Fledglings per pair^
2002	326	287	104	0.36
2003	368	301	104	0.35
2004	440	379	155	0.40
2005	550	424	140	0.40
2006	441	409	9	0.02
2007	394	355	184	0.52
2008	336	323	365	1.13
2009	346	318	253	0.80
2010	320	302	221	0.73
2011	355	329	179	0.54
2012	382	347	17	0.05
2013	292	276	215	0.78
2014	341	294	313	1.06
2015	351	328	330	1.03
2016	403	358	586	1.64
2017	447	318	182	0.79
2018	375	321	190	0.76
2019	345	311	182	0.73
2020	435	359	289	0.81
2021	420	357	169	0.47

***** Estimating number of breeding pairs.
^Ratio = Minimum # of fledglings/estimated number of breeding pairs

Table 8: Comparison of California Least Tern Egg Number per Nest from 2014-2021, Alameda, CA.

YEAR	2014	2015	2016	2017	2018	2019	2020	2021
1-Egg Nests	40 (12%)	49 (14%)	44 (11%)	206 (46%)	156 (42%)	148 (43%)	68 (16%)	174 (41%)
2-Egg Nests	256 (75%)	276 (79%)	302 (75%)	232 (52%)	218 (58%)	196 (57%)	342 (79%)	244 (58%)
3-Egg Nests	45 (13%)	26 (7%)	57 14%)	9 (2%)	1 (1%)	0 (0%)	25 (6%)	2 (1%)
4-Egg Nests	0	0	0	0	0	1 (0.3%)	0	0
# of Nests	341	351	403	447	375	345	435	420
Avg Clutch Size (#eggs/ nest)	2.02 (± 0.50 s.d.)	1.93 (± 0.46 s.d.)	2.03 (± 0.50 s.d.)	1.56 (± 0.54 s.d.)	1.59 (± 0.50 s.d.)	1.58 (± 0.51 s.d.)	1.90 (± 0.47 s.d.)	1.59 (± 0.50 s.d.)

RECOMMENDATIONS

For USFWS:

1. Continue Type 1 (2 x per week) and Type 2 (3-4 x per week) surveys for monitoring of the VA Alameda Point California Least Tern colony.

2. Continue with all current methods for monitoring and protecting the California Least Terns at their breeding colony at VA Alameda Point (see Methods section of this report). Make annual adjustments and improvements as needed.

3. Continue predator management, under an Inter-Agency Agreement with Wildlife Services. Encourage additional experimentation with different trap/relocation methods for avian predators. Continue partnership agreements with wildlife hospitals or rehabilitation centers prior to breeding season to hold in captivity any avian predators until they can be relocated, or until the end of the tern nesting season.

4. Follow the conditions and protocols for Peregrine Falcon management at VA Alameda Point, which are listed in the Memorandum of Understanding (MOU) between the California Department of Fish and Wildlife and the United States Department of Agriculture, Animal and Plant Health Inspection Services, Wildlife Services.

5. Maintain and continue to use a minimum of 1,000 chick-friendly shelters (half-cylindrical terracotta tiles, wooden A-frames, oyster shells) distributed throughout the colony to provide protection from weather and predators for Least Terns. For the grid system and as secondary chick shelters, continue using cinder blocks, lying on their short sides to be less attractive as predator perches.

6. Continue to mark nest locations using a GPS device, which provides important nest distribution data that can be compared from year to year.

7. Continue close communication with Wildlife Services and Tern Watch volunteers to locate and monitor avian predator roosting sites on VA Alameda Point prior to and during the breeding season. Continue the use of a site log to aid in communication between tern monitor(s) and predator management personnel. The site log should remain in the field station.

8. During non-pandemic times, continue to record all aircraft disturbances to the tern colony, and report small aircraft disturbances to law enforcement as soon as possible.

9. Continue close communication with East Bay Regional Parks Police by radio or landline to report human trespassing/disturbance/vandalism issues.

10. When it is safe to do so, continue the Tern Watch volunteer predator monitoring program, keeping them fully trained and updated annually. Encourage volunteers

to get involved with the VA Alameda Point Least Tern colony through outreach to maintain a minimum of 40 volunteers in the program.

11. Between sand delivery years, rent a grader and hire an operator to smooth out the sand inside the colony which shifts and blows outside the colony from the high winds each year.

For VA:

12. Use herbicide to remove/suppress as much in-colony vegetation as possible, preferably in late March, before the arrival of the Least Terns. In addition, apply pre-emergent herbicide in late fall/early winter if time, weather and funding permit.

13. Continue to conduct annual or bi-annual weed monitoring and management outside the colony. Tarmac immediately adjacent to colony and roosting areas should be kept clear of vegetation. Adult and fledgling Least Terns use these areas to loaf (roost), and the openness aids in predator detection by Least Terns. Vegetation on the remaining areas of tarmac should be kept clear as much as possible to reduce cover for predators, and to aid Wildlife Services in detection and removal of predators. Grassy areas should be mowed and kept to a maximum height of six inches.

14. Maintain existing boards along the bottom of the colony fence along the south and a portion of the east side of the colony by checking each board's integrity and any gaps under the boards or on the wire mesh attached in space between boards.

15. Continue efforts to remove/control and prevent further spread of stinkwort (*Dittrichia graveolens)* a highly invasive annual herb, not native to California. This species frequently grows in cracks and disturbed areas and forms monocultures that cause serious problems in native ecosystems, and spreads readily to the tern colony. Preventive measures should be done annually to control this species from costly spread.

16. Control other invasive plants, such as Mare's Tail (*Hippuris vulgaris)*, mustard species (*Brassica* or related species) and Pampas Grass (*Cortaderia selloana*), that are already present at VA Alameda Point and easily spread and expand throughout the site. Their roots can break up tarmac, causing additional weed problems, which can threaten the nesting site.

17. As needed, trim trees and willow patches to reduce predator perches and allow Wildlife Services access for scouting these areas for avian predators and nests.

18. Increase security around the VA Alameda Point property to deter trespassing and increased nuisance behaviors especially during the Least Tern breeding season. Recommend that all fence lines surrounding the property be strengthened and maintained, including those extending into the bay.

19. Provide funding for additional sand substrate to be added and graded to maintain a three-inch depth throughout colony. Approximately five acres are below three-inch depth at this time. Over time, winds blow away the sandy substrate, thus, exposing the underlying tarmac.

20. Make signs that say "no drone or remote-controlled device use" and "no trespassing" and attach them to north and east fence lines of the VA Alameda Point property.

21. Commit funding for contractors to spray and physically clear the nesting beaches for the Caspian and Elegant Terns in the West Wetlands (IR-2) every 2-3 years.

22. Work with the Federal Aviation Administration (FAA) to make VAAP a restricted fly-over zone due to sensitive nesting species (minimally from April 1 through September), and adding this designation to aircraft pilot charts. Painting the tarmac at the north and south ends of the property with a "No-Fly-Zone" message on the north and south ends would be encouraged.

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