CALIFORNIA LEAST TERN

(Sternula antillarum browni) (= Sterna a. b.)

5-YEAR REVIEW:

Summary and Evaluation

California least tern (*Sterna antillarum browni*). Photo credit: Matt Sadowski (least tern monitor).

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
Carlsbad, California

July 7, 2020

5-YEAR REVIEW

California Least Tern
(Sternula antillarum browni)

I. GENERAL INFORMATION

Purpose of 5-year Reviews:

The U.S. Fish and Wildlife Service (USFWS) is required by section 4(c)(2) of the Endangered Species Act (Act), as amended, to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since listing (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

The California least tern (*Sternula antillarum browni) (= Sterna a. b.*) is a subspecies of the least tern, a colonially nesting seabird. The California least tern was federally listed in 1969 under the Endangered Species Preservation Act of 1966; later, it was considered an endangered species under the Act. The State of California, pursuant to the California Endangered Species Act, listed the species in 1971.

Historically, the California least tern was considered abundant along the California coast. At the time of listing, the California least tern was known to nest at 15 sites in the United States, from San Mateo County to San Diego County, California. Shortly after listing it was estimated that only 256 pairs remained. Since listing, the minimum number of pairs steadily increased to over 7,100 pairs in 2009. In 2016, fledglings were observed at 21 nesting areas, and the breeding population estimated at 3989 pairs (Frost 2017). Preliminary estimates of 4095 pairs in 2017 were reported at 29 nesting areas (Sin 2019, pers. comm.). Surveys of the Pacific coast of the Baja California Peninsula documented 300 nesting pairs at eight nesting areas in 2018. The primary threats at the time of listing were development of nesting sites, disturbance, off-road vehicle use, and predation. Many of these threats are ongoing, but existing conservation measures have helped to reduce impacts. Despite these efforts, the California least tern remains a conservation-reliant species (Scott *et al*. 2010).

Methodology Used to Complete This Review:

The Carlsbad Fish and Wildlife Office prepared this review. We used survey information from experts who monitor nesting populations of the California least tern, information from published literature, and information from experts on the species.

This 5-year review contains updated information on the species' biology and threats, and an assessment of information compared to that known at the time of listing and since the last 5-year review. We focus on current threats to the species pursuant to the Act's five listing factors. This review synthesizes this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in performing the five-factor analysis, we herein recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

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Federal Register Notice Citation Announcing Initiation of This Review:

A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the *Federal Register* on June 18, 2018 (USFWS 2018, p. 28252). We received three responses with information relevant to the California least tern, which is incorporated in this review.

Listing History:

__Federal Listing__

FR Notice: 34 FR 5034 (USFWS 1969)*

Date of Listing: March 8, 1969

Entity Listed: California least tern (*Sternula antillarum browni*),[†] a subspecies of the least tern (*Sternula antillarum*)

Classification: Endangered
* The California least tern was first listed under the Endangered Species Preservation Act of 1966. Coverage was continued under the Endangered Species Conservation Act of 1969 and the Endangered Species Act of 1973.
[†] The scientific name currently used in the List of Endangered and Threatened Wildlife (50 CFR 17.11) is *Sterna antillarum browni*; see the Changes in Taxonomic Classification or Nomenclature section for more details.

<u>State Listing</u>

The California least tern was listed by the State of California as endangered in 1971.

Associated Rulemakings:

None

Review History:

The Service initiated 5-year status reviews for the California least tern in 1979, 1985, and 1991 (USFWS 1979, p. 29574; 1985a, p. 29906; 1991, p. 56886); all reviews were completed with no recommended change in status. Another 5-year review for the California least tern, completed in 2006, recommended a status change from endangered to threatened (USFWS 2006, p. 22). The Service also completed a Species Report for the California least tern in 2014 (USFWS 2014).

Species' Recovery Priority Number at Start of 5-year Review:

The recovery priority number for the California least tern is 15C, based on a 1 to 18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (USFWS 1983a, pp. 43098–43105; 1983b, p. 51985). This number indicates the listed entity is a subspecies that faces a low degree of threat and has a high potential for recovery. The "C" indicates conflict with construction or other development projects, or other forms of economic activity.

Recovery Plan or Outline:

Name of recovery plan: Revised California Least Tern Recovery Plan

Date: September 27, 1985

Date of previous revisions: April 2, 1980

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy:

The Act defines "species" as including any subspecies of fish or wildlife or plants, and any DPS of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. The 1996 *Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act* clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act (USFWS 1996, p. 4722).

The California least tern is listed as a subspecies and not a DPS. However, an article has challenged the distinctiveness of several least tern subspecies (Draheim *et al*. 2010, pp. 815–816). Discussion of the applicability of the article and its possible effects on least tern subspecies is ongoing (see the *Subspecies-level Taxonomy* section below). As summarized by Patten and Erickson (1996, pp. 888–890), the currently recognized five subspecies include: *Sternula antillarum antillarum* (eastern least tern) that breeds along the Atlantic and Gulf Coasts; *S. a. athalassos* (interior least tern) that breeds in interior United States; *S. a. browni* (California least tern) that breeds along the Pacific Coast of California and the west coast of the Baja California Peninsula; *S. a. mexicana* (no accepted common name, although Mexican least tern is sometimes used) that breeds along the Pacific Coast of northern mainland Mexico and east coast of the Baja California Peninsula; and *S. a. staebleri* (no accepted common name) that breeds along the Pacific Coast of southern Mexico.

For the purposes of this status review, we will continue to recognize the California least tern as a distinct subspecies, noting that a review of taxonomy and possibly a DPS analysis may be necessary in the future.

Information on the Species and its Status:

Species Description

California least terns weigh approximately 40–50 grams (1.4–1.8 ounces), have an average length of 21–23 centimeters (cm) (8.3–9.0 inches (in)), and a wingspan of 48–53 cm (19–21 in) (Thompson *et al.* 1997, p. 2). Adult California least terns are characterized by white underparts; light-gray back and wings; short, orange-yellow legs; a straight, pointed bill that is mostly yellow except for a black tip; and a white, shallowly forked tail (USFWS 1985b, p. 2). Adults in breeding plumage have a black crown and nape, and a black line that extends (anteriorly) through the eye to the bill. The black crown and eye-line frames a distinctive white patch on the forehead that extends from the bill to the forecrown and continues back (posteriorly) forming a point over each eye. Immature birds have darker plumage with a less distinct smudgy crown and a black bill.

Species Biology and Life History

California least terns feed primarily on small fishes captured in estuaries, embayments, and shallow, nearshore waters, particularly at or near estuaries and river mouths (Massey 1974, p. 5;

Collins *et al.* 1979, pp. 10–11; Massey and Atwood 1982, p. IV-2; Atwood and Minsky 1983, pp. 63–64; Atwood and Kelly 1984, p. 36; Minsky 1984, pp. 12, 27; Copper 1986, p. 27) and on occasion krill and other invertebrates (Lewison and Deutschman 2014, p 4). The depth of the water where the species forages is generally less than 8 meters (m) (25 feet (ft)) (Massey and Atwood 1982, Table IV-1; Baird 1997, p. 141). California least terns primarily forage on juvenile or larval anchovies (Engraulidae: deep-bodied anchovies (*Anchoa compressa*), slough anchovies (*A. delicatissima*), and northern anchovies (*Engraulis mordax*)), and on silverside smelt (Atherinidae: topsmelt (*Atherinops affins*), and jacksmelt (*A. californiensis*)), that are less than 9 cm (3.5 in) long and occur in the upper 15 cm (6 in) of the water column, the depth that California least terns plunge-dive (Massey 1974, pp. 5–6; Atwood and Kelly 1984, Table 3 and pp. 37, 46; Furness and Monaghan 1987, p. 27; Baird 1997, pp. 75, 153; Thompson *et al.* 1997, p. 7). Chicks consume smaller food items (less than 4 cm (1.6 in) long) than adults or juveniles (Zuria and Mellink 2005, p. 175; Ehrler *et al.* 2006, pp. 1-1, 3-1, and Figure 9).

The California least tern nests primarily between May and August (Massey and Atwood 1981, pp. 598–599). In recent years, birds have arrived at nesting sites in the last week of March (Sin 2018, pers. comm.) to the first or second week of April (Marschalek 2010, p. 7; 2011, p. 7; 2012, p. 7). Breeding commences at 2 to 3 years of age (Massey and Atwood 1981, p. 599). An ongoing study in San Diego Bay found adults of up to 23 years of age at breeding sites, with an average breeding age of 9 years in recent seasons (Patton 2011, unpubl. report). California least tern nesting is typically characterized by two waves of nest initiation (Massey and Atwood 1981, pp. 598–599). Early season nesting attempts are made primarily by experienced breeders and are completed by mid-June. A second wave of nesting, composed of some birds that re-nest after their initial nests fail and young birds nesting for the first time, usually occurs from mid-June to early August (Massey and Atwood 1981, pp. 598–599 and Table 1). These two distinct waves of nesting occur only in some years and only at some nesting sites (Keane 1998, p. 4; Marschalek 2011, p. 23); in recent years, the pattern has been less apparent across the range of the species. California least terns exhibit a high degree of nest site fidelity from year to year. Individuals often return to breed where they previously bred successfully or to their natal sites (i.e., where they hatched) significantly more than would be predicted if birds nested randomly (Atwood and Massey 1988, pp. 391–393).

The nest of the California least tern is a simple scrape or depression in the sand that the birds sometime adorn with small fragments of shell or pebbles. Chicks are semi-precocial, meaning they are covered in down and out of the nest scrape at 1 to 2 days of age, but not able to feed themselves (Thompson *et al.* 1997, p. 20). The cryptically colored chicks will hide from predators by either flattening to the ground or, when they are older (i.e., 7 to 14 days), moving under structures (Massey 1974, pp. 17–18). Parents protect the eggs and chicks from weather and predators, and provide food to chicks and fledglings until they are proficient foragers.

California least terns typically forage within 1.6 to 3.2 kilometers (km) (1 to 2 miles (mi)) of their nest site, although foraging up to 8 km (5 mi) from nest sites has been occasionally documented (Atwood and Minsky 1983, Table 5 and pp. 62–63, 70). Parents typically forage close to their nest sites and make more frequent trips to find smaller fish needed by the chicks during brood rearing (Atwood and Minsky 1983, pp. 64, 70; Atwood and Kelly 1984, pp. 36, 38; Minsky 1984, p. 28; USFWS 1985c, pp. 11–12; Copper 1986, p. 28; Zuria and Mellink 2005, p. 175; Ehrler *et al.* 2006, pp. 3-6, 4-1, 4-6). Prior to migrating south, fledglings and attendant adults are often observed at various shallow, fresh, or estuarine marshes characterized by calm water where juveniles can develop their foraging skills prior to the demands of migration (Atwood and Minsky 1983, pp. 63–64, 70; Minsky 1984, p. 28). Least terns appear highly opportunistic in the selection of foraging areas, with the location of foraging areas strongly linked to food availability (Atwood and Minsky 1983, p. 64; Minsky 1984, pp. 28–29). Certain areas may receive consistently higher levels of use, suggesting that some localities may be of greater importance (Atwood and Minsky 1983, p. 64).

Spatial Distribution

The subspecific status of Pacific coast least terns has been questioned (see the Changes in Taxonomic Classification or Nomenclature section, below). Depending on the interpretation, the California least tern subspecies could potentially include one or both of the other described subspecies of least tern that nest along the coastal periphery of the Sea of Cortez and the Pacific coast of mainland Mexico. Given that this question remains unresolved in the scientific literature, we continue to recognize the traditional circumscription of the California least tern. As such, the nesting range of the California least terns is predominantly the California coast and the Pacific coast of the Baja California Peninsula, Mexico (Massey and Atwood 1981, pp. 598–599). The vast majority of breeding California least terns nest in the United States; the rest nest along the Baja California Peninsula (Figures 1, 3).

Historically, the recorded breeding range of the California least tern extended along the Pacific coast from Moss Landing, Monterey County, California, in the north, to San Jose del Cabo, in the state of Baja California Sur, Mexico in the south (Dawson 1923, p. 1459; Grinnell 1928, p. 63; Grinnell and Miller 1944, p. 175; American Ornithologists' Union (AOU) 1957, p. 239). Within the United States, the California least tern was known from nesting sites located within or near 15 nesting bays, estuaries, or beaches at the time of listing in 1969. Nesting sites extended from Bair Island in San Mateo County to the Tijuana River Estuary in San Diego County, with a minimum of 256 pairs (Craig 1971, p. 5). Since listing, the California least tern's breeding range has extended northward, with additional nesting sites discovered or colonized in the San Francisco Bay area (USFWS 1985b, p. 3), and the Sacramento River Delta. In addition, isolated instances of nesting have been detected at more inland sites scattered in the Central Valley (Rogers *et al.* 2007, p. 575; Rogers *et al.* 2009, p. 614; Frost 2017, p. 10) (Figure 1), and in one instance in Arizona (Robertson 2009, *in litt.*; Marschalek 2010, p. 20). California least terns nested at 50 documented locations (including multiple sites within those locations) in 2016 (Frost 2017, p. 11).

Breeding populations in the United States: Since 1970, California least terns have been regularly documented nesting in California, at nesting sites ranging from the San Francisco Bay area to the mouth of the Tijuana River just north of the United States–Mexico border (Marschalek 2007, pp. 16–18). The California breeding range spans four biogeographic regions as defined in Blanchette *et al.* (2008), with breeding colonies located within San Francisco Bay (SFB), the Santa Maria Basin (SMB), north Southern California Bight (NSCB), and south Southern California Bight (SSCB). Today, California least tern nesting is confined to 29 nesting areas that total approximately 487 hectares (ha) (1,204 acres (ac)) of habitat along the California coast. The total acreage of nesting habitat is higher than the previous number reported in the 2014 Species Report (USFWS 2014) due to the use of a more quantitative assessment rather than an expansion of nesting habitat. The number of California least tern pairs nesting at each nesting area is highly variable. For example, in 2016, the number of pairs estimated nesting at sites in California ranged from 1 (e.g., Sacramento Bufferlands, Pittsburg Power Plant) to 804 (e.g., Santa Margarita River–North Beach South) (Frost 2016, Appendix B-3). In 2016, the majority (approximately 85 percent) of California least tern breeding pairs were concentrated in southern California within the coastal Counties of Ventura, Los Angeles, Orange, and San Diego (Frost 2016, p. 11; Figure 2), and almost half of the birds in San Diego County nested within lands owned and managed by Marine Corps Base (MCB) Camp Pendleton.

In the last decade, a few California least terns have been discovered nesting in areas outside their known range. In 2009, two pairs of least terns, including one banded individual, nested in Glendale, Arizona, and produced one chick (Marschalek 2010, p. 20; Stevenson and Rosenberg 2009, p. 634). The birds were suspected to be of the California subspecies because the banded individual was banded as a chick in San Diego County (Robertson 2009, *in litt.*). This was the first documented California least tern nesting in Arizona (Marschalek 2010, p. 20) and we have not recorded birds nesting there since. In 2011 and 2013, least terns nested at the Salton Sea, Imperial County, California, where nesting had been suspected previously (McCaskie and Garrett 2012, p. 687; McCaskie 2013, pers. comm.). However, it is unclear whether these birds are *Sternula antillarum browni* or *S. a. mexicanus* (van Rossem and Hachisuka 1937, pp. 333–334; Patten *et al.* 2003, p. 192; but see Patten and Erickson 1996, pp. 888–890). Breeding of least terns has also been recorded in Hawaii, though the subspecific affinity of these birds is unclear.

Figure 1. U.S. nesting areas of the California least tern (*Sternula antillarum browni*) (2013–2017).

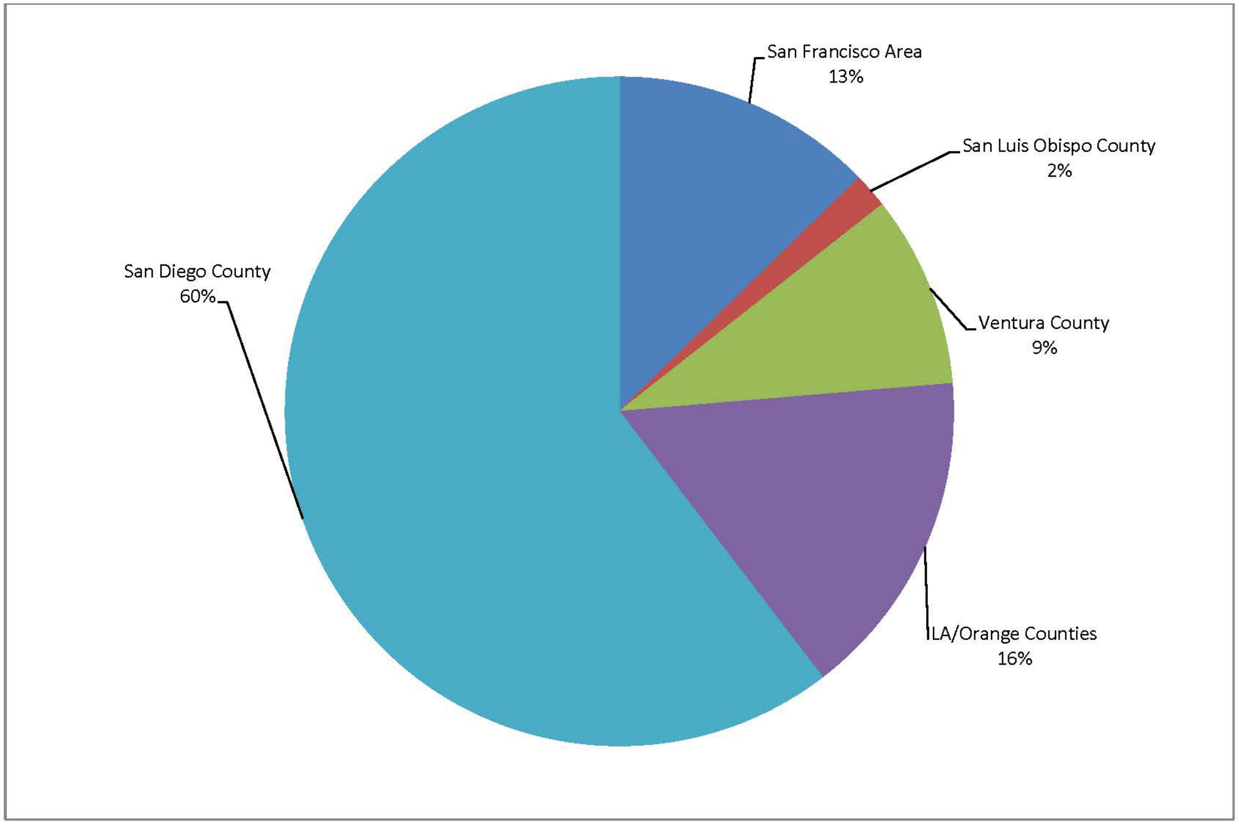

Figure 2. Distribution of 2016 California least tern (*Sternula antillarum browni*) nesting pairs by region in California. Data derived from minimum pair estimates in Frost 2017. "San Francisco Area" includes all nests in Solano, Alameda, and Contra Costa Counties, and the one nest in Bufferlands, Sacramento County.

Breeding populations in Mexico: Due to strong similarity of physical characteristics among least tern subspecies (Thompson *et al.* 1992, p. 257) and unclear genetics (see Changes in Taxonomic Classification or Nomenclature section below), the exact breeding range of the California least tern in Mexico is uncertain. Most studies consider that the California least tern breeds only along the Pacific coast of the Baja California Peninsula (Patten and Erickson 1996, p. 888).

Therefore, in this 5-year review, we consider only terns nesting along the Pacific Coast of the Baja California Peninsula, and not along the Gulf of California coast. Breeding California least terns along the Pacific Coast of the Baja California Peninsula have been documented from Ensenada Baja California in the north to San José del Cabo, Baja California Sur at the southern tip of the Peninsula (Lamb 1927, p. 155; Grinnell 1928, p. 63; Patten and Erickson 1996, p. 888). In 2017, there were six nesting areas with multiple nesting sites within those areas (Figures 3 and 4a) (Palacios 2018a). Monitoring of California least tern nesting areas in Mexico has been less intensive and less regular than in the United States.

Surveys of the Pacific coast of the Baja California Peninsula between 2002 and 2017 documented between 99 to 221 nesting pairs at 6 main nesting areas (Palacios 2018b, unpubl. data). In 2017, a total of 167 nesting pairs were recorded along the Baja California Peninsula at the following six nesting areas: Punta Banda (28 pairs), Figueroa (21 pairs), San Quintín (21 pairs), Ojo de Liebre (45 pairs), San Ignacio Lagoon (30 pairs), and Magdalena Bay (22 pairs) (see nesting areas indicated in Figure 3) (Palacios 2018b, unpublished data). In 2018, an estimated 300 pairs were documented at 8 nesting sites during one survey in June in Mexico (Palacios 2018a). Specific nesting sites are identified in Figure 4a, but not all sites are occupied in a given year.

Overall, the number of nesting pairs along the Baja California Peninsula at these nesting areas has been in decline since the early 2000s (Palacios 2018b, unpublished data). Other scattered surveys in the past decade recorded California least terns nesting from Cantamar and Estero Punta Banda to San Jose del Cabo on the tip of the Baja peninsula (Ruiz-Campos *et al.* 2005, Table 1; Perez *et al.* 2009, Appendix 1; Russo 2012, pers. comm.).

Winter distribution: The wintering range of the California least tern is not well known and what few data that are available are confounded by other least tern subspecies, which likely co-occur. Least terns of unknown subspecies have been occasionally seen in winter on the Baja California Peninsula, Mexico (Howell and Webb 2003, p. 213), and along the Pacific coast of mainland Mexico (Massey 1981, pp. 70–71; Ryan and Kluza 1999, p. 175; Howell and Webb 2003, p. 213), Guatemala (Massey 1981, pp. 70–71), Panama (Vaucher 1988, p. 1154; Ridgely and Gwynne 1989, pp. 158–159), and Costa Rica (Stiles and Skutch 1989, pp. 161–162). Scattered sightings of least terns of unknown subspecies have been recorded as far south as Peru during all seasons (Schulenberg *et al.* 1987, p. 271), including one seen in association with the closely related Peruvian tern (*Sterna lorata*) (Schulenberg *et al.* 1987, pp. 271–272). Observational data compiled by eBird further supports the information in the literature, with multiple least tern records from the Pacific coast of Central America and the northern Pacific coast of South America (Figure 4b; https://ebird.org/science/citation). These fragments of distributional information do not create a comprehensive picture of the migratory route and winter range of the any of the Pacific coast least terns subspecies, let alone the California least tern in particular. While we recognize the need for more data, for the purposes of this evaluation, we consider the California least tern to winter predominately along the Pacific coast of mainland Mexico.

Figure 3. Distribution of 2017 California least tern (*Sternula antillarum browni*) nesting areas along Baja California Peninsula, Mexico. Figure courtesy of E. Palacios.

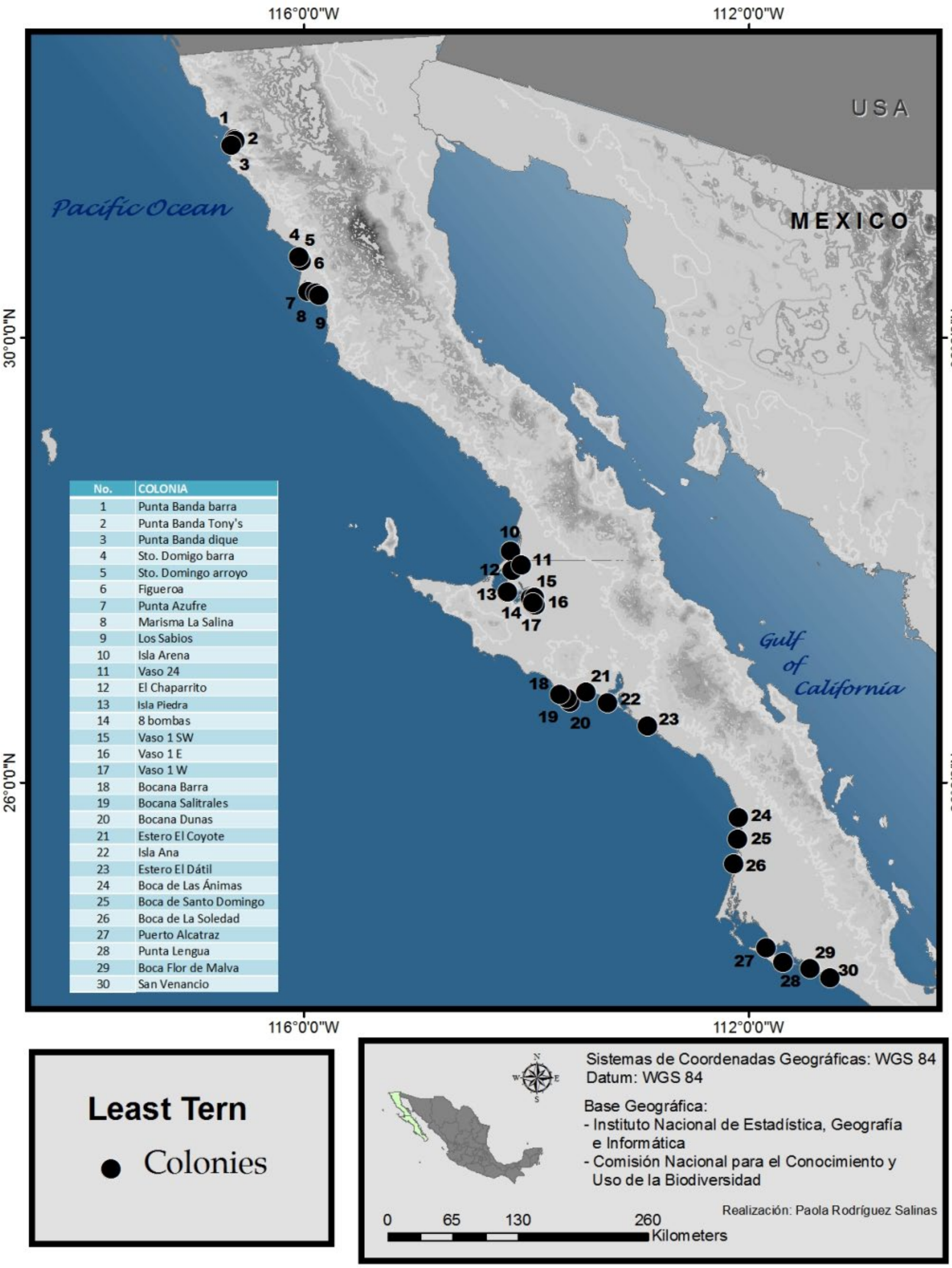

Figure 4. Locations of California least tern nesting sites along Baja California, Mexico. Not all sites are occupied in a given year. Figure courtesy of E. Palacios.

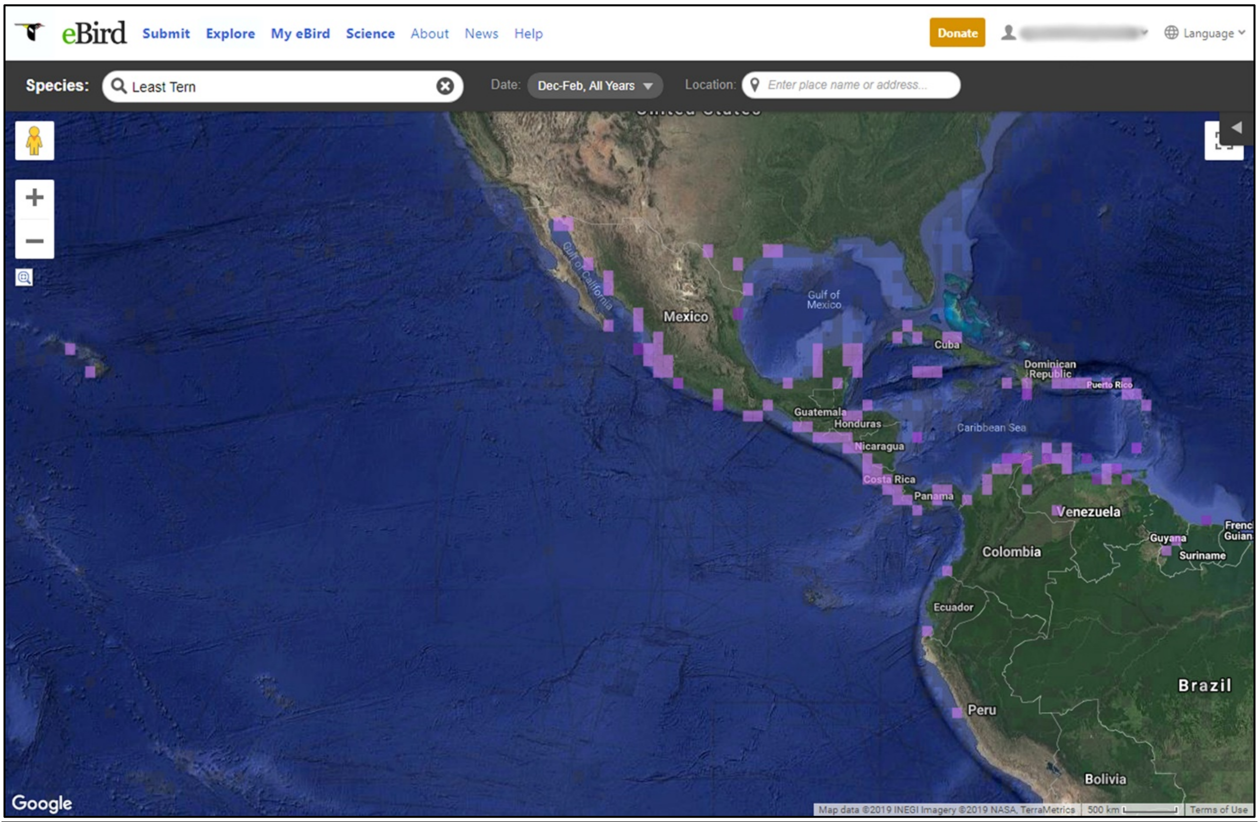

Figure 5. Locations of least tern observations from the Pacific coast of Central America and the northern Pacific coast of South America. Observational data compiled by eBird.

<u>Abundance</u>

In the early 20th century, California least terns were abundant and well distributed along the southern California coast (Shepardson 1909, p. 152; Sechrist 1915, p. 18). Scattered reports of nesting along the Baja California Peninsula also exist (Brewster 1902, p. 26; Bancroft 1927, pp. 38–39; Lamb 1927, p. 155). The development of the coastline (i.e., the building of coastal roadways and related buildings) reduced the amount of available nesting and foraging habitat and increased disturbance, pollution, and predation pressures that contributed to the gradual decline in California least tern populations (Chambers 1908, p. 237; Edwards 1919, pp. 65–68). By the 1940s, California least tern colonies were considered sparse and most beach areas within Orange and Los Angeles Counties were no longer used for nesting (Grinnell and Miller 1944, p. 175; Cogswell 1947, p. 189). The population continued to decline between the 1940s and 1970 (Craig 1971, pp. 4–7).

Shortly after listing, the California Department of Fish and Wildlife (CDFW; formerly known as California Department of Fish and Game (CDFG)) estimated that only 256 pairs nested at 15 nesting areas in San Mateo, Orange, and San Diego Counties (Craig 1971, p. 5). More extensive surveys from 1971 to 1973 found 624 pairs at 19 nesting areas in the United States (Bender 1974a, Table 1).

The increase in recorded population size immediately after listing was likely due in part to increased monitoring effort and location of existing nesting areas and not an actual increase in the number of birds (Obst and Johnston 1992, p. 4). As conservation measures were implemented throughout the 1970s and early 1980s, the number of California least tern pairs began a slow increase. In the late 1980s, the number of pairs began to increase at a much faster rate, reaching 2,400 pairs in 1993 and 4,500 pairs in 2000 (Caffrey 1994, p. 2) (Figure 5). This trend is believed to be due to increased management actions, particularly predator management, and years with abundant food supply; the change cannot be attributed to monitoring alone, as techniques remained constant throughout those years (Johnston and Obst 1992, pp. 6–7; Obst and Johnston 1992, p. 4; Caffrey 1993, p. 7; Shwiff *et al.* 2005, p. 285).

Though changes in breeding success may be a natural aspect of seabird dynamics, the increasing age of some California least tern populations and limited juvenile recruitment provides evidence that this decline may be more than a periodic fluctuation and may be indicative of a range-wide decline in numbers. Over the past decade, there has been a steady decline in the Statewide California least tern breeding population size. The estimated minimum number of pairs has dropped from 7,100 pairs in 2009 to 4,095 pairs in 2017 (Figure 5) (Sin 2019, pers. comm.).

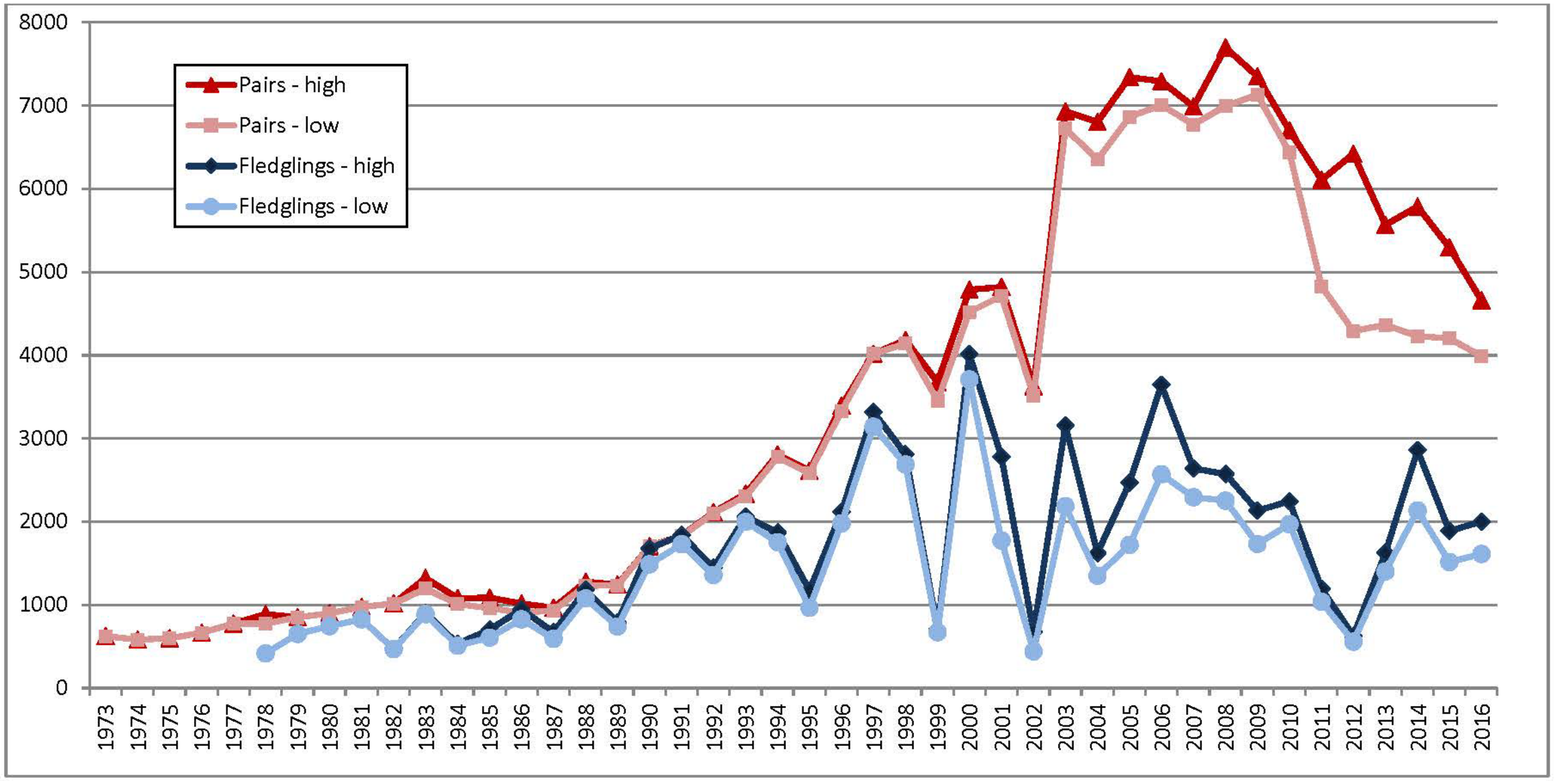

Figure 6. Minimum and maximum estimations of breeding pairs and fledglings produced for the California least tern (*Sternula antillarum browni*) in the United States from 1973–2016. Statewide surveys with unified methods began in 1973; reliable chick counts began in 1978. Data are from CDFW annual reports (Bender 1974a, Table 1; Bender 1974b, Table 1; Massey 1975, Table 1; Atwood *et al.* 1977, Table 1; Atwood *et al.* 1979, Table 1; Gustafson 1986, pp. 1–4; Collins 1983, p. 14; Collins 1984, Table 1; Collins 1987, Table 1; Massey 1988, Table 1; Massey 1989, Table 1; Johnston and Obst 1992, Table 1; Obst and Johnston 1992, Table 1; Caffrey 1993, Table 4; Caffrey 1994, Table 4; Caffrey 1995, Table 4; Caffrey 1997, p. 1; Caffrey 1998, Table 4; Keane 1998, Table 2a; Keane 2000, Table 2a; Keane 2001, Table 2a; Patton 2002, Table 1; Marschalek 2005, Table 2; Marschalek 2006, Table 2; Marschalek 2007, Table 2; Marschalek 2008, Table 2; Marschalek 2009, Table 2; Marschalek 2010, Table 2; Marschalek 2011, Table 1; Marschalek 2012, Table 1; Frost 2013, Table 1; Frost 2014, Table 1; Frost 2015, Table 1; Frost 2016, Table 1; Frost 2017, Table 1).

A study conducted by researchers at San Diego State University confirmed significant declining trends in the number of breeding pairs and reproductive success since ~2007 (Lewison and Deutschman 2014, p.10). The study also found a significant positive relationship between colony reproductive success and latitude (Lewison and Deutschman 2014, p. 3). The annual reproductive success for the San Francisco Bay region has been mostly above average and increasing in the Santa Maria Basin region, whereas the reproductive success has been consistently below average in the southern California regions for the past 15 years (Figure 6; Robinette *et al.* 2017, draft report, p. 5). The San Francisco Bay (SFB) region includes the colonies from Sacramento and the San Francisco Bay, the Santa Maria Basin (SMB) region includes the colonies at Vandenberg Air Force Base and Oceano Dunes, the north Southern California Bight (NSCB) region includes the colonies located in Ventura County, and the south Southern California Bight (SSCB) region includes colonies from Los Angeles County south to San Diego County.

In 2016, Alameda had an estimated 358 breeding pairs, approximately 9 percent of the total minimum number of nesting pairs. Pairs nesting at the site regularly fledge chicks at least twice the average statewide fledgling rate (Marschalek 2008, Table 1; 2009, Table 1; 2010, Table 1; 2011, Table 1; 2012, Table 1; Frost 2013, Table 1; 2014, Table 1; 2015, 2017, Table 1). Further, California least terns nesting at Alameda Point reached the recovery goal of one fledgling per pair in 2008, 2013, 2014, and 2016. This reproductive success is in part attributed to consistent prey availability (Robinette *et al.* 2017, draft report, p. 23).

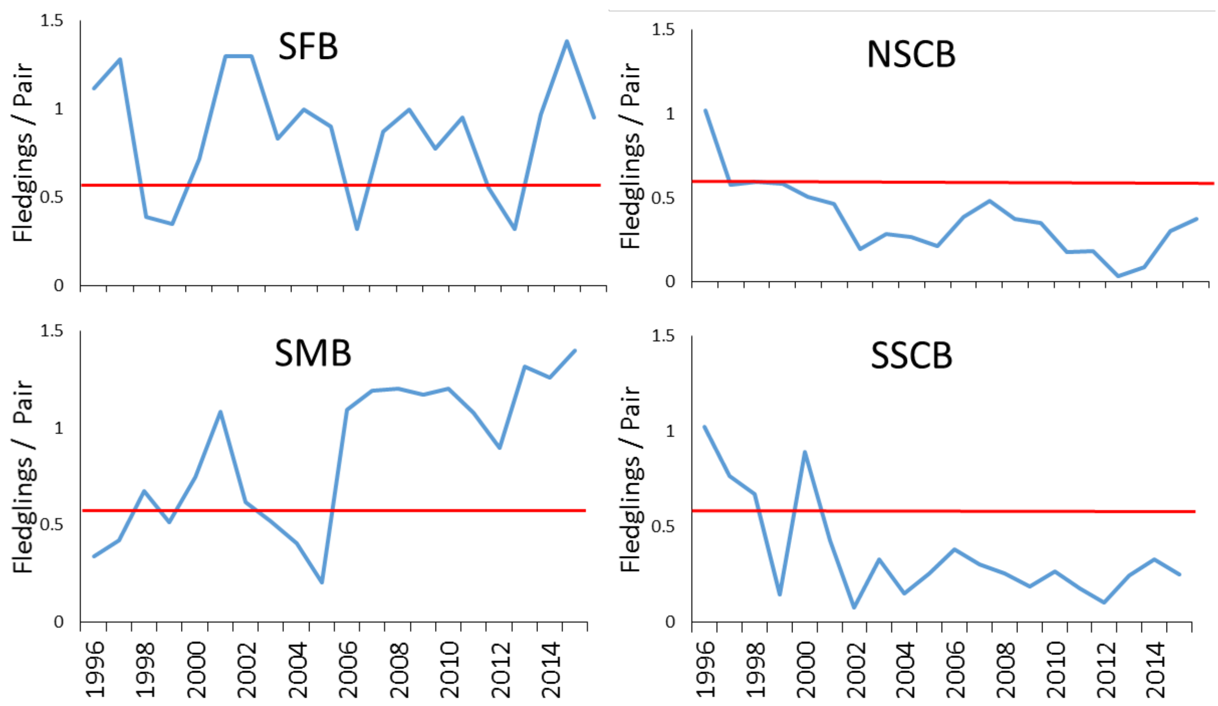

Figure 7. Annual rates of reproductive success for colonies in four regions of the California least tern breeding range: San Francisco Bay (SFB), Santa Maria Basin (SMB), north Southern California Bight (NSCB), and south Southern California Bight (SSCB). Red lines show the state average for 1996–2015. Taken from Robinette *et al.* 2017, draft report, p. 2.

Researchers have suggested that changes in prey availability and elevated predator pressure may contribute to the observed decline in least tern reproductive success and population size, although the exact causes of the observed declines remain unknown and may vary by site. Resource limitation during the breeding season, elevated predation pressure, or stressors on non-breeding population may all contribute to population decline in seabirds. Intervals of low and high breeding success are normal for seabirds; however, fluctuations in forage fish biomass can interrupt these breeding cycles and result in long-term declines (Cury *et al*. 2011, p. 1704).

It is unclear if the changing California least tern trends are due to changing food resources, habitat and predation-based threats, or both, though in either case, the decline is increasingly severe and has continued over the past decade. The listing of the California least tern resulted in increased monitoring and management at nesting sites in the United States. The number of conserved and managed least tern nesting areas has also increased, though some previously occupied nesting areas are no longer active (see **FACTOR A** below).

California least terns nest at discrete nesting sites, and in some instances multiple nesting sites occur within larger nesting areas (typically bay, estuary, salt flat, or beach). Least terns may relocate to another nest site within the nesting area in response to reduced site suitability, nest failure, or disturbance. As urbanization and intensified human uses have occurred along the coast, many known nesting sites have been protected, often with fencing to reduce disturbance, and vegetation management to assure continued suitability. Nesting areas that support multiple protected nesting sites, as described above, include: Mission Bay (four currently active nest sites); Naval Base Ventura County (NBVC) Point Mugu (four currently active nest sites); Batiquitos Lagoon (three currently active nest sites), MCB Camp Pendleton (five currently active nest sites), and San Diego Bay (two currently active nest sites in north part, five nesting sites in south part). Based on these groupings, there were 29 currently occupied nesting areas in California in 2017 (Figure 1, Appendix A). An occupied nesting area is defined as having nesting between 2012–2017. In 2017, 20 of these nesting areas produced fledglings (Sin 2019, pers. comm.). For the remainder of this document, *nest site* is used to identify a discrete nest site location, and a collective grouping of nest sites is referred to as a *nesting area*.

<u>Habitat or Ecosystem</u>

The California least tern traditionally nested on sandy beaches close to estuaries and coastal embayments relatively free from human disturbance (Grinnell and Miller 1944, p. 175; Garrett and Dunn 1981, pp. 194–195). Today, fluvial, wave, and aeolian (wind) processes that create suitable nesting conditions for California least tern are absent from or altered at most nest sites, and many of the coastal areas upon which least terns historically depended have been largely modified or lost. The majority of current nest sites are on developed lands, such as dikes (e.g., South Bay Unit of the San Diego National Wildlife Refuge (NWR), Pittsburg Power Plant), dredge spoils (e.g., Terminal Island, Anaheim Bay, Fiesta Island, Mariner’s Point, Delta Beaches, and the Sweetwater Marsh Unit of the San Diego Bay NWR), sand-topped islands specially created for California least terns around bays and estuaries (e.g., Hayward Regional Shoreline, Bolsa Chica, Upper Newport Bay, Batiquitos Lagoon, Seal Beach/Anaheim Bay, Montezuma Wetlands), and airports (e.g., Alameda Point, San Diego International Airport, Naval Air Station, North Island).

California least terns prefer beachfront habitat with sparse or low-lying vegetation and low disturbance from humans and mammalian predators. California least terns preferentially nest on unconsolidated fine to coarse sand that is interspersed with larger fragments of material and sparse ground vegetation (i.e., 0 to 20 percent total ground cover less than 40 cm (16 in) tall) (USFWS 1985c pp. 14–16; Kotliar and Burger 1986, p. 6). Ceramic roofing tiles are provided at some nest sites to provide chicks cover or protection from sun and predators.

Foraging habitat used by terns includes nearshore waters, estuarine channels, narrow bays, and other shallow water marine habitat (Atwood and Minsky 1983, p. 64; Atwood and Kelly 1984, p. 35). Terns frequently shift foraging areas within and between nesting seasons based on prey availability (Atwood and Minsky 1983, p. 63; Baird 1997, pp. 57, 66). Typical foraging habitat is within two miles of colony sites in "relatively shallow nearshore ocean waters in the vicinity of major river mouths..." (Atwood and Minsky 1983). Information on the wintering habitat of California least terns is limited and further study is required to understand the wintering range.

Changes in Taxonomic Classification or Nomenclature

<u>Species-level Taxonomy</u>

The California least tern was listed as a subspecies in 1969 with the scientific name (*Sterna albifrons browni*) (USFWS 1969, p. 5034; 34 FR 5034). Since listing, the taxonomy has been revised. Studies on vocalizations and behaviors suggested that least terns in the Old World and New World were distinct species (Massey 1976, pp. 760–773; Massey 1998, entire). In 1983, the American Ornithologist's Union (AOU) Committee on Classification and Nomenclature (AOU Committee), the generally accepted authority on avian nomenclature in North America, recognized the change and adopted *Sterna antillarum* as the species name for all of the American least terns (AOU 1983, pp. 232–233), which would include the California least tern. The Old World form of the taxon, under the common name little tern, retained the scientific name *Sterna albifrons*. In 1983, we updated 50 CFR 17.11, the List of Endangered and Threatened Wildlife, changing the scientific name of the California least tern to *Sterna antillarum browni* (USFWS 1983c, p. 34189; 48 FR 34182). This species-level separation was subsequently supported by a phylogenetic analysis of mitochondrial DNA (mtDNA) (Bridge *et al.* 2005, p. 462).

Furthermore, Bridge *et al.* (2005, Figure 1 and pp. 465–467) derived a phylogeny of nearly all tern species based on sequencing mtDNA. This phylogeny classified a group of small tern species, including *Sterna antillarum*, as a clade that was distinct from other tern species (a clade is a group of animals descended from a common ancestor). Bridge *et al.* (2005, p. 467) recommended resurrecting the genus *Sternula* for the small tern species. The AOU Committee accepted this revision (Banks *et al.* 2006, p. 927), as did the British Ornithological Union (Sangster *et al.* 2005, p. 824). Thus, in the scientific literature, the least tern became *Sternula antillarum*—and by extension the California least tern became *Sternula antillarum browni.*

None of these revisions affected the listed entity beyond changes to the scientific name. However, as of the writing of this review, the List of Endangered and Threatened Wildlife still refers to the California least tern as *Sterna antillarum browni* and has not been updated to reflect the nomenclature currently used in the scientific literature. We use *Sternula antillarum browni* for the California least tern in this document.

Subspecies-level Taxonomy

As noted previously, five subspecies of *Sternula antillarum* have been described in the scientific literature based on subtle differences in morphological features (i.e., overall size; bill, leg, and wing lengths; and plumage coloration). As summarized by Patten and Erickson (1996, pp. 888–890), these five subspecies include (1) *S. a. antillarum* (eastern least tern) that breeds along the Atlantic and Gulf Coasts, (2) *S. a. athalassos* (interior least tern) that breeds in interior United States, (3) *S. a. browni* (California least tern) that breeds along the Pacific Coast of California and the west coast of the Baja California Peninsula, (4) *S. a. mexicana* (no accepted common name, although Mexican least tern is sometimes used) that breeds along the Gulf of California coast of northern mainland Mexico and east coast of the Baja California Peninsula, and (5) *S. a. staebleri* (no accepted common name) that breeds along the Pacific Coast of southern mainland Mexico.

Many authors have questioned the distinctiveness of one or more subspecies of *Sternula antillarum* (Willett 1933, p. 78; Burleigh and Lowery 1942, p. 175–177; Massey 1976, p. 768; Thompson *et al.* 1992, p. 259; Gochfeld and Burger 1996, p. 657; Patten and Erickson 1996, pp. 888–890; Palacios and Mellink 1996, p. 49; Massey 1998, p. 181; Draheim 2006, pp. 33, 74; Whittier *et al.* 2006, p. 182; Pyle 2008, p. 704; Draheim *et al.* 2010, pp. 807). The methodologies for these studies varied, but included morphological and genetic analyses, depending on the study.

In particular, Massey (1998, p. 181) questioned whether *Sternula antillarum browni* was distinguishable from the two other west Mexico subspecies *S. a. mexicana* and *S. a. staebleri*. While some authors have merged all the Pacific coast subspecies (e.g., Draheim *et al.* 2010, p. 808; Draheim *et al.* 2012, pp. 147), there have been few studies that address the taxonomic status of the other west Mexico populations. Similarly, few studies have examined the east Mexico or Caribbean populations, although the least terns are widely considered to be the nominate subspecies. Instead, authors have mostly focused their attentions on least tern populations in the United States. Massey (1976, p. 772) did not find distinct vocalizations or behavior between the eastern and California subspecies. Thompson *et al.* (1992, p. 259) did not find consistent differences in morphology or coloration between specimens of all three U.S. subspecies collected throughout the breeding season. In contrast, Johnson *et al.* (1998, pp. 19–23) found all three U.S. subspecies distinguishable on the basis of color by only using specimens in fresh plumage collected early in the breeding season (before feathers may have faded). However, Whittier *et al.* (2006, p. 177) countered that the findings by Johnson *et al.* (1998) were potentially a function of wintering site or food, and not an inherited feature.

More recently, molecular or genetic analyses using both mtDNA and nuclear DNA have been used to assess the distinctiveness of the U.S. subspecies of the least tern (again, without including the west Mexico populations where there are other described subspecies). In general, research analyzing mtDNA shows historical separation of the subspecies or groups examined and yields less variable results, while nuclear DNA is more receptive to natural selection processes (i.e., adaptive divergence) and shows more recent population-level differences (Whittier *et al.* 2006, p. 178; Fallon 2007, pp. 1190–1191). Whittier *et al.* (2006, pp. 180–181) found no difference between California, interior, and eastern least terns using mtDNA, but found distinctiveness between interior and California least terns using nuclear DNA. Alternatively, Draheim *et al.* (2010, pp. 807–819) examined mtDNA and microsatellite DNA from least terns across the continental U.S. using sequences from two mtDNA genes (i.e., 1,400 base pairs) and 10 microsatellite loci (nuclear DNA) of at least 417 least terns from 20 nest sites. The authors concluded there was little evidence to support the distinctiveness of the three U.S. subspecies, with weak support for traditional subspecies from analyses of microsatellite DNA data and no support from mtDNA.

However, mtDNA data is relatively insensitive at distinguishing differences at the subspecific rank in birds, which are primarily based on phenotypic variation in plumage, morphology, or both (Greenberg *et al.* 1998, pp. 706–712; McKay and Latta 2002, pp. 285–291; Pruett and Winker 2010, pp. 162–171; McCormack and Maley 2015, pp. 380–388). Draheim *et al.* (2010, pp. 809) concluded that there are detectible differences in genetic structure between the California and interior/eastern subspecies, but that there are also genetic similarities between the three subspecies examined. However, as Draheim *et al.* (2010, pp. 816) note, mtDNA and microsatellite loci may not necessarily reflect adaptive variation that may be relevant in different environments, noting further that the three U.S. subspecies of least terns "may continue to function as demographically independent populations." Moreover, it is difficult to interpret negative results (such as failure to detect structure), which can be interpreted as either the true absence of genetic structure or as simply inconclusive. Species with high dispersal rates, such as birds, require additional information beyond molecular markers (i.e., reproductive isolation, adaptive divergence, spatial patterns of local adaptation) to evaluate designation of subspecies (Haig *et al.* 2006, pp. 1590–1591).

Given the equivocal information in the taxonomic literature, we examined the available information on movement of individual least terns between the ranges of the other subspecies. In our 2014 species review, we examined banding data for evidence of least tern movements (USFWS 2014, p. 14). That assessment suggested that there was little exchange of individuals between the California and other populations of least terns. We retrieved band and recapture data from the U.S. Geological Survey's Bird Banding Laboratory (BBL) (Liddick 2007, pers. comm.) to evaluate movement of least terns between geographic ranges of currently classified least tern subspecies. The BBL had records of birds banded and resighted on the west coast, interior, and eastern United States. From 1923 through 2004, a total of 799 banded least terns were sighted and reported to the BBL (USGS 2007, no page number). All least terns recaptured in California during the breeding season (217 birds) were initially banded in California, including eight birds recaptured two times and two birds recaptured three times (USGS 2007, no page number). Five birds (2.2 percent of total recaptures) initially banded in California were recaptured outside of California: four were sighted within the California least tern's suspected breeding range in Mexico and one was found dead early in the breeding season (May 10) (USGS 2007, no page number).

As noted in the Spatial Distribution section above, a banded least tern was one of four birds (two pairs) of least terns that nested in Maricopa County, Arizona. This 2009 attempt (by the two pairs) was the first and so far only nesting of least terns recorded for Arizona. This was the farthest east that a California least tern has been found. More recently, a study has been initiated to increase the number of band returns through recapturing banded least terns in California and northwestern Mexico. As of the writing of this review, the data from that effort are not available. Thus, there appears to be little movement of least terns between subspecies ranges.

Summary

The best scientific data available regarding California least tern taxonomy, including information on vocalizations, morphology and other phenotypic characteristics, and mtDNA, indicates that *Sternula antillarum* is the species-level combination recognized in the scientific literature.

While there have been several publications that question the distinctiveness of *Sternula antillarum browni*, most studies have focused only on the three U.S. subspecies (California least tern, interior least tern, and eastern least tern); none have comprehensively examined the species throughout its range, with a glaring absence of data from populations in west Mexico where two other subspecies have been described. The criteria used to distinguish subspecies should include multiple lines of evidence, such as morphology, genetics, and ecology. Based on current known information, we conclude that the California least tern subspecies is not freely interbreeding with members of other least tern subspecies. In the absence of compelling evidence to the contrary, we continue to recognize the California least tern subspecies for the purposes of the Act.

Habitat Protection

Management actions contributing to California least tern protection and recovery after the species was listed included the establishment of Huntington Beach State Park Tern Sanctuary, Seal Beach NWR, Buena Vista Lagoon Ecological Reserve, Border Field State Park, California protected nesting areas at Mission Bay Park and Sunset Aquatic Park, and acquisition of Bair Island by the State of California (CDFG 1974, p. 23).

Species-specific Research and/or Grant-supported Activities

In 2011, CDFW was awarded a traditional Section 6 grant ($179,151) for the purpose of analyzing the long-term, historical California least tern nesting data set. With the assistance of San Diego State University, least tern experts, and agency representatives, this effort focused on the: 1) identification of California least tern population trends and drivers of those trends, and 2) evaluation of current monitoring and management practices (Lewison and Deutschman 2014, p. 5). The analysis focused on 24 sites that have been consistently monitored from 1990 to 2013. One of the recommendations from this study was the adoption of new data collection and reporting protocols deployed by CDFW in 2013 (Lewison and Deutschman 2014, p. 28). Monitors began using the revised protocols during the 2016 breeding season (Frost 2017, p. 6).

Lewison and Deutschman (2014) also developed a conceptual model that identified a number of critical uncertainties that drive tern population size and distribution, and reproductive success. These uncertainties include survival, movement, and food availability, which are influenced by climate, nest attendance, age structure, and overwintering. In order to further investigate these uncertainties, in fiscal year 2014 and 2017, CDFW was awarded traditional Section 6 grants ($260,000 and $348,232, respectively) for the project: *A study of critical uncertainties that influence the population and breeding success of the endangered California least tern (Sterna antillarum browni)*. The goals of this 3-year study (2015–2017), conducted by Point Blue Conservation Science, are to: 1) assess spatio-temporal variability in least tern diet and combine with video monitoring to assess potential impacts on adult nest attendance and chick food provisioning rates, 2) use video monitoring to identify predators and document rates of predation at nests and study methods to better document predation, 3) assess the impact of habitat availability and suitability on nesting success, and 4) band and recapture adult least terns to determine age structure, survival, and movement (Robinette *et al.* 2017, draft report).

Ongoing Nesting Site Management

Most active nest sites in California are managed through pre-season preparation of the nest site (e.g., removal of vegetation, erection or repair of fencing), protection from human disturbances, monitoring and management of predators, and breeding surveys (Table 1). Least tern numbers have increased since listing under this general management approach (see Abundance section above).

In 2016, pre-season visits and preparation of nest site substrate by managers and volunteers were conducted at 93 percent (42 of 45) of the active nesting sites where we have data (Table 1) to maintain suitable habitat characteristics attractive to nesting California least terns. As described above, California least terns preferentially nest on unconsolidated fine to coarse sand that is interspersed with larger fragments of substrate material (shell; gravel; debris) and sparse ground vegetation (i.e., 0 to 20 percent total ground cover less than 40 cm (16 in) tall) (USFWS 1985c, pp. 14–16; Kotliar and Burger 1986, p. 6). This percent cover and height of vegetation allows for unfettered chick movement and protects chicks from exposure to sun and predation but does not provide cover or perches for predators (Buckley and Buckley 1980, p. 75). At some sites, high density mesh fencing is installed or repaired prior to the start of the nesting season to prevent chicks from leaving the nest site and entering areas where they could be killed by falling into rip-rap (e.g., Mission Bay), or crushed by military training activities (e.g., MCB Camp Pendleton), air traffic (e.g., Lindberg Field), or recreational users (e.g., Venice Beach, Huntington Beach, San Diego River Mouth).

In 2016, predator control was conducted at 73 percent of nesting areas where we have data (Frost 2017, Appendix B-1). Summary reports are not available for 2017 and 2018 predator activities. Predator control activities are conducted both before and during nesting activity, although the frequency, intensity, target species, and effectiveness of predator control efforts vary between different sites. Pre-nesting predator control activity includes ensuring that protective fencing is intact, providing items that chicks may use for cover, and monitoring for and potentially removing predatory animals. During the nesting season, monitors or predator management personnel conduct regular visits and look for signs of predation. If predation is detected, the impact to the least terns is assessed, and predators may be hazed or removed from the nest site to support least tern productivity. Frequent and regular visits by monitors are very effective for early detection and correction of predation and disturbance problems.

Monitoring to document breeding success of California least terns continued in 2016 at nearly all known active nest sites in California (Frost 2017, and Table 1). Established conservation and monitoring methods have been used for least terns since the 1998 nesting season to standardize data collection throughout the State. The reporting spreadsheet was updated in 2013 to include more information related to seasonal chronology. This revised data collection and reporting protocol was used by monitors in 2016 (Frost 2017, p. 6). Most recently published data and their collection methods are available in California least tern breeding report (Frost 2017, entire). Data for 2017 are in preparation.

Table 1. Coastal Management Areas (identified in the 1985 Recovery Plan (Table 3) and subsequent to the plan), management activity, and measure of productivity. Data from Frost 2017, Table 1 and Appendix B-1. Management data for 2017 not yet available.

A. San Francisco Bay

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
	Pittsburg Power Plant	Yes			Private	
A	Alvarado Salt Ponds (Currently known as Eden Landing)	-	-	-	State	
A	*Oakland Airport*				Port	
A	Alameda Point	Yes	Yes	Yes	Federal	Yes
*[6]	Hayward Regional Shoreline	Yes	Yes	Yes	Local	Yes
	Montezuma Wetlands	Yes			Private	
*[6]	Napa Sonoma Marsh Wildlife Area		Yes		State	Yes

B. San Luis Obispo/Santa Barbara Counties[5]

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
B	Pismo Beach	-	-	-	UNK	
B	Oso Flaco Lake	-	-	-	State	
C	Guadalupe-Mussel Rock (2 sites) (Santa Maria River)				State & Federal	
*[6]	Oceano Dunes SVRA	Yes	Yes	Yes	State	Yes
	Coal Oil Point Reserve	Yes			State	
D	Vandenberg AFB (5 sites)	Yes	Yes		Federal	Yes

C. Ventura County

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
E	Santa Clara River / McGrath State Beach	Yes	Yes		State	Yes
F	Ormond Beach	Yes			County	
	Hollywood Beach				State	
F	NBVC Pt Mugu (4 sites)	Yes	Yes		Federal	Yes

D. Los Angeles County

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
G	Venice Beach	Yes			County	
G	Playa del Rey	-	-	-	UNK	
H	L.A. Harbor / Pier 400 / Terminal Island	Yes	Yes		Port	Yes
I	Cerritos Lagoon	-	-	-	UNK	

E. Orange County

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
J	Surfside Beach	-	-	-	UNK	
J	Seal Beach NWR / NASA Island / Anaheim Bay	Yes	Yes		Federal	Yes
K	Bolsa Chica ER	Yes	Yes		State	Yes
L	Huntington State Beach	Yes	Yes		State	Yes
	Burris Sand Pit	Yes			Utility	
M	Upper Newport Bay ER	Yes			State	
	Anaheim Lake					

F. San Diego County

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
N	MCBCP - San Mateo Creek	-	-		Federal	
	MCBCP - Red Beach				Federal	
N	MCBCP - White Beach (Aliso Creek)	Yes	Yes		Federal	Yes
N	MCBCP - North Beach North	Yes	Yes		Federal	
N	MCBCP - North Beach South	Yes	Yes		Federal	Yes
	MCBCP - Saltflats	Yes			Federal	
	MCBCP - Saltflats Island	Yes			Federal	
O	Buena Vista Lagoon	-	-	-	State	
P	Agua Hedionda Lagoon	-	-	-	State	
Q	Batiquitos Lagoon ER (3 sites)	Yes	Yes		State	Yes
R	San Elijo Lagoon ER	Yes			State	
S	San Dieguito Lagoon	Yes			State, 22nd Ag District	
T	Los Penasquitos Lagoon	-	-	-	State	
U	Mission Bay - FAA Island	Yes	Yes		State Owned-leased to FAA	Yes
U	Mission Bay - North Fiesta Island	Yes			City	
	Mission Bay - Mariner's Point	Yes	Yes		City	Yes
U	Mission Bay - Stony Point	Yes			City	
	Mission Bay - San Diego River Mouth	Yes			City	
U	Mission Bay - South Shores	-	-	-	City	
U	Mission Bay - *Cloverleaf*	-	-	-	City	
V	San Diego Bay *Naval Training Center*	Yes	Yes		Port	
V	San Diego Bay Lindbergh Field (San Diego International Airport)	Yes	Yes		Port	Yes

Coastal Mgmt. Area[1]	Nest Site[2]	Management Activity Reported for 2016[3]	Minimum of 20 Nesting Pairs Reported for 2016	Minimum of One Fledgling per Pair for 2016	Type of Ownership[4]	Secure site with min of 20 pairs? [5]
V	San Diego Bay NBC North Island	Yes	Yes		Federal	Yes
V	San Diego Bay NBC Delta Beach North	Yes	Yes		Federal	Yes
	San Diego Bay NBC Delta Beach South	Yes	Yes		Federal	Yes
	San Diego Bay NBC NAB Ocean	Yes	Yes		State- leased to Navy	Yes
V	San Diego Bay Sweetwater Marsh Unit NWR	Yes	Yes		Federal/Port	Yes
V	San Diego Bay South San Diego Bay Unit NWR	Yes			Federal	
V	San Diego Bay Chula Vista Wildlife Reserve	Yes	Yes		Port	Yes
V	San Diego Bay *Coronado Cays*	-	-		Private/Port	
	San Diego Bay Silver Strand State Beach	-	-		State	
W	San Diego Bay Tijuana Estuary NERR	Yes	Yes		State & Federal	Yes

1 For the Coastal Management Area column, we use the capital letters as used in the Recovery Plan to distinguish different nesting areas. Blank cells indicate nesting sites that were not identified at the time of listing, and therefore, not included in Coastal Management Areas. Sites outside of coastal management areas (Sacramento, Kings, and Imperial Counties) not included.

2 Italicized nest sites are those identified in the recovery plan as essential, but have since become unsuitable for California least tern nesting or have been abandoned for decades.

3 Management Activity includes control of vegetation, protective measures against anthropogenic disturbance, chick shelters, or predator control.

4 UNK indicates an absence of data.

5 Secure nest site defined as site where “land ownership and management objectives are such that future habitat management for the benefit of least terns at those locations can be assured”, plus minimum of 20 breeding pairs in 2016.

6 Blank and dashed cells represent “No” in columns related to management activity, minimum number of 20 nesting pairs reported, minimum number of one fledgling per pair reported, and secure sites with a minimum of 20 pairs. In addition, the dash (-) indicates that nesting has not occurred within the last 5 years at that site.

7 Thirteen Coastal Management Areas contained at least 1 secure (as defined in the 1985 Recovery Plan) nest site managed to conserve California least terns, occupied by a minimum of 20 breeding pairs in 2016: Coastal Management Areas A, D, E, F, H, J, K, L, N, Q, U, V, and W. Integrating new nest sites established since 1985 brings the total number of Coastal Management Areas occupied by at least 1 nest site with 20 breeding pairs (in 2016) to 16 (adding Hayward Regional Shoreline, Napa Sonoma Marsh Wildlife Area, and Oceano Dunes).

Recovery Activities in Mexico

Since listing, California least tern nesting sites in Mexico have been identified (Zuria and Mellink 2002, p. 617), monitored, and mapped (Palacios 2018). Human disturbance and predator impacts continue to threaten California least terns nesting in Mexico; however, efforts to protect and manage nesting sites have begun, as evidenced by efforts to protect nests from flooding by elevating them (Palacios 2018, p. 1; Amador *et al*. 2008, p. 1), site fencing in 2018 at Punta Banda (supported with CDFW grant), and other education and protection programs conducted by individuals and non-government organizations (Zuria and Mellink 2002 p. 617). Although there are some locations that have educational outreach about protecting California least terns, additional, unimplemented recovery actions remain (e.g., fencing, outreach and education, monitoring).

Five-factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act. When the California least tern was first listed under the Endangered Species Preservation Act of 1966, and then under the Endangered Species Conservation Act of 1969 and the Endangered Species Act of 1973, there was no threats analysis because at that time, there was no statutory requirement to do an analysis of the five-factors. Thus, when we conducted the 2006 5-year review, the first status review conducted since 1991, we focused on summarizing all historical threats information gathered since that time, as based on older monitoring reports and the 1985 Recovery Plan. This 5-year review focuses primarily on information published since the 2006 5-year review and the 2014 Species Report. As the wintering range of California least terns is poorly defined, we do not discuss potential threats in the wintering range.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

In this analysis, we distinguish between destruction of nesting habitat, which permanently renders habitat unsuitable for nesting, and degradation of habitat, which reduces the suitability or quality of nesting habitat, but might be reversible with active management. At the time of listing, scientists recognized destruction and degradation of nesting habitat as two of the primary threats facing the California least tern at its 15 known nesting sites (Longhurst 1969, pp. 3–4; Craig 1971, p. 3). Since listing, habitat at five historical nesting areas was destroyed by urban development, including San Gabriel River and Reeves Field in Los Angeles County, and Huntington Harbor in Orange County (Bender 1974a, p.13; Atwood *et al*. 1977, p. B-7; Collins 1987, p. 7). Both destruction and degradation of least tern nesting habitat were considered threats in the 2006 5-year review and continue to threaten tern habitat today. Additionally, climate change and resulting sea level rise which were not considered in previous status reviews will impact California least tern nesting habitat (see below).

Development

At the time of listing, urban development was identified as one of the primary threats to California least tern nesting habitat, because few protections were in place to preserve this habitat and urbanization and development were underway along the California coast. Decreasing habitat availability has been linked with observed declines in the California least tern and in other least tern subspecies (Massey 1974, pp. 1–2; Fisk 1975, p. 1; Galli 1979, p. 96). Reduced nesting habitat availability has likely affected the nesting distribution of least terns, which resulted in larger, more concentrated least tern colonies, where risk of predation by some species is greater (Brunton 1999, p. 612). Therefore, any further loss of California least tern nesting habitat could increase the risk of further declines in numbers of breeding pairs.

Today, the majority of California least tern nesting habitat is on public lands. Of these public lands, a subset of these are under Federal ownership (e.g., habitat on military bases) where Department of Defense (DOD) provides management oversight and increased protection through current Integrated Natural Resource Management Plans (INRMPs) and Memoranda of Understanding (MOUs) (more information on protections afforded by these documents is discussed in **FACTOR D**). In total, 25 of the 29 (86 percent) currently occupied nesting areas are protected by local, State, and Federal law (Appendix A). Only a few colonies (Sacramento Bufferlands, Hollywood Beach, Anaheim Lake, and Salton Sea) lack habitat protection measures to ensure future availability of the colonies for breeding terns. These sites represent a small fraction of the nesting least tern population.

Although a significant proportion of the least tern nesting population is currently found in only a few large sites, even small and infrequently used colonies can be crucial for the success of nesting California least terns. Though California least terns exhibit a high degree of nest site fidelity, individuals or an entire colony may abandon a nest site in response to heavy predation and re-nest at another nearby nest site (Atwood and Massey 1988, p. 392; Massey and Fancher 1989, pp. 353–355; Jurek 1992, p. 7; Caffrey 1994, p. 5). Movement between sites may be effective in discouraging the habituation of predators to a site. Shifting California least tern use patterns likely associated with behavioral response to predation or changing conditions on nest sites has been observed in recent years. For example, researchers report that nesting pairs frequently move between Naval Air Station North Island and Lindberg Field, in North San Diego Bay, likely selecting the site that has the most favorable conditions at any given point in time. Similarly, the number of least terns nesting at MCBCP dropped significantly during 2017 when the site was faced with severe predator (coyote) pressure and in the following days and weeks, the number of least terns nesting at the closest nest site (Batiquitos Lagoon) rose significantly. Availability of multiple managed nest sites in Mission Bay has allowed California least terns to shift between sites, apparently in response to predator presence. For example, when California least terns abandoned North Fiesta Island in 2004, reportedly to avoid predation by a peregrine falcon using the site, the San Diego River Mouth was colonized, which suggests that the terns moved (Marschalek 2006, pp. 16–17). In 2006, the terns abandoned the San Diego River mouth and Mariner's Point reportedly due to predation by crows, ravens, and rats; this abandonment coincided with the first nesting reported at Stony Point since 1976, and increased use of North Fiesta Island (Marschalek 2007, pp. 16–17). Availability of unoccupied nesting sites has also been important to California least terns outside of the San Diego area. In 2012, when American kestrels and peregrine falcons were frequently present at the Alameda Point least tern colony, many California least terns pairs are believed to have relocated to Hayward Regional Shoreline (Euing 2012, pers. obs.). In 2013, in response to heavy predation pressure at Point Mugu, several hundred pairs of California least terns relocated to the nearby Hollywood Beach nest site.

California least terns may also relocate to new suitable sites or previously abandoned sites. For example, discovery of California least tern nest sites at Hayward Shoreline (southern San Francisco Bay) and Montezuma Wetlands (northern San Francisco Bay) in 2006 coincided with predation by burrowing owls and subsequent temporary abandonment of Alameda Point (Euing 2007a, pers. obs., 2007b, pers. obs.). Efforts to restore nesting habitat and re-establish least tern nesting in San Dieguito Lagoon had a small measure of success in 2013, when three pairs of least terns nested on created nest sites- the first nesting reported in San Dieguito Lagoon since 1992 (Massey 1975, p. A-7; Caffrey 1993, p. 21; Frost 2014, Table 1). Least terns also recently colonized habitat at Malibu Lagoon in 2017. Thus, having multiple sites with suitable nesting habitat that are secure from development—even if not always occupied—will reduce the magnitude of threats posed by habitat loss and predation (see **FACTOR C** for more information on predation).

In 2017, 25 of 29 currently occupied nesting areas occur on lands currently protected from development by local, State, and Federal law (see **FACTOR D** for more information on site protections). Four of these sites (Naval Amphibious Base (NAB) Coronado, MCB Camp Pendleton, NBVC Point Mugu, and Vandenberg Air Force Base (AFB)) occur on military lands, where conservation measures have been achieved through INRMPs and Biological Opinions (BOs) for protection of the least terns. Although habitat destruction has the potential to threaten the continued existence of the California least tern, the threat is currently alleviated by protections already in place for least tern nesting habitat.

As discussed above, data are limited on California least tern nesting on the Baja California Peninsula. Though some known least tern nesting sites are within protected areas (such as Ensenada de la Paz), other nesting sites that could contribute to the resiliency of the species have various levels of protection. Coastal development is a concern along the peninsula, as the development of planned desalinization facilities will enable increased development in areas previously unsuitable due to lack of water (Palacios 2018). However, the magnitude of the threat of habitat destruction in Mexico is uncertain.

Habitat Modification Due to Encroaching Vegetation

Encroaching vegetation continues to modify California least tern nesting habitat at 19 of 29 (66 percent) currently occupied nesting areas (Appendix A). As discussed in the Habitat or Ecosystem section above, many current California least tern nest sites in the United States are small and largely removed from the natural disturbance regimes that prevent or limit plant growth. Though sparse or low-lying vegetation can be used by chicks for shade or shelter (Thompson and Slack 1982, p. 165; Burger and Gochfield 1990, p. 38), terns will avoid or abandon areas with dense or tall vegetation as it has the potential to conceal predators (Burger and Gochfeld 1990, p. 38; Mazzocchi and Forys 2005, p. 74). Currently, multiple sites throughout the U.S. breeding range of the California least tern face impacts from vegetation.

The threat of encroaching vegetation has been decreased through pre-breeding season nesting site preparation. At many sites, this involves vegetation removal prior to the nesting season (Frost 2017, Appendix B-1). This necessary management is identified in INRMPs (for sites on military installations), in BOs and in Habitat Conservation Plans (HCPs). For example, the HCP for the City of San Diego, known as the City of San Diego Subarea Plan under the MSCP

(Multiple Species Conservation Plan) recommends vegetation management at sites under its ownership, and recommends measures to reduce edge effects that could degrade nesting habitat (City of San Diego 1997, p. 160). Many additional sites implement vegetation management on a yearly basis through local funding.

Lack of funding, lack of personnel, or contractual delays sometimes hinder pre-breeding season site preparation. For example, FAA Island is a dredge spoil site, and requires intensive management to maintain conditions conducive to nesting. Although CDFW had managed the site for several years, limitations on personnel and budgetary constraints precluded CDFW efforts from 2007 to 2012. In the absence of consistent management, the island became overgrown with predominantly nonnative vegetation, and tern numbers declined. If funding and/or personnel are not directed towards site preparation, many areas within the range of the species could become unsuitable to nesting. Therefore, vegetation encroachment at 19 of 29 occupied nesting areas remains a serious concern that could be significantly reduced by active management directed at pre-breeding season site preparation.

Today, several California least tern nest sites in Mexico still occur in coastal beach areas with natural sand transport systems. We were unable to find any reports of nest sites being rendered unsuitable through encroachment of vegetation. Therefore, based on the best available information, we do not expect encroachment of vegetation to pose a threat to least tern nesting habitat in Mexico in the immediate future. However, given the potential for development in some of these areas (which carries the risk of introduction of exotic vegetation); it is something that should be considered in future reviews.

Climate Change

A growing concern for the California least tern since the completion of the 2006 5-year review is impacts to the habitat resulting from climate change. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time and the term "climate change" refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a, p. 1450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, substantial increases in precipitation in some regions of the world, and decreases in other regions (for these and other examples, see Solomon *et al*. 2007, pp. 35–54, 82–85; IPCC 2013b, pp. 3–29; IPCC 2014, pp. 1–32). Results of scientific analyses presented by IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon *et al*. 2007, pp. 21–35; IPCC 2013b, pp. 11–12 and figures SPM.4 and SPM.5).

Scientists use a variety of climate models, which include consideration of natural processes and variability as well as various scenarios of potential levels and timing of greenhouse gas emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl *et al*. 2007, entire; Ganguly *et al*. 2009, pp. 11555, 15558; Prinn *et al*. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that greenhouse gas emissions will stabilize or decline. Thus, there is strong scientific support for projections that show warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of greenhouse gas emissions (Meehl *et al*. 2007, pp. 760–764, 797–811; Ganguly *et al*. 2009, pp. 15555–15558; Prinn *et al*. 2011, pp. 527, 529; IPCC 2013b, pp. 19–23). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

Pierce *et al.* (2013) used different methods to produce downscaled climate change models for California, using climate data from the period of 1985 to 1994, and predicted future temperature and precipitation changes for the future period of 2060 to 2069. The models suggest that by the 2060s, average State temperatures could increase 2.4 degrees Celsius (°C) with coastal temperatures rising about 1.9°C and inland areas warming almost 2.6°C. Increased temperatures will be more pronounced during the summer (June–August) compared to the winter (December–February) (Pierce *et al.* 2013, p. 844). In addition to temperature increases, the models predict a small annual decrease in precipitation in southern California and a negligible decrease in the north; however, precipitation patterns between seasons will be much more pronounced. Northern California is predicted to have wetter conditions in the winter with drier conditions during the rest of the year. In contrast, the southern portion of the state will experience a decrease in precipitation in every season except the summer, when projections show an increase in the amount of precipitation (Pierce *et al.* 2013, pp. 848–850). Precipitation projections also suggest there will be increased chances of flooding due to an increase in the 3-day maximum precipitation rate, especially in the northern portion of the State. It should be recognized that the projected seasonal changes are relatively small when compared to the State's natural variability (Pierce *et al.* 2013, p. 855).

Although many species already listed as endangered or threatened may be particularly vulnerable to negative effects related to changes in climate, we also recognize that, for some listed species, the likely effects may be positive or neutral. In any case, the identification of effective recovery strategies and actions for recovery plans, as well as assessment of their results in 5-year reviews, should include consideration of climate-related changes and interactions of climate and other variables. These analyses also may contribute to evaluating whether an endangered species can be reclassified as threatened, or whether a threatened species can be delisted.

Global sea level rise due to climate change could pose a threat to California least tern nesting areas. Most nesting areas are found on low-lying areas along estuaries or ocean beaches (i.e., southern San Diego Bay, MCB Camp Pendleton, Batiquitos Lagoon, Mission Bay, NBVC Point Mugu, Bolsa Chica, and Tijuana Estuary National Estuarine Research Reserve (NERR)).

Given that water expands as its temperature increases, sea-surface elevation can experience a corresponding rise as global temperatures increase (Karl *et al.* 2009, p. 18). Increased global temperatures have contributed to an accelerated decline in Arctic sea ice, further increasing sea levels across the globe (Comiso *et al.* 2008, pp. 3, 6). Researchers recorded increased sea surface temperatures of 0.8ºC (1.4 degrees Fahrenheit) to a depth of 100 m (328 ft) along the coast of southern California between 1950 and 1992 (Roemmich 1992, p. 373). A persistent sea level rise of 10 to 20 cm (4 to 8 in) was detected over the past century off the California coast (Moser and Tribbia 2007, pp. 35–36 and Figure 1) and of 0.9 mm (0.04 in) a year between 1950 and 1992 off the coast of southern California (Roemmich 1992, p. 374 and Figure 2(A)). Tide gauge analyses indicate that Global Mean Sea Level rose at a rate of about 3 mm/year (0.12 inches/year) since 1993, a result supported by satellite data indicating a trend of 3.4 ± 0.4 mm/year (0.13 ± 0.02 inches/year) over 1993–2015 (Sweet *et al.* 2017, p. 339). Sea level rise is projected to continue with a global average increase of 0.9–1.6 m (3–5.2 ft) by 2100 (AMAP 2011, p. 11). Regionally specific climate models predict a similar level of rise along the California coast of 1.0–1.4 m (3.3–4.6 ft) by 2100 (CCCC 2009a, p. 8). A summary of climate change findings by Point Reyes Bird Observatory predicts a smaller increase, of 0.1–0.72 m (0.33–2.4 ft) across several models (PRBO 2011, pp. 37, 41).

In the past five years (2012–2016), loss of California least tern nests and eggs has been attributed to flooding at nine nest sites in the United States (Frost 2013, Appendix B–5; Frost 2014, Appendix B–5; Frost 2015, Appendix B–5; Frost 2016, Appendix B–5; Frost 2017, Appendix B–5). Those sites included Santa Clara River, NBVC Point Mugu, Bolsa Chica, MCB Camp Pendleton, Batiquitos, Lindbergh Field, Saltworks, Naval Base Coronado, and Tijuana Estuary. Of these sites, NBVC Point Mugu and MCB Camp Pendleton experienced the highest loss of nests due to flooding. During the 2015–2016 winter, several severe high tide and flooding events occurred at NBVC Point Mugu. This recontoured sections of the beach and made nesting areas more prone to flooding. During the 2016 nesting season, 56 nests at Point Mugu were lost to flooding (Frost 2017, Appendix B–5). In 2016, MCB Camp Pendleton lost 42 nests, primarily at White Beach and Blue Beach (Frost 2017, Appendix B–5). In Mexico, flooding of nest sites is known to cause nest failure (Amador *et al.* 2008, p. 272; Palacios 2008, unpublished data), though the numbers lost each year are poorly understood due to infrequent survey efforts.

Future Threat of Sea Level Rise

Based on current climate predictions, the amount of habitat impacted by sea level rise is expected to increase in coming decades. A study by the California Climate Change Center (CCCC) predicted specific sea level rise within San Diego County. The study projected a rise of 0.31–0.46 m (1.0–1.5 ft.) by 2050, which would result in beach loss (CCCC 2009b, pp. 14, 16–18). These studies project that rising tides could impact areas currently used by nesting California least terns, including Tijuana Estuary, multiple sites at Naval Air Station (NAS) Coronado, and breeding sites at the San Diego Bay NWR. Loss of California least tern breeding habitat in San Diego County, which has the largest portion of least terns in the State (see Figure 2 above), could have a significant detrimental impact on California least tern productivity and on availability of nest sites.

In order to assess the future threats of sea level rise on the California least tern, we first mapped nesting sites that were occupied between 2013–2017. Then we analyzed the potential loss of nesting habitat under various scenarios of sea level rise at 2050 (a 30-year timeframe) and at 2080 (a 60-year timeframe). We selected the levels of sea level rise based on recent projections outlined in the State of California Sea-Level Rise Guidance document (COPC 2018). Since San Diego supports the largest tern nesting sites and is central to the overall nesting range of the species, we selected recent sea level rise projections for that area as a basis for our analysis (COPC 2018, Table 34, p. 38). For 2050, we analyzed a 1-foot sea level rise (a scenario that was captured by the upper end of the range where inundation was considered likely in that 30-year timeframe) and a 2-foot rise (which represented inundation that had a 1-in-200 chance of occurring in that 30-year timeframe). For 2080, we analyzed a 3-foot sea level rise (again, the scenario represented by the upper end of what was defined as likely in the 60-year timeframe) and 5-foot rise (representing a 1-in-200 chance of inundation in that longer timeframe). Therefore, for each nesting site in California, we analyzed the potential loss of nesting habitat at 1- and 2-foot sea level rise for 2050, and 3- and 5-foot sea level rise representing 2080. Results from this analysis are detailed in Table 2 and Appendix B.

In order to visualize and understand potential impacts of sea level rise to California least tern nesting habitat, we used the Sea Level Rise and Coastal Flooding Impacts Viewer, developed by the National Oceanic and Atmospheric Administration's (NOAA's) Office for Coastal Management (NOAA 2017). This tool offers access to data and information about the risks of sea level rise, storm surge, and flooding along the coastal U.S., including California. The NOAA data show the modeled extent and relative depth of inundation from 0 to 6 feet above the mean higher high water mark (MHHW), as well as confidence levels representing the known error in the elevation data and tidal corrections. Areas are assigned a high confidence of inundation, a low confidence of inundation, or a high confidence that these areas will not be inundated (i.e., remain dry) given the chosen water level represented by the scenario and time frame discussed above. A high degree of confidence was assigned to the results for locations that may be correctly mapped as "inundated" or "not inundated" at least 8 out of 10 times (i.e., 80 percent). A low degree of confidence was attributed to locations that may be mapped correctly (either as inundated or dry) fewer than 8 out of 10 times. In this analysis, we calculated the amount of inundation probability using both the high confidence (80 percent inundated or not *inundated) and the low confidence (20–80 percent) levels that fell in between (Appendix B). However, we only categorized probabilities of impacts to nesting areas based on results for inundation with high confidence (80 percent) at the MHHW using 1- and 2-foot sea level rise projections for 2050, and 3- and 5-foot sea level rise projections for 2080 (Appendices C and D).*

Table 2. Summary of impacts to California least tern nesting sites in the United States at sea level increases considered likely in 2050 and 2080.

A. 1-ft Sea Level Rise (2050)

Probable Inundation	Number of nesting sites	Total acres at sites	Percent of total CLT habitat (1,204 ac)
None (<1%)	24	643	53.4%
Minimal (1–20%)	7	248	20.6%
Moderate (21–50%)	5	132	10.9%

Probable Inundation	Number of nesting sites	Total acres at sites	Percent of total CLT habitat (1,204 ac)
Significant (51–99%)	2	178	14.8%
Complete (100%)	2	< 1	0.1%

B. 3-ft Sea Level Rise (2080)

Probable Inundation	Number of nesting sites	Total acres at sites	Percent of total CLT habitat (1,204 ac)
None (<1%)	18	418	34.7%
Minimal (1–20%)	10	358	29.8%
Moderate (21–50%)	5	131	10.9%
Significant (51–99%)	4	117	9.7%
Complete (100%)	3	177	14.7%

Impacts to Specific Nesting Sites

Although nesting sites for the California least tern are dispersed along the California coast and Baja California Peninsula, the majority of nesting occurs at a handful of sites, including MCB Camp Pendleton, NAB Coronado, Batiquitos Lagoon, Alameda, and Huntington State Beach. Therefore, it is particularly important to understand the potential impact to these specific sites from sea level rise.

MCB Camp Pendleton

2050 Timeframe: Based on the projections for the 1-foot rise in sea level and resulting inundation, impacts to nesting areas on MCB Camp Pendleton range from none (Red Beach and White Beach South), to minimal (Salt Flats and White Beach North (1 percent)), to moderate (Blue Beach (32 percent)). Based on the projections of a 2-foot rise in sea level and resulting inundation, impacts to nesting areas on MCB Camp Pendleton range from none (White Beach South; 0 percent), to minimal (White Beach North (4 percent), Red Beach (2 percent), Salt Flats (8 percent)) to moderate (Blue Beach (37 percent) (Appendix B).

2080 Timeframe: All nesting sites on MCB Camp Pendleton will be impacted to some degree with a 3-foot or a 5-foot level sea rise. Impacts to nesting areas range from minimal (White Beach North (6 percent at 3 feet or 17 percent at 5 feet), White Beach South (3 percent at 3 feet or 15 percent at 5 feet), Red Beach (5 percent at 3 feet or 14 percent at 5 feet)) to moderate (Blue Beach in the 3-foot scenario (42 percent)) to significant (Salt Flats (51 percent at 3 feet or 93 percent at 5 feet), Blue Beach (62 percent at 5 feet)) (Appendices B and C). In 2016, the majority of the nests (804) and nesting pairs (778) were documented at Blue Beach (Frost 2017,

Table 1). Of the approximately 89-acre nesting site at Blue Beach, 37 to 55 acres are projected to be inundated. The adjacent Salt Flat nesting area (111.72 ac) will be halfway to almost entirely inundated and unavailable for nesting (Appendix D). Although some nesting habitat will remain at the Blue Beach site, terns will need to shift to other nesting areas on MCB Camp Pendleton such as White Beach (51.13 ac currently) and Red Beach (7.54 ac currently). These sites, however, are smaller than Blue Beach and will be even more reduced in size in 2080 with sea level rise. The ability of these sites to support the majority of nesting pairs on MCB Camp Pendleton is uncertain and of concern.

NAS North Island/NAB Coronado

<u>2050 Timeframe</u>: Based on the 1-foot sea level rise and associated inundation, there will be no (NAS North Island and NAB Delta beaches) or minimal impacts (NAB Oceans (9 percent)). Based on the projections of a 2-foot rise in sea level and resulting inundation, impacts to these nesting areas range from none (NAS North Island) to minimal (NAB Delta Beaches (3 percent), NAB Oceans (13 percent))(Appendices B and C). In light of the projected amount of inundation, terns will likely be minimally impacted by a 1- or 2-foot rise in sea level over the next 30 years and will be able to continue to nest at these important sites.

<u>2080 Timeframe</u>: With a 3- or 5-foot level sea rise, impacts to nesting areas range from none (NAS North Island), to minimal (Delta Beaches (5 percent at 3 feet or 18 percent at 5 feet), NAB Oceans (15 percent at 3 feet)), to moderate (Oceans (22 percent at 5 feet))(Appendices B and C). Of the nesting habitat currently available at Delta (46.92 ac) and Oceans (109.45 ac), 2.35 ac and 16.42 ac are projected to be inundated in the 3-foot scenario and 8.42 ac and 23.57 ac, respectively, are projected to be inundated in the 5-foot scenario. Although the impacts increase at the 2080 timeframe, the majority of the nesting habitat will still be available for terns at these sites.

Batiquitos Lagoon

<u>2050 and 2080 Timeframe</u>: Based on the projections, there is high confidence that the nesting sites will not be impacted at the 1-, 2- (both 2050 projections) and 3-foot (2080 projection) inundation levels and only minimally impacted at the 5-foot inundation in 2080 (1 percent) (Appendices B and C).

Alameda

<u>2050 and 2080 Timeframe</u>: Based on the projections of a 1- or 2-foot (in 2050) and 3-foot (2080) rise in sea level rise, there is high confidence that the nesting sites will not be impacted. In the event of a 5-foot sea level rise in 2080, the nesting area will be only minimally impacted (2 percent) (Appendices B and C). We therefore expect that terns will be able to nest at this site into the future.

Although we are basing our analysis on the high confidence (80 percent) levels, it is important to note that there is a high degree of uncertainty associated with a 5-foot rise in sea level for this site in the 20–80% confidence interval. Should that level of inundation occur (though unlikely), the loss of up to 39% of nesting habitat could result.

Huntington State Beach

2050 and 2080 Timeframe: Based on the projections for all sea level rise scenarios, there is high confidence that the nesting sites will not be impacted in 2050 nor in 2080 (Appendices B and C). We therefore expect that terns will be able to nest at this site into the future. However, it is important to note that there is a high degree of uncertainty associated with a 5-foot rise in sea level for this site at the 20–80 percent confidence level. Should that level of inundation occur (though unlikely), the loss of up to 32 percent of nesting habitat could result.

Under natural conditions, nesting sea or shorebirds would relocate to higher or more inland areas. However, adaptation by California least tern to rising sea level is restricted by existing development and high recreational, economic, or military usage of areas proximal to nest sites (Moser and Tribbia 2007, p. 38). While the current constraints associated with existing uses is known, what we cannot anticipate are the specifics in regard to whether and how much these uses may change with the changes associated with sea level rise. Therefore, though inundation is currently only impacting a small percentage of nesting habitat, it could become a significant threat to the species within the future, particularly at key sites like MCB Camp Pendleton. The magnitude of this threat depends on the future climate of California, as discussed in **FACTOR E**, and whether or to what extent management of nest sites or identification of new nesting sites can minimize the impact.

Summary of Future Threat of Sea Level Rise

We analyzed the potential loss of nesting habitat at 1- and 2-foot sea level rise for 2050, and 3- and 5-ft sea level rise for 2080 for each nesting site in California. The more likely scenario is a 1-ft rise in sea level by 2050 and a 3-ft rise by 2080. Results from this analysis suggest that the majority of nesting sites will not be inundated at the 1-ft and 3-ft predictions. A total of 31 of the 40 nest sites (74 percent of habitat) may be up to 20 percent inundated at the 1-ft level, compared to 28 of 40 nest sites (64.6 percent of habitat) at the 3-ft level. This means that 26 percent of habitat at 1-ft and 35.4 percent at 3-ft is more than 20 percent inundated by 2050 and 2080, respectively. Under this scenario there is likely to be ongoing loss of habitat in the future, though the majority of existing nesting sites are not likely to be severely inundated over the next 60 years. More information for both scenarios can be found in Appendices C and D.

Summary of Factor A

Development of nesting habitat, encroaching vegetation, and rising sea levels contribute to the destruction, modification, and curtailment of suitable nesting habitat of the California least tern. However, the magnitude of threats attributed to development of nesting habitat and encroaching vegetation has decreased since the time of listing, and has remained relatively constant since the 2006 5-year review. The majority of currently occupied nesting areas are currently afforded protection through management actions through coordinated efforts with our partners and are implemented through ongoing management plans (i.e., INRMPs) and MOUs (Appendix A). These management activities have helped to reduce threats currently affecting California least terns, such as threats from encroaching vegetation and development of nesting habitat. Therefore, we do not consider development or habitat modification due to encroaching vegetation to be significant threats at this time. Rising sea levels as a result of climate change do not pose significant threats to low lying nesting areas across the range of the species in United

States and Mexico in the short term, at least based on current and near-term modeling. However, rising sea levels could pose a significant threat in the longer-term future by limiting the amount of available California least tern nesting habitat and potentially changing the way anticipated uses affect that amount of habitat.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The California least tern's historical decline has been partially attributed to use of the species' feathers for hat production (i.e., millinery) during the early 1900s (Fisk 1975, p. 1; USFWS 1985b, p. 20; Birdsall 2002, p. 1). However, a number of factors worked together to end this threat: protection of the species under the Migratory Bird Treaty Act of 1918, a change in the use of wild-killed feathers in millinery, and a change of fashion (Birdsall 2002, p. 1). In California, scientists are continually conducting research and performing recovery efforts through USFWS-issued 10(A)(1)(a) recovery permits. Federal recovery permits contain provisions to minimize and mitigate impacts to California least terns. Given these protections, these research activities are not posing a threat to the California least tern. Additionally, we are not aware of any substantive threats under this factor to the species within Mexico. Therefore, we have no information to suggest that overutilization is currently a threat to California least tern throughout its range, nor that it is likely to become a threat within the foreseeable future.

FACTOR C: Disease or Predation

At the time of listing, nest predation was considered a significant threat to the California least tern, and a major cause of nest failure. Despite multiple predation management strategies in place at the time of the 2006 5-year review, we found that predation remained a significant threat. Disease was not considered a threat at the time of listing or in the 5-year review.

Disease

Colonial nesting waterbirds with similar life history traits to the California least tern are known to be subject to disease outbreaks (Brand *et al*. 1983, p. 269; Friend 2002, p. 293). The flocking nature of tern species, exacerbated by loss of habitat and the concentration of large numbers of least terns at just a few nesting sites, may increase their vulnerability to disease and mass die-offs (Lafferty and Gerber 2002, p. 595; Lafferty and Holt 2003, p. 663). However, no such die-offs have been documented within the range of the California least tern, nor are we aware of any major die off in any least tern subspecies. Therefore, disease does not seem to be affecting California least terns on a large scale.

Disease may still be affecting California least terns on a smaller scale. Several California least tern deaths due to viruses have been documented since the 2006 5-year review. For example, in 2008 West Nile Virus was detected in a dead California least tern (Foster 2008, pers. comm.). Additionally, necropsy analyses have identified bacteria as the cause of death in several California least terns; pathogens detected included *Vibrio cholera, Escherichia coli,* and *Streptococcus* strains (Caffrey 1997, p. 9). The overall disease rate in California least terns is unknown, as few individuals are tested for the presence of disease. Funds for this type of testing are limited, and testing is further complicated because many strands of bacteria are no longer detectable once the body reaches the necropsy site (Foster 1996, p. 59). Nevertheless, some data are available. Necropsy results of chick and adult carcasses identified bacterial pathogens in three of five individuals examined from MCB Camp Pendleton, in one of one individual examined from NAB Coronado North Island, in two of three individuals examined from Mariner's Point in San Diego Bay, and in one of two individuals examined from Oceano Dunes State Vehicular Recreation Area (Caffrey 1997, p. 9; Marschalek 2007, Appendix B-5).

Despite those results, it is not certain that disease was the cause of death for these California least terns. While emaciated birds may more easily contract bacterial diseases due to poor health, illness due to bacteria may also cause birds to be unable to forage (Foster 1996, p. 58). This may cause the death of the bird to be misdiagnosed, making it appear to have died from inadequate food resources rather than disease (Foster 1996, p. 58). It is therefore difficult to pinpoint the exact cause of some deaths and thus the impact of disease on the California least tern population.

The introduction of West Nile Virus and avian influenza into the range of the California least tern is a cause for concern. Though few specimens are regularly analyzed, we have not seen any evidence of large-scale impact on any tern populations in California or in other parts of the United States. Given the lack of evidence of significant impacts, and the low number of deaths attributable to other viral and bacterial pathogens, disease does not likely pose a threat to the California least tern now or in the future in any portion of its range.

Nest Predation

Nest predation is a natural aspect of the California least tern's breeding ecology. However, nests were historically much more widely scattered and hard for predators to detect (Massey 1974, pp. 17–18). Today, most of the California least tern population is densely packed into relatively small, static, colony sites (average of 5.3 ha (13 ac); median of 3.2 ha (8 ac)). These dense populations with large numbers of birds can be subject to frequent and high levels of predation because they present a large food source concentrated in a small area (Massey and Atwood 1982, p. III–6; Burger 1984, p. 66). Predators can devastate California least tern reproductive success by causing nest failure or abandonment, site abandonment, and mortality (Massey and Fancher 1989, pp. 352–353). Chicks and eggs are the prey of choice; both are vulnerable and provide an easy source of food for invertebrates, rodents, skunks, opossums, raccoons, feral cats, and some species of birds (Marschalek 2010, Table 6). Predation is a rangewide threat that can impact California least terns beyond just direct mortality. Nesting birds exposed to signs of predator presence displayed decreased egg-laying, decreased chick feeding rates, and decreased fledgling success (Zanette *et al.* 2011, pp. 1399–1400). Predator control activities became more intensive after the time of listing. However, predator pressure continued to affect the species, so in the 2006 5-year review we recognized predation as a significant and ongoing threat across the range of the taxon.

At least 54 taxa (33 birds, 18 mammals, 1 reptile, and 2 invertebrates) are known to prey on California least tern eggs or chicks (Marschalek 2009, Table 6; 2010, Table 6). Although the list of known and suspected predators is long, a small number of species pose consistent threats. The northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), burrowing owl (*Speotyto cunicularia*), American crow (*Corvus brachyrhynchos*), loggerhead shrike (*Lanius ludovicianus*), van Rossem's gull-billed tern (*Gelochelidon nilotica vanrossemi*), coyote (*Canis latrans*), peregrine falcon (*Falco peregrinus*), red fox (*Vulpes vulpes*), domestic cat (*Felis catus*), and old-world rat species (*Rattus* spp.) are the most common predators, and cause the most significant impacts (Fancher 1992, p. 62). These species hone in on a site, move between nests taking eggs or chicks, and return repeatedly until the food supply is reduced to a volume not worth pursuing. These predators can cause significant loss to a California least tern nest site in a matter of hours or days (Fancher 1989, pp. 3–6; Massey *et al.* 1992, pp. 980–981). Examples of such predation events are plentiful and include, but are not limited to:

- One or more American kestrels killed approximately 100 chicks within a week at Venice Beach in 1982 (Massey and Atwood 1982, pp. III-6; Massey *et al.* 1992, p. 980).

- One red fox took eggs from 31 nests at Huntington Beach in just a few days (Fancher 1989, p. 5).

- Gull-billed terns took 10 to 12 chicks at NAB Coronado in a day in 2007 (Copper 2007, pers. comm.).

- A single coyote depredated 260 nests within 10 days at MCB Camp Pendleton in 1999 (Foster 2007, pers. comm.).

- From 2002–2005, and again in 2009, 2011, 2012, 2013, 2015, and 2016 there was zero productivity within the Venice Beach nest site due to disturbance or complete predation of the colony (Ryan and Vigallon 2009, p. 3; Marschalek 2011, Table 1; Marschalek 2012, Table 1; Frost 2013, Table 1; Frost 2014, Table 1; Frost 2016, Table 1; Frost 2017, Table 1).

- Due to lack of predator management in 2017 at MCB Camp Pendleton, 85 percent of the nests were depredated and only 4 fledglings were documented (Murbock 2018).

Development and existing urban sprawl may introduce more predators to proximal nest sites. Populations of native predatory species, such as American crow, common raven (*Corvus corax*), American kestrel, Cooper's hawk (*Accipiter cooperii*), striped skunk (*Mephitis mephitis*), and raccoon (*Procyon lotor*), can be artificially high around urban areas and urban interfaces due to their ability to exploit garbage and other food sources attributable to humans (Garrott *et al.* 1993, pp. 946, 948; Bolger *et al.* 1997, pp. 411 and 416). Existing urban development also increases the presence of nonnative predators, such as Virginia opossum (*Didelphis virginiana*), rats, and domestic cats. Furthermore, development and landscaping adjacent to nest sites can introduce predator perches with a line-of-sight into the nest site, thus making nesting California least terns more susceptible to avian predators. Habitat loss and fragmentation resulting from development also decreases the availability of forage habitat for resident predators, and thus increases resident predator concentrations on the small remaining forage habitat, which includes California least tern nest sites. Additionally, as discussed in **FACTOR A**, habitat loss and fragmentation can also affect the impacts predators have on the survival and productivity of California least terns. California least terns often abandon a site for one or more seasons if they sustain heavy losses of eggs, chicks, or adults. Therefore, development and urban sprawl can increase the impacts of predation on California least terns.

Management activities at the majority of nest sites have reduced the magnitude of the threat of predation; however, efforts to implement predator management have become more complicated by the increased public awareness and efforts to reduce potential effects to sensitive avian predators (see the Predation by Special Status Species below). Additionally, predator management techniques, target species, and effectiveness vary among sites. In 2016, 71 percent of nesting sites had predator management (Frost 2017, p. 14). Predation of California least terns is occurring at all 29 currently occupied nesting areas (Appendix A).

Much of California least tern management is conducted or overseen by Federal action agencies as a result of consultation under section 7 of the Act. Multiple military institutions, including MCB Camp Pendleton, NAB Coronado, and NBVC Point Mugu all provide for predator management at least tern sites they oversee. These management activities include fencing of nest sites, and lethal and non-lethal control of predators. The City of San Diego Subarea Plan under the MSCP also provides important predator management within the plan area (City of San Diego 1997, pp. 159–160).

As a result of predator management at military sites and other areas, California least tern reproductive success and survival increased in the late 1980s and early 1990s, greatly contributing to the overall breeding population (Fancher 1992, p. 62). Initiation of predator control mechanisms at most nest sites in the United States in the late 1980s is associated with an increased rate of population growth (Figure 5) (Fancher 1992, p. 62 and Figure 1). Shwiff *et al.* (2005, p. 285) performed a cost-benefit analysis and found a positive relationship between funds invested in predator management and reproductive success of terns at MCB Camp Pendleton. The numbers of California least tern pairs tripled 6 years after predator management began in 1995 (Shwiff *et al*. 2005, p. 285). Therefore, though high predation levels continue even on managed sites, predator management has resulted in increased California least tern population numbers and higher productivity.

On military-owned lands, predator control has been continuously funded in all years (with the notable exception of MCB Camp Pendleton in 2017), increasing productivity and preventing California least terns from abandoning sites in the middle of the season due to predator pressure. Some contractual delays have resulted in late initiation of predator management efforts in some years. Predator control on all public lands (Table 2) is subject to annual budgets and other State and Federal requirements. The closure of multiple California State Parks, including McGrath State Beach highlights the unpredictability of funding on some public lands (Van Oot 2011, pp. 1–3). Nesting has largely failed at sites that lack predator control (e.g., San Elijo Lagoon). In 2011, contractual delays resulted in the elimination of predator control and site monitoring activities at Batiquitos Lagoon. Subsequently, all nests were lost at the most productive site at the lagoon, and decreased productivity occurred across the rest of the site (Foster 2011b, pers. comm.). In 2017, predator management was not conducted on MCB Camp Pendleton due to contracting issues. The lack of predator control resulted in essentially zero productivity for the year with only four fledglings in 2017. Any further cessation or interruption of predator control could cause continued declines in productivity, and eventually significant decreases in population size of the California least tern.

In Mexico, nest predators (dogs, coyotes, and ravens) are a problem at certain California least tern nesting sites (Palacios 2008, unpublished data; Palacios 2018a), but not all (Zuria and Mellink 2002, p. 619). However, we are not aware of any annual active predator control programs at nest sites in Mexico and data on annual rates of predation are not available. Many sites in Mexico lack the same degree of urbanization that characterizes many California least tern nesting areas in the United States. Therefore, though predation is likely affecting California least terns nesting in Mexico, it is likely that predation rates are lower compared to United States nesting areas.

Predators continue to impact California least terns, particularly at the egg and chick stage. However, the magnitude of this threat has been greatly reduced in the United States by the continued implementation of predator management at the majority of nesting sites. Even if predation cannot be eliminated completely through control methods, the currently implemented predator control provides a strong benefit to the California least tern such that predation poses a moderate risk to California least terns in the United States at this time. Predation also likely poses a threat within the Mexican range of the species but the level and effect of predation is potentially lower given the reduced level of urbanization in these more remote area, compared with the United States. We anticipate that some nest predation may be locally high and significant in some colonies in Mexico given the lack of predator control program, specifically where predators have keyed into productive tern nesting areas. However, least terns are also adapted to predation by their ability to relocate and renest when nests are depredated. We expect these levels of threat to continue into the future.

Predation by Special Status Species

Reduction and fragmentation of available habitat for special status species can create predator management conflicts, particularly when one species preys on the other (Garrott *et al.* 1993, p. 948). The burrowing owl, gull-billed tern, and peregrine falcon are each identified by the USFWS as a "Bird of Conservation Concern" (USFWS 2008, Tables 30, 48). The State of California lists both the gull-billed tern and burrowing owl as "Bird Species of Special Concern" (Shuford and Garibaldi 2008, Table 1). Burrowing owls have preyed on California least terns at NAS North Island, Alameda Point, and Los Angeles Harbor (Marschalek 2006, Appendix B–6). One of two remaining coastal nesting populations of burrowing owls is located on NAS North Island in close proximity to nesting California least terns. When present, burrowing owls have the potential to significantly impact California least terns. However, in recent years, burrowing owls have not been identified as a significant predator (Frost 2015; 2017). Therefore, limited control options for burrowing owls are not likely to pose a substantial threat to California least terns, in part because the owls are absent from most current sites.

Gull-billed terns are an increasingly common predator of California least tern eggs and chicks. In 2009, the gull-billed tern emerged as one of the most prevalent predators of the California least tern, where 40 percent of all documented predation was attributed to the species (Marschalek 2010, p. 12). Gull-billed terns began nesting in San Diego Bay in 1987 (Patton 2009a, p. 1), and the colony increased to 57 pairs nesting in 2009 (Patton 2009a, Table 3). The first predation incident by gull-billed terns was recorded in 1992 at the Saltworks in San Diego Bay (Caffrey 1993, p. 31). In 2006, only two California least tern chicks were confirmed as depredated by gull-billed terns (Patton 2006, p. 13). However, the number of recorded predation events increased in 2007, when 11 percent of all predation recorded in the State was attributed to the gull-billed tern, and in 2009, it became the number one predator of California least tern eggs and chicks (Marschalek 2008, Table 7; 2010, Table 7). However, the number of least terns suspected or documented to have been depredated by gull-billed terns has decreased over the last several years with 813 individuals depredated in 2009, 222 in 2010, 149 in 2011, 87 in 2012, 2 in 2013, 7 in 2014, 14 in 2015, and 9 in 2016 (Frost 2017, p. 14).

The magnitude of gull-billed tern predation on population growth of the California least tern is difficult to separate from other factors impacting chick survival, such as low food availability (Factor E), abandonment, and predation by other species. Annual predation rates in the annual State reports include both documented and suspected predation events (Marschalek 2010, p. 11); thus, the number of actual predation events by gull-billed terns could be higher or lower than the number given in the report. Gull-billed terns hunt from the air and do not always leave characteristic marks after predation occurs (Foster 2011a, pp. 73–74).

The protected status of gull-billed terns under the Migratory Bird Treaty Act limits predator control options. Currently, gull-billed terns cannot be removed from a nesting site, as can mammalian predators. Furthermore, no lethal control methods have been approved for controlling gull-billed terns that prey upon California least terns. Other efforts that could be used to harass gull-billed terns, such as noise, cannot be used as gull-billed terns nest in close proximity to least terns and other protected species.

The threat of gull-billed terns to nesting California least terns drastically changed after an unprecedented die-off of at least 92 adult gull-billed terns in San Diego Bay in the summer of 2013 (Patton *et al*. 2017). Necropsy results determined the birds had perished due to peritonitis due to perforations of the intestine by a large quantity of the parasitic worm acanthocephala (*Profilicollis* [*Polymorphus*] *altmani*) (Patton *et al*. 2017). Mole crabs (*Emerita analoga*), the intermediate host for *P. altmani* and a major component of the gull-billed tern diet in San Diego, were found in the stomachs of necropsied terns along with cystacanths, and are the presumed source of the parasite infection (Patton *et al*. 2017). This mortality event likely significantly decreased the impact of gull-billed tern predation on California least terns from 2013–2016 (Frost 2017, p. 14).

Since the publication of the 2006 5-year review, the peregrine falcon, which is considered a fully protected species by the State of California, has become an increasingly common predator at California least tern nesting sites. The number of adult California least terns documented as depredated by peregrine falcons in 2012 (80 adults) has drastically increased from 2007 levels (3 adults). In the 2016 season, peregrine falcons were likely predators at a number of nesting locations throughout the range, including Alameda Point, Hayward Regional Shoreline, Santa Clara River, MCB Camp Pendleton, Mission Bay, and Naval Base Coronado. The peregrine falcon presents a unique challenge for predator management in large part because it preys primarily on adult or fledgling California least terns. Predation of adults and fledglings is more serious than predation of eggs and chicks because adult survival is one of the most influential factors on population growth of beach-nesting birds (Hitchcock and Gratto-Trevor 1997, p. 530). Raptors that habitually prey on least terns can be moved by permitted individuals to locations away from breeding colonies, lessening the impact of the threat on the species. However, any measures to decrease predation by peregrine falcons must take into consideration the protections afforded to the species through the Migratory Bird Treaty Act. Furthermore, if the release locations are not at a significant distance, the raptors can quickly return to their point of capture. Currently, the permitting process for removal of raptor species that impact nesting California least terns is undergoing change on both State and Federal levels. Inability to control any predators has the potential to increase the impact of predation events on California least terns.

Long-term presence of predators, particularly predators of adult California least terns such as peregrine falcons or American kestrels, can have a colony-wide impact. In some cases, sustained predation by a raptor such as a peregrine falcon can cause many California least terns to abandon their nests, as happened in Alameda Point in 2012 (Euing 2012, pers. obs.). Therefore, the impact of peregrine falcons on least tern breeding colonies has increased since the last 5-year review, and unless management actions can be developed that are not detrimental to peregrine falcons, the problem may continue to increase.

Therefore, based on the best available scientific information, special-status predators pose a considerable threat affecting productivity of nesting sites and may potentially increase in the future.

Summary of Factor C

Based on the best available scientific information, disease is not a threat to the California least tern, nor do we expect it to become a threat within the foreseeable future throughout the range of the species. As nesting California least terns continue to concentrate in limited nesting locations, management of predators becomes increasingly more important than it was at the time of listing. Predator management is especially complicated when other sensitive species are involved. Therefore, in consideration of the overall effects, predation by all species (including special status species) continues to pose a significant threat across the range of California least terns and is a threat at each nesting area. In 2016, predator control measures were employed at the majority (71 percent; Frost 2017, p. 14) of least tern sites in the United States and have helped to reduce impacts throughout much of the range. However, this rangewide threat is difficult to manage effectively and impacts are likely to continue in the future.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At listing in 1969, regulatory mechanisms that provided some protection for the California least tern included: (1) land acquisition and management by State, Federal, or local agencies or by private groups and organizations; (2) the Migratory Bird Treaty Act, and (3) local laws and regulations. The previous 5-year review analyzed the potential level of protection provided by these regulatory mechanisms and those enacted since listing, finding that though a number of State and Federal laws may afford protection, it may not always be adequate to prevent loss and degradation of California least tern habitat (USFWS 2006, p. 20). This review provides an updated summary on State, local, and Federal mechanisms that provide a conservation benefit to the California least tern.

State Protections in California

State laws potentially providing protection to the California least tern include the California Endangered Species Act (CESA), California Environmental Quality Act (CEQA), and Natural Community Conservation Planning Act enacted in 1991. The California least tern was State listed as endangered in 1971.

California Endangered Species Act

The California least tern is listed as an endangered species under the CESA of 1984 (CESA–California Fish and Game Code sections 2050 *et seq*., and California Code of Regulations, title 14, subdivision 3, chapter 6, article 1, commencing with section 783) and a fully protected species pursuant to section 3511 of the Fish and Game Code. This legislation requires State agencies to consult with CDFW on activities that may affect a State-listed species. While CESA allows for take incidental to otherwise lawful development projects, fully protected species may not be taken or possessed at any time and no licenses or permits may be issued for their take except for collecting these species for necessary scientific research, with two exceptions. Incidental take of fully protected species is authorized in relation to Natural Community Conservation Plans (NCCPs), when the plan is approved by the State and results in conservation and management for the protected species (California Fish and Game Code, section 2835). Additionally, take is authorized in relation to implementation of the Quantification Settlement Agreement, which mandates preservation of the Salton Sea. In the latter case, take is only authorized when an adaptive management plan occurs that results in substantial conservation benefit for the fully protected species (California Fish and Game Code, section 2081.7). Given the limited nesting of terns at the Salton Sea, and protections authorized under existing NCCPs (see the Natural Community Conservation Planning Act section below), those exceptions are not likely to pose a significant threat to the California least tern.

California Environmental Quality Act (CEQA)

The CEQA is the principal statute mandating environmental assessment of projects in California. The purpose of CEQA is to evaluate whether a proposed project may have an adverse effect on the environment, and if so, to determine whether that effect can be reduced or eliminated by pursuing an alternative course of action or through mitigation. CEQA applies to projects proposed to be undertaken or requiring approval by State and local public agencies (CRA 2005, p. 1). CEQA requires disclosure of potential environmental impacts and a determination of significant if a project has the potential to reduce the number or restrict the range of a rare or endangered plant or animal; however, projects may move forward if there is a statement of overriding consideration. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 2100.2). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved. Therefore, it is unlikely that this law would be adequate to protect the U.S. population of the California least tern in the absence of protections afforded it by the Act.

Natural Community Conservation Planning Act (NCCP)

In 1991, the State of California passed the Natural Community Conservation Planning Act to address the conservation needs of natural ecosystems throughout the State (California Fish and Game Code, section 2800 *et seq*.). The Natural Community Conservation Planning program is a cooperative effort involving the State of California and numerous private and public partners to protect regional habitats and species. The primary objective of NCCPs is to conserve natural communities at the ecosystem scale while accommodating compatible land uses. NCCP helps identify, and provide for, the regional- or area-wide protection of plants, animals, and their habitats while allowing compatible and appropriate economic activity. Many NCCPs are developed in conjunction with HCPs prepared pursuant to the Act. Regional NCCPs may provide protection to federally listed species by conserving native habitats upon which the species depend.

California least terns are a covered species under the MSCP (City of San Diego Subarea Plan). They are also covered by the Carlsbad Habitat Management Plan (Carlsbad HMP) under the Multiple Habitat Conservation Plan (MHCP). These NCCPs/HCPs are further discussed under the **Federal Protections** section below.

Federal Protections

National Environmental Policy Act (NEPA)

NEPA (42 U.S.C. 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. NEPA does not impose substantive environmental obligations on Federal agencies; it merely prohibits an uninformed, rather than unwise, agency action, and its public notice provisions provide an opportunity for the USFWS and others to review proposed actions and provide recommendations to the implementing agency. However, if an Environmental Impact Statement is developed for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigations that could offset those effects (40 CFR 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Clean Water Act (CWA)

Under section 404 of the CWA, the U.S. Army Corps of Engineers (Corps) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term wetland refers to areas meeting the Corps' criteria of having hydric soils, hydrology (either sufficient flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any actions within California least tern habitat that have the potential to impact waters of the United States would be reviewed under the CWA, as well as NEPA. These reviews require consideration of impacts to the California least terns and their habitat, and when significant impacts could occur, compensation to offset the proposed action would be recommended. Given that the California least tern is a coastal species that forages over water, it is likely that agencies proposing actions subject to the CWA near nest sites would review impacts to the tern. However, it is unlikely that this law would be adequate to minimize threats to the U.S. population of the California least tern in the absence of protections afforded by the Act.

Coastal Zone Management Act (CZMA)

The Coastal Zone Management Act of 1972 (16 U.S.C. 1451 *et seq.*) created a broad program based on land and seaward development controls within coastal zones, incorporating State involvement through the development of programs for comprehensive State management. The CZMA requires Federal agencies or licensees to carry out their activities in such a way that they conform to the maximum extent practicable with a State's coastal zone management program. One of the most significant provisions of the federal CZMA gives state coastal management agencies, such as the California Coastal Commission (see below), regulatory control (federal consistency review authority) over all Federal activities and federally licensed, permitted or assisted activities, wherever they may occur within respective coastal zone boundaries fixed under state law.

The California Coastal Commission was established by voter initiative and later made permanent by the California State Legislature through adoption of the California Coastal Act of 1976. The California Coastal Commission considers the presence of federally listed species in determining "environmentally sensitive habitat" lands subject to section 30240 of the California Coastal Act, which requires their protection. Coastal habitats occupied by federally listed species within the coastal zone in California are environmentally sensitive areas under Section 30107.5 of the California Coastal Act; in such the act provides protection to California least tern in those cases where they would be affected by a proposed project requiring a coastal development permit. However, state regulations, policies, and goals include mandates both for protection of beach and dune habitat and for public recreational uses of coastal areas; consequently they may conflict with protection of California least tern in some cases.

Certain local jurisdictions have developed their own Local Coastal Programs or Land Use Plans that have been approved by the California Coastal Commission. However, the CZMA and the California Coastal Act does not wholly address the injury or death of California least terns, and only reduces loss or degradation of habitat absent. Therefore, it is unclear what, if any, protections the species would receive from this law in the absence of protections afforded it by the Act.

Migratory Bird Treaty Act (MBTA)

Prior to the issuance of M-Opinion 37050, the interpretation of the Migratory Bird Treaty Act was that incidental take of birds, including active bird nests in native nesting substrates containing eggs or nestlings, would have been prohibited without a permit. Since the removal of native habitats that contain eggs and nestlings ultimately results in the destruction of those eggs and nestlings, the prior interpretation of the MBTA provided a temporary protection to native habitats that were actively being used for nesting until the colony was independent of it. Once those individuals become independent of their nests the habitat could be destroyed without violating the MBTA.

Again, the habitat of migratory birds in of itself were not actually protected by the MBTA, it was the individuals (i.e., eggs or nestlings) dependent on that substrate that were protected; the habitats they used were indirectly protected. Since the issuance of M-Opinion 37050 (DOI 2017, entire), the current interpretation of the MBTA only prohibits the purposeful take of birds without a permit and not the incidental take of birds. Therefore, if the removal of active native nesting habitat results in the destruction of eggs or nestlings, but the destruction of those eggs and nestlings is not the purpose of the action, then the removal of native nesting habitats resulting in the loss of nestlings or eggs is no longer considered a violation of the MBTA.

Since California least tern habitat with eggs present can be destroyed without a permit, the MBTA in its current form does not ameliorate the threats to the species from development and human disturbance.

National Wildlife Refuge System Improvement Act

The National Wildlife Refuge System Improvement Act of 1997 (Pub. L. 105–57) establishes the protection of biodiversity as the primary purpose of the National Wildlife Refuge System. This has led to management actions that benefit the California least tern (particularly in southern California) that are an important component of the recovery strategy for the California least tern. There are 70 acres (28 ha) of California least tern nesting habitat supporting 12 percent of the U.S. breeding population on National Wildlife Refuge System lands managed by the USFWS.

Protection on Department of Defense Lands

The Sikes Act (16 U.S.C. 670 *et seq.*) authorizes the Secretary of Defense to develop cooperative plans for conservation and rehabilitation programs on military reservations and to establish outdoor recreation facilities. The Sikes Act provides for the Secretaries of Agriculture and the Interior to develop cooperative plans for conservation and rehabilitation programs on public lands under their jurisdiction. While the Sikes Act was in effect at the time of the California least tern's listing, it was not until the amendment of 1997 (Sikes Act Improvement Act) that Department of Defense (DOD) installations were required to prepare INRMPs. Consistent with the use of military installations to ensure the readiness of the Armed Forces, INRMPs provide for the conservation and rehabilitation of natural resources on military lands. They incorporate, to the maximum extent practicable, ecosystem management principles and provide the landscape necessary to sustain military land uses. INRMPs address the conservation of natural resources on military lands and can be a proactive conservation tool promoting the recovery of endangered and threatened species. INRMPs are subject to USFWS and State review. Depending on how the INRMP is configured, it also may be used to implement actions addressing federally listed species included as part of section 7 consultations under the Act. The active military installations occupied by nesting California least terns are MCB Camp Pendleton, NAS North Island/NAB Coronado, NBVC Point Mugu, and Vandenberg Air Force Base (AFB). California least terns also nest at the former Naval Air Station Alameda. The property, now known as Alameda Point, is still owned by the Navy, but under management by USFWS. All these installations and organizations have breeding populations of California least terns, and have INRMPs that address the species and provide monitoring and species management funding for the species. Additionally, Navy Region Southwest/Naval Facilities Engineering Command Southwest and San Diego Unified Port District (SDUPD) collaborated to draft the San Diego Bay INRMP to provide "the goal, objectives, and policy recommendations to guide planning, management, conservation, restoration, and enhancement of the San Diego Bay ecosystem" (Navy and SDUPD 2000, p. 1-5). The San Diego Bay INRMP covers both military and non-military lands. The Alameda Point nesting area is still owned by the DOD, but it is not an active military site and thus does not have an INRMP.

NAB Coronado funds a full-time predator manager from the U.S. Department of Agriculture Animal and Plant Health Inspection Service to conduct predator control on its California least tern and snowy plover colonies on NAB Coronado and NAS North Island (USFWS 2010, p. 23). Management goals for the California least tern on these facilities also include monitoring and management of nesting sites within their boundaries (USFWS 2010, p. 26).

The DOD is authorized by regulation under the MBTA to take migratory birds incidental to military readiness activities (50 CFR 21.15). However, this authorization is contingent upon the DOD conferring and cooperating with the USFWS to develop and implement appropriate conservation measures to minimize and mitigate any significant adverse effects on a population of a migratory bird species that the DOD determines may result from those activities. Further, in 2001, the President signed Executive Order 13186, ‘‘Responsibilities of Federal Agencies to Protect Migratory Birds,’’ requiring Federal agencies to incorporate migratory bird conservation measures into their agency activities. Under this Executive Order, each Federal agency whose activities may adversely affect migratory birds was required to enter into a MOU with the USFWS, outlining how the agency will promote conservation of migratory birds. The Executive Order has a number of provisions that specifically relate to habitat, including the requirement for agencies, as practicable, to:

1. Restore and enhance habitat;

2. Prevent or abate the pollution or detrimental alteration of the environment;

3. Design habitat conservation principles, measures, and practices into agency plans and planning processes;

4. Ensure that NEPA analyses evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern; and

5. Identify where unintentional take reasonably attributable to agency actions is having, or is likely to have, a measurable negative effect on migratory bird populations, focusing first on species of concern, priority habitats, and key risk factors.

The DOD entered into a MOU with the USFWS under Executive Order 13186 on July 31, 2006 (71 FR 51582). The MOU emphasizes a general collaborative approach to conservation of migratory birds. Conservation measures include minimizing disturbance to breeding, migration, and wintering habitats. While this MOU is non-binding and it does not authorize the take of migratory birds, it does provide an additional opportunity for us to continue to reduce the threat of habitat loss to the California least tern on lands owned and managed by the DOD. In 2016, of the approximately 4,000 nesting pairs, approximately 55 percent of the California least tern U.S. breeding population nested on DOD lands (i.e., MCB Camp Pendleton (19 percent), NAS North Island/NAB Coronado (19 percent), Alameda Point (9 percent), NBVC Point Mugu (8 percent), and Vandenberg AFB (less than 1 percent) (Frost 2017, Table 1)).

Military activities continue in close proximity to California least tern nesting sites; however, the military works with the USFWS to minimize and mitigate training actions that could impact nesting terns. The Navy expanded training activities into the nesting areas at NAS North

Island/NAB Coronado that had been protected and used for California least tern nesting (Navy 2008, p. ES-3). This site, in large part due to the Navy's management, represents 47 percent of the nesting population in San Diego Bay and 17 percent of the U.S. population (Table 1). The USFWS completed a BO (FWS-SDG-08B0503-09F0517) on the expanded training that included conservation measures, such as a creation of a Long Term Habitat Enhancement Plan, which is expected to improve the nesting conditions for terns in select areas of the nesting beaches (USFWS 2010, pp. 125–127); we believe the conservation measures in this BO will allow for the persistence of the colonies at NAS North Island/NAB Coronado, and we will continue to work with the Navy to monitor the progress of the colonies and reduce any impacts to nesting terns (USFWS 2010, p. 128). At MCB Camp Pendleton, the USFWS is currently in consultation regarding impacts to nesting California least terns on training beaches.

In all, the stewardship of natural resources and migratory birds under the respective INRMPs and the MOU provide a benefit to the California least tern on the DOD installations covering approximately 55 percent of the U.S. nesting populations. Additionally, as described above, many DOD installations are implementing intensive management for the species resulting from previous consultations under section 7 of the Act. Nevertheless, in the absence of protections afforded by the Act, the level of management benefitting the California least tern may not be sustainable as other funding priorities may override management needs for the species.

Endangered Species Act of 1973, as amended (Act)

Since listing, the Act is the primary Federal law providing protection for the California least tern. The USFWS's responsibilities include administering the Act, including sections 7, 9, and 10. Section 7(a)(1) of the Act requires all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of endangered and threatened species. Section 7(a)(2) of the Act requires Federal agencies, including the USFWS, to satisfy two standards in carrying out their program. Federal agencies must ensure that actions they fund, authorize, or carry out are not likely to (1) jeopardize the continued existence of any listed species or (2) result in the destruction or adverse modification of designated critical habitat. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. Critical habitat has not been designated for this species.

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(18) of the Act defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." USFWS regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harassment is defined by the USFWS as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that results from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). Section 10(a)(1)(B) of the Act allows for exceptions to take prohibitions under section 9 for animals. To qualify for an incidental take permit, applicants must develop, fund, and implement a USFWS-approved HCP that details measures to [avoid] minimize and mitigate the project's adverse impacts to listed species, including listed plants. Issuance of an incidental take permit by the USFWS is subject to section 7 of the Act; thus, the USFWS is required to ensure that the actions proposed in an HCP are not likely to jeopardize the animal or plant species or result in the destruction or adverse modification of critical habitat. Therefore, HCPs may provide an additional layer of regulatory protection. Many NCCPs are developed in conjunction with HCPs prepared pursuant to the Act. The California least tern is currently covered by the MSCP (City of San Diego Subarea Plan) and the MHCP (Carlsbad HMP).

MSCP (City of San Diego Subarea Plan)

The MSCP is a sub-regional HCP and NCCP made up of several subarea plans that have been in place for more than a decade. Under the umbrella of the MSCP, each of the 12 participating jurisdictions is required to prepare a subarea plan that implements the goals of the MSCP within that particular jurisdiction. The City of San Diego Subarea Plan under the MSCP covers 206,124 ac (83,415 ha) within San Diego County. HCPs and multiple species conservation plans approved under section 10 of the Act are intended to protect covered species and their habitat by avoidance, minimization, and mitigation of impacts.

The City of San Diego Subarea Plan under the MSCP includes the California least tern as a covered species. Approximately 93 percent of California least tern habitat within plan boundaries is conserved (City of San Diego 1997, p. 160). The subarea plan mandates beach maintenance, predator control, and protection from human disturbance and edge effects for its least tern nesting areas within Mission Bay.

MHCP (Carlsbad HMP)

The MHCP is a sub-regional HCP and NCCP that covers seven cities in northwestern San Diego County. Under the umbrella of the MHCP, each of the participating jurisdictions is required to prepare a subarea plan that implements the goals of the MHCP within that particular jurisdiction. The MHCP covers 45,290 ha (110,100 ac) that includes the Cities of Oceanside, Carlsbad, San Marcos, and Solana Beach.

The City of Carlsbad is the first to have an approved Habitat Management Plan (Carlsbad HMP) under the MHCP. Under the Carlsbad HMP, least tern nesting habitats are managed to control nonnative plants and predators, maintain water quality, and minimize disturbance to nesting colonies (City of Carlsbad 2004, Table 9). The Carlsbad HMP preserves 100 percent of the current breeding habitat of Batiquitos Lagoon and 100 percent of historical breeding locations of Agua Hedionda and Buena Vista lagoons (City of Carlsbad 2004, Appendix C–39). Both lagoons are among the coastal management areas identified in the 1985 Recovery Plan (Table 2). The nesting sites at Batiquitos Lagoon, while on city property and covered by the Carlsbad HMP, are managed by CDFW (City of Carlsbad 2004, Table 9).

The City of Oceanside is currently evaluating their draft Subarea Plan under the MHCP, and is considering whether to include the California least tern as a proposed species for coverage. No major nesting areas occur within the City of Oceanside, though it contains foraging areas in portions of Buena Vista lagoon (Ogden Environmental 2000, Figure 3-4). The draft Subarea Plan for Oceanside has not been approved; therefore, no protection to the California least tern is currently provided by the plan.

We expect that protections afforded the California least tern under the MSCP and MHCP would continue even if the species was delisted as it is a covered species under these plans. The MSCP and MHCP provide crucial protections to California least terns and their current and historical nesting areas.

Protections in Mexico

Prior to 2010, the species was categorized as "*Peligro*" in Mexico (in danger of extinction under Mexican Law NOM–059–ECOL–2001. However, in 2010, it was downlisted to "*Sujetas a Protección Especial*" (Subject to Special Protection), which is the lowest risk category (SEMARNAT 2010, p. 27). Species with that status are defined as those that require recovery, preservation, restoration, and conservation (SEMARNAT 2010, p. 5). We have little information on the adequacy and effectiveness of this law for recovering breeding or wintering populations of California least terns in Mexico, other than information discussed below under **FACTOR E**. This information indicates that breeding populations continue to be subject to human disturbance, pressures from development, and predators at nest sites (we know of no ongoing predator management programs in Mexico). However, only a small percentage of the California least tern breeding population nests in Mexico.

Summary of Factor D

Since the time of listing, the number of regulatory mechanisms providing protection for the California least tern and its nesting habitat has increased. In the United States, the Act is the primary Federal regulation governing protection, management, and recovery of the California least tern. As noted above, the U.S. population of California least tern has increased from 256 pairs at listing to an estimated 4,095 pairs in 2017 (Figure 5 and references within). A large percentage of this growth is likely attributable to conservation measures enacted by Federal action agencies in response to consultations under section 7 of the Act. A number of State and Federal laws also provide some protection to the California least tern and its habitat. Currently, California least terns are afforded protection at 70 percent of the breeding populations through implementation of existing INRMPs and HCPs. Additional nest sites are protected on state or Federal lands, such as state parks and National Wildlife Refuges, for a total of 86 percent. Though existing regulatory mechanisms are currently reducing the magnitude of threats facing the species, absent the Act, it is unlikely that existing mechanisms would be sufficient to assure the necessary protection and management for the California least tern. Only a small proportion of the U.S. breeding population has assured management, in the absence of the protections afforded by the Act, based on protections afforded by HCPs and long-term conservation agreements. Therefore, based on the need of California least terns for multiple nesting sites and their strong dependence on predator management programs, existing regulatory mechanisms in the United States continue to reduce the magnitude of current threats, but are likely not sufficient to protect California least terns without protections afforded under the Act.

In Mexico, the California least tern is a protected species; however, we have little information on the effectiveness of laws to protect the species from the various threats to this species and its habitat. Therefore, it is unclear if inadequate regulatory mechanisms in Mexico result in increased threats to the California least tern.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

At the time of listing, anthropogenic disturbance was considered a significant threat to the nesting success of California least terns. Prior to listing and at the time of listing, high levels of human disturbance contributed to the decline of the California least tern (Chambers 1908, p. 237; Edwards 1919, pp. 65–68; Craig 1971, pp. 4–7), such as off-highway vehicles (OHVs) driving near or through nesting sites (Longhurst 1969, pp. 1, 3). The 2006 5-year review identified anthropogenic disturbance as a continuing threat to the tern, and identified new threats from food shortages and environmental contamination. We discuss those threats below and explore the link between climate change and food availability.

Human Disturbance

The 2006 5-year review considered human disturbance to threaten the continued existence of the California least tern. Humans can destroy or kill California least tern eggs and chicks by inadvertently stepping on them or by OHV and beach grooming activity (Cowgill 1989, pp. 83–85; Lingle 1993, pp. 131–132; Smith and Renken 1993, pp. 41–42; Kirsch 1996, pp. 26–28; Muñoz del Viejo and Vega 2002, p. 235; Zuria and Mellink 2002, pp. 619–621). However, the greatest impact of human activities on least terns is through indirect impacts. Seabirds respond to humans as they do to predators (Frid and Dill 2002, p. 1), resulting in altered foraging behavior, decreased incubation time, and reduced feeding of young (Verhulst *et al.* 2001, p. 379; Ruhlen *et al*. 2003, p. 303). These alterations in behavior can result in decreased fitness of adults and chicks or cause complete colony failure (Burger 1984, p. 66; Frid and Dill 2002, p. 1). Humans can have indirect effects on nesting least terns through helicopter use, paragliding, noise from nearby recreation or construction sites, or military training exercises (USFWS 2006, pp. 14–15).

The California least tern Recovery Plan recommends a combination of fencing and visitor education to reduce the threat of human disturbance to nesting California least terns (USFWS 1985b, p. 36). Of those for which we have data, 76 percent of active nest sites have some type of barrier (either literal or symbolic) to minimize access to nesting sites and reduce impacts to terns (Table 1). The nest sites near areas with high levels of recreational use, like Venice and Huntington Beach, are completely fenced to reduce human encroachment. Symbolic barriers do not exclude human encroachment into the nest sites, but do provide a deterrent. Outreach programs can help educate the public on the role of fencing and the importance of undisturbed areas for nesting birds. Visitors that receive education on conservation issues are more likely to act in environmentally responsible ways (Orams 1997, p. 304). For California least terns, efforts to educate and direct the public, such as posting signs and fencing at access points, has helped reduce the threat of disturbance to tern colonies (Patton 2009b, p. 11).

Despite efforts to protect nesting sites from human disturbance, indirect and direct human disturbance continue to impact the California least tern at nest sites throughout its breeding range. In recent years, nests and chicks have been impacted by:

- Equestrian, pedestrian, and border patrol activity at the Tijuana Estuary (Collins 2007, p. 1; Collins 2018, pers. comm.);
- Regular ingress by fishermen and pedestrians into nesting areas at Batiquitos Lagoon (Squires 2010, pp. 16–17; Wolf 2010, p. 17), including at least one egg crushed by a pedestrian (Squires and Wolf 2010, p. 17);
- Unauthorized access and vandalism of fencing and signs at the NAB Coronado Ocean nesting site in 2007 and 2008 by unknown individuals (Copper 2008, pers. comm.);
- Unauthorized ingress by the public and military personnel from the unfenced side of the Sweetwater Marsh Unit of the San Diego Bay NWR (Collins 2008, p. 1);
- Regular disturbance at Huntington Beach colonies due to low flights from helicopters and airplanes (Marschalek 2008, p. 17; Sea and Sage Audubon 2010, no page number);
- Intentional release of feral cats near the D Street fill colony in National City/Chula Vista (Collins 2018, pers. comm.); and,
- Ultralight aircraft and drones entering air space just above tern colonies in south San Diego Bay and at Tijuana Estuary (Collins 2018, pers. comm.).

Impacts to breeding California least terns also are known to occur in association with authorized military training activities adjacent to nest sites. Military training activities may result in disturbance that reduces the suitability of nesting areas, and may also result in harm or death of some individuals. These training activities are necessary to maintain levels of military readiness in accordance with the mission of the Navy and the U.S. Marine Corps to provide critical national security functions (USFWS 2010, p. 4). We have consulted with the Marine Corps at MCB Camp Pendleton (USFWS 1995, p. 31), Navy at NAB Coronado (USFWS 2005, p. 31; USFWS 2007a, pp. 4–5, USFWS 2010, entire) and NBVC at Pt. Mugu, and the Air Force at Vandenberg AFB under section 7 of the Act. We have determined that military training activities result in incidental take of California least terns; however, avoidance and minimization measures reduce the impact of incidental take (USFWS 2010, p. 120, Table 12). Additionally, nest sites on military installations experience reduced disturbance from recreational activities, since the general public is largely restricted from these sites, and they have benefited from consistent funding to support active management (pre-breeding season site preparation, predator management, and monitoring).

Several proposed projects near least tern nesting areas could result in higher levels of disturbance to breeding birds. For instance, the Navy is also building a 1.5 million square foot Silver Strand Coastal Training Complex, located just west of the south bay unit of San Diego Bay NWR. The project contains measures to decrease impacts resulting from human disturbance activities, such as construction of fencing to separate the project area form the adjacent wildlife refuge and measures to decrease perching by raptors on building signs. However, the project may still impact terns by drawing predators (such as crows) to the area; crows are frequently associated with people and have a strong negative effect on tern nesting (see **FACTOR C** above). Additionally, while the nest site at Delta Beach South is currently protected with fencing and signage, the NAB Coronado Ocean nesting site is not fully fenced and is subject to human disturbance.

The Veterans Administration is in the process of developing a proposal to construct a clinic, columbarium, and other associated facilities on lands at Alameda Point in close proximity to the California least tern nesting area (USFWS 2012, pp. 9–11). In late August 2012, USFWS finalized a BO related to the proposed project. The BO includes substantial measures to minimize and mitigate for the effects of the proposed project, including restrictions on building height, vegetation height, noise, nighttime lighting, and dredging activities during the breeding season (USFWS 2012 pp. 15–16; 19–33). The project proponent will implement nest site management and predator management at the same or greater levels than currently occur, as well as restrictions on transfer of the land that supports the tern colony (USFWS 2012, pp. 22–26). These measures will greatly decrease the impact of the proposed project on California least terns.

In Mexico, uncontrolled human use of beaches is the primary conservation problem for nesting California least terns. At Punta Banda, a nesting colony in Baja California, tourist use of beaches caused least terns to abandon their preferred nesting site for a secondary area (Zuria and Mellink 2002, p. 620). Though specific information is lacking on OHV use of California least tern nesting beaches in Mexico, heavy use of recreational OHVs has forced other nesting least tern subspecies into less favorable sites (Palacios and Mellink 1996, p. 54). More recent information on tourist development and OHV use from known least tern nesting areas in Mexico is limited. We are unaware of any laws or regulations restricting human use of beaches. Therefore, human disturbance likely continues to negatively impact California least terns nesting in Mexico.

In summary, human disturbance effects can pose a direct threat to California least terns through crushing of eggs and young as well as cause detrimental effects on nesting behavior. However, active management, conservation measures, and fencing of nesting sites have greatly reduced the impacts from this threat in the United States since the time of listing. Therefore, though human disturbance does affect the species, we do not expect those effects to pose a significant threat to the California least tern in the United States now or in the future, due in large part to current conservation efforts and current regulatory mechanisms. However, in Mexico where less active management is implemented, human disturbance continues to pose a significant threat to the California least tern, something that will likely continue into the future.

Food Availability

Studies have highlighted a potential link between food availability for breeding California least terns and changes in regional weather patterns, particularly ocean surface temperature changes known as the El Niño Southern Oscillation (ENSO) (Massey *et al.* 1992, pp. 982–983; Caffrey 1993, pp. 5, 8). Following the 1982–83 ENSO, there was a drastic reduction in California least tern breeding success in southern California (Fancher 1992, p. 62; Massey *et al.* 1992, pp. 980 and 982). The population of adults returning to nest in subsequent years was reduced (Massey *et al.* 1992, pp. 980 and 982). Production of fledglings was lower statewide during the years following the 1991–92, 1994–95, 1997–98, and 2009–2010 ENSO events, though the effect of the 1982–83 event is less clear (Figure 3). The population of adults returning to nest a year after the 1997–98 ENSO was reduced by approximately 1,300 adults, and the statewide production of fledglings also was significantly reduced (0.2 fledgling per pair; Figures 2 and 3) (Keane 2001, p. 7). Sea surface temperatures related to ENSO may, therefore, be linked to reduced California least tern productivity.

The primary effect of ENSO on tern populations may be related to food availability for nesting terns. Major ENSO events, such as in 1982–83, are associated with large-scale mortality of fish and marine plants (Tegner and Dayton 1987, p. 267 and Table 2; Ahrens 1991, p. 322). An inadequate prey base has been found to contribute to strong decreases in nesting success of other tern species. In a 14-year study, Crawford (2003, p. 49) found that significantly fewer swift terns (*Thalasseus bergii*) bred during periods of low food availability. Additionally, monitors for the California least tern have frequently observed decreased success of nests in years when adult birds bring inadequate or inappropriate fish sizes to feed to mates and chicks (Massey *et al*. 1992, p. 980; Caffrey 1993, p. 5; Caffrey 1997, pp. 8–9; Keane 2001, pp. 9–10).

The impact of low suitable food availability continues to impact nesting California least terns. In 2006, weather and food issues were believed to be the cause of 22 to 55 percent of chick mortality (Marschalek 2007, p. i; Marschalek 2010, p. 20). Due to a lack of regular and consistent population surveys in Mexico during the same period, we are uncertain if the same population fluctuations occurred on the Baja California Peninsula. However, despite these apparent patterns, Schuetz (2011, p. 6) failed to find a statistically significant pattern between ENSO events (which affect winter sea surface temperatures) and decreased productivity of California least terns. However, he did find a pattern between summer sea surface temperatures linking higher least tern productivity with warmer summer sea surface temperatures (Schuetz 2011, p. 6). Therefore, the link between ENSO events and food availability might not be as straightforward as previously hypothesized.

Sea surface temperatures, particularly those attributable to ENSO events, can impact California least tern nesting through general effects on weather. Increased storm events associated with higher sea surface temperatures can cause an increase in mortality during and after the breeding season. A heavy storm event during the 1995 ENSO caused chick mortality across the State (Caffrey 1997, p. 9). All five significant ENSO events that have occurred since 1980 were associated with declines in California least tern reproductive success or adult survival (Figure 3). Any increase in ENSO strength or frequency could cause chick mortality and corresponding population declines, however we lack reliable forecasts on which to estimate the impact of storm changes.

The 2013 IPCC climate report predicts, "there is *high confidence* that ENSO will remain as the dominant mode of interannual variability…Due to increased moisture availability, ENSO-related precipitation variability on regional scale *will likely* intensify. Natural variations of the amplitude and spatial pattern of ENSO are large and thus *confidence* in any specific projected change in ENSO and related regional phenomena for the 21st century remains *low*" (Chapter 14, Executive Summary, IPCC 2013b, p. 21). However, an analysis conducted by Lenton *et al*. (2008, p. 1790) found that based on past climate trends, an increase in ENSO amplitude (magnitude of both strong and weak events) was significantly probable, though the forecast is uncertain. Any increase in ENSO amplitude could affect food availability and thus impact reproductive success of California least terns.

As discussed in **FACTOR A**, there is much uncertainty to make reliable predictions of the future impacts of climate change. However, changing food availability, whatever its cause, has the potential to severely impact reproductive efforts and thus continued persistence of the species. California least terns have been periodically sighted in low numbers far offshore during the breeding season. It is unknown, however whether or not the individuals sighted were breeding. In addition, Pacific saury, typically an offshore species, is sometimes observed as part of the diet, which implies that least terns sometimes forage farther offshore. When prey resources are scarce, it appears that least terns will spend more time foraging at distances farther from the colony, resulting in less parental attendance, lower food delivery rates, and poor productivity.

Therefore, we find decreased food availability is likely to continue to impact California least terns across their range within the future.

Environmental Contamination

Contaminants such as DDT (dichlorodiphenyltrichloroethane), selenium, oil, and mercury have historically been identified in nesting areas throughout the range of California least terns. Boardman (1988, Table 3) detected DDT and its metabolites in California least tern eggs and liver samples from adult birds and nest sites throughout southern California in the 1980s (e.g., Bolsa Chica, Costa Del Sol, MCB Camp Pendleton, Chula Vista, Terminal Island). High levels of pesticides and heavy metals are known to cause reproductive harm in breeding birds (Longcore *et al.* 1971, p. 486; King *et al.* 1978, p. 17). The organochlorine pesticide DDT breaks down in the environment to form DDE (dichlorodiphenyldichloroethylene), a compound that causes thinning of eggshells and decreased reproductive success in many species of birds (Longcore *et al.* 1971, pp. 486, 489). Selenium is a naturally occurring element that may also act as a contaminant and affect birds under certain conditions. At low levels, selenium is an essential trace nutrient that serves multiple metabolic functions in animals (Arthur and Beckett 1994, p. 620), but at higher concentrations it can cause embryo malformation and death (Hoffman *et al.* 1988, p. 521). Mercury causes both decreased fledgling success and decreased parental care in waterbirds (Evers *et al.* 2008, pp. 74–75).

Birds are exposed to contaminants mainly through the food they eat. For substances that bio accumulate, like DDT and mercury, fish-eating birds are exposed to higher dietary concentrations and accumulate higher levels of contaminants in their tissues than birds that feed on seeds or invertebrates (Frank *et al.* 1975, p. 214; Focardi *et al.* 1988, p. 253; Ruelas-Inzunza *et al.* 2009, p. 418). For example, past studies have linked reproductive failure with heightened pesticide levels in the common tern (*Sterna hirundo*) and the roseate tern (*Sterna dougallii*), both fish-eating species (Hays and Risebrough 1972, p. 21; Fox 1976, p. 470), but these effects were less pronounced in the black tern (*Chlidonias niger*), which is primarily insectivorous (Frank *et al.* 1975, pp. 211, 214). Therefore, the California least tern may be at more risk of exposure and subsequent contaminant-related impacts than many other bird species because of their diet.

Several California least tern nesting areas are in proximity to areas known to be contaminated with heavy metals or pesticides. For example, environmental concentrations of lead at Seal

Beach National Wildlife Refuge are high enough to potentially result in reproductive harm to nesting birds (Naval Facilities Engineering Command 2005, p. 49). In San Francisco Bay, mercury is the contaminant of highest concern to nesting birds. Fish-eating terns in San Francisco Bay had high blood and liver concentrations of mercury, the highest concentration of all species studied (Eagles-Smith *et al*. 2009, p. 1998). However, we were unable to find any studies that quantified effect levels of contaminants on California least terns. Results of field studies on exposure and effects are often site- and species-specific that is a source of uncertainty when extrapolating across sites or species. Mercury exposure was highly site specific for Forster's terns (*Sterna forsteri*) in San Francisco Bay (Ackerman, Eagles-Smith, Takekawa, Bluso, and Adelsbach 2008, p. 903). The study did examine two sites where least terns nest: Eden Landing Ecological Reserve and Napa-Sonoma Marsh Wildlife Area. At those sites, Forster's terns had mean blood levels of mercury below a moderate level of concern (1 microgram (µg)/gram (g) wet weight), but with some confidence intervals extending above that level (Ackerman, Eagles-Smith, Takekawa, Bluso, and Adelsbach 2008, Figure 2). However, despite elevated levels, mercury-related effects such as decreased chick and fledging survival at those areas have not been observed (Ackerman, Eagles-Smith, Takekawa, and Iverson 2008, p. 798). Because least terns have lower levels of mercury exposure than Forster's terns (Ackerman *et al*. 2016), we do not expect mercury concentrations in San Francisco Bay to pose a threat to the California least tern.

San Diego Bay, which hosted approximately 24 percent of all nesting California least terns in 2013, has historically had high levels of DDE and polychlorinated biphenyls (PCB) exposure, measured as concentrations in eggs (Ohlendorf *et al.* 1985, p. 47). Potential DDT-related eggshell thinning has been reported by field monitors for seabird species nesting at San Diego Bay (USFWS 2008, p. 7). Caspian tern eggs collected in 2005 exhibited some eggshell thinning, which may be attributed to DDE at the concentrations measured in the eggs (USFWS 2008, p. 21). Contaminant levels measured in Caspian tern eggs are consistently higher than contaminant levels measured in California least tern eggs. Although still elevated, concentrations of DDE and PCBs have declined for both species since the 1980s (USFWS 2008, pp. 18–19). Most recently measured concentrations of DDE and PCBs in California least tern eggs are well below levels associated with serious reproductive impairments in seabirds (USFWS 2008, pp. 21–22). Least tern colonies in San Diego Bay are closely monitored for productivity, and no widespread nest failure due to eggshell cracking (caused by DDE) or embryo mortality (caused by PCBs) has been reported. Therefore, though DDE and PCBs are present in San Diego Bay, the best available scientific information does not show that these contaminants are resulting in adverse effects on California least terns at this time.

California least tern populations could also be negatively impacted by oil spills from offshore oil platforms or marine tankers. Oiled birds lose their ability to regulate their body temperature because of loss of feather loft, and often die of hypothermia or exposure (U.S. Coast Guard 2007, p. 1). Additionally, oiled adults can transfer oil onto eggs they are incubating (U.S. Coast Guard 2007, p. 1). Oil on eggs reduces the amount of gas exchange (in a sense, the egg's ability to breathe) and introduces toxic hydrocarbons into the egg. Likewise, oiled adults inhale and ingest toxic hydrocarbons when they preen (Hartung 1963, p. 51). Thus, should an oil spill occur during the California least tern breeding season and in close proximity to a high density nesting area, the oil spill could have detrimental impacts on that colony's survival and productivity.

The magnitude of the impact of oil spills on the California least tern's status in the future is dependent on how often the spills might occur. The former Mineral Management Services calculated the risk of spills occurring from offshore oil activities, including drilling platforms and pipelines. They found that there is a 41.2 percent chance of a spill occurring due to Federal offshore oil drilling and pipelines and an 8.4 percent chance of an oil spill occurring from state lands in the next 28 years (McCrary *et al.* 2003, pp. 45–46). These numbers do not take into account the risk of spills from oil tankers traversing the California coast (McCrary *et al*. 2003, p. 48). That risk, however, applies to the entire stretch of the coast where oil platforms occur; therefore, the risk of an oil spill impacting an individual nesting colony along the California coast would be lower.

Oil spills have previously occurred in close proximity to California least tern nesting areas. In the past two decades, two large oil spills occurred in San Francisco Bay (USFWS 2007b, p. 1), but neither occurred during the California least tern breeding season. Smaller spills occur as a result of leaks from pipelines, operations at on-shore facilities, and tanker truck accidents in areas adjacent to lagoons and beaches with least tern colonies (California Emergency Management Agency Hazardous Materials Release/Spill reporting system). California least terns may also be affected by chronic oil pollution not easily attributable to specific spills. Intermittent oil spills from unknown sources have been noted on southern and central California beaches for decades (Carter 2003, p. 2 and Table 1). The cause of some of these spills, such as those related to periodic oil leakages from the sunken vessel S.S. Jacob Luckenbach, have recently been identified, while the source of others remains a mystery (Carter 2003, pp. 1–3; Hampton *et al*. 2003, pp. 35–37). Natural occurring oil seeps also occur in the waters off southern California. Therefore, oil spills have the potential to result in decreased productivity and survival in affected colonies.

California least terns may face greater exposure to contaminants in Mexico than in the United States. Although DDT was banned in the United States in the 1970s, it was used for malarial control in Mexico until the early 1990s (García-Hernández *et al.* 2006, p. 1640). Coastal lagoons in Mexico have widely varying levels of pesticides (Páez-Osuna *et al.* 2002, p. 1305), but specific data for areas where least terns nest in Mexico are unavailable. In addition, there are no data on DDT concentrations in least tern eggs or in forage fish where least terns nest in Mexico. Therefore, the best available scientific information does not show a detrimental effect of contaminants on nesting California least terns in Mexico.

Contaminants of emerging concern are among the many new chemicals developed and put into production every year. These include polybrominated diphenyl ethers (PBDEs) or flame retardants, which, through bioaccumulation are now known to occur in tern eggs at concentrations exceeded only by DDTs and PCBs (USFWS 2008, pp. 35, 53). Polybrominated diphenyl ethers alter blood thyroid hormone homeostasis and vitamin A stores, which in turn can alter development, ability to fight infection, reproductive success and other physiological processes. Concentrations observed in California least tern eggs are well below concentrations associated with adverse effects in kestrels (USFWS 2008, p. 23). Whether PBDE concentrations in tern eggs are sufficient to impact these species is unknown because data on effect levels for seabirds are lacking. However, the prevalence and relatively high concentrations at which PBDEs occur compared with organochlorine compounds, warrant monitoring and underscore an ongoing need to consider contaminants of emerging concern in future evaluations of the species' status. The uncertain future effects of contaminants is enhanced by the complex effects of climate change on the presence and concentration of contaminants (Schiedek *et al.* 2007, p. 1852, Figure 2) and the continual discovery of new contaminants in the environment.

Contaminants have the potential to pose a threat to California least terns. However, though moderate or high levels of contaminants are present in several high-density least tern nesting areas (such as sites around San Francisco Bay and San Diego Bay); we were unable to find any studies documenting mortality or reproductive harm from contaminants. Oil spills have the potential to have detrimental impacts on nesting California least terns, despite their rarity. However, the impact would likely be limited to one or two seasons. Furthermore, the Service is an active participant in the southern California area contingency planning efforts (USCG Sector Los Angeles/Long Beach Area Contingency Plan (ACP 4 and ACP5) and U.S. Coast Guard Sector San Diego Area Contingency Plan (ACP) 6) (Department of Homeland Security *et al*. 2011a, 2011b, entire). In the event of a spill, our pre-planning efforts serve to avoid and minimize impacts from both spills and response actions. Therefore, though oil spills have the potential to pose a threat to California least terns in the future, the magnitude of this threat is low. Overall, based on the best scientific and commercial information, we do not expect contaminants to pose a significant threat to the continued existence of the California least tern throughout its range now or in the future.

Summary of Factor E

Based on a review of the best scientific and commercial data available regarding human disturbance, sea surface temperature and food availability, and contaminants, we find that only food availability poses a substantial threat to the California least tern across the range of the species, and human disturbance poses a substantial threat in its Mexico breeding areas. Neither of these threats was assessed at the time of the 2006 5-year review. Impacts from human disturbance have been reduced through active management and conservation measures in the U.S. Furthermore, we find that oil spills pose a minimal threat to the species; we reached a similar conclusion in the 2006 5-year review. There is insufficient evidence to support that contaminants other than oil currently pose a threat to the species.

Cumulative Impacts

Several of the threats discussed in this review have the potential to work in concert with each other. For example, human development can interact with multiple other threats affecting the California least tern. Between 2016 and 2060, California is projected to grow by 30 percent: from 39.4 million to 51.1 million people (DOF 2017). Current uses of coastal areas may likely see increased demands due to this population growth for development, access, and recreational purposes. As a result, at areas that have not previously been afforded permanent protection, California least terns may be forced into lower quality habitat types or a more limited number of sites. As discussed in **FACTOR A**, reduced availability of nesting sites may decrease the California least tern's natural ability to shift between colonies in response to predator pressure or human disturbance. This shift in colony location and character may also impact food availability, as increased intraspecific competition for food may decrease success in large waterbird colonies. Hunt *et al*. (1986) found a link between increased colony size and decreased fledgling success in several waterbird species. At the larger colonies, chicks about to fledge were up to 59 percent lower in body weight than chicks of similar age at the smaller colony (Hunt *et al.* 1986, pp. 308–309).

Therefore, larger colony size may lead to decreased food availability for chicks or longer duration of foraging trips by adults.

Limited food availability and longer foraging trips may also increase the threat of predation to California least tern colonies. With adults gone from the area, they are unable to defend the colony, and thus more chicks may be lost to predation (Suddaby and Ratcliffe 1997, p. 528). Therefore, limited food availability can increase the threat of predation by disrupting the least terns' natural colony defense against predators. Additionally, as discussed in **FACTOR C**, as the amount of human development around a colony increases, so does the number of predators in an area.

Development, urbanization, limited food availability, and predation can act in concert to decrease the population numbers and viability of the California least tern. With urbanization rates and human population numbers in California still growing, the best available scientific and commercial data indicate that the magnitude of these threats will continue to increase. Therefore, we find that cumulative impacts may provide a substantial threat to the California least tern across its range now and in the future.

III. RECOVERY CRITERIA

Pursuant to section 4(f) of the Act, recovery plans are developed to provide guidance to the USFWS, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. Recovery plans are required to contain objective, measurable criteria, which, when met, would result in a determination that the species be downlisted or delisted. Conservation (i.e., recovery) is defined in section 3 of the Act as the "use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." In accordance with section 4(a)(1) of the Act, we determine if any species is an endangered or threatened species because of any of the five threat factors identified in the Act and evaluated in this 5-year review. Therefore, we revise the listed status of a species based on the outcome of an analysis of these five factors.

Although recovery plans are not regulatory documents, they provide a guide on how to achieve recovery based on information available at the time the recovery plan is finalized. Recovery criteria describe measurable projected outcomes or an estimated species response to a reduction or removal of the threats to a species as described in a five-factor analysis. However, reduction or removal of threats may occur without meeting all recovery criteria contained in a recovery plan, as there are many paths to accomplishing recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded, while other criteria may not have been accomplished. In other cases, recovery opportunities may have been recognized that were not known at the time the recovery plan was finalized. Likewise, we may learn information about the species or threats that was not known at the time the recovery plan was finalized. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not fully follow the guidance provided in a recovery plan.

Consistent with section 4 of the Act, determinations whether any federally listed species should be: (i) removed from the list; (ii) changed in status from endangered to threatened; or (iii) changed in status from threatened to endangered, will be made in accordance with an analysis of the five factors. Therefore, although we expect at the time a recovery plan is published that recovery criteria will be met, the actual determination of appropriate listing status is not based solely on whether recovery criteria have been met. Rather, progress towards fulfilling recovery criteria serves to indicate the extent to which threats have been reduced or eliminated. In absence of meeting recovery plan criteria, the USFWS may judge in some cases that overall the threats have been reduced sufficiently and the species is sufficiently robust to either reclassify the species from endangered to threatened, or delist the species.

The criteria to assess recovery of the California least tern provided in the 1985 Recovery Plan do not reflect the most current information available. The recovery criteria are not threats-based, which is current policy for recovery plan development, but the criteria speak indirectly to the threats outlined in the five-factor analysis section of this review and the 2006 5-year review. Overall, progress is being made toward satisfying the recovery criteria. However, as we concluded in the 2006 5-year Review and based on recent data, the Recovery Plan should be revised and updated to provide threats-based recovery criteria and address the other shortcomings of the Recovery Plan. Areas of the plan that need updating include inclusion of Mexico populations of California least terns, further analysis of the fledgling per pair ratio, and future impacts from a changing climate, such as seal level rise.

Recovery Criteria for Downlisting

The 1985 revised Recovery Plan outlines the criteria for the downlisting of California least terns as three objectives (USFWS 1985b, pp. 25–26). The recovery objectives for stabilizing and downlisting California least terns are as follows:

Objective 1: *The annual breeding population in California must increase to at least 1,200 breeding pairs.*

The breeding population of California least terns currently exceeds Objective 1. The estimated number of California least tern breeding pairs has increased from approximately 624 pairs in 1973 to a peak of approximately 7,100 pairs in 2009 (Figure 2). The number of breeding pairs has dropped in the past few years from the peak to estimates of 3,989 pairs in 2016 and 4095 pairs in 2017. In the 2006 5-year Review, we acknowledged the species had far exceeded this population objective (USFWS 2006, p. 3).

Recovery Objective 1 does not identify specific threats to be alleviated but is a proxy for whether overall threats are being reduced. We interpret the intent of this objective to be that threats would have had to be sufficiently reduced in order for the population to reach 1,200 pairs (from the 745 pairs breeding in the state when the Recovery Plan was first drafted in 1980).

However, due to variable methodologies in estimating the number of California least tern pairs between nest sites and years (Marschalek 2006, pp. 2–5), the estimated breeding population may not accurately reflect the actual size of the California least tern breeding population. We use the estimated breeding pair population from the CDFW statewide annual reports, which compile data reported from each nest site. The number of breeding pairs is calculated based on the historical frequency of California least tern pairs nesting in a second wave (Massey and Atwood 1981, pp. 598–604; Marschalek 2012, p. 3). However, monitors have the option of using one of three different formulas to calculate total number of pairs (see Marschalek 2012, p. 3 and

Appendix B-3 for more details), which creates some inconsistency in reported pair numbers. On occasion, there may also be undiscovered and unmonitored nest sites that are not reflected in reported data. For instance, 32 pairs were documented nesting at Montezuma Wetlands at San Francisco Bay Area in 2006 (Euing 2007b, pers. obs.), but were not included in the annual statewide report. Additionally, California least tern populations in Mexico are not regularly monitored; as such, the CDFW reports only reflect U.S. tern populations.

Regardless of possible error in the minimum breeding pair estimate, the current California least tern breeding population in the United States substantively exceeds the numeric goal of 1,200 breeding pairs in the 1985 Recovery Plan for downlisting and delisting. The minimum breeding pair estimate has exceeded this numeric goal since 1988, after which time it generally increased and then began to fluctuate after 2003, beginning a downward trend after 2010. In summary, we again affirm that Objective 1 has been met and exceeded for downlisting.

Objective 2: *Fifteen* [of 23] *Coastal Management Areas support viable and secure California least tern nest sites and are managed to conserve California least terns. Further, San Francisco Bay, Mission Bay, and San Diego Bay have at least three, five, and four secure and viable nest sites, respectively.*

The 1985 Revised California Least Tern Recovery Plan states that the chief limiting factor influencing the number of breeding pairs is the availability of undisturbed suitable habitat for breeding (USFWS 1985b, p. 26). Meeting the criteria of Objective 2 would reduce threats associated with destruction and modification of nesting habitat (Factor A), predation at nest sites (Factor C), and regional weather conditions (Factor E) through protection and management of nest sites across a wide geographic range. The adequacy and appropriateness of this objective were not discussed in the 2006 5-year review.

This objective requires that sites within 15 Coastal Management Areas be both secure and viable; we will first discuss the “secure” portion of the objective. The Recovery Plan defines a secure nest site as a site where, “land ownership and management objectives are such that future habitat management for the benefit of least terns at those locations can be assured” (USFWS 1985b, p. 26). We interpret this to mean that such management will be in place after the time of downlisting. Coastal Management Areas are distinguished here and in the 1985 Recovery Plan by the letters A–W (Table 1). Thirteen Coastal Management Areas contained at least 1 secure (as defined in the 1985 Recovery Plan) nest site managed to conserve California least terns, occupied by a minimum of 20 breeding pairs in 2016: Coastal Management Areas A, D, E, F, H, J, K, L, N, Q, U, V, and W (Table 3). Integrating three new nesting areas established since 1985 brings the total number of Coastal Management Areas occupied by at least 1 nest site with 20 breeding pairs (in 2016) to 16 (adding Hayward Regional Shoreline, Napa Sonoma Marsh Wildlife Area, and Oceano Dunes). While currently secure, some of these sites are likely to be impacted by sea level rise in the future (see Factor A above and Appendices B and C); 4 of 40 sites evaluated at 1 foot SLR and 7 of 40 sites at 3 foot SLR are likely to be >50 percent inundated. Therefore, sea level rise remains a concern that will need to be closely monitored and evaluated. Information on which sites have predator management and site management (including vegetation management) is provided in Appendix A.

Table 3. Coastal Management Areas (13) and Nesting Areas (3) that supported a minimum of 20 nesting pairs in 2016.

Coastal Mgmt. Area identified in 1985 Recovery Plan (Table 3)	Location
A	Alameda Point
	Hayward Regional Shoreline
	Napa Sonoma Marsh Wildlife Area
	Oceano Dunes SVRA
D	Vandenberg AFB
E	Santa Clara River / McGrath State Beach
F	NBVC Point Mugu
H	L.A. Harbor / Pier 400 / Terminal Island
J	Seal Beach NWR / NASA Island / Anaheim Bay
K	Bolsa Chica ER
L	Huntington State Beach
N	Marine Corps Base Camp Pendleton
Q	Batiquitos Lagoon
U	Mission Bay
V	San Diego Bay
W	Tijuana Estuary NERR

Though we now have more than the required number of secure sites for downlisting, these 16 sites alone would not be sufficient to meet the downlisting criteria as originally stated. Objective 2 for downlisting also specifies that San Francisco Bay, Mission Bay, and San Diego Bay should have three, five, and four secure and viable nest sites, respectively. At San Francisco Bay, Alameda Point has been the primary secure nest site managed for California least terns and contained far greater than 20 nesting pairs in 2016 (Frost 2017, Table 1). Two additional nesting sites in San Francisco Bay (Hayward Regional Shoreline and Napa Sonoma Marsh Wildlife Area) were colonized in 2007 and 2008 and have each supported a minimum of 20 nesting pairs in recent years. At Mission Bay, two sites (FAA Island and Mariner's Point) had more than 20 nesting pairs in 2017 and 2016 , but there was only one site with more than 20 nesting pairs in 2015 and 2014 (Mariner's Point). At San Diego Bay, there were six nesting sites occupied by more than 20 nesting pairs in 2016 that occur on public land and are managed for California least terns (Table 1). The sustainability of the new nest sites in San Francisco Bay and Mission Bay is untested because they have only been recently colonized.

As mentioned above, three of the secure nesting areas counting to the total of 16 have been colonized since the Recovery Plan was finalized. Oceano Dunes is currently a publicly owned California least tern nest site occupied by more than 20 breeding pairs and managed to conserve the species (Table 1). Based on geography, Oceano Dunes would be located within Coastal Management Area C. We also consider Terminal Island to be a secure nesting site. Although it does not occur on public land, we consider it secure because there is an irreversible written agreement to manage this nest site for the conservation of the California least tern (Table 1) (Fancher 2006, pers. obs., Table of California Least Tern Nest Site Parameters). Terminal Island is located in Coastal Management Area H.

For nest sites in Mexico, the information available to us indicates that nesting areas are generally not secure by the Recovery Plan's definition. Although some nesting areas in Mexico have more than 20 breeding pairs, the sites are not monitored regularly or intensively enough to determine whether they meet the definition of viable.

The distribution of the California least tern population is approaching the thresholds in Objective 2 for numbers of secure nesting areas. At least 16 Coastal Management Areas or new nesting areas established since 1985 contain a nest site with at least 20 breeding pairs, providing a good representation of nest sites throughout the U.S. breeding range of the California least tern. Further, new nest sites have been colonized in the greater San Francisco Bay Area (including such areas as Montezuma Wetlands and Pittsburg Power Plant), increasing redundancy of nesting locations for California least terns in these Coastal Management Areas. In Los Angeles County, a new nesting site at Malibu Lagoon was recently colonized with a minimum of 22 pairs in 2017.

Objective 2 was intended to address the availability of undisturbed suitable habitat for breeding, which was identified as a chief limiting factor influencing the number of least tern breeding pairs (USFWS 1985b, p. 26). Overall, the number of secure sites and the number of sites used by California least terns has increased since the recovery plan was developed, although Objective 2 for downlisting has not been met explicitly with the number of sites that must be secure and viable.

Objective 3: *A 3-year mean reproductive rate of at least 1.0 young/breeding pair is achieved.*

This objective does not identify explicitly specific threats to be alleviated, but is a proxy for whether threats to reproduction and fecundity are being reduced. In the 2006 5-year review, we concluded that based on the population data at that time, the species could likely be considered recovered without meeting this goal (USFWS 2006, p. 5), as the sharp growth in pairs had occurred while estimated fledgling rates were below 1.0 fledglings per pair. This definition of viability is the same for what is required for secure nesting sites in Objective 2, though it is unclear from the recovery criteria if this level of viability must be maintained for 3 or 5 years (USFWS 1985b, pp. 25–26).

The mean reproductive rate, as it was called in the Recovery Plan, is identical to the fledgling per pair ratio. It is calculated by dividing the estimated number of fledglings produced by the estimated number of adult breeding pairs. The minimum fledgling rate is calculated as the minimum number of fledglings divided by the maximum number of pairs, while the maximum fledgling count is calculated as the maximum number of fledglings divided by the minimum number of pairs. The fledgling per pair ratio for the California least tern population in the United States has only once reached the goal of 1.0 (Figure 7). From 1984 to 2000, the minimum reproductive rate was generally above 0.5, ranging from approximately 0.2 to 1.0 and averaging 0.7. The annual number of reported fledglings increased with the adult breeding population after listing, peaking in 2000 at 3,710 (Figure 5). Despite the annual reproductive rate not approaching that called for in the 1985 draft revised recovery plan, the adult population of breeding California least terns has increased seven-fold since listing (Figure 5), well exceeding the number of breeding pairs target. This suggests that, as we concluded in the 2006 5-year review, a reproductive rate of at least 1.0 young fledged per year per breeding pair is unrealistically high and unnecessary for an increasing or stable population.

However, over the last 15 years, the fledgling per pair ratio has been on a decreasing trend. Since 2001, the reproductive rate has been generally below 0.5, ranging from approximately 0.1 to 0.4 (Figure 7, Appendix A). Much of this low reproductive success is being driven by the poor productivity of southern California colonies where the majority of the population breeds. As discussed in the five-factor analysis, the population appears to be limited by availability of nest sites, level of predation at nest sites, and/or availability of food required for brood rearing. It is not known whether the recent estimated reproductive rate (0.17 fledglings per pair in 2011, 0.09 in 2012, 0.25 in 2013, 0.37 in 2014, 0.29 in 2015, 0.35 in 2016, and 0.2 in 2017; average of 0.25 fledglings per pair) will sustain the present size of the California least tern population. The recent, consistently low fledgling per pair ratio is cause for concern.

There has always been uncertainty regarding calculation of birds fledged each year. Terns often leave the nesting area shortly after fledging (Massey 1989, p. 3), so fledgling numbers may be underestimated. Additionally, fledgling count methods vary between sites (Marschalek 2012, p. 4). However, though the fledgling ratio may be underestimated, there is no doubt that fledgling counts have steeply declined over the past 15 years. Least terns are a long-lived species and therefore populations may show delayed responses to reproductive problems (Thompson *et al.* 1997, p. 18); however, their long life span may help buffer against variations in productivity.

Nest sites in Mexico likely contribute to the overall California least tern population, but we are not aware of any site that is monitored regularly or intensively enough to meet this objective's threshold.

No consensus currently exists on what reproductive rate would be needed for a stable population size. Determining a more appropriate rate is not straightforward. Fledgling rates may often be underestimated, given the early and rapid departure of newly fledged chicks from the breeding site (Akçakaya *et al.* 2003, p. 835). In the early 1990s, Fancher (1992, p. 6) noted that historical data showed a fledgling per pair ratio of 0.7 or above would result in a subsequent increase in the breeding population, and a ratio below 0.7 would result in a decline in the breeding population. Since then, the breeding population has continued to increase even as the fledgling per pair ratio has regularly fallen below 0.5 fledgling per pair. However, in 2016, the breeding population represented the lowest count since 2002 levels at 3,989 pairs (Figure 5). It is unclear if this is the beginning of a true population decline or a temporary fluctuation in numbers, or if the decline is due to an aging breeding population. Determining reliable, accurate measures of population growth and success is crucial to understanding the recovery of the California least tern.

Since the 2006 5-year review, estimates of population size and least tern productivity have continued to decline, raising concerns over the future viability of the least tern population. We are concerned about the consistent poor reproductive success, particularly over the 5 years when minimum fledglings per pair ratio averaged 0.29. At the current time, Objective 3 for downlisting (a mean reproductive rate of 1 fledgling per pair for 3 consecutive years) has not been met.

Recovery Criteria for Delisting

Currently, we are only considering this species for downlisting as most coastal management areas are not secure throughout the breeding range. In addition, poor productivity has been reported over the past 10 years, with decreasing trend in numbers and increasing age of some populations. Threats continue to be ongoing (e.g., predation, food availability) and are likely to impact the California least tern into the future. Therefore, we will not discuss delisting criteria here. Details on delisting criteria for the California least tern are available in the 1985 Recovery Plan.

Summary of the Recovery Criteria

A total of 4,095 breeding pairs were reported in 2017, supporting that the species has met and exceeded Objective 1 (requiring over 1,200 nesting pairs) in the United States. The California least tern partially meets Objective 2 for downlisting, with 13 Coastal Management Areas and an additional three nesting areas that support secure California least tern nesting areas (Table 3). However, there are still not enough secured and viable breeding sites at the San Francisco and Mission Bay coastal management areas to meet this criterion. Objective 3 has not been met as productivity remains significantly below that recommended (average of 1.0 fledgling per pair) and reported values have declined significantly since the last 5-year review. The sustained poor productivity over the last decade is of concern and warrants further attention.

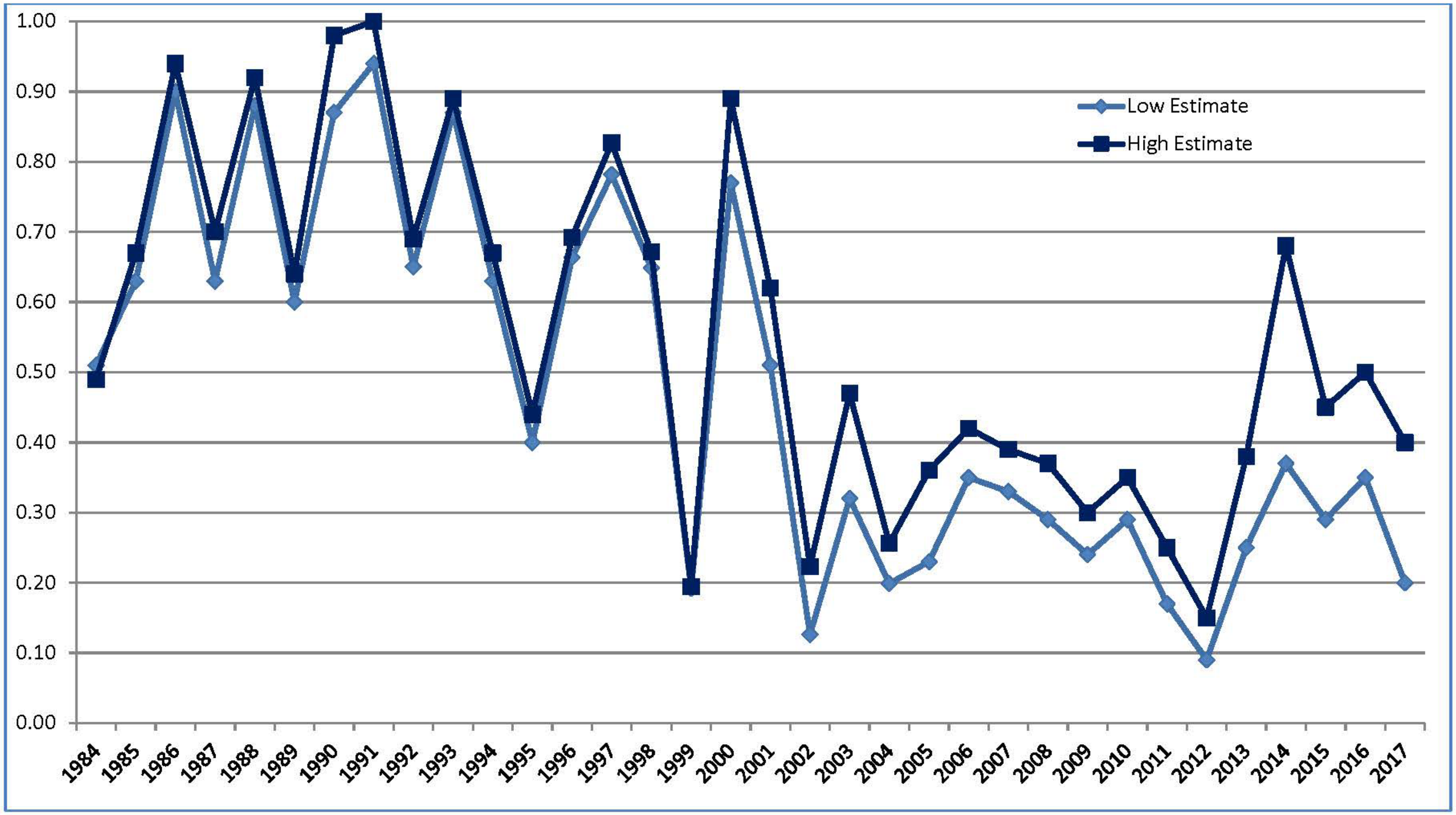

Figure 8. High and low estimates of California least tern fledglings produced per breeding pair in the United States. Only data from 1984 to 2017 are shown because fledgling data prior to 1984 is less reliable. Data are from CDFW annual reports (Collins 1987, Table 1; Massey 1988, Table 1; Massey 1989, Table 1; Johnston and Obst 1992, Table 1; Obst and Johnston 1992, Table 1; Caffrey 1993, Table 4; Caffrey 1994, Table 4; Caffrey 1995, Table 4; Caffrey 1997, p. 1; Caffrey 1998, Table 4; Keane 1998, Table 2a; Keane 2000, Table 2a; Keane 2001, Table 2a; Patton 2002, Table 1; Marschalek 2005, Table 2; Marschalek 2006, Table 2; Marschalek 2007, Table 2; Marschalek 2008, Table 2; Marschalek 2009, Table 2; Marschalek 2010, Table 2; Marschalek 2011, Table 1; Marschalek 2012, Table 1; Frost 2013, Table 1; Frost 2014, Table 1; Frost 2015, Table 1; Frost 2016, Table 1; Frost 2017, Table 1; Sin 2018, pers. comm.).

IV. SYNTHESIS

The California least tern was federally listed as endangered in 1969 (October 13, 1970; 35 FR 16047) and listed as endangered by the State of California in 1971 (CDFG 2008, p. 9) due to threats such as habitat destruction, human disturbance, and predation (Craig 1971, pp. 4–7; CDFG 1974, p. 23). The 2006 5-year review considered many of those threats to be reduced, but not eliminated (USFWS 2006, p. 22). Today, these threats are ongoing and continue to impact the continued survival and recovery of the California least tern, though many of these threats, including human disturbance, vegetation encroachment, and predation, are actively managed and reduced by volunteer, local, State and Federal agency implementation of management plans. In total, 86 percent of the current nesting areas are actively managed to ensure future nest site suitability.

We find that rising sea levels as a result of climate change (Factor A), may in the future pose a substantial threat to nesting habitat of the California least tern. We find that predation (Factor C), continues to threaten the California least tern. This threat is reduced, though not eliminated, by predator management conducted at the majority of active colonies. Predator management is confounded when the predator is a protected species. We also find that food availability (Factor E) poses a threat to California least terns, though its impact varies from year to year with an uncertain overall magnitude. Cumulative impacts of food availability, predation, and destruction of nesting habitat together pose a substantial threat to the persistence of the California least tern, although management at a majority of the U.S. nesting sites helps to reduce the impact of these combined threats. Though there are few data available on nesting areas in Mexico, lack of legal protection and conservation measures result in a higher degree of threats attributable for nesting California least terns than in the United States.

The U.S. population of California least tern has increased from an estimated 256 pairs at listing to an estimated 4,095 pairs in 2017. While the decreasing population trend of California least terns over the past 10 years and the low levels of productivity have been an ongoing cause for concern, the number of pairs remains significantly higher than called for in the Recovery Plan. Though intervals of low breeding success related to food resources are a natural aspect of seabird dynamics (Cury *et al*. 2011, p. 1704), the apparently increasing age of some California least tern populations and lack of juvenile recruitment provides evidence that this decline may be more than a periodic fluctuation and may be indicative of a range-wide decline in numbers. Based on our review of the Recovery Plan, the status of the species has improved since listing through recovery efforts that have successfully ameliorated Factor A threats. However, we are recommending no change in status at this time, because of the decreasing trend in numbers, increasing age of some populations, sustained poor productivity over the last 10 years, and on-going threats (e.g., predation, food availability). We recommend that the status of this subspecies be reconsidered upon completion of the recommended actions identified below.

We are recommending the following actions prior to reconsidering the status of the subspecies:

1. Analyze existing California least tern data to develop a population model that estimates the population demographics necessary for population and breeding colony stability.

2. Continue to work with our partners regarding ongoing site management activities to minimize impacts of predation, encroaching vegetation, and human disturbance.

3. Investigate the impact of shifting food resources on survival, productivity, and colony dynamics of the California least tern, and explore potential for new nesting areas that address any anticipated changes in nesting distribution driven by shifting food resources.

4. Update the California least tern recovery plan and recovery criteria with current science, population data, and biology. Utilize threats-based criteria and analysis to develop updated recovery objectives supported by population modeling.

5. Analyze genetic samples to better understand the current distribution of California least terns and other subspecies in Mexico.

While the California least tern has met the population size recommended in the Recovery Plan for downlisting, the population has been recently declining, exhibited poor reproductive success, and, multiple ongoing threats continue to impact the species. Therefore, current information does not support reclassifying the California least tern at this time. Additional information on threats, management techniques, and current population models should be obtained before reassessing the taxon again in the future.

V. RESULTS

Recommended Listing Action:

☐ Downlist to Threatened

☐ Uplist to Endangered

☐ Delist (indicate reason for delisting according to 50 CFR 424.11):

  ☐ *Extinction*

  ☐ *Recovery*

  ☐ *Original data for classification in error*

☒ No Change

New Recovery Priority Number and Brief Rationale: Change from 15C to 18C

The California least tern has a recovery priority number of 15C, which is defined as a subspecies that faces a low degree of threat and has a high recovery potential (USFWS 1983b, p. 51985). The taxon is distributed widely from San Francisco Bay to the North to the Tijuana River to the South. The U.S. population of California least tern has increased from an estimated 256 pairs at listing to an estimated 4,095 pairs in 2017, though impacts from current threats has resulted in a decreasing population trend of California least terns over the past 10 years. Successful reproduction at many nesting areas is dependent on ongoing management, particularly predator management. Therefore, due to the reliance on ongoing management, we are changing the recovery priority number from 15C to 18C.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

The actions listed below are recommendations to be completed over the next 5 years. These will help guide continuing recovery of the California least tern by providing information to better manage nesting sites. Conservation of the California least tern is dependent on continued cooperation with our partners to minimize impacts from current threats and aid in future restoration.

1. Continue to coordinate with CDFW, San Diego State University, and other partners to conduct analysis of existing least tern data, to determine trends; create reliable, accurate population models that identify demographic requirements for a stable population; quantify long-term trends; and direct future management priorities to determine population and breeding colony stability.

2. Work with the DOD (the Navy, the Marine Corps, and Air Force), CDFW, California Department of Parks and Recreation, and other partners to continue current successful site management that minimizes impacts of encroaching vegetation, predation, and human disturbance. Investigate innovative techniques of site management and monitoring to reduce costs and better protect the species.

3. Continue food availability studies already started by monitors or initiate new studies on the impact that shifting food resources have on survival, productivity, and colony dynamics of the California least tern.

4. Partner with Mexican nongovernmental organizations, scientists, and Federal agencies on potential recovery and management actions at nesting sites in Mexico.

5. Update the California least tern recovery plan and recovery criteria with current science, population data, and biology. Utilize threats-based analysis to develop recovery goals.

6. Continue efforts to identify the wintering range of the California least tern and the threats that impact the species on its wintering grounds and migration route.

7. Develop banding protocol to create unified data collection rangewide. Continue banding and recapture studies to determine age structure, survival, and movement.

8. Develop standardized monitoring protocols and on-line data portal to facilitate synthesis, analysis, and sharing of data.

9. Enter into long-term agreements that will assure continued protection and management of California least tern nest sites.

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APPENDIX A

[California least tern occurrence table]

Table A1. Status of the California least tern (*Sternula antillarum browni*) at currently occupied nesting sites (2012–2017) in California. Site management includes at least two of the following: vegetation removal, fencing, chick shelters, or interpretive signs.

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
Sacramento Area	1	Bufferlands	Sacramento Regional County Sanitation District	None	suitable, occupied	2017: 1 2016: 1 2015: 1 2014: 0 2013: 0 2012: 1	2017: 0.00-0.00 2016: 2.00-2.00 2015: 1.00-1.00 2014: N/A 2013: N/A 2012: 0.00-0.00	A: Development C: Predation E: Contaminants, Food availability
San Francisco Bay Area	2	Pittsburg Power Plant	Mirant Delta, LLC	Site management, predator management	suitable, occupied	2017: unk 2016: 1 2015: 2 2014: 0 2013: 0 2012: 1	2017: 2016: 0.00-0.00 2015: 0.00-0.00 2014: N/A 2013: N/A 2012: 0.00-0.00	A: Habitat modification, Sea level rise C: Predation; predation by special-status species E: Contaminants, Food availability
San Francisco Bay Area	3	Alameda Point	U.S. Navy	Site management, predator management	suitable, occupied	2017: 382 2016: 358 2015: 321 2014: 281 2013: 281 2012: 306	2017: 0.47-0.65 2016: 1.54-1.78 2015: 0.99-1.67 2014: 1.22-1.39 2013: 1.07-1.08 2012: 0.50-0.50	A: Habitat modification, development C: Predation E: Human disturbance, Food availability, Contaminants
San Francisco Bay Area	4	Hayward Regional Shoreline	County Parks	Site management, predator management	suitable, occupied	2017: 66 2016: 83 2015: 67 2014: 77 2013: 80 2012: 143	2017: 1.04-1.17 2016: 1.80-1.89 2015: 1.29-1.58 2014: 1.42-1.66 2013: 1.46-1.53 2012: 0.58-1.14	A: Habitat modification, Sea level rise C: Predation E: Contaminants, Food availability

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
San Francisco Bay Area	5	Montezuma Wetlands	Montezuma Wetlands, LLC	None	suitable, occupied	2017: 7 2016: 4 2015: 12 2014: 15 2013: 25 2012: 18	2017: 0.63-0.71 2016: 0.17-0.25 2015: 0.00-0.00 2014: 0.06-0.07 2013: 0.12-0.16 2012: 0.83-1.00	A: Habitat modification, Sea level rise C: Predation E: Contaminants, Food availability
San Francisco Bay Area	6	Eden's Landing Ecological Reserve	CDFW[1]	None	suitable, occupied	2017: 14 2012-2016: no nesting	2017: 1.00-2.00 2012-2016: N/A	A: Sea level rise C: Predation E: Contaminants, Food availability
San Francisco Bay Area	7	Napa Sonoma Marsh Wildlife Area	CDFW	Site preparation	suitable, occupied	2017: 65 2016: 60 2015: 63 2014: 38 2013: 61 2012: 16	2017: 1.23-1.23 2016: 0.07-0.10 2015: 0.34-0.38 2014: 1.36-1.84 2013: 0.14-0.33 2012: 0.14-1.88	A: Habitat modification, Sea level rise C: Predation E: Contaminants, Food availability
San Luis Obispo/Santa Barbara Counties	8	Oceano Dunes SVRA	DPR[3]	Site management, predator management	suitable, occupied	2017: 44 2016: 46 2015: 50 2014: 45 2013: 43 2012: 42	2017: 0.15-0.16 2016: 1.20-1.28 2015: 1.30-1.38 2014: 1.23-1.29 2013: 1.04-1.30 2012: 0.93-1.00	A: Habitat modification C: Predation E: Human disturbance, Food availability
San Luis Obispo/Santa Barbara Counties	9	Vandenberg AFB (5 sites)	U.S. Air Force	Site management, predator management	suitable, occupied	2017: 19 2016: 21 2015: 20 2014: 17 2013: 14 2012: 16	2017: 0.30-0.42 2016: 0.72-0.86 2015: 1.32-1.45 2014: 1.00-1.18 2013: 1.27-1.36 2012: 0.56-0.63	C: Predation E: Food availability

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
Ventura County	10	Santa Clara River / McGrath State Beach	DPR	Site management	suitable, occupied	2017: 7 2016: 40 2015: 45 2014: 4 2013: 37 2012: 38	2017: 0.00-0.00 2016: 0.19-0.28 2015: 0.39-0.60 2014: 0.50-0.50 2013: 0.00-0.00 2012: 0.21-0.21	C: Predation E. Human disturbance, Food availability
Ventura County	11	Ormond Beach	Ventura County, City of Oxnard	Site management	suitable, occupied	2017: 25 2016: 15 2015: 0 2014: 18 2013: 6 2012: 6	2017: 0.54-0.80 2016: 0.78-0.93 2015: N/A 2014: 0.50-0.50 2013: 0.00-0.00 2012: 0.00-0.00	C: Predation E. Human disturbance, Food availability
Ventura County	12	Hollywood Beach	City of Oxnard	Site management	suitable, occupied	2017: 0 2016: 0 2015: 15 2014: 77 2013: 117 2012: 0	2017: N/A 2016: N/A 2015: 0.00-0.00 2014: 0.26-0.38 2013: 0.15-0.26 2012: N/A	A: Rising sea levels, habitat modification C: Predation E: Human Disturbance, Dredging, Food availability
Ventura County	13	NBVC Point Mugu (4 sites)	U.S. Navy	Site management	suitable, occupied	2017: 262 2016: 315 2015: 323 2014: 407 2013: 203 2012: 608	2017: 0.09-0.19 2016: 0.16-0.27 2015: 0.26-0.46 2014: 0.29-0.31 2013: 0.00-0.00 2012: 0.02-0.02	A: Rising sea levels C: Predation E: Food availability
Los Angeles/Orange Counties	14	Malibu Lagoon	State Parks	UNK	suitable, occupied	2017: 22 2012-2016: no nesting	2017: 0.52-1.00 2016-2016: N/A	A: Rising sea levels C: Predation E: Human disturbance, Food availability

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
Los Angeles/Orange Counties	15	Venice Beach	Los Angeles County	Site management	suitable, occupied	2017: 0 2016: 2 2015: 8 2014: 47 2013: 12 2012: 0	2017: N/A 2016: 0.00-0.00 2015: 0.00-0.00 2014: 1.14-2.13 2013: 0.00-0.00 2012: 0.00-0.00	A: Habitat modification C: Predation E: Food availability; Human disturbance
Los Angeles/Orange Counties	16	L.A. Harbor / Pier 400	Port of Los Angeles	Site management, predator management	suitable, occupied	2017: 0 2016: 109 2015: 103 2014: 110 2013: 237 2012: 144	2017: N/A 2016: 0.33-0.64 2015: 0.00-0.00 2014: 0.14-1.02 2013: 0.13-0.62 2012: 0.17-0.24	C: Predation; predation by special-status species E: Food availability, Contaminants
Los Angeles/Orange Counties	17	Seal Beach NWR/ NASA Island	Service	Site management, predator management	suitable, occupied	2017: 118 2016: 73 2015: 50 2014: 115 2013: 149 2012: 117	2017: 0.03-0.07 2016: 0.31-0.34 2015: 0.07-0.14 2014: 0.03-0.03 2013: 0.13-0.62 2012: 0.55-0.60	A: Habitat modification C: Predation E: Contaminants, Food availability
Los Angeles/Orange Counties	18	Bolsa Chica Ecological Reserve	CDFW	Site management, predator management	suitable, occupied	2017: 158 2016: 124 2015: 184 2014: 205 2013: 137 2012: 154	2017: 0.03-0.04 2016: 0.31-0.34 2015: 0.07-0.14 2014: 0.03-0.03 2013: 0.13-0.62 2012: 0.55-0.60	A: Habitat modification, Sea level rise C: Predation; predation by special-status species E: Food availability
Los Angeles/Orange Counties	19	Huntington State Beach	DPR	Site management, predator management	suitable, occupied	2017: 560 2016: 304 2015: 411 2014: 407 2013: 303 2012: 422	2017: 0.04-0.25 2016: 0.30-0.40 2015: 0.25-0.30 2014: 0.34-0.86 2013: 0.30-0.33 2012: 0.17-0.21	A: Habitat modification C: Predation E: Human disturbance

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
Los Angeles/Orange Counties	20	Burris Sand Pit	Orange County Water District	Site Management	suitable, occupied	2017:12 2016: 6 2015: 18 2014: 16 2013: 17 2012: 11	2017: 0.71-0.83 2016: 0.00-0.00 2015: 0.14-0.17 2014: 0.56-0.63 2013: 0.04-0.24 2012: 0.64-0.64	A: Habitat modification C: Predation E: Contaminants, Food availability
Los Angeles/Orange Counties	21	Upper Newport Bay Ecological Reserve	CDFW	Site Management	suitable, occupied	2017: 15 2016: 18 2015: 19 2014: 1 2013: 27 2012: 16	2017: 0.81-0.87 2016: 0.10-0.11 2015: 0.05-0.05 2014: 0.00-0.00 2013: 0.26-0.30 2012: 0.19-0.25	A: Habitat modification, Sea level rise C: Predation E: Food availability
Los Angeles/Orange Counties	22	Anaheim Lake		Unknown	suitable, occupied	2017: 0 2016: 2 2012-2015: no nesting	2017: N/A 2016: 0.00-0.00 2012-2015: N/A	C: Predation
San Diego County	23	MCB Camp Pendleton (7 sites)	U.S. Marine Corps	INRMP. Site management, predator management (no predator management in 2017)	suitable, occupied	2017: 212 2016: 747 2015: 918 2014: 858 2013: 786 2012: 507	2017: 0.00-0.02 2016: 0.09-0.28 2015: 0.13-0.19 2014: 0.32-0.62 2013: 0.13-0.19 2012: 0.02-0.05	A: Rising sea levels, habitat modification C: Predation; predation by special-status species, Disease E: Food availability, Contaminants, Human disturbance
San Diego County	24	Batiquitos Lagoon Ecological Reserve (5 sites)	CDFW	Site management, predator management (no predator management in 2011)	suitable, occupied	2017: 658 2016: 414 2015: 296 2014: 311 2013: 443 2012: 550	2017: 0.26-0.34 2016: 0.39-0.48 2015: 0.22-0.48 2014: 0.49-0.86 2013: 0.21-0.37 2012: 0.06-0.07	A: Habitat modification C: Predation; predation by special-status species E: Human disturbance; Food availability

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
San Diego County	25	San Dieguito Lagoon (4 sites)	UNK	Site management, predator management	Suitable, occupied	2017: 0 2016: 0 2015: 0 2014: 0 2013: 3 2012: 0	2017-2014: N/A 2013: 0.00-0.00 2012: N/A	A. Habitat modification C: Predation E. Food Availability
San Diego County	26	Mission Bay (5 sites)	City of San Diego	MBNRMP, SD MSCP, Site management, predator management	suitable, occupied	2017: 181 2016: 114 2015: 199 2014: 106 2013: 148 2012: 36	2017: 0.36-0.49 2016: 0.25-0.37 2015: 0.27-0.42 2014: 0.48-0.79 2013: 0.03-0.04 2012: 0.00-0.01	A: Habitat modification C: Predation; Predation by special-status species E: Contaminants, Food availability
San Diego County	27	San Diego Bay: Lindbergh Field	Airport Authority	Site management, predator management	suitable, occupied	2017: 21 2016: 31 2015: 8 2014: 67 2013: 91 2012: 102	2017: 0.54-0.81 2016: 0.27-0.55 2015: 0.44-1.13 2014: 0.34-0.69 2013: 0.32-0.37 2012: 0.29-0.35	A: Habitat modification C: Predation, Disease E. Contaminants, Food availability
San Diego County		San Diego Bay: NBC Coronado (4 sites)	U.S. Navy	NBC INRMP, Site management, predator management	suitable, occupied	2017: 804 2016: 748 2015: 707 2014: 556 2013: 714 2012: 803	2017: 0.32-0.59 2016: 0.12-0.26 2015: 0.21-0.33 2014: 0.21-0.35 2013: 0.17-0.22 2012: 0.01-0.02	A: Rising sea levels, Habitat modification C: Predation; predation by special-status species E: Food availability, Contaminants, Human Disturbance
San Diego County		San Diego Bay: Sweetwater Marsh Unit NWR	Service / Port of San Diego	SDNWR CCP, Site management, predator management	suitable, occupied	2017: 33 2016: 106 2015: 105 2014: 100 2013: 113 2012: 102	2017: 0.20-0.24 2016: 0.19-0.21 2015: 0.18-0.24 2014: 0.12-0.34 2013: 0.18-0.28 2012: 0.08-0.24	A: Rising sea levels, Habitat modification C: Predation; predation by special-status species E: Food availability, Contaminants, Human disturbance

Area	Nesting Area	Name	Ownership	Conservation Measures	Current Status	Minimum Number of Breeding Pairs (2012-2017)	Fledglings per pair ratio min-max (2012-2017)	Threats
San Diego County		San Diego Bay: South San Diego Bay Unit NWR	Service	Site management, predator management	suitable, occupied	2017: 33 2016: 16 2015: 24 2014: 22 2013: 27 2012: 49	2017: 0.05-0.09 2016: 0.24-0.44 2015: 0.34-0.42 2014: 0.31-0.50 2013: 0.05-0.07 2012: 0.01-0.02	A: Rising sea levels, Habitat modification C: Predation; predation by special-status species E: Contaminants, Food availability, Inter-specific disturbance
San Diego County		San Diego Bay: Chula Vista Wildlife Reserve	Port of San Diego	San Diego Bay INRMP. Site management, predator management	suitable, occupied	2017: 86 2016: 63 2015: 69 2014: 59 2013: 66 2012: 37	2017: 0.18-0.27 2016: 0.21-0.29 2015: 0.43-0.54 2014: 0.27-0.46 2013: 0.44-0.59 2012: 0.35-0.64	A. Rising sea levels, Habitat modification C: Predation; predation by special-status species E: Contaminants
San Diego County	28	Tijuana Estuary NERR	DPR/Service	Site management, predator management	suitable, occupied	2017: 197 2016: 144 2015: 144 2014: 229 2013: 206 2012: 109	2017: 0.35-0.42 2016: 0.19-0.28 2015: 0.15-0.22 2014: 0.14-0.17 2013: 0.23-0.32 2012: 0.00-0.00	A: Rising sea levels, Habitat modification C: Predation; predation by special-status species E. Food availability, Human disturbance
Imperial County	29	Salton Sea	UNK	UNK	Suitable, occupied	2017: 0 2016: 0 2015: 0 2014: 2 2013: 2 2012: 0	2017: N/A 2016: N/A 2015: 0.00-1.00 2014: 0.00-0.50 2013: 1.00-1.00 2012: N/A	C: Predation E: Contaminants

1. CDFW: California Department of Fish and Wildlife
2. UNK: Unknown
3. DPR: California Department of Parks and Recreation

APPENDIX B

[Inundation probability with sea level rise]

Table B1. Inundation Probability at occupied (2013-2017) California Least Tern Nesting Sites in the U.S. based on NOAA Sea Level Rise Modeling.

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
Alameda NAS (9.63 ac)	1	9.63	100	0	0	0	0
	2	9.63	100	0	0	0	0
	3	9.39	97	0.24	3	0	0
	5	5.69	59	3.73	39	0.21	2
Anaheim Lake (0.06 ac)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Batiquitos Lagoon Ecological Reserve (20.87 ac)	1	20.82	100	0.03	0.1	0.03	0.1
	2	20.79	100	0.04	0.2	0.04	0.2
	3	20.75	99	0.07	0.3	0.05	0.3
	5	18.22	87	2.53	12	0.12	1
Bolsa Chica Ecological Reserve (9.86 ac)	1	7.81	79	0.44	4	1.61	16
	2	7.75	79	0.18	2	1.93	20
	3	7.59	77	0.22	2	2.05	21
	5	6.26	64	1.33	14	2.26	23
Bufferlands (1.37 ac)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Burris Sand Pit/Burris Basin (0.72 ac)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eden Landing (176.33 ac)	1	1.35	1	9.96	6	165.02	94
	2	0.46	0	4.71	3	171.16	97
	3	0.09	0	1.53	1	174.71	99
	5	0	0	0.13	0	176.20	100
Hayward Regional Shoreline (0.36 ac)	1	0	0	0.32	91	0.03	9
	2	0	0	0.22	63	0.13	37
	3	0	0	0.01	4	0.34	96
	5	0	0	0	0	0.36	100

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
Hollywood Beach (30.88 ac)	1 2 3 5	19.86 18.34 14.58 9.25	64 59 47 30	1.06 2.11 5.35 5.74	3 7 17 19	9.97 10.43 10.96 15.90	32 34 35 51
Huntington State Beach (10.96 ac)	1 2 3 5	10.96 10.96 10.95 7.46	100 100 100 68	0 0 0.01 3.49	0 0 0.05 32	0 0 0 0	0 0 0 0
L.A. Harbor (14.73 ac)	1 2 3 5	14.73 14.730 14.73 14.73	100 100 100 100	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
Malibu Lagoon (3.57 ac)	1 2 3 5	1.01 0.36 0.02 0	28 10 0.5 0	0.81 1.14 1.07 0.05	23 32 30 1	1.75 2.07 2.49 3.52	49 58 70 98
MCB Camp Pendleton (259.03 ac) Blue Beach (88.64 ac)	1 2 3 5	51.24 42.08 32.92 11.76	58 47 37 13	8.98 13.90 18.73 21.56	10 16 21 24	28.42 32.66 37.00 55.33	32 37 42 62
MCB Camp Pendleton (259.03 ac) Red Beach (7.54 ac)	1 2 3 5	7.15 7.00 6.44 5.09	95 93 85 67	0.38 0.35 0.72 1.38	5 5 10 18	0 0.18 0.38 1.07	0 2 5 14
MCB Camp Pendleton (259.03 ac) Salt Flats (111.72)	1 2 3 5	53.13 24.39 7.02 0	48 22 6 0	57.69 78.02 47.61 7.61	52 70 43 7	0.91 9.31 57.10 104.11	1 8 51 93

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
MCB Camp Pendleton (259.03 ac) White Beach North/Central (17.41 ac)	1 2 3 5	16.24 15.51 14.43 8.41	93 89 83 48	0.94 1.19 1.86 6.09	5 7 11 35	0.24 0.71 1.12 2.91	1 4 6 17
MCB Camp Pendleton (259.03 ac) White Beach South (33.72 ac)	1 2 3 5	32.72 31.20 28.50 6.43	97 93 85 19	1.00 2.46 4.29 22.20	3 7 13 66	0 0.06 0.93 5.08	0 0.2 3 15
Mission Bay (23.94 ac) FAA Island (1.58 ac)	1 2 3 5	1.57 1.37 0.51 0	99 87 33 0	0.01 0.21 1.05 0.56	1 13 67 35	0 0 0.01 1.02	0 0 1 65
Mission Bay (23.94 ac) Mariner's Point (2.19 ac)	1 2 3 5	2.19 2.19 2.19 2.16	100 100 100 99	0 0 0 0.03	0 0 0 1	0 0 0 0	0 0 0 0
Mission Bay (23.94 ac) North Fiesta Island (12.52 ac)	1 2 3 5	12.52 12.52 12.52 12.52	100 100 100 100	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
Mission Bay (23.94 ac) San Diego River Mouth (3.16 ac)	1 2 3 5	2.03 1.09 0.26 0	64 34 8 0	1.13 1.94 1.80 0.31	36 61 57 10	0 0.14 1.09 2.86	0 4 35 90
Mission Bay (23.94 ac) Stony Point (4.49 ac)	1 2 3 5	4.49 4.48 4.40 2.82	100 100 98 63	0 0.01 0.09 1.60	0 0.2 2 36	0 0 0 0.07	0 0 0 2

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
Montezuma Wetlands (0.29 ac)	1 2 3 5	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0.29 0.29 0.29 0.29	100 100 100 100
Napa Sonoma Marsh Wildlife Area (1.71 ac)	1 2 3 5	0.04 0 0 0	2 0 0 0	0.46 0.24 0.06 0	27 14 4 0	1.21 1.46 1.65 1.71	71 86 96 100
Oceano Dunes SVRA (135.42 ac)	1 2 3 5	135.42 135.31 134.77 131.60	100 100 100 97	0 0.11 0.66 3.24	0 0.1 0.5 2	0 0 0 0.59	0 0 0 0.4
Ormond Beach (45.18 ac)	1 2 3 5	40.54 39.73 37.13 18.01	90 88 82 40	0.23 0.94 3.42 19.43	1 2 8 43	4.41 4.50 4.63 7.74	10 10 10 17
Pittsburg Power Plant (0.59 ac)	1 2 3 5	0.00 0.00 0.00 0.00	0 0 0 0	0.00 0.00 0.00 0.00	0 0 0 0	0.59 0.59 0.59 0.59	100 100 100 100
Pt Mugu (60.42 ac)	1 2 3 5	55.21 53.20 48.34 25.30	91 88 80 42	1.17 2.46 6.92 23.56	2 4 11 39	4.04 4.75 5.16 11.56	7 8 9 19
Salton Sea (acres unknown)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area Chula Vista Wildlife Reserve (4.99 ac)	1 2 3 5	4.48 3.71 2.49 1.17	90 74 50 24	0.20 0.93 2.00 1.42	4 19 40 28	0.31 0.35 0.50 2.40	6 7 10 48

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area NAS North Island, Coronado, MAT Site (19.14 ac)	1 2 3 5	19.14 19.14 19.14 19.14	100 100 100 100	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area NAB Coronado, Delta Beaches (46.92 ac)	1 2 3 5	44.42 41.82 38.31 30.36	95 89 82 65	2.37 3.83 6.22 8.15	5 8 13 17	0.14 1.27 2.39 8.42	0.3 3 5 18
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area NAB Coronado, Oceans (109.45 ac)	1 2 3 5	92.43 89.36 85.64 73.85	84 82 78 67	6.73 6.17 6.92 12.04	6 6 6 11	10.30 13.93 16.89 23.57	9 13 15 22
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area San Diego International Airport (12.55 ac)	1 2 3 5	12.55 12.55 12.55 5.42	100 100 100 43	0 0 0 7.13	0 0 0 57	0 0 0 0	0 0 0 0
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area Saltworks (4.98 ac) Note: 0.25 ac outside modeled area	1 2 3 5	3.29 2.54 1.05 0.18	66 51 21 4	0.30 0.95 2.25 0.91	6 19 45 18	1.13 1.24 1.42 3.63	23 25 29 73
San Diego Bay (224.71 ac) Note: .25 ac outside modeled area D Street Fill (26.68 ac)	1 2 3 5	26.68 26.68 25.83 21.21	100 100 97 80	0 0 0.84 4.66	0 0 3 17	0 0 0 0.81	0 0 0 3

Nesting Area	Sea Level Rise (ft)	High Confidence (80 percent) of No Inundation (ac)	Inundation Probability (percent)	Low Confidence (20 to <80) of Either Inundation or No Inundation (ac)	Inundation Probability (percent)	High Confidence (80 percent) of Inundation (ac)	Inundation Probability (percent)
San Dieguito Lagoon (14.68 ac)	1	14.58	99	0.11	1	0.00	0
	2	14.38	98	0.30	2	0.01	0
	3	14.17	97	0.41	3	0.10	1
	5	13.46	92	0.74	5	0.48	3
Santa Clara River Mouth/McGrath State Beach (55.49 ac)	1	55.38	100	0.05	0.1	0.05	0.1
	2	55.21	100	0.21	0.4	0.07	0.1
	3	55.08	99	0.31	1	0.10	0.2
	5	54.28	98	0.81	1	0.39	1
Seal Beach NWR - Anaheim Bay (2.45 ac)	1	2.42	99	0.03	1	0	0
	2	2.09	86	0.35	14	0	0
	3	1.13	46	1.30	53	0.01	1
	5	0	0	1.22	50	1.23	50
Tijuana Estuary NERR (22.7 ac)	1	21.87	96	0.72	3	0.11	0.5
	2	20.13	89	2.40	11	0.17	1
	3	17.93	79	4.00	18	0.77	3
	5	13.57	60	4.46	20	4.68	21
Upper Newport Bay Ecological Reserve (3.63 ac)	1	2.06	57	0.56	15	1.02	28
	2	1.80	50	0.55	15	1.29	35
	3	1.47	41	0.60	17	1.56	43
	5	0	0	1.49	41	2.15	59
Vandenberg AFB (66.86 ac)	1	66.42	99	0.17	0.3	0.26	0.4
	2	66.30	99	0.16	0.2	0.39	1
	3	66.27	99	0.15	0.2	0.43	1
	5	66.18	99	0.10	0.1	0.58	1
Venice Beach (7.3 ac)	1	7.30	100	0	0	0	0
	2	7.30	100	0	0	0	0
	3	7.30	100	0	0	0	0
	5	7.30	100	0	0	0	0

* NA: These sites are inland and not subject to inundation.

APPENDIX C

[Probable inundation with 1 ft and 3 ft sea level rise]

Table C1. Probable Inundation of Individual California Least Tern Nesting Sites for the Likely Inundation Scenarios in 2050 and 2080 using only the High (80%) Confidence Model Results. Green Represents No Loss of Nesting Habitat (0%), Yellow Represents Minimal Loss (1-20%), Tan Represents Moderate Loss (21-50%), Orange Represents Significant Loss (51-99%), Red Represents Complete Loss (100%).

Probable Inundation	1 ft Sea Level Rise (2050)	Probable Inundation	3 ft Sea Level Rise (2080)
None (<1%) (643.36 ac)	Alameda NAS (9.63 ac)	None (<1%) (417.60 ac)	Alameda NAS (9.63 ac)
None (<1%) (643.36 ac)	Anaheim Lake (0.06 ac)	None (<1%) (417.60 ac)	Anaheim Lake (0.06 ac)
None (<1%) (643.36 ac)	Batiquitos Lagoon Ecological Reserve (20.87 ac)	None (<1%) (417.60 ac)	Batiquitos Lagoon Ecological Reserve (20.87 ac)
None (<1%) (643.36 ac)	Huntington State Beach (10.96 ac)	None (<1%) (417.60 ac)	Huntington State Beach (10.96 ac)
None (<1%) (643.36 ac)	L.A. Harbor (14.73 ac)	None (<1%) (417.60 ac)	L.A. Harbor (14.73 ac)
None (<1%) (643.36 ac)	MCB Camp Pendleton, Red Beach (7.54 ac)	None (<1%) (417.60 ac)	Mission Bay, FAA Island (1.58 ac)
None (<1%) (643.36 ac)	MCB Camp Pendleton, Salt Flats (111.72 ac)	None (<1%) (417.60 ac)	Mission Bay, Mariner's Point (2.19 ac)
None (<1%) (643.36 ac)	MCB Camp Pendleton, White Beach South (33.72 ac)	None (<1%) (417.60 ac)	Mission Bay, North Fiesta Island (12.52 ac)
None (<1%) (643.36 ac)	Mission Bay, FAA Island (1.58 ac)	None (<1%) (417.60 ac)	Mission Bay, Stony Point (4.49 ac)
None (<1%) (643.36 ac)	Mission Bay, Mariner's Point (2.19 ac)	None (<1%) (417.60 ac)	Oceano Dunes SVRA (135.42 ac)
None (<1%) (643.36 ac)	Mission Bay, North Fiesta Island (12.52 ac)	None (<1%) (417.60 ac)	San Diego Bay, D Street Fill (26.68 ac)
None (<1%) (643.36 ac)	Mission Bay, San Diego River Mouth (3.16 ac)	None (<1%) (417.60 ac)	San Diego Bay, NAS North Island, Coronado, MAT Site (19.14 ac)
None (<1%) (643.36 ac)	Mission Bay, Stony Point (4.49 ac)	None (<1%) (417.60 ac)	San Diego Bay, San Diego International Airport (12.55 ac)
None (<1%) (643.36 ac)	Oceano Dunes SVRA (135.42 ac)	None (<1%) (417.60 ac)	San Dieguito Lagoon (14.68 ac)

Probable Inundation	**1 ft Sea Level Rise (2050)**	**Probable Inundation**	**3 ft Sea Level Rise (2080)**
None (<1%) (643.36 ac)	San Diego Bay, D Street Fill (26.68 ac)	None (<1%) (417.60 ac)	Santa Clara River Mouth/McGrath State Beach (55.49 ac)
None (<1%) (643.36 ac)	San Diego Bay, NAB Coronado, Delta Beaches (46.92 ac)	None (<1%) (417.60 ac)	Seal Beach NWR - Anaheim Bay (2.45 ac)
None (<1%) (643.36 ac)	San Diego Bay, NAS North Island, Coronado, MAT Site (19.14 ac)	None (<1%) (417.60 ac)	Vandenberg AFB (66.86 ac)
None (<1%) (643.36 ac)	San Diego Bay, San Diego International Airport (12.55 ac)	None (<1%) (417.60 ac)	Venice Beach (7.3 ac)
None (<1%) (643.36 ac)	San Dieguito Lagoon (14.68 ac)	Minimal (1-20%) (358.19 ac)	Bolsa Chica Ecological Reserve (9.86 ac)
None (<1%) (643.36 ac)	Santa Clara River Mouth/McGrath State Beach (55.49 ac)	Minimal (1-20%) (358.19 ac)	MCB Camp Pendleton, Red Beach (7.54 ac)
None (<1%) (643.36 ac)	Seal Beach NWR - Anaheim Bay (2.45 ac)	Minimal (1-20%) (358.19 ac)	MCB Camp Pendleton, White Beach North/Central (17.41 ac)
None (<1%) (643.36 ac)	Tijuana Estuary NERR (22.7 ac)	Minimal (1-20%) (358.19 ac)	MCB Camp Pendleton, White Beach South (33.72 ac)
None (<1%) (643.36 ac)	Vandenberg AFB (66.86 ac)	Minimal (1-20%) (358.19 ac)	Ormond Beach (45.18 ac)
None (<1%) (643.36 ac)	Venice Beach (7.3 ac)	Minimal (1-20%) (358.19 ac)	Pt Mugu (60.42 ac)
Minimal (1-20%) (247.67 ac)	Bolsa Chica Ecological Reserve (9.86 ac)	Minimal (1-20%) (358.19 ac)	San Diego Bay, Chula Vista Wildlife Reserve (4.99 ac)
Minimal (1-20%) (247.67 ac)	Hayward Regional Shoreline (0.36 ac)	Minimal (1-20%) (358.19 ac)	San Diego Bay, NAB Coronado, Delta Beaches (46.92 ac)
Minimal (1-20%) (247.67 ac)	MCB Camp Pendleton, White Beach North/Central (17.41 ac)	Minimal (1-20%) (358.19 ac)	San Diego Bay, NAB Coronado, Oceans (109.45 ac)
Minimal (1-20%) (247.67 ac)	Ormond Beach (45.18 ac)	Minimal (1-20%) (358.19 ac)	Tijuana Estuary NERR (22.7 ac)
Minimal (1-20%) (247.67 ac)	Pt Mugu (60.42 ac)	Moderate (21-50%) (131.28 ac)	Hollywood Beach (30.88 ac)
Minimal (1-20%) (247.67 ac)	San Diego Bay, Chula Vista Wildlife Reserve (4.99 ac)	Moderate (21-50%) (131.28 ac)	MCB Camp Pendleton, Blue Beach (88.64 ac)
Minimal (1-20%) (247.67 ac)	San Diego Bay, NAB Coronado, Oceans (109.45 ac)	Moderate (21-50%) (131.28 ac)	Mission Bay, San Diego River Mouth (3.16 ac)
Moderate (21-50%) (131.70 ac)	Hollywood Beach (30.88 ac)	Moderate (21-50%) (131.28 ac)	San Diego Bay, Saltworks (4.98 ac)
Moderate (21-50%) (131.70 ac)	Malibu Lagoon (3.57 ac)	Moderate (21-50%) (131.28 ac)	Upper Newport Bay Ecological Reserve (3.63 ac)

Probable Inundation	1 ft Sea Level Rise (2050)	Probable Inundation	3 ft Sea Level Rise (2080)
Moderate (21-50%) (131.70 ac)	MCB Camp Pendleton, Blue Beach (88.64 ac)	Significant (51-99%) (117.36 ac)	Hayward Regional Shoreline (0.36 ac)
Moderate (21-50%) (131.70 ac)	San Diego Bay, Saltworks (4.98 ac)	Significant (51-99%) (117.36 ac)	Malibu Lagoon (3.57 ac)
Moderate (21-50%) (131.70 ac)	Upper Newport Bay Ecological Reserve (3.63 ac)	Significant (51-99%) (117.36 ac)	MCB Camp Pendleton, Salt Flats (111.72 ac)
Significant (51-99%) (178.04 ac)	Eden Landing (176.33 ac)	Significant (51-99%) (117.36 ac)	Napa Sonoma Marsh Wildlife Area (1.71 ac)
Significant (51-99%) (178.04 ac)	Napa Sonoma Marsh Wildlife Area (1.71 ac)	Complete (100%) (177.21 ac)	Eden Landing (176.33 ac)
Complete (100%) (0.88 ac)	Montezuma Wetlands (0.29 ac)	Complete (100%) (177.21 ac)	Montezuma Wetlands (0.29 ac)
Complete (100%) (0.88 ac)	Pittsburg Power Plant (0.59 ac)	Complete (100%) (177.21 ac)	Pittsburg Power Plant (0.59 ac)

APPENDIX D

[Probable inundation with 2 ft and 5 ft sea level rise]

Table D1. Probable Inundation of California Least Tern Nesting Sites for the 1-in-200 Inundation Levels at 2050 and 2080 using only the High (80%) Confidence Model Results. Green Represents No Loss of Nesting Habitat (<1%), Yellow Represents Minimal Loss (1-20%), Tan Represents Moderate Loss (21-50%), Orange Represents Significant Loss (51-99%), Red Represents Complete Loss (100%).

Probable Inundation (Percent Loss of Habitat) Total Estimated Acreage	2 ft Sea Level Rise (2050)	Probable Inundation (Percent Loss of Habitat) Estimated Acreage	5 ft Sea Level Rise (2080)
None (<1%) (474.02 ac)	Alameda NAS (9.63 ac)	None (<1%) (358.09 ac)	Anaheim Lake (0.06 ac)
None (<1%) (474.02 ac)	Anaheim Lake (0.06 ac)	None (<1%) (358.09 ac)	Batiquitos Lagoon Ecological Reserve (20.87 ac)
None (<1%) (474.02 ac)	Batiquitos Lagoon Ecological Reserve (20.87 ac)	None (<1%) (358.09 ac)	Huntington State Beach (10.96 ac)
None (<1%) (474.02 ac)	Huntington State Beach (10.96 ac)	None (<1%) (358.09 ac)	L.A. Harbor (14.73 ac)
None (<1%) (474.02 ac)	L.A. Harbor (14.73 ac)	None (<1%) (358.09 ac)	Mission Bay, Mariner's Point (2.19 ac)
None (<1%) (474.02 ac)	MCB Camp Pendleton, White Beach South (33.72 ac)	None (<1%) (358.09 ac)	Mission Bay, North Fiesta Island (12.52 ac)
None (<1%) (474.02 ac)	Mission Bay, FAA Island (1.58 ac)	None (<1%) (358.09 ac)	Oceano Dunes SVRA (135.42 ac)
None (<1%) (474.02 ac)	Mission Bay, Mariner's Point (2.19 ac)	None (<1%) (358.09 ac)	San Diego Bay, NAS North Island, Coronado, MAT Site (19.14 ac)
None (<1%) (474.02 ac)	Mission Bay, North Fiesta Island (12.52 ac)	None (<1%) (358.09 ac)	San Diego Bay, San Diego International Airport (12.55 ac)
None (<1%) (474.02 ac)	Mission Bay, Stony Point (4.49 ac)	None (<1%) (358.09 ac)	Santa Clara River Mouth/McGrath State Beach (55.49 ac)
None (<1%) (474.02 ac)	Oceano Dunes SVRA (135.42 ac)	None (<1%) (358.09 ac)	Vandenberg AFB (66.86 ac)
None (<1%) (474.02 ac)	San Diego Bay, D Street Fill (26.68 ac)	None (<1%) (358.09 ac)	Venice Beach (7.3 ac)

Probable Inundation (Percent Loss of Habitat) Total Estimated Acreage	2 ft Sea Level Rise (2050)	Probable Inundation (Percent Loss of Habitat) Estimated Acreage	5 ft Sea Level Rise (2080)
None (<1%) (474.02 ac)	San Diego Bay, NAS North Island, Coronado, MAT Site (19.14 ac)	Minimal (1-20%) (289.37 ac)	Alameda NAS (9.63 ac)
None (<1%) (474.02 ac)	San Diego Bay, San Diego International Airport (12.55 ac)	Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, Red Beach (7.54 ac)
None (<1%) (474.02 ac)	San Dieguito Lagoon (14.68 ac)	Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, White Beach North/Central (17.41 ac)
None (<1%) (474.02 ac)	Santa Clara River Mouth/McGrath State Beach (55.49 ac)	Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, White Beach South (33.72 ac)
None (<1%) (474.02 ac)	Seal Beach NWR - Anaheim Bay (2.45 ac)	Minimal (1-20%) (289.37 ac)	Mission Bay, Stony Point (4.49 ac)
None (<1%) (474.02 ac)	Tijuana Estuary NERR (22.7 ac)	Minimal (1-20%) (289.37 ac)	Ormond Beach (45.18 ac)
None (<1%) (474.02 ac)	Vandenberg AFB (66.86 ac)	Minimal (1-20%) (289.37 ac)	Pt Mugu (60.42 ac)
None (<1%) (474.02 ac)	Venice Beach (7.3 ac)	Minimal (1-20%) (289.37 ac)	San Diego Bay, D Street Fill (26.68 ac)
Minimal (1-20%) (289.37 ac)	Bolsa Chica Ecological Reserve (9.86 ac)	Minimal (1-20%) (289.37 ac)	San Diego Bay, NAB Coronado, Delta Beaches (46.92 ac)
Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, Red Beach (7.54 ac)	Minimal (1-20%) (289.37 ac)	San Dieguito Lagoon (14.68 ac)
Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, Salt Flats (111.72 ac)	Minimal (1-20%) (289.37 ac)	Tijuana Estuary NERR (22.7 ac)
Minimal (1-20%) (289.37 ac)	MCB Camp Pendleton, White Beach North/Central (17.41 ac)	Moderate (21-50%) (126.75 ac)	Bolsa Chica Ecological Reserve (9.86 ac)
Minimal (1-20%) (289.37 ac)	Mission Bay, San Diego River Mouth (3.16 ac)	Moderate (21-50%) (126.75 ac)	San Diego Bay, Chula Vista Wildlife Reserve (4.99 ac)
Minimal (1-20%) (289.37 ac)	Ormond Beach (45.18 ac)	Moderate (21-50%) (126.75 ac)	San Diego Bay, NAB Coronado, Oceans (109.45 ac)
Minimal (1-20%) (289.37 ac)	Pt Mugu (60.42 ac)	Moderate (21-50%) (126.75 ac)	Seal Beach NWR - Anaheim Bay (2.45 ac)
Minimal (1-20%) (289.37 ac)	San Diego Bay, Chula Vista Wildlife Reserve (4.99 ac)	Significant (51-99%) (248.16 ac)	Hollywood Beach (30.88 ac)
Minimal (1-20%) (289.37 ac)	San Diego Bay, NAB Coronado, Delta Beaches (46.92 ac)	Significant (51-99%) (248.16 ac)	Malibu Lagoon (3.57 ac)

Probable Inundation (Percent Loss of Habitat) Total Estimated Acreage	2 ft Sea Level Rise (2050)	Probable Inundation (Percent Loss of Habitat) Estimated Acreage	5 ft Sea Level Rise (2080)
Minimal (1-20%) (289.37 ac)	San Diego Bay, NAB Coronado, Oceans (109.45 ac)	Significant (51-99%) (248.16 ac)	MCB Camp Pendleton, Blue Beach (88.64 ac)
Moderate (21-50%) (138.49 ac)	Hayward Regional Shoreline (0.36 ac)	Significant (51-99%) (248.16 ac)	MCB Camp Pendleton, Salt Flats (111.72 ac)
Moderate (21-50%) (138.49 ac)	Hollywood Beach (30.88 ac)	Significant (51-99%) (248.16 ac)	Mission Bay, FAA Island (1.58 ac)
Moderate (21-50%) (138.49 ac)	MCB Camp Pendleton, Blue Beach (88.64 ac)	Significant (51-99%) (248.16 ac)	Mission Bay, San Diego River Mouth (3.16 ac)
Moderate (21-50%) (138.49 ac)	San Diego Bay, Saltworks (4.98 ac)	Significant (51-99%) (248.16 ac)	San Diego Bay, Saltworks (4.98 ac)
Moderate (21-50%) (138.49 ac)	Upper Newport Bay Ecological Reserve (3.63 ac)	Significant (51-99%) (248.16 ac)	Upper Newport Bay Ecological Reserve (3.63 ac)
Significant (51-99%) (181.61 ac)	Eden Landing (176.33 ac)	Complete (100%) (179.28 ac)	Eden Landing (176.33 ac)
Significant (51-99%) (181.61 ac)	Malibu Lagoon (3.57 ac)	Complete (100%) (179.28 ac)	Hayward Regional Shoreline (0.36 ac)
Significant (51-99%) (181.61 ac)	Napa Sonoma Marsh Wildlife Area (1.71 ac)	Complete (100%) (179.28 ac)	Montezuma Wetlands (0.29 ac)
Complete (100%) (0.88 ac)	Montezuma Wetlands (0.29 ac)	Complete (100%) (179.28 ac)	Napa Sonoma Marsh Wildlife Area (1.71 ac)
Complete (100%) (0.88 ac)	Pittsburg Power Plant (0.59 ac)	Complete (100%) (179.28 ac)	Pittsburg Power Plant (0.59 ac)

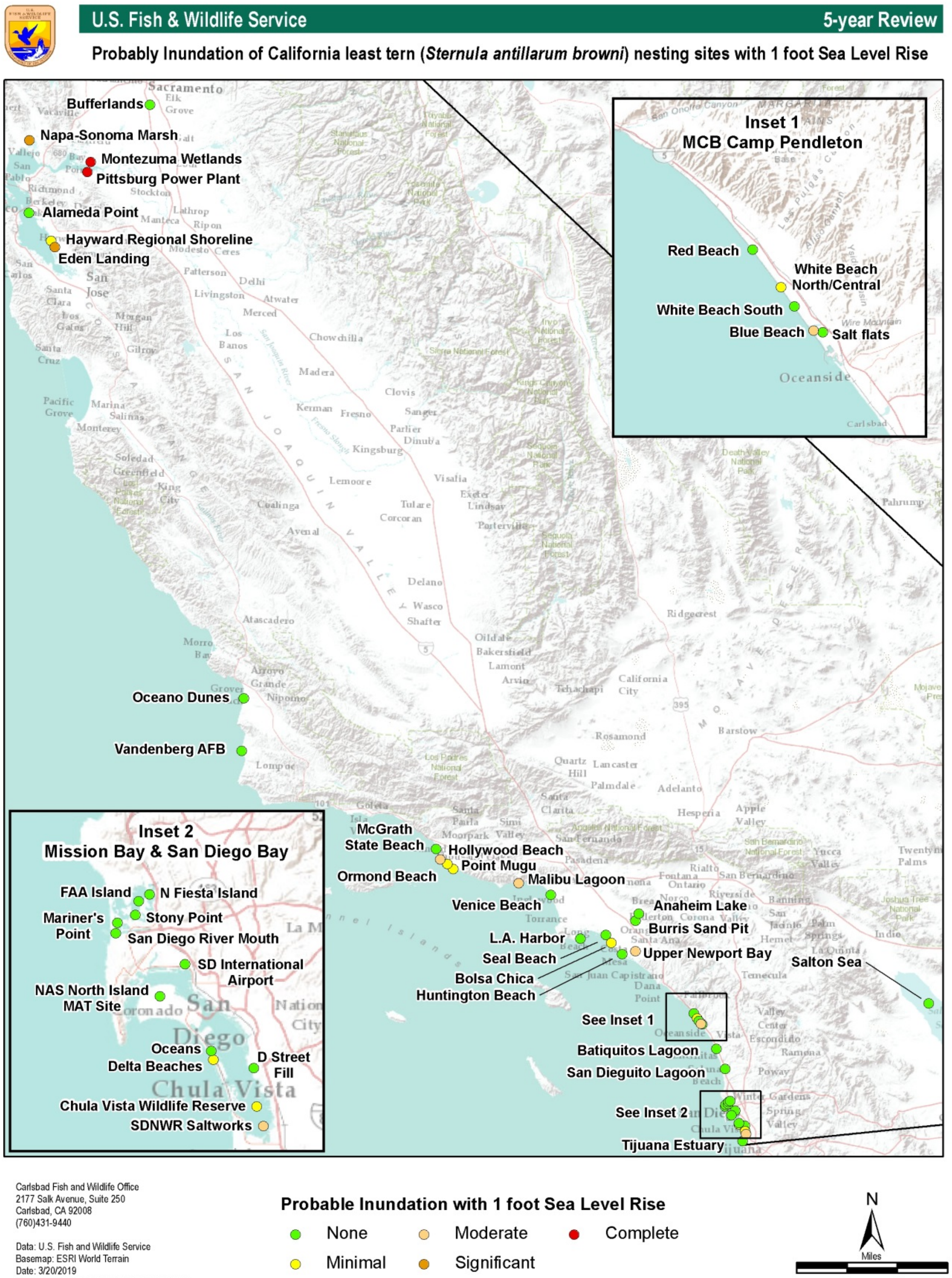

Figure D1. Probable inundation of California least tern sites with 1-foot sea level rise.

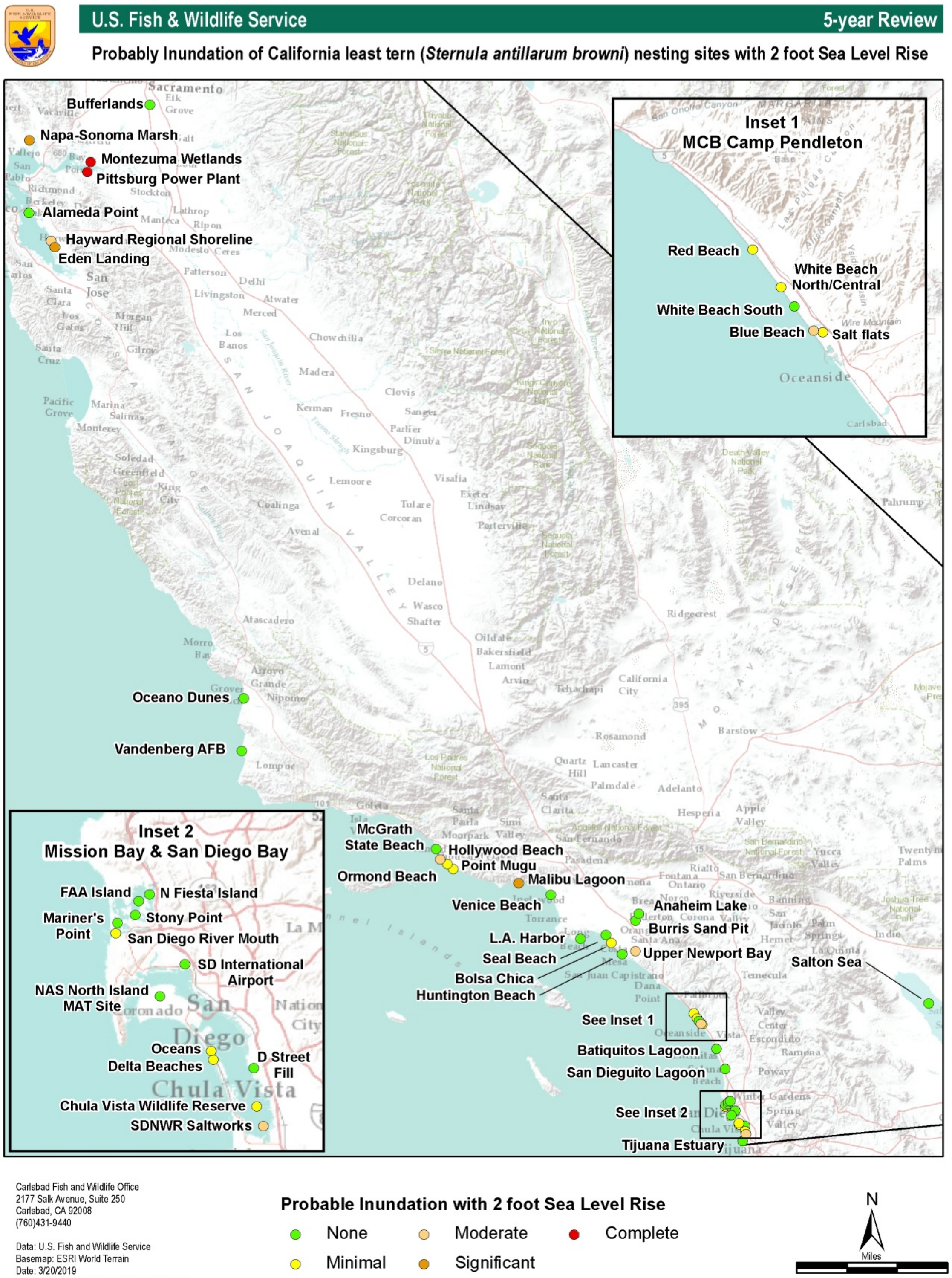

Figure D2. Probable inundation of California least tern sites with 2-foot sea level rise.

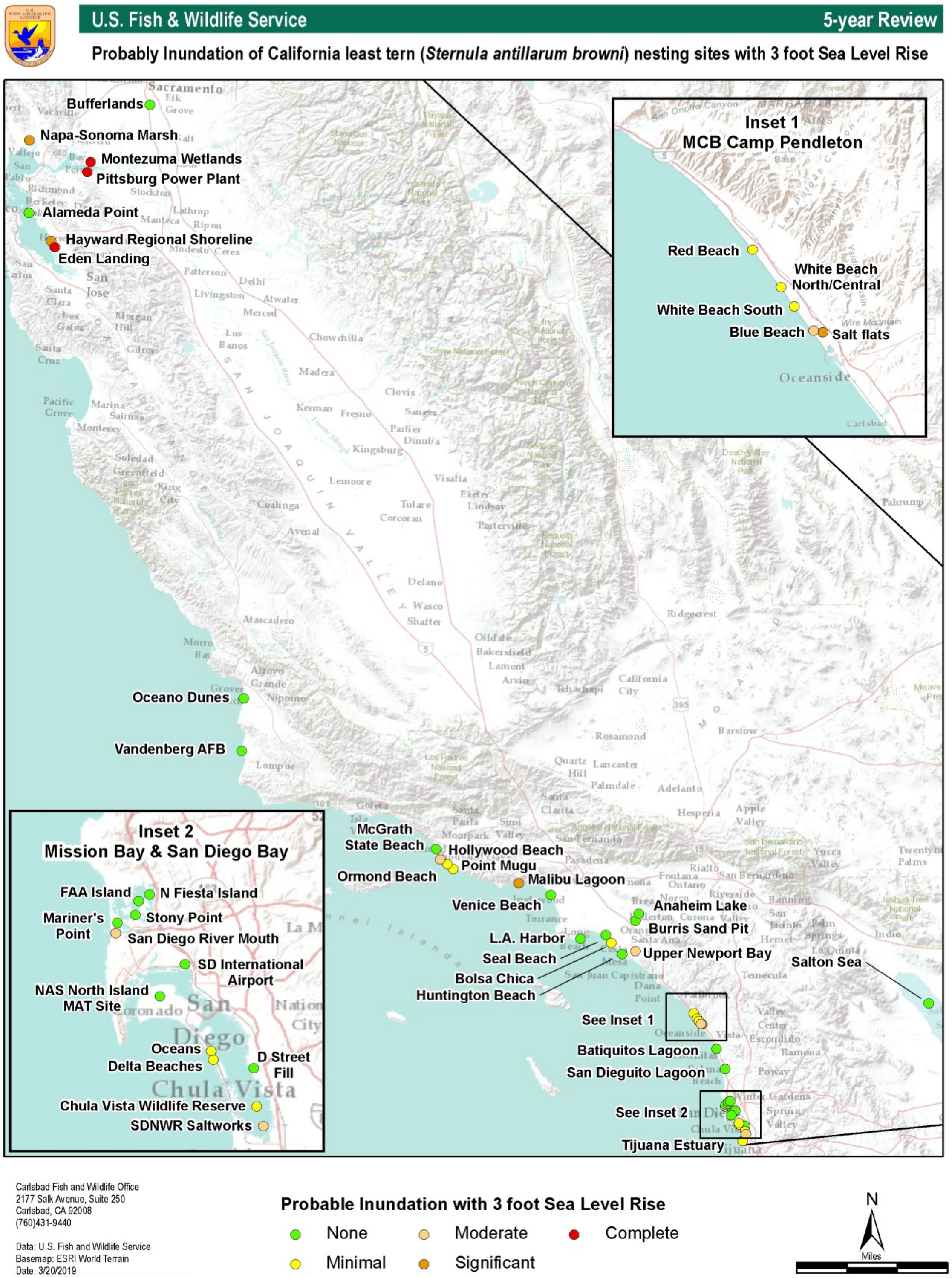

Figure D3. Probable inundation of California least tern sites with 3-foot sea level rise.

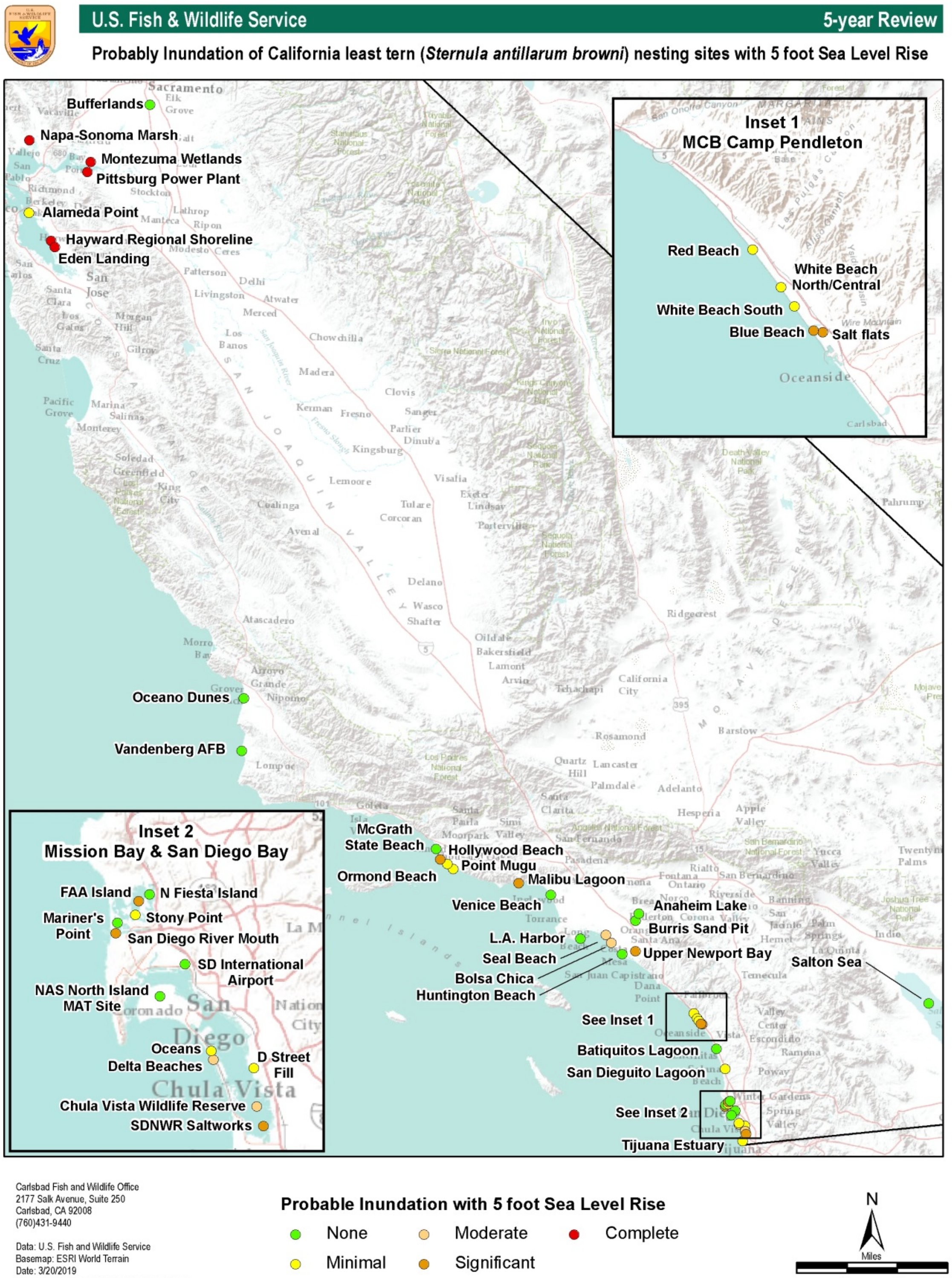

Figure D4. Probable inundation of California least tern sites with 5-foot sea level rise.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

California Least Tern
(*Sternula antillarum browni*)

Current Classification: Endangered

Recommendation Resulting from the 5-year Review:

☐ Downlist to Threatened

☐ Uplist to Endangered

☐ Delist

☒ No change needed

Review Conducted By: Carlsbad Fish and Wildlife Office

New Recovery Priority Number and Brief Rationale: Change from 15C to 18C

The California least tern has a recovery priority number of 15C, which is defined as a subspecies that faces a low degree of threat and has a high recovery potential (USFWS 1983b, p. 51985). The taxon is distributed widely from San Francisco Bay to the North to the Tijuana River to the South. The U.S. population of California least tern has increased from an estimated 256 pairs at listing to an estimated 4,095 pairs in 2017, though impacts from current threats has resulted in a decreasing population trend of California least terns over the past 10 years. Successful reproduction at many nesting areas is dependent on ongoing management, particularly predator management. Therefore, due to the reliance on ongoing management, we are changing the recovery priority number from 15C to 18C.

Lead Field Supervisor, Fish and Wildlife Service

☒ Approve

SCOTT SOBIECH

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Date: 2020.07.09 15:10:14 -07'00'

Scott A. Sobiech
Field Supervisor