Managed Relocation of Albatross to the California Channel Islands: Conservation Basis and Preliminary Suitability Assessment

Eric. A. VanderWerf,[1] Nick D. Holmes,[2] Scott A. Morrison,[2] C. Robby Kohley,[1] Alex Wegmann,[2] and Lindsay C. Young[1]

[1] Pacific Rim Conservation, Honolulu, Hawaii
[2] The Nature Conservancy of California




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EXECUTIVE SUMMARY

Albatross species that nest in the north Pacific are at significant risk from global climate change. More than 95% of the global populations of the Laysan Albatross (*Phoebastria immutabilis*) and the Black-footed Albatross (*P. nigripes*) nest on low-lying atolls in the Northwestern Hawaiian Islands (NWHI) that are threatened by inundation from sea level rise and increasing storm surge associated with global climate change. Protection of suitable breeding habitat and restoration or creation of breeding colonies on higher islands are among the highest priority conservation actions for these species.

Managed relocation to establish breeding colonies on higher islands is an option for enhancing viability of albatross species in the United States. Natural resource managers often have few options when devising strategies to combat the threat of climate change. The deliberate moving of a species to a new location, referred to as managed relocation, assisted colonization, or assisted migration, is increasingly being considered as a viable conservation strategy to mitigate the threat of climate change. A rigorous, detailed framework for assessing potential risks associated with managed relocation was provided recently by Karasov-Olson et al. (2021a) as part of a collaborative process funded by the National Park Service.

In 2011, The U.S. Fish and Wildlife Service and U.S. Geological Survey evaluated the potential value of creating new Black-footed Albatross colonies to abate climate change risk, including scenarios with three Mexican islands, three main Hawaiian islands and two California Islands. Efforts are underway in Hawaii and Mexico, but none have been undertaken yet in California. In 2020, The Nature Conservancy engaged Pacific Rim Conservation to evaluate the potential role the California Channel Islands could play in conservation of Laysan and Black-footed Albatrosses, and to evaluate the need, feasibility, and risks of attempting to establish albatross breeding colonies on the Channel Islands.

The California Current is part of the natural foraging range of Laysan and Black-footed Albatrosses; they are native to this region. Some albatrosses that nest in Hawaii commute to California to forage. Both species commonly feed in deeper water outside the continental shelf and occasionally visit shallower continental shelf water around the Channel Islands. Laysan Albatross have been seen recently on San Nicolas. The Short-tailed Albatross (*P. albatrus*) currently is very rare in California waters but formerly was the most abundant albatross in this region and is being seen more often again as the population recovers on breeding islands in Japan.

Laysan Albatrosses are expected to occur with greater frequency in waters off southern California and may attempt to nest on one or more of the Channel Islands. The Laysan Albatross colony on Guadalupe Island, Mexico, is growing rapidly and birds from that colony are known to forage in California waters. Albatrosses may visit and attempt to nest in locations on the Channel Islands where they would be threatened by predation or could pose a hazard to aircraft or conflicts with visitor facilities. Establishing a colony in a suitable site by translocation could encourage other adults to visit that site.

Archaeological evidence indicates that all three North Pacific albatross species were present in the Channel Islands prehistorically and that they were commonly harvested by Native Americans. Albatross remains have been recovered from 44 archaeological sites on all eight of the Channel Islands, with the largest concentrations on San Miguel, San Nicolas, and San Clemente. The Short-tailed Albatross was the most abundant of the three species, comprising 97% of all specimens. Albatrosses are the most common seabird in many archaeological sites and appeared to suffer disproportionate human predation. **Although no evidence of albatross nesting has been found in the Channel Islands, it is possible that one or more albatross species bred in the Channel Islands but were extirpated due to predation by humans and non-native mammals introduced by humans, or that they might have established breeding colonies if they had not been depredated.** Predation by humans is also thought to have contributed to the extinction of Dow's Puffin (*Fratercula dowi*), which was known only from the Channel Islands and disappeared 12,000 years ago shortly after humans arrived in the islands.

Creating an albatross breeding colony in the Channel Islands is feasible. There are two primary methods for restoring or creating seabird breeding colonies: social attraction and translocation. Social attraction involves attracting seabirds to a site with decoys and broadcast of calls. Translocation involves physically moving birds from one location to another, usually when they are chicks, and caring for them until they fledge. Social attraction is less expensive and less labor intensive and is most effective in colonial species with weak natal philopatry and where existing colonies of the target species are nearby. Translocation is more labor intensive and is necessary more often in species with strong natal philopatry, including albatrosses, and where there are no nearby colonies. Social attraction is less likely to result in establishment of albatross colonies in the Channel Islands because few albatrosses come close to the islands, but the chance of success may increase over time because the number of albatrosses visiting the Channel Islands is expected to increase. We focused on Black-footed and Laysan Albatross because of the urgency for creating solutions to habitat loss. Translocation of Laysan and Black-footed Albatross eggs or chicks from Hawaii is feasible and has a high probability of success in the Channel Islands. Translocation of Short-tailed Albatross from Japan would be appropriate biologically but would require a different assessment that must include Japanese partners.

Several of the Channel Islands would be suitable for establishing and maintaining albatross breeding colonies. A preliminary assessment of each of the Channel Islands using 16 criteria indicated that **Santa Barbara and San Nicolas** offered the best opportunities. Favorable attributes of these islands include conditions necessary for albatross flight and nesting, absence of predators or ability to reduce exposure to predators, ability to reduce risk of human-wildlife conflicts, compatibility with land manager mandates and goals, and accessibility to facilities and resources needed for translocation activities.

The risks associated with attempting to establish albatross breeding colonies in the Channel Islands are generally low. The only high risk is to the target species (albatrosses) if no action is taken. There were four moderate potential risks to the ecosystem, other native species, and land uses in the Channel Islands, including: (1) introduction of a disease or parasite to the Channel Islands that is not already present, although this risk can be mitigated to a large degree; (2) dispersal of albatross from the island on which they were released or attracted to different islands where they are not wanted; (3) Attraction of albatross to airfields because of their flat terrain and favorable wind conditions, where they could pose a collision hazard with aircraft; (4) if albatrosses were translocated to an island with Island Foxes it would be necessary to build a predator exclusion fence to protect albatrosses from foxes. If foxes got inside the fence or if albatrosses settled outside the fence, it could create a situation in which the welfare of albatrosses must be weighed against the welfare of foxes. Intentional siting and establishment of breeding colonies could be a means of the reducing risks of the birds eventually colonizing locations that may be less ideal for their nesting success or avoidance of human conflicts.

Conservation of wide-ranging species such as albatrosses requires effective, coordinated, and collaborative management across agencies and jurisdictions. The existing network of public and private partners involved in translocation of albatrosses is extensive, including governmental agencies, NGOs, private foundations, and corporate sponsors (e.g., airlines that have facilitated safe transport of eggs and chicks). This creates a robust foundation of technical expertise and other resources to support an expansion of this conservation initiative into the California Channel Islands. Collaborative albatross conservation already has involved Mexican colleagues on Guadalupe Island, Mexico, which is a sister park to the Channel Islands. Proactive conservation efforts for these charismatic species can also have multiple co-benefits for managers, including providing a focus of communications regarding leadership in climate-informed conservation management, enhancing visitor experience, and sharing responsibility for management of public trust resources and species of conservation concern across federal holdings in the Pacific.

Table of Contents

Executive Summary 2
Table of Contents 5
List of Tables 5
List of Figures 6
Introduction 7
Background on the Channel Islands 8
    Biogeography, Ownership, and Land Use 8
    Human history 10
Background on the 3 North Pacific albatross species 10
    Population Size, Status, and Distribution 10
    Threats and Future Population Projections 13
    Conservation Strategy and Current Management Actions 15
    Recent Observations of Albatrosses in the Channel Islands and the California Current ... 15
    Archaeological Evidence of Albatrosses in the Channel Islands 18
    Human Impacts on Albatrosses in the Channel Islands in the Past 20
    Human Impacts on Albatrosses in the North Pacific in the Present 21
Seabird Restoration Methods 21
    Social Attraction vs. Translocation 21
    Examples of Social Attraction and Translocation Projects with Albatrosses 23
    Recommendations for Establishing Albatrosses in the Channel Islands 26
Island Suitability Criteria 27
    Preliminary Island Assessments 33
Ecological Risk Assessment 36
    I. Risks of no Managed Relocation Action 36
    II. Risk to the Target Species of Managed Relocation Action 37
    III. Risks of Action to Non-targets in the Recipient Ecosystem 38
    IV. Risks of Action to Higher Order Attributes of the Recipient Ecosystem 39
    V. Risks Associated with Biological Invasion 40
    VI. Risks Associated with Socio-economic Values 41
    Ecological Risk Summary 42
Timeline 43
Conclusions 44
Acknowledgments 46
Literature Cited 47
Appendix 1. Distribution of Laysan and Black-footed Albatrosses off North America 54
Appendix 2. Ecological Risk Assessment Individual Criteria .... Attachment

List of Tables

Table 1. Geographic summary of the Channel Islands 9
Table 2. Laysan, Black-footed, and Short-tailed Albatross population status and threats 13
Table 3. Predicted loss of albatross nests on Midway Atoll resulting from climate change 14
Table 4. Recent reports of Laysan Albatross on or near each the Channel Islands 16
Table 5. Occurrence of albatross remains in archaeological sites in the Channel Islands 19
Table 6. Occurrence of albatross remains in archaeological sites in mainland California 19

Table 7. Comparison of social attraction and translocation....22
Table 8. Summary of feasibility, cost, and probability of establishing albatross species in the Channel Islands by social attraction and translocation....26
Table 9. Preliminary assessments of the eight Channel Islands for albatross....35

List of Figures

Figure 1. Map of the Channel Islands....9
Figure 2. Distributions at sea of Laysan and Black-footed Albatrosses....11
Figure 3. Predicted inundation of Laysan Albatross nests on Midway Atoll....14
Figure 4. GPS tracks of Laysan Albatrosses from Guadalupe Island....17
Figure 5. Laysan and Black-footed Albatross decoys and sound system....25
Figure 6. Visual summary of potential ecological risks of managed relocation of albatrosses to the Channel Islands....42
Figure 7. Growth of the Laysan Albatross colony on Guadalupe....45

List of Acronyms Used in this Report

BASH – Bird Aircraft Strike Hazard
BFAL – Black-footed Albatross
CCS – California Current System
CINP – Channel Islands National Park
DOD – Department of Defense
ESA – Endangered Species Act
GECI – Grupo de Ecología y Conservación de Islas
IUCN – International Union for the Conservation of Nature
JCNWR – James Campbell National Wildlife Refuge
LAAL – Laysan Albatross
MBTA – Migratory Bird Treaty Act
NEPA – National Environmental Policy Act
NPS – National Park Service
PMRF – Pacific Missile Range Facility
PRC – Pacific Rim Conservation
STAL – Short-tailed Albatross
TNC – The Nature Conservancy
USFWS – U.S. Fish and Wildlife Service

INTRODUCTION

More than 95% of the global populations of the Laysan Albatross (*Phoebastria immutabilis*) and the Black-footed Albatross (*P. nigripes*) nest on low-lying atolls in the Northwestern Hawaiian Islands (NWHI) that have a maximum elevation of just a few meters above mean sea level (USFWS 2005, Arata et al. 2009). These islands and the animal and plant populations they support are threatened by sea level rise and increasing storm surge associated with global climate change, as well as catastrophic events like tsunamis (USFWS 2005, Baker et al. 2006, Reynolds et al. 2015, 2017). Protection of suitable breeding habitat and restoration or creation of breeding colonies on higher islands are among the highest priority conservation actions for these species (Flint et al. 2011, Young et al. 2012, VanderWerf et al. 2019).

Natural resource managers often have few options when devising strategies to combat the threat of climate change. Some species are responding naturally to climate change by shifting their range toward higher latitudes, higher elevations, and in other ways, but the capacity of many species to shift in range is limited by their physical ability, behavior, or geophysical barriers (Thomas et al. 2004, Freeman and Freeman 2014, MacLean and Beissinger 2017, Dunn and Moller 2019). One conservation strategy to help facilitate range shifts in species is deliberately moving a species to a new location, which is referred to as managed relocation (Richardson et al. 2009, Karasov-Olson et al. 2021), assisted colonization (Hoegh-Guldberg et al. 2008, Seddon 2010, IUCN/SSC 2013), or assisted migration (McLachlan et al. 2007). There has been much debate about whether the potential risks of managed relocation action outweigh the consequences of possible extinction resulting from inaction (McLachlan et al. 2007, Richardson et al. 2009, Ricciardi and Simberloff 2009, Maier and Simberloff 2016). Managers are increasingly considering managed relocation as a viable conservation strategy, even though there are risks of species becoming invasive or other unforeseen consequences of species introductions (Kostyack et al. 2011, Lawler and Olden 2011, Wallingford et al. 2020), because the risks associated with doing nothing are less uncertain and potentially severe. There have been several efforts to provide methods for evaluating the value and risks associated with specific managed relocation projects (McLachlan et al. 2007, Richardson et al. 2009), and the most rigorous, detailed framework yet for assessing managed relocation projects was provided recently by Karasov-Olson et al. (2021a, 2021b), as part of a collaborative process funded by the National Park Service (NPS).

In 2011, the USFWS convened a structured decision-making workshop in Hawaii to help guide management of the Black-footed Albatross to mitigate effects of climate change (Flint et al. 2011). The workshop identified several actions that could be undertaken to increase the resiliency of the species to climate change, including translocation to, and social attraction at, higher islands, and recommended this be done on three Mexican islands, two California islands, and three main Hawaiian Island sites. The report by Flint et al. (2011) did not specify islands by name, but the focus of discussion regarding California islands centered on the Channel Islands (E. Flint pers. comm.). In the main Hawaiian Islands, efforts are underway to restore or create breeding colonies of Laysan Albatross at James Campbell National Wildlife Refuge (JCNWR) on Oahu, and of Black-footed Albatross at JCNWR and at Kaena Point, Oahu (Young and VanderWerf 2016, VanderWerf et al. 2019). In Mexico, translocation of Black-footed Albatrosses to Guadalupe Island began in 2021 (Ortega 2021, PRC and Grupo de Ecología y Conservación de Islas, unpublished data). No such actions have been undertaken yet on any islands in California.

In November 2020, The Nature Conservancy (TNC) engaged Pacific Rim Conservation (PRC) to evaluate the potential role of the Channel Islands in conservation of Laysan and Black-footed Albatrosses, specifically the feasibility of attempting to establish albatross breeding colonies in the Channel Islands. This report is a first step in attempting to evaluate the feasibility and appropriateness of undertaking such an action, by providing information about the Channel Islands, the albatross species, logistical and biological factors that could affect implementation of such a project, and the potential benefits and risks of undertaking active albatross conservation actions in the Channel Islands. Assessing the value and feasibility of attempting to establish albatross breeding colonies in the Channel Islands can be broken down into several questions:

1. **WHY** is there a need to undertake managed relocation of North Pacific albatrosses?
2. **WHERE** is the best location to attempt establishing an albatross colony in the Channel Islands?
3. **HOW** could establishment of albatross colonies in the Channel Islands be accomplished most effectively?
4. **WHEN** would it be most advantageous to attempt establishing an albatross colony in the Channel Islands?
5. **IF** it is appropriate to establish albatrosses breeding colonies in the Channel Islands. This involves weighing the potential benefits to albatrosses against the potential risks to the ecosystems, other native species, and land uses in the islands.

This report does not provide an answer to question 5 (IF it is appropriate to establish albatrosses breeding colonies in the Channel Islands); that decision is ultimately up to the three primary landholders—TNC, Department of Defense, and Channel Islands National Park (hereafter "Channel Islands Stakeholders"). To help managers better understand what such a project would involve and how it would be implemented, this report provides information relevant to the first four questions and provides recommendations for where, how, and when to undertake such a project. Question #1 (WHY) is addressed in the section on Albatross Background Information. Information relevant to question #2 (WHERE) is described in the section on Island Suitability Criteria. Information about question #3 (HOW) is presented in the section on Seabird Restoration Methods. Question #4 (WHEN) is discussed in the short section called Timeline. In addition, an important part of question #5 is assessing the potential ecological risks associated with managed relocation. This report uses a rigorous framework to assess potential ecological risks associated with managed relocation developed by Karasov-Olson et al. (2021a,b) under contract and in collaboration with the National Park Service and other agencies.

BACKGROUND ON THE CHANNEL ISLANDS

Biogeography, Ownership, and Land Use

The Channel Islands consist of eight islands that are part of three southern California counties (Figure 1, Table 1). These islands are located within the continental shelf of North America. The islands are often divided into two groups, the four Northern Channel Islands, which were still connected as one large island called Santarosae until roughly 10,000 years ago when sea levels were lower (Erlandson et al. 2011), and the four Southern Channel Islands

(Table 1). The Channel Islands are recognized as a biodiversity hotspot and support many endemic taxa (Schoenherr et al. 2003).

Figure 1. Map of the Channel Islands. From Wikimedia.

Table 1. Geographic summary of the Channel Islands, listed from northwest to southeast. Size, maximum elevation, and distance to coast are from Wikipedia or Junak (2008). Distance to the continental shelf was measured to the 1,000 m depth contour on Google Earth.

Island	Indigenous name	Ownership	County	Size km² (mi²)	Maximum elevation m (ft)	Distance to coast km (mi)	Distance to shelf km (mi)
Northern Islands							
San Miguel	Tuqan	Navy (managed by NPS)	Santa Barbara	38 (14.6)	253 (831)	42 (26)	15 (9)
Santa Rosa	Wi'ma	NPS	Santa Barbara	215 (83)	484 (1,589)	42 (26)	25 (16)
Santa Cruz	Limuw	TNC+NPS	Santa Barbara	250 (97)	740 (2,430)	30 (19)	55 (34)
Anacapa	Anyapakh	NPS	Ventura	2.8 (1.1)	283 (930)	14 (9)	100 (62)
Southern Islands							
San Nicolas	Several*	Navy	Ventura	59 (23)	277 (910)	98 (61)	5 (3)
Santa Barbara	Tchunashngna	NPS	Santa Barbara	2.6 (1)	193 (634)	61 (38)	20 (12)
Santa Catalina	Pimuu'nga	Mixed, largely Catalina Island Conservancy	Los Angeles	194 (75)	639 (2,097)	32 (20)	50 (31)
San Clemente	Kinkipar	Navy	Los Angeles	147 (57)	599 (1,965)	79 (49)	10 (6)

* Several tribes are associated with San Nicolas Islands and some tribes may have different traditional names for the island.

Human history

The human history of the Channel Islands goes back at least 13,000 years, when native Americans are documented to have reached the islands (Glassow et al. 2010). The archaeological sites in the Channel Islands provide some of the earliest known evidence of humans in North America (Erlandson et al. 2011). Archaeological evidence indicates the early Channel Islands human inhabitants were proficient at traveling along the coast and among the islands in large ocean-going canoes and that they inhabited all the Channel Islands and used them extensively (Glassow et al. 2010, Erlandson et al. 2011).

The Chumash and Tongva were removed from the islands in the early 19th century and taken to Spanish missions and pueblos on the adjacent mainland. For much of the 1800s and early 1900s, the Channel Islands were used primarily for ranching and fishing, which had significant negative impacts on island ecosystems. Today, the islands are largely in some form of conservation management (Rick et al. 2014, McEachern et al. 2016). All eight islands were designated as a biosphere reserve under UNESCO in 1976. The National Park Service owns and manages Santa Barbara, Anacapa, and Santa Rosa Islands, as well as the eastern 24% of Santa Cruz Island. The Nature Conservancy owns and manages the remainder of Santa Cruz. The U.S. Navy owns San Miguel, San Nicolas, and San Clemente, though San Miguel is managed by NPS. Santa Catalina Island is largely managed by the Catalina Island Conservancy. Channel Islands National Park encompasses 1 nautical mile of the waters offshore of all the Park islands; Channel Islands National Marine Sanctuary extends 6 nautical miles from the islands' shores. Significant ecological restoration has been accomplished on all the islands over the last several decades, including the eradication of most of the introduced ungulate populations (McEachern et al. 2016) and a subsequent recovery of many vegetation communities (e.g., Beltran et al. 2014).

BACKGROUND ON THE 3 NORTH PACIFIC ALBATROSS SPECIES

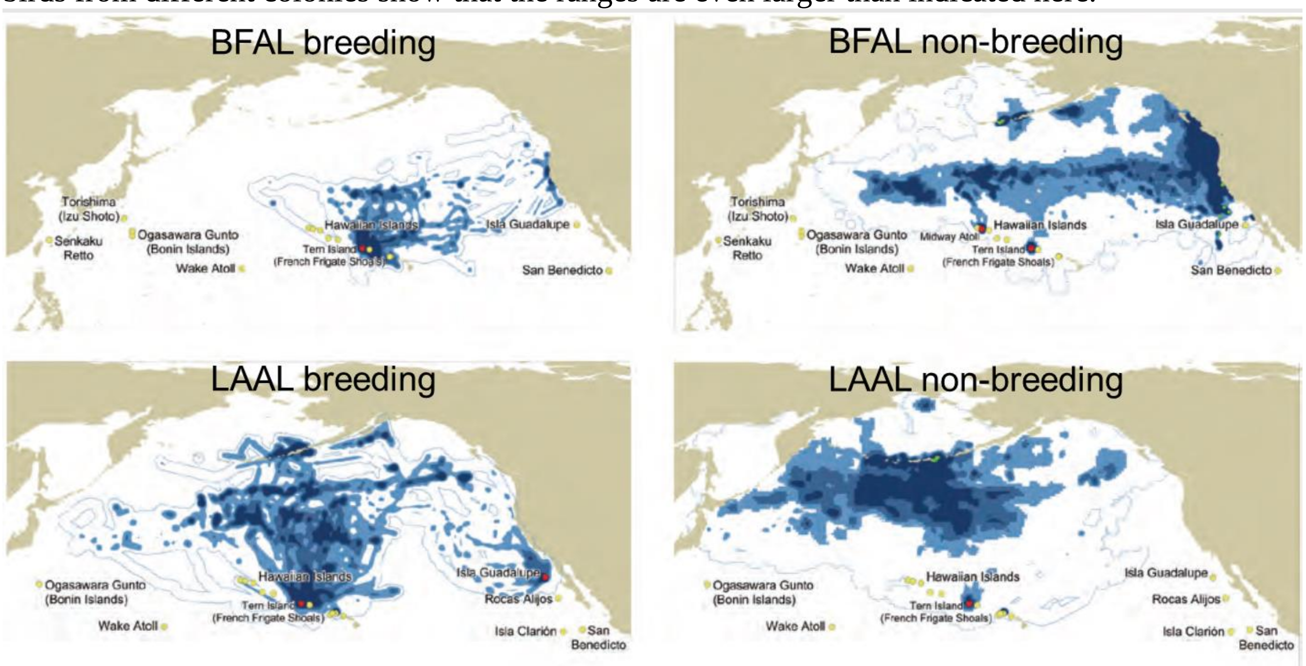
Three species of albatrosses inhabit the North Pacific Ocean: the Laysan Albatross (*Phoebastria immutabilis*), the Black-footed Albatross (*P. nigripes*), and the Short-tailed Albatross (*P. albatrus*). These three albatross species are ecologically similar, but there are important differences in their population size, distribution, conservation status, and threats, which are described in this section and summarized in Table 2. Although all three species potentially are suitable candidates for managed relocation to the Channel Islands, this report focuses on the Laysan Albatross and Black-footed Albatross due to the current feasibility challenges with the Short-tailed Albatross described below.

Population Size, Status, and Distribution

Laysan and Black-footed Albatrosses are relatively abundant, with breeding populations of 800,000 pairs and 67,500 pairs, respectively, and the population sizes of both species are thought to be stable currently (Table 2; Arata et al. 2005, BirdLife International 2018). Both species are also relatively widespread. The Laysan Albatross currently breeds on 19 islands, including 13 islands in Hawaii, four islands near Mexico (Guadalupe, Clarión, Alijos, and San Benedicto), and two islands in the western Pacific (Wake Island and Mukojima near Japan; Chiba et al. 2007, Hernández-Montoya et al. 2014, VanderWerf and Young 2017, Henry et al. 2021). Despite the growth of several new colonies of Laysan Albatross in Mexico, over 99% of the global Laysan Albatross population nests in the Hawaiian Islands (VanderWerf and Young 2017). The Black-footed Albatross currently breeds on 24 islands, including 11 islands in Hawaii and 13 islands in three island groups near Japan (Izu-Torishima, three of the Senkaku Islands, and nine of the Bonin Islands; Eda et al. 2008, VanderWerf and Young 2017). The great majority of the population breeds in Hawaii, with about 1,500 pairs on the Japanese islands and the remaining 97% in Hawaii. Midway Atoll supports the largest colonies of both species, with 28,000 pairs of Black-footed Albatross and about 600,000 pairs of Laysan Albatross.

The at-sea distributions of Laysan and Black-footed Albatrosses encompass pelagic areas across virtually the entire North Pacific Ocean, from the tropics to the Bering Sea and from Japan and Russia to the west coast of North America (Figure 2). The Black-footed Albatross tends to have a more a more easterly and southerly range than the Laysan Albatross.

Figure 2. Distributions at sea of Laysan and Black-footed Albatrosses during the breeding season and non-breeding season. From Arata et al. (2009). Data from more recent tracking studies of birds from different colonies show that the ranges are even larger than indicated here.



Although Laysan and Black-footed Albatrosses currently are relatively abundant and widespread, both species are considered Near Threatened on the IUCN red list of threatened species, primarily because of projected population declines that are expected to occur from climate change and, to a lesser degree, mortality of adults in fisheries bycatch (see threats section below; BirdLife International 2018). They are not listed under the U.S. Endangered Species Act (ESA), but they are considered Birds of Conservation Concern, which are species that without additional conservation action are likely to become candidates for listing under the ESA and that represent the highest conservation priorities of the USFWS (USFWS 2021).

The Black-footed Albatross was petitioned for listing under the ESA by Earth Justice on 1 October 2004. On 9 October 2007, the USFWS published a finding that the petition presented substantial scientific or commercial information indicating that listing the Black-footed Albatross may be warranted and initiated a status review of the species. That review resulted in publication of a comprehensive status assessment (Arata et al. 2009). On 7 October 2011, the USFWS published in the Federal Register (76 FR 62504-62565) a 12-month finding, based on information presented by Arata et al. (2009), that listing of the species was not warranted at that time because the best available information indicated the Black-footed Albatross population was not declining and acknowledged the presence of threats, but found that the threats were not causing effects at the population level.

Estimating the population size and trend of Laysan and Black-footed Albatrosses is somewhat difficult because there are large annual fluctuations in the number of breeding pairs, primarily because some birds skip breeding in some years. VanderWerf and Young (2011) showed that 19% ± 3% of pairs skip breeding in some years, and that the chance of skipping depends on reproduction in the previous year, resulting in variation in the number of pairs that skip and thus some uncertainly about the population size and ability to estimate trends (Arata et al. 2009).

The Short-tailed Albatross currently has a much smaller population size and a more limited distribution than the other two North Pacific albatross species, breeding on just 4 islands. In 2014, the total population was estimated to be 4200 individuals, with most of the population, 3540 birds, on Torishima in the Izu Islands, and 650 birds on Minami-Kojima in the Senkaku Islands (Eda et al. 2020). Individuals in the Senkaku Islands population are morphologically and genetically distinct and appear to comprise a separate species, and occasionally visit the Torishima colony but do not interbreed (Eda et al. 2016, 2020). Translocation was used to re-establish a breeding colony on Mukojima in the Bonin Islands, which is small but appears to be growing (Deguchi et al. 2012, 2017). The total breeding population was thought to be 1734 individuals, or 867 pairs, in 2018 (Birdlife International 2018). Short-tailed Albatrosses have nested on two islands in Hawaii, though the number of breeding pairs there is very small. On Midway, a pair laid infertile eggs starting in 1993, and single pairs have raised a chick in several years, starting in 2011 (Pyle and Pyle 2017). On Kure, two females have paired with each other and laid infertile eggs in most years since 2011.

The Short-tailed Albatross was formerly much more abundant and widespread; it nested on at least 14 islands in the western and central Pacific in the late 1800s and the population is thought to have been at least 1 million individuals, perhaps up to 5 million (Tickell 2000, Hasegawa 2003, USFWS 2008, Eda et al. 2020). The primary cause of decline was unsustainable hunting for feathers on its breeding islands, and it was thought to be extinct in the 1930s, but the species was rescued from extinction by subadult birds that had been at sea for several years while the breeding colonies were wiped out (Hasegawa and DeGange 1982). Protection and management of the colony on Torishima has allowed the population to grow, but it is still small and is threatened by volcanic activity on the island (Deguchi et al. 2014, 2017, Eda e al. 2020). Remarkably, the Short-tailed Albatross is also known to have bred on Bermuda in the Atlantic Ocean but it was extirpated there during the Pleistocene by sea level rise (Olson and Hearty 2003).

At sea, Short-tailed Albatrosses range widely across the northern Pacific Ocean, with most activity in waters near Japan, Russia, and Alaska. In U.S. waters, most birds are concentrated along the edge of the continental shelf in the northern Gulf of Alaska, Bering Sea, and Aleutian Islands, but some reach the continental shelf off western North America (USFWS 2005, Suryan et al. 2006, 2007).

Table 2. Laysan, Black-footed, and Short-tailed Albatross population status, conservation status, and threats.

Attribute	Laysan Albatross	Black-footed Albatross	Short-tailed Albatross
IUCN status	Near Threatened	Near Threatened	Vulnerable
U.S. ESA status	Species of concern	Species of concern	Endangered
Total breeding population (pairs)	800,000	67,500	867
No. of islands with breeding colonies	19	24	4
Population trend	Stable	Stable	Increasing
Threats	Sea level rise, fisheries bycatch, plastic ingestion, predation at nesting colonies	Sea level rise, fisheries bycatch, plastic ingestion, predation at nesting colonies	Fisheries bycatch, volcanic activity at nesting colony, plastic ingestion
Percent of population breeding <3m above sea level	99%	97%	<1%

Threats and Future Population Projections

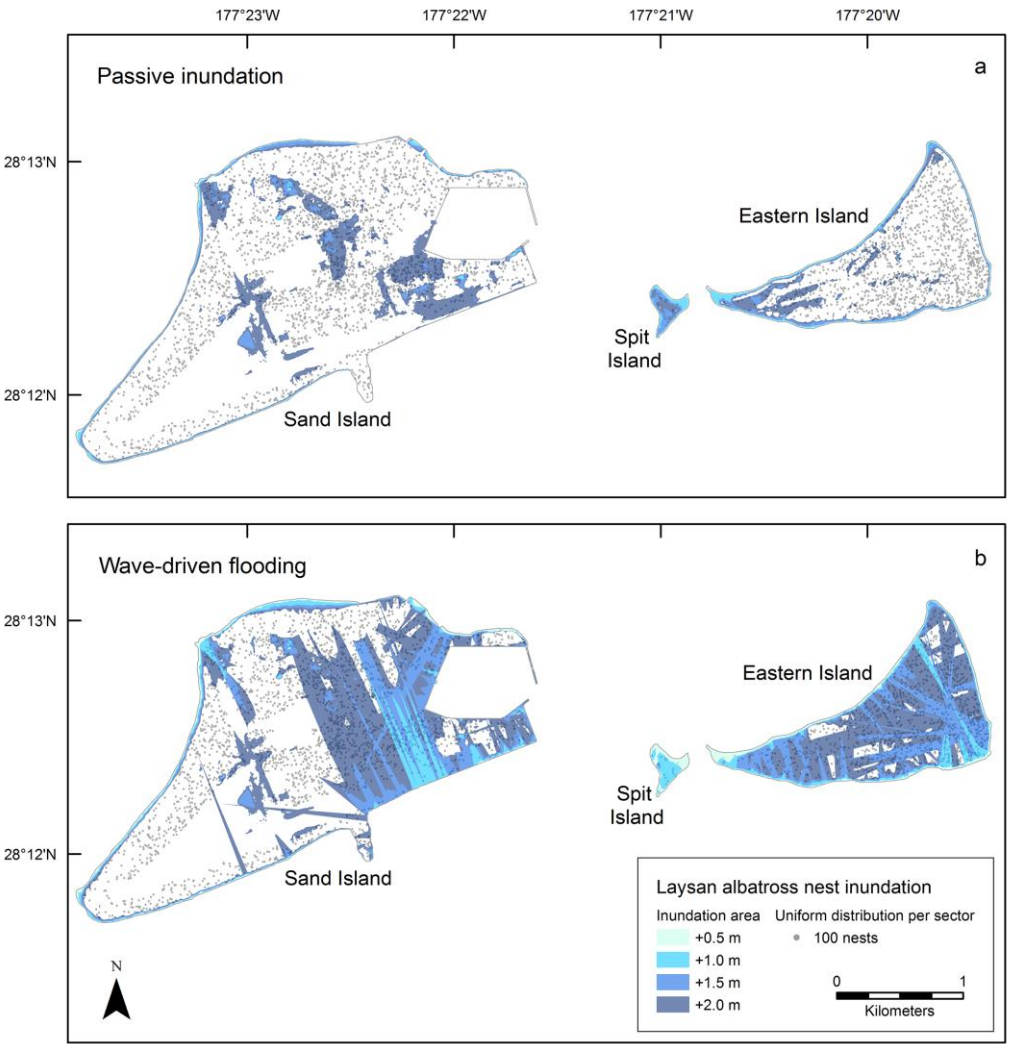
The primary threats to both Laysan and Black-footed Albatrosses are inundation of breeding colonies caused by sea level rise and other aspects of climate change, mortality of adults from fisheries bycatch, ingestion of plastics and contaminants, and predation by non-native mammalian predators on some islands (USFWS 2005, Arata et al. 2009, VanderWerf 2012, Young et al. 2012, Bakker et al. 2017). In the long-term, inundation of breeding colonies is the most serious of these threats because it is expected to impact a large proportion of the population. Reynolds et al. (2015) modeled inundation and wave-driven flooding on Midway Atoll under various climate change scenarios and predicted that a 2.0-meter rise in sea level combined with wave-driven flooding events would result in loss of 61% and 60% of Laysan and Black-footed Albatross nests, respectively. Black-footed Albatrosses tend to nest near the perimeter of atolls more often, and thus were predicted to experience greater losses than Laysan Albatrosses in a 1.0-meter sea level rise scenario (Table 3). However, a higher proportion of Laysan Albatross on Midway atoll nest on Eastern Island, which was expected to experience almost complete inundation under a 2.0-meter sea level rise because of its lower elevation (Figure 3), thereby resulting in loss of more Laysan nests in that scenario. Similarly, Baker et al. (2006) modeled habitat loss in the Northwestern Hawaiian Islands predicted to result from sea level rise by 2100, and found that expected inundation varied among islands, with 3% to 65% loss of habitat with a 48cm rise in sea level, and 5% to 75% loss with an 88 cm rise in sea level, with some islands, such as French Frigate Shoals and Pearl and Hermes, expected to be completely lost.

Laysan Albatrosses colonized Guadalupe in 1983 (Gallo-Reynoso and Figueroa-Carranza 1996), and this colony has flourished since then, growing to 193 pairs in 2000 (Pitman et al. 2004), at an average rate of 10% per year to a total of 646 pairs from 2003 to 2013 (Henry 2011, Hernández-Montoya et al. 2014), up to 1,279 pairs in 2019 (Hernández-Montoya et al. 2019). This growth will help to offset some of the expected declines of colonies in Hawaii, but the overall population trend of the species will be determined largely by the colonies in Hawaii for many years because they are so much larger.

Table 3. Predicted loss of albatross nests on Midway Atoll resulting from climate change by 2100, including sea level rise and wave-driven flooding. Data from Reynolds et al. (2015).

Species	1.0 m sea level rise		2.0 m rise sea level rise	
	# of nests	Proportion of nests	# of nests	Proportion of nests
Laysan Albatross	22,548	6%	236,456	61%
Black-footed Albatross	2,556	10%	15,282	60%

Figure 3. Predicted inundation of Laysan Albatross nests on Midway Atoll in various sea level rise scenarios by 2100. From Reynolds et al. (2015).



For the Short-tailed Albatross, the primary threats are volcanic activity at the primary nesting colony on Torishima, fisheries bycatch, and political instability in the Senkaku Islands, which has prevented biologists from visiting the islands since 2002 (Deguchi et al. 2017, Eda et al. 2020). Bycatch in fisheries in Alaskan waters is closely monitored because of its endangered status (Suryan et al. 2007). The Short-tailed Albatross population has been growing steadily at a rate of about 7% per year and is expected to continue growing at this rate (Deguchi et al. 2017), perhaps faster if the colony re-established recently by translocation on Minami-Kojima on continues to grow.

Conservation Strategy and Current Management Actions

Management actions for Laysan and Black-footed Albatrosses can be grouped into several categories (Arata et al. 2005, USFWS 2005, VanderWerf 2016):

- Protection of nesting islands, most recently through establishment of the Papahānaumokuākea Marine National Monument in 2006 and its enlargement in 2016.
- Habitat management, including:
    - Removal of invasive, non-native plants, especially golden crown-beard (*Verbesina encelioides*), that reduce habitat quality on Midway and Kure.
    - Removal of lead-based paint from buildings and soil on Midway to prevent ingestion and poisoning of albatross chicks.
- Reducing mortality of adults from fisheries bycatch.
- Predator management, including:
    - Eradication of house mice from Midway.
    - Eradication of Pacific rats from Lehua Islet in 2019 (Raine et al. 2021)
    - Construction of predator exclusion fences in the main Hawaiian Islands, including those at:
        - Kaena Point Natural Area Reserve, Oahu (Young et al. 2013)
        - Kilauea Point NWR, Kauai (Young et al. 2018)
        - James Campbell NWR, Oahu (VanderWerf et al. 2019)
- Creation of new breeding colonies on high islands, including:
    - James Campbell NWR, Oahu (Laysan and Black-footed Albatrosses; VanderWerf et al. 2019)
    - Guadalupe Island, Mexico (Black-footed Albatross; VanderWerf et al. in press)

Recent Observations of Albatrosses in the Channel Islands and the California Current

The California Current and the Channel Islands are within the natural foraging ranges of Laysan, Black-footed, and Short-tailed Albatrosses, and thus all three species are native to this region. Several sources of information are available about the recent occurrence of albatrosses in the California Current and in the Channel Islands: 1) Collins (*in press*) compiled information about historical and recent observations of albatrosses in the Channel Islands from eBird, pelagic birding trip reports, research cruises, and other sources through 2020; 2) Range maps from Leirness et al. (2021), who analyzed observations at sea from 21 data sets collected from 1980-2017 during research cruises off the Pacific coast of the United States; and 3) tracking data of Laysan Albatrosses from Mexico (Hernández-Montoya et al. 2019). Information from these sources is described below, by species.

Laysan Albatross. Collins (in press) wrote that “Laysan Albatrosses are a rare post-breeding visitor in spring and summer to shallow continental shelf waters in the general vicinity of the Channel Islands with most sightings to the west and southwest of the Channel Islands.” Lehman (2020) offered a similar assessment, that Laysan Albatrosses are a regular late fall and winter visitor primarily in deeper waters well offshore of central and southern California, with most birds found from late October to February.

Collins (in press) also compiled observations of Laysan Albatrosses on each of the Channel Islands or that were sufficiently close (within 1 mile, or reported as in the vicinity of, off, close to, or near) to shore to suggest they might have been attracted to the island, which are summarized in Table 4.

Table 4. Recent reports of Laysan Albatross on or near each the Channel Islands. Summarized from Collins (In press).

Island	# reports	Dates	Notes
San Miguel	1	May 2010	“in vicinity”
Santa Rosa	0		
Santa Cruz	0		
Anacapa	1	Aug 1996	on water in a cove at Middle Anacapa
Santa Barbara	0		
San Nicolas	6	Apr 1909, Feb-Mar 1991, May 1996, Jun 1998, Feb 2016, Feb 2017.	1 collected on beach Apr 1909. 1 flying over Rock Crusher May 1996. 2 seen from Rock Crusher Jun 1998. 1 in kelp off Dutch Harbor Feb 2016. 1 seen from Phoca Reef Feb 2017.
Santa Catalina	0		
San Clemente	2	Jul 2001, Mar 2004	1 each observed from shore at China Point and Boulders South.

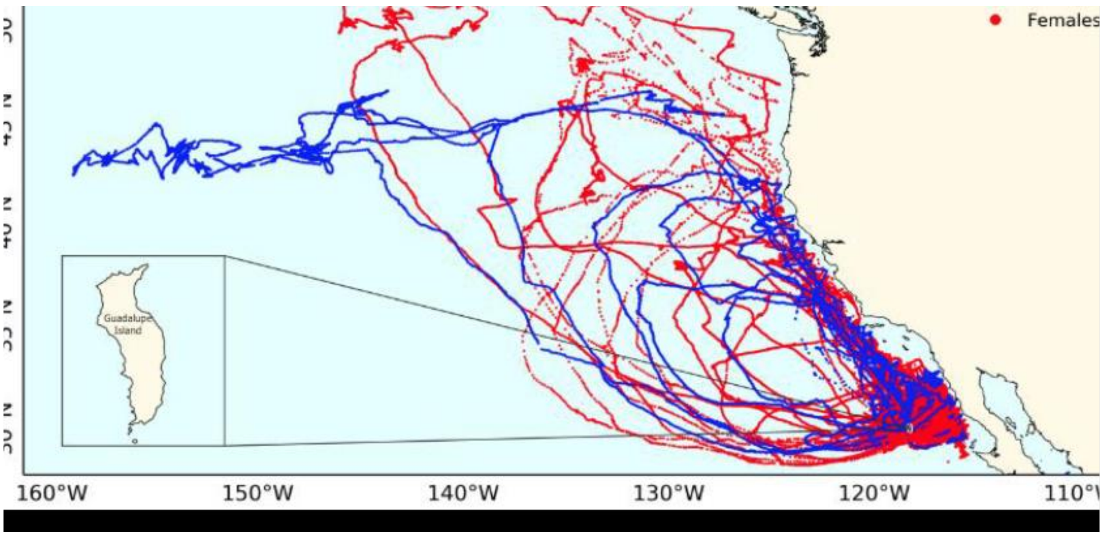
As mentioned by Collins (in press), the increase in sightings of Laysan Albatross offshore of southern California since the 1980s is due to two factors: 1) the growing population of Laysan Albatrosses on Guadalupe Island and other islands off the west coast of Mexico, and 2) greater observer effort; there has been an increase in the number of research cruises and especially the number of commercial pelagic birding trips to offshore waters west and southwest of the Channel Islands (Lehman 2020).

Collins (in press) also stated that “Laysan Albatrosses are expected to occur with greater frequency to waters off southern California and may at some point in the future also attempt to nest on one or more of the Channel Islands.” And that “several recent observations of this species at San Nicolas could represent the first birds from the Mexican breeding colonies beginning to prospect for new breeding sites at the islands.”

Quantitative analysis of the distribution of Laysan Albatross observations at sea during NOAA research cruises (Leirness et al. 2021) corroborates the anecdotal range descriptions by Collins (in press) and Lehman (2020). Leirness et al. (2021) found that Laysan Albatrosses are uncommon in waters of the California Current off California and occur primarily in deeper water outside the continental shelf and were somewhat more numerous in winter (Appendix 1).

Direct evidence that some of the Laysan Albatrosses seen in waters off California are from the breeding colony on Guadalupe was provided by Hernández-Montoya et al. (2019), who tracked breeding Laysan Albatrosses from Guadalupe using GPS devices. These tracks showed that birds from the Guadalupe colony commonly foraged in the California Current, and that they occasionally ventured into shallower waters inside the continental shelf and farther west into the Central Pacific (Figure 4).

Figure 4. GPS tracks of male (blue) and female (red) Laysan Albatrosses breeding on Guadalupe Island, Mexico. From Hernandez-Montoya et al. 2019.



Black-footed Albatross. Collins (in press) wrote that “This species is generally an uncommon to rare nonbreeding year-round visitor to pelagic waters well offshore of the Channel Islands. Off southern California, they are most commonly associated with cold California Current waters both along and seaward of the continental shelf break. While birds can occasionally be seen on waters overlying the continental shelf, most sightings are from waters west and southwest of the Channel Islands with only a few sightings from waters within 1 mi (1.6 km) of the islands. Off southern California birds were found to congregate on the coolest and most productive waters found within 15.5 mi (25 km) of the axis of the Santa Cruz-Cortez Ridge, particularly west of San Miguel Island and off Tanner and Cortés Banks”

Collins (in press) also compiled observations of Black-footed Albatrosses on each of the Channel Islands or that were sufficiently close (within 1 mile, or reported as in the vicinity of, off, close to, or near) to shore to suggest they might have been attracted to the island, of which there were only three. By island, these included: **San Miguel,** one female collected ca. 1 mi (1.6 km) off San Miguel 3 August 1938; **Santa Cruz**, 1 seen from shore sitting on the water (possibly injured) 0.6 mi (1 km) or less off Coche Point 18 and 25 APR 1977; **San Nicolas**. 1 observed from shore off Brine 18 MAY 2010.

Quantitative analysis of the distribution of Black-footed Albatross observations at sea during NOAA research cruises (Leirness et al. 2021) corroborates the anecdotal range descriptions made by Collin (in press). Black-footed Albatross were fairly common in the California Current off California (Appendix 1). They occurred year-round but were more numerous in Spring and Summer and least numerous in winter. They occurred closer to the coast more often in Spring and Summer and occurred primarily farther offshore in fall and winter. They were observed closer to the coast more often than Laysan Albatross, but still rarely visited shallower nearshore waters within the continental shelf and around the Channel Islands.

Short-tailed Albatross. The following information is paraphrased from Collins (in press). Before 1900, Short-tailed Albatrosses were common, year-round, nonbreeding visitors to nearshore and offshore waters off the California coast. Unlike Laysan and Black-footed Albatrosses, Short-tailed Albatrosses often visited shallower waters along the California coast within the continental shelf, including those around the Channel Islands. In the mid-to-late 1800s, there were a few records of the species on three of the Channel Islands (San Clemente, Santa Catalina, and San Nicolas; Cooper 1870b, Streator 1888).

However, by the early 1900s, the species had disappeared from waters off California because the population was decimated by over-exploitation by Japanese feather collectors on their breeding islands and by volcanic eruptions on Torishima Island, Japan, where the largest breeding colony is located (Austin 1949, Hasegawa 1979, Hasegawa and De Gange 1982). It was not recorded again in California waters until 1977, after the population had begun to recover. Many of the 18 sightings of this species off California since 1977 have been of birds seen 10-80 nautical miles from the mainland coast (Singer and Terrill 2009). There are two recent well-documented records of birds seen in nearshore waters at Santa Barbara and Santa Cruz islands (Lehman 2020). An immature bird, thought to be a first- or second-year bird based on its coloration, was first observed approximately 0.5 mi (0.8 km) off the northwest end of Santa Barbara Island on 19 February 2002 and was last reported 300 m off Landing Cove on 22 March 2002, which represented the first recent sighting for this species in the Channel Islands in more than 100 years (Collins in press). A subadult observed 100–200 yds off Prisoners Harbor pier on Santa Cruz on 6 July 2005 was reviewed and accepted by California Bird Records Committee. There were five reports of Short-tailed Albatross off Santa Cruz Island in 2020 (NPS, unpubl. data). Currently, Collins (in press) considers the Short-tailed Albatross to be a rare nonbreeding visitor to waters off southern California and inshore waters near the Channel Islands.

Archaeological Evidence of Albatrosses in the Channel Islands

Extensive archaeological investigations have been conducted in the Channel Island and these have revealed that all three North Pacific albatross species were present in the Channel Islands prehistorically and that they commonly were harvested by Native Americans (Porcasi 1999, Erlandson et al. 2011, Glassow et al. 2010). P. Collins (unpublished) compiled all known records of albatrosses from archaeological sites in North America, which showed that albatross remains have been recovered from a total of 44 sites on all eight of the Channel Islands, with the largest concentrations of remains and the most individuals on San Miguel, San Nicolas, and San Clemente (Table 5). The Short-tailed Albatross was the most abundant of the three species, comprising 97% of all identified specimens and 90% of all identified individuals (Table 5).

Archaeological evidence from coastal sites in the Holocene period (~11200−300 years BP) throughout the Pacific region indicates that the Short-tailed Albatross ranged from the mainland coast in the Japan and Okhotsk Seas, north to the Bering Strait and Aleutian Islands, and in the eastern Pacific from the Gulf of Alaska to Baja California (Yesner 1976, Hasegawa and DeGange 1982, Porcasi 1999, Eda and Higuchi 2004). The Short-tailed Albatross is the dominant seabird species in some central and southern California archaeological sites, particularly the Channel Islands (Porcasi 1999, Erlandson et al. 2011).

Porcasi (1999) speculated that albatross may have nested in the Channel Islands, but no evidence of breeding by albatrosses, such as eggshells or juvenal or medullary bones, has been found in the Channel Islands (P. Collins, pers. comm. Sep 2021). It is possible that one or more of the species did breed in the Channel Islands, but the breeding sites have not yet been found, are now below sea level, or have been destroyed due to the widespread erosion that followed the vegetation loss during the ranching era. Gaps in fossil and archaeological records on the Channel Islands have been noted in other bird taxa, which are a reminder that absence of evidence is not evidence of absence (Collins et al. 2018; Morrison et al. 2018). Other lines of evidence may be helpful in the elucidation of historic albatross distributions. For example, Vokhshoori et al. (2019) used isotopic analysis of tissue samples from modern Short-tailed Albatrosses and ancient samples from archeological sites in Japan and the Channel Islands and found that ancient Short-tailed Albatrosses spent more time foraging in the California Current than modern individuals, and that ancient remains from the Channel Islands were isotopically distinct from those in Japan, suggesting the species had a more complex population structure in the past.

Table 5. Occurrence of albatross remains in archaeological sites in the Channel Islands. Data compiled by Paul Collins from many sources. NISP = number of identifiable specimens. MNI = minimum number of individuals. Unid. alb. sp. = Unidentified albatross species.

Island	# sites	STAL NISP	STAL MNI	LAAL NISP	LAAL MNI	BFAL NISP	BFAL MNI	Unid. alb. sp. NISP	Unid. alb. sp. MNI	All sp. NISP	All sp. MNI
San Miguel	13	79	30	0	0	0	0	0	0	79	30
Santa Rosa	5	23	6	0	0	0	0	0	0	23	6
Santa Cruz	9	10	6	0	0	5	4	0	0	15	10
Anacapa	1	2	1	0	0	0	0	0	0	2	1
Santa Barbara	1	3	1	0	0	0	0	0	0	3	1
San Nicolas	10	274	53	1	1	4	3	6	5	285	62
Santa Catalina	2	13	5	1	1	1	1	19	5	34	12
San Clemente	3	9	1	0	0	2	1	217	26	228	28
Total	44	413	103	2	2	12	9	242	36	669	150

Remains of all three albatross species also have been recovered from archaeological sites on mainland California, but albatross abundance was much lower in mainland sites despite extensive archaeological work, with only a total of 202 specimens of 69 individuals recovered from 21 sites in 11 counties (Table 6). The higher relative abundance of albatross remains in archaeological sites in the Channel Islands indicate they were used much more often by albatrosses than sites on the mainland. This is not surprising, because albatrosses generally cannot coexist with mammalian predators, and predator-free islands support most existing colonies today.

Table 6. Occurrence of albatross remains in archaeological sites in mainland California, by county. Data compiled by Paul Collins from many sources. NISP = number of identifiable specimens. MNI = minimum number of individuals. Unid. alb. sp. = Unidentified albatross species.

California county	# sites	STAL NISP	STAL MNI	LAAL NISP	LAAL MNI	BFAL NISP	BFAL MNI	Unid. alb. sp. NISP	Unid. alb. sp. MNI	All spp. NISP	All spp. MNI
Alameda	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	3	9	3	0	0	0	0	0	0	9	3
Marin	0	0	0	0	0	0	0	0	0	0	0
Mendocino	1	3	1	0	0	0	0	0	0	3	1
Monterey	1	2	1	0	0	0	0	0	0	2	1
San Diego	1	7	1	0	0	0	0	0	0	7	1
San Francisco	1	0	0	0	0	0	0	1	1	1	1
San Luis Obispo	1	0	0	0	0	0	0	5	3	5	3
San Mateo	1	46	20	0	0	1	1	0	0	47	21
Santa Cruz	2	2	2	0	0	0	0	0	0	2	2
Santa Barbara	10	10	8	1	1	4	1	5	5	20	15
Sonoma	2	1	1	0	0	0	0	3	1	4	2
Ventura	3	97	22	0	0	1	1	18	1	116	24
Total	21	163	54	1	1	6	3	32	11	202	69

Human Impacts on Albatrosses in the Channel Islands in the Past

Archaeological evidence from numerous sites in the Channel Islands indicates that Native Americans in the Channel Islands commonly harvested albatrosses for food and for materials to make tools (Porcasi 1999, Glassow et al. 2010). The high abundance of albatrosses compared to other bird species suggests they were especially targeted, or more easily captured using the methods available at that time, or both (Porcasi 1999), and thus suffered disproportionate mortality. Harvesting of albatross is a common practice among native people along the west coast of North America and in northeastern Asia (Vokshoori et al. 2019), and this custom may have been brought to the Channel Islands during human migrations down the west coast of North America (Erlandson et al. 2011). Porcasi (1999) speculated on various methods by which native peoples could have captured albatross and concluded that they probably were captured on land by simply walking up and grabbing them, and at sea either by hand or with lines or nets. Albatrosses are easily attracted by fish and offal in the water and readily follow vessels at sea in search of food, a behavior that today makes them vulnerable to incidental bycatch in fisheries (Suryan et al. 2006, USFWS 2008). The ease of catching albatross at sea and their lack of fear on land would have made them easy prey for people in both environments (Porcasi 1999).

Native Americans also introduced island foxes to some, perhaps all, of the Channel Islands (Collins 1999, Rick et al. 2014), which could have preyed on albatrosses, extirpated any existing colonies, and prevented albatross from establishing colonies on those islands. Albatrosses are naïve to mammalian predators and often make little effort to flee from them and are thus extremely vulnerable to predation and generally unable to persist at locations where such predators are present (see section below on Island Suitability Criteria).

Although no evidence of albatross nesting has been found, it is possible that one or more albatross species bred in the Channel Islands in the past but were extirpated due to predation by humans and non-native mammals introduced by humans, or that they might have established breeding colonies if they had not been depredated.

Predation by humans is also thought to have contributed to the extinction of Dow's Puffin (*Fratercula dowi*). This alcid was intermediate in appearance between extant puffin species (*Fratercula* sp.) and the Rhinoceros Auklet (*Cerorhinca monocerata*) and is known only from the Channel Islands (Guthrie et al. 2002). Thousands of Dow's Puffin remains ranging in age from 100,000 to 12,000 years before present have been found in the Channel Islands, primarily on San Miguel and San Nicolas, including adults, immatures, and eggs (Guthrie et al. 2002). The extinction of this bird thus corresponds with the arrival of humans in the Channel Islands about 13,000 years ago (Glassow et al. 2010, Erlandson et al. 2011).

Human Impacts on Albatrosses in the North Pacific in the Present

Today, human-caused changes in the earth's climate are expected to result in severe loss of albatross breeding habitat in the Hawaiian Islands, with large declines predicted in the populations of Laysan and Black-footed Albatrosses (Baker et al. 2005, Flint et al. 2011, Reynolds et al. 2015). Much of their current breeding range is becoming increasingly less suitable because of global climate changes caused by humans. Several new Laysan Albatross colonies have formed naturally in the past few decades on islands in Hawaii and islands off Mexico, possibly by individuals displaced from islands in Hawaii that have been washed away (Young et al. 2009, Hernandez-Montoya et al. 2017, Henry et al. 2021). To make up for colonies in the NWHI that will be lost to sea level rise, new colonies must be created on high islands (Flint et al. 2011). Efforts are underway to establish additional colonies on higher islands in Hawaii and Mexico (VanderWerf et al. 2019, Ortega 2021, VanderWerf et al. in press), but there are few suitable islands high enough to be safe from sea level rise and where non-native predators are absent or can be effectively managed.

All three North Pacific albatross species are visiting California waters more often today than just a few years ago. Laysan Albatrosses are visiting California waters more often, and occasionally landing on the Channel Islands, in part because their numbers are growing in newly established colonies in Mexico. Black-footed Albatrosses are increasingly visiting California and the main Hawaiian Islands because so many have been displaced from low-lying islands in the Northwestern Hawaiian Islands. Short-tailed Albatrosses are again visiting the Channel Islands more frequently, reclaiming some of their previous foraging range, as the population recovers from near extinction caused by hunting by humans on the nesting islands in Japan. The numbers of albatross in the California Current can be expected to continue increasing, and it seems likely that one or more species will eventually attempt to nest in the Channel Islands. Facilitating the establishment of colonies in suitable locations would help to mitigate impacts of humans elsewhere and would help to avoid potential conflicts that could be created by albatrosses attempting to breed in unsuitable locations.

SEABIRD RESTORATION METHODS

Social Attraction vs. Translocation

There are two primary methods for restoring or creating seabird breeding colonies: social attraction and translocation. Social attraction involves attracting seabirds to a site with visual, auditory, and occasionally olfactory lures (Kress 1983, Jones and Kress 2012, VanderWerf et al. in press). Translocation involves physically moving birds from one location to another, usually when they are chicks, and caring for them until they fledge (Gummer 2003, Deguchi et al. 2012, Jacobs et al. 2020). The methods and effectiveness of these two techniques are discussed below, followed by examples in which they have been used with albatrosses. These techniques have been used in at least 857 projects involving 138 seabird species at 550 sites around the world (Seabird Restoration Database 2021).

The effectiveness of social attraction and translocation for restoring or creating seabird breeding colonies depends on multiple factors, including the natural history of the species involved, the biotic and abiotic characteristics of the restoration site, and proximity to the nearest existing colony of the target species (Table 7; Oro and Ruxton 2001, Jones and Kress 2012, Buxton et al. 2014, Brooke et al. 2018, VanderWerf et al. 2019). Social attraction alone is more likely to be effective in colonial species with weak natal philopatry and that require post-fledging parental care, and where existing colonies of the target species are close enough that birds are likely to fly near the site. Translocation is necessary more often in species with strong natal philopatry, including albatross, and in cases where there are no nearby colonies and thus a lower chance of visitation by prospecting birds (Jones and Kress 2012, VanderWerf et al. in press); translocation is usually combined with social attraction.

An advantage of social attraction is that it often is less expensive and less labor intensive than translocation. Once attraction systems are deployed, they can operate independently with little labor required. Well-chosen sites can provide early success with both surface and burrow nesting species (Sawyer and Fogle 2010, 2013). On the other hand, in species with strong natal philopatry or that have no nearby colonies, social attraction may take many years to achieve success and sometimes will not succeed at all (Kappes and Jones 2014). Selecting the best method using information about the life history and geographic distribution of the species can result in evidence of success earlier, which can help garner public support and overcome administrative, permitting, and funding obstacles. This is especially important because of the long-term nature of seabird restoration projects that may require decades for achieving even early milestones of success.

Table 7. Comparison of social attraction and translocation as seabird restoration methods. From VanderWerf et al. (in press).

	Social Attraction	Translocation
Overview and techniques involved	Using decoys and sound playback systems to simulate a colony and attract adult birds to a site.	Moving chicks or eggs from a source colony to a release site and raising them by hand until fledging. Birds return to release site later as adults.
Preferred species	Species with weak natal philopatry and high coloniality, such as gulls, terns, and cormorants, and existing colonies nearby.	Species with strong natal philopatry and no post-fledging parental care, such as albatross, petrels, shearwaters, and no colonies nearby.
Cost and effort	Low. After equipment is deployed little labor is needed.	High. Chicks must be selected, transported, and hand-fed until fledging.

Limitations	Colonization may happen quickly in highly social species but can be very slow or ineffective if few birds of the target species visit.	Requires facilities for storing and preparing food and housing people. May take years to establish a colony; many species do not breed until several years old. Some birds may not return.

Seabirds vary greatly in natal philopatry and in the age at which they imprint on their natal location and the cues by which the imprinting occurs (Coulson 2016, Antaky et al. 2020). Almost all Procellariiform seabirds (albatrosses, shearwaters, petrels), some Suliformes (boobies and gannets) and Phaethontiformes (tropicbirds), and most alcids (auks) are strongly philopatric (Antaky et al. 2020), which means they are more likely to return to nest at their natal site, although some species may visit multiple colonies before selecting where they will nest (Kress and Nettleship 1988). In contrast, the majority of gull, tern, and cormorant species have weaker philopatry and typically visit multiple breeding locations in addition to their natal site prior to nesting, and readily nest at new sites where they find suitable habitat (Coulson 2016).

Albatrosses develop natal site recognition early during development, sometime between 1 and 5 months of age (Fisher 1971). Establishing albatross breeding colonies at new locations using translocation therefore requires moving birds prior to this imprinting age, usually at 3 to 5 weeks, and then raising them at the new site (Deguchi et al. 2012, 2014, VanderWerf et al. 2019). Moving chicks at a few weeks of age also allows them time to imprint on their own species and to be inoculated with the gut micro-biome by their parents (VanderWerf e al. 2019, Góngora et al. 2021).

Examples of Social Attraction and Translocation Projects with Albatrosses

The first albatross translocations were done by Fisher (1971) on Midway Atoll when it was a military base, and their purpose was to determine if albatross numbers on Midway could be reduced by moving birds to other locations when they were young. Fisher moved groups of albatross chicks when they were either one month or five months in age. Most birds that were moved when one month old returned to the release site, and most birds moved when they were five months old returned as adults to their natal site, demonstrating the strong natal philopatry of albatross, and that they imprint before they are five months old.

The first albatross translocations done for conservation purposes were with the Short-tailed Albatross (Deguchi et al. 2012, 2017). From 2008-2012, 70 Short-tailed Albatross chicks were moved at 33-40 days of age from Torishima, where the main colony is located, to Mukojima, where the species had nested historically. The chicks were flown by helicopter between the islands and transported in wooden boxes. The project was very successful in the short-term, with all chicks surviving the transport and 69 of 70 (99%) surviving to fledge. In the long-term, the results have been moderately successful, with 39% of translocated birds visiting the release site and 80% visiting the natal site (some birds visited both sites), and the first translocated bird nesting at the release site when five years old (Deguchi et al. 2017).

Laysan and Black-footed albatrosses were translocated in 2006-2007 as part of the Short-tailed Albatross translocation project to develop techniques that were subsequently used in translocation of the endangered Short-tailed Albatross (Deguchi et al. 2012). Of 10 Laysan Albatross chicks moved from Midway to Kilauea Point National Wildlife Refuge on Kauai in 2006, three died of exposure, one was injured and could not be released, and two died from gastrointestinal bacterial infections, and only four chicks fledged (USFWS 2008). Of 10 Black-footed Albatross chicks moved from Nakodojima to Mukojima islands in Japan, methods were improved based on experience with the Laysan Albatross translocation the previous year, and nine of the 10 chicks fledged. The long-term fate of the translocated birds was not monitored, so the overall success of these translocations is not known.

From 2015-2021, Pacific Rim Conservation, in collaboration with the U.S. Fish and Wildlife Service, translocated Laysan Albatross and Black-footed Albatross to James Campbell National Wildlife Refuge (JCNWR) on Oahu to create new colonies resilient to climate change (VanderWerf et al. 2019). From 2015-2017, 51 Laysan Albatross eggs were moved from the U.S. Navy's Pacific Missile Range Facility on Kaua'i, where albatross attempt to nest near an active runway and are a collision hazard for aircraft (Young et al. 2014). The eggs were placed temporarily in foster nests at Kaena Point Natural Area Reserve, then the chicks were transferred to JCNWR when they were about three weeks old. From 2018-2021, 102 Black-footed Albatross chicks were moved to JCNWR at age 3 weeks from Midway Atoll National Wildlife Refuge. Survival of chicks to fledging was 90% for Laysan Albatross and 94% Black-footed Albatross. Laysan Albatrosses began returning to the release site at 3 years of age, and Black-footed Albatrosses at four 4 years, and it is hoped that translocated birds will begin breeding at JCNWR in the next few years.

In 2021 and 2022, Black-footed Albatross eggs and chicks were translocated from Midway Atoll to Guadalupe Island, Mexico by PRC and Grupo de Ecología y Conservación de Islas (GECI) in partnership with government agencies from Mexico and the USA to establish a new colony to increase species resilience to climate change. In 2021, Twenty-one eggs and 12 chicks were translocated by plane from Midway, Hawaii, to Guadalupe Island. Eggs were placed in foster nests of experienced pairs of Laysan Albatrosses in which the natural egg was infertile, inviable, or broken, and the hatched chicks were raised by their foster parents. Nine translocated chicks survived the transport and were hand-fed. In 2022, 36 eggs were moved from Midway to Guadalupe. Chicks were released within an artificial colony consisting of 50 Black-footed Albatross decoys and a sound system installed on the island since 2017. The project has been very successful during the first two years. Hatching rate of eggs was 86% in 2021 and 97% in 2022. In 2021, all 27 chicks survived to fledging (18 from translocated eggs and 9 translocated as chicks). During the next 2-3 years, egg translocations will continue until 100 chicks have fledged from Guadalupe Island.

In the Chatham Albatross (*Thalassarche eremita*), chicks were moved at 3 months of age, and all have returned to the source colony on The Pyramid (Mike Bell pers. comm.).

There have been several previous efforts at social attraction of Laysan Albatross. At Kilauea Point National Wildlife Refuge, Laysan Albatross began visiting and nesting in 1975 but the incipient colonies were affected by dog predation and human disturbance, so an attempt was made to attract them to safer locations by Podolsky (1990), who found they were attracted more frequently to areas where both decoys and vocalizations were present than in areas with only visual stimuli, and that three-dimensional decoys in a sky-pointing posture exhibited by the species during courtship were the most attractive. A social attraction project for Laysan Albatross was conducted at Kaohikaipu Islet off the eastern coast of Oahu from 1993-1996 (Podolsky and Kress 1994), but it was largely ineffective. During the 1993-1994 season, albatrosses were observed on only 27 of 97 days (27%), and a maximum of four birds were observed at once. During the 1994-1995 season, albatrosses were observed on 37 of 111 days (33%), but no birds ever nested and the project was discontinued.

A social attraction program for Laysan Albatross has been conducted at JCNWR on Oahu since 2015 by PRC in conjunction with translocations of Laysan Albatross chicks (VanderWerf et al. 2019). Each year 20 decoys and a solar-powered sound system were deployed during the albatross breeding season from November to June, and translocated chicks were present from February-June during the 2015-2017 seasons. The number of visits has increased each year, with a maximum of 748 documented visits by adult Laysan Albatross in 2021. The exact number of individual birds that visited is unknown because many were not banded, but at least 105 different banded birds were observed at the refuge in 2021, and at least 191 different banded birds have visited since 2015. A maximum of 19 LAAL adults visiting simultaneously was observed in 2021. The first nesting attempt at JCNWR by socially attracted Laysan Albatross occurred in 2017, the first successful nest was in 2019 (VanderWerf et al. 2019), and in 2021 there were six breeding attempts by socially attracted Laysan Albatross at JCNWR (PRC unpubl. data). It should be emphasized that Laysan Albatross were known to be visiting and nesting in areas near the refuge before the project began, and that the presence of translocated chicks was a strong social attractant that is not present in most attraction programs.

Social attraction of Black-footed Albatross has been attempted twice, once at Kaena Point Natural Area Reserve on Oahu, Hawaii by PRC, and once at Guadalupe Island, Mexico by GECI. At Kaena Point, up to four decoys and a solar-powered sound system were deployed from 2011-2015, but the visitation rate was low, and no pairs attempted to nest during that time (Young and VanderWerf 2016). The visitation rate increased somewhat since 2015, and the first nesting attempt began in November 2021. On Guadalupe Island, a social attraction program involving 50 decoys and a solar-powered sound system has been used since 2017, but no birds have visited. Black-footed Albatrosses are known to forage in the California Current near Guadalupe, and there had been a few observations of the species on the island previously, but none since 2009. The lack of visitation was part of the reason a translocation was undertaken.

Social attraction using decoys and a sound system has been used for the Short-tailed Albatross on the primary nesting island of Torishima since 1991 to attract birds to an area of the island that is at less risk from landslides and volcanic activity (USFWS 2008). The effort was successful, with the first pair nesting at the new site in 1996, and the number of pairs increasing to 36 by 2008 (USFWS 2008).

Efforts to attract Short-tailed Albatross have been made on Midway for many years using decoys. A pair of Short-tailed Albatross did nest near the decoys for several years and raised several chicks, but the decoys were placed in a location where the adults were already visiting, and it is not clear if the birds were attracted to the decoys or simply continued to visit a site that was already of interest to them.

Figure 5. Decoys and sound system at JCNWR, Oahu, for Laysan Albatross (left) and Black-footed Albatross (right).

Recommendations for Establishing Albatross in the Channel Islands

This section discusses which methods would be most appropriate and effective for each species, which are summarized in (Table 8).

Social attraction would be relatively easy and inexpensive the implement on any of the Channel Islands, but the likelihood of establishing a colony through social attraction currently is relatively low because few birds visit the islands and the shallow water inside the continental shelf. Decoys and sound systems are only effective if the birds come close enough to see and hear them; they cannot attract birds from miles away. However, the potential for successful social attraction is likely to increase over time. The number of Laysan Albatrosses in California waters is increasing because their population on Guadalupe Island, Mexico, is growing. The numbers of both species in California waters also are likely to increase as more birds are displaced from colonies in Hawaii that become inundated. The chance of successful social attraction is higher for Laysan Albatross, which already have been observed on or flying over San Nicolas on two occasions. Furthermore, another beneficial aspect of social attraction is that it would decrease the chance of albatrosses visiting sites that are less suitable. If no action is taken, the chance of albatross naturally establishing a breeding colony is low, but there is a high chance they would choose to do so in an area where they are either vulnerable to predation, because most of the islands have predators, particularly the Island Fox, or where they could cause conflict with military operations or visitor use.

Translocation of both albatross species is feasible and has a high probability of success, though it would be a long-term process and would be more expensive and labor intensive than social attraction. Translocation of both species would use similar methods in general, but the sources would differ between the species. For Laysan Albatross, the most appropriate source would be eggs collected from the U.S. Navy's Pacific Missile Range Facility (PMRF) on Kauai, where they pose a bird-aircraft strike hazard and are legally removed each year. Eggs from PMRF have been the source in previous translocations within Hawaii and there is surplus of eggs available every year. The eggs from PMRF could be moved directly to the Channel Islands, which would require raising them by hand from hatching. Alternatively, the eggs from PMRF could be placed in foster nests at another colony in Hawaii, and the chicks could be moved after hatching; this approach has been used in previous Laysan Albatross translocation in Hawaii. For Black-footed Albatross, the most appropriate source would be chicks from Midway Atoll National Wildlife Refuge, which supports the largest breeding colony of the species. Midway has been the source of previous Black-footed Albatross chicks in previous translocation projects on Oahu (VanderWerf et al. 2019) and Guadalupe Island, Mexico (VanderWerf et al. in press).

Table 8. Summary of feasibility, cost, and probability of establishing albatross species in the Channel Islands by social attraction and translocation.

Species	Translocation			Social attraction		
	Feasibility	Cost	Prob. of success	Feasibility	Cost	Prob. of success
Laysan	High	High	High	High	Low	Low but increasing?
Black-footed	High	High	High	High	Low	Low

Although the Short-tailed Albatross would be an appropriate species to consider for establishment in the Channel Islands, it is not considered a priority because it is not at risk from sea level rise and because obtaining chicks for translocation from the breeding colonies in Japan is not feasible at this time.

ISLAND SUITABILITY CRITERIA

This section presents information about the relative suitability of each of the Channel Islands for potential albatross managed relocation. Suitability is assessed using 16 criteria that could influence the feasibility and success of attempting to establish an albatross breeding colony in the Channel Islands. The description of each criterion mentions why it is important and how it may differ among islands.

List of suitability criteria (order does not indicate importance):

- Permitting and Environmental compliance-NEPA, USFWS section 7 consultation, Section 106 historical consultation
- Compatibility with existing land and ocean uses and plans (habitat restoration, public use and recreation, wilderness areas, marine protected areas, permitted fisheries, Navy Bird/Wildlife Aircraft Strike Hazard prevention)
- Compatibility with other native biota
- Assisted migration policy of landowner
- Logistics, e.g., ease of access to the island
- Infrastructure on the island for supporting people and birds
- Readiness, e.g., time to implementation
- Capacity of landowners to monitor and manage a new colony
- Island size [or amount of suitable habitat with appropriate topography, windscape (i.e., the direction and speed of predominant winds interacting with island topography), and thermal conditions for successful albatross nesting]
- Distance to continental shelf
- Distance to continental coast
- Presence of ground predators
- Presence of predatory birds
- Potential for parasite or disease transmission
- Potential for introduction of invasive alien species
- Cultural considerations

- (Cost). Cost was not considered in this site suitability analysis. Cost must be considered eventually if a translocation is done, but the current goal is to identify islands with the greatest chance of success and the least impact to other resources, regardless of cost.

1. Permitting and environmental compliance and planning

Environmental review will be required for a project of this type, and managers pursuing a formal evaluation of this concept will need to determine the planning and permitting documents required. It will be necessary to obtain several permits and complete one or more environmental compliance documents to implement this project. An Environmental Assessment (EA) or Environmental Impact Statement (EIS) might be required under the National Environmental Policy Act (NEPA). The island chosen could affect whether an EA or EIS might be required, and which agency would be responsible for writing the document. Other permits would be required from the U.S. Fish and Wildlife Service Migratory Bird Program, and consultation with the USFWS under section 7 of the ESA might be required if the island chosen supported endangered plants or animals that may be affected. Engagement with the State of California's Department of Fish and Wildlife will be necessary, especially for actions that would be implemented on private property on the islands (e.g., on TNC's Santa Cruz Island Preserve or Santa Catalina Island). Review and approval of the California Coastal Commission would be required, particularly if plans involve ground disturbance and construction within the coastal zone (e.g., installation of predator fencing). Consultation with the tribes would be required. On NPS islands, activities would need to be consistent with the Wilderness Act.

2. Compatibility with existing land uses and plans

This is a broad category intended to encompass compatibility with a variety of other activities and uses on the islands. Albatrosses are sometimes attracted to large, open areas, like runways, and there are several paved runways and other airstrips across the archipelago. In Hawaii, Laysan Albatross are actively removed and hazed from airfields at the Pacific Missile Range Facility on Kauai, and at Marine Corps Base Hawaii and U.S. Army Dillingham Airfield on Oahu. Other potential compatibility issues include ability to continue needed invasive plant removal and native plant restoration, and presence of infrastructure in wilderness areas. Compatibility with public visitor use also should be considered on islands owned by NPS and TNC. The presence of albatross could be an additional attraction to visitors, but proximity of visitors might need to be managed.

3. Compatibility with other native biota

Albatrosses are large birds, and though they generally are not aggressive toward other species, they potentially could have negative impacts on plant and animal species on the island. Albatrosses nest on the surface and do not dig burrows, but they gather soil and plant material around them to form a nest cup. They also require a runway for taking off and landing, and their repeated foot traffic can inhibit plant growth in a small area. On islands with large albatross colonies the density of nests can be high, up to 1 nest per square meter. If albatrosses increase in number on the island, they could compete for space with other surface nesting birds such as Western Gulls and California Brown Pelicans.

4. Assisted migration policy of landowner

Laysan Albatross and Black-footed Albatross commonly forage in waters off California, and in this sense they are native to the region, but there are no records of them nesting in the Channel Islands. Establishing a nesting colony of either species in the Channel Islands therefore could be viewed as a managed relocation rather than a re-introduction. However, it is also ambiguous how the terms and concepts apply in a circumstance like this, where the action being contemplated is facilitating the species' use of an area for an additional life stage: the use of habitat for breeding that is already encompassed by the habitat used for foraging.

National Park Service policy currently does not allow introduction of species not known to have inhabited an area previously, but this policy may change as awareness grows about the impacts of climate change and the importance of managed relocation in some cases (Karasov-Olson et al. 2021a, 2021b). Channel Islands National Park is facing similar questions in at least one other bird conservation management challenge, that of the Island Scrub-Jay (*Aphelocoma insularis*); in that instance, managers must determine the degree to which potential gaps in knowledge due to patchy historical records should affect decision-making regarding management in an era of global change (Morrison 2014).

5. Logistics- ease of transport to the island

The ability to transport people, birds, and supplies to the island is crucial to successfully implementing this project. Birds will need to be transported just once at the beginning of the season, which would be in January or February, but regular access will be needed to switch out project staff and bring more supplies to the island, particularly bird food. One albatross needs about 15% of its body weight in food each day. For 20 chicks this would require preparing 1,200 kg of food over the entire 5-month season. Transport could be by either boat or aircraft; the most important determinant regarding mode would be reliability and affordability. If access might be affected by weather and some trips are cancelled, this might be acceptable if there is sufficient infrastructure on the island to store emergency supplies.

6. Infrastructure on the island for supporting people and birds

There must be sufficient infrastructure on the island to support the birds and 2-3 people to care for them for up to five months. This includes shelter, cooking, and bathroom facilities for people, ability to keep bird food cold/frozen, and water for cooking and cleaning. It is essential to sterilize all equipment used to feed birds every day, and this requires water. It is possible to use salt water for some things, but the final rinse and soak in disinfectant must be with fresh water. Sites where sufficient infrastructure already exists would be given higher scores. Sites where this infrastructure does not exist currently but could be built would be given moderate scores. Sites where it would be impractical or incompatible to build such infrastructure would be given the lowest score.

7. Readiness – time to implementation

This criterion represents the time required to obtain all necessary permits and prepare the island for implementation of the project. This could include things like building or improving infrastructure, building a predator exclusion fence, and securing permits and completing environmental compliance. Sites that will require more preparation would be given lower scores.

8. Capacity of landowner to monitor and manage a new colony

It will take several years before the birds begin returning to the release site and several more years before they start breeding there. In the interim, it will be important to monitor the site to determine if/when birds return, how many, and their bands numbers. Once a colony is established, it would be desirable to monitor its success and growth, and whether any problems are occurring to the albatrosses or other resources that require management. This monitoring and management will require some staff time and resources from the landowner, and the feasibility of conducting these activities may vary among islands.

9. Island size/Suitable habitat area

A larger island would be preferable in general because it could support a larger albatross population, but the terrain of the island also determines how much of the island area is suitable for albatross, and wind exposure also affects habitat suitability for albatross. Laysan and Black-footed Albatrosses prefer flat ground for nesting, consistent exposure to strong winds to facilitate flight, and the presence of some soil to build a nest. They do nest on slopes and rocky ledges in a few locations, but those habitat types are not preferred. Steep slopes and bare rock would not be suitable. On islands where it would be necessary to build a predator exclusion fence, the amount of suitable habitat would be the size of the fence, not the size of the entire island. Albatross do not require much space on land, just enough to build a nest out of reach of their neighbors, so a lot of albatrosses can nest in a relatively small space. Midway Atoll is just 1,100 acres in size but supports over 600,000 pairs of breeding albatross.

10. Distance to continental shelf and coast

Albatross forage primarily in deep water and areas of upwelling over the continental slope, not in nearshore waters. Islands that are closer to the edge of the shelf would require a shorter commute for breeding adults and make it easier for fledglings to reach areas where they are more likely to find food. None of the distances involved are that long and albatrosses can cover them easily, but all else being equal, an island closer to the continental shelf would be preferable. For social attraction, proximity to the shelf is more important because albatrosses are more likely to naturally encounter such islands while foraging. Social attraction on islands far from the shelf is unlikely to succeed because albatross will rarely, if ever, visit such islands. It is not a coincidence that the two islands visited by Laysan Albatross most often, San Nicolas and San Clemente (Table 6), are also the two islands closest to the continental shelf (Table 1).

11. Distance to continental coast

Islands closer to the coast are more likely to be reached by predatory birds such as Bald Eagles and Common Ravens, and these species may prey on albatross eggs, chicks, and adults (see section below on predatory birds). On islands closer to the coast there also is greater potential for accidental introduction of ground predators as stowaways on private boats.

12. Presence of ground predators

Albatrosses and other Procellariform seabirds are naïve to ground predators and generally cannot coexist with mammalian predators; this is the main reason they usually nest on islands (Spatz et al. 2014, Dias et al. 2019). Dogs, cats, and mongooses are the most serious predators in Hawaii, but rats and, rarely, even mice can be a problem. House mice (*Mus musculus*) recently began attacking adult Laysan Albatross on Midway, causing some mortality and nest abandonment (USFWS 2019), and house mice on Gough Island are known to attack and feed on live Wandering Albatross (*Diomedea exulans*) chicks (Cuthbert and Hilton 2004). However, the risk of native deer mice (*Peromyscus maniculatus*) in the Channel Islands eating albatrosses is very low. Deer mice have never been reported to attack adults of large seabird species like pelicans, cormorants, or gulls. Deer mice are known to eat seabird eggs, but only eggs of smaller species that nest underground in burrows or rock crevices, and only when adult birds are absent from the nest and eggs are unattended. For example, on Santa Barbara Island deer mice are known to eat Scripps's Murrelet (formerly called Xantus's Murrelet) eggs, which weigh 37 grams, but only when the parents left the egg unattended (Murray et al. 1983, Millus et al. 2007). Predation by deer mice also has observed on Rhinoceros Auklets eggs, which weigh 79 grams, on Triangle Island, Canada, primarily in years of low food abundance when the adult auklets spend more time foraging and leave eggs unattended (Blight et al. 1999). The risk of predation by deer mice on albatross eggs is negligible because albatross rarely leave eggs unattended and their eggs are much larger (average weight 278 grams in Laysan Albatross and 304 grams in Black-footed Albatross; Fisher 1969); the small gape size of deer mice would make it very difficult for mice to break albatross eggs.

Snakes are also a potential predator on albatross eggs and chicks. On Clarion Island, Mexico, Clarion Racers (*Masticophis anthonyi*) have been documented to kill Laysan Albatross chicks, even though they are too large for the snakes to swallow (Wanless et al. 2009, Daniel Portillo, GECI unpubl. data). In the Channel Islands, the Santa Cruz Gopher Snake (*Pituophis catenifer pumilus*) occurs on Santa Cruz and Santa Rosa, the Western Yellow-bellied Racer (*Coluber constrictor*) occurs on Santa Cruz, and the San Diego Nightsnake (*Hypsiglena ochrorhyncha klauberi*) occurs on Santa Cruz (http://www.californiaherps.com/islands/caislandherps.html). The nightsnake is small and would not be a threat to albatrosses, but the gopher snake and the racer can be relatively large (up to 91 cm and 190 cm, respectively) and both are known to eat bird eggs and nestlings. The presence of these snakes makes Santa Cruz and Santa Rosa less suitable for albatross. Santa Catalina has several other snake species, but no snakes are known from any of the other Channel Islands. (http://www.californiaherps.com/islands/caislandherps.html).

The Island Fox (*Urocyon littoralis*) is endemic to the Channel Islands and currently occurs on six of the eight Channel Islands; it is absent from Anacapa and Santa Barbara islands. The Island Fox likely would be a threat to albatross eggs and chicks and possibly to breeding adults that did not flee from the nest. Island Spotted Skunks (*Spilogale gracilis amphialus*) occur on Santa Cruz and Santa Rosa islands; they too may depredate eggs and chicks. Feral cats (*Felis catus*) occur on Santa Catalina Island, and rats (*Rattus spp*.) occur on San Miguel, Santa Catalina, San Nicolas, and San Clemente islands. Santa Catalina Island also has large ungulate populations, including American bison (*Bison bison*), that if unmanaged could potentially pose a trampling risk in nesting areas.

If albatrosses were translocated to an island with an Island Fox population, it would be necessary to build a predator exclusion fence to protect albatrosses from foxes. Predator exclusion fences that exclude all mammals cost about $300-$400 per meter including materials and labor, though transporting materials to the island could make the cost higher. The cost would be a little lower if a design was used that excluded only larger predators like foxes. Predator exclusion fences are generally effective if well sited and built according to specifications, but there could be occasional breaches of the fence caused by erosion or rockfall (Young et al. 2013, 2018), and foxes might be able to dig under a fence depending on the hardness of the substrate and their motivation. It is also possible that some albatrosses would settle outside the fence, where they would be vulnerable to foxes. A larger fence would be desirable to provide a larger area of suitable habitat and increase the chance that returning birds settle inside the fence.

13. Presence of predatory birds

Albatrosses are large birds, but large predatory birds have been known to kill and eat eggs, chicks, and even adult albatrosses. In the Channel Islands, the bones of an adult Black-footed Albatross were found under an historical Bald Eagle (*H. leucocephalus*) nest on San Nicolas (Collins in press). Following a successful conservation reintroduction program, Bald Eagles are now a common year-round resident on the Channel Islands, with 20 nesting pairs and over 60 individuals present in 2021. Newsome et al. (2010) found that seabirds were an important dietary component of Bald Eagles in the Channel Islands prehistorically, but their diet switched to non-native ungulates, primarily sheep, from 1850-1950 when seabirds declined and ranching was prevalent, and speculated that as eagle numbers recover, they could put increasing predation pressure on recovering seabird populations now that non-native ungulates have been removed. Newsome et al. (2015) found that recent Bald Eagle diets consist of 40-45% seabirds in the Northern Channel Islands and 25-30% on Santa Catalina. The Northern Channel Islands are known to be occasionally visited by transient Golden Eagles (*Aquila chrysaetos*), but they have not been resident or bred on the islands since the removal of ungulate prey subsidies and since the repopulation of Bald Eagles.

In the Hawaiian Islands, a Steller's Sea-Eagle (*H. pelagicus*) was observed on Midway and Kure Atolls in 1978 and predation of an adult Laysan Albatross by the eagle was witnessed at Kure, and carcasses of both Laysan and Black-footed albatrosses were found with evidence of raptor predation (Balazs and Ralph 1979). Another Steller's Sea-Eagle was present on Tern Island in 1983 (Pyle and Pyle 2017). On Kauai, a visiting White-tailed Eagle killed and ate at least five adult Laysan Albatrosses over a seven-month period in 2007 (Zaun 2009). Zaun (2009) also reported the following instances of predation on albatrosses in Japan: a Steller's Sea-Eagle was suspected of killing three adult Black-footed Albatrosses on Torishima Island in early February 2001 (F. Sato pers. comm.); in February 1960, seven Short-tailed Albatross chicks on Torishima Island were taken by a raptor (Fujisawa 1967); a White-tailed Eagle was seen on Torishima and Mukojima islands in March 2008 and carcasses of Black-footed Albatrosses with evidence of raptor predation were observed; in March 2008 several carcasses of Black-footed Albatrosses were found on Nakodojima Island, 5 km south of Mukojima (T. Deguchi pers. comm.). Recovery of sea-eagle (*Haliaeetus* spp.) populations in North America and Europe has affected many species of seabirds and is suspected of contributing to population declines in some cases (Hipfner et al. 2012).

Over 50 pairs of Peregrine Falcons breed in the Channel Islands and their numbers are likely to continue increasing, but they are not large enough to pose a threat to adult albatross. Peregrines are regular visitors to the Hawaiian Islands but there are no reports of them ever attacking albatross adults or chicks. A variety of owl species occur on the Channel Islands, but none of them are large enough to pose a predation risk to albatross. Barn Owls are common in the main Hawaiian Islands, and they are abundant at James Campbell NWR on Oahu where Laysan and Black-footed Albatross conservation efforts are underway, but there are no reports of Barn Owls attacking albatross adults or chicks.

Common Ravens (*Corvus corax*) occur in varying group sizes on the islands. Ravens are not large enough to kill adult albatross, but they are known to take albatross eggs and chicks. On Isla Clarión off Mexico, Daniel Portillo of GECI used trail cameras to record ravens harassing adult Laysan Albatross and eventually taking eggs and chicks from the nest. It would be difficult to prevent predatory birds from eating albatrosses in the Channel Islands. On Isla Clarión, GECI tried putting cages over albatross nests, but this requires someone to be present to let the adult in when it returns to feed the chick and is not a long-term solution. Management of problematic individual predatory birds via capture and relocation or other means would likely be complicated. A large albatross colony probably could withstand some level of predation, but predation might prevent establishment of a small, incipient colony.

Western Gulls are opportunistic predators that could depredate albatross eggs but are not likely to be a threat to adult albatross or chicks. On Guadalupe Island, Mexico, Western Gulls have preyed on a few albatross eggs, but only when the eggs are unattended, and have shown no interest in albatross chicks.

14. Potential for parasite or disease transmission

Albatrosses moved to the Channel Islands could carry parasites or diseases that could spread to other bird species on the island. In previous albatross translocations, the chicks were treated with an external insecticide designed specifically for birds and an internal antibiotic to kill parasites, and this would greatly reduce the risk. If eggs were moved, there would be no risk because the eggshell itself is a barrier to parasites and most pathogens. This potential threat can be largely avoided, but it could be worse on islands with breeding colonies of other seabirds.

15. Potential for Invasive Alien Species Introduction

The activities and transport of equipment associated with social attraction and translocation could accidently result in the introduction of invasive alien species. All precautions should be taken to avoid this, including thorough cleaning and inspection of all materials and dedicated clothing and equipment that would be used only the specified island, but there still might be some risk. The potential risk might be the same for all islands, and this criterion might not help in selecting the most suitable island, but it should be considered in all cases. Part of the capacity of the landowner to support the project would be ability to monitor for alien species and respond if necessary.

16. Cultural Considerations

Albatrosses were important in the culture of the Native American groups that formerly inhabited the Channel Islands, as evidenced by the abundance of albatross bones in archaeological sites. Albatross were used as food and a source of materials to make tools and decorations. It is not clear if albatross were hunted on land, at sea, or both (Porcasi 1999), but restoring albatross to the Channel Islands also could help to restore a cultural connection with the species that has been lost. Hunting of albatross would not be appropriate but viewing of albatross and cultural practices involving albatross feathers and bones might be possible through a permitting process, as it is done in Hawaii. Islands where the public could view albatross could be given higher scores, or this might apply equally to all islands, in which case it would not help in selection of the most suitable island, but it should be considered in all cases.

Preliminary Island Assessments

Based on the above criteria and considerations, we recommend narrowing the focus of consideration to two islands: Santa Barbara and San Nicolas. Below is a brief, preliminary assessment of each island, including the most important positive and negative aspects, with a summary presented in Table 9. This evaluation could be carried out in more detail by giving each island a score for each criterion ranging from 1 to 5, and the scores summed to obtain an overall score, but for now each island was given a plus (+) or minus (-) based on whether it was generally favorable with regards to that factor.

San Miguel. Overall, this is one of the less suitable islands for attempting to establish an albatross colony, for several reasons. San Miguel is relatively close to the continental shelf, but also moderately close to the coast. There are ground predators, including Island Foxes and rats, and avian predators including Bald Eagles and Common Ravens. There is no regular boat service to the island and there is no dock, so the landing is "wet", but there are two airstrips so access by helicopter and fixed wing travel aircraft would be possible. There is little existing infrastructure apart from a NPS ranger station and a NOAA research station, which probably would not be available for albatross work. There is limited freshwater on the island, and it might be necessary to bring water which would be difficult.

Santa Rosa. This is also one of the less suitable islands for attempting to establish an albatross colony. Like San Miguel, Santa Rosa is relatively close to the continental shelf, but also moderately close to the coast. There are ground predators, including Island Foxes and Island Spotted Skunks, and avian predators including Bald Eagles and Common Ravens. There is regular boat service to the island and a dock, and there is an airstrip so access by aircraft would be possible.

Santa Cruz. This island has several desirable features but also several unfavorable aspects. It is moderately close to the continental shelf and distant from the coast. There are ground predators, including Island Foxes, Island Spotted Skunks, gopher snakes and racers, and avian predators including Bald Eagles and Common Ravens, all of which make the island less suitable. It is easily accessible by boat and has good existing infrastructure. Large portions of the island would be suitable for albatross but a predator fence would be needed, and albatross might be limited to the fenced area.

East Anacapa. This island has some desirable features, but overall, it is one of the less suitable islands. It is the closest island to the coast and the most distant from the continental shelf. It is easily accessible by boat and has good existing infrastructure. There are no ground predators, but there is one pair of Bald Eagles on East Anacapa and a large colony of Western Gulls. Most of the island is steep and rocky and there is a limited amount of flat and gently sloping terrain that would be preferred for nesting by albatross.

Santa Barbara. This would be an excellent island for albatross. It is moderately close to the continental shelf and moderately distant from the coast. There are no ground predators and no predatory birds large enough to be a threat to adult albatross, though there is a Western Gull breeding colony that could result in some predation on unattended eggs. It is accessible by boat, but the landing is difficult sometimes because the dock is damaged. It is unlikely that the dock will be rebuilt anytime soon because of the high cost, though minor improvements are planned to increase safety. NPS also regularly accesses the island by helicopter. It has good existing infrastructure at the NPS field station. There is no source of fresh water on the island, but there are large storage tanks and water is delivered by boat and pumped into the tanks. Although it is relatively small, most of the island consists of suitable habitat for albatross, with gently sloping, open terrain. No predator fence would be needed, so the entire island would be accessible to albatross. Public visitation is allowed and visitors are required to stay on existing trails, so public viewing of albatross would be possible. Public access to the area where albatrosses are released might need to be managed with educational signage.

San Nicolas. This island is suitable in most respects, but there could be conflicts with Navy uses of the island. It is the closest island to the continental shelf and the most distant from the coast, so it has the best geographic location of any of the Channel Islands for albatross. It is easily accessible by airplane and has excellent existing infrastructure. Laysan Albatross have already visited the island and may already prefer this island, and social attraction has the best chance of succeeding here. Much of the island consists of gently sloping terrain that would be suitable for albatross, but Island Foxes are present, so a predator fence would be needed, and albatross might be limited to the fenced area. The airfield might be attractive to albatross, and albatross might visit other areas used for military operations, where they could be a nuisance.

Santa Catalina. This island is not suitable because of the large human population, presence of several ground predators, particularly feral cats, rats and several snakes, and a variety of potentially conflicting land uses.

San Clemente. This island is suitable in some respects, but there could be conflicts with Navy uses of the island and several ground predators are present. It is the second-closest island to the continental shelf and the second-most distant from the coast (after San Nicolas). It is easily accessible by airplane and has excellent existing infrastructure. It is a large island and much of the island would be suitable for albatross, but Island Foxes, feral cats, and rats are present, so a predator fence would be needed, and albatross might be limited to the fenced area. The airfield might be attractive to albatross, and albatross might visit other areas used for military operations where they could be a nuisance.

Table 9. Preliminary assessments of the eight Channel Islands for albatross using the selection criteria described above.

Island	Permitting	Land use compatibility	Biological compatibility	Assisted migration policy	Logistics	Infrastructure	Readiness	Landowner capacity	Size/suitable habitat available	Distance to shelf	Distance to coast	Ground predators	Predatory birds	Pathogen transmission	Invasive species introduction	Cultural considerations	# of pluses
San Miguel	-	+	+	-	-	-	-	+	+	+	-	-	-	-	-	+	6
Santa Rosa	-	+	+	-	+	-	-	+	+	+	-	-	-	-	-	+	7
Santa Cruz	-	+	+	-	+	+	-	+	+	-	-	-	-	-	-	+	7
Anacapa	-	+	+	-	+	+	+	+	-	-	-	+	-	-	-	+	8
Santa Barbara	-	+	+	-	-	+	+	+	+	+	+	+	+	-	-	+	11
San Nicolas	-	-	+	+	+	+	-	+	+	+	+	-	-	-	-	+	9
Santa Catalina	-	-	+	?	+	+	-	+	+	-	-	-	-	-	-	+	6
San Clemente	-	-	+	+	+	+	-	+	+	+	+	-	-	-	-	+	9

ECOLOGICAL RISK ASSESSMENT

Assessing the ecological risks associated with different climate adaptation strategies is essential prior to implementation, but until recently the process for assessing potential risks was nebulous and poorly defined. However, in 2021, a collaboration among academic, NPS, and DOI biologists, funded by NPS, produced a technical report that contained a rigorous, systematic method for evaluating such risks (Karasov-Olson et al. 2021a). A summary of the goals and methods of the report were later published in a peer-reviewed scientific journal (Karasov-Olson et al. 2021b). The technical report also provided a spreadsheet that can be downloaded (https://irma.nps.gov/DataStore/Reference/Profile/2280035) and used by managers to assess the risks associated with an individual project. The spreadsheet uses categories to evaluate each risk and includes a method for categorizing the strength, agreement, and confidence of the evidence. This report uses the ecological risk assessment methods in Karasov-Olson et al. (2021a), including the downloadable spreadsheet.

In the method devised by Karasov-Olson et al. (2021a), risks are broken down into six categories, each of which is further divided into subcategories to evaluate more specific risks:

I. Risks of no managed relocation action
II. Risk to the target species of managed relocation action
III. Risks of action to non-targets in the recipient ecosystem
IV. Risks of action to non-target, higher order attributes of the recipient ecosystem
V. Risks associated with biological invasion
VI. Risks associated with socio-economic values

The potential risk in each of these categories of managed relocation of albatross to the Channel Islands is discussed in detail below. Some of the risk categories are less relevant in this project, but all risks are evaluated. The spreadsheet used to quantify the evidence for each type of risk and the strength and confidence of the evidence is attached as Appendix 2, and a visual summary of the risks is presented in Figure 6. The values shown in Appendix 2 were assigned by Eric VanderWerf based on personal knowledge and discussions with biologists knowledgeable of the Channel Islands and should be viewed as preliminary; further discussion of the values is encouraged, and scores can be modified as warranted.

I. Risks of no managed relocation action

A. *Risk of no action to the target species.* **VERY HIGH**. The only risk identified as high or very high was the risk of no action to the target species. Laysan and Black-footed albatross populations are predicted to decline sharply over the next several decades because of inundation from sea level rise and increasing storm surge caused by global climate change (Baker et al. 2005, Flint et al. 2011, Reynolds et al. 2015), as described in detail in the section above on Background on North Pacific albatross species. The risk to both species is thus high, the evidence of this risk is strong, all sources of information about albatross population trends concur, and thus the confidence in the evidence of this risk is high. Establishing albatross colonies in the Channel Islands would not alleviate the risk alone, but it is recognized as an important part of the climate change mitigation strategy (Flint et al. 2011).

Another risk of no action is that if albatross attempt to colonize the Channel Islands without human facilitation, there is a considerable likelihood that the initial nesting attempts would be in areas where they are unlikely to be successful, given that most the archipelago's land area has mammalian predators. There is also a possibility that prospecting albatross would select sites where they could create conflicts with human activities, such as airfields, military training areas, or visitor facilities. Proactively steering albatrosses to places where they are more likely be both successful and non-problematic would be beneficial to albatrosses and people.

B. *Risk of no action to the recipient ecosystem*. **LOW.** There is no risk to the Channel Islands of not establishing albatross breeding colonies there. This is a species conservation project, not an ecosystem restoration project. Seabirds can provide valuable ecosystem services, such as nutrient input from the marine environment, but these services are already provided by other seabirds present in the Channel Islands.

II. Risk to the target of managed relocation action

A. *Risk of action to the relocated individuals*. **LOW**. The risk to albatross eggs or chicks during translocation is low, and the evidence for this is strong and the confidence is high. There have been several previous translocation projects involving albatrosses using eggs and chicks, as described above in the section on Seabird Restoration Methods. The logistics and techniques required to transport and raise albatrosses have been worked out and are reasonably safe (Deguchi et al. 2014, VanderWerf et al. 2019). If social attraction were selected as the method of colony establishment, the risk to albatrosses also would be low, provided the project is undertaken in a location that is safe for albatross.

B. *Risk that the target source population cannot withstand diminished numbers*. **LOW**. The risk to the source population from removing individuals for relocation is very low for both species, and the evidence strength and confidence are high. If the Laysan Albatross is selected for managed relocation, eggs would be collected for translocation from a colony at the U.S. Navy Pacific Missile Range Facility on Kauai where albatross are a collision hazard to aircraft. All eggs are legally removed from the colony every year and placed in foster nests (Young et al. 2014). The source population is not wanted, and the goal of current Navy management is to reduce the bird-aircraft strike hazard, in part by reducing the albatross population size (Anders et al. 2009). In this context, removal of individuals from the source population at PMRF is a benefit, not a risk.

If the Black-footed Albatross is selected for managed relocation, chicks would be collected from Midway Atoll National Wildlife Refuge, which supports the largest colony of the species in the world, with about 28,000 pairs. The number of chicks that would be removed for translocation (about 25 per year) is very small compared to the size of colony (<0.1% of the breeding population size). Furthermore, every year hundreds of Black-footed Albatross nests on Midway are destroyed by high waves (Reynolds et al. 2017). Eggs and chicks collected during previous translocations have been taken from areas on the atoll that are at highest risk from inundation and where the nests have a low chance of surviving anyway (VanderWerf et al. 2019).

C. *Risk that removing the target will negatively impact a key function in the source ecosystem*. **LOW**. As described in II.B., Laysan Albatrosses are already being removed from the source population at PMRF to reduce human-wildlife conflict, so there is no additional risk of removal that would result from managed relocation to the Channel Islands. For Black-footed Albatross, the number of chicks that would be removed from the source population is negligible in terms of ecosystem function. The risk of impacting ecosystem function is thus low, and the evidence strength and confidence are high.

D. *Risk of causing undesired evolution in the target species*. **LOW**. This risk category is less relevant to the case of albatrosses in the Channel Islands. No changes in evolution of Laysan or Black-footed Albatrosses are expected to occur because of managed relocation to the Channel Islands. Both species of albatross already forage in waters of the California Current near the Channel Islands. It is possible that albatrosses that nest in the Channel Islands would experience different temperature regimes that might select for tolerance of different thermal regimes, but any such evolution would be beneficial, and the climate in the Channel Islands is not much different from that on Guadalupe Island, where they already nest and which shares some endemic plant species with the Channel Islands.

E. Other risks to the target species. None known.

III. Risks of action to non-targets in the recipient ecosystem

A. *Risk of target transmitting novel disease or pests*. **MODERATE (LOW).** There is some risk that translocated albatross chicks or socially attracted adult albatrosses could carry a disease or parasite to the Channel Islands that is not already present. However, this risk can be reduced using several techniques that have been employed in previous albatross translocations, as described in more detail below. This risk was scored as "moderate" to draw attention to it, but it can be reduced to "low" using the prescribed techniques.

Some albatrosses on Midway and in the main Hawaiian Islands are known be infected with avian poxvirus (*Poxvirus avium*; Young and VanderWerf 2008, VanderWerf and Young 2016). This disease is known to cause decreased survival in some seabirds, and decreased recruitment in Laysan Albatross. In Hawaii it is transmitted primarily by mosquitoes, but it also can be transmitted by physical contact with an infected surface (VanderWerf and Young 2016).

In previous translocations of Black-footed Albatross chicks from Midway to Guadalupe Island, Mexico, chicks were tested for avian poxvirus before being translocated to ensure no chicks were infected. To reduce the risk of introducing external parasites, chicks were treated with a liquid insecticide designed specifically to kill external parasites on birds (Avian Insect Liquidator, Vetafarm brand). This insecticide also has been used to reduce mortality caused by pox virus in Shy Albatross chicks (*Thalassarche cauta*; Alderman and Hobday 2016). Black-footed Albatross chicks translocated to Mexico also were treated for internal parasites using the antiparasitic medications ivermectin and praziquantel, which have proven efficacy against a broad spectrum of parasites including roundworms and tapeworms, respectively.

If eggs were used for translocation instead of chicks, the risk of introducing a disease or parasite would be even lower, because the eggshell itself serves as a barrier to pathogens and parasites. In previous translocation of Black-footed Albatross eggs to Mexico, only eggs that were clean and free of dirt, plant material, and feces on the exterior were selected for translocation, and the exterior of each egg was wiped with a clean, damp cloth to remove any small amount of dirt.

If social attraction were used as the method of attempting to establish albatross colonies in the Channel Islands, the risk of introducing a novel disease or pathogen would be less relevant, because albatrosses already visit the Channel Islands occasionally and thus there is already some risk that visiting albatrosses could introduce a pathogen, though social attraction could cause potential establishment of a pathogen to occur more quickly.

We also note that Channel Islands managers have experience in assessing and managing risks such as these in wildlife management. The Island Fox recovery efforts included the establishment of a Fox Health Working Group of wildlife veterinarians who helped managers assess and manage pest and pathogen risks to the target species (Coonan et al. 2010). A similar group could be established to focus on albatross-related questions and protocols.

B. *Risk of competitive interaction negatively affecting abundance or distribution of non-targets*. **LOW**. Albatrosses are large birds, and though they are generally not aggressive toward other birds, there is a low risk that there could be negative effects on other seabirds that nest on the surface, such as California Brown Pelicans and Western Gulls.

Laysan and Black-footed Albatrosses build a nest cup by scraping together soil and picking small pieces of vegetation around them. Albatrosses often use a “runway” to take off and land, particularly when there is not much wind, and they must get a running start to gain enough lift for takeoff. Albatrosses usually avoid areas with dense, tall vegetation where landing and taking off is more difficult, but if there are endangered, rare, or sensitive plants that have a restricted distribution and grow low to the ground, there is a low risk that albatross could cause negative effects by trampling them or using them for nest material. Seabird trampling of vegetation is an existing issue in the Channel Islands, particularly on Santa Barbara Island, where recovery of native vegetation has been slow because of the high degree of habitat degradation in the past. The endangered Santa Barbara Island live-forever (*Dudleya traskiae*), which is endemic to Santa Barbara Island, has a small population and damage from nesting Brown Pelicans is one of the threats to the species. The live-forever currently occurs primarily on steep rocky slopes of bluffs and canyons, which would not be attractive to albatross, but it presumably was more widespread in the past (USFWS 1985) and restoration efforts are underway to increase its population in other locations away from seabird colonies (D. Mazurkiewicz, NPS, pers. comm). Albatrosses would be less numerous than pelicans or gulls, at least initially, but the risk from albatrosses to native plants, especially the live-forever, should be carefully considered. Further efforts to increase the distribution and abundance of the live-forever might be needed to offset any damage from albatrosses.

C. *Risk of consumptive effects reducing the abundance or distribution of non-targets*. **LOW**. This risk is not relevant to establishing albatross in the Channel Islands. Albatrosses obtain all their food at sea, they do not forage on land, and they already forage in California waters.

D. *Risk of driving undesired evolution in non-targets*. **LOW**. Establishment of albatross in the Channel Islands is not anticipated to cause any changes in the evolution of other species living in the islands.

E. *Other risks of non-target impacts*. None known.

IV. Risks of action to non-target, higher order attributes of the recipient ecosystem

A. *Risk of indirect and negative impacts on ecosystem structure*. **LOW.**

It is conceivable that, if albatrosses are eaten by Bald Eagles, their presence could indirectly increase predation on other native species by increasing the eagle population. Roughly two decades ago, Island Fox populations on the Northern Channel Islands underwent a dramatic decline due to hyper-predation by Golden Eagles whose presence on the islands was supported by the presence of abundant introduced ungulates (Coonan et al. 2010). Removal of this prey subsidy via eradication of feral pigs, deer, and elk was key to the recovery of the fox populations. Introduced Wild Turkeys (*Meleagris gallopavo*) also were removed from Santa Cruz Island in part to remove them as a potential attractant of eagles; there were also concerns about the birds' increasing use of the island's two mowed airstrips for lekking (Morrison et al. 2016). The risk of albatross providing such a subsidy that it would encourage residency and breeding of Golden Eagles was scored as low, because the availability of albatross as prey would be only seasonal, and the Bald Eagles that have been re-established on the island (and which do not regularly depredate foxes) appear to be a deterrent to Golden Eagle settlement due to agonistic interactions.

The natural colonization of Guadalupe Island by Laysan Albatross in the 1980s and subsequent growth of the population offers a parallel scenario, and no negative ecosystem impacts have been described on Guadalupe. This risk was therefore scored as low, and the evidence was scored as moderate.

B. *Risk of changing ecosystem function*. Same as IV.A. Same as IV.A.

C. *Other risks to the recipient ecosystem*. None known.

V. Risks associated with biological invasion

A. *Risk of invasion within the intended recipient ecosystem*. **N/A.** This risk is not relevant to the case of establishing albatross in the Channel Islands. If an attempt is made to establish a breeding colony on an island, the goal would be to have the population on the island increase in size.

B. *Risk of invasion beyond the recipient ecosystem*. **MODERATE.** Albatross forage exclusively in the pelagic ecosystem and they use islands exclusively for nesting and resting, so the risk that they would invade a different ecosystem is low. However, it is possible that albatross could move to different islands from the island on which they were released or attracted, and this can be regarded as a form of invasion beyond the intended recipient island. Albatross already have visited some of the Channel Islands, and it is not clear if social attraction or translocation would increase the chance of albatross visiting non-target islands. Translocation would increase the number of albatrosses visiting the region, but the translocated individuals would be imprinted on the target island, and their presence and social attraction on the target island might decrease the chance that prospecting albatross visit different islands. The risk of movement beyond the target island is difficult to assess and was scored as moderate, with strength of evidence, agreement, and confidence scored as low.

C. *Risk of irreversibility of the managed relocation action*. **LOW.** The risk of establishing albatross in the Channel Islands being irreversible is low, and the evidence for this is strong and confidence is high. Albatross cannot increase in number rapidly because they do not begin breeding until 7-9 years of age and lay only a single egg per year. Moreover, if a breeding population of albatross in the Channel Islands became undesirable for some reason, it would be easy to capture and remove them from the island, though adult albatrosses might return again after they are removed if they are sufficiently imprinted on the island. If necessary, it would be easy to permanently remove them by lethal means. Albatrosses are easy to locate because of their large size and surface-nesting habits. They show little fear of people and predators and can be easily approached and captured. Nesting birds in particular will not leave their nest unless physically removed. Their naivete makes them vulnerable to predators, including people, as evidenced by their abundance in Native American archaeological sites in the Channel Islands and elsewhere in North America, as described in the section above on archeological evidence.

D. *Other risks associated with invasion*. **MODERATE.** Because of their large size and high wing-loading, albatross often favor flat, open, windy areas because those conditions make it easier for them to take off and land. Airfields are often located in areas with these qualities for the same reasons, and there is some risk that albatross will visit and attempt to nest on airfields in the Channel Islands. Laysan Albatross have attempted to nest on the airfield at the Pacific Missile Range Facility on Kauai since the 1980s, where they pose a bird-aircraft collision hazard (BASH), and the U.S. Navy has a management program to decrease this risk, which includes reducing the number of albatross present at the facility (Anders et al. 2009). This risk was scored as moderate, and the evidence strength and confidence were scored as high because this scenario has occurred elsewhere. This risk would be higher if albatross were released on, or attracted to, islands that already contain an airfield, and lower if the action was conducted on islands without an airfield. On the other hand, Laysan Albatross are already visiting San Nicolas, though they have not been observed on the airfield. Social attraction in areas of San Nicolas where albatross would not be a hazard could decrease the chance that they visit the airfield. On islands with military infrastructure, the presence of albatross in training areas could be regarded as a nuisance that might interfere with training activities.

VI. Risks associated with socio-economic values

A. *Risk to a culturally or economically important species*. **MODERATE.** The Island Fox (*Urocyon littoralis*) is endemic to the Channel Islands and is a species with high social and cultural value. It is descended from the Gray Fox (*U. cinereoargenteus*) of North America. The origins of the Island Fox are not clear, with various researchers pointing to archaeological and biological evidence that indicate a natural colonization, translocation by native Americans, or a combination of both, but at least the populations in the southern Channel Islands probably were introduced by Native Americans 2,200 to 3,800 years ago (Collins 1991, Rick et al. 2014). Six subspecies of Island Fox are recognized, each endemic to one of the Channel Islands (it is absent only from Anacapa and Santa Barbara). The subspecies on four of the islands (San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina) were listed as Endangered under the federal Endangered Species Act in 2004; three were delisted, and one was downlisted to Threatened, in 2016. The Island Fox is thought to have played an important role in the culture of native Channel Islanders, who may have kept it as a semi-domesticated pet, and foxes still are regarded as a culturally valuable species.

Albatrosses are naïve and vulnerable to ground predators, and the Island Fox likely would be a threat to albatross eggs and chicks and possibly breeding adults that did not flee from the nest. If albatrosses were translocated to an island with an Island Fox population, it would be necessary to build a predator exclusion fence to protect albatrosses from foxes. Predator exclusion fences are generally effective if well sited and built according to specifications, but there could be occasional breaches of the fence caused by erosion or rockfall (Young et al. 2013), and foxes might be able to dig under a fence depending on the substrate. It is also possible that some albatrosses would settle outside the fence, where they would be vulnerable to foxes. Any of these scenarios could create a controversial situation in which the welfare of albatrosses must be weighed against the welfare of foxes, with potentially strong opinions on both sides.

B. *Risk to a valued ecosystem service*. None known.

C. *Other risk associated with socio-economic values*. None known.

Ecological Risk Summary

Based on an analysis using the framework provided by Karasov-Olson et al. (2021a), the risks associated with attempting to establish albatross breeding colonies in the Channel Islands are generally low. The only high or very high risk is to the target species (albatross) if no action is taken (Figure 6, Appendix 2). There were four potential risks rated as moderate to the ecosystem, other native species, and land uses in the Channel Islands:

- III.A. There is some risk that translocated albatross chicks or socially attracted adult albatross could carry a disease or parasite to the Channel Islands that is not already present. This risk can be mitigated to a large degree using techniques employed in previous albatross translocation so that the risk would be low.
- V.B. Albatross could move from the island on which they were released or attracted to different islands where they are not wanted, and this can be regarded as a form of invasion beyond the intended recipient ecosystem. However, Laysan Albatross already have visited some of the Channel Islands, and it is not clear if social attraction or translocation would increase or decrease the chance of albatross visiting non-target islands.
- V.D. Albatrosses are sometimes attracted to airfields because of their flat terrain and favorable wind conditions, and there is some risk that albatross will visit and attempt to nest on airfields in the Channel Islands, where they could pose a collision hazard with aircraft.
- VI.A. If albatrosses were translocated to an island with an Island Fox population, it would be necessary to build a predator exclusion fence to protect albatrosses from foxes. If foxes were able to dig under the fence or there was fence break caused by erosion or rockfall, or if albatrosses settle outside the fence, it could create a situation in which the welfare of albatrosses must be weighed against the welfare of foxes.

Figure 6. Visual summary of potential ecological risks of managed relocation of albatrosses to the Channel Islands. From Karasov-Olson et al. 2021a. Values used to produce this summary are shown in Appendix 2. Row numbers refer to rows in the spreadsheet in Appendix 2.

Section	**Risk Criteria**				
Risk of:	A	B	C	D	E
I. No action	Row 12	Row 13			
II. Action to the target	Row 18	Row 20	Row 22	Row 24	Row 26
III. Action to non-targets	Row 33	Row 34	Row 35	Row 36	Row 38
IV. Action to recipient ecosystem	Row 45	Row 46	Row 48		
V. Spread and invasion	Row 55	Row 56	Row 58	Row 60	
VI. Adverse socio-economic values	Row 67	Row 68	Row 70		

Risk	**Confidence**
Low	High
Moderate	Moderate
High	Low
Very High	

TIMELINE

There are several advantages to undertaking this action soon. Waiting could increase the difficulty and cost of the project and decrease its value.

- Laysan and Black-footed Albatrosses currently are relatively common and widespread, and collecting eggs or chicks for translocation currently is easy. Their populations are expected to decline, however, as breeding colonies in Hawaii become inundated. Collecting chicks in particular will become more difficult over time because many nests will be destroyed by waves before the eggs hatch. If either species becomes listed under the ESA, additional permits and consultations would be required and that would add to the regulatory requirements and cost of the project. The Black-footed Albatross was petitioned for listing under the ESA once before.
- Laysan Albatrosses are already visiting the Channel Islands and this visitation can be expected to increase as the colony on Guadalupe Island grows and albatross are displaced

from inundated colonies in Hawaii. They may begin attempting to breed on one or more of the Channel Islands, and they may choose a location that is not safe for them or where they might be considered a nuisance. Creating a colony in a safe, desirable location proactively could attract visiting albatrosses to the site, avoiding potential conflict and harm to the species. If this project is implemented after albatross have already begun nesting elsewhere in the Channel Islands, the managed colony would have to compete for recruits with the naturally established colony.

- Establishing an albatross colony is a long-term process. Laysan and Black-footed Albatrosses begin breeding when they are about 7-9 years old (VanderWerf and Young 2016), and they lay only a single egg per year. Albatross populations grow slowly and it will take decades to establish an albatross breeding colony in the Channel Islands. For example, Laysan Albatross colonized Guadalupe in 1983 (Gallo-Reynoso and Figueroa-Carranza 1996), and this colony grew to 193 pairs in 2000 (Pitman et al. 2004), at an average rate of 10% per year from 2003 to 2013 to 646 pairs (Henry 2011, Hernández-Montoya et al. 2014), and to 1,279 pairs in 2019 (Hernández-Montoya et al. 2019). Figure 7 shows the growth rate of the Laysan Albatross colony at Punta Sur on the main island of Guadalupe (not including the offshore islets).

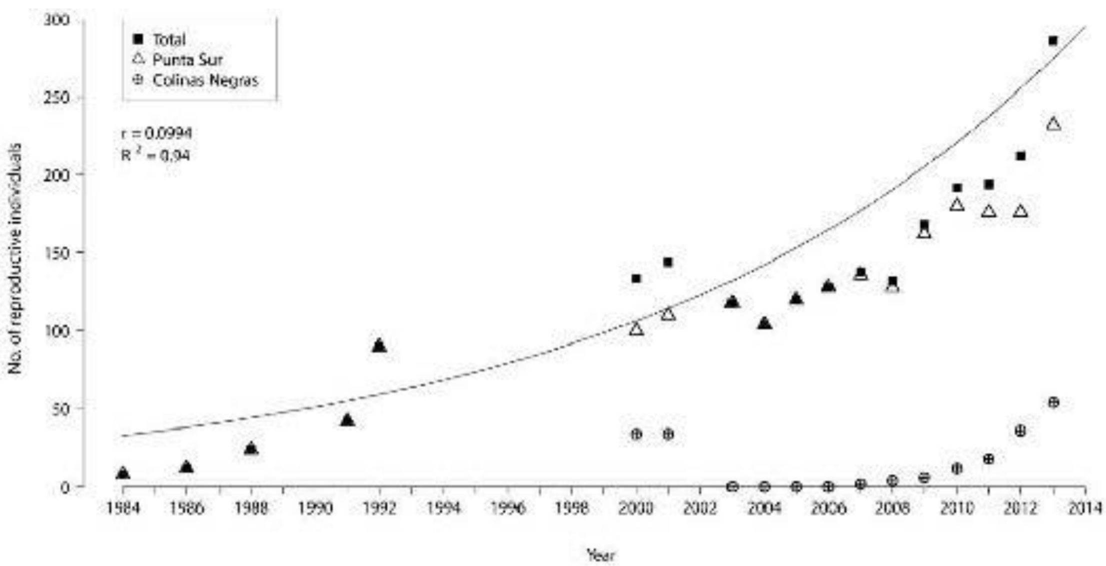


Figure 7. Growth of the Laysan Albatross colony on Guadalupe's main island from 1984 to 2013. Taken from Figure 3 of Hernández-Montoya et al. (2014).

CONCLUSIONS

1. **WHY** is there a need to undertake managed relocation of North Pacific albatrosses?
   a. Laysan and Black-footed Albatrosses are threatened by climate change and their populations are expected to decline severely in the next several decades as breeding colonies on low-lying islands in Hawaii are inundated.
   b. The USFWS recommended in 2011 that additional albatross breeding colonies be created on higher islands. Such efforts are underway in Hawaii and Mexico but have not begun in California.

2. **WHERE** is the best location to attempt establishing an albatross colony in the Channel Islands?
    a. A preliminary assessment of each of the Channel Islands using 16 criteria indicated that **Santa Barbara and San Nicolas** offered the best opportunities.
3. **HOW** could establishment of albatross colonies in the Channel Islands be accomplished most effectively?
    a. **Social attraction** has a low probability of resulting in establishment of an albatross colony in the Channel Islands because few albatrosses come close to the islands, but it would be easy and inexpensive to implement, and the chance of success may increase over time as the number of visiting albatross increases. Social attraction of Laysan Albatross would have the greatest chance of success on San Nicolas, where they have already visited.
    b. **Translocation** could be used effectively with either Laysan or Black-footed Albatross and has a high chance of success. The techniques for translocating and raising albatrosses are well established and have been used successfully with both species previously.
4. **WHEN** would it be most advantageous to attempt establishing an albatross colony in the Channel Islands?
    a. This project would be easier to implement before the albatross species decline. Large declines are expected in Laysan and Black-footed Albatross populations as a result of climate change, but the rate of decline is difficult to predict because of uncertainties in the rate and extent of sea level rise. However, significant portions of the predicted declines can be expected to occur in the next several decades. If either species were listed as endangered under the ESA, additional permits and consultation would be required, which could increase the cost of the project and require more time to complete regulatory requirements.
    b. Collecting eggs or chicks for translocation will become more difficult as current colonies on low islands are inundated and there are fewer nests to choose from. Although the number of nests currently is large, obtaining chicks of the right age for translocation limits the number that are suitable and narrows the window when the project can be implemented.
    c. The frequency of observations of all three albatross species in California waters is increasing and can be expected to continue increasing. It is possible that Laysan Albatross may naturally colonize one or more of the Channel Islands and they may choose a location that is not safe for them or where they might be considered a nuisance. Creating a colony in a safe, desirable location proactively could attract visiting albatrosses to the site, avoiding potential conflict and harm to the species.
5. **IF** it is appropriate to establish albatrosses breeding colonies in the Channel Islands. As mentioned in the Introduction, this report does not attempt to reach a conclusion about *if* efforts should be made to establish an albatross breeding colony in the Channel Islands; that decision is the purview of the island managers, but the following conclusions are relevant to making that decision.
    a. Failing to undertake this project would eliminate one of few management actions available to help mitigate the effects of human-caused climate change on north Pacific albatross species.

b. Laysan, Black-footed, and Short-tailed Albatrosses are native to this region; the California Current is part of the natural foraging range. They commonly feed in deeper water outside the continental shelf and occasionally visit shallower water around the Channel Islands and the islands themselves. Establishing a breeding colony would change the way in which albatross use the region, but it would not be an introduction.
c. Archaeological evidence demonstrates that albatrosses occurred historically in the Channel Islands, and that they were hunted disproportionately compared to other seabirds. It is possible that predation by humans and predators introduced by humans extirpated any previously existing breeding colonies or prevented albatrosses from establishing breeding colonies in the Channel Islands.
d. Establishing albatross breeding colonies in the Channel Islands could help to restore Native American cultural connections to the species.
e. The risks associated with managed relocation of albatross to the Channel Islands are generally low. There are a few moderate risks, some of which can be at least partially alleviated. Some of the risks are already occurring because the Laysan Albatross is already visiting the islands and establishing a breeding colony might not substantially alter the existing risk levels.

In closing, we offer the following additional considerations and observations. Conservation of wide-ranging species, especially in an era of global change, often requires coordination and collaboration across jurisdictions and scales. An extensive network of land managers, agencies, NGOs, and academic scientists have been active in advancing initiatives to proactively address climate-exacerbated risks to the three North Pacific albatross species. Indeed, these collaborative actions have proven very successful, highlighting the strength of the existing partnership capacity and demonstrating that albatrosses respond well to these actions. If managers of the California Channel Islands were to decide to proceed with planning and implementation in this arena, they would be able to leverage that well-established network of expertise and experience. And their engagement in this Pacific-wide initiative would not only strengthen and expand this collaborative network, it also would create another demonstration of the power of partnerships for rising to the unprecedented conservation challenges of our day. Efforts at albatross conservation have extended across international boundaries to Mexico and have demonstrated the capacity to collaborate effectively even during difficult times. Parallel efforts at albatross conservation in the Channel Islands and Guadalupe Island would further solidify their status as sister parks and build on previous collaborations on seabird and habitat restoration.

Managers of the California Channel Islands do have experience with conservation translocations, having accomplished several high-profile reintroductions, including Bald Eagles (Newsome et al. 2010) and Sea Otters (Rathbun et al. 2000, Couffer 2017). Notably, these projects had uncertainties and recognized risks prior to implementation – including risks of failure and risks to non-target species – but managers nevertheless made the decision to proceed using an experimental rubric (Morrison et al. 2014). Today those successful projects are held up as examples of inspiring conservation leadership and provide an evidence-based structure for approaching albatross translocation. The success of these experimental conservation interventions has led to visitor benefits for Channel Islands National Park. Bald Eagle nest camera livestreams are now a popular element of the Channel Islands National Park public engagement and interpretation program. Sightings are now common across the Channel Islands and are recognized for enhancing the visitor experience. Albatross could be the focus of similar public attention. Especially because albatross are such charismatic species, their translocation in the Channel Islands would offer similar opportunities for public education and interpretation about the natural and cultural history of the islands, conservation, and climate change.

At this juncture, the next question to address is whether managers would like to conduct further planning and analysis. If it is decided that the Channel Islands should be a focus of albatross breeding colony establishment, the next questions would be: 1) which *species* to work with (Laysan or Black-footed); 2) which *island* to work on; and 3) *when* to act. Our strong recommendation would be to implement this project sooner rather than later. Due in large part to the birds' biology, establishing a self-sustaining and robust albatross breeding colony will take time, probably decades. For that colony to best serve its needed conservation purpose, it needs to be meaningfully contributing to the broader population and species viability *before* the existing breeding colonies further degrade in habitat quality (McDonald-Madden et al. 2011; Bakker et al 2017). As we discussed throughout this document, the low-lying breeding colonies are highly vulnerable: sea level rise is accelerating and catastrophic events like tsunamis can occur at any time.

As we have presented here, establishing albatross breeding colonies on the California Channel Islands would be both important for the viability of the focal species and technically feasible to implement. Next steps in the exploration of this concept in the Channel Islands would include:

- Assess manager interest in undertaking further consideration of this initiative on their island holdings; identify lead personnel for further planning.
- Identify the planning, environmental review, and permitting process requirements, which may differ based on the focal island; identify agency lead(s) for compliance processes.
- Conduct island-specific planning, including considerations related to alignment with mission, mandates, goals, and priorities of the focal island manager.

As discussed above, an extensive network of collaborators in albatross conservation – including Pacific Rim Conservation – stands ready to assist in these efforts.

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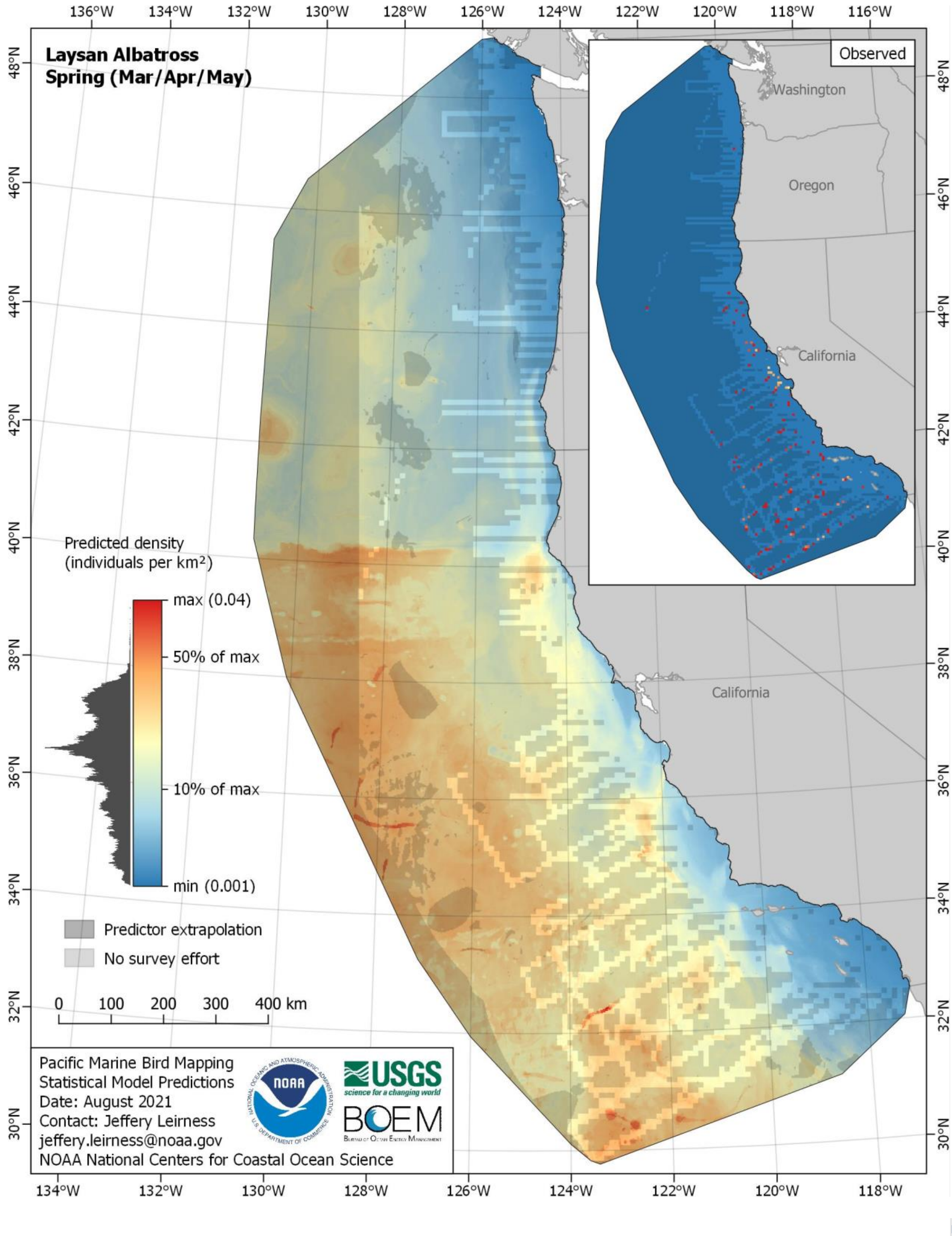
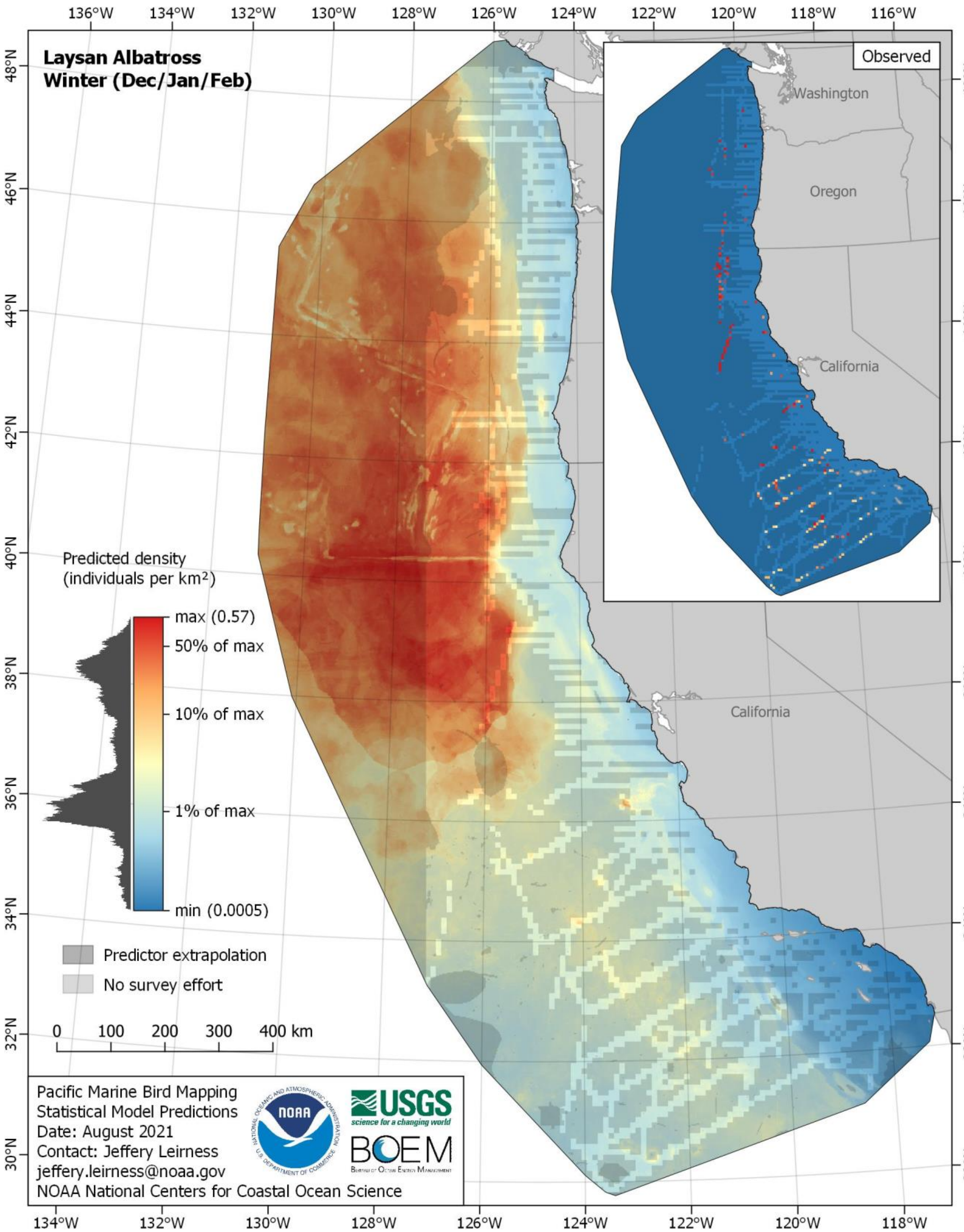
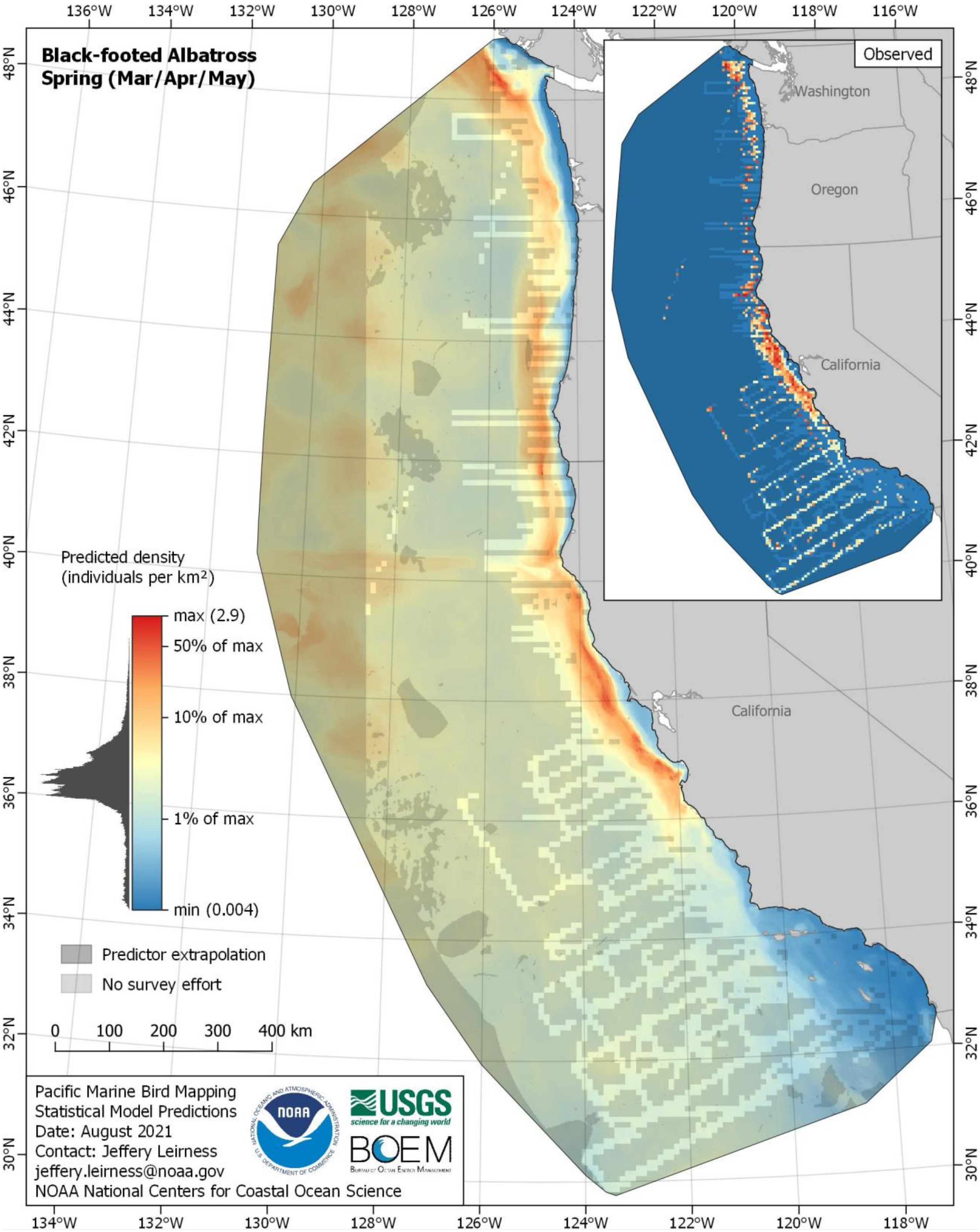
Appendix 1. Distribution maps of Laysan and Black-footed Albatrosses off western North America based on observations from NOAA research cruises, from Leirness et al. (2021). For Black-footed Albatross, separate maps were created for Spring, Summer, Fall, and Winter. For Laysan Albatross, there were enough observations to create maps only for Spring and Winter.

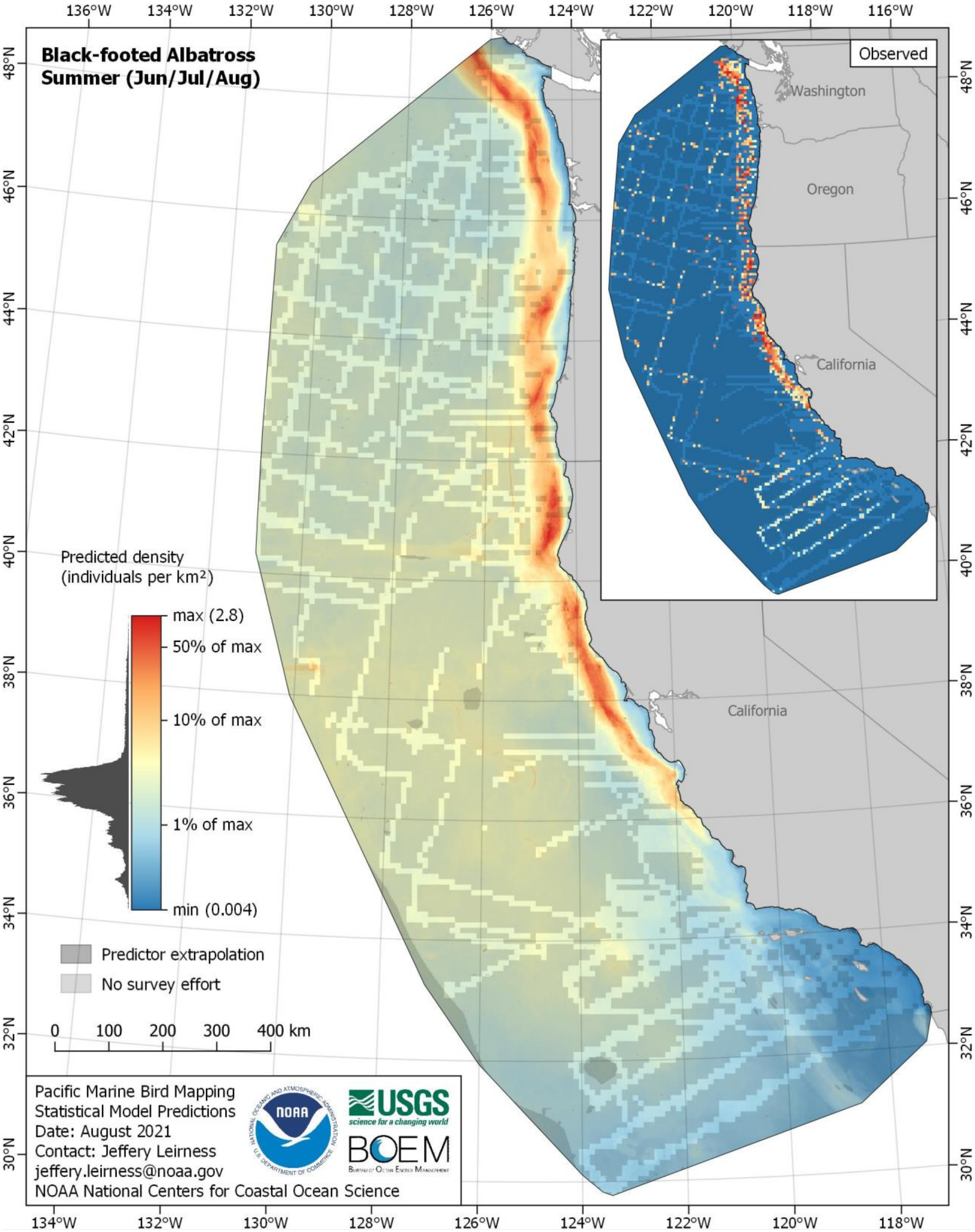




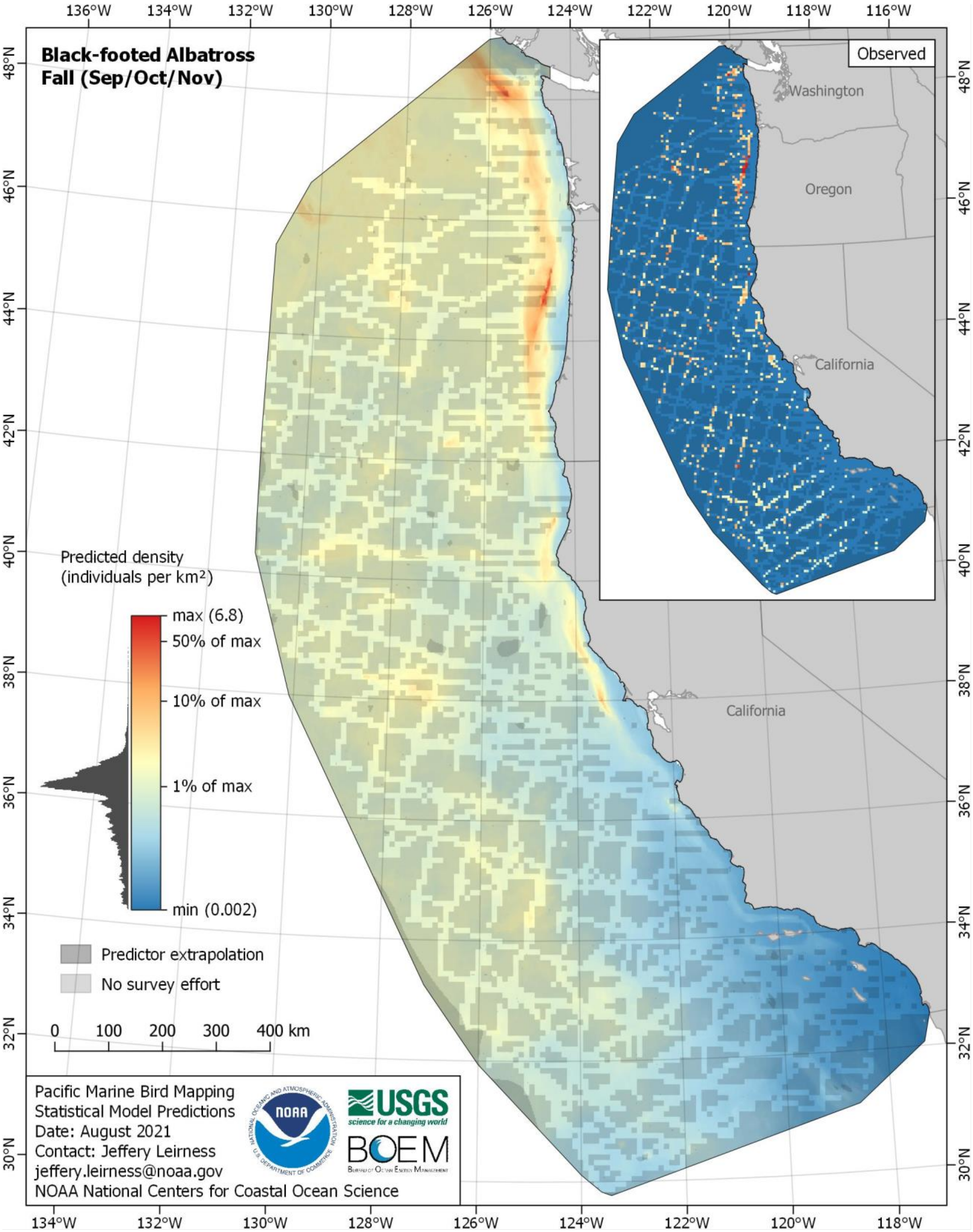
Laysan Albatross
Winter (Dec/Jan/Feb)
Observed
Washington
Oregon
California
California
Predicted density
(individuals per km²)
max (0.57)
50% of max
10% of max
1% of max
min (0.0005)
Predictor extrapolation
No survey effort
0 100 200 300 400 km
Pacific Marine Bird Mapping
Statistical Model Predictions
Date: August 2021
Contact: Jeffery Leirness
jeffery.leirness@noaa.gov
NOAA National Centers for Coastal Ocean Science
136°W 134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W
134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W
48°N 46°N 44°N 42°N 40°N 38°N 36°N 34°N 32°N 30°N

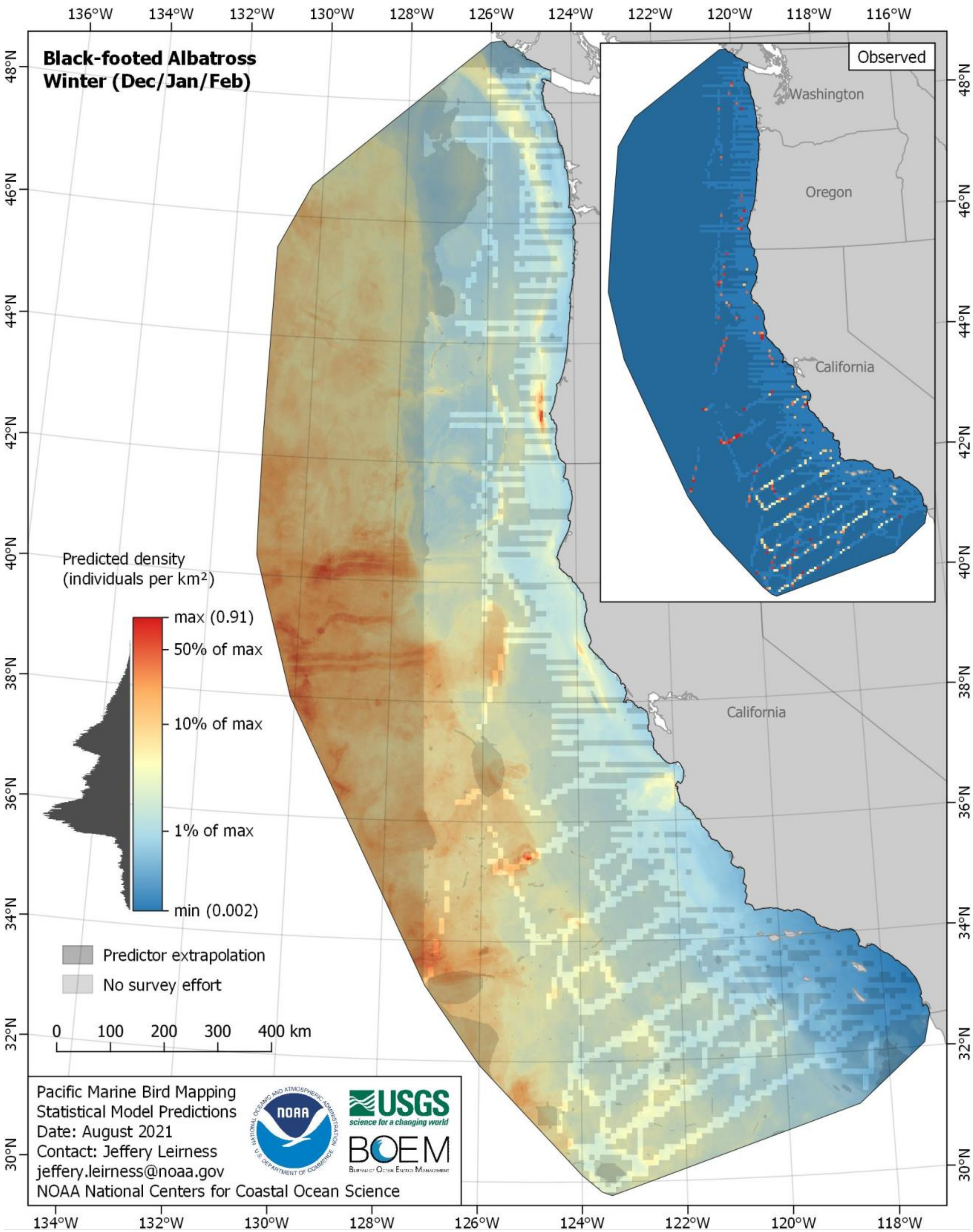


Black-footed Albatross
Spring (Mar/Apr/May)
Observed
Washington
Oregon
California
California
Predicted density
(individuals per km²)
max (2.9)
50% of max
10% of max
1% of max
min (0.004)
Predictor extrapolation
No survey effort
0 100 200 300 400 km
Pacific Marine Bird Mapping
Statistical Model Predictions
Date: August 2021
Contact: Jeffery Leirness
jeffery.leirness@noaa.gov
NOAA National Centers for Coastal Ocean Science
136°W 134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W
134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W
48°N 46°N 44°N 42°N 40°N 38°N 36°N 34°N 32°N 30°N



Black-footed Albatross
Summer (Jun/Jul/Aug)
Observed
Washington
Oregon
California
California
Predicted density
(individuals per km²)
max (2.8)
50% of max
10% of max
1% of max
min (0.004)
Predictor extrapolation
No survey effort
0 100 200 300 400 km
Pacific Marine Bird Mapping
Statistical Model Predictions
Date: August 2021
Contact: Jeffery Leirness
jeffery.leirness@noaa.gov
NOAA National Centers for Coastal Ocean Science
136°W 134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W
48°N 46°N 44°N 42°N 40°N 38°N 36°N 34°N 32°N 30°N
134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W


Black-footed Albatross
Fall (Sep/Oct/Nov)
Observed
Washington
Oregon
California
California
Predicted density
(individuals per km²)
max (6.8)
50% of max
10% of max
1% of max
min (0.002)
Predictor extrapolation
No survey effort
0 100 200 300 400 km
Pacific Marine Bird Mapping
Statistical Model Predictions
Date: August 2021
Contact: Jeffery Leirness
jeffery.leirness@noaa.gov
NOAA National Centers for Coastal Ocean Science
USGS
science for a changing world
BOEM
136°W 134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W
134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W
48°N 46°N 44°N 42°N 40°N 38°N 36°N 34°N 32°N 30°N


Black-footed Albatross
Winter (Dec/Jan/Feb)
Observed
Washington
Oregon
California
California
Predicted density
(individuals per km²)
max (0.91)
50% of max
10% of max
1% of max
min (0.002)
Predictor extrapolation
No survey effort
0 100 200 300 400 km
Pacific Marine Bird Mapping
Statistical Model Predictions
Date: August 2021
Contact: Jeffery Leirness
jeffery.leirness@noaa.gov
NOAA National Centers for Coastal Ocean Science
136°W 134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W 116°W
134°W 132°W 130°W 128°W 126°W 124°W 122°W 120°W 118°W
48°N 46°N 44°N 42°N 40°N 38°N 36°N 34°N 32°N 30°N