A Summary and Gap Analysis of Seabird Monitoring in the U.S. Tropical Pacific

Dr. Eric A. VanderWerf and Dr. Lindsay C. Young

Pacific Rim Conservation, PO Box 61827, Honolulu, HI 96839

Report prepared for the U.S. Fish and Wildlife Service, National Wildlife Refuge System, Office of Migratory Birds, and the Inventory & Monitoring Program

Suggested citation: VanderWerf, E.A., and L.C. Young. 2017. A summary and gap analysis of seabird monitoring in the U.S. Tropical Pacific. Report prepared for the U.S. Fish and Wildlife Service, Region 1, Portland OR. Pacific Rim Conservation, Honolulu, HI. 59 pp, 1 table, 45 figures, 4 appendices.

Executive Summary: The Pacific Seabird Program (PSP) was created by the U.S. Fish and Wildlife Service in 2015 in order to address information needs, promote partnerships, meet legal mandates, and contribute to effective delivery of relevant and transparent products that can inform seabird conservation in the Pacific Region. The U.S. Tropical Pacific (USTP) is a globally important area for seabirds, supporting breeding populations of at least 31 seabird species. For purposes of this report relative to seabird monitoring, the USTP can be partitioned into five geographic regions: the Main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), the Mariana Islands (MI), American Samoa (AS), and Pacific Remote Islands Marine National Monument (Remotes). In order to better understand seabird monitoring in the USTP, identify gaps in geographic and species coverages, and provide strategic guidance, an electronic questionnaire was distributed to resource managers and biologists in these USTP regions. It included questions about species present at sites and various aspects of the monitoring activities, including what types of data are being or have been collected for each species. The questionnaire was sent to 30 individuals. Responses were received from 23 individuals characterizing seabird monitoring at 43 sites on 30 islands; where necessary, supplemental data about species presence and monitoring was obtained from reports and other sources to provide more complete information.

Goals of monitoring programs varied and all programs had multiple goals. The most common goals were monitoring population size and trend and measuring effects of threats and/or management. Monitoring programs varied considerably in how often results were summarized, length of the data set, use and source of written protocols, number of people involved, and funding sources.

The 31 seabird species in the USTP varied in their distribution, with some species being widespread and occurring on most islands in all regions (e.g., Wedge-tailed Shearwater, Red-tailed Tropicbird, Black Noddy), and other species being restricted to just one or a few islands in one region (e.g., Short-tailed Albatross, Tahiti Petrel, Tropical Shearwater, White-throated Storm-petrel). Thirty species (97%) were monitored in at least a portion of their range. The proportion of islands where each species was monitored varied considerably. Some species were monitored on every island where they occur and others were monitored in just one location. Species were monitored on an average of 64% of the islands on which they occurred in all geographic regions combined. In general, monitoring levels were highest in the MHI (65%), NWHI (63%), and Remotes (91%), and lower in the MI (26%) and AS (33%).

The intensity of monitoring and types of information collected varied widely among species, ranging from irregular visits to determine presence/absence to comprehensive demographic and behavioral monitoring. Intensity of monitoring also was related to relative ease of monitoring. For example, larger species that roost and nest above ground and are easy to detect (e.g., albatross, boobies, frigatebirds) were generally monitored in more locations than smaller species that nest in burrows, and more information was collected about them. There also was more comprehensive monitoring for species federally listed under the Endangered Species Act (Short-tailed Albatross, Hawaiian Petrel, Newell's Shearwater, and Band-rumped Storm-petrel). Each of these species was monitored on every island where it was known to occur, sometimes at multiple sites, and also on islands where they were suspected to occur.

Table of Contents

List of Appendices

List of Tables

List of Figures

INTRODUCTION

The U.S. Fish and Wildlife Service (USFWS) has resource responsibility for tens of millions of seabirds across the Pacific, from Alaska to California and the tropical Pacific islands. Results of long-term monitoring efforts have shown that seabirds can be used as indicators of local and large-scale change in the marine environment (Dearborn et al. 2001, Piatt et al. 2007). Seabird populations can be dramatically impacted by human activities including fisheries, oil extraction and transportation, persistent organic pollutants, commercial harvest, introductions of invasive species, disturbance, and anthropogenically influenced increases in predator populations (Furness 2003, USFWS 2005, Jones et al. 2008, Curry et al. 2011). Scientific information about current distribution and abundance of seabird species is needed for a variety of reasons ranging from resource and public-use management to assessing the impacts of sea level rise, informing fisheries stock assessments, and geographic planning for preventing and responding to oil spills or seabird-fisheries interactions. Unfortunately, strategic and necessary seabird conservation measures sometimes are hindered by limited and outdated data or data that is not managed, analyzed, and reported in a timely manner.

The majority of seabirds in the U.S. portion of the Tropical Pacific (USTP), which consists of Hawaii and other U.S. affiliated islands in the tropical Pacific, nest on national wildlife refuges on remote islands or other public lands. Many of these species spend the majority of their time at sea and only return to land to breed (Harrison 1990). As a result, breeding colony surveys often provide the most accurate and efficient method of assessing and monitoring population sizes (Citta et al. 2007). In some areas of the USTP, such as the Commonwealth of the Northern Mariana Islands (CNMI), an inventory of species is needed as well as more in-depth colony or population monitoring. During a time of global decline for approximately 70% of seabird populations as well as shifting ranges (Gremillet et al. 2009, Weimerskirch et al 2012), it is imperative to conduct a consistent, comprehensive assessment of the abundance and distribution of seabirds in the USTP, particularly for those species that are rarely monitored.

In addition, monitoring protocols for many seabird species in the Pacific have not been standardized among sites or have been modified over time, making spatial and temporal comparisons of status and trends of populations and quantification of long-term demographic parameters (e.g., productivity) problematic (Citta et al. 2007). Existing protocols need to be updated and then widely embraced to ensure common standards across the USTP. Inventories of many species and locations are either incomplete or greatly outdated (>30 years old) throughout the USTP (Fefer et al. 1983). Moreover, application of new technologies may reduce expense, increase efficiency, improve safety and, in turn, enhance the sustainability of seabird surveys at remote sites.

The purpose of this project was to conduct a gap analysis of seabird monitoring to support the prioritization of species to be inventoried and monitored in the USTP. This analysis identified gaps in survey information for species, sites, and time periods based on data being collected in order to identify seabird monitoring needs in the USTP. The information for the gap analysis was generated from a questionnaire to identify species of seabirds occurring on all islands in the USTP, whether they are being or were historically monitored, what types of data are collected, and the objectives of the monitoring. By identifying gaps, it is anticipated that there will be increased coordination and consistency among seabird biologists in USTP, and ultimately increased capacity for monitoring seabird populations. Moreover, this information will

be valuable to inform the priority work of USFWS's new Pacific Seabird Program (PSP), which seeks to address seabird monitoring and conservation issues throughout the Pacific.

METHODS

Geographic scope

This analysis focused on the USTP, which includes the State of Hawaii and various other U.S. territories, possessions, and islands that have an association with the U.S. (Figure 1). For the purposes of this report, these islands were grouped into five geographic regions: 1) the Main Hawaiian Islands (MHI), encompassing the larger islands from Hawaii Island west to Niihau, and including the offshore islets that are geologically associated with each larger island; 2) the Northwestern Hawaiian Islands (NWHI) from Nihoa west to Kure Atoll; 3) the Mariana Islands (MI), including Guam and the Commonwealth of the Northern Mariana Islands (CNMI); 4) American Samoa (AS), including Rose Atoll and Swains Island; and 5) the Pacific Remote Islands Marine National Monument (Remotes), which includes Palmyra Atoll, Kingman Reef, Wake, Johnston, Jarvis, Howland, and Baker. This analysis did not include the Republic of Palau or the Federated States of Micronesia, although those island groups do have associations with the U.S. A list of all islands in each region is in Appendix 1, and maps of these regions are shown in Appendix 2.

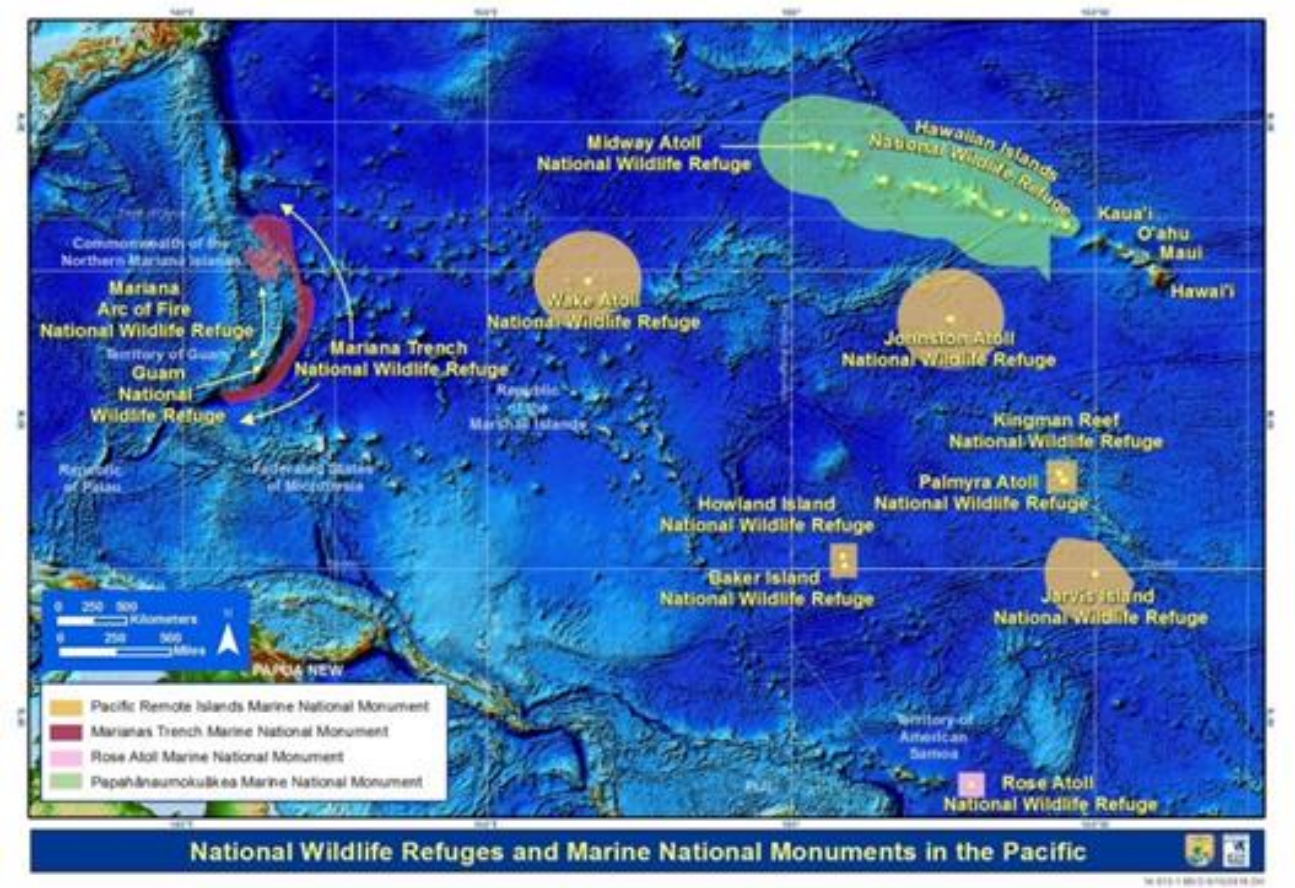


Figure 1. Map of U.S. Tropical Pacific for purposes of assessing seabird monitoring activities.

Selection of questionnaire participants

Participants were identified based on whether they actively worked with seabirds in a management or research capacity, including state, federal, and private entities. Organizations and individuals whose involvement with seabirds in the USTP was limited to project funding or development were not asked to complete the questionnaire because they were not conducting seabird monitoring in the USTP.

The first step in identifying potential participants was attendance at a PSP monitoring session during the Pacific Seabird Group annual meeting in Hawaii in February 2016; a primary goal of that session was to discuss seabird monitoring in the USTP, and a result of the discussion was a recommendation to conduct a gap analysis and develop a seabird geospatial database. A list was subsequently compiled of managers or other scientists responsible for all sites known or suspected to support seabirds on every island within all five of the geographic regions of the USTP. This resulted in a list of 30 biologists and managers (Appendix 3). Each person on this list was asked to complete the questionnaire. Some individuals were responsible for multiple sites on multiple islands. In some cases, the questionnaire was sent to more than one person in the same agency responsible for a given site in order to increase the likelihood of receiving a response, and to ensure supervisors were aware of the request for information. If a participant did not respond to the email requesting assistance with the questionnaire, a follow-up email was sent asking him or her again to complete it.

Questionnaire design

The questionnaire consisted of an Excel spreadsheet with three tabs (Appendix 4), and was distributed via e-mail. The first tab, labelled "Questions," asked each respondent to provide his/her name, organization, title, region or state, and email address, and then answer a series of questions about various aspects of their monitoring activities (Table 1).

Table 1. Information requested under the first tab of the seabird monitoring questionnaire.

Question
Name
Organization
Title
Region/state
email address
How long have you (or your organization) been collecting seabird data at your sites?
How many people typically are involved in your surveys?
What currently limits your ability to conduct monitoring?
How are your data stored?
Do you have a written data collection protocol that is followed during your surveys?
Who developed your protocols?
How frequently are your results summarized or reported?
Who funds your work?
Are volunteers or the public involved in the monitoring?
What are the goals of your monitoring? (choose for each one)
Goal 1: Measure population size+trend

Goal 2: Determine distribution
Goal 3: Measure aspects of population biology/breeding biology
Goal 4: Collect natural history information
Goal 5: Measure effect of threats and/or management
Goal 6: Scientific research
Other goals (please specify):
Do you plan to begin collecting any additional data?
Is there other information would you like to know about your species or sites?
Are there sites where seabirds are suspected to occur but not confirmed or species that have not been identified?

The second tab, entitled "Species by site," consisted of a list of seabird species known to occur in the USTP, recognizing that not all species listed would occur at every site. Respondents were asked to add the name(s) of the sites where they monitored seabirds and indicate whether each species was present and monitored at each site. If a species didn't occur at a site, then the cell was to be left blank.

Under the third tab, entitled "Data by species," respondents were asked to indicate the frequency and season/months of monitoring, types of data being collected on each species present at their monitoring site(s), and whether each type of monitoring is done currently, historically only, or is anticipated. The categories of data were the following:

- Total colony counts
- Total nest counts
- Minimum incubation counts
- Roosting counts
- At-sea counts from shore
- At-sea counts from vessel
- Nest/burrow occupancy
- Hatching success
- Fledging success
- Overall breeding success
- Chick growth or morphometrics
- Adult morphometrics
- Nesting phenology
- Adult banding
- Chick banding
- Mark-recapture
- Diet
- Plastics ingested
- Tracking movements
- Blood, feather, or tissue sampling
- Contaminants
- Predation
- Acoustic monitoring
- Remote cameras

Data analysis of questionnaire responses

Responses to questions under the first tab about aspects of monitoring activities were tallied by category and then summarized graphically using pie charts. In cases where the goals or methods varied among sites or islands covered by a single respondent, the responses for each site or island were counted separately.

Geographic data about species presence and monitoring were compiled for all sites, then grouped by island (e.g., Kauai), and then binned into the five regions. Bar graphs were created to depict the number of islands on which each species was known or suspected to be present, and to illustrate the proportion of islands on which each species was monitored, for all islands combined, and by region to illustrate geographic variation.

Monitoring of individual species was measured and illustrated in several ways. First, graphs illustrating the proportion of sites where each species is monitored were generated to identify gaps in regional and species coverage. Second, pie charts were used to illustrate the frequency of monitoring for each species. Third, to elucidate the individual monitoring coverage, bar graphs of the number of sites employing each monitoring method were generated for each species.

RESULTS

Questionnaire response rate

We received questionnaire responses from 23 of 30 individuals (77%) characterizing seabird monitoring at 43 sites on 30 islands. Some respondents provided information about sites we did not know about or subdivided their response into additional sites. One respondent answered the questions on the first tab of the questionnaire but did not provide any information about the species present and whether they were monitored. In one case where a response was not received (Farallon de Medinilla in the CNMI), the individual was contacted by phone and the information provided verbally was entered into the questionnaire. In six cases where we did not receive information (Kaula Islet, Kilauea Point National Wildlife Refuge on Kauai, Oahu offshore islets, Swains Island in American Samoa, the National Park of American Samoa, and Tinian and Aguigan islands in the CNMI), we obtained information from reports provided by the individual or from other sources or our personal knowledge that allowed us to complete at least some portions of the questionnaire. This resulted in a final data set consisting of 51 sites on 35 of the 47 islands in the USTP.

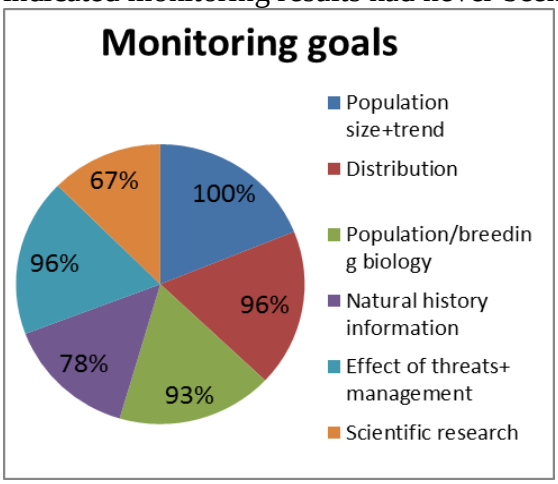
The response rate to the questionnaire varied by region. For the MHI, we obtained information for 24 of 25 sites (all except Kauai coastal sites) on all nine islands, except Niihau, which was not included in the questionnaire. For the NWHI, we obtained information for all nine islands, each of which comprised a single site. For the Remotes, we obtained information for all seven islands, each of which comprised a single site. For the MI, we obtained information for eight sites on six islands (Tinian, Aguiguan and Naftan Rock, Rota, FDM, Alamagan, Sarigan, and Managaha Islet off Saipan). For AS, we obtained information on four islands (Tutuila, Tau, Swains Island, and Rose Atoll, but not Ofu-Olosega).

Monitoring program aspects

Goals of monitoring programs varied among respondents, and all programs had multiple goals. The most common goal was monitoring population size and trend of species present at the site, which was a goal of every program (Figure 2). The second most common goals were

monitoring species distribution and measuring effects of threats and/or management. The least common goal was scientific research, though research was still a goal for two-thirds of the programs.

Programs also varied substantially in how often the results monitoring activities were summarized and reported. Although >50% of programs provided annual reports, >25% of respondents indicated their results were reported only irregularly, and a few participants indicated monitoring results had never been summarized or reported (Figure 3).



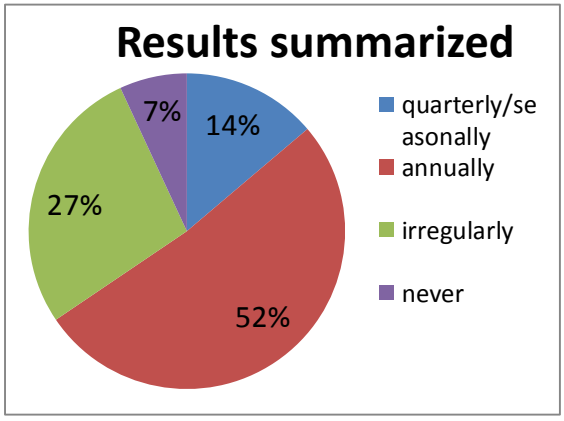
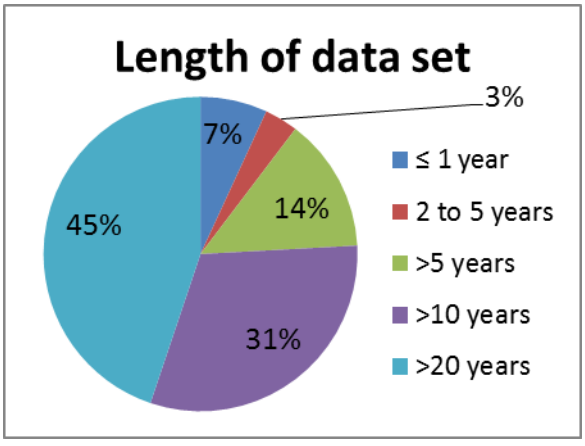


Figure 2 (left). Goals of seabird monitoring programs in the USTP. The percentages add up to more than 100% because respondents were allowed to select multiple answers.
Figure 3 (right). Frequency with which monitoring results of seabird monitoring activities in the USTP are summarized.

The duration of data collection varied among monitoring programs. Almost half of the programs had been in existence for over 20 years (Figure 4), many of which were in the NWHI and were administered by the USFWS. Some long-term programs have been discontinued. In contrast, there also were relatively new monitoring programs activities that began within the last year.

Although most monitoring programs in the USTP store their data on a computer, only a few utilize servers or cloud-based storage (Figure 5). One respondent indicated that data existed only in notebooks or paper form which had not been entered electronically (Figure 5).



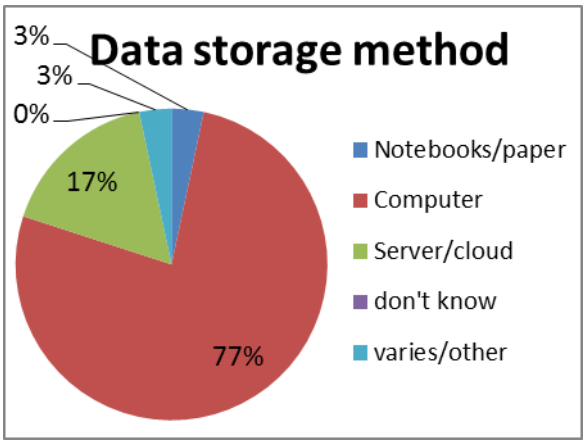
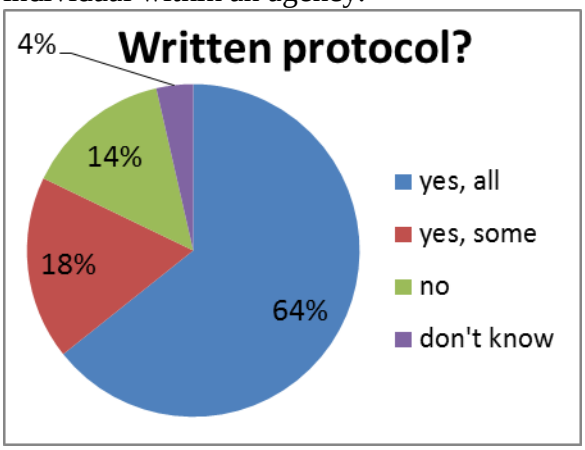


Figure 4 (left). Duration of data collection in seabird monitoring programs in the USTP.
Figure 5 (right). Data storage methods used by seabird monitoring programs in the USTP.

Most programs had written protocols for all species that were monitored, but some had written protocols for only some species (Figure 6). Some programs had no written protocol (14%), and in one program it was uncertain if a written protocol existed. Almost half of respondents indicated their monitoring protocols were previously developed by their government agency, and almost a quarter of the respondents indicated they developed their monitoring protocols themselves (Figure 7). It was unclear whether individuals who answered "agency" were using standardized protocols developed by agencies or just protocols developed by an individual within an agency.



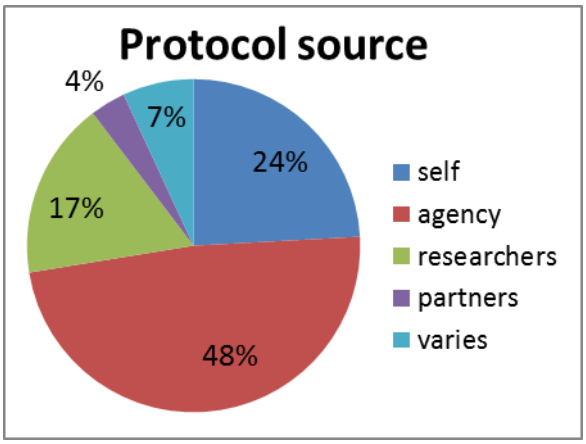
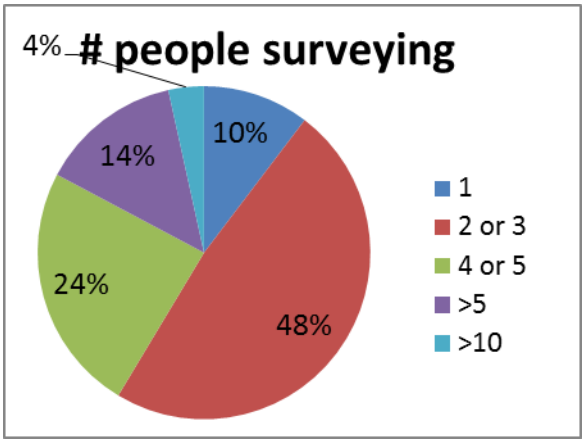


Figure 6 (left). Use of written seabird monitoring protocols in the USTP.
Figure 7 (right). Source of written monitoring protocols used in the USTP.

The number of people conducting the monitoring varied (Figure 8). Almost half of programs use teams of 2-3 people, almost a quarter involve teams of 4-5 people, and only a few have large teams of >5 or >10 people. Ten percent of monitoring programs consist of a single person. Most programs use volunteers in their monitoring, where possible (Figure 9), but some do not, most often on military lands or in sites where access is very difficult.



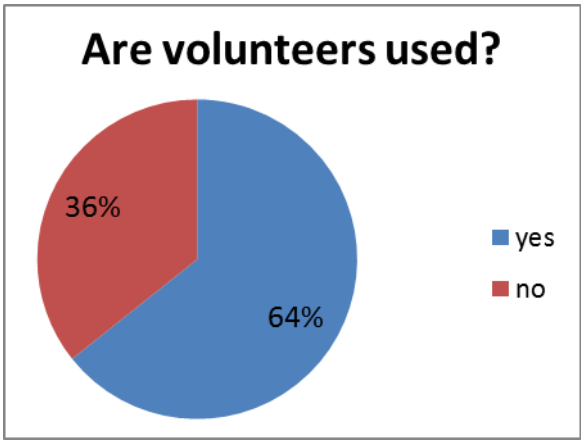


Figure 8 (left). Number of people involved in seabird monitoring activities in the USTP.
Figure 9 (right). Use of volunteers in seabird monitoring activities in the USTP.

The funding for more than half of the monitoring activities came from federal sources (Figure 10), most of which were on national wildlife refuges, national parks, or military lands,

but some was for programs for species listed under the Endangered Species Act on other lands. Almost a quarter of programs received funding from multiple sources (Figure 10).

There were several common limitations to seabird monitoring programs (Figure 11). Lack of funding and/or staff were the most common limitations, but lack of access limited monitoring in almost a third of cases. One participant indicated that nothing limited their seabird monitoring.

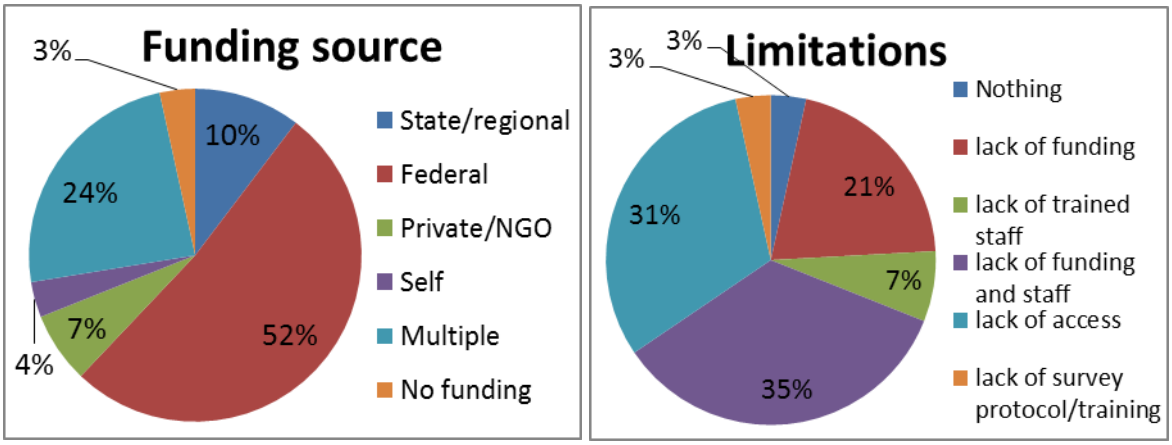


Figure 10 (left). Funding sources for seabird monitoring activities in the USTP.
Figure 11 (right). Limitations to seabird monitoring activities in the USTP.

Geographic monitoring summary and gaps

Thirty-one seabird species are known to breed and occur regularly on the 47 islands in the USTP included in this analysis (Figure 12). The number of species was roughly similar among the five regions, with 20 species in the MHI, 21 in the NWHI, 19 in the Remotes, 14 in the MI, and 17 in AS. These species varied in their distribution (Figure 13), with some species being widespread and occurring on most islands in all five regions of the USTP (e.g., Wedge-tailed Shearwater, Red-tailed Tropicbird, Black Noddy), whereas other species were restricted to just one or a few islands in one region (e.g., Short-tailed Albatross, Tropical Shearwater, White-throated Storm-petrel).

Several other seabird species have been recorded breeding rarely or visiting breeding colonies of other species in the USTP but are not known to be regular in occurrence and were not included in this analysis. Specifically, a Nazca Booby (*Sula granti*) was observed sitting on eggs and apparently paired with a Masked Booby on Moku Manu islet off Oahu (VanderWerf et al. 2008). Because the outcome of that nesting attempt is unknown and the species has not been observed nesting again, Nazca Booby is not regarded as a regularly occurring or breeding species. An unknown species of shearwater, possibly Tropical Shearwater, has been observed on Sarigan and is suspected to occur on Alamagan in the CNMI; whether it occurs regularly or breeds on either island is unknown. Athough Red-billed Tropicbirds (*Phaethon aethereus*) have been observed in the MHI occasionally, and one was observed sitting on the egg of a Red-tailed Tropicbird (VanderWerf and Young 2007), they are not known to breed in the USTP. Single Bryan's Shearwaters (*Puffinus bryani*) were observed calling from rock crevices on Midway in 1963 and 1990-1992, but this species is not known to nest on Midway nor anywhere else in the USTP (Pyle et al. 2014).

Of the 31 seabirds in the USTP, 30 species (97%) are monitored in at least a portion of their ranges (Figure 14). The proportion of islands where each species is monitored varied

considerably, with some species are being monitored on every island where they occur and others being monitored in just one location. Species are monitored on an average of 64% of the islands on which they occurred in all geographic regions combined. The only species not monitored at all is the Phoenix Petrel, which is only suspected to occur on some of the Remote islands. It should be emphasized that these totals include any type of monitoring, and the amount of information collected varied substantially among species. It is also worth noting that some participants responded that a species was monitored if the only monitoring was historical, whereas others counted only current monitoring efforts. More details about species-specific monitoring methods and current vs. historical data collection are presented below in the section on species monitoring methods and gaps.

The amount of monitoring conducted varied among geographic regions (Figures 15-19). In general, monitoring levels were highest in the MHI and the Remotes. In the MHI, species are monitored on an average of 65% of the islands on which they occur, 15 of 20 species are monitored on at least 50% of islands, eight species are monitored on every island on which they occur, and only one species, Christmas Shearwater, is not monitored at all (Figure 15). The high degree of monitoring in the MHI is not surprising given that many biologists are present on these islands plus many locations on these islands are relatively accessible. The MHI are relatively large islands, and many species occurred at several sites on each island. Some areas of each island are difficult to access because of steep terrain, and the level of monitoring often differed among sites. More details about the types of data collected at various sites on each island are presented in the species accounts below.

In the NWHI, species are monitored on an average of 63% of the islands on which they occur, 14 of 21 species are monitored on at least 50% of islands, two species are monitored on every island on which they occur, and only one species, Blue-gray Noddy, is not monitored at all (Figure 16). Although the level of monitoring reported was generally high in the NWHI, the monitoring activities on several islands were discontinued or reduced in scope recently, so many types of data collection are now regarded as historical only (see species accounts below).

In the Remotes, species are monitored on an average of 91% of the islands on which they occur, all 19 species were monitored on at least 50% of islands, and 13 species are monitored on every island on which they occur (Figure 17). The apparently high level of monitoring in the Remotes is somewhat misleading, however, because most species on several of these islands are monitored only with automated remote cameras and fewer types of information are collected on most species. One species, Phoenix Petrel (*Pterodroma alba*), was suspected to occur in the USTP only in the Remotes, but its presence has not been confirmed.

Seabird monitoring in the Mariana Islands was generally low (Figure 18). Species are monitored on an average of 26% of the islands on which they occurred, three species are monitored on at least 50% of islands, and five species are not monitored at all (Figure 17). Seabird monitoring in the MI occurs for the following: Managaha Islet off Saipan for Wedge-tailed Shearwaters; FDM using helicopter flights that detect only larger seabirds above ground; nest counts of Red-footed Boobies at Saguaghaha on the southeastern coast of Rota; and occasional vessel surveys and visits to Tinian, Aguiguan and Naftan Rock. Additional information about several islands and species is available from some older references, but it is largely limited to presence and rough estimates of abundance and was not considered in this report (Baker 1951, Eldredge et al. 1977, Reichel 1991, Stinson 1995, Lusk et al. 2000). Monitoring is especially difficult on the northernmost of the MI, which are uninhabited, distant, not served regularly by any vessels, and volcanically active in some cases.

In American Samoa, species are monitored on an average of 33% of the islands on which they occur, five of 17 species are monitored on at least 50% of islands, two species are monitored on every island on which they occur, and three species are not monitored at all (Figure 19). Several species are monitored only on Rose Atoll, where there are quarterly visits (B. Peck, pers. comm.). Swain's Island was visited by biologists in 2014 for first time in several decades (Titmus et al. 2016), which provided important information about the species present and their abundances. Two species, Herald Petrel (*Pterodroma arminjoniana*) and Tahiti Petrel (*Pterodroma rostrata*), occur in the USTP only in AS, and although both species are monitored, the information collected is limited to presence and rough measures of relative abundance obtained from acoustic monitoring. Thorough seabird surveys were conducted in AS by O'Connor and Rauzon (2004), but at most sites they were largely limited to presence/absence and measures of relative abundance. Still, these surveys identified many locations where seabirds could be monitored and established some baseline data.

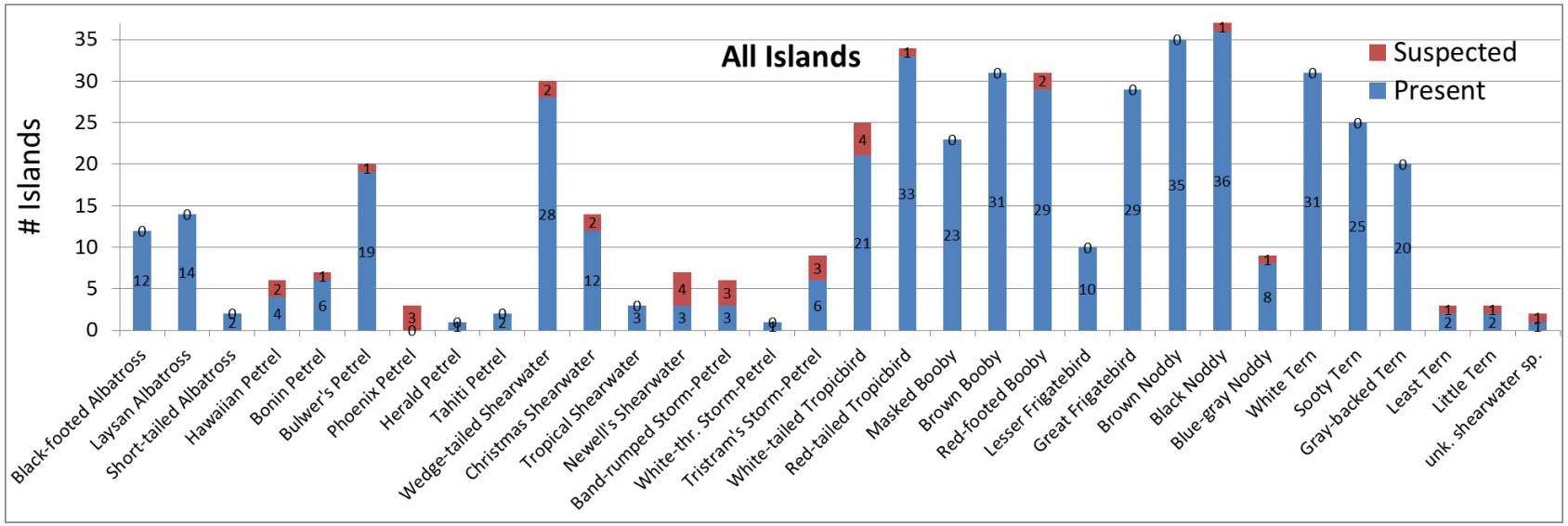


Figure 12. Seabird species in the U.S. Tropical Pacific and number of islands on which each species is known or suspected to occur, all islands combined. N = 47 islands total.

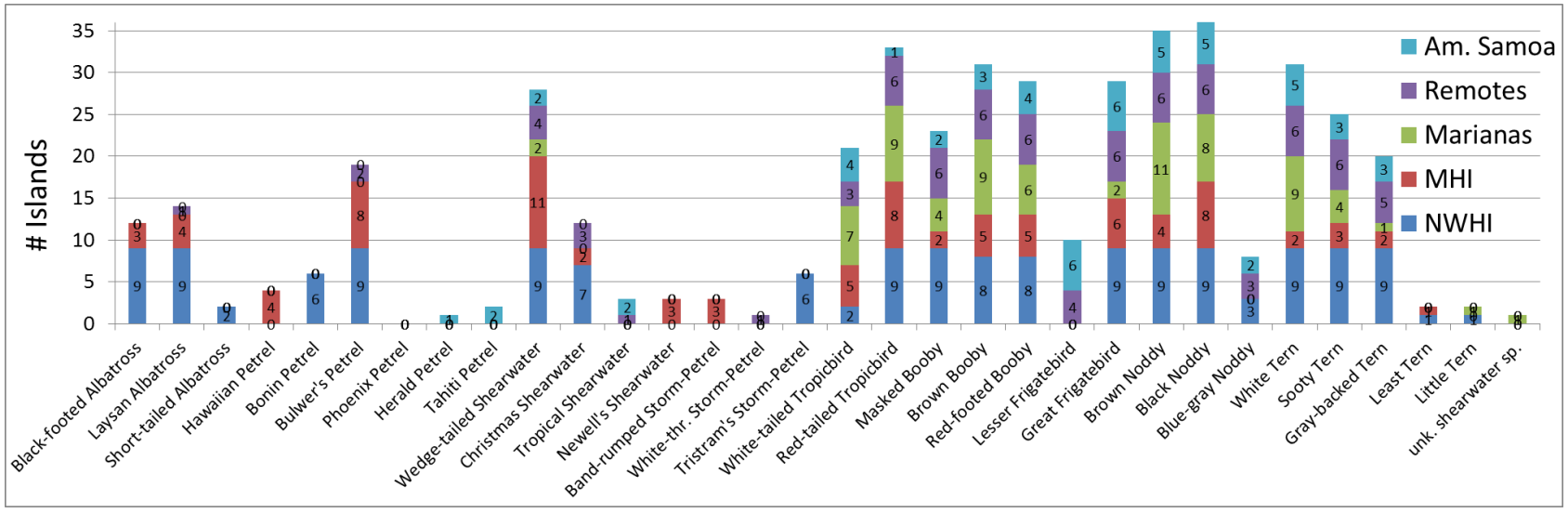


Figure 13. Seabird species in the U.S. Tropical Pacific and number of islands on which each species occurs, by region.

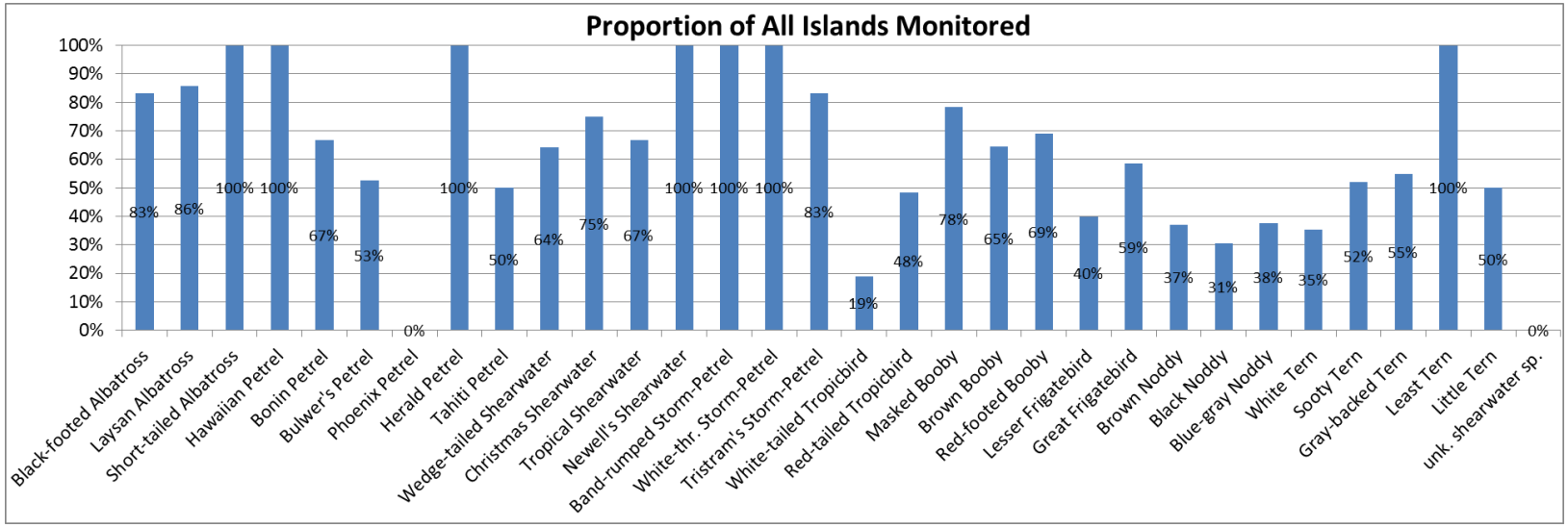


Figure 14. Proportion of all islands where seabird species are monitored in the U.S. Tropical Pacific, all regions combined. Species with zero values are known to occur in the region but have not been monitored. N = 47 islands total.

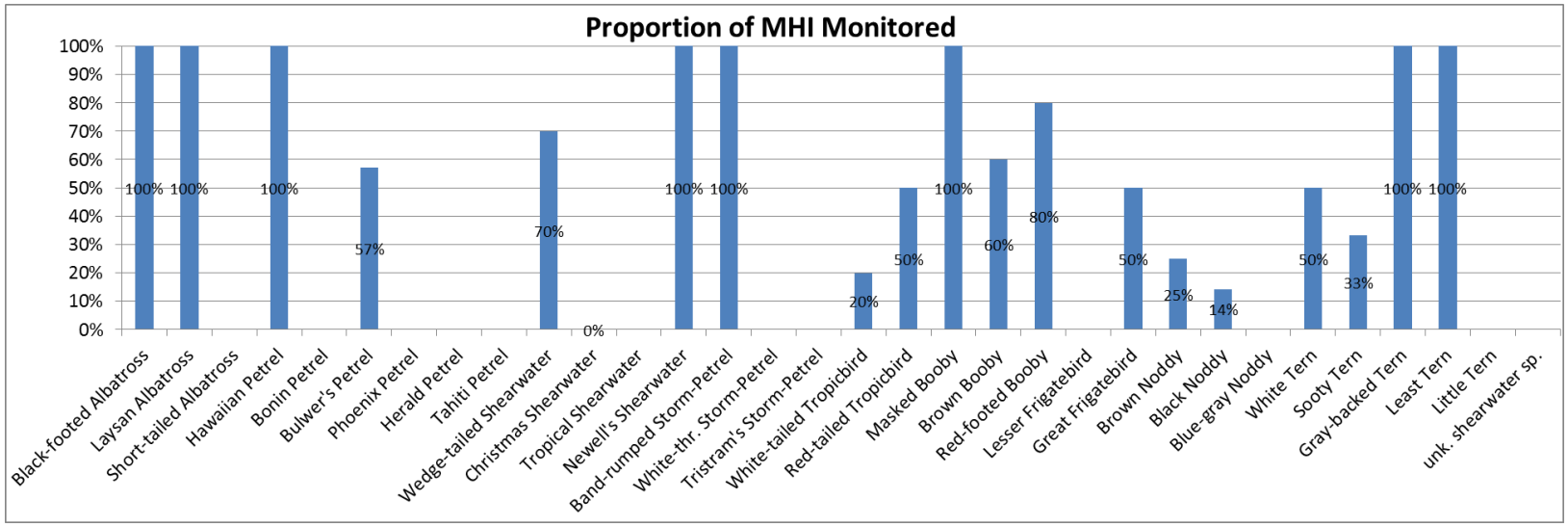


Figure 15. Proportion of islands where seabird species are monitored in the Main Hawaiian Islands. Species with zero values are known to occur in the region but have not been monitored. N = 11 islands total.

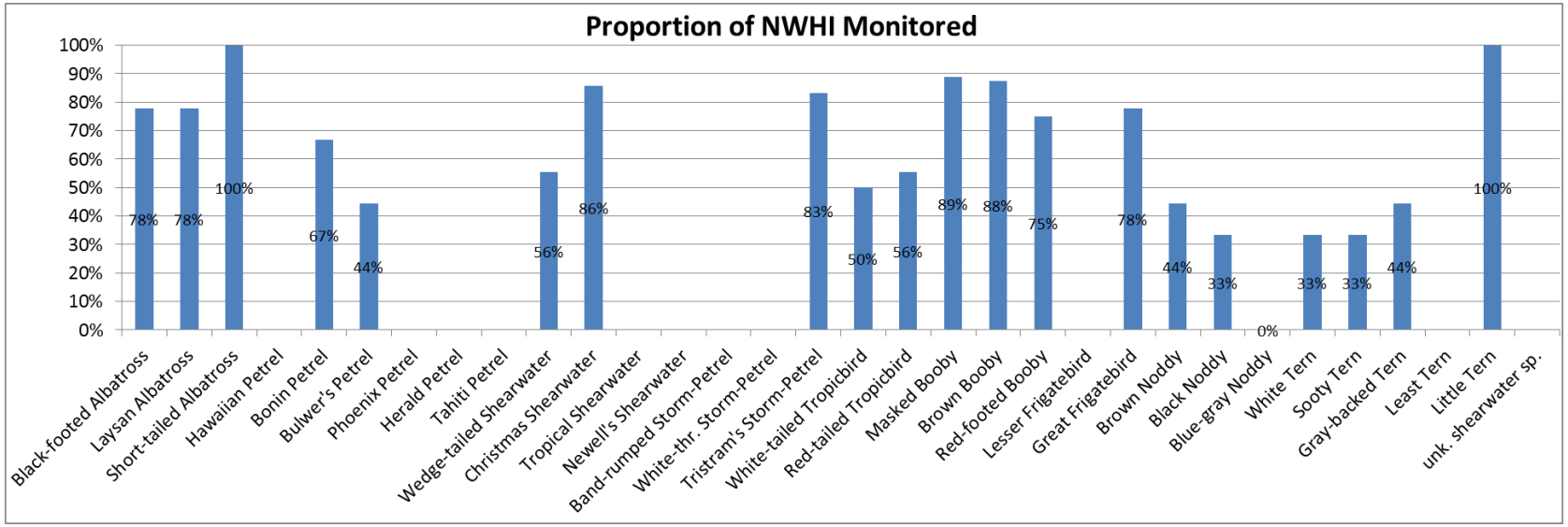


Figure 16. Proportion of islands on which seabird species are monitored in the Northwest Hawaiian Islands. Species with zero values are known to occur in the region but have not been monitored. N = 9 islands total.

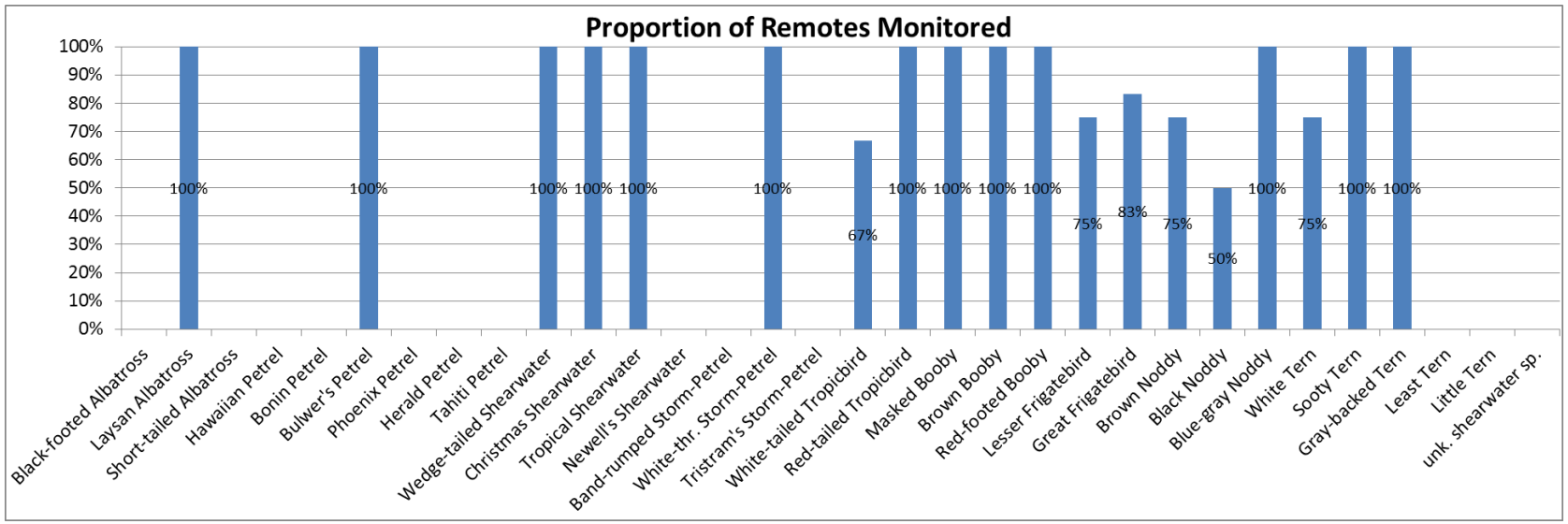


Figure 17. Proportion of all islands on which seabird species are monitored in the Remote Refuges Islands. N = 6 islands total.

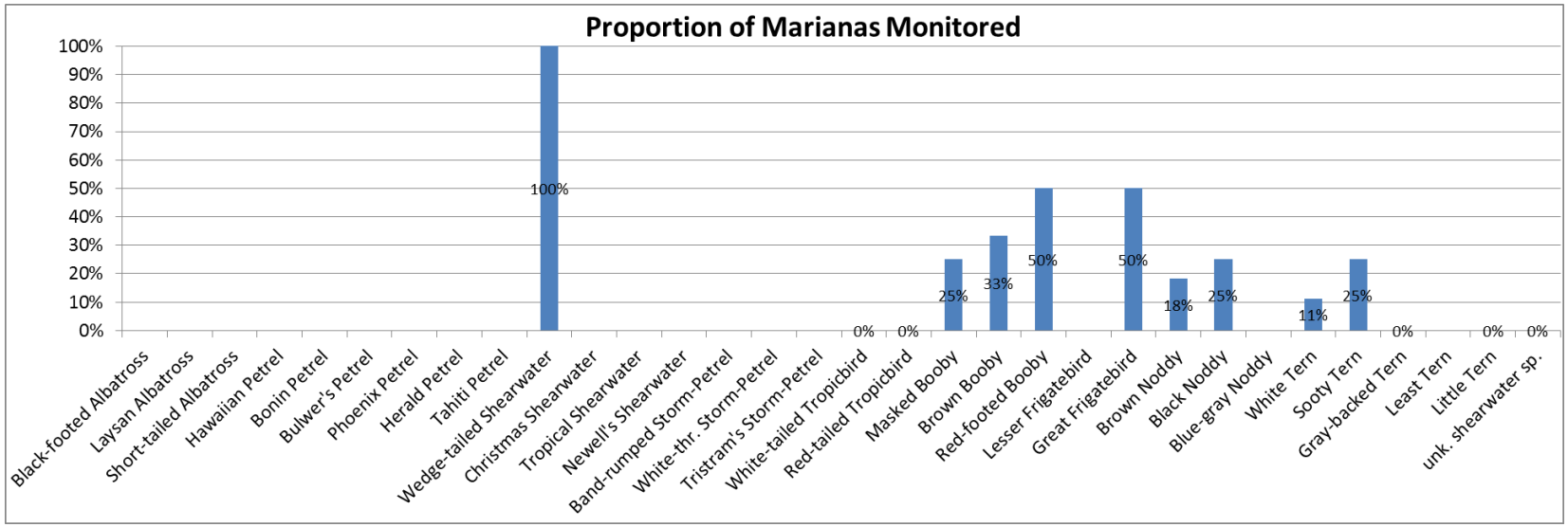


Figure 18: Proportion of all islands on which seabird species are monitored in the Mariana Islands. Species with zero values are known to occur in the region but have not been monitored. N = 15 islands total.

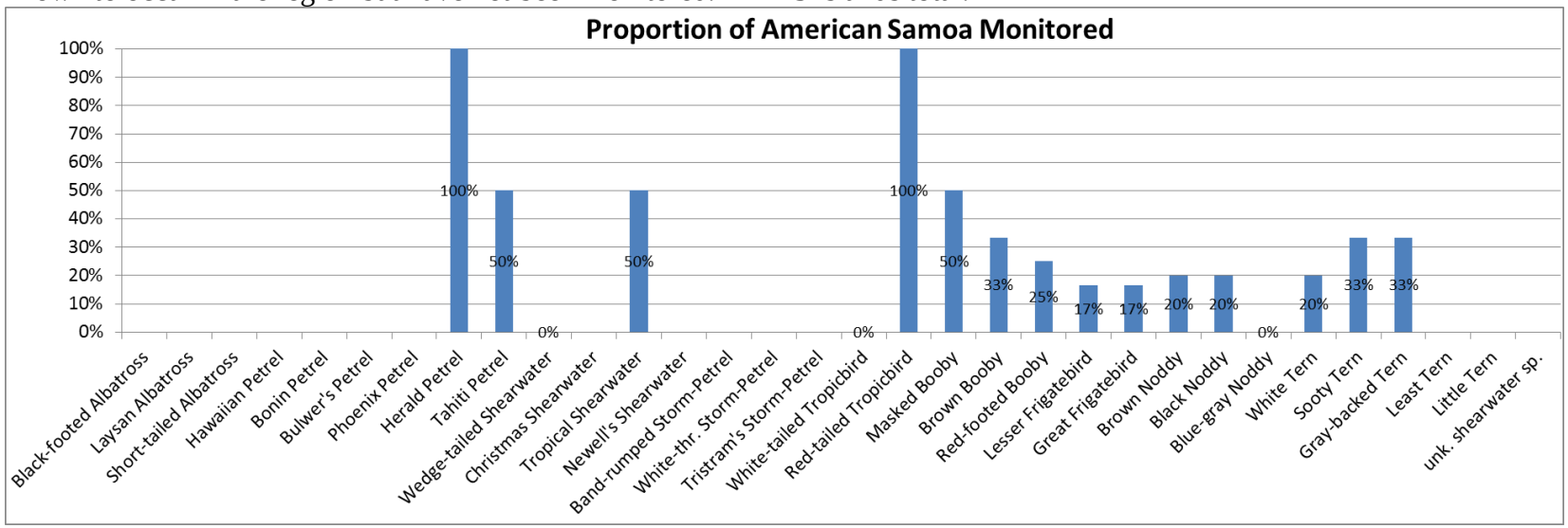


Figure 19: Proportion of all islands on which seabird species are monitored in American Samoa. Species with zero values are known to occur in the region but have not been monitored. N = 6 islands total.

Species monitoring methods and gaps

The intensity of monitoring and types of information collected varies widely among species, ranging from brief, irregular visits for determining presence/absence to comprehensive measurements of reproduction, demography, behavior, threats, and tracking at sea. There also is considerable variation among species and geographic regions in how much information is being collected currently vs. historically. In the NWHI, most monitoring activities were discontinued recently on Tern, Lisianski, and Laysan when camps were closed on those islands. In the Remotes, some of which are visited only once every three years, automated cameras have been deployed recently to help augment monitoring of many species. Although this technique provides limited types of information, automated cameras can operate continuously for months, thereby providing a relatively inexpensive addition to previous monitoring efforts that were irregular in occurrence and short in duration.

There is more comprehensive monitoring for species listed under the Endangered Species Act (Short-tailed Albatross, Hawaiian Petrel, Newell's Shearwater, and Band-rumped Storm-petrel). Each of these species is monitored on every island where it is known to occur, sometimes at multiple sites, and also on islands where they are suspected to occur but have yet to be confirmed. It also was apparent that managers and biologists intended to intensify monitoring for these species based on their anticipated collection of additional types of data. Three of these species (all except Short-tailed Albatross) nest in burrows or rock crevices and, therefore, are difficult to monitor, yet more effort was expended on these species and, for Hawaiian Petrel and Newell's Shearwater, more types of information have been collected about them.

Intensity of monitoring also is related to ease of monitoring. Larger species such as albatrosses, boobies, and frigatebirds that roost and nest above ground and are active during the day generally are easier to observe and are monitored in more locations with more information collected about them. Species that nest in burrows and are active in the colony at night, such as most petrels and shearwaters, are monitored at fewer locations and fewer types of information were collected about them. This was particularly true for the smallest species such as storm-petrels, that nest in narrow burrows or crevices that are difficult to find and examine. Similarly, less information was collected at fewer locations for species that nest primarily on steep cliffs, such as White-tailed Tropicbirds and Black Noddies in the MHI. One of the most common and widespread species in the USTP, the White Tern, is monitored in few locations, even on islands with large human populations. Although this species is common and widespread, it often nests high in trees and does not nest in discrete colonies, making it more difficult to monitor.

Monitoring has been conducted by aircraft only at two sites, Kaula Islet near Kauai and FDM in the CNMI, in recent years because of difficulty and danger in accessing the islands due to military training and unexploded ordnance. At FDM, the surveys are visual counts and only large species can be detected and roughly counted (Camp et al. 2014). On Kaula, high-resolution photographs are taken from the aircraft and examined later using a computer algorithm to identify species (Normandeau Associates and APEM 2016). Using this method, it is possible to identify and count small species such as Brown Noddies, Sooty Terns, and Gray-backed Terns, but it is not possible to distinguish roosting from nesting seabirds.

Most seabird monitoring in the USTP is focused terrestrially on islands where birds nest and roost, but a large portion of their lives is spent at sea. Some species have been tracked at sea using various devices and at-sea surveys have been conducted from vessels in some areas (see species accounts below), but these efforts are relatively short in duration and limited in scope.

The distribution of seabirds at sea and their use of the marine environment thus is a gap in our knowledge.

Specialized monitoring methods have been used for some species to collect specific types of data needed to assess a threat or facilitate other methods of monitoring. For example, light attraction and collisions are monitored for species listed under the US Endangered Species Act to document take and assess efficacy of mitigation measures (Telfer et al. 1987, Podolsky et al. 1998, Raine et al. 2017a). Tissue samples have been collected from some species to measure stable isotopes and contaminants to determine trophic relationships and effects of marine pollution and overfishing (Auman et al. 1997, Finkelstein et al. 2006). Radar has been used to monitor species that are difficult to locate due to the location of their colonies and nocturnal behavior, such as Hawaiian Petrels and Newell's Shearwaters (Cooper and Day 1998, Day et al. 2003a, Raine et al. 2017a). Specially trained detection dogs have been used to locate nests of the Band-rumped Storm-petrel on Hawaii Island (N. Galase pers. comm.).

Species Accounts

Below are species accounts for 26 of the 31 seabird species in the USTP. Each account includes a bar graph of the number of islands or sites where the species is monitored and the types of data collected currently or historically and a pie chart of monitoring frequency. If the vertical axis indicates the number of sites rather than islands, then the species is monitored at multiple sites on at least some islands. Each account also briefly discusses geographic patterns of monitoring, gaps by region and type of data, and any special monitoring needs or methods.

Species accounts are not included for five of the 31 species in the USTP because they occur sporadically or in very small numbers and do not have established breeding populations, or very little information is available about them. These species are the Tahiti Petrel (*Pterodroma rostrata*), Herald Petrel (*Pterodroma arminjoniana*), Phoenix Petrel (*Pterodroma alba*), Least Tern (*Sternula antillarum*), and Little Tern (*Sternula albifrons*). Herald and Tahiti petrels occur in the USTP only in AS, where monitoring has been done with brief visits or automated recording units that document their presence and measure relative abundance based on call rates (O'Connor and Rauzon 2004, Titmus 2017). Phoenix Petrel may occur on Baker, Howland, and Jarvis in the Remotes, but its presence there has not been confirmed. Little Terns are observed regularly and probably breed in the MI, particularly on Saipan, but apparently are not monitored. Small numbers of Little Terns have been documented occasionally in the NWHI, and breeding has been confirmed on at least three occasions on Midway Atoll as well as Pearl and Hermes, but they do not occur regularly in the USTP (Clapp 1989, Conant et al. 1991, Pyle et al. 2001, Pyle and Pyle 2017). Least Terns have bred on the Kona side of Hawaii Island since 2015 (P. Baird pers. comm.) and sporadically on Midway Atoll, and a pair may have bred sporadically on Oahu (Pyle and Pyle 2017), although the number of birds present is small.

Black-footed Albatross (*Phoebastria nigripes*)

The Black-footed Albatross occurs on 12 islands in the USTP and has been monitored on 10 of them (83%), all of which were in the Hawaiian Islands. These include all nine of the NWHI and three of the MHI (Kaula, Lehua, and Oahu). The largest colonies are on Midway, Laysan, and Kure in the NWHI. The species nests on Kaula and Lehua in small numbers (VanderWerf et al. 2007, Normandeau Associates and APEM 2016). On Oahu it is an annual visitor to Kaena Point but has not bred despite attempts at social attraction (Young and VanderWerf 2016). Many different types of data have been collected about this species, but the amount of information gathered varied among locations. Although the species has been monitored at 10 locations, the same type of data was collected at a maximum of five locations (Figure 20). Discontinuation of monitoring on several of the NWHI has reduced the amount of information collected recently.

This species was proposed for listing under the Endangered Species Act in 2004, but after a comprehensive status assessment (Arata et al. 2009) the USFWS determined in 2011 that listing was not warranted. Never the less, there is considerable concern about this species because almost all of the islands on which it nests are threatened by sea level rise and increased storm surge associated with global climate change (Reynolds et al. 2015, 2017). Monitoring this species' distribution at sea in relation to fishing effort is especially important (Hyrenbach et al. 2002, Kappes et al. 2010) because it follows ships to scavenge for food and bycatch mortality is a serious threat (Veran et al. 2007, Finkelstein et al. in press).

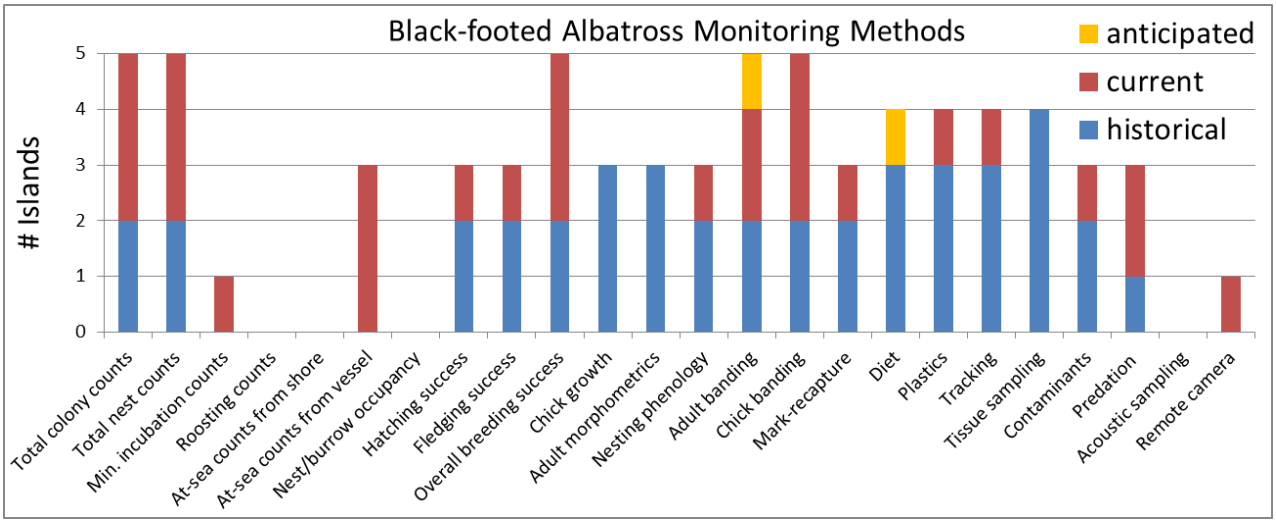
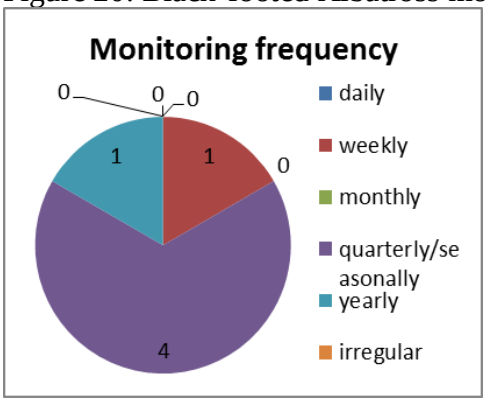


Figure 20. Black-footed Albatross monitoring methods (above) and frequency (below).



Laysan Albatross (*Phoebastria immutabilis*)

The Laysan Albatross occurred on 14 islands in the USTP and was monitored on 12 of them (86%), including all nine of the NWHI, Oahu, Kauai, Lehua, and Kaula (VanderWerf et al. 2007, Young et al. 2009, U.S. Navy 2016), and Wake Island in the Remotes. Many types of data have been collected on this species at most locations, but at some sites monitoring is limited to nest counts. It has been the subject of intensive demographic monitoring on Oahu, where adult survival, juvenile survival, recruitment, and breeding success have been measured (Young 2010, VanderWerf and Young 2011, 2016, Young and VanderWerf 2014). Similar historical data are available from Midway Atoll (Rice and Kenyon 1962, Fisher 1975a,b). Demographic studies have been conducted at Midway Atoll and Kilauea Point NWR since 2005 but results have not been published. Some colonies are closely monitored on private land on Kauai (Young et al. 2014) and more data analysis is needed. Monitoring of chemical contaminants has shown bioaccumulation in tissues and negative demographic effects have been observed (Work and Smith 1996, Guruge et al. 2001, Finkelstein et al. 2006). Avian pox occurs in some areas and can be debilitating and decrease long-term survival (VanderWerf and Young 2016). Laysan Albatrosses have been tracked at sea more intensively than any other seabird in the USTP, with efforts in multiple locations and years (Hyrenbach et al. 2002, Fischer et al. 2009, Young et al. 2009, Kappes et al. 2010). Research is being done currently to investigate the use of satellite photos as a monitoring method (R. Suryan et al. unpubl. data).

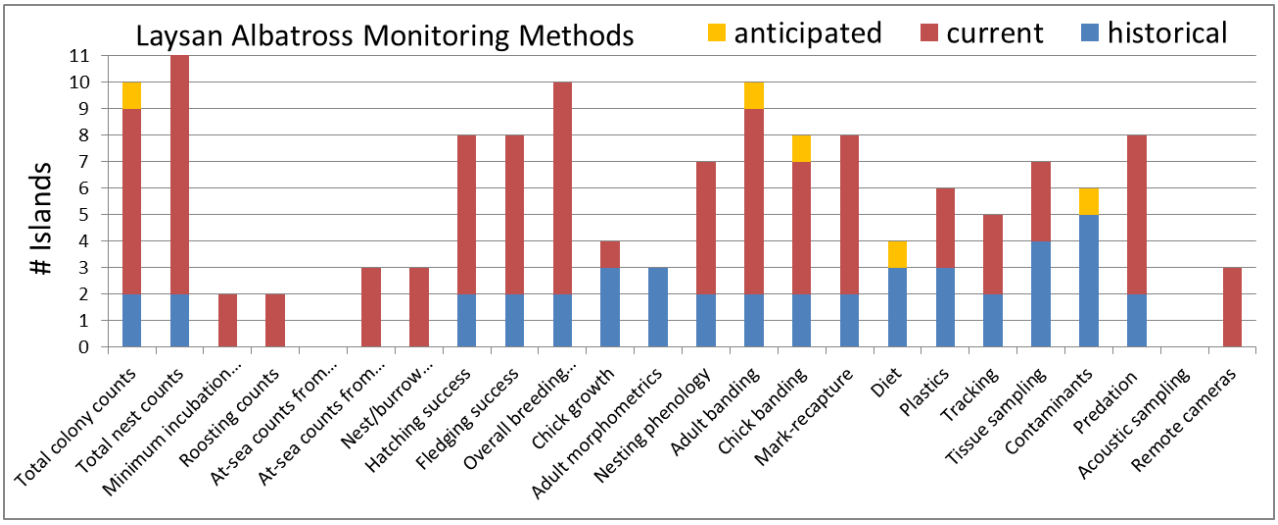
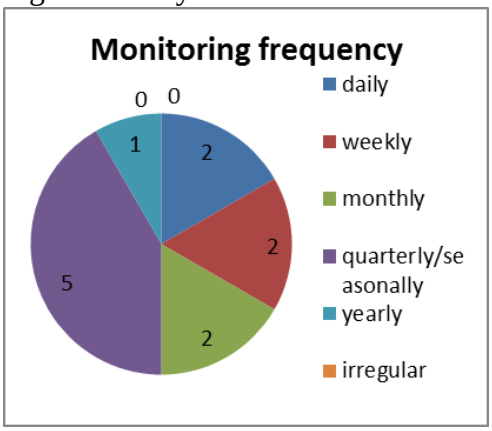


Figure 21. Laysan Albatross monitoring methods (above) and frequency (below).



Short-tailed Albatross (*Phoebastria albatrus*)

The Short-tailed Albatross is listed as endangered under the U.S. Endangered Species Act (USFWS 2008). The vast majority of the global population of about 3,000 birds occurs on islands near Japan, primarily Torishima, with smaller numbers on Minami-kojima, and a third colony was created recently by translocation on Muko-jima but is still very small (Deguchi et al. 2014). In the USTP, the Short-tailed Albatross occurs in very small numbers only on Midway and Kure, though it has been seen sporadically on other islands in the NWHI (Pyle and Pyle 2017). On Midway, a pair laid infertile eggs starting in 1993, and a pair raised chicks in 2011, 2012, and attempted to nest until 2014 (Pyle and Pyle 2017). On Kure, two females have paired with each other and laid infertile eggs from 2011-2016. Because of the high level of conservation concern about this species, all breeding attempts and visits by non-breeding birds have been intensively monitored, and the monitoring is done frequently (Figure 22). The species forages to the north of the USTP, and movements of adults and juveniles have been tracked at sea from Japan (Suryan et al. 2006, 2007). Bycatch in fisheries in Alaskan waters is closely monitored because of its endangered status (Suryan et al. 2007).

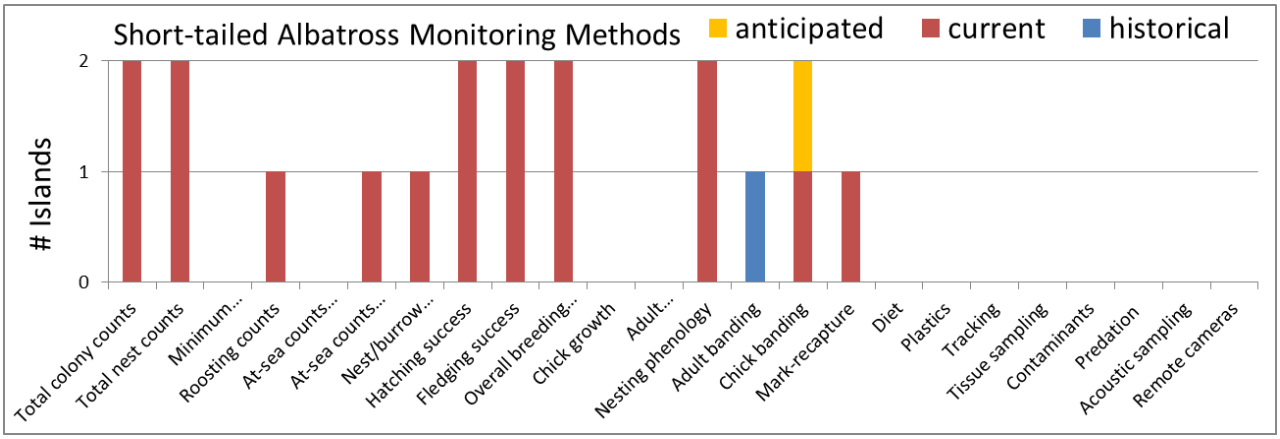
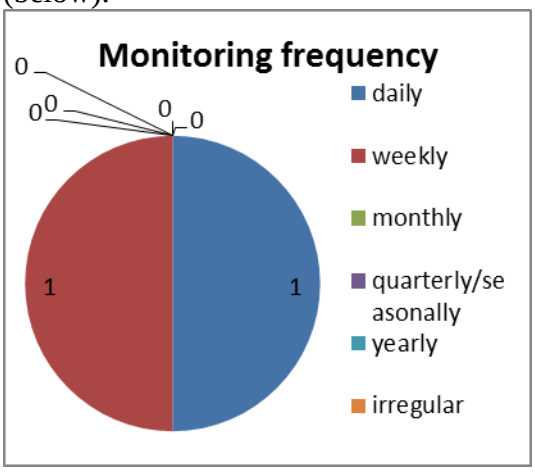


Figure 22. Short-tailed Albatross monitoring methods (above) and monitoring frequency (below).



Hawaiian Petrel (*Pterodroma sandwichensis*)

This species is listed as endangered under the U.S. Endangered Species Act (USFWS 1983) and is one of only two endemic seabirds in Hawaii and the region. It is present on four of the MHI (Kauai, Lanai, Maui, Hawaii) and suspected on two more (Molokai, Kahoolawe). It is monitored on all islands where it is known or suspected to occur, and at multiple sites on some islands. A wide range of monitoring is conducted, several research and conservation projects are underway, and there are plans to expand the monitoring to include additional methods. Radar has been used to measure abundance and trend of populations on several islands because of the remote location and nocturnal behavior of birds at colonies (Cooper and Day 1998, Day et al. 2003a, Raine et al. 2017a). Nest occupancy and reproductive biology have been monitored at several colonies (Simons 1985, Judge 2011). Predation, light attraction, and collisions are serious threats and are monitored closely, especially on Kauai (Telfer et al. 1987, Raine et al. 2017a). The population on Kauai has declined by 78% in recent years (Raine et al. 2017a). The population on Maui has increased as a result of predator control (Hodges et al. 2001). A substantial portion of the monitoring has been funded as a part of mitigation for take under the ESA. In addition, birds from several colonies have been tracked at sea (Adams and Flora 2010), extensive genetic research has been completed (Welch et al. 2011, 2012a,b, Wiley et al. 2012), and stable isotope research has shown changes in diet over time (Wiley et al. 2013).

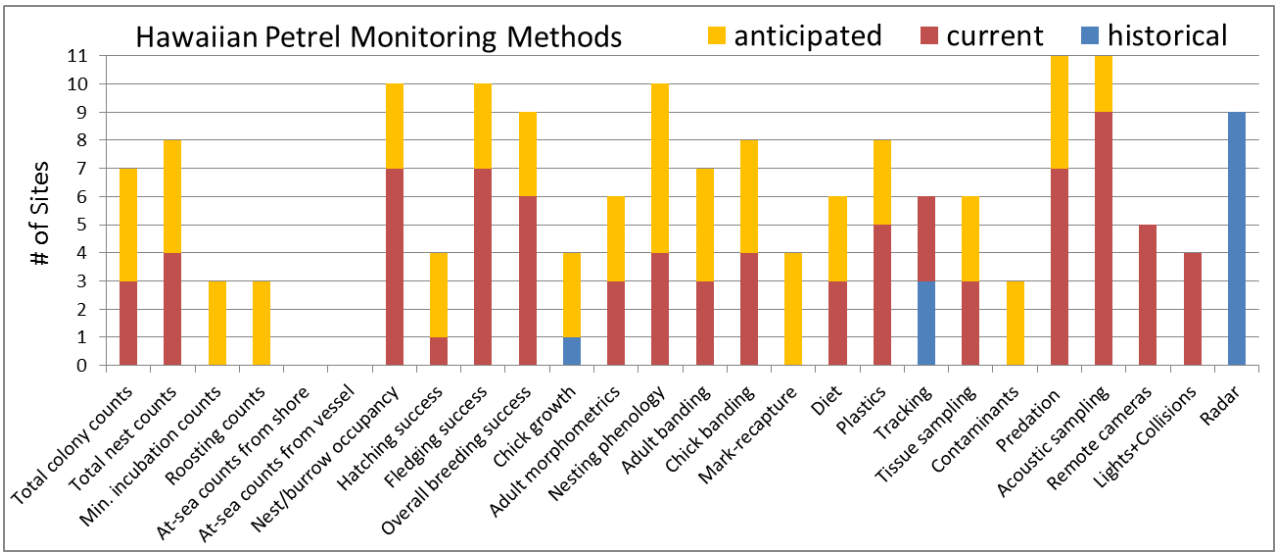
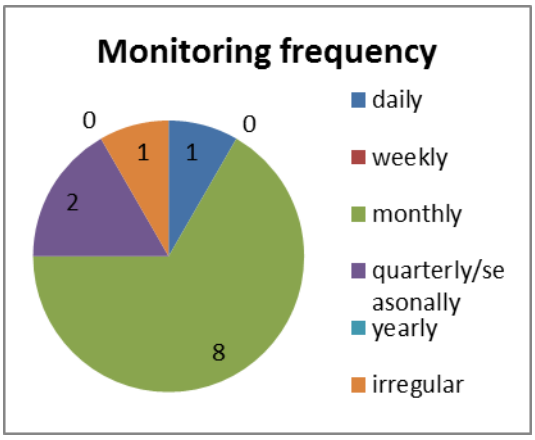


Figure 23: Hawaiian Petrel monitoring methods (above) and frequency (below).



Bonin Petrel (*Pterodroma hypoleuca*)

Bonin Petrels are present on six islands and suspected on one more, all in the NWHI. Historically they also were found throughout the MHI (Pyle and Pyle 2017). Most monitoring data are historical and were collected on Midway (Seto 1994) and Laysan (USFWS unpubl. data). Populations on Midway and Kure have grown hugely since rats were eradicated from those islands. An attempt was made to estimate the Bonin Petrel population on Midway through mark-recapture methods (Moore 2009), but current population sizes, suspected to be in the hundreds of thousands, remain poorly known. Recent research funded by USFWS to investigate the potential of passive acoustic monitoring to monitor this species on Midway Atoll is near completion (McKown et al. unpubl. data). This species nests in underground burrows, but burrows are abundant and easy to locate on most islands. Given the accessibility on Midway and potential for mouse predation, monitoring should be increased to include reproductive success as part of the mouse eradication planning.

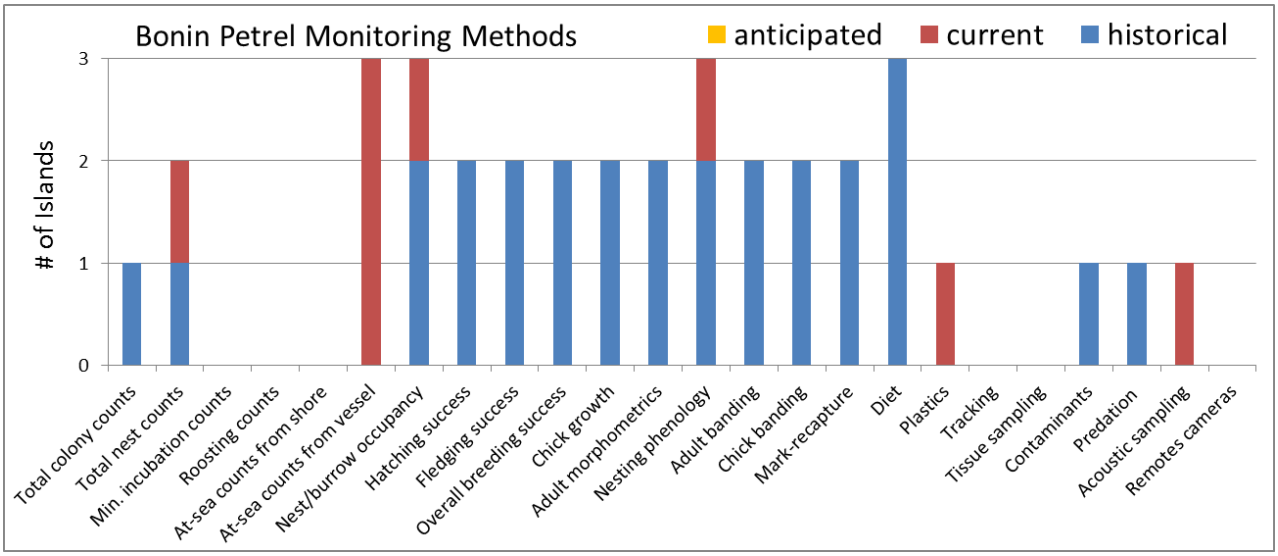
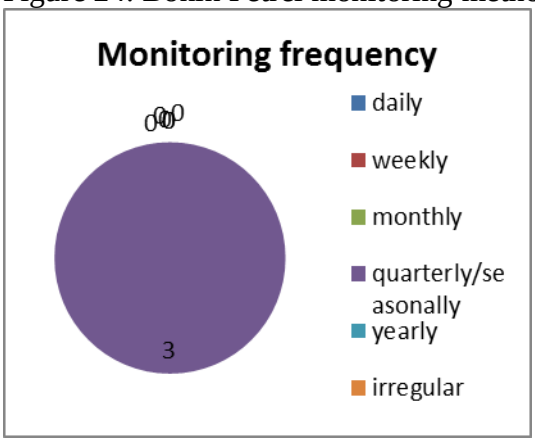


Figure 24. Bonin Petrel monitoring methods (above) and frequency (below).



Bulwer's Petrel (*Bulweria bulwerii*)

This is the second most widespread Procellariform seabird in the USTP (after Wedge-tailed Shearwater) and is present on 19 islands in the MHI (n=8), NWHI (n=9) and Remotes (n=2). Despite their broad distribution, they are hard to detect and monitor because of their nocturnal habits and nest placement in small rock crevices. They are monitored on 10 of 19 islands (53%), but on most islands current monitoring is limited to presence/absence and rough nest counts. More extensive information was collected historically, mostly on islets off Oahu (Whittow 1994, Megyesi and O'Daniel 1997). Monitoring that occurred on several of the NWHI was discontinued recently. There has been no tracking at sea and the distribution at sea is poorly known. The only current measures of reproduction are from Lehua Islet off Niihau and Moku 'ae'ae off Kauai, where the species suffers from high predation by Pacific rats (*Rattus exulans*) and/or Barn Owls (*Tyto alba*; VanderWerf et al. 2007, VanderWerf and Raine 2016, Raine et al. 2017).

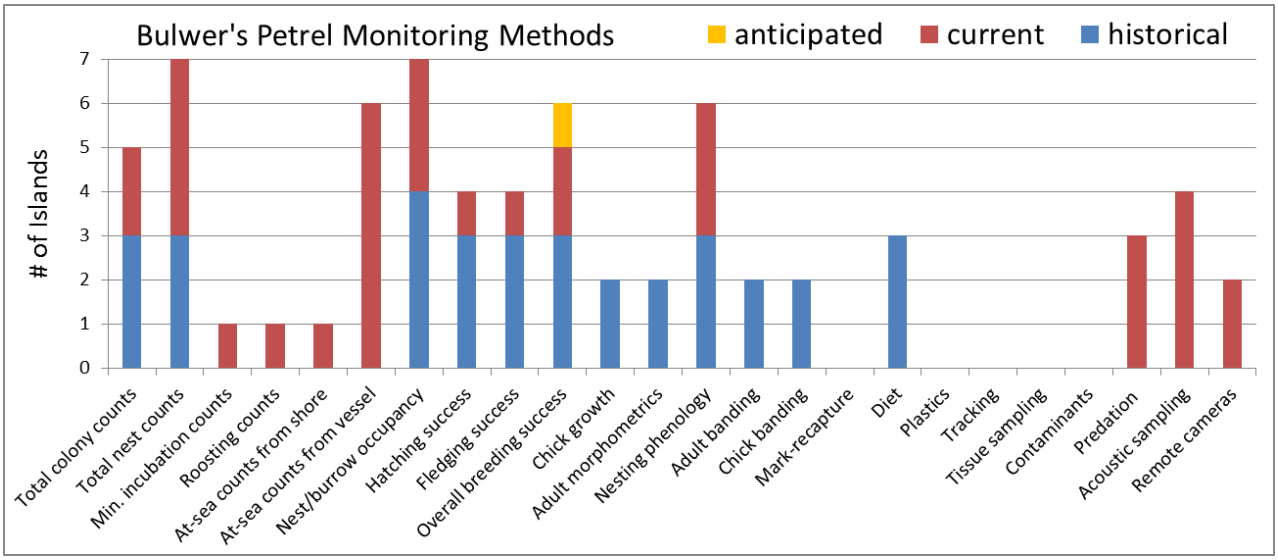
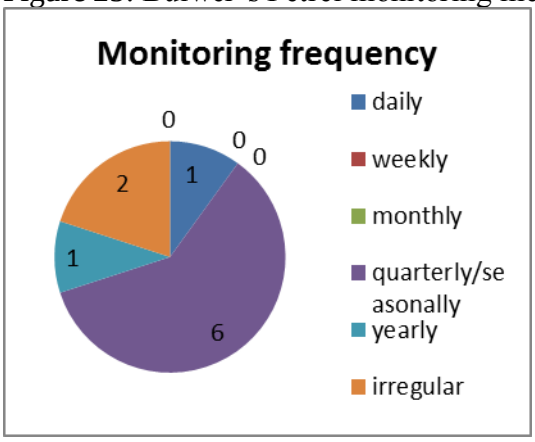


Figure 25. Bulwer's Petrel monitoring methods (above) and monitoring frequency (below).



Wedge-tailed Shearwater (*Ardenna pacifica*)

This is the most widespread Procellariform seabird in the USTP, occurring on 28 islands in all five regions and suspected to occur on two more islands. It is monitored on 18 of 28 islands (64%) in four of the five regions; a monitoring site needs to be located in American Samoa. Although it nests in underground burrows, most of the colonies are in easily accessible coastal locations. A variety of monitoring has been conducted on this species, including detailed studies of nesting phenology, reproduction, diet, behavior, effects of oiling, and predator removal (Shallenberger 1973, 1975, Byrd et al. 1983, Fry et al. 1986, Smith et al. 2002, 2006, Marie et al. 2014, Pravder et al. 2015), rivaling the albatrosses for the most thorough monitoring regime. There is current information from several sites on abundance, reproduction, and predation (VanderWerf et al. 2014, VanderWerf and Raine 2016, Raine et al. 2017). Monitoring of light attraction, fallout, and collisions occurs on Oahu and Kauai. A large amount of at-sea tracking data was collected in the MHI recently, but only during breeding; the non-breeding range is still poorly known. This would be an excellent indicator species of broad-scale geographic patterns and effects of changes in climate and oceanographic patterns because it is common, widespread, and easy to monitor.

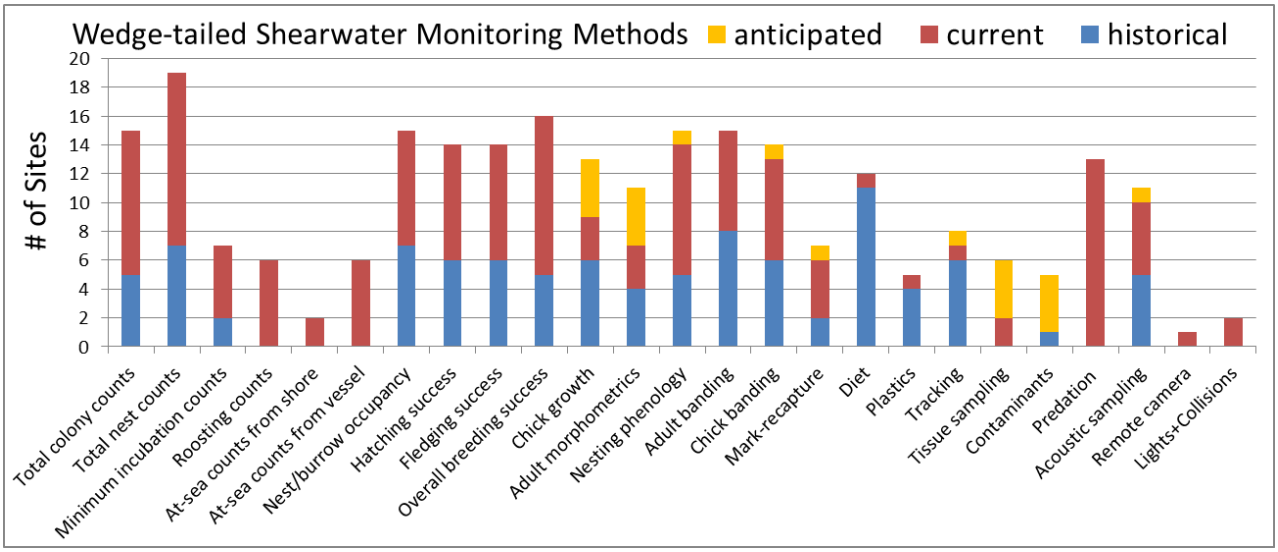
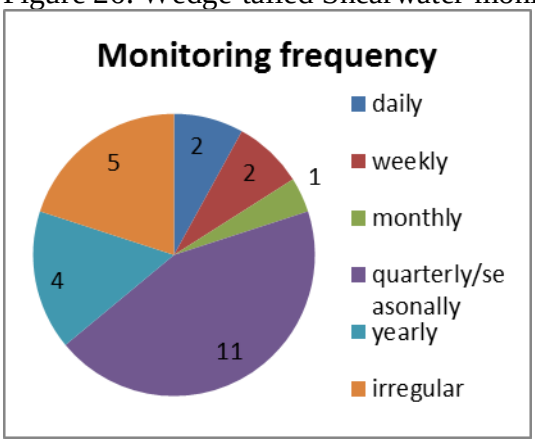


Figure 26. Wedge-tailed Shearwater monitoring methods (above) and frequency (below).



Christmas Shearwater (*Puffinus nativitatis*)

Christmas Shearwaters occur on 12 islands in the USTP, including seven of the NWHI, Kaula off Niihau and Moku Manu off Oahu in the MHI, and Wake, Jarvis, and Johnston in the Remotes, and are suspected to occur on Lehua and Necker. They are monitored on 9 of 12 islands (75%), but few types of information are being collected currently on most islands. Much of the monitoring in the NWHI was discontinued recently. Current efforts on Midway are limited to total nest counts and nesting phenology. In the Remote islands, monitoring is done with automated cameras. The two colonies in the MHI are difficult to access and are not monitored. Most monitoring currently occurs on Kure, where a long-term banding and mark/recapture project has allowed estimation of survival, population size, and immigration estimates (VanderWerf et al 2015). Additional monitoring work is planned on Kure, including reproduction and at-sea tracking.

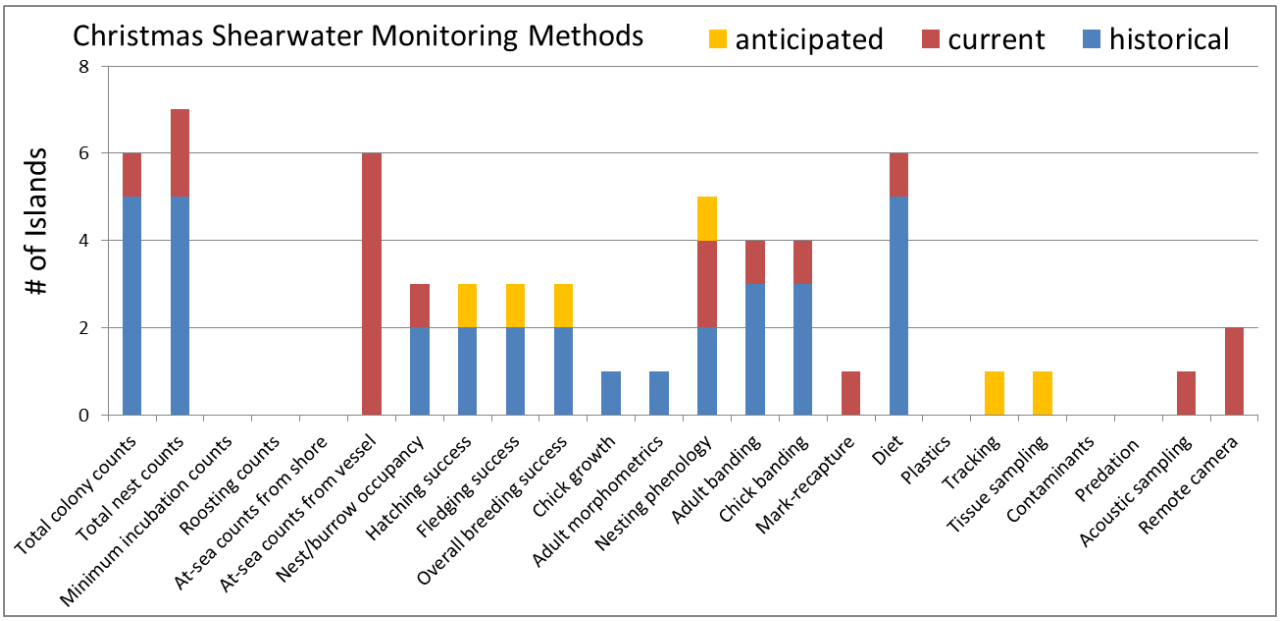
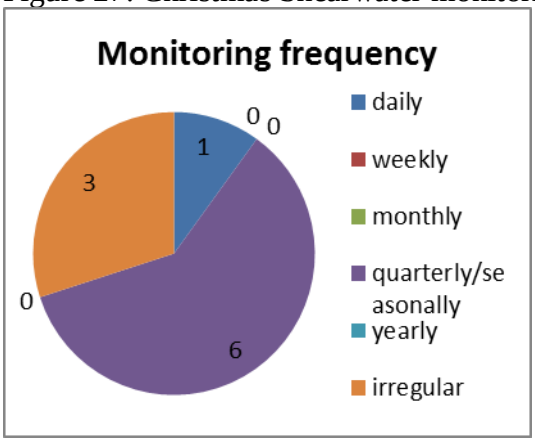


Figure 27. Christmas Shearwater monitoring methods (above) and frequency (below).



Tropical Shearwater (*Puffinus bailloni*)

The Tropical Shearwater is known to occur on only two islands in the USTP, Jarvis in the Remotes and Ta'u in American Samoa. An unidentified shearwater species on Sarigan in the CNMI may be this species, and they may be more widespread than is currently known because they are small, nocturnal, burrow-nesting, and difficult to detect. As a result, there is virtually no information on this species from the USTP. Remote cameras and song meters are deployed on Jarvis, but no information is gathered beyond presence/absence. On Ta'u, Tropical Shearwaters nest under dense vegetation or on remote cliffs and they have been detected primarily by remote acoustic monitoring (O'Connor and Rauzon 2004, Titmus 2017). Greater effort is needed to better understand the status of this species in the USTP.

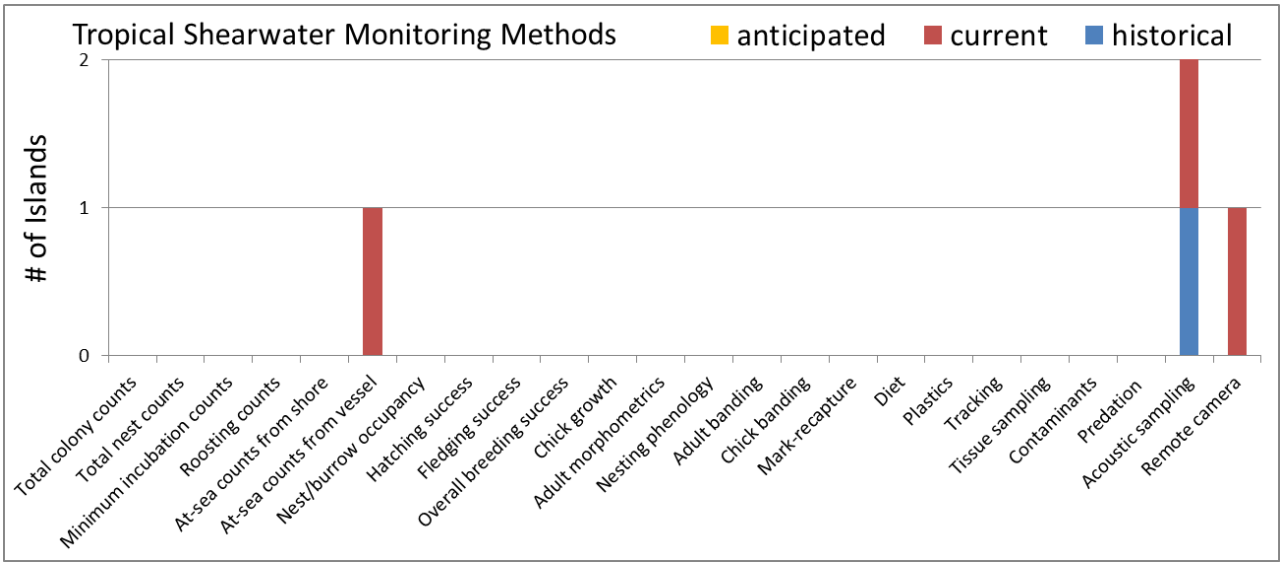
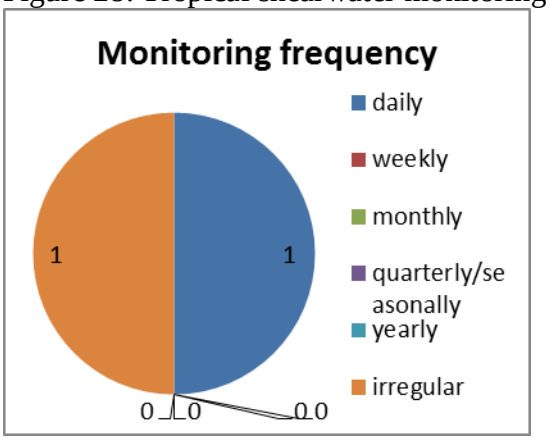


Figure 28. Tropical shearwater monitoring methods (above) and frequency (below).



Newell's Shearwater (*Puffinus newelli*)

This species is listed as threatened under the U.S. Endangered Species Act and is one of only two endemic seabirds in Hawaii and the region (USFWS 1983). It is present on three of the MHI (Kauai, Maui, Hawaii) and suspected to occur on five more (Lehua, Oahu, Lanai, Kahoolawe, and Molokai). Because of the remote locations of most colonies and their nocturnal habits, radar has been used to monitor abundance of this species on several islands (Cooper and Day 1998, Day et al. 2003a,b, Raine et al. 2017). A population estimate also was derived from large-scale at-sea surveys (Spear et al. 1995). Radar data indicate the population on Kauai, where more than 90% of the worldwide population occurs, has declined by 94% in the last 20 years alone (Raine et al. 2017). It is monitored on all islands where present, including multiple locations on Kauai, and on all islands where it is suspected to be present. Managers are planning to expand monitoring programs to include additional sites and types of information. Light attraction, collisions, and grounding have been monitored on Kauai for many years (Podolsky et al. 1998). On Kauai, a wide range of monitoring occurs and several research and conservation projects are underway. A substantial portion of this monitoring is funded as a part of mitigation for several habitat conservation plans (HCP's) and past take under the ESA and thus the majority of the monitoring is related to conservation outcomes and efficacy of those actions. On islands other than Kauai, most monitoring is done with the use of automated acoustic recorders.

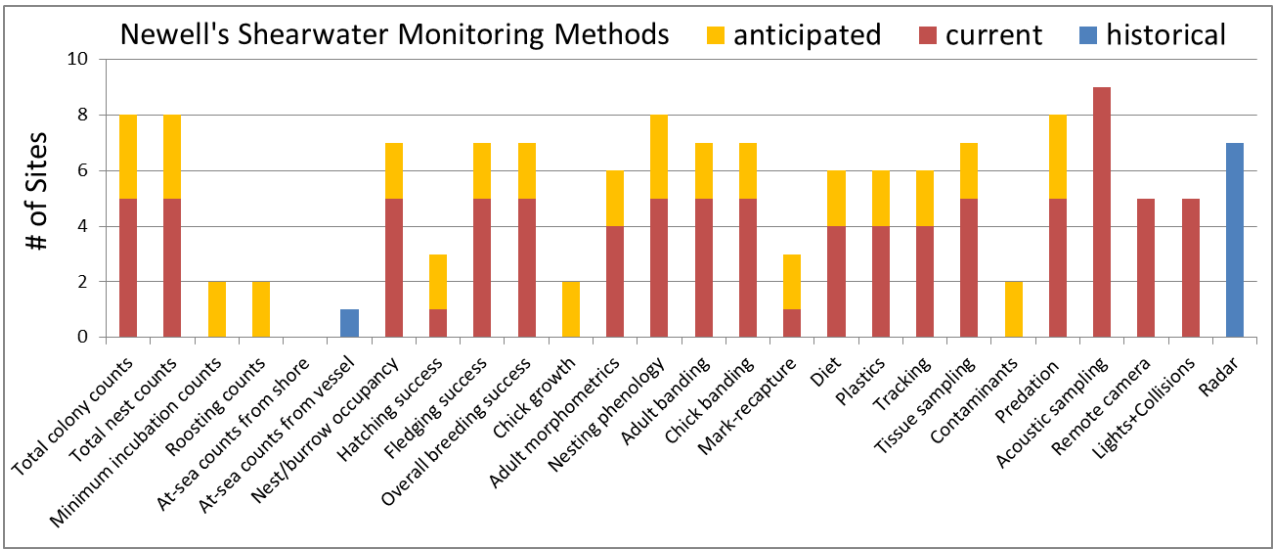
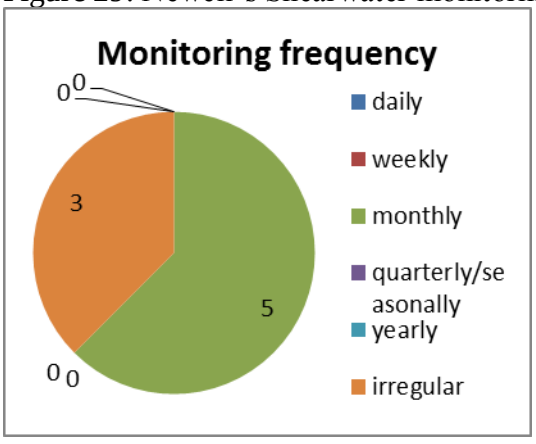


Figure 29. Newell's Shearwater monitoring methods (above) and frequency (below).



Band-rumped Storm-petrel (*Oceanodroma castro*)

This species was listed as endangered under the U.S. ESA in 2016. It is present on three of the MHI (Kauai, Kahoolawe, Hawaii) and suspected to occur on three more (Lehua, Maui, Molokai). It is monitored on all islands where present, and on all islands where it is suspected to occur. Monitoring has been limited by an inability to find nests on the ground, but after substantial effort for years on several islands, the first active nest was found in 2016 at Pohakuloa Training Area (PTA) on Hawaii Island, where detection dogs have been employed to aid in the search for nests (N. Galase et al. unpubl. data). Automated acoustic monitoring (song meters) has been the primary method used at most sites, but there are plans to collect additional information at PTA as more nests are located.

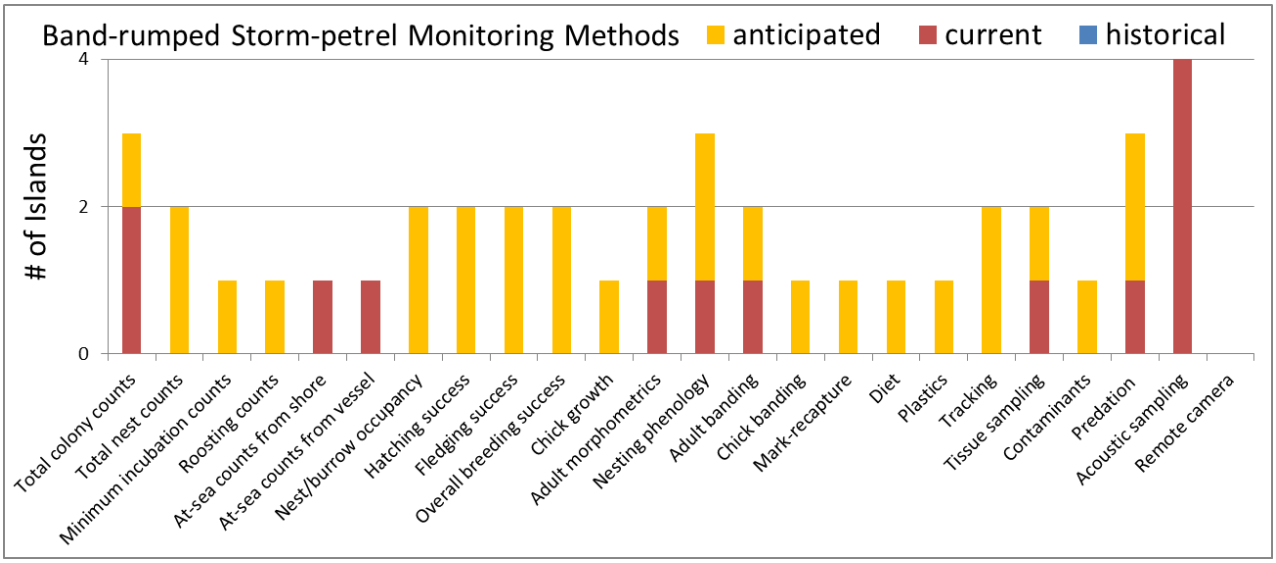
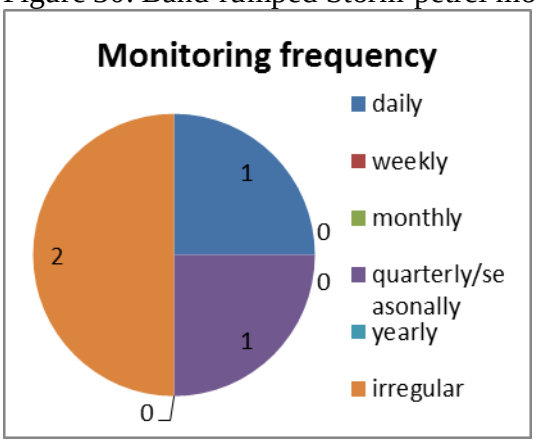


Figure 30. Band-rumped Storm-petrel monitoring methods (above) and frequency (below).



White-throated Storm-petrel (*Nesofregetta fuliginosa*)

This species, also known as the Polynesian Storm Petrel, occurs widely in the Pacific but is rare in most areas and is considered endangered by the IUCN (Pratt et al. 1987, IUCN 2017). It varies substantially in appearance in different portions of its range, and it is possible that it comprises more than one species. In the USTP, White-throated Storm-petrels are known to occur only on Jarvis in the Remotes and Tutuila in AS, but they are difficult to detect because of their small size and nocturnal habits at colonies. It is possible they also occur on other islands, including Howland and Baker in the Remotes. There is virtually no information available on this species in the USTP. Similarly to Tropical Shearwater, remote cameras and song meters are deployed on Jarvis, but no information is gathered beyond presence/absence. This species is very sensitive to predation and is a possible candidate for translocation/social attraction to Palmyra.

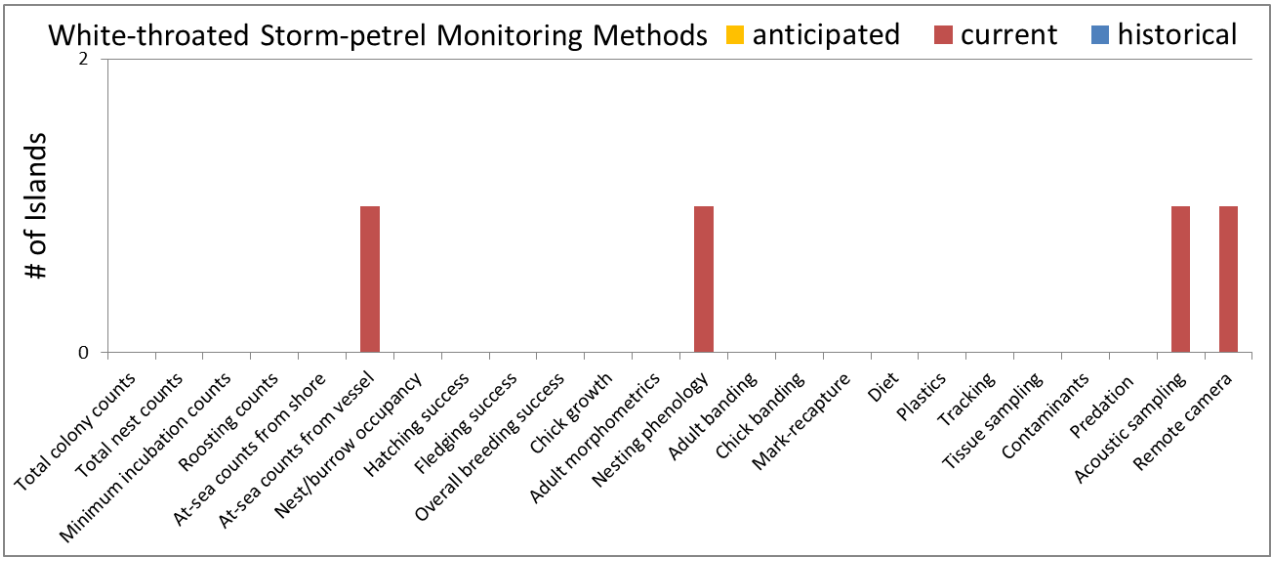
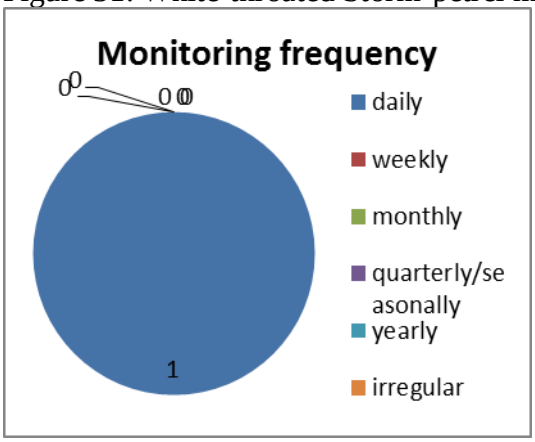


Figure 31. White-throated Storm-petrel monitoring methods (above) and frequency (below).



Tristram's Storm-petrel (*Oceanodroma tristrami*)

This species is present on six islands in the NWHI and is suspected to occur on three more. They are hard to detect because of their small size, nocturnal habits, and nest placement in small crevices and burrows. A large portion of global population nests in the USTP and thus increasing monitoring for this species should be a priority. Unfortunately, monitoring was discontinued at several sites in NWHI due to camps being decommissioned. More data are being collected from the incipient colony on Midway and plans are underway to translocate this species to the MHI in 2018.

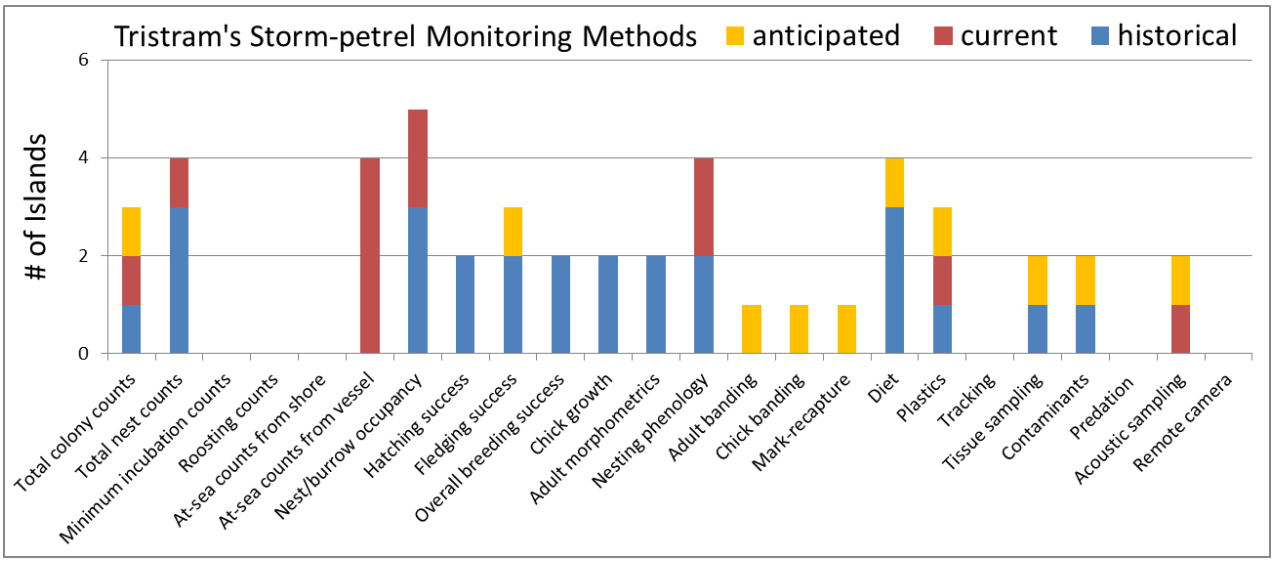
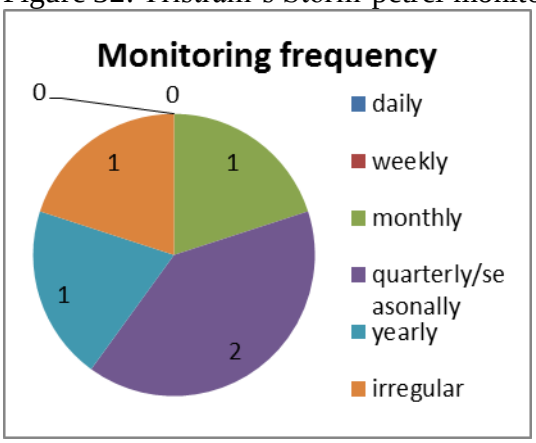


Figure 32. Tristram's Storm-petrel monitoring methods (above) and frequency (below).



White-tailed Tropicbird (*Phaethon lepturus*)

This species is widespread and present on 21 islands in all five regions of the USTP and suspected on four more. It has the dubious distinction of being the least monitored seabird species in the USTP; it is monitored on only 4 of 21 islands where it occurs (19%). Moreover, little information is collected at the few locations where it is monitored. The lack of monitoring is caused by the difficulty in locating and accessing nests, which are placed on small ledges or caves on steep cliffs, in tree cavities, or among dense palm fronds, depending on the island. It is frequently seen on most of the MHI, particularly near coastal and montane cliffs, but few nest sites are accessible. On Midway and Wake Island, where the species nests in tree cavities, monitoring is limited to nest counts and phenology, on Johnston nest success also is measured, but those islands each support a small number of pairs. In the CNMI, where it nests in trees in addition to coastal areas, it has been included in forest bird surveys using point-transects on three islands, but the frequency of detections was too low to effectively estimate abundance (Camp et al. 2009, USFWS 2009). Point-transects also have been used to estimate abundance of this species in Palau (VanderWerf 2005). Nest monitoring and banding formerly was conducted at Kilauea Point NWR, one of only sites where some nests are accessible, but that data has not been made available. Virtually no at-sea data exists on this species. Given the dearth of information, effort should be put into intensive monitoring of known nests.

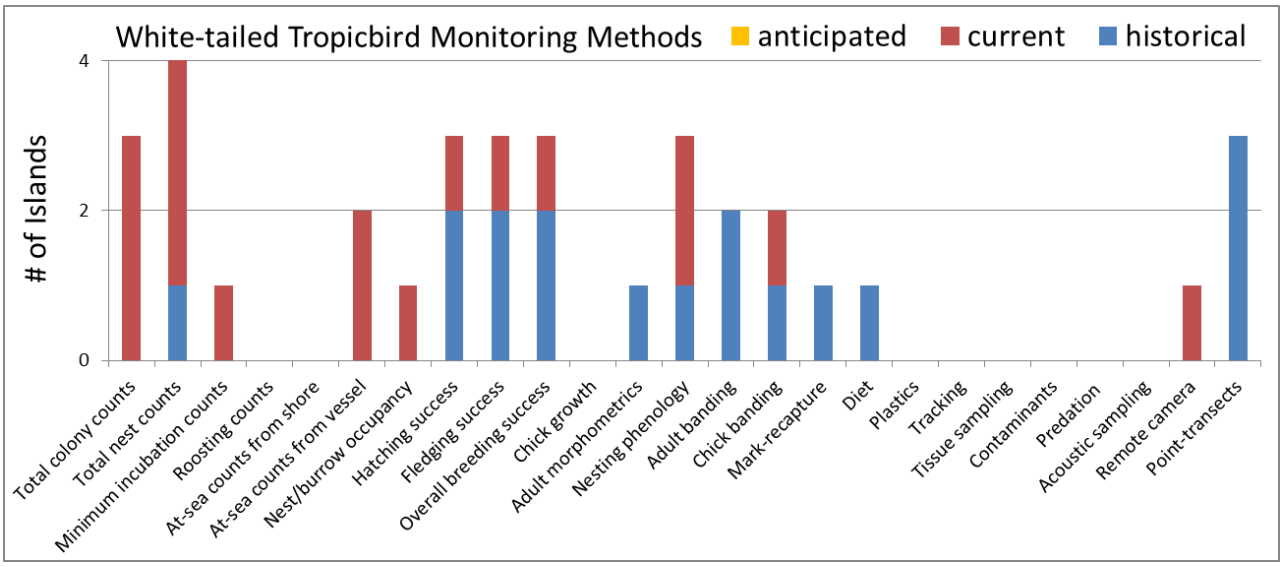
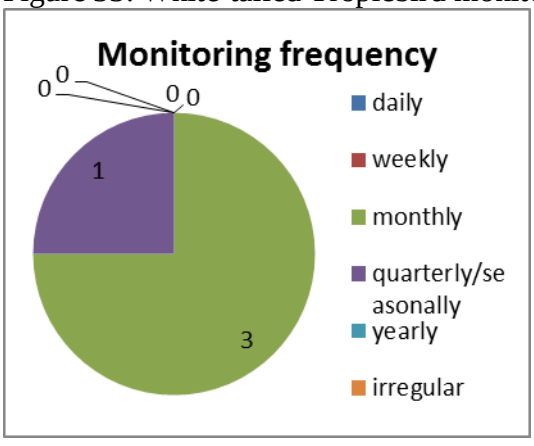


Figure 33. White-tailed Tropicbird monitoring methods (above) and frequency (below).



Red-tailed Tropicbird (*Phaethon rubricauda*)

The Red-tailed Tropicbird is present on 33 islands in all five regions and is the second most widespread seabird species in the USTP. It has been monitored on 16 of 33 islands (48%) overall, but the level of monitoring varied among regions; 50% in MHI, 56% in NWHI; 100% in the Remotes and AS, and zero of nine islands in the Marianas. The somewhat lower overall monitoring level is likely related to access difficulties; on some islands this species nests in small caves on steep cliffs or under dense vegetation. There is a wide range of data types being collected, particularly on Oahu where there is an easily accessible colony (VanderWerf and Young 2014). Many types of data were collected during a comprehensive study on Kure in the NWHI (Fleet 1974). It is vulnerable to predation, despite its loud calls and aggressive behavior (VanderWerf and Young 2014, VanderWerf and Raine 2016). Monitoring on some of the NWHI was discontinued recently, but most data types are still collected elsewhere. In the CNMI counts have been conducted irregularly from vessels, but the data do not provide an accurate indication of abundance (USFWS 2009). Tracking studies have been done recently on several of the MHI, including Oahu, Kauai, and Lehua, giving good data on at-sea distribution. This species has good potential as an indicator species because it is widespread, common, and relatively easy to monitor.

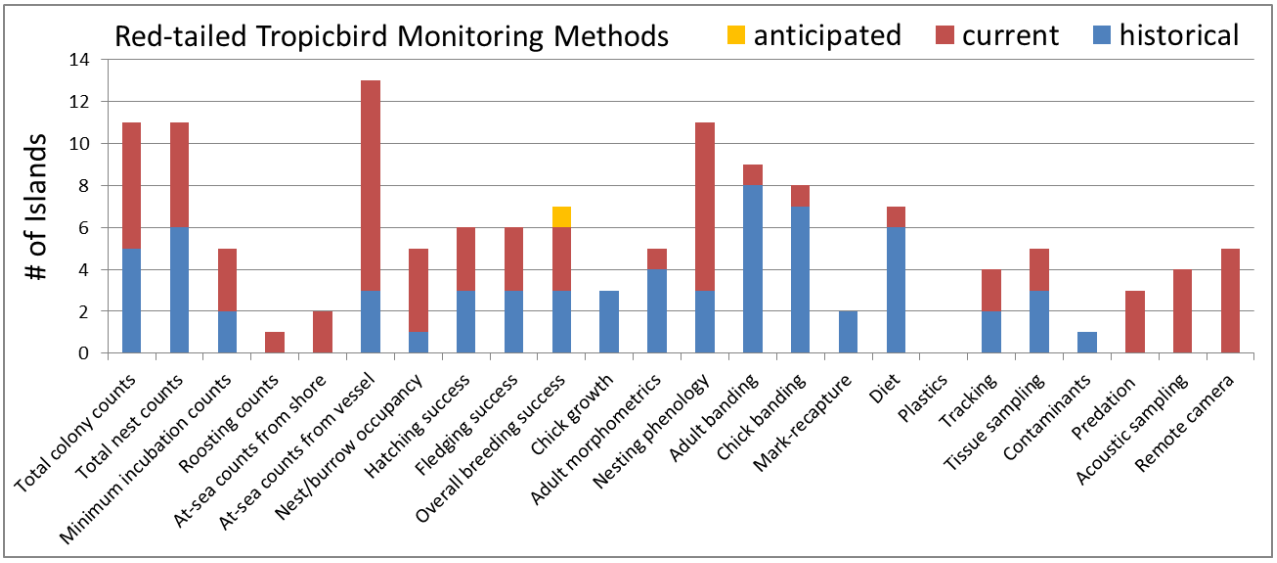
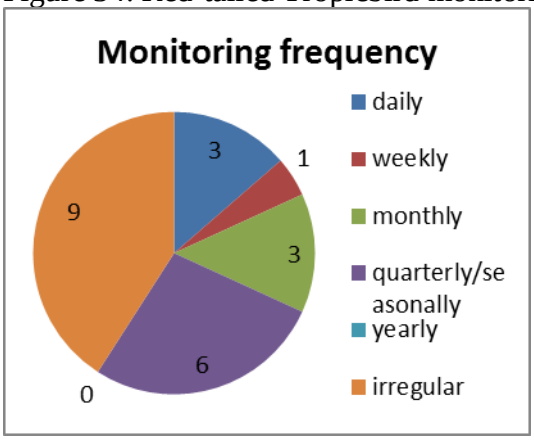


Figure 34. Red-tailed Tropicbird monitoring methods (above) and frequency (below).



Masked Booby (*Sula dactylatra*)

The Masked Booby is found on 23 islands in all five regions of the USTP, but is the least common of the three booby species. It is monitored on 18 of 23 islands (78%), one of the highest rates for all species. By region, it is monitored on the following percentage of islands: 100% in the MHI, 89% in the NWHI: 100% in the Remotes: 25% in the Marianas, and 50% in AS. The high monitoring coverage is likely because this species is large, easy to see because of its white coloration, and nests on the surface. However, despite being monitored at many sites, the amount of data collected is low, and is limited to nest counts and phenology at most sites. Monitoring is done from an aircraft at Kaula and FDM (Camp et al. 2014, Normandeau Associates, Inc. and APEM, Ltd. 2016). Monitoring was discontinued recently on some of the NWHI. There has been some at-sea tracking data and tissue sampling to measure stable isotopes, but only on Palmyra (Young et al. 2010a,b). This species is somewhat sensitive to disturbance, at least at some sites, and the small naked chicks are vulnerable to exposure and overheating, so monitoring must be done cautiously.

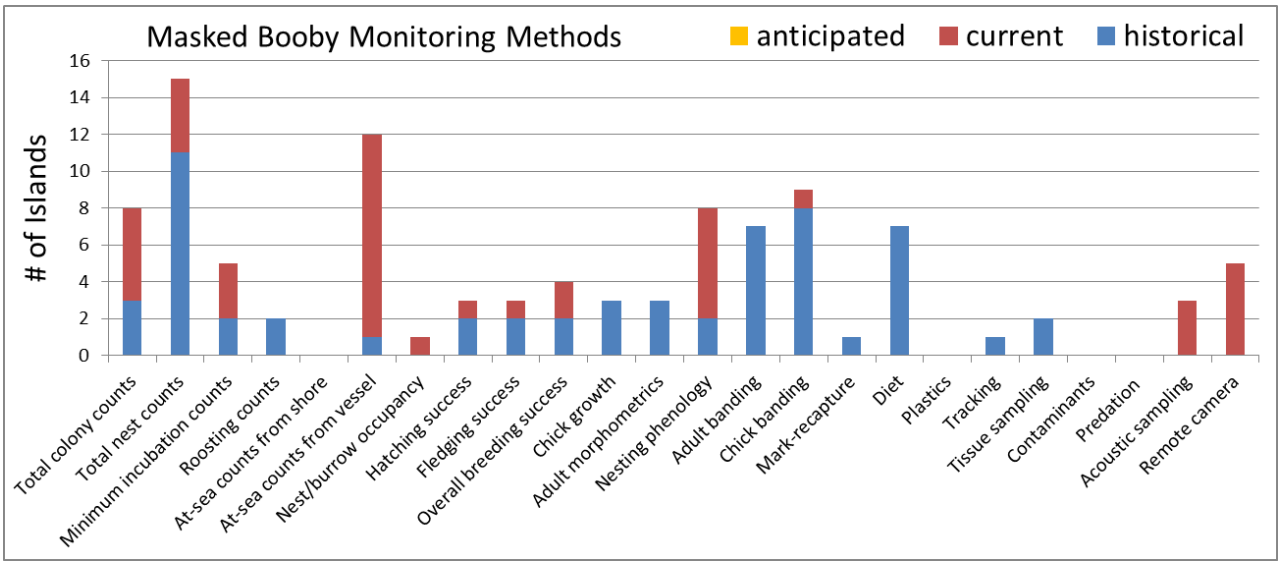
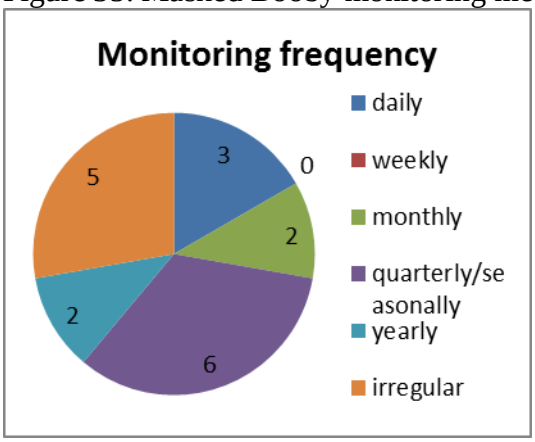


Figure 35. Masked Booby monitoring methods (above) and frequency (below).



Brown Booby (*Sula leucogaster*)

The Brown Booby is found on 31 islands in all five regions, making it the most widespread species of booby and the fourth most widespread seabird in the USTP. It is monitored on 20 of the 31 islands where it occurs (65%). By region, it is monitored on the following percentage of islands: 60% in the MHI, 88% in the NWHI, 100% in the Remotes, 33% in the Marianas, and 33% in AS. However, despite being monitored at many sites, the amount of data collected is low at most sites and is limited to nest counts and phenology, and monitoring on almost half of islands was irregular. Monitoring is done from an aircraft at Kaula and FDM (Camp et al. 2014, Normandeau Associates and APEM, Ltd. 2016). Monitoring was discontinued recently at several sites in NWHI. There has been some at-sea tracking data and tissue sampling to measure stable isotopes, but only on Palmyra (Young et al. 2010a,b). More detailed monitoring is conducted annually on Kure and Johnston. This species is somewhat sensitive to disturbance and the small naked chicks are vulnerable to exposure and overheating, so monitoring must be done cautiously.

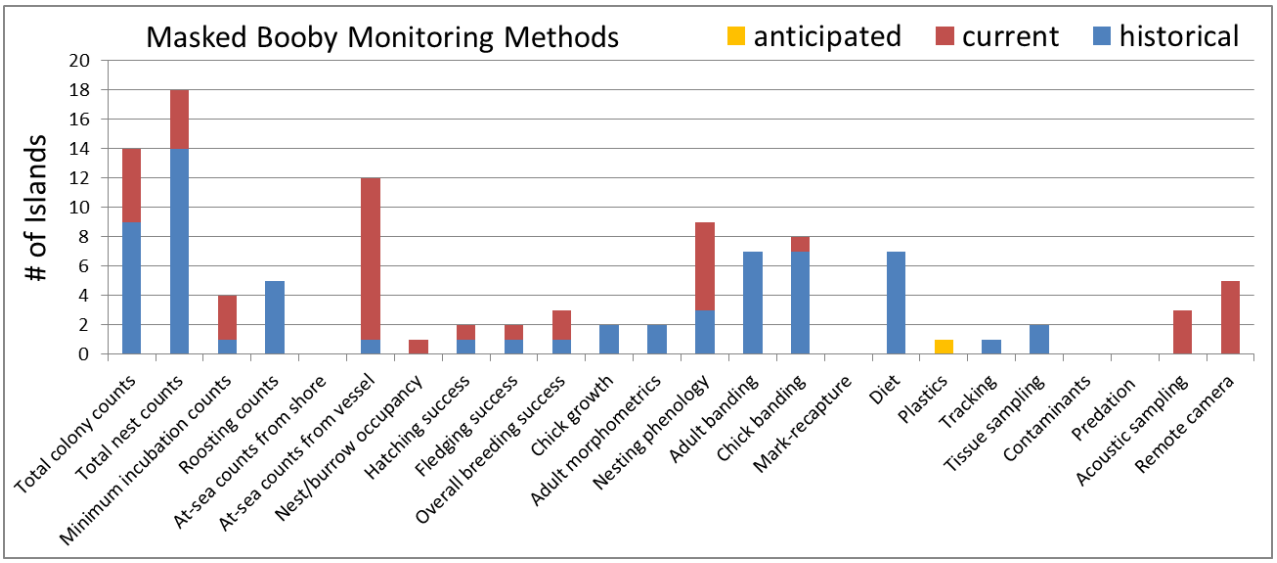
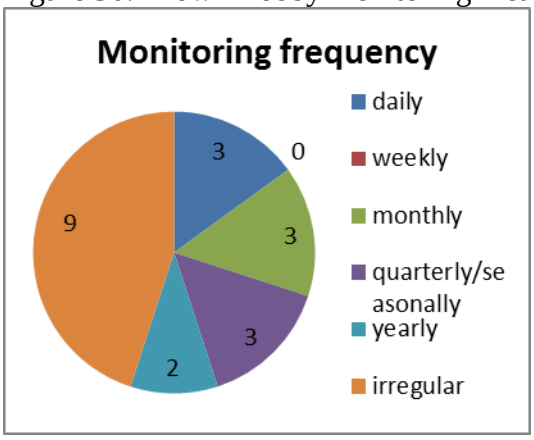


Figure 36. Brown Booby monitoring methods (above) and frequency (below).



Red-footed Booby (*Sula sula*)

Red-footed Boobies are present on 29 islands in all five regions in the USTP, and they are monitored on 20 of those islands (69%). By region, they are monitored on the following percentage of islands: 80% in the MHI, 75% in the NWHI, 100% in the Remotes, 50% in the Marianas, and 25% in AS. However, despite being monitored at many sites, the amount of data collected is low at most sites and is limited to nest counts and phenology, and monitoring is irregular at many sites. More detailed monitoring of reproduction has been done at Marine Corps Base Hawaii on Oahu, where there is an easily accessible colony (Russell and VanderWerf 2010). Monitoring is done from an aircraft at Kaula and FDM (Camp et al. 2014, Normandeau Associates, Inc. and APEM, Ltd. 2016). A wider variety of information has been collected from some locations in the past (e.g. Schreiber 1994). Tracking has been used to gather information about foraging range and behavior of breeding birds on several islands, including Oahu, Kauai, Lehua, and Palmyra. Monitoring was discontinued recently at several sites in NWHI.

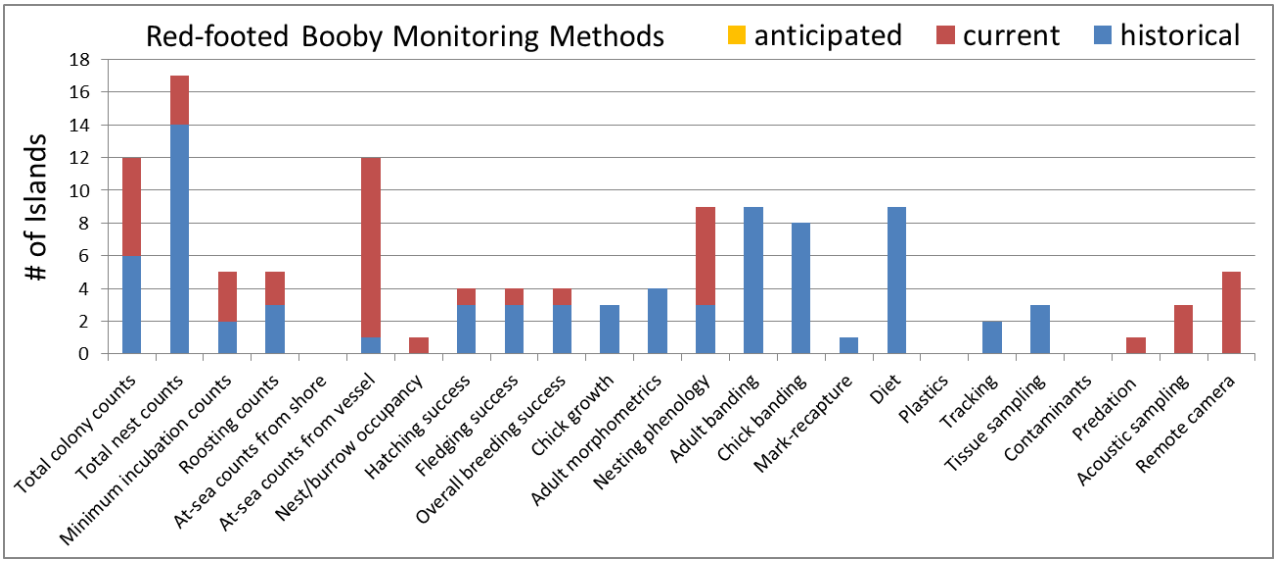
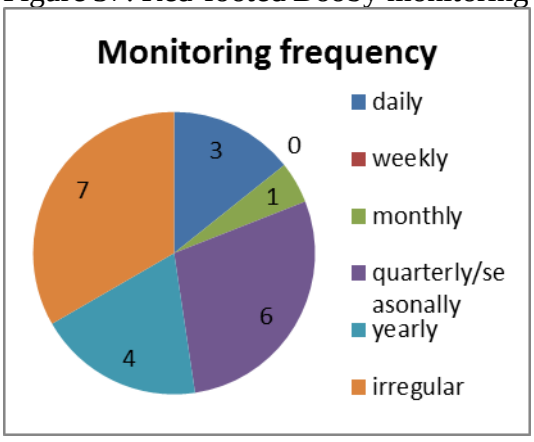


Figure 37. Red-footed Booby monitoring methods (above) and frequency (below).



Lesser Frigatebird (*Fregata ariel*)

Lesser Frigatebirds are present on 10 islands in the USTP and are present only in the Remotes and AS, making them the most restricted range species in the Pelecaniformes order considered in this analysis. They are monitored on only 4 of the 10 islands where they occur (40%), and little information is being collected on this species. Monitoring in the Remotes is done by automated remote cameras and automated acoustic recording. The only monitoring in AS is at Rose Atoll, where data are limited to quarterly nest counts and nesting phenology (B. Peck pers. comm).

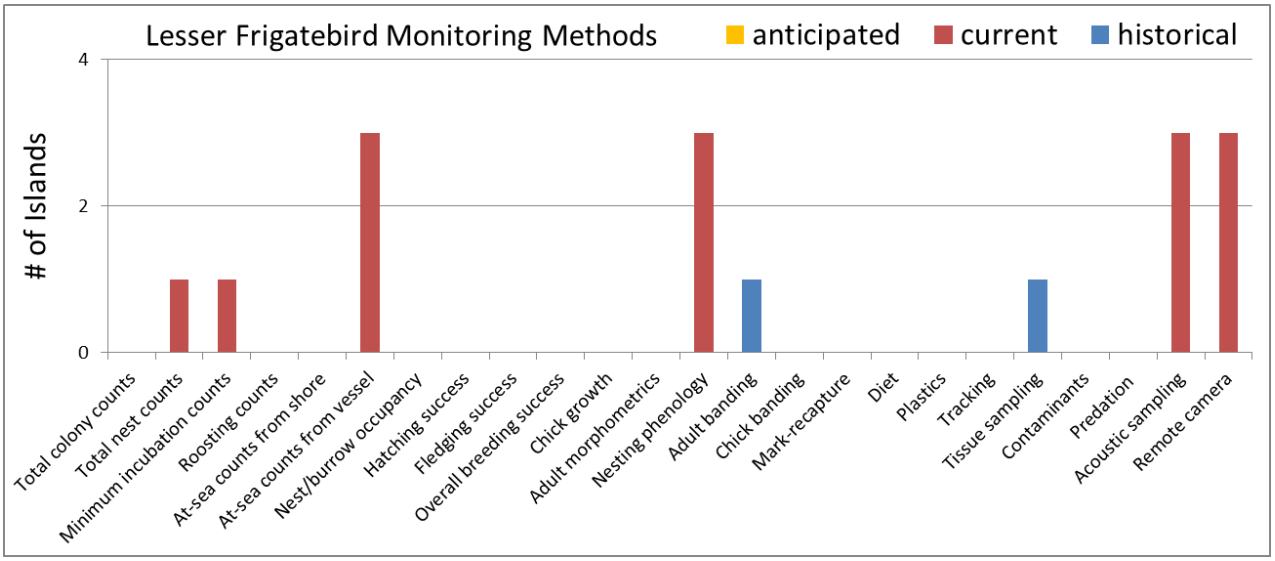
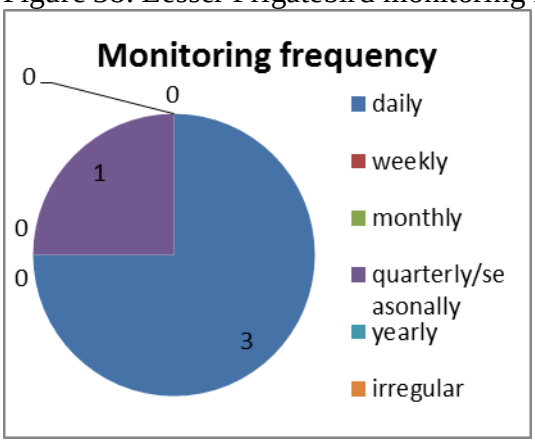


Figure 38. Lesser Frigatebird monitoring methods (above) and frequency (below).



Great Frigatebird (*Fregata minor*)

Great Frigatebirds are present on 29 islands in all five regions of the USTP and are monitored on 17 of those islands (59%). By region, they are monitored on the following percentage of islands: 50% in the MHI, 78% in the NWHI, 100% in the Remotes, 50% in the Marianas, and 33% in AS. Monitoring was recently discontinued at some sites in the NWHI. Adult frigatebirds are easy to detect and monitor because they are large and roost on surface, but nests can be more difficult to detect and can be present sporadically. Relatively few types of data are collected at most sites, partly because some locations are used for roosting only, not nesting. Banding returns and genetic studies indicate Great Frigatebirds can travel long distances and visit several islands, including islands outside the USTP (Dearborn et al. 2003, F. Juola, pers. comm.). They are monitored exclusively by aircraft at Kaula (MHI) and FDM (AS). The Great Frigatebird would be a good indicator species because it is widespread, common, and easy to detect and monitor, and broad-scale monitoring would improve understanding of this species. A substantial amount of research has been conducted on various aspects of this species biology, which could be used to help inform monitoring methods (e.g., Dearborn and Anders 2006, Juola et al. 2006, Juola and Dearborn 2007).

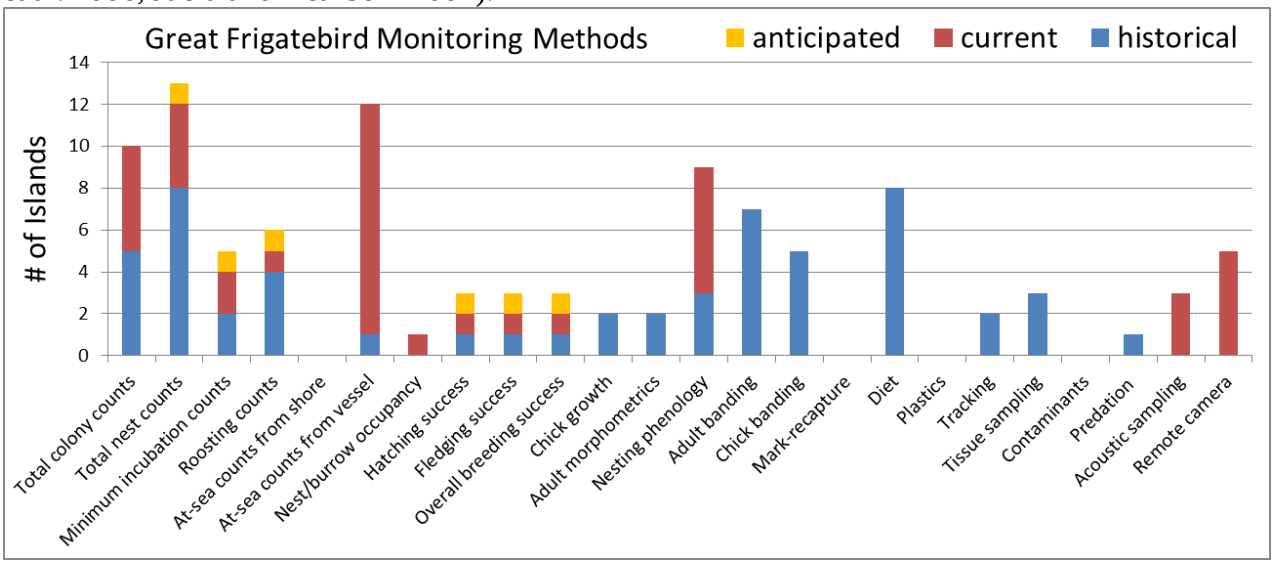
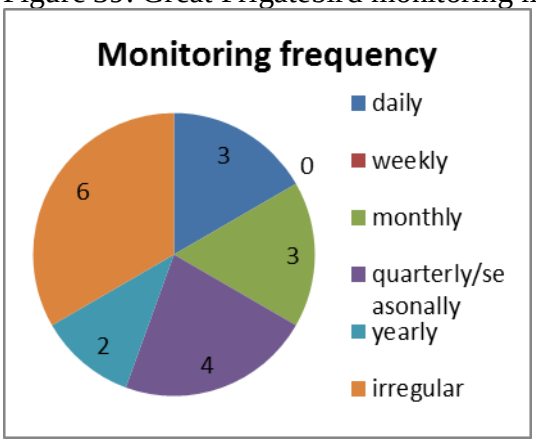


Figure 39. Great Frigatebird monitoring methods (above) and frequency (below).



Brown Noddy (*Anous stolidus*)

Brown Noddies are present on 35 islands in all five regions, making them the second most widespread seabird in the USTP, but they are only monitored on 13 (37%) of those islands. The low level of monitoring is related to inaccessibility of nests in some areas, and to remoteness of some islands used by this species. The nest sites vary among islands; in the MHI they nest on steep rocky cliffs, but on other islands they nest in trees, including coconut palms, shrubs, and on the ground. Monitoring was discontinued recently at several sites in NWHI, and these were the main sites where this species was monitored, so many types of data are now historical only. Little data is currently being collected, mostly counts with no reproductive data. Numbers on Kaula are counted by aircraft, but this method does not allow collection of reproductive data.

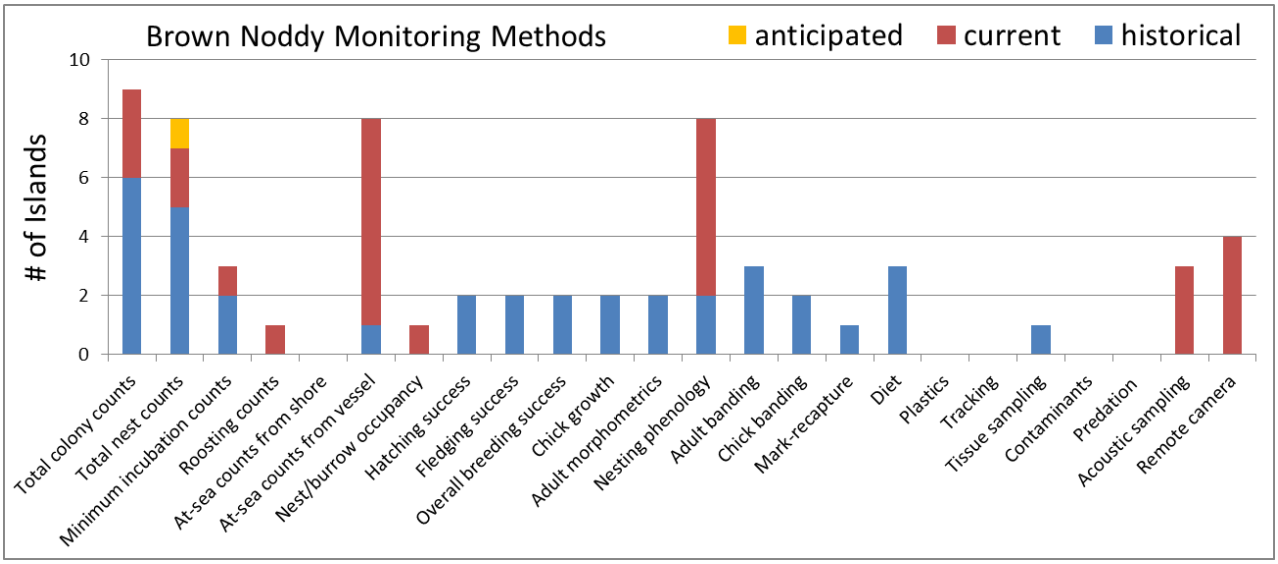
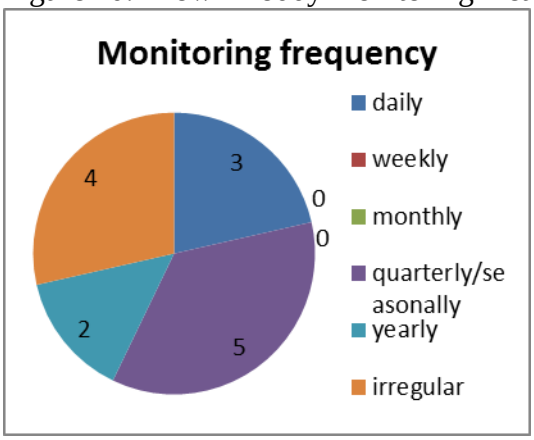


Figure 40. Brown Noddy monitoring methods (above) and frequency (below).



Black Noddy (*Anous minutus*)

The Black Noddy is the most widely distributed seabird in the USTP, occurring on 36 islands in all five geographic regions. However, it is the second-least monitored seabird species in the USTP, with data being gathered on only 11 of 36 islands where it occurs (31%). Moreover, relatively few types of information have been collected about Black Noddies, mostly nest counts, nesting phenology, and roosting counts. The low level of monitoring conducted for this species is likely related to its preferred nest locations, which are relatively difficult to access compared to nest sites of most seabirds. In the MHI, the endemic subspecies *A. m. melanogenys*, sometimes called the Hawaiian Noddy, nests on coastal sea cliffs that are difficult to view from land and difficult to reach by sea. In other parts of the USTP, the subspecies *A. m. marcusi* nests in trees, sometimes high in tall trees where nests are difficult to see. This species was the subject of detailed research in the past, primarily on Tern Island (Gauger 2000), but monitoring was discontinued recently on several of the NWHI. In the CNMI, where it nests in trees and in coastal areas, this species has been included in forest bird surveys using point-transects on three islands, but the frequency of detections was too low to effectively estimate abundance (Camp et al. 2009, USFWS 2009). Because this species often forages close to the islands where it nests, it would be a useful indicator species in which to examine geographic variation in breeding success and other parameters that could be related to oceanographic conditions and changes.

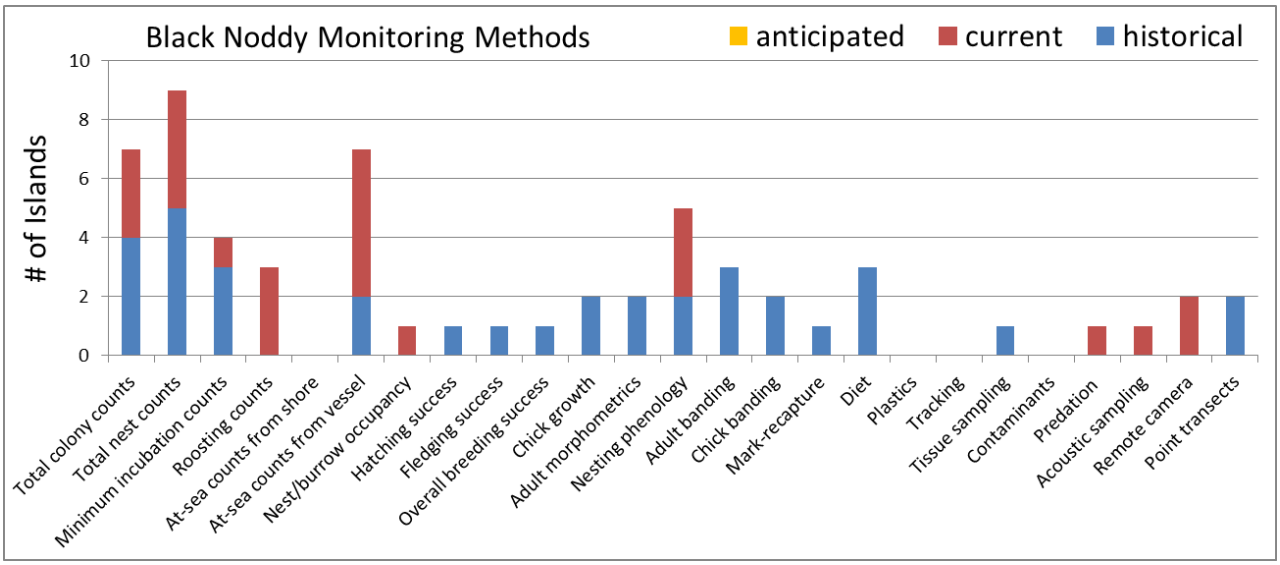
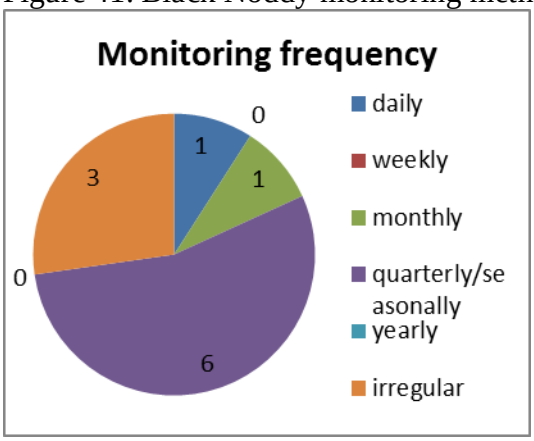


Figure 41. Black Noddy monitoring methods (above) and frequency (below).



Blue-gray Noddy (*Anous ceruleus*)

The Blue-gray Noddy occurs on only 8 islands in three of the five regions in the USTP (NWHI, Remotes, and AS; it is an occasional visitor in the Marianas and MHI but does not nest or occur regularly). It is monitored on only three of the eight islands (38%), primarily because most of the nesting areas are located on remote islands, often on steep cliffs. Very little information is collected about this species in the USTP and large data gaps exist for this species. The only monitoring is done in the Remotes with automated remote cameras and recording units (song meters), and visits once every three years.

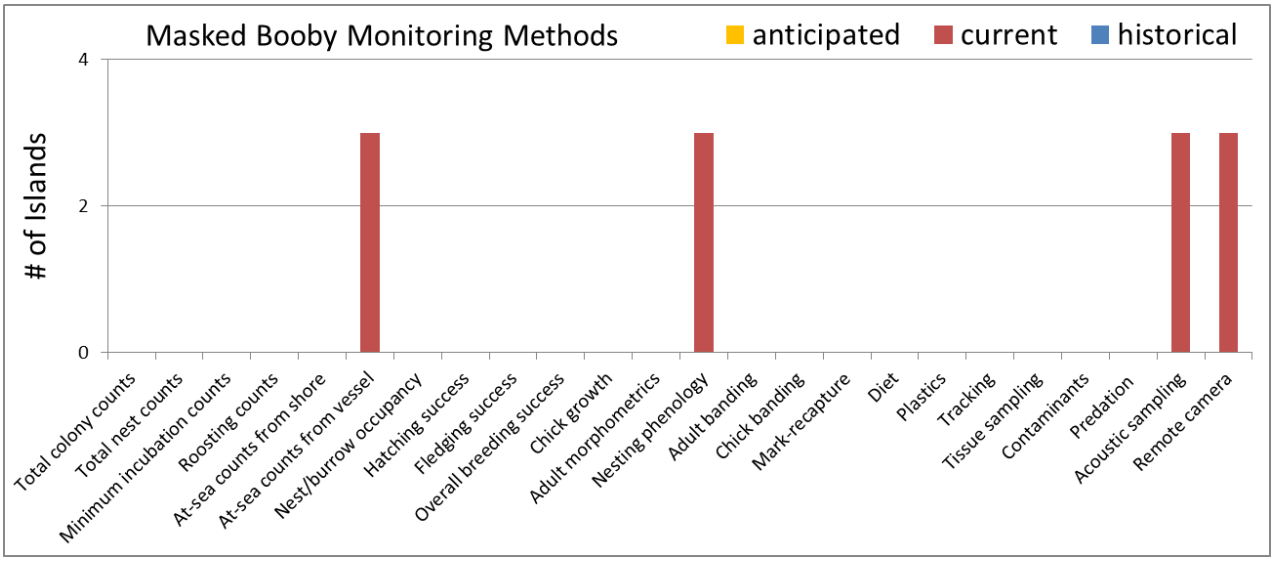
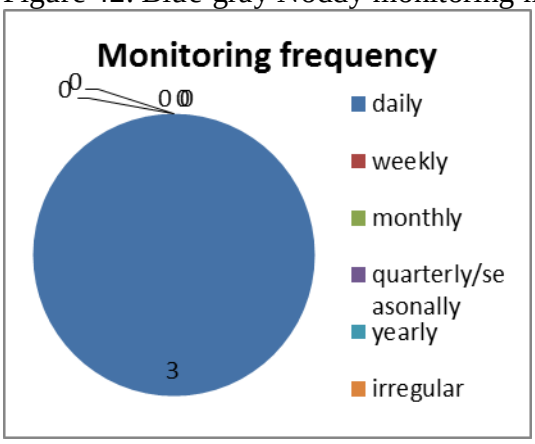


Figure 42. Blue-gray Noddy monitoring methods (above) and frequency (below).



White Tern (*Gygis alba*)

The White Tern is the fourth most widespread seabird in the USTP, occurring on 31 islands in all five regions. In the MHI it is present only on Oahu and strangely absent from other islands (VanderWerf and Downs 2017). However, it is also the fourth least monitored seabird in USTP, being monitored on only 11 islands (35%). The most comprehensive monitoring currently occurs on Oahu, where several measures of abundance and reproduction are collected (VanderWerf 2003, VanderWerf and Downs 2017). A citizen science project is being used to help monitor White Terns on Oahu (www.whiteterns.org). Most monitoring in the NWHI was discontinued recently. Few data types currently are collected at most sites. Although White Terns are common and their nesting areas are easily accessible on most islands, their nests tend to be dispersed and sometimes high in trees and not in discrete, dense colonies, making them more difficult to monitor. A point-transect survey method, which is more commonly used for forest birds, has been used to estimate population density and size of White Terns on islands where they are widespread in forested areas, including Palau (VanderWerf 2007) and Saipan, Tinian, and Aguiguan in the CNMI (USFWS 2008, Camp et al. 2009). White Terns are among the seabirds most resistant to predation, and are even spreading on Guam (J. Quitugua, pers. comm.). There is no data yet on at-sea distribution, but tracking is anticipated on Oahu. This could be useful indicator species in the USTP because it is widespread, common, and nests are accessible.

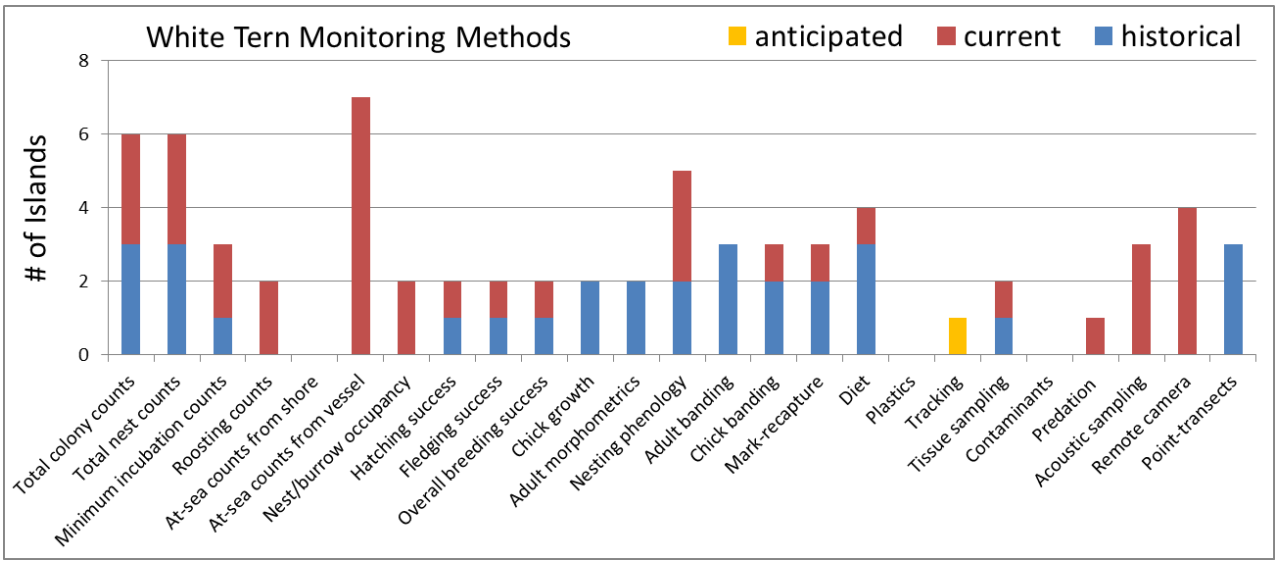
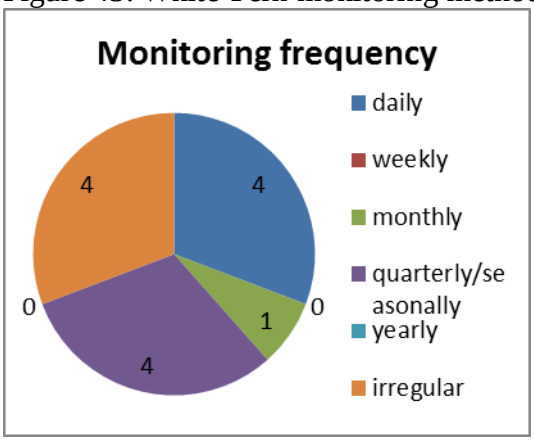


Figure 43. White Tern monitoring methods (above) and frequency (below).



Sooty Tern (*Onychoprion fuscatus*)

Sooty Terns are present on 25 islands in all five regions of the USTP and are monitored on 13 of those islands (52%). They are sensitive to disturbance and vulnerable to predators, and occur primarily on uninhabited islands or small islets off larger islands (Rauzon et al. 2011). Sooty Terns usually nest in large dense colonies and their nesting phenology is variable (B. Flint, pers. comm.), complicating monitoring. By region, monitoring is done on the following proportion of islands: 33% in the NWHI, 67% in the MHI, 25% in the Marianas, 100% in the Remotes, and 33% in AS. Monitoring was discontinued recently at some sites in NWHI, and many types of information are now historical only. At most sites monitoring is limited to nest and colony counts, but some other data is still collected on Wake Atoll. Monitoring frequency is more irregular than for most species, but the species itself is irregular because of its variable nesting phenology.

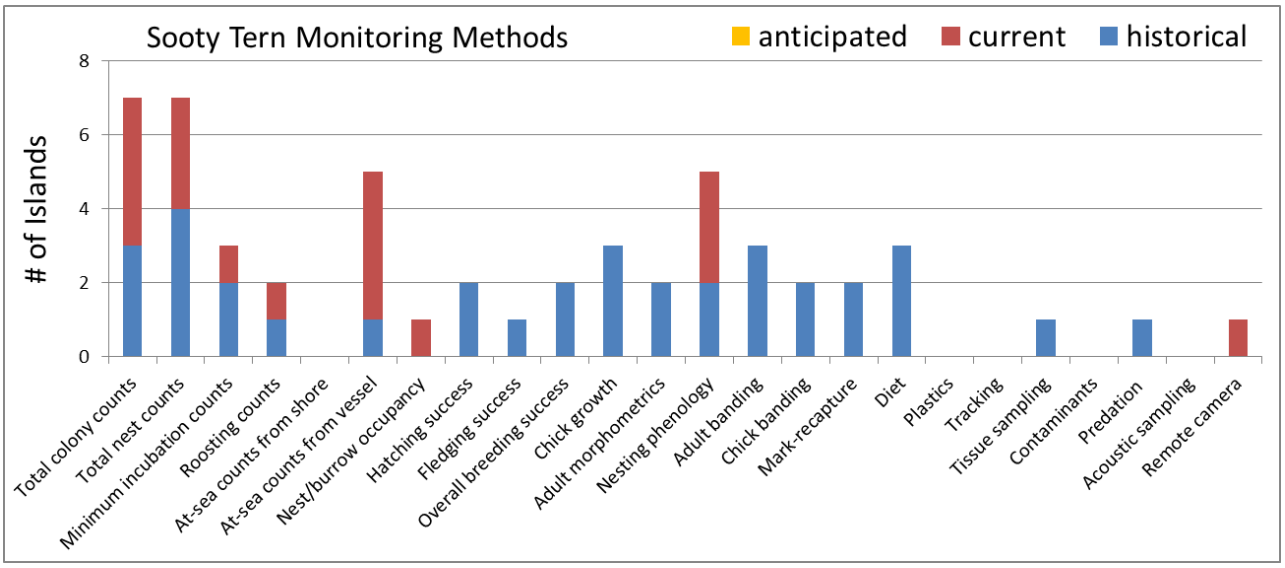
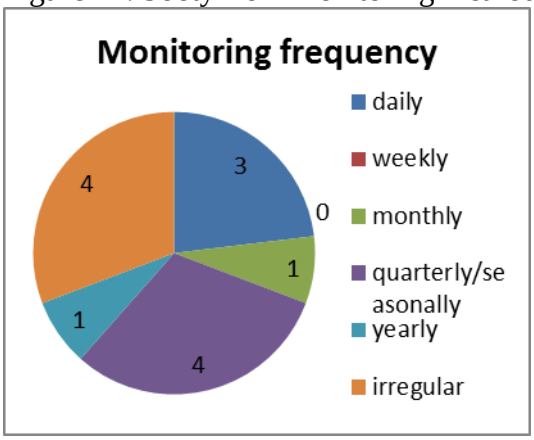


Figure 44. Sooty Tern monitoring methods (above) and frequency (below).



Gray-backed Tern (*Onychoprion lunatus*)

The Gray-backed Tern is present on 20 islands in all five regions of the USTP, and is monitored on 11 of those islands (55%). By region, monitoring is done on the following proportion of islands: 44% in the NWHI, 50% in the MHI, 0% in the Marianas, 100% in the Remotes, and 33% in AS. Monitoring was discontinued recently at some sites in NWHI, and many types of information are now historical only. There is no current information on reproduction, but there are plans to begin collecting more data on Kure Atoll.

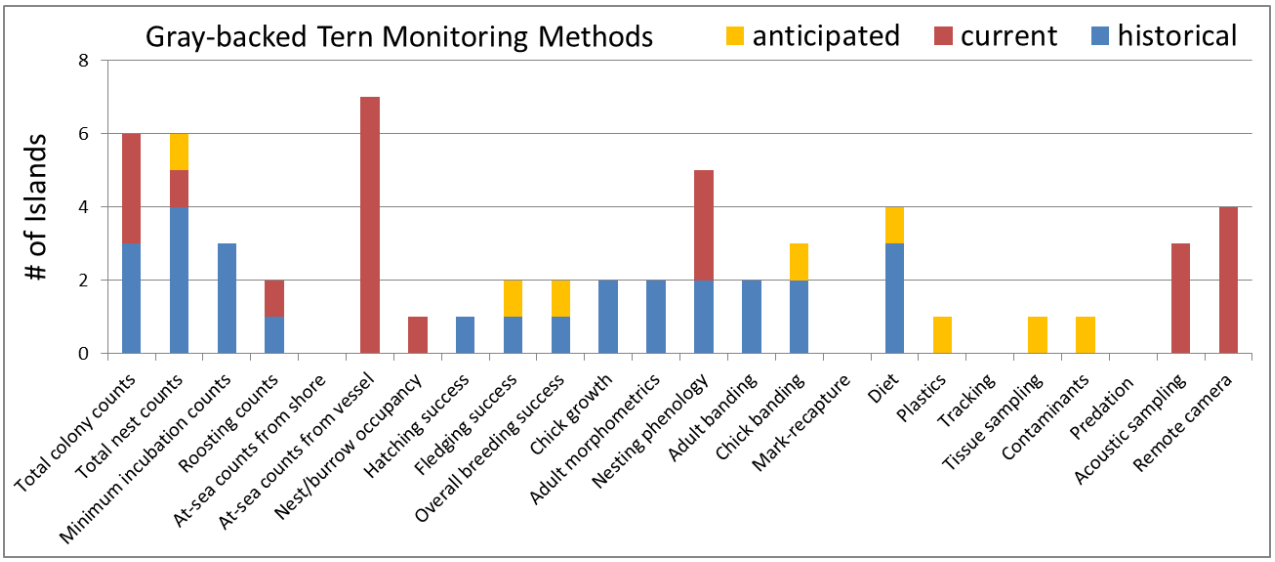
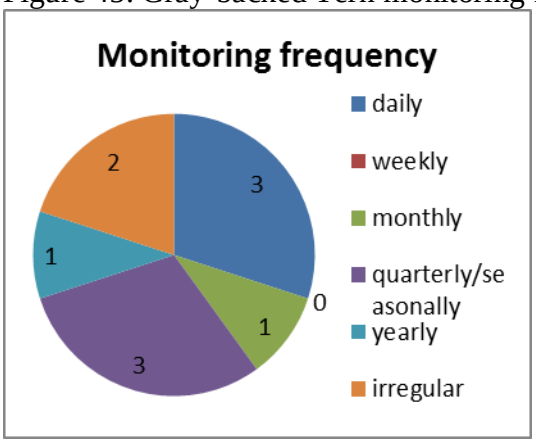


Figure 45. Gray-backed Tern monitoring methods (above) and frequency (below).



DISCUSSION

Geographic patterns and gaps

There is considerable variation in seabird monitoring among the geographic areas within the USTP, which resulted in several information gaps. The proportion of species monitored is highest in the MHI and Remotes, and amount of data collected is highest in the MHI and NWHI. The proportion of species monitored is lowest in the MI and in AS. There likely are several causes for the monitoring gap in these regions, including the difficulty of accessing some remote islands, limited funding and staff, and, in some cases, the lack of long-term institutional history in managing monitoring activities. There was more intensive monitoring of seabirds in the CNMI in the past; several older reports provide information about distribution and abundance of seabirds on most islands. It is possible some of these efforts have continued, and that further enquiries and searching might reveal additional data that are still collected.

The Remotes appear to have a high level of monitoring for most species, but the amount of data collected for each species varies substantially among islands and is limited in some cases. For example, on Wake Island, there has been consistent quarterly monitoring for almost all species. On Palmyra, only a few species are monitored and most surveys are done irregularly. On Baker, Howland, and Jarvis, the intensity of monitoring appears to be high, but visits occur only once every three years and the primary monitoring method for most species is automated remote cameras, which provide limited types of information.

Another data gap that was less apparent from the questionnaire is that most seabird monitoring in the USTP is focused on the terrestrial life history of species on their nesting islands. By comparison, there is much less data about them at sea. Tracking has been done for several species, and frequency of tracking studies has been increasing, with improvements in technology making it possible to track smaller species (Hyrenbach et al. 2002, Kappes et al. 2010, Gutowski et al. 2014), but the data that has been collected still represents a small window into the biology of these species while they are at sea. The designation of large marine national monuments in the USTP should help protect important foraging areas used by seabirds, but in order to know how species use those areas and whether the protections are sufficient and effective, we need more data about seabirds in the marine environment.

Species patterns and gaps

Monitoring is needed to assess the status of species and measure effect of threats and management actions, especially for endangered species. In contrast, lack of information inhibits assessment of status and management needs making it difficult for decision makers. Below are the patterns for each taxonomic group.

<u>Albatrosses</u>

The three albatross species were among the most intensively monitored seabird species in the USTP. This probably is a result of several factors. Albatrosses as a group are highly threatened and there is concern about the status of all three North Pacific Albatross species (Tickell 2000, Arata et al. 2009; IUCN 2017). The Short-tailed Albatross is federally listed as endangered, the Black-footed Albatross was proposed for listing under the ESA several years ago but was determined not to warrant listing, and the Laysan Albatross is considered a species of concern and is near threatened according to the IUCN (Arata et al. 2009; IUCN 2017, USFWS

albatross action plan). Albatrosses are also large and they nest on the surface, making them easy to detect and monitor (Tickell 2000).

Petrels and Shearwaters

Although all the species in this group share largely similar breeding biology, they vary greatly in their abundance, range, and preferred breeding habitat. This group includes some of the most widespread species in the USTP, and also some of the rarest (USFWS 2005). Consequently, there is enormous variation in the degree to which the various petrels and shearwaters have been and are currently being monitored in the USTP. Some species are well monitored virtually everywhere they occur, such as Wedge-tailed Shearwater and all three of the ESA listed species. Other species, such as the petrels found only in AS, nest in dense vegetation on the summit of steep mountains and are infrequently monitored. Others, such as the White-throated Storm-petrel and Band-rumped Storm-petrel, are difficult to detect because of their small size, nocturnal habits, and the remote location of their breeding colonies. Some of this variation is geographic in nature, with species that are restricted to certain regions that are monitored less intensively.

Tropicbirds, Boobies, and Frigates

These species are generally well monitored, at least in part because they are large and nest and roost above ground, making them easy to detect and facilitating measurement of breeding activity. For example, on FDM in CNMI, boobies and frigatebirds were the only species effectively monitored because they are the only species readily visible from an aircraft. An exception is the White-tailed Tropicbird, which is monitored on the lowest proportion of islands of any species. This low level of monitoring is caused by the types of nest sites used by this species. In the MHI, White-tailed Tropicbirds nest exclusively on steep cliffs either on the coast or in high mountains because of the abundance of predators. Nests are accessible in only a few sites in the MHI, such as Kilauea Point NWR. In other locations such as Midway Atoll, Palmyra, and some areas of the CNMI, they nest in hollow trees or among palm fronds, where they are difficult to observe and access. Despite having relatively good coverage in this group, a limited subset of data is being collected at most sites. Most monitoring is limited to counts, which do not provide much biological information. Adding reproductive success at more sites for more species would be beneficial. It would also be helpful to pick a representative focal species that is widespread for increased monitoring and comparisons among sites (such as Red-footed Booby and Red-tailed Tropicbirds).

Terns and Noddies

This group includes some of the most widespread seabirds in the USTP, such as Black Noddy, Brown Noddy, and White Tern, and some of the most abundant, such as the Sooty Tern, yet they are among the least monitored species, resulting in an information gap. Blue-Gray Noddy is a complete species gap with no existing monitoring data being collected. Some of this gap is related to the inaccessibility of the nesting sites used by these species. In the MHI, Sooty Terns, Brown Noddies, and Black Noddies nest on steep cliffs or on small offshore islets, where they are difficult to observe well or access. On Kaula, their numbers are counted using high resolution photographs taken from an aircraft, but no information about breeding is collected with this method. White Terns are less colonial that many other tern species and their nests are

often scattered over a large geographic area, making it more difficult to collect many types of information (VanderWerf 2003).

The species in this group vary widely in their use of the marine environment. Some of these species are common and widespread throughout the USTP and elsewhere in the Pacific, so there is less concern about them, but their broad distribution and abundance could make them useful indicators of broad geographic patterns, if sufficient information was available. Some species, like Black Noddies and White Terns, often forage close to their nesting islands, at least during the nesting season, and thus may reflect local-scale oceanographic patterns. In contrast, Sooty Terns, which are one of the most abundant seabird species in the USTP, wander widely over the USTP and exhibit a variable nesting phenology in response to very broad-scale oceanographic patterns. They also can be more susceptible to disturbance than many seabirds, requiring additional care when conducting monitoring activities.

Limitations and Issues with the Questionnaire

When reviewing data received during this exercise, it became clear that certain methodologies could be improved for future efforts to identify seabird monitoring gaps. For example, the questionnaire did not require people to distinguish between breeding vs. roosting, and thus it is not recommended that this analysis be used as a definitive reference for breeding range of seabirds in the USTP. As previously discussed, there was confusion over whether simply determining presence/absence should be counted as monitoring, and whether historical monitoring should still count as the species being monitored. This was addressed on an individual basis in the species accounts by asking for clarification from respondents, but it should be noted for future efforts that clarifying and expanding upon these terms will provide a more robust picture of the monitoring being undertaken.

Future Directions

The purpose of this report was to conduct a gap analysis of seabird monitoring to support the prioritization of species to be surveyed in the USTP. Identifying gaps in survey information for species as well as sites will help to prioritize seabird monitoring needs in the USTP in the future. To complement the work presented in this report, a stand-alone tropical seabird monitoring manual has been developed concurrently for the PSP, using this analysis as a foundation. The monitoring manual builds upon previous efforts by Citta et al. (2007) and offers a flexible, multi-tiered approach to monitoring, designed to help readers choose the methods that are best suited to their objectives, available resources, and capacity. The monitoring manual assumes that some managers do not have any previous seabird monitoring experience and thus recommends techniques for both beginners and experts. It also outlines situations where monitoring can only be conducted during limited time periods (such as during rapid assessments) and also in scenarios where long term, regular access is possible. As a result of the varying needs and backgrounds of those conducting monitoring in the USTP, multiple scenarios are presented for each type of monitoring and grouped according to both monitoring goals, and species-specific monitoring needs. It is hoped that the combination of this report and the monitoring manual will provide seabird managers in the USTP with a template from which to conduct future monitoring that builds upon what has been done previously.

ACKNOWLEDGEMENTS
This work was funded by the USFWS Region 1 Inventory and Monitoring Initiative. We gratefully acknowledge Amanda Pollock, Beth Flint, Roberta Swift, and Kevin Kilbride for their input in guiding the project and development and review of the gap report. We also thank the questionnaire respondents and workshop participants for providing information and contributing to this effort in many ways.

LITERATURE CITED

Adams, J. and S. Flora. 2010. Correlating seabird movements with ocean winds: linking satellite telemetry with ocean scatterometry. Marine Biology 157:915-929.

Arata, J. A., Sievert P.R., Naughton, M.B. 2009. Status assessment of Laysan and black-footed albatrosses, North Pacific Ocean, 1923-2005. U.S. Geological Survey Scientific Investigations Report 2009-5131, 80 p.

Auman, H. J., J. P. Ludwig, C. L. Summer, et al. 1997. PCBS, DDE, DDT, and TCDD-EQ in two species of albatross on Sand Island, Midway Atoll, North Pacific Ocean. Environmental Toxicology and Chemistry 16:498-504.

Baker, R.H. 1951. The avifana of Micronesia, its origin, evolution, and distribution. University of Kanas Publications, Museum of Natural History 3(1):1-359.

Bakker, V.J., Finkelstein, M.E., Doak, D.F., Young, L.C., VanderWerf, E.A., Arata, J., Sievert, P.R. and Vanderlip, C. 2017. The albatross of assessing and managing risk for long-lived pelagic seabirds. Biological Conservation. In press.

Byrd, G. V., Moriarty, D. I., & Brady, B. G. 1983. Breeding biology of Wedge-tailed Shearwaters at Kilauea Point, Hawaii. Condor 85:292-296.

Camp, R.J., C. Leopold, K.W. Brinck, and F. Juola. 2014. Farallon de Medinilla seabirds and Tinian moorhen analyses. Hawaii Cooperative Studies Unit, University of Hawaii at Hilo, Technical Report HCSU-060.

Camp, R.J., Pratt, T.K., Marshall, A.P., Amidon, F. and Williams, L.L. 2009. Recent status and trends of the land bird avifauna on Saipan, Mariana Islands, with emphasis on the endangered Nightingale Reed-warbler *Acrocephalus luscinia*. Bird Conservation International 19(4):323-337.

Citta, J., M. H. Reynolds, and N. Seavy. 2007. Seabird Monitoring Assessment for Hawai`i and the Pacific Islands. Hawai`i Cooperative Studies Unit Technical Report. HSCU-007. University of Hawai`i at Hilo, 122 pp.

Clapp, R.B. 1989. First record of the Little Tern, *Sterna albifrons*, from Hawaii. ‘Elepaio 49:41-46.

Conant, S., R. Clapp, L. Hiruki and B. Choy. 1991. A new tern (*Sterna*) breeding record for Hawaii. Pacific Science 45:348-354.

Cooper, B.A. and R.H. Day. 1998. Summer behavior of dark-rumped petrels and Newell’s shearwaters at power lines on Kauai. Colonial Waterbirds 21: 11-19.

Cury, P.M., Boyd, I.L., Bonhommeau S., Anker-Nilssen, T., Crawford, R.J.M., Furness, R.W., et al. 2011. Global seabird response to forage fish depletion—one-third for the birds. Science 334: 1703–1706.

Day, R.H., B.A. Cooper, and R.J. Blaha. 2003a. Movement patterns of Hawaiian petrels and Newell’s shearwaters on the island of Hawai`i. Pacific Science 57: 147-159.

Day, R.H., B.A. Cooper, and T.C. Telfer. 2003b. Decline of Townsend’s (Newell’s) shearwaters (*Puffinus auricularis newelli*) on Kauai, Hawaii. Auk 120: 669-679.

Dearborn, D.C. and Anders, A.D. 2006. Demography and reproductive ecology of great frigatebirds. Atoll Research Bulletin 543:159-171.

Dearborn, D.C., Anders, A.D., Schreiber, E.A., Adams, R.M. and Mueller, U.G. 2003. Inter-island movements and population differentiation in a pelagic seabird. Molecular Ecology 12(10):2835-2843.

Dearborn, D.C., Anders, A.D. and Flint, E.N. 2001. Trends in reproductive success of Hawaiian seabirds: is guild membership a good criterion for choosing indicator species? Biological Conservation 101(1):97-103.

Deguchi, T., Suryan, R.M., Ozaki, K., Jacobs, J.F., Sato, F., Nakamura, N. and Balogh, G.R. 2014. Translocation and hand-rearing of the short-tailed albatross *Phoebastria albatrus*: early indicators of success for species conservation and island restoration. Oryx 48(2):195-203.

Eldredge, J.G., R.T. Tsuda, P. Moore, M. Chernin, and S. Neudecker. 1977. A natural history of Maug, Northern Mariana Islands. University of Guam Marine Laboratory, Technical Report No. 43. December 1977.

Fefer, S.I., Hu, D., Naughton, M.B. 1983. Catalog of Hawaiian Seabird Colonies. U.S. Fish and Wildlife Service. 236 pp.

Finkelstein, M., Keitt, B.S., Croll, D.A., Tershy, B., Jarman, W.M., Rodriguez-Pastor, S., Anderson, D.J., Sievert, P.R. and Smith, D.R. 2006. Albatross species demonstrate regional differences in North Pacific marine contamination. Ecological Applications 16(2):678-686.

Fischer, K. N., R. M. Suryan, D. D. Roby, and G. R. Balogh. 2009. Post-breeding season distribution of black-footed and Laysan Albatrosses satellite-tagged in Alaska: Inter-specific differences in spatial overlap with North Pacific fisheries. Biological Conservation 142:751-760.

Fisher, H. I. 1975a. Mortality and survival in the Laysan Albatross, *Diomedea immutabilis*. Pacific Science 29:279–300.

Fisher, H.I. 1975b. The relationship between deferred breeding and mortality in the Laysan Albatross: Auk 92:433–441.

Fleet, R.R. 1974. The Red-tailed Tropicbird on Kure Atoll. Ornithological Monographs 16:1-64.

Fry, D.M., Swenson, J., Addiego, L.A., Grau, C.R. and Kang, A. 1986. Reduced reproduction of wedge-tailed shearwaters exposed to weathered Santa Barbara crude oil. Archives of Environmental Contamination and Toxicology 15(4):453-463.

Furness, R.W. 2003 Impacts of fisheries on seabird communities. Scientia Marina 67(S2):33-45

Gauger, V.H. 2000. Double brooding in the black noddy (*Anous minutus*): incidence and effect of an unusual seabird reproductive strategy. Ph.D. dissertation, University of Hawaii, Manoa, Honululu, HI.

Grémillet, D., and T. Boulinier. 2009. Spatial Ecology and Conservation of Seabirds Facing Global Climate Change: a Review. Marine Ecology Progress Series. 391:121–138.

Guruge, K. S., M. Watanabe, H. Tanaka, and S. Tanabe. 2001. Accumulation status of persistent organochlorines in albatrosses from the North Pacific and the Southern Ocean. Environmental Pollution 114:389-398.

Gutowsky, S.E., Tremblay, Y., Kappes, M.A., Flint, E.N., Klavitter, J., Laniawe, L., Costa, D.P., Naughton, M.B., Romano, M.D. and Shaffer, S.A. 2014. Divergent post-breeding distribution and habitat associations of fledgling and adult Black-footed Albatrosses *Phoebastria nigripes* in the North Pacific. Ibis 156(1):60-72.

Harrison, C.S. 1990. Seabirds of Hawai`i: Natural History and Conservation. Cornell University Press. 249 pp.

Hodges, C. S. N., and R. J. Nagata, Sr. 2001. Effects of predator control on the survival and breeding success of the endangered Hawaiian Dark-rumped Petrel. In Evolution, Ecology, Conservation, and Management of Hawaiian Birds: A Vanishing Avifauna (J. M. Scott, S. Conant, and C. Van Riper, III, Editors). Studies in Avian Biology 22:308–318.

Hyrenbach, K.D., Fernández, P. and Anderson, D.J. 2002. Oceanographic habitats of two sympatric North Pacific albatrosses during the breeding season. Marine Ecology Progress Series 233:283-301.

International Union for the Conservation of Nature. 2017. The IUCN Red List of Threatened Species. Version 2017-1. Available at: www.iucnredlist.org.

Jones, H.P., B.R. Tershy, E.S. Zavaleta, D.A. Croll, B.S. Keitt, and M.E. Finkelstein. 2008. Severity of the effects of invasive rats on seabirds: A global review. Conservation Biology 22(1): 16-26.

Judge, S.W. 2011. Interisland comparison of behavioral traits and morphology of the endangered Hawaiian Petrel: evidence of character differentiation. M.S. thesis, University of Hawaii, Hilo.

Juola, F.A. and Dearborn, D.C. 2007. Does the differential cost of sons and daughters lead to sex ratio adjustment in great frigatebirds Fregataminor?. Journal of Avian Biology 38(1):94-104.

Juola, F.A., Haussmann, M.F., Dearborn, D.C. and Vleck, C.M. 2006. Telomere shortening in a long-lived marine bird: cross-sectional analysis and test of an aging tool. Auk 123(3):775-783.

Kappes, M.A., Shaffer, S.A., Tremblay, Y., Foley, D.G., Palacios, D.M., Robinson, P.W., Bograd, S.J. and Costa, D.P. 2010. Hawaiian albatrosses track interannual variability of marine habitats in the North Pacific. Progress in Oceanography 86(1):246-260.

LeBreton, J.-D., and S. Véran. 2012. Direct evidence of the impact of longline fishery on mortality in the Black-footed Albatross *Phoebastria nigripes*. Bird Conservation International doi:10.1017/S0959270912000299.

Lusk, M.R., P. Bruner, and C. Kessler. 2000. The avifauna of Farallon de Medinilla, Mariana Islands. J. Field Ornithology 71(1):22-33.

Marie. A., VanderWerf, E.A., Young, L.C., Smith, D.G., Eijzenga, J., and M.T. Lohr. 2014. Response of Wedge-tailed Shearwaters to eradication of black rats from Moku`auia Island after reinvasion. Pacific Science 68:547-553.

Megyesi, J.L., and D.L. O'Daniel. 1997. Bulwer's Petrel (*Bulweria bulwerii*). No. 281 in A. Poole and F. Gill, editors. The birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Moore, J. 2009. A comparative analysis of population estimation methods for a burrow-nesting seabird: a novel ground-capture method and closed population capture-recapture modeling. Unpublished Master's thesis, Saint Mary's University, Nova Scotia.

Normandeau Associates, Inc. and APEM, Ltd. 2016. Aerial survey of seabirds and marine mammals at Ka'ula Island, Hawai'i, March 2016. Report prepared for the U.S. Navy, Commander, U.S. Pacific Fleet. December 2016. 44 pp.

O'Connor, P.J., and M.J. Rauzon. 2004. Inventory and monitoring of seabirds in National Park of American Samoa. Technical Report 136, University of Hawaii at Manoa, National Park Service Contract No. 8036-2-9004. October 2004. 145 pp.

Piatt, J.F., Sydeman, W.J., and Wiese, F. 2007. Seabirds as indicators of marine ecosystems. Marine Ecology Progress Series 352: 199-204.

Podolsky, R., D.G. Ainley, G. Spencer, L. de Forest, and N. Nur. 1998. Mortality of Newell's Shearwaters caused by collisions with urban structures on Kauai. Colonial Waterbirds 21:20-34.

Pravder, H., C. Prestridge, and K.D. Hyrenbach. 2015. Wedge-tailed Shearwater breeding phenology at the Freeman seabird preserve, O'ahu, Hawai'i. 'Elepaio 75(3):17-21.

Pyle, P., R. David., B.D. Eilerts, A.B. Amerson, A. Borker, and M. McKown. 2014. Second record of Bryan's Shearwater *Puffinus bryani* from Midway Atoll, with notes on habitat selection, vocalizations and at-sea distribution. Marine Ornithology 42:5-8.

Pyle, P., N. Hoffman, B. Casler and T. McKee. 2001. Little and Least Terns breeding on Midway Atoll: Identification, range extensions, and assortative breeding behavior. North American Birds 55:3-6.

Pyle, R.L., and P. Pyle. 2017. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. B.P. Bishop Museum, Honolulu, HI, U.S.A. Version 2 (1 January 2017) http://hbs.bishopmuseum.org/birds/rlp-monograph/

Raine, A.F., Holmes. N.D., Travers, M., Cooper, B.A., Day, R.H. 2017a. Declining population trends of Hawaiian Petrel and Newell's Shearwater on the island of Kaua'i, Hawaii, USA. Condor 119:405-415.

Raine, A.F., B. McFarland, M. Boone, and N. Banfield. 2017b. An updated avifauna of Moku'ae'ae Rock Islet, Kauai. Pacific Science. 71(1):67-76.

Rauzon, M.J., Forsell, D.J., Flint, E.N. and Gove, J.M. 2011. Howland, Baker and Jarvis Islands 25 years after cat eradication: the recovery of seabirds in a biogeographical context. Veitch, CR, Clout, MN, Towns, DR (eds), pp.345-349.

Reichel, J.D. 1991. Status and Conservation of Seabirds in the Mariana Islands. ICBP Technical Publication No. 11. *In* CNMI-DFW 5-year progress report 1987 to 1997 to U.S. Fish & Wildlife Service, Honolulu, HI.

Reynolds, M.H., K. N. Courtot, P. Berkowitz, C. D. Storlazzi, J. Moore, and E. Flint. 2015. Will the effects of sea-level rise create ecological traps for Pacific island seabirds? PLOS ONE. Doi: 10.1371/journal.pone.0136773.

Reynolds MH, Berkowitz P, Klavitter JL, Courtot KN. 2017. Lessons from the Tōhoku tsunami: A model for island avifauna conservation prioritization. Ecology and Evolution. 7:5873–5890.

Rice, D.W. and Kenyon, K.W. 1962. Breeding distribution, history, and populations of North Pacific albatrosses. The Auk 79(3):365-386.

Russell, T. A., and E. A. VanderWerf. 2010. Red-footed Booby *Sula sula* breeding success at Ulupa'u Crater, Marine Corps Base Hawaii. Marine Ornithology 38:129-131.

Schreiber, E.A. 1994. El Niño-Southern Oscillation effects on provisioning and growth in red-tailed tropicbirds. Colonial Waterbirds 17:105-119.

Seto, N. 1994. The effects of rat (*Rattus rattus*) predation on the reproductive success of the Bonin Petrel (*Pterodroma hypoleuca*). Unpublished Master's thesis, University of Hawaii, Manoa.

Shallenberger, R.J. 1973. Breeding biology, homing behavior, and communication patterns of the Wedge-tailed Shearwater, *Puffinus pacificus*. Unpublished Doctoral dissertation, Los Angeles, Univ. California.

Shallenberger, R.J. 1975. Olfactory use in the wedge-tailed shearwater (*Puffinus pacificus*) on Manana is. Hawaii. Olfaction and Taste 5:355-359.

Sievert, P.R., and Sileo L. 1993 The effects of ingested plastic on growth and survival of albatross chicks. In: Vermeer K, Briggs K.T, Morgan KH, Siegal-Causey D, editors. The status, ecology, and conservation of marine birds of the North Pacific Ottawa: Canadian Wildlife Service Specie Publication. pp 212-17.

Simons, T.R. 1985. Biology and behavior of the endangered Hawaiian Dark-rumped Petrel. Condor 87:229-245.

Smith, D.G., J.T. Polhemus, and E.A. VanderWerf. 2002. Comparison of managed and unmanaged Wedge-tailed Shearwater colonies: effects of predation. Pacific Science 56:451-457.

Smith, D.G., Shiinoki, E.K., and VanderWerf, E.A. 2006. Recovery of native species following rat eradication on Mokolii Island, Oahu, Hawai`i. Pacific Science 60:299-303.

Spear, L. B., D. G. Ainley, N. Nur, and S. N. G. Howell. 1995. Population size and factors affecting at-sea distributions of four endangered procellariids in the tropical Pacific. The Condor 97:613–638.

Stinson, D.W. 1995. Status and conservation of birds in the Mariana Islands, Micronesia. Natural History Research 3:211–218.

Suryan, R.M., Dietrich, K.S., Melvin, E.F., Balogh, G.R., Sato, F. and Ozaki, K. 2007. Migratory routes of short-tailed albatrosses: Use of exclusive economic zones of North Pacific Rim countries and spatial overlap with commercial fisheries in Alaska. Biological Conservation 137(3):450-460.

Suryan, R.M., Sato, F., Balogh, G.R., Hyrenbach, K.D., Sievert, P.R. and Ozaki, K., 2006. Foraging destinations and marine habitat use of short-tailed albatrosses: A multi-scale

approach using first-passage time analysis. Deep Sea Research Part II: Topical Studies in Oceanography, 53(3):370-386.

Telfer, T. C., J. L. Sincock, G. V. Byrd, and J. R. Reed. 1987. Attraction of Hawaiian seabirds to lights: Conservation efforts and effects of moon phase. Wildlife Society Bulletin 15:406–413.

Tickell, W. L. N. 2000. Albatrosses . Pica Press, Robertsbridge, UK. 448 pp.

Titmus, A.J. 2017. Investigating spatiotemporal distribution and habitat use of poorly understood Procellariiform seabirds on a remote island in American Samoa. Ph.D. Dissertation, University of Hawaii, Manoa.

Titmus, A.J., N. Arcilla, and C.A. Lepczyk. 2016. Assessment of the birds of Swains Island, American Samoa. The Wilson Journal of Ornithology 128:163-168.

U.S. Fish and Wildlife Service. 1983. Hawaiian Dark-rumped Petrel and Newell's Manx Shearwater Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR, USA

U.S. Fish and Wildlife Service. 2005. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, OR.

U.S. Fish and Wildlife Service, 2008. Short-tailed Albatross Recovery Plan. U.S. Fish and Wildlife Service. Anchorage, AK. 105 pp.

U.S. Fish and Wildlife Service. 2009. Terrestrial resource surveys of Tinian and Aguiguan, Mariana Islands, 2008. Report prepared for Marine Force Pacific and Naval Facilities, Pearl Harbor, HO.

VanderWerf, E. A. 2003. Distribution, abundance, and breeding biology of White Terns on Oahu, Hawaii. Wilson Bulletin 115:258-262.

VanderWerf, E. A. 2007. 2005 bird surveys in the Republic of Palau, final Report. Unpublished report prepared for the U.S. Fish and Wildlife Service and the Palau Conservation Society. Pacific Rim Conservation, Honolulu, Hawaii, May 2007. 88 pp.

VanderWerf, E. A., B. L. Becker, J. Eijzenga, and H. Eijzenga. 2008. Nazca Booby *Sula granti* and Brewster's Brown Booby *Sula leucogaster brewsteri* in the Hawaiian Islands and Johnston and Palmyra Atolls. Marine Ornithology 36: 67–71.

VanderWerf, E. A., and R. E. Downs. 2017. Current distribution, abundance, and breeding biology of White Terns (*Gygis alba*) on Oahu, Hawaii. Wilson Journal of Ornithology in press.

VanderWerf, E.A., and A. Raine. 2016. Lehua Islet seabird monitoring report - 2016. Unpublished report prepared for Island Conservation. Pacific Rim Conservation, Honolulu, HI. October 2016.

VanderWerf, E.A., D.G Smith, C. Vanderlip, A. Marie, M. Saunter, J. Parrish and N. Worcester. 2015. Status and demographic rates of the Christmas Shearwater on Kure Atoll. Marine Ornithology 43:199-205.

VanderWerf, E.A., K.R. Wood, C.S. Swenson, M. LeGrande, H. Eijzenga, and R.L. Walker. 2007. Avifauna and Conservation Assessment of Lehua Islet, Hawai`i. Pacific Science 61:39-52.

VanderWerf, E. A., and L. C. Young. 2007. The Red-billed Tropicbird in Hawaii, with notes on interspecific behavior of tropicbirds. Marine Ornithology 35:81-84.

VanderWerf, E. A., and L. C. Young. 2011. Estimating survival and life stage transitions in the Laysan Albatross using multi-state mark-recapture models. Auk 128:726-736.

VanderWerf, E. A., and L. C. Young. 2014. Breeding biology of Red-tailed Tropicbirds *Phaethon rubricauda* and response to predator control on O'ahu, Hawai'i. Marine Ornithology 42:73-76.

VanderWerf, E. A., and L. C. Young. 2016. Juvenile survival, recruitment, population size, and effects of avian poxvirus in Laysan Albatross (*Phoebastria immutabilis*) on Oahu, Hawaii. Condor 118:804-814.

VanderWerf, E. A. L. C. Young, S. E. Crow, E. Opie, H. Yamazaki, C. J. Miller, D. G. Anderson, L. S. Brown, D. G. Smith, and J. Eijzenga. 2014. Increase in Wedge-tailed Shearwaters and changes in soil nutrients following removal of alien mammalian predators and nitrogen-fixing plants at Kaena Point, Hawaii. Restoration Ecology 22:676-684. DOI 10.1111/rec.12126.

Véran, S., O. Gimenez, E. Flint, W. L. Kendall, P. F. Doherty, Jr., and J.-D. LeBreton. 2007. Quantifying the impact of longline fisheries on adult survival in the black-footed albatross. Journal of Applied Ecology 44:942-952.

Weimerskirch, H., Louzao, M, de Grissac, S. Delord, K. 2012. Changes in Wind Pattern Alter Albatross Distribution and Life-History Traits**.** Science. 335(6065): 211.

Welch, A.J., Fleischer, R.C., James, H.F., Wiley, A.E., Ostrom, P.H., Adams, J., Duvall, F., Holmes, N., Hu, D., Penniman, J. and Swindle, K.A. 2012a. Population divergence and gene flow in an endangered and highly mobile seabird. Heredity 109(1):19.

Welch, A. J., Wiley, A. E., James, H. F., Ostrom, P. H., Stafford Jr, T. W., & Fleischer, R. C. 2012b. Ancient DNA reveals genetic stability despite demographic decline: 3,000 years of population history in the endemic Hawaiian petrel. Molecular Biology and Evolution 29(12):3729-3740.

Welch, A.J., Yoshida, A.A. and Fleischer, R.C. 2011. Mitochondrial and nuclear DNA sequences reveal recent divergence in morphologically indistinguishable petrels. Molecular Ecology 20(7):1364-1377.

Whittow, G. C. 1994. Incubation biology and nestling growth of Bulwer's Petrels on Manana Island, Oahu, Hawaii. Pacific Science 48:136-144.

Wiley, A.E., Ostrom, P.H., Welch, A.J., Fleischer, R.C., Gandhi, H., Southon, J.R., Stafford, T.W., Penniman, J.F., Hu, D., Duvall, F.P. and James, H.F., 2013. Millennial-scale isotope records from a wide-ranging predator show evidence of recent human impact to oceanic food webs. Proceedings of the National Academy of Sciences 110(22):8972-8977.

Wiley, A.E., Welch, A.J., Ostrom, P.H., James, H.F., Stricker, C.A., Fleischer, R.C., Gandhi, H., Adams, J., Ainley, D.G., Duvall, F. and Holmes, N., 2012. Foraging segregation and genetic

divergence between geographically proximate colonies of a highly mobile seabird. Oecologia 168(1):119-130.

Work, T. M., and M. R. Smith. 1996. Lead exposure in Laysan Albatross adults and chicks in Hawaii: Prevalence, risk, and biochemical effects. Archives of Environmental Contamination and Toxicology 1:115-119.

Young, H.S., McCauley, D.J., Dirzo, R., Dunbar, R.B. and Shaffer, S.A. 2010a. Niche partitioning among and within sympatric tropical seabirds revealed by stable isotope analysis. Marine Ecology Progress Series 416:285-294.

Young, H.S., Shaffer, S.A., McCauley, D.J., Foley, D.G., Dirzo, R. and Block, B.A. 2010b. Resource partitioning by species but not sex in sympatric boobies in the central Pacific Ocean. Marine Ecology Progress Series 403:291-301.

Young, L.C. 2010. Inferring colonization history and dispersal patterns of a long-lived seabird by combining genetic and empirical data. Journal of Zoology. 281:232-240.

Young, L.C., R.M. Suryan, D. Duffy, W.J. Sydeman. 2012. Climate change and seabirds of the California Current and Pacific Islands ecosystems: Observed and potential impacts and management implications. An addendum to the Seabird Conservation Plan USFWS Pacific Region, 2005.

Young, L.C., Vanderlip, C., Duffy, D.C., Afanasyev, V., and Shaffer, S.A. 2009. Bringing home the trash: do colony-based differences in foraging lead to increased plastic ingestion in Laysan Albatrosses? PLoS ONE 4(10): e7623.

Young, L.C., and E.A. VanderWerf. 2014. Adaptive value of same-sex pairing in Laysan albatross. Proceedings of the Royal Society Series B 281:20132473.

Young, L.C., and E.A. VanderWerf. 2016. The beginning of Black-footed Albatross colonization on O'ahu, Hawai'i. 'Elepaio 76(1):1-4.

Young, L. C., E. A. VanderWerf, C. Granholm, H. Osterlund, K. Steutermann, and T. Savre. 2014. Breeding performance of Laysan Albatrosses *Phoebastria immutabilis* in a foster parent program. Marine Ornithology 42:99-103.

Young, L.C., VanderWerf, E.A., Smith, D.G., Polhemus, J., Swenson, N., Swenson, C., Liesemeyer, B.R., Gagne, B., and Conant, S. 2009. Demography and natural history of Laysan Albatross on Oahu, Hawaii. Wilson Journal of Ornithology 121:722-729.

Appendix 1. List of islands in the U.S. Tropical Pacific by region.

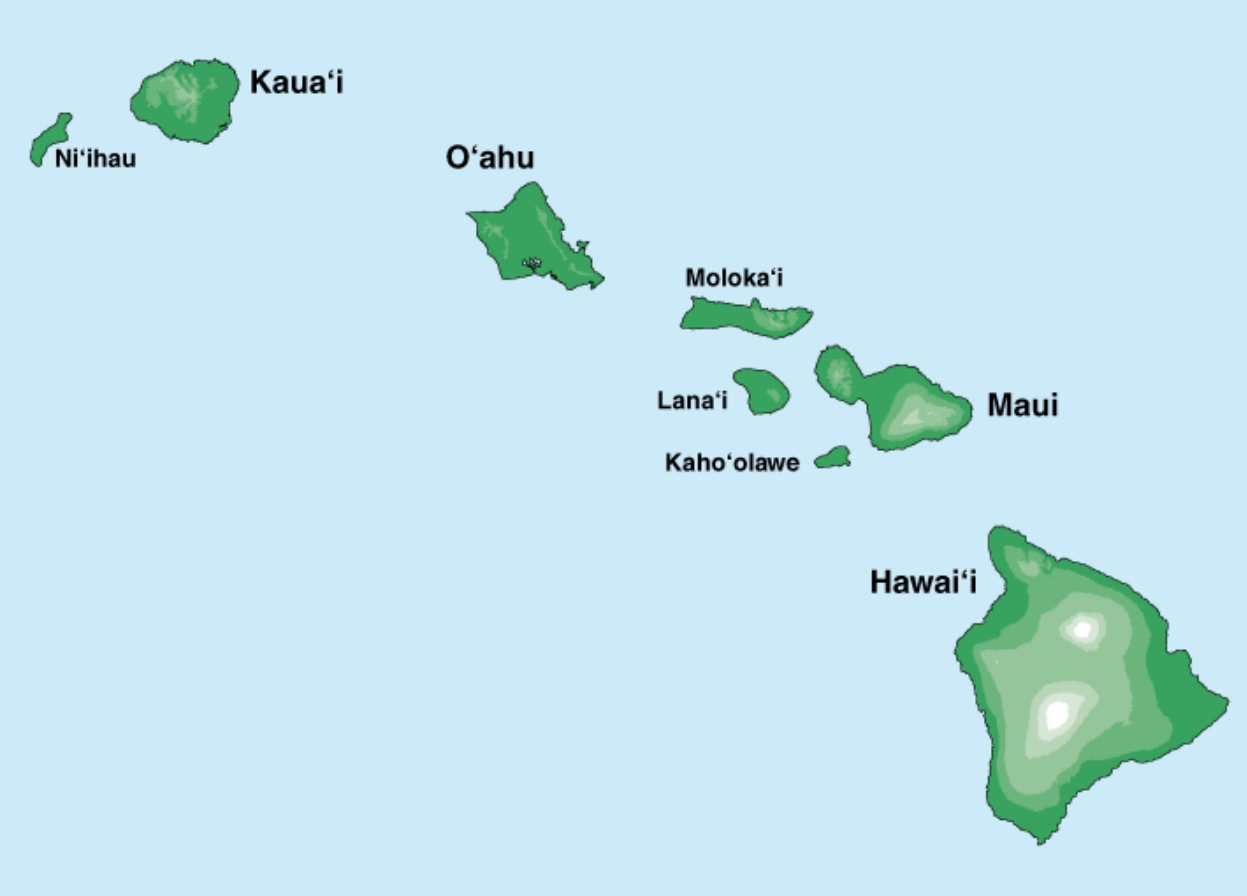
The table below lists the islands in each region of the U.S. Tropical Pacific that were included in this report and associated analyses. In the main Hawaiian Islands, Niihau was not included because there was no information available about seabird monitoring from this island; however, the two large islets geologically associated with Niihau (Lehua and Kaula) were included individually. For the other main Hawaiian Islands, all offshore islets were combined with their parent island, except on Oahu, where Moku Manu and other islets were treated separately because of their exceptionally large and diverse assemblages of seabirds. For the Northwestern Hawaiian Islands, all islets within each atoll were considered together. For example, Eastern, Sand, and Spit islands were combined on Midway Atoll. For the Mariana Islands, small islets were combined with the larger islands with which they are geologically associated (e.g. Cocos with Guam, Naftan with Aguiguan, Managaha and Bird Island with Saipan). In American Samoa, Ofu and Olosega were combined.

Region	Island	Notes
Main Hawaiian Islands	Niihau	No information
	Lehua	
	Kaula	
	Kauai	Including Moku Aeae
	Oahu	
	Moku Manu	
	Oahu offshore islets	
	Kahoolawe	
	Lanai	
	Molokai	
	Maui	Including Molokini + others
	Hawaii	
Northwestern Hawaiian Islands	Kure	
	Midway	
	Pearl & Hermes	
	Lisianski	
	Laysan	
	Gardner Pinnacles	
	French Frigate Shoals	
	Necker	
	Nihoa	
Mariana Islands	Guam	Including Cocos
	Rota	
	Aguiguan	Including Naftan
	Tinian	
	Saipan	Incl. Managaha and Bird
	Farallon de Medinilla	

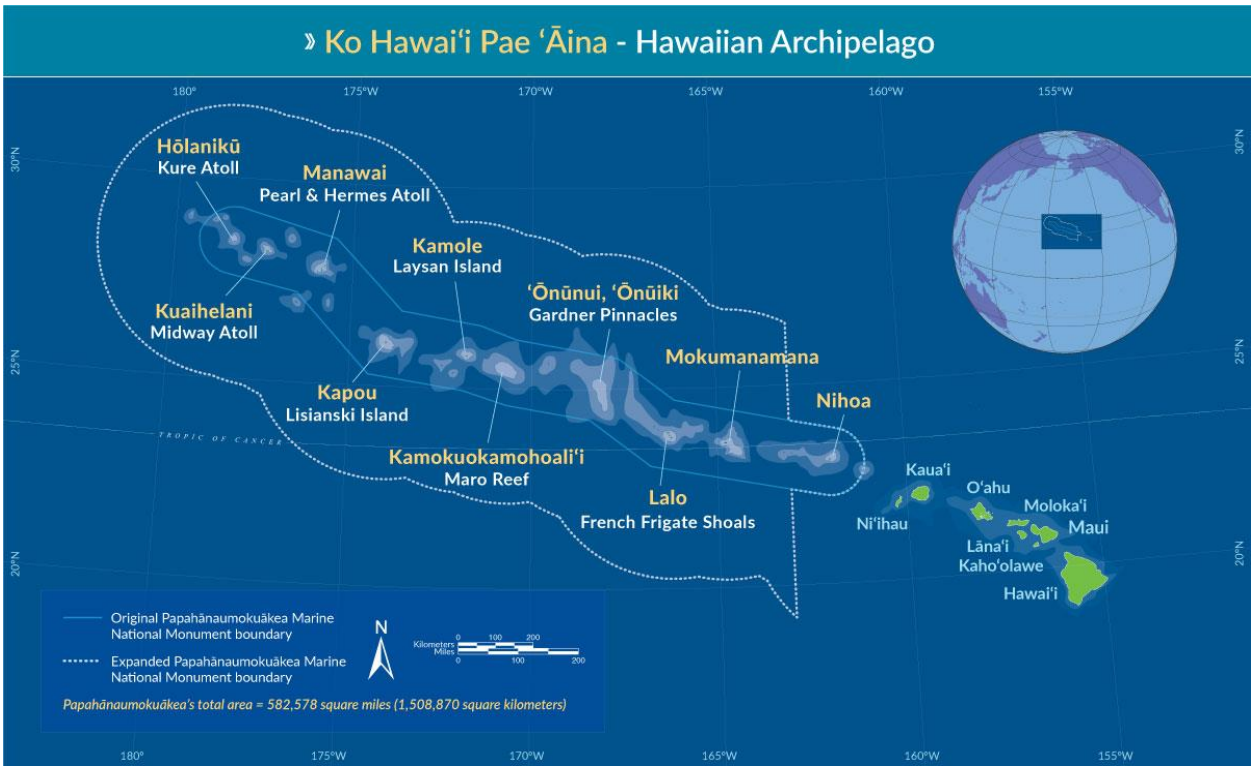
	Anatahan	
	Sarigan	
	Guguan	
	Alamagan	
	Pagan	
	Agrihan	
	Asuncion	
	Maug	
	Uracas	
Remotes	Wake	
	Palmyra	
	Baker	
	Howland	
	Jarvis	
	Johnston	
American Samoa	Tutuila	
	Aunu'u	
	Ofu-Olosega	
	Ta'u	
	Swains	
	Rose	

Appendix 2. Regional maps of the U.S. Tropical Pacific.

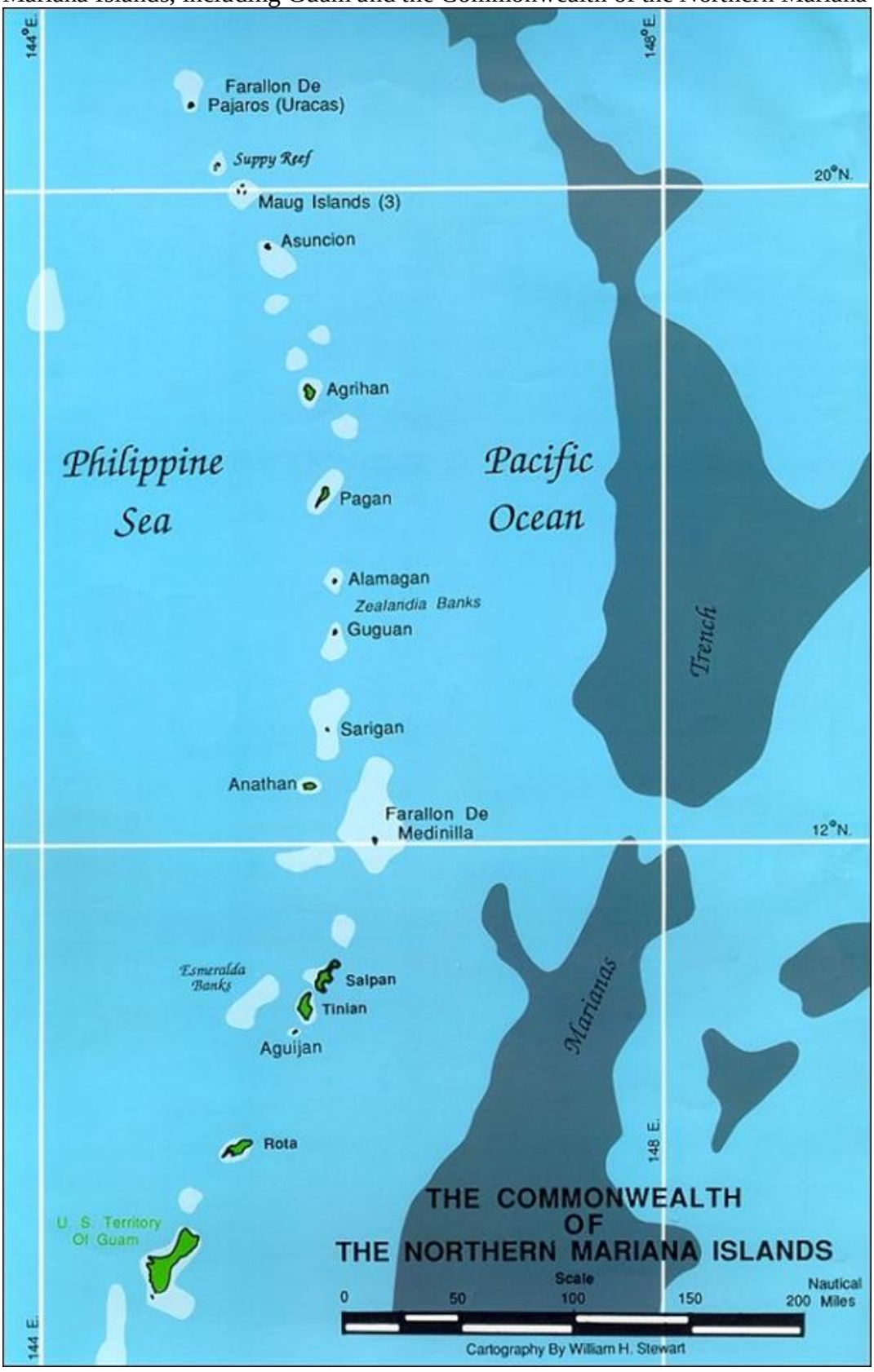
Main Hawaiian Islands



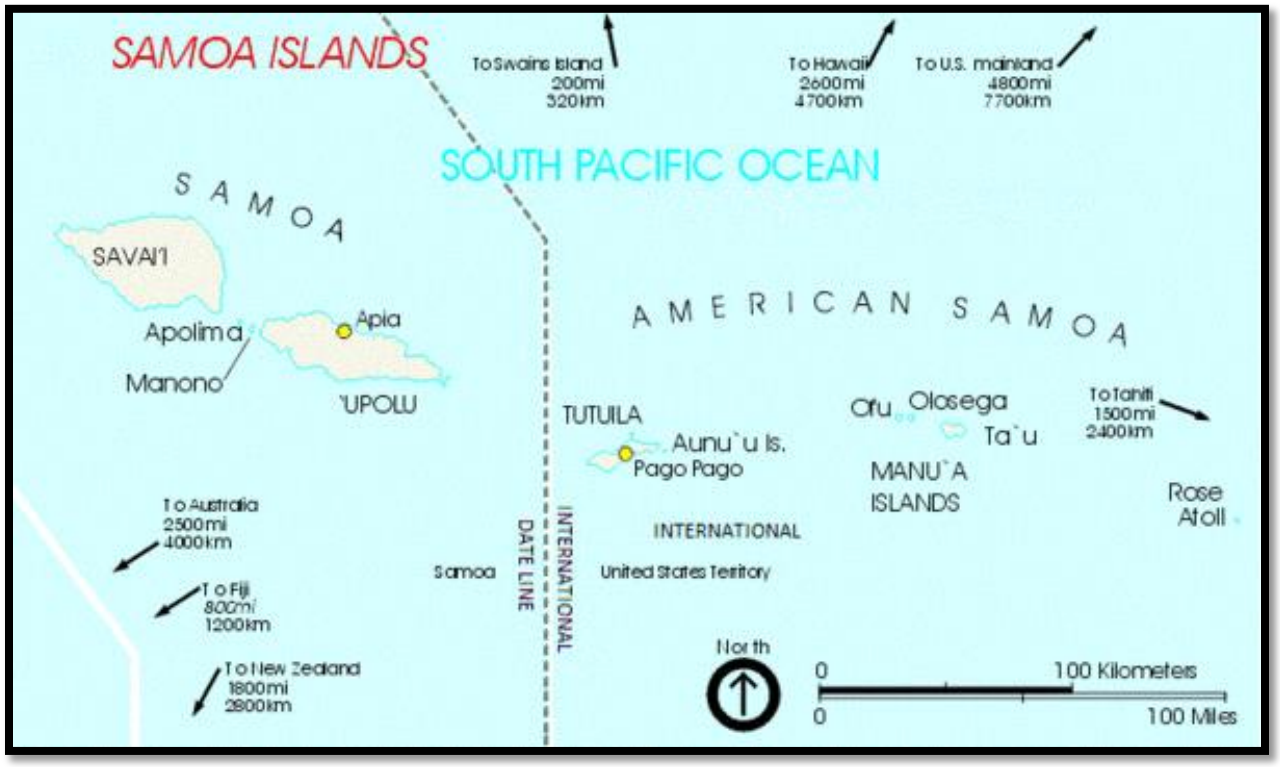
Northwestern Hawaiian Islands



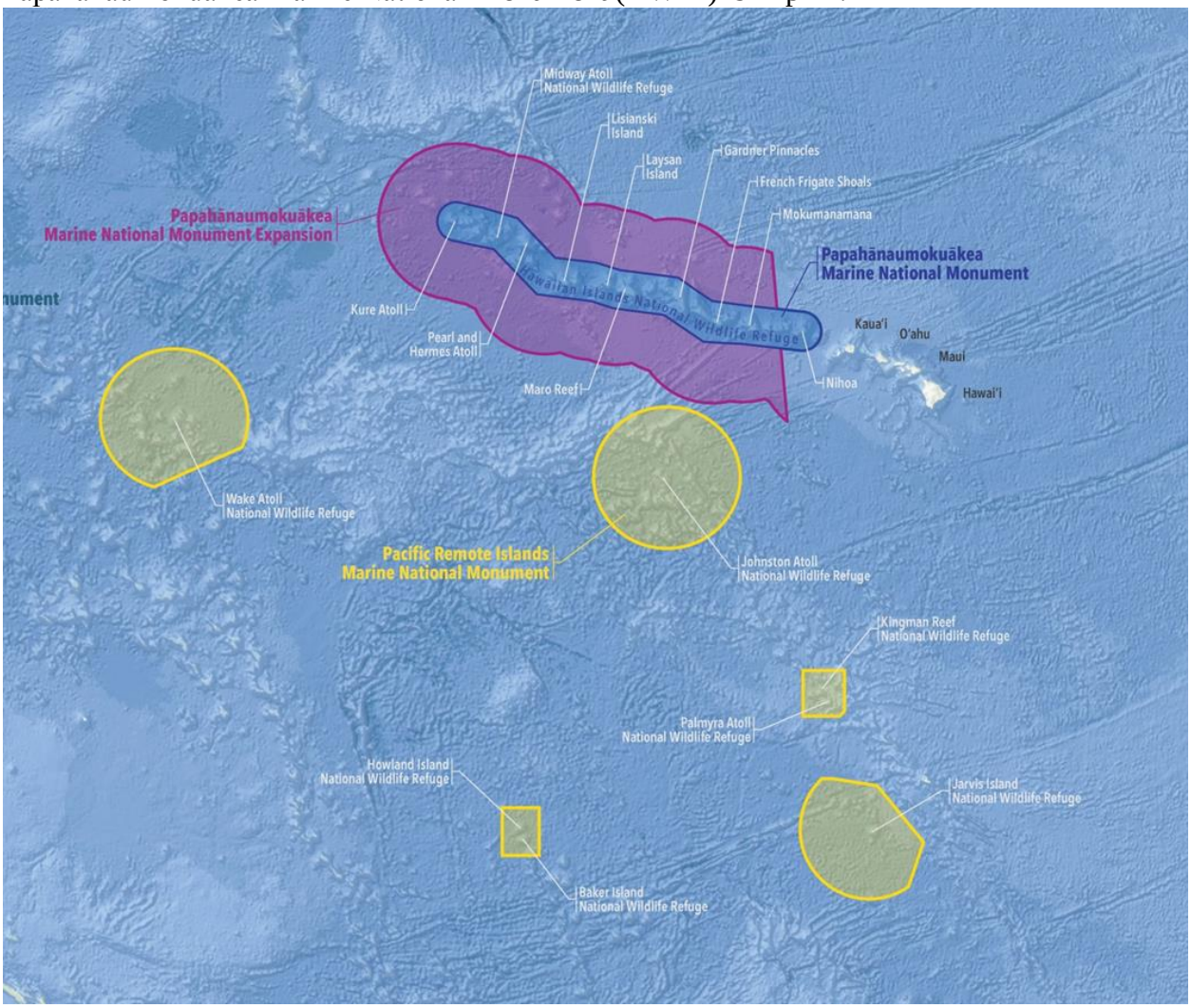
Mariana Islands, including Guam and the Commonwealth of the Northern Mariana Islands.



American Samoa



Pacific Remote Islands Marine National Monument (Remotes) is demarcated in Yellow and the Papahānaumokuākea Marine National Monument (NWHI) is in pink.



Appendix 3

Region	Island	Name	Agency/Organization	Attended workshop
Main Hawaiian Islands	Hawaii-HAVO	Darcy Hu	National Park Service	remotely
Main Hawaiian Islands	Hawaii-HAVO	Kathleen Misajon	National Park Service	no
Main Hawaiian Islands	Hawaii-NARS	Alex Wang	Hawaii-NARS	yes
Main Hawaiian Islands	Hawaii-NARS	Nick Agorastos	Hawaii-NARS	no
Main Hawaiian Islands	Hawaii-PTA	Nicole Galase	PTA/Colorado State Univ.	remotely
Main Hawaiian Islands	Hawaii-PTA	Lena Schnell	US Army	no
Main Hawaiian Islands	Kahoolawe	Jamie Bruch	KIRC	no
Main Hawaiian Islands	Kauai, Lehua	Thomas Kaiakapu	Hawaii DOFAW	yes
Main Hawaiian Islands	Kauai, Lehua	Andre Raine	Hawaii DOFAW, KESRP	yes
Main Hawaiian Islands	Kauai-Kilauea Pt NWR	Kim Uyehara	USFWS	no
Main Hawaiian Islands	Kauai-PMRF	April Teekell	US Navy	no
Main Hawaiian Islands	Kauai-PMRF	Rebecca Johnson	US Navy	no
Main Hawaiian Islands	Kaula	Frans Juola	US Navy	yes
Main Hawaiian Islands	Lanai	Rachel Seabury-Sprague	Pulama Lanai	yes
Main Hawaiian Islands	Maui, Molokai	Jay Penniman	Hawaii DOFAW, Mauinui	yes
Main Hawaiian Islands	Maui-Haleakala NP	Cathleen Natividad Bailey	National Park Service	remotely
Main Hawaiian Islands	Molokai	Arleone Dibben-Young	Private	remotely
Main Hawaiian Islands	Molokai	William "Butch" Haase	Molokai Land Trust	no
Main Hawaiian Islands	Oahu	Eryn Opie	Hawaii DOFAW	yes
Main Hawaiian Islands	Oahu	David Hyrenbach	Hawaii Pacific University	no
Main Hawaiian Islands	Oahu	Jason Misaki	Hawaii DOFAW	no
Main Hawaiian Islands	Oahu	Michelle Hester	Oikonos	remotely
Main Hawaiian Islands	Oahu-MCBH	Lance Bookless	Marine Corps Base Hawaii	yes
Main Hawaiian Islands	Oahu-MCBH	Todd Russell	Marine Corps Base Hawaii	yes
NWHI	All but Kure	Beth Flint	USFWS	yes
NWHI	Kure	Cynthia Vanderlip	Hawaii DOFAW	no
NWHI	Kure	Matthew Saunter	Hawaii DOFAW	no
NWHI	Kure	Naomi Worcester	Hawaii DOFAW	no
NWHI	Midway	Kelly Goodale	USFWS	no
NWHI	Midway	Ann Humphrey	USFWS	no
NWHI	Midway	Bob Peyton	USFWS	no
Remotes	All	Beth Flint	USFWS	yes
Remotes	Johnston	Aisha Rickli-Rahman	USFWS	yes

Appendix 3

Remotes	Palmyra	Tim Clark	USFWS	remotely
Remotes	Palmyra	Stefan Kropidlowski	USFWS	remotely
Remotes	Palmyra	Alex Wegmann	TNC	no
Remotes	Wake Atoll	Joel Helm	US Air Force	no
Marianas	All	Lainie Zarones	CNMI DFW	yes
Marianas	FDM	Steve Mosher	US Navy	no
Marianas	Guam	Jeff Quitugua	Guam DAWR	yes
Marianas	Guam	Diane Vice	Guam DAWR	no
Marianas	Mariana Trench MNM	Larisa Ford	USFWS	no
American Samoa	American Samoa	Mark MacDonald	Am. Samoa DMWR	remotely
American Samoa	American Samoa	Tavita Togia	National Park Service	yes
American Samoa	Rose Atoll	Brian Peck	USFWS	yes
General	All	Eric VanderWerf	Pacific Rim Conservation	yes
General	All	Lindsay Young	Pacific Rim Conservation	yes
General	All	Afsheen Siddiqi	Hawaii DOFAW	yes
General	Ecological Services	Megan Laut	USFWS	yes
General	Inventory&Monitoring	Amanda Pollock	USFWS	yes
General	Inventory&Monitoring	Kevin Kilbride	USFWS	yes
General	Inventory&Monitoring	Khem So	USFWS	yes
General	Inventory&Monitoring	Rachel Rounds	USFWS	yes
General	Inventory&Monitoring	Steve Holzman	USFWS	yes
General	Migratory Birds	Roberta Swift	USFWS	yes
General	Migratory Birds	Jenny Hoskins	USFWS	no
General	refuges	Barry Stieglitz	USFWS	yes
General	refuges	Allie Hunter	USFWS	yes
General	refuges	Kaua Fraiola	USFWS	yes
General	refuges	Amanda Boyd	USFWS	yes
General	refuges	Cindy Rehkemper	USFWS	yes
General		Josh Adams	USGS	remotely
General	PMNM	Matt Brown	Papahanaumokuakea MNM	no
General		Michelle Reynolds	USGS	no
General		Edna Diaz Negron	USFWS-KUPU	yes
General		Taylor Smith	USFWS-KUPU	yes

Appendix 4

Question	Please answer b	Notes (optional)		Selection options (do n
Your name				
Organization				
Title				
Region/state				
email address				
How long have you (or your organization) been collecting seabird data at your sites?				1 year or less
How many people typically are involved in your surveys?				1
What currently limits your ability to conduct monitoring?				Nothing
How are your data stored?				Notebooks/paper
Do you have a written data collection protocol that is followed during your surveys?				yes, for all
Who developed your protocols?				self
How frequently are your results summarized or reported?				quarterly/seasonally
Who funds your work?				State/regional
Are volunteers or the public involved in the monitoring?				yes
What are the goals of your monitoring? (choose for each one)				
Goal 1: Measure population size+trend				yes
Goal 2: Determine distribution				
Goal 3: Measure aspects of population biology/breeding biology				yes
Goal 4: Collect natural history information				yes
Goal 5: Measure effect of threats and/or management				yes
Goal 6: Scientific research				yes
Other goals (please specify):				yes (specify in notes)
Do you plan to begin collecting any additional data?				yes (specify in notes)
Is there information would you like to know about your species or sites that you currently do not know?				yes (specify in notes)
Are there sites where seabirds are suspected to be present but not confirmed or the species have not been identified?				yes (specify where in note

Appendix 4

ot type in columns E to K)

2 to 3 years	4 to 5 years	>5 years	>10 years	>20 years	
2 or 3	4 or 5	>5	>10	Other (specify in notes)	
lack of funding	lack of trained staff	lack of fundin	lack of access	lack of survey protocol/training	Other
Computer	Server/cloud	don't know	varies/other (specify in notes)		
yes, for some	no	don't know			
agency	researchers	partners	don't know	varies/other (specify)	
annually	irregularly	never	other (specify in notes)		
National	Private foundation/NGO	Self	Multiple funding sources (spe	No funding	don't know
no	don't know				
no	don't know				
no	don't know				
no	don't know				
no	don't know				
no	don't know				
no					
no					
no					
no					

Appendix 4

Species	Add name of Site 1		Add name of Site 2		Add name of Site 3	
Albatrosses	**present?**	**monitored?**	**present?**	**monitored?**	**present?**	**monitored?**
Black-footed Albatross						
Laysan Albatross						
Short-tailed Albatross						
Shearwaters & Petrels						
Hawaiian Petrel						
Bonin Petrel						
Bulwer's Petrel						
Phoenix Petrel						
Herald Petrel						
Tahiti Petrel						
Wedge-tailed Shearwater						
Christmas Shearwater						
Tropical Shearwater						
Newell's Shearwater						
Storm-Petrels						
Band-rumped Storm-Petrel						
White-throated Storm-Petrel						
Tristram's Storm-Petrel						
Tropicbirds						
White-tailed Tropicbird						
Red-tailed Tropicbird						
Boobies						
Masked Booby						
Brown Booby						
Red-footed Booby						
Frigatebirds						
Lesser Frigatebird						
Great Frigatebird						
Terns & Noddies						
Brown Noddy						
Black Noddy						
Blue-gray Noddy						
White Tern						
Sooty Tern						
Gray-backed (Spectacled) Tern						
Least Tern						
Little Tern						
Other (please add name)						

Instructions:
In the top row please add the name of each site where you monitor seabirds.
For the species present at each site, choose one option from the drop-down menu. If the species does not occur at
If you need more columns for additional sites please send an email to eric@pacificrimconservation.org and ask for

List of choices (Please do not type in the cells below)	
yes	yes
suspected	no
unknown	unknown

Appendix 4

Add name of Site 4		Add name of Site 5		Add name of Site 6	
present?	**monitored?**	**present?**	**monitored?**	**present?**	**monitored?**

that site leave the cell blank.
an expanded version of the spreadsheet.

Appendix 4

Species	Frequency of monitoring	Season/months of monitoring	Total colony counts	Total nest counts
Albatrosses				
Black-footed Albatross				
Laysan Albatross				
Short-tailed Albatross				
Shearwaters & Petrels				
Hawaiian Petrel				
Bonin Petrel				
Bulwer's Petrel				
Phoenix Petrel				
Herald Petrel				
Tahiti Petrel				
Wedge-tailed Shearwater				
Christmas Shearwater				
Tropical Shearwater				
Newell's Shearwater				
Storm-Petrels				
Band-rumped Storm-Petrel				
White-throated Storm-Petrel				
Tristram's Storm-Petrel				
Tropicbirds				
White-tailed Tropicbird				
Red-tailed Tropicbird				
Boobies				
Masked Booby				
Brown Booby				
Red-footed Booby				
Frigatebirds				
Lesser Frigatebird				
Great Frigatebird				
Terns & Noddies				
Brown Noddy				
Black Noddy				
Blue-gray Noddy				
White Tern				
Sooty Tern				
Gray-backed (Spectacled) Tern				
Least Tern				
Little Tern				
Other (please add name)				
Instructions	choose from drop-down menu	enter seasons or months when monitoring occurs	choose from drop-down menu	choose from drop-down menu
Definitions (You do not need to enter any numbers in these cells, this is just a description of each data type)		e.g. Summer, or July	Total # birds in colony	Total # nests throughout season
Note: If you have more than one site and collect certain data only at some sites choose "current" and specify in the note				
List of choices	daily monthly quarterly/seasonally yearly irregular other (specify in notes column)		current historical only no anticipated	current historical only no anticipated

Appendix 4

Minimum incubation counts	**Roosting counts**	**At-sea counts from shore**	**At-sea counts from vessel**	**Nest/burrow occupancy**	**Hatching success**	**Fledging success**	**Overall breeding success**
choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu
Nest counts spaced at incubation period	# non-breeding birds	birds at sea counted from shore	birds at sea counted from a boat or aircraft	Number or proportion of nests occupied	Proportion of eggs that hatch	Proportion of chicks that fledge	Proportion attempts resulting in fledging

es where that data is collected.

current	current	current	current	current	current	current	current
historical only	historical only	historical only	historical only	historical only	historical onl	historical onl	historical only
no	no	no	no	no	no	no	no
anticipated	anticipated	anticipated	anticipated	anticipated	anticipated	anticipated	anticipated

Appendix 4

Chick growth or morphometrics	Adult morphometrics	Nesting phenology	Adult banding	Chick banding	Mark-recapture	Diet	Plastics	Tracking
choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu
Measurement of any body part, once or repeated	Measurement of any body part	Months when nesting	Banding adults	Banding chicks	Reading band numbers regularly	Collection of diet samples	Collecting plastic from gut, boluses	Measuring by GPS, GLS, or satellite

current	current	current	current	current	current	current	current	current
historical only	historical onl	historical on	historical or	historical or	historical onl	historical onl	historical on	historical on
no	no	no	no	no	no	no	no	no
anticipated	anticipated	anticipated	anticipated	anticipated	anticipated	anticipated	anticipated	anticipated

Appendix 4

Blood, feather, or tissue sampling	Contamina nts	Predation	Acoustic sampling	Remote cameras	Other
choose from drop-down menu	choose from drop-down menu	choose from drop-down menu	choose from drop-down menu		Please specify
Collection and preservation of any tissue	Collecting tissue for contamina nts	Recording predation events	Recording or monitoring sounds		Anything else, notes for other answers

current	current	current	current
historical only	historical on	historical on	historical only
no	no	no	no
anticipated	anticipated	anticipated	anticipated