OCS Study
BOEM 2019-042

Synopsis of Research Programs that can Provide Baseline and Monitoring Information for Offshore Energy Activities in the Pacific Region: Seabird and Marine Mammal Surveys in the Pacific Region

US Department of the Interior
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DISCLAIMER

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REPORT AVAILABILITY

To download a PDF file of this report, go to the U.S. Department of the Interior, Bureau of Ocean Energy Management's Recently Completed Environmental Studies webpage (https://www.boem.gov/Pacific-Completed-Studies/) and click on the link for 2019-042. Data summarized in this report are available at (https://doi.org/10.5066/F7X0669S).

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ABOUT THE COVER

Cover photo: Two humpback whales viewed by ship in the Santa Barbara Channel, November 2017. (Credit: Kevin Lafferty, USGS-WERC. Public domain.)

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AK	Alaska
AMNWR	Alaska Maritime National Wildlife Refuge
AWEA	American Wind Energy Association
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
CA	California
CCP	Comprehensive Conservation Plan
CDFW	California Department of Fish & Wildlife
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	U.S. Department of the Interior
EIS	Environmental Impact Statement
ESA	Endangered Species Act
HI	Hawaii
IMP	Inventory and Monitoring Plan
MMPA	Marine Mammal Protection Act
NGO	Non-Governmental Organization
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NSP	National Seabird Program
NWR	National Wildlife Refuge
OCS	Outer Continental Shelf
OR	Oregon
POCS	Pacific Outer Continental Shelf
PSG	Pacific Seabird Group
SEFI	Southeast Farallon Islands
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish & Wildlife
WERC	Western Ecological Research Center

USGS WERC scientist Emma Kelsey
At False Klamath Rock, CA doing seabird monitoring research. (Credit: Jonathan Felis, USGS WERC. Public domain.)

Abstract

We assembled and tabulated information about marine bird and mammal research and monitoring programs that could provide data needed to support environmental risk assessments. This included identifying ongoing or completed research programs that contain information on species and habitats sensitive to offshore energy activities and that could provide baseline and monitoring data to understand and mitigate potential impacts of offshore energy development in the Southern California Planning Area, Washington-Oregon Planning Area, and the Hawaiian OCS of the Bureau of Ocean Energy Management (BOEM). When available, we also included information regarding programs in Alaska, but the catalog for Alaska is not comprehensive. We included programs that assessed the distribution, abundance, or biology of marine birds (seabirds, waterbirds, or sea ducks) and marine mammals (cetaceans, pinnipeds, and sea otters), some of which are protected species under the Endangered Species Act (ESA of 1973) or the Marine Mammal Protection Act (MMPA of 1972). We canvassed data providers with spreadsheet or web-based survey forms. The marine bird survey returned information on research and monitoring efforts for 28 parameters across 46 species from 36 entities. The marine mammal survey returned information on research and monitoring efforts for 24 parameters across 22 marine mammal species from 22 entities. We tabulated the parameters by species to show which parameters are most commonly measured and where there might be information gaps. Both marine bird and marine mammal research and monitoring are widespread throughout the Pacific, with 535 entries for marine mammals and 1,911 entries for marine birds. Although we provide summaries of key aspects within research and monitoring programs, the associated database can be further queried in several ways. Versioning of this database format essentially creates a “living database” that can be updated in the future as new information becomes available.

1 Background

The mission of the U.S. Geological Survey (USGS) is to provide reliable scientific information to describe and understand the Earth, minimize loss of life and property from natural disasters, manage water, biological, energy, and mineral resources, and enhance and protect the quality of life. To this end, the USGS collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. The USGS Western Ecological Research Center (WERC) provides its clients and partners with the research, scientific understanding, and technology needed to support management of Pacific ecosystems.

As with all human use of the marine environment, understanding the potential impacts of offshore energy infrastructure on the marine ecosystem is an integral part of offshore energy research (Desholm 2009, Vaissière et al. 2014). BOEM requires both baseline and monitoring data for marine ecosystems, habitats, and species-of-interest. Baseline data describe existing conditions and define reference points to monitor trends among potentially impacted resources. Monitoring data are used to assess effects of industry activities, and to determine effectiveness of mitigation measures contained within offshore energy lease stipulations and conditions of permit approval. Several other entities have established research programs that collect environmental data within areas of ongoing or prospective energy development. BOEM seeks to understand if these ongoing or completed datasets can also be used to satisfy BOEM's information needs and thereby provide timely and cost-effective information to decision-makers regarding the offshore and coastal environment.

2 Introduction

The USGS-WERC was requested by BOEM to create a database that describes marine bird and mammal research and monitoring programs that exist throughout the Pacific Offshore Continental Shelf (POCS), including California, Oregon, and Washington (Figure 1). Conventional energy infrastructure and production in offshore waters has documented effects on marine resources through oil spills (Troisi et al. 2016), noise pollution, light pollution (Wiese et al. 2001, Black 2005), and habitat alteration (Hamer et al. 2014, Beyer et al. 2016). Furthermore, there is an increasing need for renewable energy sources within the United States and globally. To help meet this need, the United States set a goal for 20% of the country's overall electricity production to come from wind-power by 2030 (DOE 2008). The production capacity of wind energy facilities in the United States has already grown by an order of magnitude in the last 1.5 decades (4,147 MW generated in 2001 to 84,944 MW in 2017; AWEA 2017). Looking forward, offshore wind-energy has the potential to produce a significant proportion of the power needed to reach the 20% wind-energy goal (Musial and Ram 2010). The DOI and the States of California, Oregon, and Hawaii have received proposals to develop commercial-scale offshore renewable energy capacity within state and federal waters. The vulnerability of seabirds to offshore wind energy infrastructure has been addressed in the Atlantic along the eastern seaboard (Robinson Willmott et al. 2013) and for the California Current System off the west coast of the US (Adams et al. 2016, Kelsey et al. 2018).

California, Oregon, and Washington already are among the top-six leading wind-energy states in the country and all three states have set goals to generate a significant portion of their states' energy from renewable energy sources by the 2020s (AWEA 2013). Herein, we also address Hawaii (Figure 2) because there is industry interest in offshore wind-energy and Hawaii has set the state's goal for 100% renewable energy by 2045 (Hawaii State Legislature 2015). Although environmental assessments have been initiated addressing Hawaiian marine resources (Costa and Kendall 2016) potentially affected by offshore renewable energy development including seabirds and marine mammals, vulnerability

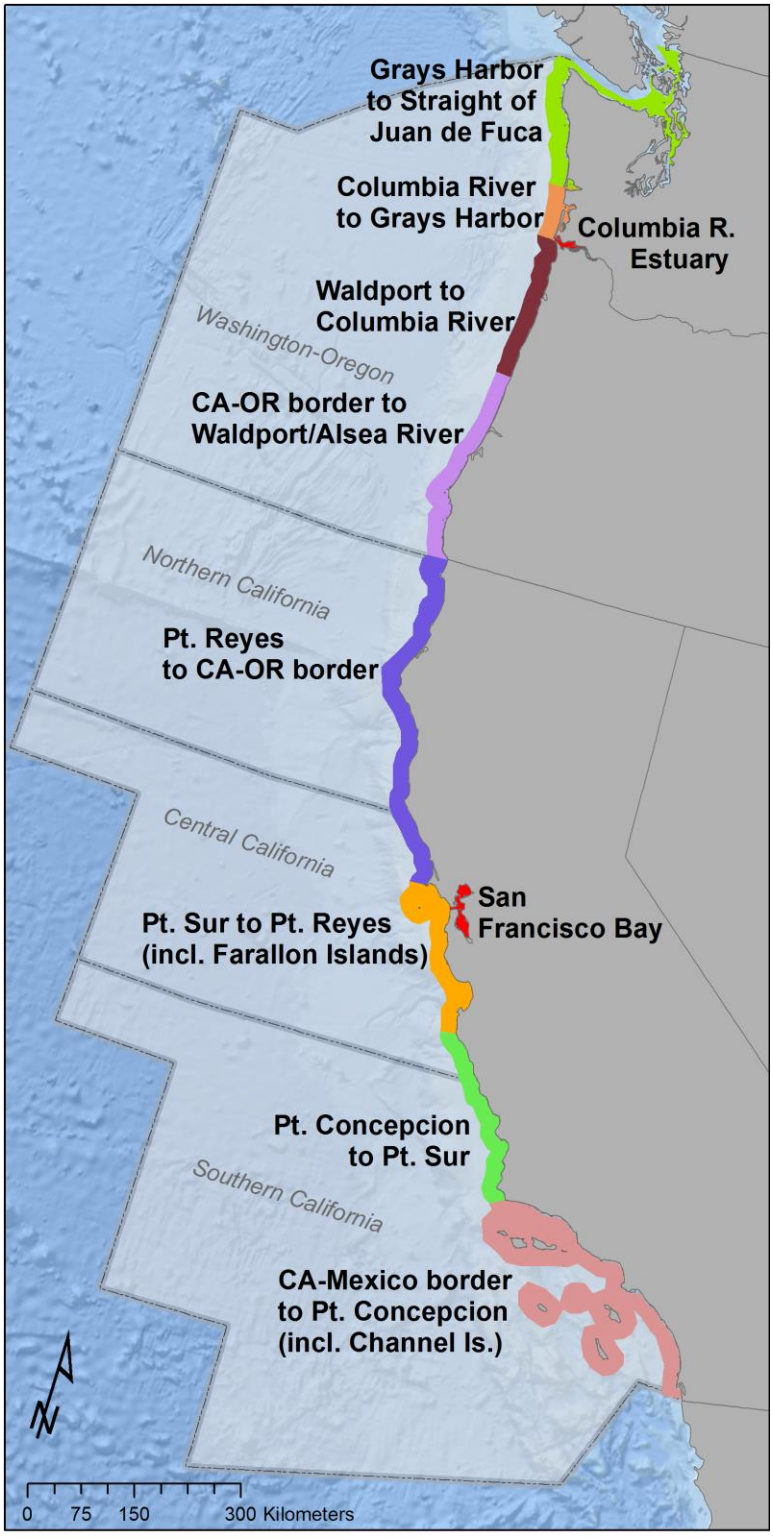

Figure 1. Western U.S. Pacific offshore continental shelf regional areas
These polygon areas were defined by physical geographic breaks and used to aggregate seabird and marine mammal research and monitoring programs in the associated database.

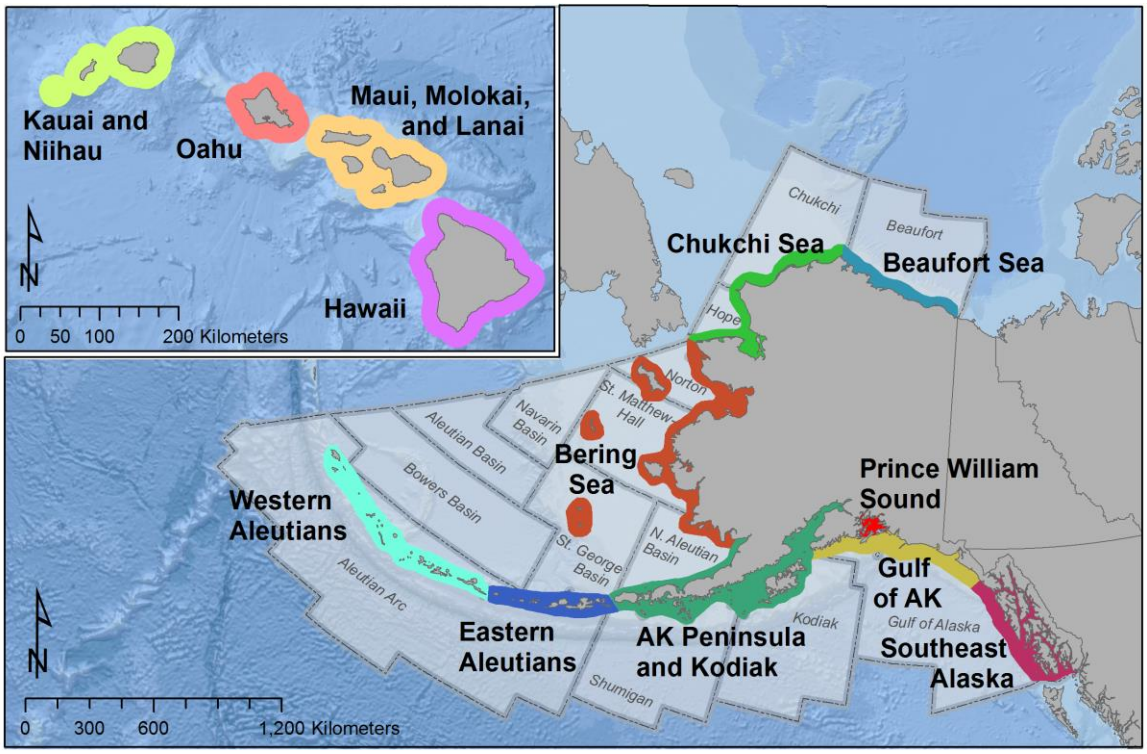

Figure 2. Alaskan and Hawaiian U.S. Pacific offshore continental shelf regional areas
These polygon areas were defined by physical geographic breaks and used to aggregate seabird and marine mammal research and monitoring programs in the associated database. Regions not shown here, but included in the database include other inland areas, the Northwest Hawaiian Islands, Guam, and other Pacific Islands.

assessments for Hawaiian seabird species (similar to the California Current effort) are not yet complete because they require better information supported by several efforts now underway quantifying breeding seabird distribution in the main Hawaiian Islands (USGS, unpublished data, BOEM NSL #PC-17-03, see also, Pyle and Pyle 2017), and ranging behaviors at sea (USGS, unpublished data, BOEM NSL #PC-13-03). Several Hawaiian seabird species, including Endangered Hawaiian Petrels (*Pterodroma sandwichensis*), are killed by terrestrially-sited wind turbines in Hawaii (J. Charrier, USFWS unpublished data, communication 22 November 2016) and future turbine infrastructure at sea and marine cable-laying operations pose strike, grounding, and mortality risks to free-ranging seabirds that nest in Hawaii. Potential future renewable energy sources include power generation infrastructure and support activities that would be located within continental shelf waters, and potentially within deeper waters off the US Pacific coast and beyond state waters (i.e., outside three nautical miles [NM]). BOEM has received expression of interest from industry for renewable energy projects off the coasts of California, Oregon, and Hawaii. Several other Federal, State, academic and non-governmental organizations (NGOs) have research programs that collect environmental data within areas of ongoing or prospective energy development. BOEM seeks to understand if these continuing research and monitoring efforts and their associated datasets can also be used to satisfy information needs to provide timely and cost-effective information to decision-makers regarding the offshore and coastal environments.

The overall goal of this study was to collect and tabulate for BOEM, information about marine bird and mammal research and monitoring programs that could provide data needed to support environmental risk assessments, environmental impact statements (EIS), and other decision documents related to ongoing and foreseeable offshore energy projects in the POCS. Specific objectives included (1) identifying

ongoing or completed research programs that contain information on species and habitats sensitive to offshore energy activities and (2) compiling a review of the capability of these programs to provide baseline and monitoring data to understand and mitigate potential impacts of offshore energy development in the POCS. In the POCS, there are three areas with ongoing or prospective development of offshore energy projects: Southern California Planning Area, Washington-Oregon Planning Area, and the Hawaiian OCS (Figure 1). Based on survey responses and programs that span several regional areas, we also included some information from Alaska (Figure 2) monitoring programs because they include monitoring programs that address similar marine birds and mammals as those studied in the three other Pacific regions.

Our strategy was to tabulate and review programs that can provide baseline or monitoring data that could be used to help inform (1) ongoing conventional energy projects within the Southern California Planning Area, (2) prospective renewable energy projects within the Southern California Planning Area, (3) prospective renewable energy projects within the Washington-Oregon Planning Area and, (4) prospective renewable energy projects on the Hawaiian OCS. Research and monitoring programs of interest included those that have one or more of the four components:

- Programs are managed by another Bureau within Department of the Interior (e.g., USGS; National Park Service; U.S. Fish and Wildlife Service's National Wildlife Refuges; Bureau of Land Management's National Monuments, etc.).
- Programs assessed the distribution, abundance, or biology of marine birds (seabirds, waterbirds, sea ducks, or shorebirds).
- Programs assessed the distribution, abundance, or biology of protected species under the Endangered Species Act (ESA of 1973) or the Marine Mammal Protection Act (MMPA of 1972).
- Programs collected information used to generate ecological indices that describe salient features of sensitive or pristine habitats and ecosystems with the Planning Areas of interest.

Evaluation of tabulated research programs and datasets will assist BOEM with understanding the strengths and weaknesses of program efforts according to the Bureau's information needs, define the temporal and spatial scope of research and monitoring efforts, and help identify the ecosystem components, habitats, and species of interest pertinent to either ongoing conventional energy or prospective renewable energy. Furthermore, a comprehensive database of research and monitoring programs would facilitate research networking and shed light on information gaps that exist for certain study regions, marine birds, and marine mammals.

3 Methods

3.1 Marine bird survey format and solicitation

On 26 January 2015, USGS-WERC met with the California seabird research and monitoring community at the annual California Seabird Coordination Meeting in Davis, CA. At this meeting USGS circulated a paper questionnaire that initiated the first voluntary collection of data describing past and current seabird monitoring efforts. These data were used to construct an "outward facing" web survey form (Figure 3)

that could be distributed via email so that willing voluntary participants could enter a standardized set of information describing their research and monitoring (Table 1). On 21 August 2015, the first email request for information was sent to the California seabird research and monitoring community. The original email provided the following information:

Greetings folks,

You may remember at last January's meeting I proposed an effort to coordinate, collect, and share information about on-going seabird monitoring efforts. Some of you filled out a similar questionnaire on paper that helped us simplify this on-line survey.

Please check out the following link and spend 5 minutes or so filling in the blanks and hitting the submit button!

http://www.werc.usgs.gov/seabirds/ (this link is no longer functional, and will redirect to USGS-WERC)

Background: Catalog of seabird research programs in the North East Pacific

Many people monitor seabirds using regular counts or other measures. However, coordination and sharing of mutual knowledge among seabird monitoring programs often are limited. BOEM and USGS are partnering on a study (1) to identify ongoing or completed research programs that contain information on seabird species, and (2) to review the capability of these programs to provide baseline and monitoring data to understand change. The overall strategy is to summarize the main components of each research program, identify spatial and programmatic gaps, and to assess whether a research program could easily be enhanced to better address information needs through additional support. Our first step is to catalog descriptions of seabird monitoring programs and to share these with you and the seabird community, to foster greater visibility of seabird monitoring and hopefully expand opportunities for funding and collaboration. Here, we ask some simple questions.

If you have multiple programs (by species or region), or if this form does not accommodate your info, please consider filing out multiple survey questionnaires.

If you have any questions, please email:

josh_adams@usgs.gov

This email initiated the first responses and was used to contribute new information to the data that we collected in person at the first meeting in Davis. Once the remote data capture capacity was established, we were able to troubleshoot the survey data acquisition and create appropriate response criteria for OR, WA, AK, and HI (e.g., standardized regions, appropriate species, etc.). The request to the California seabird research and monitoring community was made a second time on 28 December 2016 (N = 46 email addresses). On 22 September 2015, we solicited the Oregon seabird research and monitoring community with a similar email (N = 6 email addresses) and specifically requested that members "*Please share this with other folks in Oregon*". On 24 September 2015, we solicited the Washington seabird research and monitoring community (N = 12 email addresses) and specifically requested that members "*Please share this with other folks in Washington*". A second request was sent to the OR and WA seabird community on 4 January 2017 (N = 15 email addresses). During June 2016, email solicitation for AK and HI also were generated by the Pacific Seabird Group regional executive representative members who maintain the most complete list of email contacts (Alaska: AK.RU_Rep@pacificseabirdgroup.org [Robb Kaler] and Hawaii: SoCA.HI.LA_Rep@pacificseabirdgroup.org [Yuri Albores-Barajas]. A second request was sent to the HI community on 5 January 2017 (N = 36 email addresses). To acquire and complete missing seabird information for Oregon and Washington, Adams (USGS) contacted Shawn Stephenson (USFWS) and Scott Pearson (WDFW) during August 2018.

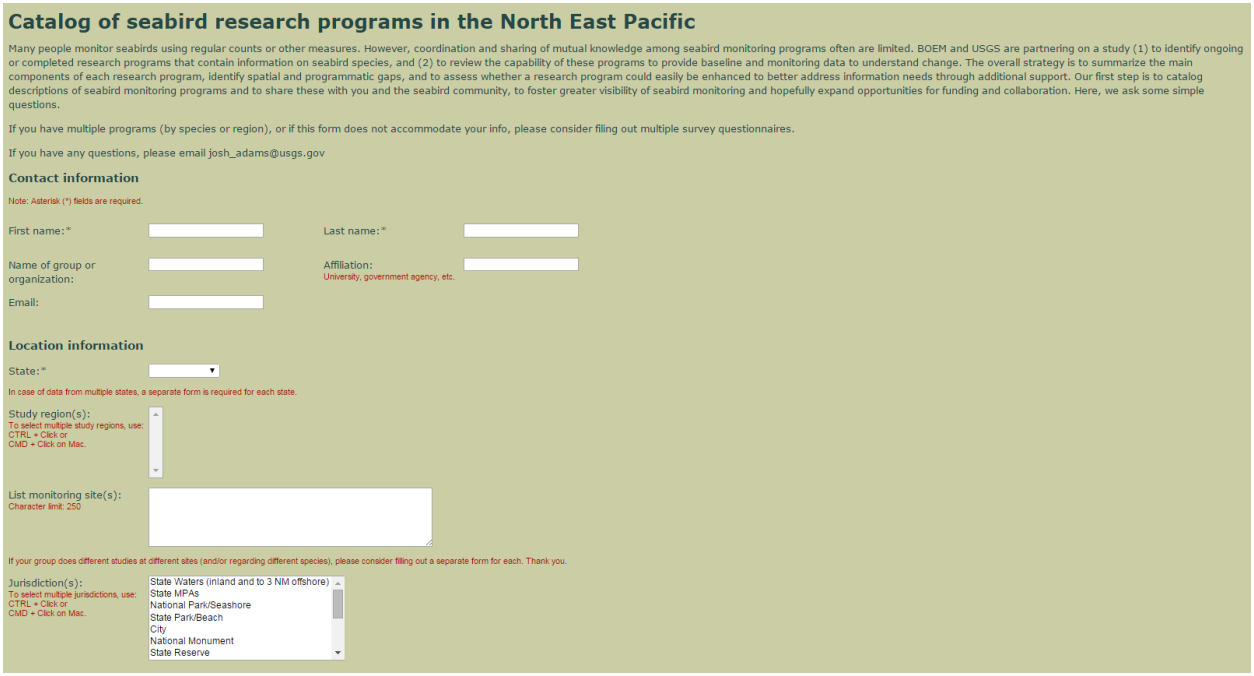

Figure 3. Screen capture image of the online data gathering survey
This survey was shared with seabird monitoring communities throughout the POCS. Data were captured in a secure SQL database maintained by USGS-WERC.

3.2 Marine mammal survey format and solicitation

The marine mammal survey database was established in January 2017. Candidate species lists were compiled from Pacific regional resources, and the geographic area, study design, and data format fields were parameterized according to the previously established marine bird survey (Table 1). A specialist in marine mammal research and monitoring was consulted during the parameterization of mammal-specific database components, especially study method and data type collected. The database was formatted into a spreadsheet populated with drop-down menus containing a fixed set of options for each component. Initial participants were identified through literature authorship and via online keyword and agency searches; subsequent contributors were identified by collaborators or through research facilities and organizations. Any contributors to the marine bird database who indicated the collection of marine mammal data were also contacted for details regarding their marine mammal monitoring. For each identified potential contributor, data entries were initiated based on online reporting detailing research activities. Initial entries were then emailed to the candidate contributor for verification and completion using the following email:

> [Researcher name]:
>
> We are helping BOEM collate a list of marine mammal monitoring in the Pacific. Based on our searches, we have identified you as a contact person for [name] marine mammal monitoring or research program. We want to be sure that we have the correct information about your program in our list of marine mammal monitoring programs to be shared with potential funders and colleagues. To ensure that we have correct information about your program, **please take a quick look at how we describe your work to help us correct errors and fill in missing information** (directions appended below).
>
> If you are not the appropriate contact person, but know who is, we'd appreciate your forwarding our message to that contact person.

A note on the purpose of this BOEM database:

By identifying ongoing or completed research programs that contain information on marine mammal species, this monitoring list will help determine the capability of these programs to provide baseline and monitoring data to understand change while fostering greater visibility of monitoring and hopefully expanding opportunities for funding and collaboration.

To modify your program's information in our database:

There are two tabs of data for you to examine: one contains metadata about your agency and the basics about its monitoring efforts, the second contains the details of individual monitoring programs (e.g., per species, region, etc.). Each monitoring program is entered in a separate column. For guidance, a completed example is included on each tab.

For easy modification, fields in the database are primarily filled via drop-down menus; to change any response, you can simply click on a cell, click on the small arrow that appears in the right corner to open the drop-down menu, and then select the appropriate option. The few fields that require manual filling will have a yellow pop-up note to direct you. You can clear any cell by simply highlighting it and then hitting the "backspace" key.

If you do additional monitoring (of other species or in other regions) that we have missed, you may add column(s) of responses characterizing those efforts. Redundant information can be left blank or copied into adjacent cells using the green square in the lower right corner of a field (the standard Excel drag to copy function).

If you have any questions, please email coraann.johnston@gmail.com, cc: klafferty@usgs.gov.

Finally, if you have collaborators or know of other researchers who should be included in our database, we would appreciate your suggestions of who to contact.

Thank you for helping us validate your research records.

On behalf of BOEM,

Cora Johnston, Ph.D.
Post-doctoral research scientist
U.S. Geological Survey & UC Santa Barbara

Kevin Lafferty, Ph.D.
Marine Ecologist
Western Ecological Research Center
U.S. Geological Survey

Entry confirmations (N = 65 email addresses) were collected between March and November 2017.

Table 1. List of parameters and their descriptions collected for describing marine bird and mammal research and monitoring programs or efforts throughout the Pacific OCS.

Parameters collected	Description of parameters collected
Contact Name	Person responsible for information about the program (usually the person submitting the information)
Contact Email	Email address for Contact Name
Taxa Set	Either "Seabird" or "Mammal"

Parameters collected	Description of parameters collected
Taxa	Broad taxonomic group (e.g., avian Family, mammalian Order, etc.)
Common Name	Standardized common name for taxa of interest (at species-level)
Scientific Name	Currently recognized North American Latin binomial nomenclature
Alpha Code	4-character alpha code commonly used to identify marine birds and mammals in related data sets
Notes on species	Any user-specified notes regarding species selected
Study Region	Geographic study regions where research or monitoring activities occur (can be multiple listings)
State Name	State name for planning area reference; States encompass Study Regions
Monitor Site	Unique geographic names if participants wanted to indicate specific research or monitoring sites
Jurisdiction[1]	Geographic/management jurisdiction for region or habitats where specific research or monitoring occurs or is related to (can be multiple listings)
Organization	Specific organization, group, entity or individual associated with a given Affiliation
Affiliation[2]	14 parent organizations or entities encompassing specific Organizations
Data Collected	45 parameters describing the types of information collected for each species or taxa group (See Table 3)
Survey Method	For seabirds and mammals, methodological description used to specify greater detail
Other Methods	For mammals, methodological description used to specify greater detail for Data Collected and/or Survey Method
Start Year	Year group or researcher-initiated data collection
End Year	Ending Year group or researcher finished data collection
Missing Year	List of any years where data were not collected
Data Collection Seasons	Season when research or monitoring occurs (can be multiple listings)
Data Collection Frequency	Approximate frequency at which research or monitoring occurs (can be multiple listings
Notes	Any general applicable notes added by participants used to clarify any of the responses describing specific parameters collected

[1] Specific jurisdictions available included: State Waters (inland and to 3 NM offshore), State MPAs, National Park/Seashore, State Park/Beach, City, National Monument, State Reserve, County, National Marine Sanctuaries, Military/Coast Guard, National Wildlife Refuge, Private Land, and Federal Land (VA).

[2] Specific parent organization affiliations included: California Department of Fish & Wildlife, California Sea Grant, California State Parks, College or University, DOC National Oceanographic and Atmospheric Administration, DOD Marine Corps, DOI Bureau of Land Management, DOI National Park Service, DOI U.S. Fish & Wildlife Service, DOI U.S. Forest Service, DOI U.S. Geological Survey, NGO For-profit, NGO Independent, and NGO Non-profit.

Figure 4. Sea otter researcher records behavior
A researcher at the Monterey Bay Aquarium, records sea otter behavior on data sheets as part of a study with the USGS and the University of California at Santa Cruz on sea otter behavior. (Credit: Tania Larson, U.S. Geological Survey. Public domain.)

4 Results

4.1 Marine Bird Research and Monitoring Programs

Survey participants who indicated their organization collects information for research or monitoring in California, Oregon, Washington, Alaska, Hawaii and the Pacific Islands indicated a total of 47 specific marine birds of 13 Families (Table 2). Participants indicated 28 research or monitoring parameters were collected (Table 3), with the oldest data collected beginning in 1960 (Band-rumped Storm-Petrel, Hawaiian Petrel, and Newell's Shearwater data collected by the National Park Service) and the most recent data indicated in 2017. The complete database is available online (Lafferty et al. 2019; https://doi.org/10.5066/F7X0669S).

Table 2. List of 46 specific marine birds (listed alphabetically by Family then by Common Name) identified by survey respondents who indicated their organization collects information for research or monitoring in California, Oregon, Washington, Alaska, Hawaii and the Pacific Islands. Respondents also indicated "All Birds" and "Other Birds". Non-marine waterbirds (e.g. herons) and shorebirds (e.g. Black Oystercatcher) were rarely indicated and are not included in this table.

Taxa (Family)	Common Name	Scientific Name	Alpha Code
Alcidae	Ancient Murrelet	*Synthliboramphus antiquus*	ANMU
	Cassin's Auklet	*Ptychoramphus aleuticus*	CAAU
	Common Murre	*Uria aalge*	COMU
	Horned Puffin	*Fratercula corniculata*	HOPU
	Kittlitz's Murrelet	*Brachyramphus brevirostris*	KIMU
	Marbled Murrelet	*Brachyramphus marmoratus*	MAMU
	Parakeet Auklet	*Aethia psittacula*	PAAU
	Pigeon Guillemot	*Cepphus columba*	PIGU
	Rhinoceros Auklet	*Cerorhinca monocerata*	RHAU
	Scripps's Murrelet	*Synthliboramphus scrippsi*	SCMU
	Tufted Puffin	*Fratercula cirrhata*	TUPU
Diomedeidae	Black-footed Albatross	*Phoebastria nigripes*	BFAL
	Laysan Albatross	*Phoebastria immutabilis*	LAAL
Fregatidae	Great Frigatebird	*Fregata minor*	GRFR
Gaviidae	Red-throated Loon	*Gavia stellata*	RTLO
Hydrobatidae	Ashy Storm-Petrel	*Oceanodroma homochroa*	ASSP
	Band-rumped Storm-Petrel	*Oceanodroma castro*	BSTP
	Black Storm-Petrel	*Oceanodroma melania*	BLSP
	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	LESP
	Fork-tailed Storm-Petrel	*Oceanodroma furcata*	FTSP
Laridae	Aleutian Tern	*Onychoprion aleuticus*	ALTE
	Arctic Tern	*Sterna paradisaea*	ARTE
	Black Noddy	*Anous minutus*	BLNO
	Black-legged Kittiwake	*Rissa tridactyla*	BLKI
	California Gull	*Larus californicus*	CAGU
	Caspian Tern	*Hydroprogne caspia*	CATE
	Elegant Tern	*Thalasseus elegans*	ELTE
	Glaucous-winged Gull	*Larus glaucescens*	GWGU

Taxa (Family)	Common Name	Scientific Name	Alpha Code
	Least Tern	*Sternula antillarum*	LETE
	Mew Gull	*Larus canus*	MEGU
	Western Gull	*Larus occidentalis*	WEGU
	White Tern	*Gygis alba*	WHTT
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	BRPE
Phaethontidae	Red-tailed Tropicbird	*Phaethon rubricauda*	RTTR
	White-tailed Tropicbird	*Phaethon lepturus*	WTTR
Phalacrocoracidae	Brandt's Cormorant	*Phalacrocorax penicillatus*	BRAC
	Double-crested Cormorant	*Phalacrocorax auritus*	DCCO
	Pelagic Cormorant	*Phalacrocorax pelagicus*	PECO
	Red-faced Cormorant	*Phalacrocorax urile*	RFCO
Podicipedidae	Western/Clark’s Grebe	*Aechmophorus occidentalis/clarkii*	WEGR/CLGR
Procellariidae	Christmas Shearwater	*Puffinus nativitatis*	CHSH
	Hawaiian Petrel	*Pterodroma sandwichensis*	HAPE
	Newell's Shearwater	*Puffinus newelli*	NESH
	Wedge-tailed Shearwater	*Ardenna pacifica*	WTSH
Stercorariidae	Parasitic Jaeger	*Stercorarius parasiticus*	PAJA
Sulidae	Brown Booby	*Sula leucogaster*	BRBO
	Red-footed Booby	*Sula sula*	RFBO

Figure 5. Horned Puffin
One of the species affected by a recent seabird die-off in the Pribilof Islands, AK. Near Chisik Island in Lower Cook Inlet, Alaska. (Credit: Sarah Schoen, U.S. Geological Survey, Alaska Science Center. Public domain.)

Table 3. List of the research or monitoring parameters identified in programs associated with collecting data about marine birds (N = 28 parameters). Contributors were asked to identify specific species or grouped taxa for each parameter measured.

Parameter	Description	Value for informing potential effects of offshore energy activities
Acoustics	methods and devices used to collect sonic information (e.g. directional hydrophones for marine mammals, acoustic sound recorders deployed on islands to record bird vocalizations, recording stations to archive sonic tags deployed on marine animals)	*moderate – high*. Depending on the context, acoustic monitoring techniques can be one of the only tools available for measuring the relative abundance of cryptic nocturnal species such as petrels and storm-petrels.
Adult Diet	samples, either collected or observed, that describe the diet or food habits of adult animals	*low*
Adult Morphometrics	measurements used to describe the size of an adult animal	*moderate.* Measurements of individuals may already be available for certain species and are important for describing aspects related to flight behavior and maneuverability including aspect ratio and wing-loading.
At-sea Behavior	discrete or categorical information that describes some behavior exhibited by animals while at sea (e.g., diving, feeding, flying, etc.)	*high*. Although behavior at sea can be difficult to measure, behaviors exhibited by birds at sea can influence their vulnerability to offshore energy activities either affecting collision vulnerability or displacement vulnerability
At-sea Count From Shore	counts of animals at sea or on land made from a land-based vantage point	low
At-sea Distribution/Abundance Vessel	counts or recorded locations of animals at sea made from a vessel such as a boat, aircraft, or autonomous vessel (e.g., drone)	*high*. Although logistically complex and expensive, vessel surveys at sea are the only way to measure the distribution and abundance of seabirds and marine mammal at sea. Surveys can be modified to achieve appropriate temporal and spatial resolution to address site-specific needs.
Beach Carcass Surveys	surveys conducted on beaches or along waterfronts that describe the location, species, and counts for animal carcasses deposited on shore	*moderate*. Beach carcass surveys provide and index to seasonal and annual trends in seabird mortality and can also signal events that cause exacerbated mortality and deposition. There are several regional, long-term programs on the west coast of the US.

Parameter	Description	Value for informing potential effects of offshore energy activities
Blood/Feather/Tissue Sampling	collection of blood, feathers, or other tissues from birds	*low*
Breeding Success	quantified information related to reproductive success (e.g., number chicks fledged per nest for birds or number of pups weened for pinniped population)	*low*
Chick Diet	samples, either collected or observed, that describe the diet or food habits of chicks or nestlings (birds)	*low*
Chick Growth/Morphometrics	measurements (usually repeated) used to describe the change in size (growth) of individual birds from hatching to fledging.	*low*
Colony Behavior	discrete or categorical information that describes some behavior exhibited collectively by animals in a colony (e.g., flushing or fleeing in response to disturbance)	*low*
Colony Count	counts of animals located within a discrete colony (e.g. seabird breeding colony or pinniped breeding colony)	*moderate – high.* Systematic colony count data among species that are at greater vulnerability associated with offshore energy activities (i.e., offshore wind energy infrastructure) based on colony location, together with information from reference site locations, could provide information to colony specific changes in abundance.
Contaminants	information related specifically to the evaluation of chemicals or chemical exposure among animals, tissues, or eggs	*low*
Disturbance	information related to disturbance or harassment of birds or marine mammals	*low*
Fledging Success	quantified information related to reproductive success (e.g., number chicks fledged per nest for birds or number of pups weened for pinniped population)	*low*
Hatching Success	quantified information related to reproductive success (e.g., number eggs hatched per number of eggs laid)	*low*
Mistnetting	a fine mesh netting method used for capturing birds	*low*

Parameter	Description	Value for informing potential effects of offshore energy activities
Necropsy/Tissue Archival	procuring, storing, or archiving animals or animal tissue samples collected during post-mortem examination	*low*
Nest/Burrow Occupancy	quantified information used to calculate the proportion of nests or burrows (for burrow-nesting seabirds) available within a sample that are occupied by a breeding adult or breeding adult pair (birds only)	*moderate – high*. Systematic nest or burrow occupancy data among species that are at greater vulnerability associated with offshore energy activities (i.e., offshore wind energy infrastructure) based on colony location, together with information from reference site locations, could provide information to colony specific changes in abundance.
Nest Count	number of nest sites (or burrows for burrow-nesting seabirds) per sample (count data)	*moderate – high*. Systematic nest count data among species that are at greater vulnerability associated with offshore energy activities (i.e., offshore wind energy infrastructure) based on colony location, together with information from reference site locations, could provide information to colony specific changes in abundance.
Phenology	information related to the seasonal timing of animal life history events (nesting season, pupping season, dispersal or migration timing)	*low*
Photography	information collected using cameras, can include nest counts, counts at sea, species identification, nest site activity or visitation on land	*low*
Predation	information related to depredation of seabirds. For example, are seabirds taken as prey by mammals, or other birds?	*low*

Parameter	Description	Value for informing potential effects of offshore energy activities
Radar	radar is used to detect and map flight trajectories among seabirds – usually associated with flyways and site-specific colony attendance	*moderate – high.* Measuring the flight behavior and transiting movements among seabirds can be difficult, especially at night or during periods of poor visibility. Radar offers a convenient method to measure flight trajectories (flight height and speed) associated with offshore energy activities. Data may be useful for determining the effect of activities or infrastructure on flight behavior and movements.
Roosting/Haulout Count	number animals counted at roosting sites (birds) or at haulout locations (pinnipeds) (count data)	*low*
Subadult/Adult Survival	information collected to record, document or calculate survival of sub-adult or adult members of a population	*moderate – high*. Among long-lived seabirds with low reproductive output, adult survival rates are important to measure because small changes in adult survival over time translate to changes in population growth rates.
Telemetry/Sensors	devices usually attached to animals that are used to measure or record an individual animal's location, trajectory, movement, physiology, or information about an animal's habitat or environment	*moderate.* Telemetry and bird-borne sensors provide a convenient way to track the movements and behavior of seabirds at sea. GPS technology allows relatively hi-resolution spatial information (several m) and can also be useful for assessing flight heights, and behaviors (resting, transiting) among different species

Table 4. List of the research or monitoring parameters identified in programs associated with marine mammal (N = 24 parameters) taxa. Contributors were asked to identify specific species or grouped taxa for each parameter measured.

Parameter	Description	Value for informing potential effects of offshore energy activities
Abundance	records of the number of individuals per sample or in a study area	*high*. An understanding of the distribution and abundance among species in areas potentially affected by offshore energy activities is key information.
Acoustics	records of species presence, identity, and/or activity inferred from acoustic recording devices including devices used to document species presence, identity, and/or activity. Some devices are left unattended (e.g., at buoys) and retrieved at intervals for data download; others are collected in real time (e.g., by towing behind a vessel)	*moderate – high*. Depending on the context, acoustic monitoring techniques can be an effective method for measuring the presence/absence or abundance of diving cetaceans.
Beach Carcass Surveys	surveys conducted on beaches or along waterfronts that describe the location, species, and counts for animal carcasses deposited on shore	*moderate*. Beach carcass surveys provide and index to seasonal and annual trends in seabird mortality and can also signal events that cause exacerbated mortality and deposition. There are several regional, long-term programs on the west coast of the US.
Behavior	observations or recordings of behavior, including inter- and intra-species interactions, foraging, diving, mating, ship evasion, etc.	*moderate – high*. Depending on the context, marine mammal behavior can provide information about individuals reactions to modified environments or stressors. Normal behavioral observations yield information about timing or habitats of importance (e.g., mating, resting, or feeding areas).
Blood/Tissue Sampling	collection of blood or other tissues from marine mammals	*low.* Tissue sampling may be important for genetic species ID or population structure analyses
Density	Recordings of number of individuals per unit area (similar to abundance).	*moderate – high*. Similar to Abundance, an understanding of the distribution and abundance among species in areas potentially affected by offshore energy activities is key information

Parameter	Description	Value for informing potential effects of offshore energy activities
Diet or foraging or contaminants	Observations or measurements of food consumption, diet composition, and related intake of contaminants.	*low – moderate*. Depending on context, information regarding feeding behavior or distribution of key forage species can provide important information about important areas at sea for marine mammals.
Distribution or range	Evaluation or observations of the spatial extent of species occurrence.	*moderate – high*. Similar to Abundance and Density, an understanding of the distribution and range among species in areas potentially affected by offshore energy activities is key information.
Disturbance	Records of conflict between wildlife and sources of disturbance, including beach users, ship traffic, etc.	*moderate – high*. Depending on context, information regarding disturbance to marine mammals caused by anthropogenic factors associated with offshore energy activities (e.g., benthic surveys, construction and operational noise under water, sub-surface cabling or infrastructure hazards, etc.).
Habitat occupancy	Records of species presence in or association with a given habitat type.	*moderate.* Information that describes habitat associations among marine mammals can be important for evaluating siting and potential effects associated with offshore energy activities.
Haulouts	Records of pinniped emergence along shorelines.	*low.* Unless haulouts are associated with offshore energy infrastructure.
Morphometrics	Measures of body attributes that characterize size, shape, or condition.	*low.*
Mortality	Observations of mortality events or records of dead individuals and associated causes.	*low.* Unless associated with offshore energy activities.
Movement or migration or dispersal	Observations or estimates of individual mobility at small (movement) and large (migration) scales.	*low – moderate*. Depending on context, identification of key movement corridors could be important related to offshore energy activities
Necropsy/Tissue Archival	procuring, storing, or archiving animals or animal tissue samples collected during post-mortem examination	*low.*

Parameter	Description	Value for informing potential effects of offshore energy activities
Occurrence	Records of species encounter across space and habitats. Generally, at less resolution then actual quantification of abundance or density.	*low – high*. Similar to Abundance, Density, and Distribution or Range, an understanding of the occurrence among species in areas potentially affected by offshore energy activities is key information.
Pathology	Observations or evaluations of symptoms or disease and causes thereof.	*low.*
Physiology	information to help explain marine mammal body function including diving and locomotion, nutrition and energetics, reproduction, sensory systems, and environmental interactions	*low.* Unless associated with offshore energy activities.
Population structure or individual ID	estimates of population size, age distribution, or composition of known individuals developed primarily from tagging, observational, and genetic approaches.	*moderate.* Demographic information that can be associated with population growth or vulnerability (i.e., survival rates) is important for determining population structure and status.
Predation	information related to depredation of marine mammals. For example, are marine mammals taken as prey by other marine mammals or sharks?	*low.*
Reproduction	records of the occurrence of mating or production and survival of offspring	*low.*
Strike or stranding or entanglement	records of injured or distressed animals evidently resulting from encounters with agents of disturbance (vessels, etc.), disease, or similar	*high.*
Subadult/Adult Survival	information collected to record, document or calculate survival of sub-adult or adult members of a population	*moderate – high*. Among long-lived marine mammals with low reproductive output, adult survival rates are important to measure because small changes in adult survival over time translate to changes in population growth rates.

Parameter	Description	Value for informing potential effects of offshore energy activities
Telemetry/Sensors	devices usually attached to animals that are used to measure or record an individual animal's location, trajectory, movement, physiology, or information about an animal's habitat or environment	*moderate.* Telemetry and marine mammal-borne sensors provide a convenient way to track the movements and behavior of individuals at sea. GPS technology allows relatively hi-resolution spatial information (several m) and time-a-depth sensors can also be useful for assessing sub-surface behaviors among different species

4.1.1 California

In California, there exists a large, relatively well-organized community of researchers and resource managers participating in marine bird monitoring and research. Our survey outreach successfully gathered metadata from 34 organizations or individual persons about their research or monitoring programs (Table 5). Organizations included a diverse assemblage of Federal and State government agencies, academic institutions, NGOs, and independent researchers.

Organizations indicating that they collected information on “All Birds” included primarily programs engaged in variable-scale ocean surveys that measure distribution and abundance at sea from aircraft or by boat (Crescent Coastal Research, Farallon Institute, Greater Farallones National Marine Sanctuary, Monterey Bay National Marine Sanctuary, Northwest Fisheries Science Center, Point Blue Conservation Science, Southwest Fisheries Science Center, and USGS Western Ecological Research Center, Santa Cruz Field Station), programs engaged in beach carcass surveys (Greater Farallones National Marine Sanctuary/Beach Watch, Moss Landing Marine Laboratories/BeachCOMBERS, and Redwood National and State Parks), and organizations that are engaged in seabird rescue and rehabilitation (International Bird Rescue) or study and sample dead seabirds from carcass survey programs (Marine Veterinary Care and Research Center/Seabird Health Program (UCD and CDFW), Moss Landing Marine Laboratories/BeachCOMBERS, San Jose State University/Oregon State University).

Respondents from organizations researching or monitoring marine birds in California identified 20 species (26 parameters) for which data are collected including: Ashy Storm-Petrel (15 parameters), Black Storm-Petrel (5 parameters), Leach's Storm-Petrel (7 parameters), Pelagic Cormorant (14 parameters), Brandt's Cormorant (15 parameters), Double-crested Cormorant (8 parameters), Brown Pelican (22 parameters), California Gull (7 parameters), Western Gull (19 parameters), Caspian Tern (5 parameters), Elegant Tern (11 parameters), Least Tern (16 parameters), Cassin's Auklet (20 parameters), Common Murre (16 parameters), Pigeon Guillemot (16 parameters), Rhinoceros Auklet (19 parameters), Tufted Puffin (4 parameters), Marbled Murrelet (11 parameters), Scripps's Murrelet (8 parameters), and Western/Clark’s Grebe (5 parameters) (Table 6). The 5 most-indicated parameters for these 20 species included: colony counts/behaviors (19 species), nest counts (16 species), fledging success (15 species), hatching success (14 species), and breeding success (13 species) (Table 5). The 5 least-indicated parameters included: at-sea behavior (Brown Pelican), at-sea counts from shore (Pelagic Cormorant and Pigeon Guillemot), at-sea distribution and abundance from vessel (Marbled Murrelet and Brown Pelican), dedicated species-specific beach carcass surveys (Brown Pelican and Elegant Tern), and necropsy / tissue archival (Table 6).

Figure 6. Passive, digital acoustic recording unit
Scientists use these tools to quantify vocal activity levels and environmental sounds within remote habitats used by seabirds. For example, this technology can be used to study the distribution of seabirds without causing damage to sensitive habitat or disturbing the animals. (Credit: Emma Kelsey, USGS Western Ecological Research Center. Public domain.)

Table 5. List of parent organizations or organization type and affiliates contributing survey information regarding marine bird research and monitoring programs in California.

Parent Organization name or type Affiliated Organization name
California Department of Fish & Wildlife (CDFW)
Marine Veterinary Care and Research Center/Seabird Health Program (UCD and CADFW)
Office of Spill Prevention and Response
California Sea Grant
Crescent Coastal Research
California State Parks
CA State Parks Cooperating Association: Stewards of the Coast and Redwoods
California State Parks
College or University
Humboldt State University, Common Murre Restoration Project (HSU and USFWS)
Moss Landing Marine Laboratories/BeachCOMBERS
San Jose State University
San Jose State University/Oregon State University
University of California Santa Cruz
University of Oklahoma, Oklahoma Biological Survey
DOC National Oceanographic and Atmospheric Administration (NOAA)
Greater Farallones National Marine Sanctuary
Greater Farallones National Marine Sanctuary/Beach Watch
Monterey Bay National Marine Sanctuary
Northwest Fisheries Science Center
Southwest Fisheries Science Center
DOI Bureau of Land Management (BLM)
California Coastal National Monument
DOI National Park Service (NPS)
Channel Islands National Park
Golden Gate National Recreation Area
Golden Gate National Recreation Area/Alcatraz Island
Point Reyes National Seashore
Redwood National and State Parks

Parent Organization name or type Affiliated Organization name
DOI U.S. Fish & Wildlife Service (USFWS)
Friends of Alameda National Wildlife Refuge
U.S. Fish & Wildlife Service
DOI U.S. Geological Survey (USGS)
USGS Western Ecological Research Center, Santa Cruz Field Station
NGO Independent researchers
Bill Henry
Ron LeValley
NGO Non-profit organizations
Audubon California
Audubon California Black Oystercatcher Monitors
California Institute of Environmental Studies
Farallon Institute
International Bird Rescue
Oikonos Ecosystem Knowledge
Point Blue Conservation Science

Table 6. California marine bird research and monitoring parameters (data collected for each species, listed in alphabetical order). Columns indicate specific parameters collected for each species (rows). Numbers and row totals indicate the total number of unique entries in the database (organizations, study regions, monitoring sites, etc.) for each species (cell colors green to red indicate quartile breaks). Row counts indicate the total number of parameters collected for a species. Column totals and counts indicate the same for each research or monitoring parameter.

Common Name	Acoustics	Adult Diet	Adult Morphometrics	At-sea Behavior	At-sea Count From Shore	At-sea Dist. Abundance Vessel	Beach Carcass Surveys	Blood / Feather Tissue Sampling	Breeding Success	Chick Diet	Chick Growth / Morphometrics	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Mist-netting	Necropsy / Tissue Archival	Nest / Burrow Occupancy	Nest Count	Phenology	Predation	Roosting / HaulOut Count	Sub-adult / Adult Survival	Telemetry / Sensors	Total	Count
Ashy Storm-Petrel	4		4					3	3			4	2			3	3	5		3	1	3	1		2	3	44	15
Black Storm-Petrel	3		4									1	2					1									11	5
Brandt's Cormorant		8						5	12	1		5	13		9	12	12			1	13	12	2	10	2		117	15
Brown Pelican		1	1	1		1	1	1	2	1	1	3	4	1	3	2	1		1		3	6	2	7	1	1	45	22
California Gull									1			3	5		1						2	2	1				15	7
Caspian Tern													3			1	1				1				1		7	5
Cassin's Auklet	2	1	7					3	10	5	8	2	3	2		8	10	2	1	10	8	7	1		4	7	101	20
Common Murre			6					6	3	2		4	6	7	2	3	3				2	3	1	2	2	9	61	16
Double-crest. Cormorant									1			2	3		1	1	1				4			2			15	8
Elegant Tern		2	2				2	2				2	3			2		2			2		2			2	23	11
Leach's Storm-Petrel	2		4					3				3	1					3		2							18	7
Least Tern		1							4	2		2	5	2	2	4	4		1	1	2	2	2	1	1		36	16
Marbled Murrelet						1			2			1	1		1	3	2			2		1	2			3	19	11
Pelagic Cormorant		1			1				9			4	9	1	5	9	9			1	10	4	3	3			69	14
Pigeon Guillemot			2		4				7	4	3	5	6		2	7	6			5	4	8	3	2	2		70	16
Rhinoceros Auklet		4	6					6	6	4	4	3	3	1		4	4	4	2	6	4	4	2		4	7	78	19
Scripps's Murrelet	3											2	1			1	1			1	1					4	14	8
Tufted Puffin												2	1							2	2						7	4
Western Gull		2	4					6	13	2	2	5	14	6	7	11	13			2	14	13	2	7	2	4	129	19
Western/Clark's Grebe			6					6						6	2											6	26	5
Total	**14**	**20**	**46**	**1**	**5**	**2**	**3**	**41**	**73**	**21**	**18**	**53**	**85**	**26**	**35**	**71**	**70**	**17**	**5**	**36**	**73**	**65**	**24**	**34**	**21**	**46**	**905**	
Count	**5**	**8**	**11**	**1**	**2**	**2**	**2**	**10**	**13**	**8**	**5**	**18**	**19**	**8**	**11**	**15**	**14**	**6**	**4**	**12**	**16**	**12**	**13**	**8**	**10**	**10**		

4.1.2 Oregon and Washington

In Oregon and Washington there exists a relatively smaller (compared with California), yet equally well-organized community of researchers and resource managers participating in marine bird monitoring and research. Our survey outreach successfully gathered metadata from 11 organizations about their research or monitoring programs (Table 7). Organizations included mostly Federal government agencies (NOAA, USDA Forest Service), academic institutions (Oregon State University and University of Washington), and 2 NGOs (Pacific Eco Logic and Audubon Society).

Organizations indicating that they collected information on "All Birds" included primarily programs engaged in variable-scale ocean surveys that measure distribution and abundance at sea from shore (NOAA Northwest Fisheries Science Center) or by aircraft or boat (Northwest Fisheries Science Center, Olympic Coast National Marine Sanctuary, Oregon State University, Southwest Fisheries Science Center, USDA Forest Service, USFWS) and programs engaged in beach carcass surveys (University of Washington/COASST).

Respondents from organizations researching or monitoring marine birds in Oregon and Washington identified 14 species (27 parameters) for which data are collected including: Leach's Storm-Petrel (9 parameters), Fork-tailed Storm-Petrel (3 parameters), Pelagic Cormorant (8 parameters), Brandt's Cormorant (8 parameters), Double-crested Cormorant (7 Parameters), Brown Pelican (12 parameters), Western Gull (13 parameters), Glaucus-winged Gull (4 parameters), Common Murre (15 parameters), Pigeon Guillemot (7 Parameters), Rhinoceros Auklet (6 parameters), Tufted Puffin (12 parameters), and Marbled Murrelet (2 parameters) (Table 7). The 4 most-indicated parameters for these 14 species included: phenology (12 species), colony counts (9 species), disturbance (9 species), and breeding success (8 species) (Table 8). The 5 least-indicated parameters included: mistnetting (Leach's Storm-Petrel), nest counts (Pigeon Guillemot), photography, and radar (Leach's Storm-Petrel), and sub-adult survival (Brown Pelican) (Table 8).

Figure 7. University of Washington graduate student
Preparing to sample diet from a Common Murre off the coast of Washington. (Credit: Josh Adams, USGS Western Ecological Research Center. Public domain.)

Table 7. List of parent organizations or organization type and affiliates contributing survey information regarding marine bird research and monitoring programs in Oregon and Washington.

Parent Organization name or type Affiliated Organization name
College or University
Oregon State University
University of Washington/COASST
DOC National Oceanographic and Atmospheric Administration
Northwest Fisheries Science Center
Olympic Coast National Marine Sanctuary
Southwest Fisheries Science Center
DOI U.S. Forest Service
USDA Forest Service
DOI U.S. Fish & Wildlife Service
Oregon Coast National Wildlife Refuge
State Government
Washington Department of Fish & Wildlife
NGO For-profit
Pacific Eco Logic
Whidbey Audubon Society
Seattle Audubon society

Table 8. Oregon & Washington marine bird research and monitoring parameters (data collected for each species, listed in alphabetical order). Columns indicate specific parameters collected for each species (rows). Numbers and row totals indicate the total number of unique entries in the database (organizations, study regions, monitoring sites, etc.) for each species (cell colors green to red indicate quartile breaks). Row counts indicate the total number of parameters collected for a species. Column totals and counts indicate the same for each research or monitoring parameter.

Common name	Acoustics	Adult Diet	Adult Morphometrics	At-sea Behavior	At-sea Count From Shore	At-sea Dist. Abundance Vessel	Beach Carcass Surveys	Blood / Feather Tissue Sampling	Breeding Success	Chick Diet	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Mist-netting	Necropsy / Tissue Archival	Nest / Burrow Occupancy	Nest Count	Phenology	Photography	Predation	Radar	Roosting / Haul Out Count	Sub-adult / Adult Survival	Telemetry / Sensors	Total	Count
All Bird Species			1	14	4	16	2					1									1		1					40	8
Brandt's Cormorant									2	1		1		1	2	1					2		1					11	8
Brown Pelican		3	3			1		3	3				3	3				3			3				4	3	3	35	12
Common Murre		7	2	1				2	2	1	2	2		2	2	2		1			2		1				8	37	15
Double-crested Cormorant									1	1		1		1	1	1					1							7	7
Fork-tailed Storm-Petrel	1																		1		1							3	3
Glaucous-winged Gull												1		1							1						1	4	4
Leach's Storm-Petrel	3		1					1			2						1		3		1	1		1				14	9
Marbled Murrelet															1												1	2	2
Pelagic Cormorant									2	1		1		1	2	1					2		1					11	8
Pigeon Guillemot				1						1	1	1		1					1	1								7	7
Rhinoceros Auklet									1	1		1		1					1		1							6	6
Tufted Puffin		1	1	1				1	2	1		1			1	1			2		1						1	14	12
Western Gull		2	3					3	1		1		2	1	1	1					2		1		1		3	22	13
Western/Clark's Grebe						1																						1	1
Total	**4**	**13**	**11**	**17**	**4**	**18**	**2**	**10**	**14**	**7**	**6**	**10**	**5**	**12**	**10**	**7**	**1**	**4**	**8**	**1**	**18**	**1**	**5**	**1**	**5**	**3**	**17**	**214**	
Count	**2**	**4**	**6**	**4**	**1**	**3**	**1**	**5**	**8**	**7**	**4**	**9**	**2**	**9**	**7**	**6**	**1**	**2**	**5**	**1**	**12**	**1**	**5**	**1**	**2**	**1**	**6**		

4.1.3 Alaska

In Alaska, there exists a relatively smaller (compared with California) community of researchers and resource managers participating in marine bird monitoring and research. Our survey outreach successfully gathered metadata from 7 organizations about their research or monitoring programs (Table 9). Organizations included a mix of Federal government agencies (USGS, NPS, USFWS), academic institutions (University of Alaska), and one NGO (Institute for Seabird Research and Conservation).

Organizations indicating that they collected information on "All Birds" included primarily programs engaged in variable-scale ocean surveys that measure distribution and abundance at sea by boat (Gulf Watch Alaska [USGS and NPS], University of Alaska Anchorage, USGS Alaska Science Center), and organizations engaged in carcass surveys (Gulf Watch Alaska (USGS and NPS), Kodiak National Wildlife Refuge, and University of Washington/COASST), and tissue sampling/archival (University of Alaska Anchorage).

Respondents from organizations researching or monitoring marine birds Alaska identified 19 species (18 parameters) for which data are collected including: Glaucous-winged Gull (6 parameters), Mew Gull (1 parameter), Black-legged Kittiwake (16 parameters), Aleutian Tern (10 parameters), Arctic Tern (3 parameters), Parasitic Jaeger (1 parameter), Kittlitz's Murrelet (6 parameters), Marbled Murrelet (2 parameters), Ancient Murrelet (1 parameter), Parakeet Auklet (2 parameters), Common Murre (2 parameters), Pigeon Guillemot (2 parameters), Rhinoceros Auklet (10 parameters), Tufted Puffin (8 parameters), Horned Puffin (2 parameters), Double-crested Cormorant (2 parameters), Pelagic Cormorant (12 parameters), Red-faced Cormorant (3 parameters), and Red-throated Loon (1 parameter) (Table 10). The 4 most-indicated parameters for these 18 species included: at-sea distribution and abundance (18 species), colony count (12 species), fledging success (6 species), and hatching success (6 species). The least-indicated parameters included: adult diet (Black-legged Kittiwake), tissue sampling (Black-legged Kittiwake), and sub-adult survival (Pelagic Cormorant and Rhinoceros Auklet) (Table 10).

Table 9. List of parent organizations or organization type and affiliates contributing survey information regarding marine bird research and monitoring programs in Alaska.

Parent Organization name or type Affiliated Organization name
College or University
University of Alaska Anchorage
University of Alaska Anchorage/Aleutian Tern Technical Committee
University of Washington/COASST
DOI U.S. Fish & Wildlife Service
Kodiak National Wildlife Refuge
DOI U.S. Geological Survey
Gulf Watch Alaska (USGS and NPS)
USGS Alaska Science Center
NGO Non-profit
Institute for Seabird Research and Conservation

Table 10. Alaska marine bird research and monitoring parameters (data collected for each species, listed in alphabetical order). Columns indicate specific parameters collected for each species (rows). Numbers and row totals indicate the total number of unique entries in the database (organizations, study regions, monitoring sites, etc.) for each species (cell colors green to red indicate quartile breaks). Row counts indicate the total number of parameters collected for a species. Column totals and counts indicate the same for each research or monitoring parameter.

Common Name	Adult Diet	Adult Morphometrics	At-sea Distribution Abundance Vessel	Blood / Feather / Tissue Sampling	Breeding Success	Chick Diet	Chick Growth Morphometrics	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Nest / Burrow Occupancy	Nest Count	Phenology	Sub-adult / Adult Survival	Telemetry / Sensors	Total	Count
Aleutian Tern	1	1	1	1				1	2	1	1				1			1	11	10
Ancient Murrelet			1																1	1
Arctic Tern			1						1						1				3	3
Black-legged Kittiwake	1	1	1	1	1	1	1	1	2			1	1	1	2	1	1	1	18	16
Common Murre			1						1										2	2
Double-crested Cormorant			1						1										2	2
Glaucous-winged Gull			1				1		2				1	1		1			7	6
Horned Puffin			1						1										2	2
Kittlitz's Murrelet			1			1	1					1	1		1				6	6
Marbled Murrelet			1									1							2	2
Mew Gull			1																1	1
Parakeet Auklet			1						1										2	2
Parasitic Jaeger			1																1	1

Common Name	Adult Diet	Adult Morphometrics	At-sea Distribution Abundance Vessel	Blood / Feather / Tissue Sampling	Breeding Success	Chick Diet	Chick Growth Morphometrics	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Nest / Burrow Occupancy	Nest Count	Phenology	Sub-adult / Adult Survival	Telemetry / Sensors	Total	Count
Pelagic Cormorant			1		1	1		1	6			1	1	1	5	1	1	1	**21**	**12**
Pigeon Guillemot			1						1										**2**	**2**
Red-faced Cormorant			1						5						4				**10**	**3**
Red-throated Loon			1																**1**	**1**
Rhinoceros Auklet			1		1	1	1		1			1	1	1		1		1	**10**	**10**
Tufted Puffin			1		1		1		2			1	1	1		1			**9**	**8**
Total	**2**	**2**	**19**	**2**	**4**	**4**	**5**	**3**	**26**	**1**	**1**	**6**	**6**	**5**	**14**	**5**	**2**	**4**	**111**	
Count	**2**	**2**	**19**	**2**	**4**	**4**	**5**	**3**	**13**	**1**	**1**	**6**	**6**	**5**	**6**	**5**	**2**	**4**		

4.1.4 Hawaii and the Pacific Islands

In Hawaii and the Pacific Islands, there exists a relatively smaller (compared with California) community of researchers and resource managers participating in marine bird monitoring and research. Our survey outreach successfully gathered metadata from 9 organizations about their research or monitoring programs (Table 11). Organizations included a mix of Federal government agencies (NOAA, USGS, NPS, DOD), academic institutions (University of Hawaii), and three NGOs.

Organizations indicating that they collected information on "All Birds" included primarily programs engaged in variable-scale ocean surveys that measure distribution and abundance at sea by boat (NOAA Southwest Fisheries Science Center).

Respondents from organizations researching or monitoring marine birds in Hawaii and the Pacific Islands identified 14 species (23 parameters) for which data are collected including: Band-rumped Storm-Petrel (8 parameters), Hawaiian Petrel (22 parameters), Newell's Shearwater (19 parameters), Wedge-tailed Shearwater (13 parameters), Christmas Shearwater (1 parameter), Black-footed Albatross (8 parameters), Laysan Albatross (16 parameters), Black Noddy (5 parameters), White Tern (8 parameters), Brown Booby (2 parameters), Red-footed Booby (8 parameters), Great Frigatebird (1 parameter), Red-tailed Tropicbird (12 parameters), and White-tailed Tropicbird (2 parameters) (Table 12). The 4 most-indicated parameters for these 14 species included: nest/burrow occupancy (9 species), predation (9 species), colony count (8 species), nest count (8 species) and phenology (8 species) (Table 11). The least-indicated parameters included: adult diet (Hawaiian Petrel and Newell's Shearwater), chick diet (Hawaiian Petrel and Newell's Shearwater), and a variety of other parameters only measured among 3 species (Table 11). In a similar survey of seabird monitoring effort (more regionally focused on the US Tropical Pacific), VanderWerf and Young (2017) reported that within the main Hawaiian Islands, 19 seabirds are or have been monitored (see Figure 15 in VanderWerf and Young 2017). Species for which we were not able to record information from surveys include Least Tern, Grey-backed Tern, Sooty Tern, Brown Noddy, Bulwer's Petrel, and Black-footed Albatross.

Table 11. List of parent organizations or organization type and affiliates contributing survey information regarding marine bird research and monitoring programs in Hawaii and the Pacific Islands.

Parent Organization name or type Affiliated Organization name
College or University
University of Hawaii PCSU/Kauai Endangered Seabird Recovery Project
University of Hawaii PCSU/Maui Nui Seabird Recovery Project
DOC National Oceanographic and Atmospheric Administration
Southwest Fisheries Science Center
DOD Marine Corps
Marine Corps Base Hawaii
DOI National Park Service
Haleakala National Park

Parent Organization name or type Affiliated Organization name
DOI U.S. Geological Survey
USGS Western Ecological Research Center, Santa Cruz Field Station
NGO For-profit
Auwahi Wind
NGO Non-profit
American Bird Conservancy
Pacific Rim Conservation

Figure 8. Monitoring Hawaiian Petrels in Haleakala National Park
Endangered Species Management staff check the status of nesting Hawaiian Petrels at Haleakala National Park. (Credit: Josh Adams, USGS Western Ecological Research Center. Public domain.)

Table 12. Hawaii and Pacific Islands marine bird research and monitoring parameters (data collected for each species, listed in alphabetical order). Columns indicate specific parameters collected for each species (rows). Numbers and row totals indicate the total number of unique entries in the database (organizations, study regions, monitoring sites, etc.) for each species (cell colors green to red indicate quartile breaks). Row counts indicate the total number of parameters collected for a species. Column totals and counts indicate the same for each research or monitoring parameter.

Common Name	Acoustics	Adult Diet	Adult Morphometrics	At-sea Count From Shore	At-sea Distribution Abundance Vessel	Blood / Feather /Tissue Sampling	Breeding Success	Chick Diet	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Mist-netting	Necropsy / Tissue Archival	Nest / Burrow Occupancy	Nest Count	Phenology	Predation	Roosting / Haul-Out Count	Sub-adult Adult Survival	Telemetry / Sensors	Total	Count
Band-rumped Storm-Petrel	3		1	1	1	1									1				1	1				10	8
Black Noddy									1	1							1	2		1				6	5
Black-footed Albatross							1			2			1				2	2	1	1	1			11	8
Brown Booby																				1	1			2	2
Christmas Shearwater																						1		1	1
Great Frigatebird																				1				1	1
Hawaiian Petrel	5	1	1	1	1	2	4	1	4	4	1	3	5	3	1	1	5	4	4	5		1	4	61	22
Laysan Albatross						3	3		1	3	1	1	3	2		1	2	3	3	2	1	2	3	34	16
Newell's Shearwater	4	1	1	1	1	2	1	1	1	1	1		1		1	1	1	1	1	1			2	24	19
Red-footed Booby						1	1			1			1	1						1	1		1	8	8
Red-tailed Tropicbird				1		1	2			3			2	2			2	3	2	3	1		1	23	12

Common Name	Acoustics	Adult Diet	Adult Morphometrics	At-sea Count From Shore	At-sea Distribution Abundance Vessel	Blood / Feather /Tissue Sampling	Breeding Success	Chick Diet	Colony Behavior	Colony Count	Contaminants	Disturbance	Fledging Success	Hatching Success	Mist-netting	Necropsy / Tissue Archival	Nest / Burrow Occupancy	Nest Count	Phenology	Predation	Roosting / Haul-Out Count	Sub-adult Adult Survival	Telemetry / Sensors	Total	Count
Wedge-tailed Shearwater	2						3		2	5		1	3	3			4	5	2	3	1		1	**35**	**13**
White Tern							2			2			2	2			1	2	2		1			**14**	**8**
White-tailed Tropicbird				1													1							**2**	**2**
Total	**14**	**2**	**3**	**5**	**3**	**10**	**17**	**2**	**9**	**22**	**3**	**5**	**18**	**13**	**3**	**3**	**19**	**22**	**16**	**20**	**7**	**4**	**12**	**232**	
Count	**4**	**2**	**3**	**5**	**3**	**6**	**8**	**2**	**5**	**9**	**3**	**3**	**8**	**6**	**3**	**3**	**9**	**8**	**8**	**11**	**7**	**3**	**6**		

4.2 Marine Mammal Research and Monitoring Programs

Survey participants who indicated their organization collects information for research or monitoring in California, Oregon, Washington, Alaska, Hawaii and the Pacific Islands indicated a total of 25 specific marine mammals and 3 taxonomic groupings (Beaked Whales, Toothed Whales, and All pinnipeds) (Table 13). Participants indicated 24 research or monitoring parameters were collected (Table 4), with the oldest data collected beginning in 1968 (pinnipeds at the Farallon Islands, data collected by Point Blue Conservation Science, [then, Point Reyes Bird Observatory] and the most recent data indicated in 2018.

Table 13. List of 25 specific marine mammals and 3 taxonomic groupings (Beaked Whales, Toothed Whales, and All pinnipeds) identified by survey respondents who indicated their organization collects information for research or monitoring in California, Oregon, Washington, Alaska, Hawaii and the Pacific Islands. Some respondents also indicated "All Cetaceans" (CETA; not included in this table).

Taxa	Common Name	Scientific Name	Alpha Code
Cetacea	Beaked Whales	Ziphiidae	ZIPH
	Beluga Whale	*Delphinapterus leucas*	MMDL
	Blue Whale	*Balaenoptera musculus*	MMBL
	Bowhead Whale	*Balaena mysticetus*	MMBM
	Bryde's Whale	*Balaenoptera edeni*	MMBX
	Cuvier's Beaked Whale	*Ziphius cavirostris*	MMZX
	Fin Whale	*Balaenoptera physalus*	MMBP
	Gray Whale	*Eschrichtius robustus*	MMER
	Harbor Porpoise	*Phocoena phocoena*	MMPP
	Humpback Whale	*Megaptera novaeangliae*	MMMN
	Killer whale	*Orcinus orca*	MMOO
	North Pacific Right Whale	*Eubalaena japonica*	MMLB
	Sperm Whale	*Physeter macrocephalus*	MMPM
	Spinner Dolphin	*Stenella longirostris*	MMSL
	Toothed Whales	Odontoceti	ODON
Odobenidae	Walrus	*Odobenus rosmarus*	MMOR
Pinnipedia	All pinnipeds	Pinnipedia	PINN
	Bearded Seal	*Erignathus barbatus*	MMEB
	California Sea Lion	*Zalophus californianus*	MMZC
	Steller's Sea Lion	*Eumetopias jubatus*	MMEJ
	Harbor Seal	*Phoca vitulina*	MMPV
	Hawaiian Monk Seal	*Neomonachus schauinslandi*	MMNS

Taxa	Common Name	Scientific Name	Alpha Code
	Northern Elephant Seal	*Mirounga angustirostris*	MMMA
	Ringed Seal	*Phoca hispida*	MMPH
	Spotted Seal	*Phoca largha*	MMPL
Mustelidae	Northern Sea Otter	*Enhydra lutris kenyoni*	MMEK
	Southern Sea Otter	*Enhydra lutris nereis*	MMEN

4.2.1 California

The community of researchers and resource managers focused on collecting information regarding marine mammals in California is relatively large (Table 14). Our survey outreach successfully gathered metadata from 22 organizations about their research or monitoring programs (Table 14). Organizations included a mix of Federal government agencies (NOAA, USGS, NPS, USFWS), academic institutions (University of California Santa Cruz, Scripps Institution of Oceanography, Moss landing Marine Laboratories), and a couple NGOs (Farallon Institute and Oikonos).

Table 14. List of parent organizations or organization type and affiliates contributing survey information regarding marine mammal research and monitoring programs in California.

Parent Organization name or type Affiliated Organization name
California
California Department of Fish & Wildlife
Marine Veterinary Care and Research Center/Seabird Health Program (UCD and CADFW)
College or University
Moss Landing Marine Laboratories/BeachCOMBERS
University of California San Diego, Scripps Institution of Oceanography
University of California Santa Cruz
University of Hawaii/Oceanwide Science Institute
University of Washington/COASST
DOC National Oceanographic and Atmospheric Administration
Greater Farallones National Marine Sanctuary
Greater Farallones National Marine Sanctuary/Beach Watch
Monterey Bay National Marine Sanctuary
Monterey Bay National Marine Sanctuary, Sanctuary Integrated Monitoring Network
Northwest Fisheries Science Center
Southwest Fisheries Science Center
Southwest Fisheries Science Center/Scripps Institution of Oceanography MMTD

Parent Organization name or type Affiliated Organization name
DOI National Park Service
Golden Gate National Recreation Area
Golden Gate National Recreation Area/Alcatraz Island
Point Reyes National Seashore
Redwood National and State Parks
DOI U.S. Fish & Wildlife Service
U.S. Fish & Wildlife Service
DOI U.S. Geological Survey
USGS Western Ecological Research Center, Santa Cruz Field Station
NGO Independent
Bill Henry
NGO Non-profit
Farallon Institute
Oikonos Ecosystem Knowledge
Point Blue Conservation Science

Organizations indicating that they collected information on “all cetaceans or all pinnipeds” included primarily programs engaged in variable-scale ocean surveys that measure distribution and abundance at sea by boat, aircraft or from land (Greater Farallones National Marine Sanctuary, Monterey Bay National Marine Sanctuary, Northwest Fisheries Science Center, Point Blue Conservation Science, Southwest Fisheries Science Center, USGS Western Ecological Research Center, Santa Cruz Field Station), and organizations engaged in carcass surveys (Greater Farallones National Marine Sanctuary/Beach Watch, Moss Landing Marine Laboratories/BeachCOMBERs, Redwood National and State Parks), and tissue sampling/archival (Moss Landing Marine Laboratories/BeachCOMBERs).

Respondents from organizations researching or monitoring marine mammals in California identified 12 specific marine mammal species for which data (mostly abundance and behavior) are collected including: Blue Whale, Bryde's Whale, Cuvier's Beaked Whale, Fin Whale, Gray Whale, Harbor Porpoise, Killer whale, Sperm Whale, California Sea Lion, Harbor Seal, Northern Elephant Seal, and Southern Sea Otter (Table 15).

Figure 9. Mixed dolphin herd
Several species of dolphin often co-occur in large herds within the California Current System. (Credit: Jonathan Felis, USGS Western Ecological Research Center. Public domain.)

Table 15. Eastern North Pacific marine mammal research and monitoring parameters (data collected for each species, listed in alphabetical order). Columns indicate specific parameters collected for each species (rows). Numbers and row totals indicate the total number of unique entries in the database (organizations, study regions, monitoring sites, etc.) for each species (cell colors green to red indicate quartile breaks). Row counts indicates the total number of parameters collected for a species. Column totals and counts indicate the same for each research or monitoring parameter.

Taxa or Common Name	Abundance	Acoustics	Behavior	Blood / Tissue Sampling	Density	Diet or foraging or contaminants	Distribution or range	Disturbance	Habitat occupancy	Haul-outs	Morphometrics	Mortality	Movement or migration or dispersal	Necropsy / Tissue Archival	Occurrence	Pathology	Physiology	Population structure or individual ID	Predation	Reproduction	Strike or stranding or entanglement	Telemetry / Sensors	Total	Count
All Cetaceans	65	8	38		1	4	6	3	2	5	3	9	1	3	5			1			13		**167**	**16**
All pinnipeds	48		20			7		7		10	3	10		3	1				3		13		**125**	**11**
Beaked Whales			1																				**1**	**1**
Bearded Seal	2	1				2					1					1	1						**8**	**6**
Beluga Whale		1	2												1								**4**	**3**
Blue Whale									1						1								**2**	**2**
Bowhead Whale													1										**1**	**1**
Bryde's Whale							1																**1**	**1**
California Sea Lion	3					4	5																**12**	**3**
Cuvier's Beaked Whale			1																				**1**	**1**
Fin Whale									1						2			1					**4**	**3**
Gray Whale	4						12											4					**20**	**3**

Taxa or Common Name	Abundance	Acoustics	Behavior	Blood / Tissue Sampling	Density	Diet or foraging or contaminants	Distribution or range	Disturbance	Habitat occupancy	Haul-outs	Morphometrics	Mortality	Movement or migration or dispersal	Necropsy / Tissue Archival	Occurrence	Pathology	Physiology	Population structure or individual ID	Predation	Reproduction	Strike or stranding or entanglement	Telemetry / Sensors	Total	Count
Harbor Porpoise	3						5																8	2
Harbor Seal	3		1		1	1	2			1			1										10	7
Hawaiian Monk Seal	1		1			1				2	1	1								1	1		9	8
Humpback Whale	1						3								1			2			1		8	5
Killer whale															3								3	1
North Pacific Right Whale									1						1								2	2
Northern Elephant Seal	1						1						1										3	3
Northern Sea Otter	9		4		1	1	1					4											20	6
Ringed Seal		1				1																	2	2
Selected Cetaceans			4				3		1			1			5								14	5
Southern Sea Otter	21		10	6		9	3	3		5	9	4		3				3			8	6	90	13
Sperm Whale	1						3											1					5	3
Spinner Dolphin			2				1								2								5	3
Spotted Seal						1																	1	1

Taxa or Common Name	Abundance	Acoustics	Behavior	Blood / Tissue Sampling	Density	Diet or foraging or contaminants	Distribution or range	Disturbance	Habitat occupancy	Haul-outs	Morphometrics	Mortality	Movement or migration or dispersal	Necropsy / Tissue Archival	Occurrence	Pathology	Physiology	Population structure or individual ID	Predation	Reproduction	Strike or stranding or entanglement	Telemetry / Sensors	Total	Count
Toothed Whales						1									1								**2**	**2**
Walrus		1																					**1**	**1**
Total	**162**	**12**	**84**	**6**	**3**	**32**	**46**	**13**	**6**	**23**	**17**	**29**	**4**	**9**	**23**	**1**	**1**	**12**	**3**	**1**	**36**	**6**	**529**	
Count	**13**	**5**	**11**	**1**	**3**	**11**	**13**	**3**	**5**	**5**	**5**	**6**	**4**	**3**	**11**	**1**	**1**	**6**	**1**	**1**	**5**	**1**		

4.2.2 Oregon and Washington

Respondents from 9 organizations researching or monitoring marine mammals in Oregon and Washington (Table 16) identified 4 specific marine mammal species for which data are collected including: Gray Whale, Killer Whale, Northern and Southern Sea Otter (Table 15). In addition, researchers indicated data were collected also for the following taxonomic groups: all cetaceans, all pinnipeds, beaked whales, and selected cetaceans (Table 15).

Table 16. List of parent organizations or organization type and affiliates contributing survey information regarding marine mammal research and monitoring programs in Oregon and Washington.

Parent Organization name or type Affiliated Organization name
Oregon and Washington
College or University
Oregon State University
University of California San Diego, Scripps Institution of Oceanography
University of Hawaii/Oceanwide Science Institute
University of Washington/COASST
DOC National Oceanographic and Atmospheric Administration
Northwest Fisheries Science Center
Southwest Fisheries Science Center
Southwest Fisheries Science Center/Scripps Institution of Oceanography MMTD
Olympic Coast National Marine Sanctuary

4.2.3 Alaska

Respondents from 8 organizations researching or monitoring marine mammals in Alaska (Table 17) identified 12 specific marine mammal species for which data are collected including: Beluga Whale, Bowhead Whale, Fin Whale, Gray Whale, Humpback Whale, North Pacific Right Whale, Harbor Seal, Bearded Seal, Ringed Seal, Spotted Seal, Walrus, and Northern Sea Otter (Table 15). In addition, researchers indicated data were collected also for the following taxonomic groups: all cetaceans, and all pinnipeds; missing from respondents were groups specifying Northern (Steller's) Sea Lion and Northern Fur Seal, both well studied in Alaska (Table 15).

Table 17. List of parent organizations or organization type and affiliates contributing survey information regarding marine mammal research and monitoring programs in Alaska.

Parent Organization name or type Affiliated Organization name
Alaska
College or University
University of California San Diego, Scripps Institution of Oceanography
University of Hawaii/Oceanwide Science Institute
University of Washington/COASST
DOC National Oceanographic and Atmospheric Administration
National Marine Mammal Laboratory
Southwest Fisheries Science Center/Scripps Institution of Oceanography MMTD
DOI U.S. Fish & Wildlife Service
Kodiak National Wildlife Refuge
DOI U.S. Geological Survey
Gulf Watch Alaska (USGS and NPS)
USGS Alaska Science Center

4.2.4 Hawaii and the Pacific Islands

Respondents from 5 organizations researching or monitoring marine mammals in Hawaii and the Pacific Islands (Table 18) identified 3 specific marine mammal species for which data are collected including: Humpback Whale, Spinner Dolphin, and Hawaiian Monk Seal (Table 15). In addition, researchers indicated data were collected also for the following taxonomic groups: all cetaceans and toothed whales (Table 15).

Table 18. List of parent organizations or organization type and affiliates contributing survey information regarding marine mammal research and monitoring programs in Hawaii and the Pacific Islands.

Parent Organization name or type Affiliated Organization name
Hawaii and Pacific Islands
College or University
University of California San Diego, Scripps Institution of Oceanography
University of Hawaii
University of Hawaii/Oceanwide Science Institute
DOC National Oceanographic and Atmospheric Administration
Pacific Islands Fisheries Science Center, Hawaiian Monk Seal Research Program

Parent Organization name or type Affiliated Organization name
Southwest Fisheries Science Center
Southwest Fisheries Science Center/Scripps Institution of Oceanography MMTD
DOD Marine Corps
Marine Corps Base Hawaii

5 Summary of spatial distribution of marine bird and mammal research and monitoring efforts

Both marine bird and mammal research and monitoring are widespread throughout the Pacific (N = 1,911 and 535 entries, respectively; Figures 10, 11, Table 19). The most numerous records for marine bird monitoring occurred in California followed by Hawaii, Alaska, Oregon, and Washington (Figure 10). The most numerous records for marine mammal monitoring occurred in California followed by Alaska, Washington, Oregon, and Hawaii (Figure 10). Of the research and monitoring records collected in the database, 24% are affiliated with colleges and universities, 32% with NGOs, and 44% with government agencies (both state and federal); many research efforts involve collaboration among entities. Whereas academic contributions to the database are widespread throughout all states, NGO programs were not well represented in Alaska (Figure 12).

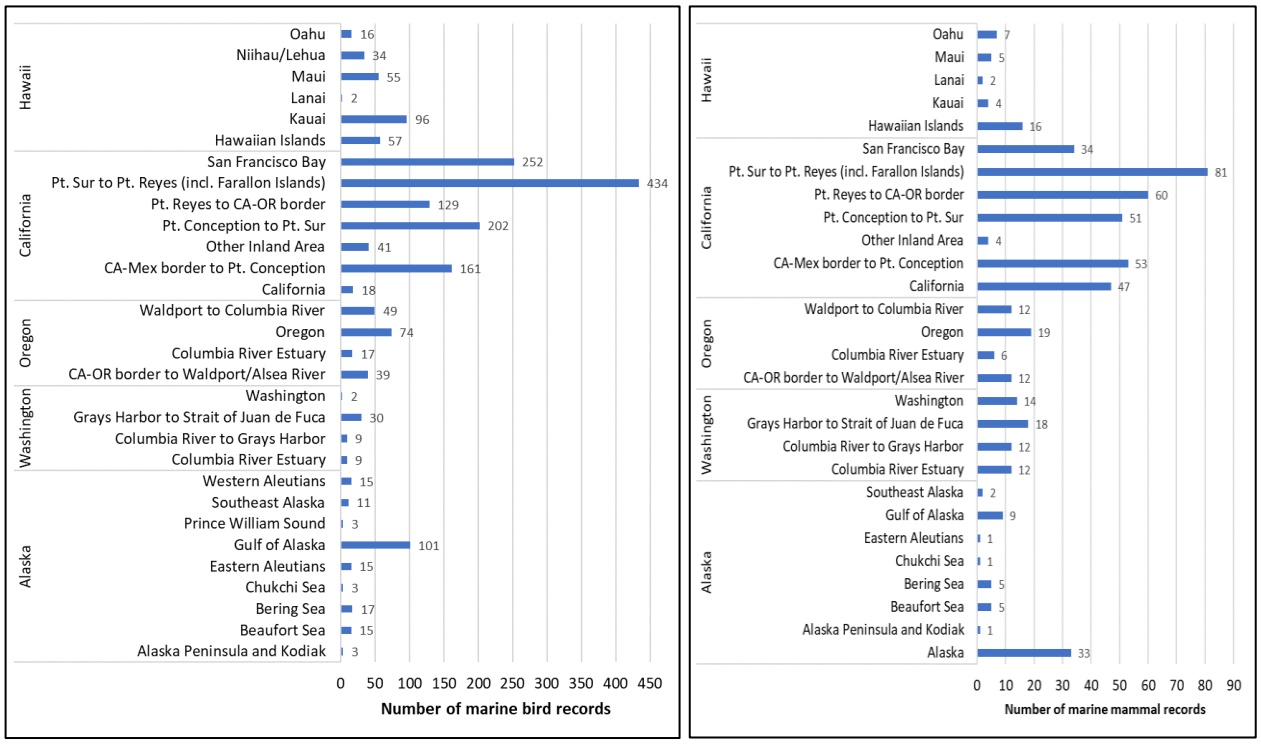

Figure 10. Summary of database records
Records for marine bird (left) and marine mammal (right) programs according to study regions within states.

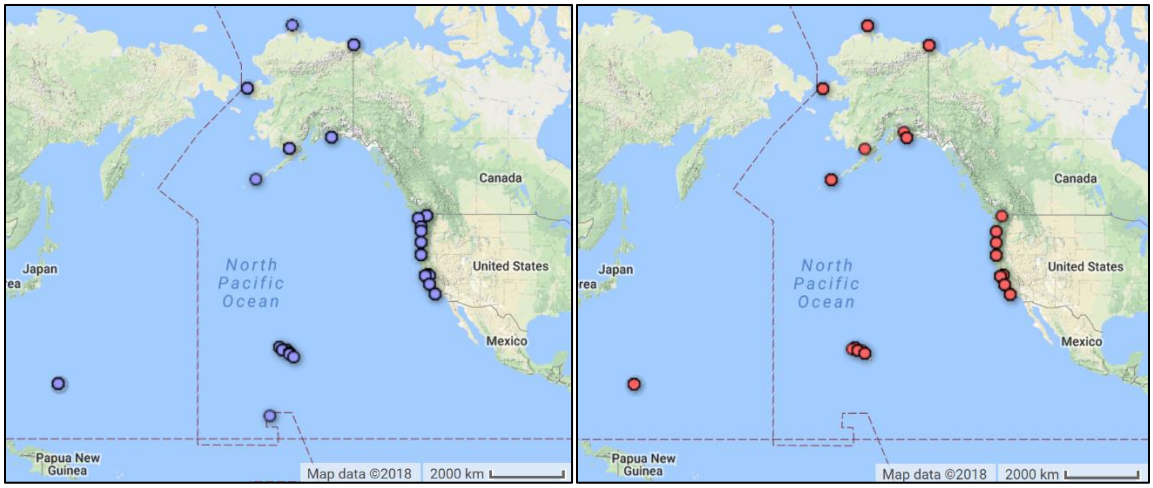

Figure 11. Marine mammal and bird monitoring in US states and territories of the Pacific
Points may indicate the presence of a broader research or monitoring program for marine mammals (blue) and marine birds (red). More detail is available from the database, which contains points and polygons for each program (see: Lafferty et al. 2019; https://doi.org/10.5066/F7X0669S).

Table 19. Distribution of research and monitoring records by taxa and state.

Research and monitoring records			
State or Territory	**Marine birds**	**Marine mammals**	**Totals**
Alaska	183	57	**240**
California	1237	330	**1567**
Hawaii	260	34	**294**
Oregon	179	49	**228**
Pacific Islands	2	9	**11**
Washington	50	56	**106**
Totals	**1911**	**535**	**2446**

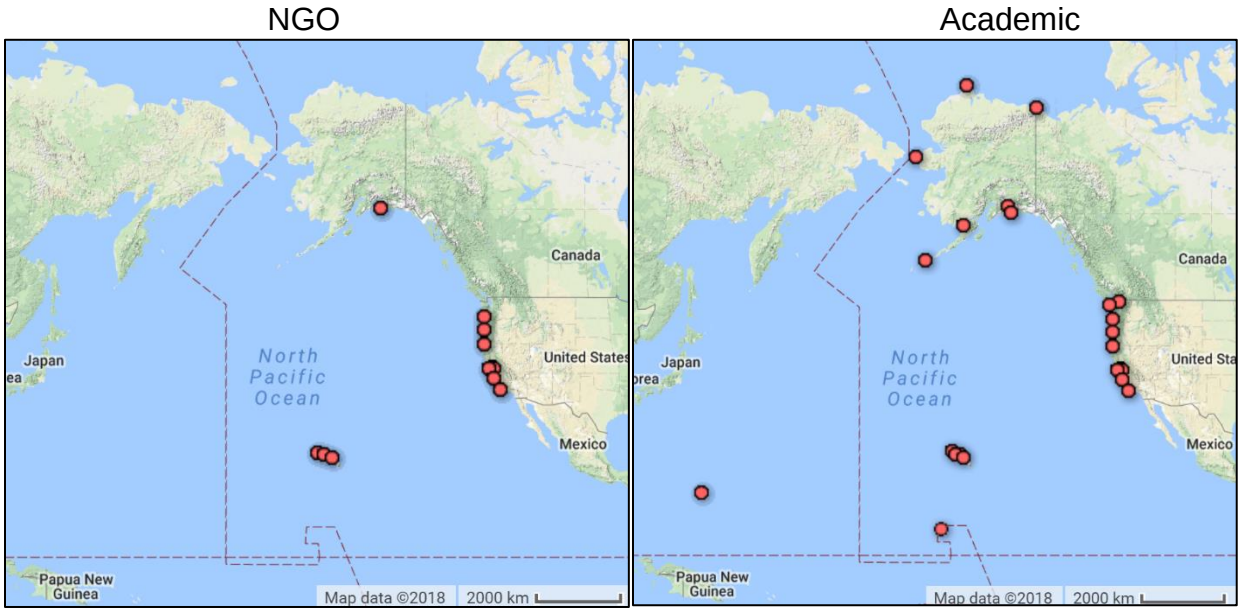

Figure 12. Geographic extent of research and monitoring
Research and monitoring for all taxa conducted by NGOs (left) and academic institutions (right). Extent of government agency coverage was intermediate to these. Points may indicate the presence of a broader research or monitoring program in the state. More detail is available from the database, which contains points and polygons for each program (see: Lafferty et al. 2019; https://doi.org/10.5066/F7X0669S).

Among marine mammals, cetaceans were studied across the greatest geographic distribution, including remote Pacific islands, pinniped monitoring occurred in all Pacific states, and sea otter monitoring was restricted to the continental United States, reflecting the species' distribution. Research and monitoring records for these groups (cetaceans, pinnipeds, and otters) were greatest in California (N = 132, 111, and 84 database entries, respectively). Walrus monitoring was restricted to Alaska.

Among marine birds, seabirds were studied across the greatest geographic extent, based on our survey responses, we were not able to capture the full extent of seabird monitoring throughout the US Tropical Pacific; therefore, we urge the interested reader to see VanderWerf and Young (2017). Marine bird research and monitoring occurred in AK, OR, and CA. Shorebird monitoring was restricted to AK and CA. As with mammals, bird monitoring was highest in California (N = 634, 272, and N = 173 entries, respectively).

Mammal monitoring methods vary in their use and geographic coverage. Vessel, acoustic, and shoreline surveys were most common and most widespread, whereas genetic, aerial, and tagging/tracking approaches were less common and concentrated in Hawaii, Alaska, and southern California. However, mammal monitoring documented during seabird database collections did not specify monitoring method, making these estimates and distributions conservative.

Data types collected also varied in their geographic coverage. Among mammals, abundance and distribution and behavioral data were widely collected (N = 279 and N = 84 entries, respectively), whereas morphometric (N = 17), diet (N = 32), and mortality/pathology/predation (N = 78) data were collected in a smaller subset of regions (Figure 23). Among marine birds, behavior (N = 94) and at-sea (N = 151) data were widespread, and mistnet (N = 21) data was restricted to California, Alaska, and Hawaii (Figure 14).

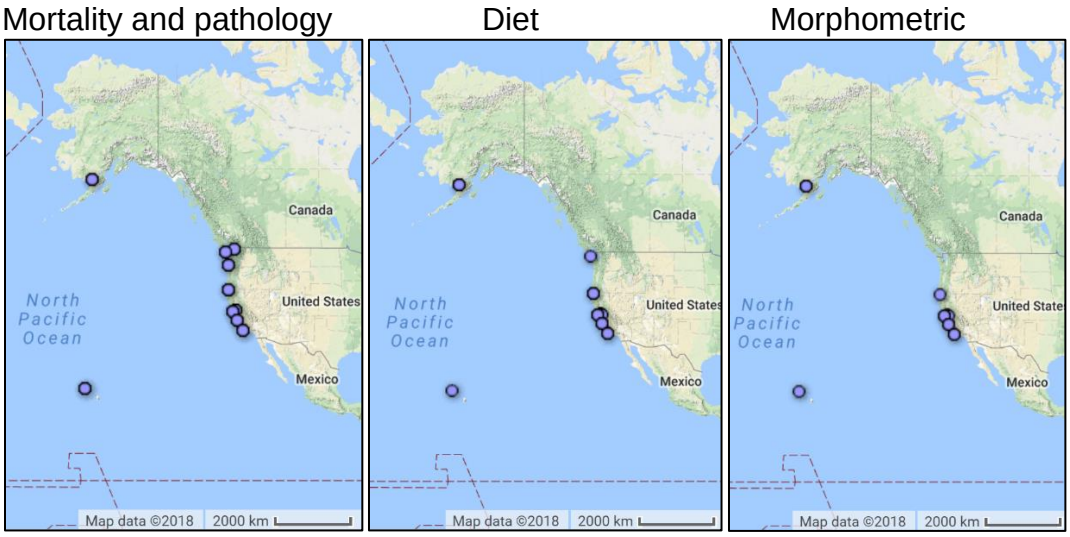

Figure 13. Geographic distribution of focal data types collected for marine mammals
Occurrence and behavior were widely monitored (not shown), while mortality and pathology (left), diet (center), and morphometric (right) data were collected from a smaller subset of Pacific regions. Points may indicate the presence of a broader research or monitoring program in the state. More detail is available from the database, which contains points and polygons for each program (see: Lafferty et al. 2019; https://doi.org/10.5066/F7X0669S)

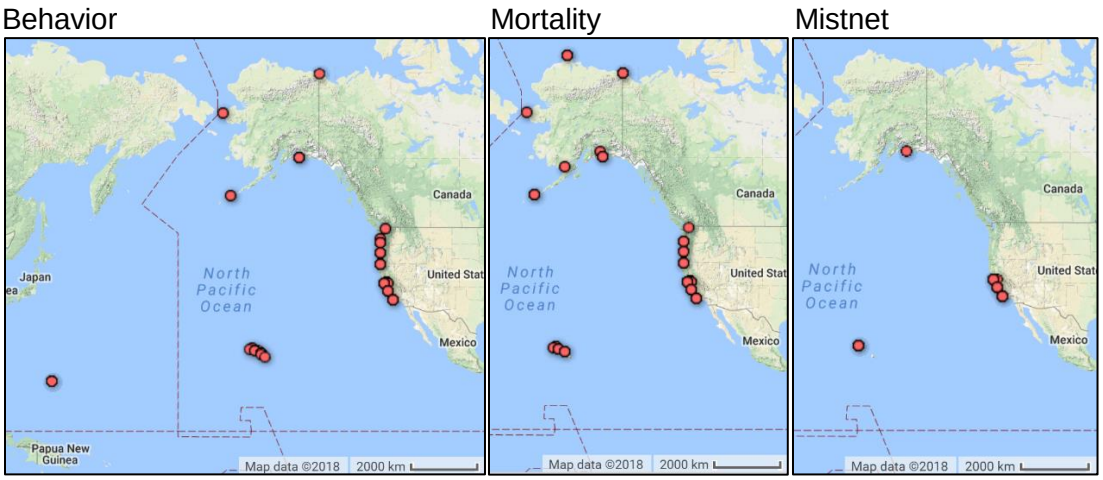

Figure 14. Geographic distribution of focal data types collected for marine birds
Data such as behavior (left) were widespread; mortality (center) and other data were widely collected excepting the Pacific Islands; mistnet (right) data were collected from the smallest area. Points may indicate the presence of a broader research or monitoring program in the state. More detail is available from the database, which contains points and polygons for each program (see: Lafferty et al. 2019; https://doi.org/10.5066/F7X0669S)

Although less than half of the ~55 marine mammal species in the region are specifically targeted in monitoring programs, many programs monitor several species at a time, without specifying a species (Table 20). There were 167 programs that count cetaceans in general, 125 that count pinnipeds in general, 14 that count selected cetaceans, and 2 that count toothed whales. On the other hand, 221 programs specify species that they track.

Table 20. North Pacific marine mammals. A "yes" indicates a species-level monitoring program and a blank means species will be recorded during general mammal surveys.

Marine Mammal Species	Species-level program?
Baird's Beaked Whale (*Berardius bairdii*)	
Bearded seal (*Erignathus barbatus*)	yes
Beluga Whale (*Delphinapterus leucas*)	yes
Blainville's beaked whale (*Mesoplodon densirostris*)	
Blue whale (*Balaenoptera musculus*)	yes
Bottlenose dolphin (*Tursiops truncatus*)	
Bowhead whale (*Balaena mysticetus*)	yes
Bryde's whale (*Balaenoptera edeni*)	yes
California sea lion (*Zalophus californianus*)	yes
Cuvier's beaked whale (*Ziphius cavirostris*)	yes
Dall's Porpoise (*Phocoenoides dalli*)	
Dwarf sperm whale (*Kogia sima*)	
False killer whale (*Pseudorca crassidens*)	
Fin whale (*Balaenoptera physalus*)	yes
Fraser's dolphin (*Lagenodelphis hosei*)	
Gray whale (*Eschrichtius robustus*)	yes
Giant beaked whale (*Berardius bairdii*)	
Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*)	
Guadalupe fur seal (*Arctocephalus townsendi*)	
Harbor Porpoise (*Phoceoena phocoena*)	yes
Harbor seal (*Phoca vitulina*)	yes
Hawaiian Monk Seal (*Neomonachus schauinslandi*)	yes
Hubbs' beaked whale (*Mesoplodon carlhubbsi*)	
Humpback whale (*Megaptera novaeangliae*)	yes
Killer whale (*Orcinus orca*)	yes
Long-beaked common dolphin (*Delphinus capensis*)	
Longman's beaked whale (*Indopacetus pacificus*)	
Melon-headed whale (*Peponocephala electra*)	
Minke whale (*Balaenoptera acutorostrata*)	
North Pacific right whale (*Eubalaena japonica*)	yes
Northern (Steller) sea lion (*Eumetopias jubatus*)	
Northern elephant seal (*Mirounga angustirostris*)	yes
Northern fur seal (*Callorhinus ursinus*)	
Northern right whale dolphin (*Lissodelphis borealis*)	
Northern sea otter (*Enhydra lutris kenyoni*)	yes
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	
Pantropical spotted dolphin (*Stenella attenuata*)	
Perrin's beaked whale (*Mesoplodon perrini*)	
Pygmy beaked whale (*Mesoplodon peruvianus*)	

6 Conclusions

Within the Pacific OCS there exists a large and diverse assemblage of people and organizations who collect information about marine birds and mammals. Although many of the individuals and groups included in these surveys coordinate their efforts, there exist few examples of consistent, standardized, region-wide research and monitoring. Although our effort herein is limited in spatial extent, focused on the northeastern Pacific, Hawaii, and Alaska, there have been important past efforts to maintain and implement a "World Seabird Colony Register and World Seabird Monitoring Database" (see: https://www.seabirds.net/seabird_information_network/). Efforts by the World Seabird Colonies Working Group, proposed in 2010, have largely stalled out due to lack of support and logistical problems associated with the database. It was intended that this group would work to ensure: (a) coordination during data discovery and enrollment, and (b) sound mechanics and effective linkages between databases from design through implementation stages. It was intended that the group would self-organize to encompass two subcommittees—a Regional Coordinating Committee and a Technical Committee[3]. Perhaps in the future, the information captured herein could be used in additional regional assessments and ultimately, be incorporated into a more global-scale database.

Despite a concerted effort, we did not obtain information directly from several entities; therefore, we have attempted to summarize these here. One of the four criteria important for inclusion in this database was that programs be managed by another Bureau within the Department of the Interior. USFWS Refuges have site-specific Comprehensive Conservation Plans (CCPs) that highlight Inventory and Monitoring Plans (IMPs). Yet, for seabirds (and perhaps marine mammals) few IMPs exist or have not yet been fully articulated or made available. For example, when looking for specific IMPs at USFWS Refuges, we were unable to locate any IMPs for several Refuges that are important for seabirds (e.g., Farallon NWR, CA, James Campbell NWR, Oahu, HI, Kilauea Point NWR, Kauai, HI, Oregon Islands NWR, OR). This does not reflect lack of involvement by USFWS in actual monitoring and research involving marine birds and mammals. On the contrary, many Refuges and National Parks work cooperatively with other entities to support research and monitoring targeting marine birds and mammals. For example, two of the longest running, standardized, and comprehensive seabird monitoring programs include the seabird program at the Southeast Farallon Islands (SEFI; carried out by Point Blue Conservation Science [formerly Point Reyes Bird Observatory]) and the USFWS Alaska Maritime National Wildlife Refuge AMNWR. Although SEFI has no formal IMP plan available (https://www.fws.gov/Refuges/NaturalResourcePC/IandM/index.html), certain marine bird IMP goals are well-established. The SEFI research and monitoring information are captured herein (Point Blue), but the activities for AMNWR were not communicated to be included here. Therefore, in advance of integrating AMNWR in to the current version of the database, we describe their scope based on information available to us (Byrd 2019). AMNWR hosts approximately 80% of the seabirds breeding in Alaska (~30 species) and staff monitor at least 8 seabird species annually at 10 designated sites throughout the massive refuge that ranges from Southeast Alaska to the Pribilof Islands in the Bering Sea. Colony monitoring includes estimating timing of nesting events, reproductive success, population trends, and prey used by representative species of various foraging guilds.

NPS also has site- or network-specific IMPs (https://www.nps.gov/im/networks.htm) that refer to seabird monitoring (e.g., Channel Islands NP, CA, Glacier Bay NP, AK, Katmai NP, Ak, and Kenai Fjords NP, AK). Of these, we do not have records corresponding to Glacier Bay NP (Kittlitz's Murrelet abundance and spatial distribution), Katmai NP, or Kenai Fjords NP[4]. Other National Parks with marine bird

[3] See: http://www.seabirds.net/files/PostConferenceImplementationPlan.pdf

[4] Monitoring at Katmai and Kenai Fjords NP focuses on birds and marine mammals (e.g., sea otters) that are linked to the nearshore food web, including Harlequin Ducks, Goldeneye, and Bufflehead, Long-tail Ducks, Scoters,

resources that may or may not be included specifically in their IMPs include Redwood NP, CA, Point Reyes National Seashore, CA, Golden Gate National Recreation area, CA, Haleakala National Park, Maui, HI and Hawaii Volcanoes National Park, Hawaii, HI. For these, we did not capture information only from Hawaii Volcanoes NP (Hawaiian Petrel and Band-rumped Storm-Petrel).

Another source of information related to seabirds and marine mammals with multi-year focus and standardized approaches for annual or semi-annual monitoring is the NOAA National Seabird Program (NSP; https://www.st.nmfs.noaa.gov/national-seabird-program/). The NSP's two main goals include monitoring and mitigating fisheries bycatch and promoting seabirds as ecosystem indicators. Although we did not include the fisheries bycatch program specifics in this database, we did capture the scope of the NSP ship-based seabird and marine mammal observing program. For more information about seabird bycatch, we urge the reader to contact NOAA or view their annual reports issued for 2016–2018 available through the NSP website.

Based on our examination of the entries recorded in this database, we have attempted to identify several parameters that are recorded for species that might be particularly helpful when evaluating potential effects on marine birds and mammals. For marine birds 11 of 28 parameters monitored were classified of moderate- to high-value for informing potential effects of offshore energy activities (Table 3). The highest value parameters included at-sea behavior and at-sea distribution. Although behavior at sea can be difficult to measure, behaviors exhibited by birds at sea (e.g., flight height) can influence their vulnerability to offshore energy activities either affecting collision vulnerability or displacement vulnerability (Kelsey et al. 2018). Additionally, programs that record and measure at-sea distribution and abundance, although logistically complex and expensive, provide the only way to measure the distribution and abundance of seabirds and marine mammal at sea. Surveys can be modified to achieve appropriate temporal and spatial resolution to address site-specific needs. Other parameters including colony counts, beach carcass surveys, nest occupancy and counts—especially among species that are at greater vulnerability associated with offshore energy activities (i.e., offshore wind energy infrastructure) based on colony location—together with information from reference site locations, could provide information to best understand species, region, or colony specific changes. Lastly, among long-lived seabirds with low reproductive output, adult survival rates are important to measure because small changes in adult survival over time translate to changes in population growth rates.

For marine mammals 11 of 24 parameters were classified of moderate- to high-value for informing potential effects of offshore energy activities (Table 4). The highest-value parameters included at sea-abundance, distribution at sea, and strike, stranding, or entanglement. Similar to marine birds, an understanding of the distribution and abundance among marine mammal species in areas potentially affected by offshore energy activities is key information. Surveys can be modified to achieve appropriate temporal and spatial resolution to address site-specific needs. Also of key importance for marine mammals, is understanding the potential for collision (Boehlert et al. 2008) or entanglement (Harnois et al. 2015) posed by offshore activities associated with energy infrastructure and construction and maintenance activities (see, Boehlert and Gill 2010). Other parameters including marine mammal acoustics (both for detecting individual presence in an area and behavioral responses to underwater sound), beach carcass surveys, behavior at sea, disturbance, especially among species that are at greater vulnerability associated with offshore energy activities (i.e., offshore wind energy infrastructure) based on breeding, feeding, or resting locations.

As seabird and marine mammal research and monitoring continue in the future, this database can be updated periodically and made available as new versions are created. Readers are encouraged to contact

several species of seabirds, and shorebirds (specifically Black Oystercatcher). During monitoring, all observed marine birds are recorded. Contact: Heather Coletti (https://www.nps.gov/articles/heather-coletti.htm)

the authors of this report to make specific requests to update missing or new information, including contacts and other programmatic changes. Should coordinated efforts to monitor seabirds and marine mammals be focused on understanding offshore energy effects on wildlife and habitats, the information captured here should serve as an effective guide and provide a baseline for managers to understand the scope of present research and monitoring efforts throughout the Pacific OCS.

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Department of the Interior (DOI)

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation’s trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.