Annual seabird productivity at breeding colonies around the world from 1964 to 2023 (Stratification Impacts on Seabirds Project)

Website: https://www.bco-dmo.org/dataset/985565
Data Type: Other Field Results
Version: 1
Version Date: 2025-09-30

Project
» Global analysis of stratification impacts on seabirds through food resources (Stratification impacts on seabirds)

Contributors	Affiliation	Role
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Abstract
This global dataset on breeding productivity represents a compilation of individual time series from species and sites (seabird breeding colonies) across the world. Each time series was contributed by a Global Seabird Working Group (GSWG) collaborator. It contains the number of offspring produced per nesting female per year, which is a variable measured similarly by researchers. Seabird breeding productivity is typically measured by monitoring individual nest sites through time within each breeding season. Data from multiple females are then averaged to produce estimates of annual productivity for each species at each site, resulting in “species-site” time series. Typically, measurements are made for multiple species at each site, so data are often available for a portion of the full seabird community, including species feeding at different trophic levels and in different parts of the water column. Variance for species-site breeding productivity is estimated as the standard error across years for each time series. Here, there are 202 time series encompassing 87 sites and 73 seabird species.

Table of Contents

Coverage

Location: Global
Spatial Extent: **N**:74.2 **E**:178.8052 **S**:-66.6667 **W**:-177.378195
Temporal Extent: 1964 - 2023

Methods & Sampling

Breeding performance is measured similarly by seabird ecologists around the world (see Materials and Methods from Cury et al. 2011 for examples). In general, most seabird ecologists determine breeding success by selecting a random sample of nesting pairs (females), and monitoring egg laying, egg hatching, and chick

fledging by conducting periodic nest checks every 3-5 days (e.g. Sydeman et al. 1991, 2001). This enables calculation of measurements of central tendency (means, medians, etc.), as well as between-nest (female) variability in these metrics. Individual nest site (female) data is then averaged to produce annual mean values, which is what we report in this dataset. For this particular study, we requested updates on annual mean seabird breeding success and annual sample size from researchers across the globe, many of whom had previously contributed to our Global Seabird Breeding Success dataset (Sydeman et al. 2021, DOI:10.5281/zenodo.4667747). Almost all previous data contributors responded by updating their data time series for this new study (ideally to 2022). We requested new time series for species and locations not previously included in Sydeman et al. 2021, and many new researchers joined the Global Seabird Working Group (see Observing Seabirds, Understanding Oceans webstory, https://seabirds.farralloninstitute.org/). Cury et al. (2011, Supplemental Material) showed that 13 years of data are needed to demonstrate non-linear numerical responses of seabirds to prey abundance, and given our interest in similar seabird breeding success and climate/food web dynamics, we decided on this same minimum limit for time series length. We requested data in annual time series format of at least 13 years in duration, and ending no sooner than the 2014 boreal breeding season. However, some data contributors submitted data in bulk for their colonies, and included time series of shorter duration, or time series that ended before 2014. Seven time series did not fit the criterion of continuing until 2014: 1) black-footed and Laysan albatross at Tern Island, Hawaii (ended in 2008), 2) wedge-tailed shearwater from Varanus Island, Western Australia (ended in 2013), 3) macaroni and gentoo penguins at Bird Island (ended in 2013), and 4) Adélie and gentoo penguins at Admiralty Bay, King George Island (ended in 2012).

Data Processing Description

An initial version of this dataset was published in Sydeman et al. 2021 Science (doi: 10.1126/science.abf1772). Overall, we increased the number of annual measurements of breeding success in the dataset by ~40%, from n=3,596 used by Sydeman et al. (2021) to n=5,963 now.

Individual species-site productivity time series were submitted by different data providers. The productivity data they contributed to this project were made into a standardized table format where all time series are contained together in long format (fields: year, site, species, productivity, n, etc.) This work was done in MS Excel.

BCO-DMO Processing Description

* Special characters have been removed from the parameters/column names in the primary data file (985565_v1_global_seabird_breeding_success.csv) and replaced with underscores ("_").
* Latitude and longitude values have been rounded to six decimal places.
* Originally, the primary data file only contained common name representations of observed species. Scientific names have been added to the data file, along with corresponding AphiaID and LSIDs from the World Register of Marine Species (WoRMS) database.

Problem Description

No dataset problems or issues have been noted by the dataset authors.

[table of contents | back to top]

Data Files

File	
985768_v1_ocean_conditions_at_seabird_colony_sites.csv	(Comma Separated Values (.csv), 1.24 MB) MD5:7413e85e53ea28aacecca22929cde39d
Primary data file for dataset ID 985768, version 1	

File

[table of contents | back to top]

Related Publications

Cury, P. M., Boyd, I. L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R. J. M., Furness, R. W., Mills, J. A., Murphy, E. J., Österblom, H., Paleczny, M., Piatt, J. F., Roux, J.-P., Shannon, L., & Sydeman, W. J. (2011). Global Seabird Response to Forage Fish Depletion—One-Third for the Birds. Science, 334(6063), 1703–1706. https://doi.org/10.1126/science.1212928
Methods

Schoeman, D. (2021). DavidSchoeman/sydeman_et_al_seabirds: Code for Sydeman et al seabird analysis (Version 1) [Computer software]. Zenodo. https://doi.org/10.5281/zenodo.4667747
Software

Sydeman, W. J., Hester, M. M., Thayer, J. A., Gress, F., Martin, P., & Buffa, J. (2001). Climate change, reproductive performance and diet composition of marine birds in the southern California Current system, 1969–1997. Progress in Oceanography, 49(1–4), 309–329. https://doi.org/10.1016/s0079-6611(01)00028-3 https://doi.org/10.1016/S0079-6611(01)00028-3
Methods

Sydeman, W. J., Penniman, J. F., Penniman, T. M., Pyle, P., & Ainley, D. G. (1991). Breeding Performance in the Western Gull: Effects of Parental Age, Timing of Breeding and Year in Relation to Food Availability. The Journal of Animal Ecology, 60(1), 135. https://doi.org/10.2307/5450
Methods

Sydeman, W. J., Schoeman, D. S., Thompson, S. A., Hoover, B. A., García-Reyes, M., Daunt, F., Agnew, P., Anker-Nilssen, T., Barbraud, C., Barrett, R., Becker, P. H., Bell, E., Boersma, P. D., Bouwhuis, S., Cannell, B., Crawford, R. J. M., Dann, P., Delord, K., Elliott, G., … Watanuki, Y. (2021). Hemispheric asymmetry in ocean change and the productivity of ecosystem sentinels. Science, 372(6545), 980–983. https://doi.org/10.1126/science.abf1772
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
year	Year of annual breeding success observation. Observations made in the southern hemisphere summer were adjusted to match northern hemisphere summer for comparative purposes (ex: southern hemisphere summer 2021-2022 included as 2021 to match northern hemisphere summer 2021; northern hemisphere summer leads southern hemisphere summer).	unitless
site	Seabird colony site name.	unitless
latitude	Latitude value of the geographic coordinate representing the site in decimal degrees; a positive value indicates a northern coordinate.	decimal degrees
longitude	Longitude value of the geographic coordinate representing the site in decimal degrees; a negative value indicates a western coordinate.	decimal degrees
speciesnum	Unique identifier number for each seabird species.	unitless
species	Common name of the observed species, as written by the dataset authors.	unitless
ScientificName_accepted	Scientific name that corrisponds with the represented species common name.	unitless
AphiaID	AphiaID associated with the represented scientific name of the observed seabird species, matched from the World Register of Marine Species (WoRMS) database.	unitless
LSID	LSID associated with the represented scientific name of the observed seabird species, matched from the World Register of Marine Species (WoRMS) database.	unitless
breeding_success	Breeding success value given by the data providers, equaling number of offspring produced per female in the population.	reproduction_rate
n	Sample size for the breeding success measurement.	individuals

[table of contents | back to top]

Project Information

Global analysis of stratification impacts on seabirds through food resources (Stratification impacts on seabirds)

Coverage: global

NSF Award Abstract:
Global warming is affecting the world's oceans by altering marine habitats, yet the effects on marine life vary by ocean region. One factor that may explain these observations is that ocean surface waters have warmed faster than deeper waters. Temperature differences may act as a physical barrier to mixing, thereby impeding deeper nutrients from reaching the sunlit surface where they are used by ocean plants in photosynthesis. With less mixing, the upper layers of the ocean may have become less productive, which may in turn impact marine fish, bird, and mammal populations of economic and cultural (ecological) value to society. To conduct this study, the investigators are examining the effects of ocean warming by depth on the abundance of plankton, small fish, and the breeding success of marine birds across the world using existing long-term data. They are developing mathematical relationships to understand how ocean warming at various depths is linked to plankton, fish, and bird productivity. Results will provide key information for selecting which seabird species may be best suited as ecological indicators of change for different ecosystems across the globe, and therefore has implications for remote-ocean monitoring. The project will contribute new scientific understanding for upcoming United Nation assessment reports and enhance public awareness of ocean health through outreach materials centered on popular seabirds such as puffins and penguins. It will support early career and postdoctoral scientists.

Ocean thermal stratification is an important factor determining primary productivity in epipelagic zones of the world's oceans. A recent global analysis showed declining trends in the breeding productivity of fish-eating seabirds that forage in the epipelagic zone, but increasing stratification has yet to be investigated as an explanatory factor. The primary objective of this project is to test the hypothesis that seabird species groups vary in their responses to increasing thermal stratification through the indirect effects of stratification on epipelagic food resource availability and/or prey use by the birds. The investigators are testing the prediction that thermal stratification has the largest effect on breeding productivity of piscivorous, surface-foraging species. They are integrating a new global database on seabird productivity with high-resolution data on thermal stratification available from the European GLORYS model, as well as satellite-based chlorophyll-a data from NASA. They are using Generalized Linear Mixed Models to test for variation between seabird groups and Structural Equation Models to test direct and indirect pathways of response from stratification through prey availability to seabird productivity, focusing on mid-to-high latitude ecosystems across ocean basins in both the northern and southern hemispheres. Results will improve understanding of how seabirds respond to increasing thermal stratification in relation to fundamental differences in seabird life history traits. The retrospective analysis will advance knowledge of how seabirds that feed on different prey, and in different epipelagic habitats of the world's oceans, have responded to recent increases in stratification. More generally, the study will contribute insight into how physical changes in the upper ocean affect predators through the availability of food resources.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Location Description:
Data to be analyzed are from around the world and contributed from numerous local providers and other groups. The study area is the global ocean. Analysis will be done at the Farallon Institute, located in Petaluma, California.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2142918

[table of contents | back to top]