Bird and fish data for a 600 year reconstruction of winter climate variability in the California Current from 2011-2013 (California Current upwelling modes project)

Website: https://www.bco-dmo.org/dataset/472578
Version: 2013-12-03

Project
» History and Future of Coastal Upwelling Modes and Biological Responses in the California Current (California Current upwelling modes)

Contributors	Affiliation	Role
Black, Bryan	Oregon State University (OSU-HMSC)	Principal Investigator
Bograd, Steven	National Oceanic and Atmospheric Administration - Southwest Fisheries Science Center (NOAA SWFSC ERD)	Co-Principal Investigator
Sydeman, William	Farallon Institute for Advanced Ecosystem Research	Co-Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

Dataset Description

In this study, we hypothesized that seasonal variation in upwelling-favorable winds has differential influences on species of the central California Current pelagic ecosystem. To test this hypothesis, we developed multivariate indicators of upwelling and species' responses using wind and sea surface temperature (SST) data from buoys and growth and reproductive data for 11 species of fish and seabirds.

Methods & Sampling

We selected 15 upper trophic level biological variables (also referred to as "indicators") for this analysis based on overlapping geographic extent, availability of long-term data, and species diversity (Table 1). Egg-laying date (phenology) and reproductive success (offspring fledged per pair) were obtained from the literature for six seabird species nesting on Southeast Farallon Island, California (SEFI; 37.7°N 123.0°W) and Año Nuevo Island, California (ANI; 37.1°N 122.3°W) (Sydeman and others 2001; Thayer and Sydeman 2007; Schroeder and others 2009; Thayer 2009). Species included were common murre (*Uria aalge*), pigeon guillemot (*Cepphus columba*), Cassin's auklet (*Ptychoramphus aleuticus*), rhinoceros auklet (*Cerorhinca monocerata*), pelagic cormorant (*Phalacrocorax pelagicus*), and Brandt's cormorant (*P. penicillatus*). A sample of focal nests was selected for monitoring on both islands, beginning on 2 March each year. The sample size of nests varied by species, from a low of n=30-100 in for auklets to n=150-250 for murres. Each nest site was marked and mapped, and the nest contents were assessed every 3-5 days. In addition, we collated Brandt's cormorant adult survival estimated during the spring time initiation of breeding (Nur and Sydeman 1999). Brandt's cormorants were marked (banded) when ~30 days of age. Upon return to the colony 2-3 years later, bands were read from a distance of 10-30 m using a telescope.

We also used three Pacific rockfish (*Sebastes spp.*) chronologies that represent sample-wide anomalies in annual otolith growth-increment widths following the removal of age-related growth declines. Chronologies were generated using standard dendrochronological techniques as described by Black and others (2008; 2011). The first two chronologies were for splitnose (S. diploproa) and yelloweye rockfish (*S. ruberrimus*) from individuals collected between approximately 35 to 40°N (Black and others 2005; 2011). An aurora rockfish (*S. aurora*) otolith growth-increment chronology from the Oregon coast (42 to 46.2°N) was also obtained from the literature (see Thompson and Hannah 2010 for details). In addition, we used a northern California Chinook salmon (*Oncorhynchus tshawytscha*) chronology (~42°N; Wells and others 2007) that had been derived from growth-increment widths in scales, as calculated by Black and others (2011). Pacific sardine (*Sardinops sagax*) recruitment (stock biomass for sardines age 1+) based on a stock assessment model for the entire west coast (Hill and others 2010) was added as a final biological indicator.

Data Processing Description

To investigate variability in upwelling with respect to season, we computed the monthly mean, standard deviation and coefficient of variation for each physical variable (Uw, SST, and UI). Subsequently, we conducted a Principal Component Analysis (PCA) to explore shared patterns of variability among these time series, which were extracted and used as multivariate indices of the CCE. Given that upwelling varies among locations, among season and among years (García-Reyes and Largier 2012; Thompson and others 2012), we arranged each physical data variable (Uw, SST and UI) into a three-dimensional matrix consisting of 12 locations x 12 months x 23 years; resulting components were labeled as PCUw, PCSST, and PCUI. Each column was normalized (zero mean and variance equal to 1 standard deviation) before calculating the PCA. Next we ran a PCA that combined Uw and SST data by arranging their data arrays into a single matrix with dimensions: 24 locations (12 Uw locations + 12 SST locations) x 12 months x 23 years. Resulting PCs, labeled as PCenv, captured the dominant and sub-dominant seasonal "modes" or patterns in upwelling and their interannual variability. PCs (scores) from the three physical variables (PCUw, PCSST, and PCUI) were compared to one another as well as to PCenv using Spearman ranked correlations. PCs with Eigenvalues < 1 and explaining < 10% of the variability in the data set were dropped from further analysis (Jolliffe 2002).

The 15 biological indicators included in the study were cross-correlated with one another to generally assess the extent to which they shared common patterns. Subsequently, we conducted a PCA (resulting components labeled as PCbio) using the nine longest (1982-2006) biological indicators. Biological indicators excluded from the PCA were correlated against the PCbio components as a measure of their agreement with dominant patterns in the longer datasets. Those that were significant at the $p < 0.05$ level were retained. To summarize physical-biological interactions, the scores of the environmental PCs (PCUw, PCSST, PCUI and PCenv), the biological indices, and biological PCs (PCbio) were compared using Spearman correlations.

Biological Principal Component Sources and Loading (PDF)

Environmental Principal Component Sources and Loading (PDF)

References, this data:

Reyes, M., W. J. Sydeman, S. A. Thompson, B. A. Black, R. R. Rykaczewski, J. A. Thayer, and S. J. Bograd. 2013. Integrated assessment of wind effects on Central California’s pelagic ecosystem. Ecosystems. DOI: 10.1007/s10021-013-9643-6.

Related References:

Black BA, Boehlert GW, Yoklavich MM. 2005. Using tree-ring crossdating techniques to validate age in long-lived fishes. Can J Fish Aquat Sci 62:2277–84.

Black BA, Boehlert GW, Yoklavich MM. 2008. Establishing climate-growth relationships for yelloweye rockfish (*Sebastes ruberrimus*) in the northeast Pacific using a dendrochronological approach. Fisheries Oceanography 17:368-379.

Black, BA, Schroeder ID, Sydeman WJ, Bograd SJ, Lawson PW. 2010. Wintertime ocean conditions synchronize rockfish growth and seabird reproduction in the central California Current ecosystem. Canadian Journal of Fisheries and Aquatic Sciences 67:1149-1158.

Black BA, Schroeder ID, Sydeman WJ, Bograd SJ, Wells BK, Schwing FB. 2011. Winter and summer upwelling modes and their biological importance in the California Current Ecosystem. Global Change Biology 17:2536-2545.

García-Reyes M, Largier JL. 2012. Seasonality of coastal upwelling off central and northern California: New insights, including temporal and spatial variability. Journal of Geophysical Research, 117:C03028.

Hill KT, Lo N, Macewicz B, Crone P, Felix-Uraga R. 2010. Assessment of the Pacific sardine resource in 2010 for US management in 2011. NOAA Southwest Fisheries Science Center. November 2010.

Jolliffe IT. 2002. Principal component analysis. 2nd ed. Springer series in statistics. ISBN 0-387-95442-2.

Nur N, Sydeman WJ. 1999. Survival, breeding probability and reproductive success in relation to population dynamics of Brandt's cormorants *Phalacrocorax penicillatus*. Bird Study 46(Suppl):S92-103.

Schroeder ID, Sydeman WJ, Sarkar N, Thompson SA, Bograd SJ, Schwing FB. 2009. Winter pre-conditioning of seabird phenology in the California Current. Mar Ecol Prog Ser 393:211–23.

Schwing FB, O’Farrell M, Steger JM, Baltz K. 1996. Coastal upwelling indices, west coast of North America, 1946-95. NOAA Technical Report NOAA-TM-NMFS-SWFSC-231. 32p.

Sydeman WJ, Hester MM, Thayer JA, 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. Prog Oceanogr 49:309–29.

Thayer JA, Sydeman WJ. 2007. Spatio-temporal variability in prey harvest and reproductive ecology of a piscivorous seabird, *Cerorhinca monocerata*, in an upwelling system. Mar Ecol Prog Ser 329:253–65.

Thayer JA. 2009. Rhinoceros auklet reproduction, survival and diet in relation to ocean climate. Ph.D. Dissertation. University of California, Davis.

Thompson JE, Hanna RW. 2010. Using cross-dating techniques to validate ages of aurora rockfish (*Sebastes aurora*): estimates of age, growth and female maturity. Environmental Biology of Fishes 88:377-388.

Thompson SA, Sydeman WJ, Santora JA, Black BA, Suryan RM, Calambokidis J, Peterson WT, Bograd SJ. 2012. Linking predators to seasonality of upwelling: using food web indicators and path analysis to infer trophic connections. Prog Oceanogr 101:106–20.

Wells BK, Grimes CB, Waldvogel JB. 2007. Quantifying the effects of wind, upwelling, curl, sea surface temperature and sea level height on growth and maturation of a California Chinook salmon (*Oncorhynchus tshawytscha*) population. Fish Oceanogr 16:363–82.

[table of contents | back to top]

Data Files

File
bio2.csv (Comma Separated Values (.csv), 2.11 KB) MD5:a6b2ce73f453729e383a57408bb874d4 Primary data file for dataset ID 472578

[table of contents | back to top]

Parameters

Parameter	Description	Units
year	year	YYYY

MuLD	Common murre average lay date from Southeast Farallon Island	yearday
AuLD	Cassin's auklet average lay date from Southeast Farallon Island	yearday
MuRS	Common murre reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number
AuRS	Cassin's auklet reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number
RARS	Rhinoceros auklet reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number
AARS	Rhinoceros auklet reproductive success from Ano Nuevo Island; number of offspring fledged per pair of birds	fledged offspring number
BCRS	Brandt's cormorant reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number
BCSv	Brandt's cormorant survival from Southeast Farallon Island after 2-3 years	percent
PCRS	Pelagic cormorant reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number
SRGC	Splitnose rockfish otolith chronology from California coast, 35-40°N; 'increment width index' for which values greater than 1 indicate above-average growth and values below 1 indicate below-average growth.	unitless
YRGC	Yelloweye rockfish otolith chronolgy from California continental shelf: 36-40°N; 'increment width index' for which values greater than 1 indicate above-average growth and values below 1 indicate below-average growth.	unitless
ARGC	Aurora rockfish otolith chronology from Oregon coast, 42-46°N; 'increment width index' for which values greater than 1 indicate above-average growth and values below 1 indicate below-average growth.	unitless
SaGC	Chinook salmon otolith chronology from Smith river California 42°N: a normalized growth index such that values greater than 0 indicate above-average growth and values below 0 indicate below-average growth.	unitless
SrRe	Pacific sardine recruitment from Southern California: recruitment anomalies; stock biomass for sardines age 1+ based on a stock assessment model; values greater than 0 indicate above-average recruitment and values below 0 indicate below-average recruitment.	unitless

PGRS	Pigeon guillemot reproductive success from Southeast Farallon Island; number of offspring fledged per pair of birds	fledged offspring number

[table of contents | back to top]

Deployments

Black_model

Website	https://www.bco-dmo.org/deployment/472783
Platform	OSU
Start Date	2011-09-01
End Date	2013-05-31
Description	climate reconstruction model

[table of contents | back to top]

Project Information

History and Future of Coastal Upwelling Modes and Biological Responses in the California Current (California Current upwelling modes)

Coverage: North-central California Current between approx 36N, 122W and 39N, 125W

From NSF award abstract:

Climate variability on multiple temporal scales is increasingly recognized as a major factor influencing the structure, functioning, and productivity of the California Current Ecosystem (CCE). Yet, despite many long-term and integrative studies, a detailed understanding of climatic impacts on upwelling and biological processes is still lacking, compromising our abilities to assess important concepts such as ecosystem "health" and "resilience." To address these issues in the central-northern CCE, the PIs have recently collated and analyzed records of rockfish and salmon growth and seabird reproductive success with respect to upwelling variability (NSF award #0929017). These diverse, multi-decadal time series revealed the importance of wintertime upwelling on ecosystem structure and function, even though upwelling, a principal driver of productivity in the CCE, is largely a summertime process. This research led to an unexpected discovery that winter and summer upwelling vary independently of one another in distinct seasonal "modes", with some biological processes affected by the winter mode and others by the summer mode. This is of significance because the summer mode shows a long-term increase (despite inter-decadal variability) while the winter mode does not.

In this new project, the PIs will test the overarching hypothesis that upwelling modes are forced by contrasting atmospheric-oceanographic processes, exhibit contrasting patterns of low- and high-frequency variability, and will be differentially impacted by global climate change with corresponding impacts on biology. To address this hypothesis the PIs propose a three-tiered approach to better understand seasonal upwelling modes and their differential impacts on biology of the CCE. First, they will examine the responses of an entirely new suite of species to upwelling modes, including Pacific sardine (recruitment), black rockfish (growth), rhinoceros auklet and Brandt's cormorant (survival), and coho salmon (survival). Previously, coarsely resolved upwelling indices were used in these analyses, but the PIs now will integrate winds and temperatures from local buoy data to better capture climate variability on finer timescales. Second, they will derive a more mechanistic understanding of seasonal upwelling modes and use this information in combination with global climate models to forecast upwelling responses under various climate-change scenarios. Third, preliminary results indicate that tree-ring data co-vary with the fish and seabirds and are similarly sensitive to a driver of winter upwelling, the Northern Oscillation Index (NOI). The PIs will use tree-ring data to provide a 300-400 year reconstruction of the winter NOI to assess the historical range of variability in upwelling mean and variance. This study will reveal the past, present forcing, and potential future of upwelling and its biological consequences in the California Current.

Related Publications:
García-Reyes, M., W. J. Sydeman, S. A. Thompson, B. A. Black, R. R. Rykaczewski, J. A. Thayer, and S. J. Bograd. 2013. Integrated assessment of wind effects on Central California's pelagic ecosystem. Ecosystems. DOI: 10.1007/s10021-013-9643-6.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1130125

[table of contents | back to top]