



Title:

Connectivity of West Coast Marine Sanctuaries: Tracking Sooty Shearwaters Throughout Dynamic Upwelling Ecosystems in the California Current System

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seabird, habitat, marine protected areas, sanctuary, upwelling

Abstract:

We propose that as a super-abundant, top-level-predator, Sooty Shearwaters are an ideal California Current Ecosystem (CCE) bioindicator species. Sooty Shearwaters dominate the CCE avifauna during the spring-summer 'upwelling season' and depend on massive amounts of energy-dense forage fishes (anchovy, sardine, krill). We hypothesize that Sooty Shearwater distribution (and abundance), and residency patterns, are related to upwelling dynamics (i.e., offshore transport, upwelling retention, wind-stress curl) that structure and control bottom-up productivity and energy transfer through the CCE foodweb.

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Project Information

Year Final _____

Grant No.: NA08OAR4170669

Number R/ENV-204 _____

Title Connectivity of West Coast Marine Sanctuaries: Tracking Sooty Shearwaters Throughout Dynamic Upwelling Ecosystems in the California Current System

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Last Harvey First James Init

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Project Hypothesis

We propose that as a super-abundant, top-level-predator, Sooty Shearwaters are an ideal California Current Ecosystem (CCE) bioindicator species. Sooty Shearwaters dominate the CCE avifauna during the spring-summer 'upwelling season' and depend on massive amounts of energy-dense forage fishes (anchovy, sardine, krill). We hypothesize that Sooty Shearwater distribution (and abundance), and residency patterns, are related to upwelling dynamics (i.e., offshore transport, upwelling retention, wind-stress curl) that structure and control bottom-up productivity and energy transfer through the CCE foodweb.

Project Goals and Objectives

Our proposed study of shearwater movements associated with measures of environmental variability and oceanographic habitats will (1) provide unique information about how dominant marine predators respond to spatial and temporal variability associated with environmental conditions that affect prey distributions, (2) highlight key persistent foraging areas (habitat hotspots) within the CCS, (3) demonstrate interconnectivity among the network of west coast National Marine Sanctuaries, and (4) provide information about residency and inter-regional movements for better interpretation of declines based on transect survey estimates of shearwater abundance.

Briefly describe project methodology

We used satellite telemetry to track the movements of Sooty Shearwaters captured in the CCE. Shearwaters were outfitted with small satellite transmitters, and their locations were determined approximately every 2-hrs during a 10-hr on period per day. First, we used custom programs to filter spurious location data and then interpolate along individual track lines to determine hourly locations for our set of individuals. Second, we convert individual bird data to a continuous raster (grid) coverage of kernel density (probability of location) surface for analyses in a GIS framework of time-spent per area, degree of individual overlap, and 'hot-spot' mapping. Raster data was integrated with physical environmental data (e.g., surface chlorophyll concentration and bathymetry). Ultimately, we will relate shearwater distribution to physical parameters using multivariate modeling.

Describe progress and accomplishments toward meeting goals and objectives.

In 2011 (granted extension year), we continued to analyze satellite tracking data, remote environmental buoy observations, and area use patterns among WC National Marine Sanctuaries. Map-based tracking data are still available to the public via the internet (www.seaturtle.org), and 1 location per day for all individuals also were made available to teachers through this web site. As of 3 January 2013, our 2009 project site had received 19798 views from the public, and our 2008 project had received 34445 views, this is a 77 and 73 percent increase in views, respectively since 2011. In 2012, we published a peer reviewed journal article detailing at-sea habitat use among satellite-tracked sooty shearwaters within the west coast National Marine Sanctuary network and US Exclusive Economic Zone.

PROJECT MODIFICATIONS: Explain briefly any substantial modifications in research plans, including new directions pursued and ancillary research topics developed. Describe major problems encountered and how they were resolved.

In extension year (2012) we hired a graphic design consulting biologist to coordinate scientific outreach media. Public interpretive signage is now in preparation for installations ranging throughout the study area from southern California through northern Washington.

PROJECT OUTCOMES: Briefly describe data, databases, physical collections, intellectual property, models, instruments, equipment, techniques, etc., developed as a result of this project and how they are being shared.

Unfiltered tracking data (maps 2004-2009), project description, and additional web links, are currently available to the public for viewing via www.seaturtle.org. Filtered tracking data are archived at USGS. Sea Grant Trainee, Melinda Nakagawa continues to work with her advisor, Jim Harvey and co-investigator Erika McPhee-Shaw, to acquire and archive daily QuikSCAT and NDBC buoy winds and has completed preliminary analyses. Adams has continued to work with colleagues in New Zealand to develop filtering, interpolation, and kernel density techniques for ongoing spatial analyses. Analyses techniques for this project supported in part by Sea Grant, were recently applied by Adams and others to a published analyses of Grey-faced Petrel foraging distribution in the southern Pacific and Tasman Sea, and similar collaborative analyses currently are underway with Adelie Penguin, Hawaiian Petrel, Black-footed Albatross, and Pink-footed Shearwater. Techniques developed and applied in this study will be used to assess spatial-temporal overlap for seabirds that interact with certain fisheries, and be contributed to a California Current Seabird Telemetry Atlas (in prep by USGS), and to inform marine spatial planning related to potential developments in alternative marine-based energy infrastructure off CA, OR, and WA (in prep by USGS).

IMPACTS OF PROJECT: Briefly describe how this project has contributed to a discipline; to developing human resources; to developing physical, institutional or information resources; technology transfer; and society beyond science and technology. Please notify CASG of impacts that occur after your project ends; CASG may contact you after your project ends to learn about additional impacts that occur over time.

This project has contributed toward new methods for analyzing the movements of far-ranging medium-sized seabirds. Additional research will provide new tools for analyzing the habitat use of marine vertebrates tracked using satellite transmitters, geolocation technology, and GPS. Seabird telemetry provides robust information to evaluate marine spatial planning and conservation management.

BENEFITS, COMMERCIALIZATION, AND APPLICATION OF PROJECT RESULTS: Please list any companies, agencies, organizations or individuals who have used your project results, scientific/technical advice, etc., and provide names, emails and phone numbers. Briefly describe how results were used and quantify results and socioeconomic benefits, if possible.

Rob Ronconi: Researcher, Grand Manan Whale and Seabird Research Station, New Brunswick, Canada, rroconid@dal.ca: provided advice for the attachment of satellite transmitters on Greater and Sooty Shearwaters captured in the Bay of Fundy, Canada.
 Carolina Proano (carolinabps@gmail.com), Graduate Researcher, Charles Darwin Foundation and Max Planck Institute for Ornithology: attachment methods were provided to Proaño, along with technical expertise in the field which led to the successful tracking of Endangered Galapagos Petrels at sea
 Phil Lyver (lyverp@landcareresearch.co.nz) and Catriona MacLeod, Landcare Research, New Zealand: This project has stimulated interaction between USGS/MLML and Landcare Research regarding spatial analyses of satellite tracking data (including Grey-faced Petrel and Adelie Penguin).
 Peter Hodum (Oikonos Ecosystem Knowledge), peter@oikonos.org: technical advice and field support regarding transmitter deployments on Pink-footed Shearwater (California and Chile).

ECONOMIC BENEFITS generated by discovery, exploration and development of new, sustainable coastal, ocean and aquatic resources (i.e., aquaculture, marine natural products, foods, pharmaceuticals).

Issue-based **forecast capabilities** to predict the impacts of a single ecosystem stressor, developed and used for management (i.e., climate change, extreme natural events, pollution, invasive species, and land resource use).

NA

Tools, technologies and information services developed (i.e., land cover data, benthic habitat maps, environmental sensitivity index maps, remote sensing, biosensors, AUVs, genetic markers, technical assistance, educational materials, curricula, training).

Publications (list in appropriate category below) Each listing should be a stand-alone bibliographic reference, including all authors' names. For each Publication type, specify title, authors, date and journal details, where appropriate (repeat headers as necessary).

Technical Reports

Title	Authors	Date
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Conference Papers, Proceedings, Symposia

Conference Title	90th Annual Meeting of the Western Society of Movements of non-breeding Sooty Shearwaters (<i>Puffinus griseus</i>) in the California Current System: seabird response to spatial and temporal variability in winds	Location	Monterey Bay, Seaside,	Date	12-14 November
Authors	Melinda Nakagawa, Josh Adams, Erika McPhee-Shaw, and James T. Harvey				
Conference Title	Climate Change Natural Resources and Coastal Seabirds and their marine environments: movements, dynamic habitats, and change	Location	San Francisco	Date	2009
Authors	Adams, J. and M. Nakagawa				
Conference Title	Pacific Seabird Group Annual Meeting Response of non-breeding Sooty Shearwaters (<i>Puffinus griseus</i>) to spatial and temporal variability in winds within the California Current System	Location	Long Beach, CA	Date	Feb. 2010
Authors	Nakagawa, M. S., J. Adams, E. E. McPhee-Shaw, and J. T. Harvey				
Conference Title	Eos Trans. AGU, 91(26), Ocean Sci. Meet. Suppl., Response of non-breeding Sooty Shearwaters (<i>Puffinus griseus</i>) to spatial and temporal variability in winds within the California Current System	Location	Portland, OR	Date	22 to 26 February
Authors	Nakagawa, M., J. Adams, E. McPhee-Shaw, and J. T. Harvey				
Conference Title	First World Seabird Conference Advances in seabird conservation: towards Ecosystem-Based Management	Location	Victoria, B.C., Canada	Date	Sept. 7 to 11 2010
Authors	Hyrenbach, K. D., M. Le Corre, J. Adams, M. Louzao, and A. Rieser				
Conference Title	First World Seabird Conference Connectivity and summertime use of West Coast U.S. National Marine Sanctuaries by migratory Sooty Shearwaters (<i>Puffinus griseus</i>)	Location	Victoria, B.C., Canada	Date	Sept. 7 to 11 2010
Authors	Adams, J., R. Suryan, K. D. Hyrenbach, J. Harvey, C. MacLeod, and A. DeVogelaere				
Conference Title	Oregon Marine Renewable Energy Environmental Pacific Continental Shelf Environmental Assessment (PacSEA): Seabird and Marine Mammal Surveys off the Northern California, Oregon, and Washington Coasts	Location	OSU, Corvallis, OR	Date	28 to 29 November
Authors	Adams, J.				

Peer-reviewed journal articles or book chapters

Journal	Proceedings of DEEP: Talks and thoughts celebrating Diversity in New Zealand's untouched Kermadecs	Issue Num		Page Num		Date	2010
Title	Migrations and patterns of seabird occurrence in the Kermadec region	Authors	Gaskin, C., E. Bell, J. Adams, C. MacLeod, PO.B. Lyver, and M. Rayner				
Journal	Journal of the Royal Society of New Zealand	Issue Num	39(4)	Page Num	183 to	Date	2009
Title	International and cross-cultural management in conservation of migratory species	Authors	Nevins, H. M., J. Adams, H. Moller, J. Newman, M. Hester, and K. D. Hyrenbach				
Journal	Biological Conservation	Issue Num	156	Page Num	105 to	Date	2012
Title	Summer-time use of west coast US National Marine Sanctuaries by migrating sooty shearwaters (<i>Puffinus griseus</i>)	Authors	Adams, J, C MacLeod, RM Suryan, KD Hyrenbach, JT Harvey				

Non-peer Reviewed Reprints

Satellite Tracking Leads to Compilation of Important Conservation Data	Rebecca Buddingh, California Sea Grant	22 November	▲
			▼

Publications, Brochures, Fact Sheets**Books & Monographs****Handbooks, Manuals, Guides**

Electronic publications: (non-print formats).

Maps, Charts, Atlases**Theses, dissertations**

Movements and migration of six Pacific Seabird species	Adams. J	University of Otago	2011	▲
				▼

Newsletters, periodicals**Program reports (annual/biennial, strategic plans, implementation plans)****Educational Documents****Topical Websites and Blogs****Miscellaneous documents (not listed above).**

MEDIA COVERAGE: Select 'Yes' or 'No'. If yes, describe any radio, TV, web site, newspaper, magazine coverage your project has received. Send original clippings or photocopies to the Sea Grant Communications Office.

This research involving Sooty Shearwater tracking was featured by CA Sea Grant in an on-line news piece: <http://www-csgc.ucsd.edu/NEWSROOM/NEWSRELEASES/2010/SatelliteTracking.html> A similar cross linked outreach piece was posted on-line by USGS: http://www.werc.usgs.gov/outreach.aspx_RecordID_28. Josh Adams participated in a 30 minute radio-interview hosted on KWMR FM 90.5, Point Reyes, CA. 3 October 2011. Ocean Currents, Discovering the Secrets of Sooty Shearwaters [Live radio interview]; <http://cordellbank.noaa.gov/education/radiopodcast2011.html>

Publication notifications were linked at the following 2 websites:

<http://www.migratoryconnectivityproject.org/6-december-full-life-cycle-protection-for-seabirds/>;

<http://montereybay.noaa.gov/research/techreports/tradams2012.html>

MEDIA NOTES: Brief description of the type media coverage your project has received.

DISSEMINATION OF RESULTS: List any other ways in which results of your project have been disseminated. Indicate targeted audiences, location, date and method.

WORKSHOPS AND PRESENTATIONS: A brief description of location, date, time, topic, number of attendees and name of presenter.

COOPERATING ORGANIZATIONS: List those (e.g., county or state agencies, etc.) who provided financial, technical or other assistance to your project since its inception. Describe the nature of their cooperation.

Federal Organizations

US Geological Survey, Western Ecological Research Center

National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center

Regional Organizations**State Organizations**

Department of Fish and Game, Marine Veterinary Care and Research Center, Santa Cruz

Nongovernment Organizations

Oikonos Ecosystem Knowledge

International Organizations

Landcare Research, NZ

Industry Organizations

Academic Organizations

Moss Landing Marine Laboratories, Moss Landing, CA
Oregon State University
Duke University Marine Labs, Durham, NC

Sea Grant Organizations

Other Organizations

INTERNATIONAL IMPLICATIONS: Does your project involve any colleagues overseas or have international implications?

The techniques for the analyses of shearwater movements generated in part from this study currently are benefiting similar analyses by researchers in New Zealand (Grey-faced Petrel, Adelle Penguin), collaborative work to assist researchers in Ecuador investigating the movements of the Galapagos Petrel, and collaborative research by Oikonos Ecosystem Knowledge in the Juan Fernandez Islands, Chile (Peter Hodem).

AWARDS: List any special awards or honors that you, or any co-project leaders, have received during the duration of this project.

KEYWORDS: List keywords that will be useful in indexing your project.

seabird, habitat, marine protected area, sanctuary, upwelling

PATENTS: Please list any patents or patent licenses that have resulted from this project, and complete the patent statement form available on website.

NOTES: Please list any additional information in the notes area

FOR ALL STUDENTS SUPPORTED BY THIS GRANT, PLEASE LIST:

Volunteer Count 10

Graduate Student Info

Last Name	Nakagawa	First Name	Melinda	Middle Initial	
Contact Email	mnakagawa@mlml.calstate.edu	Contact Phone	831-771-4422		
Institution	Moss landing Marine Labs				
Department	Vertebrate Ecology				
Degree Program	MSc				
Thesis Title	Factors affecting the movements of Sooty Shearwaters in the California Current				
Supported by Sea Grant	Yes	Start Date	1/1/2009	End Date	12/31/2011
Last Name	Adams	First Name	Josh	Middle Initial	
Contact Email	josh_adams@usgs.gov	Contact Phone	831-460-7566		
Institution	University of Otago				
Department	Zoology				
Degree Program	PhD				
Thesis Title	Movements, migration, and ocean habitats of six Pacific Seabird Species				
Supported by Sea Grant	Yes	Start Date	1/3/2013	End Date	1/3/2013