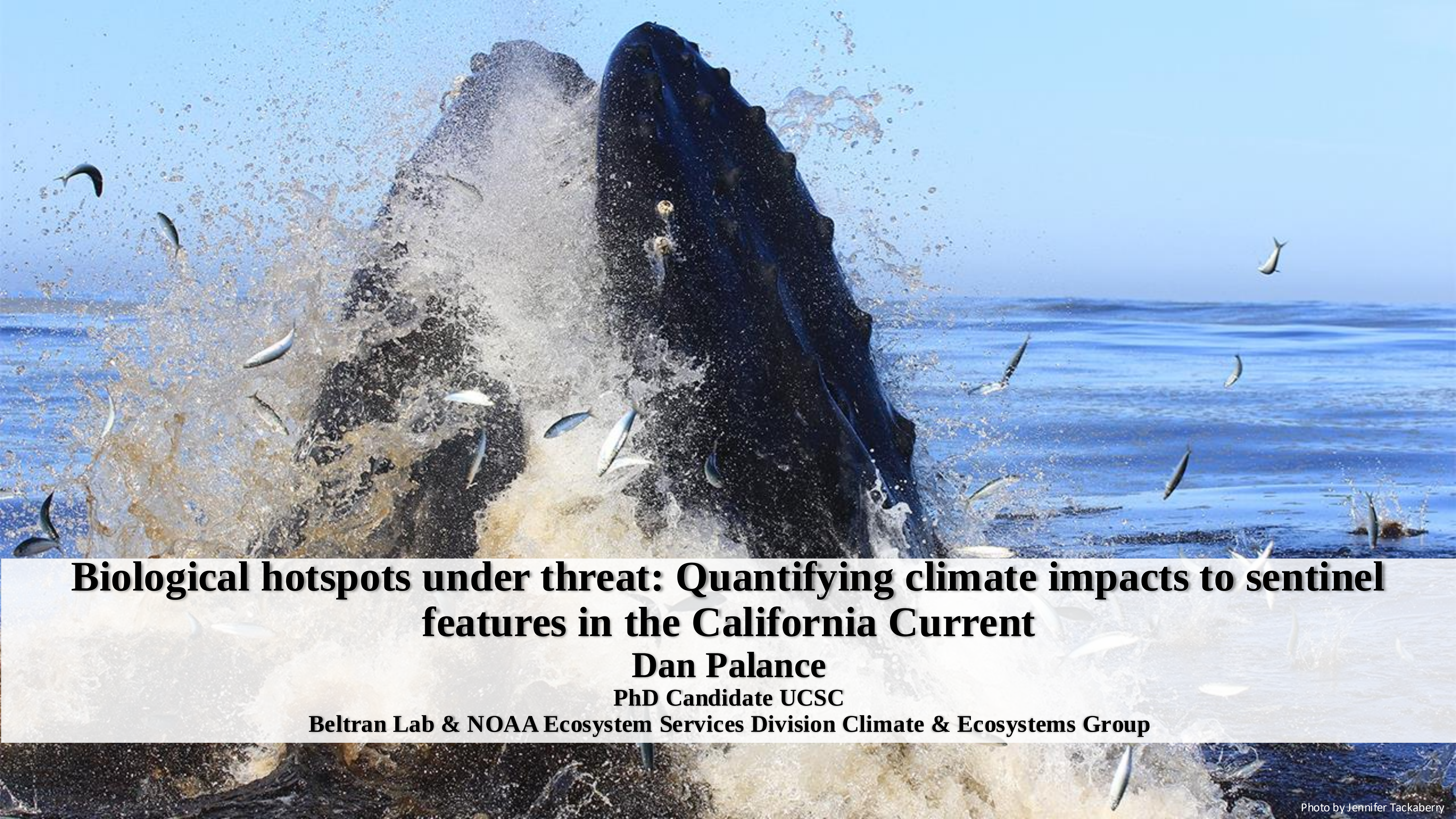


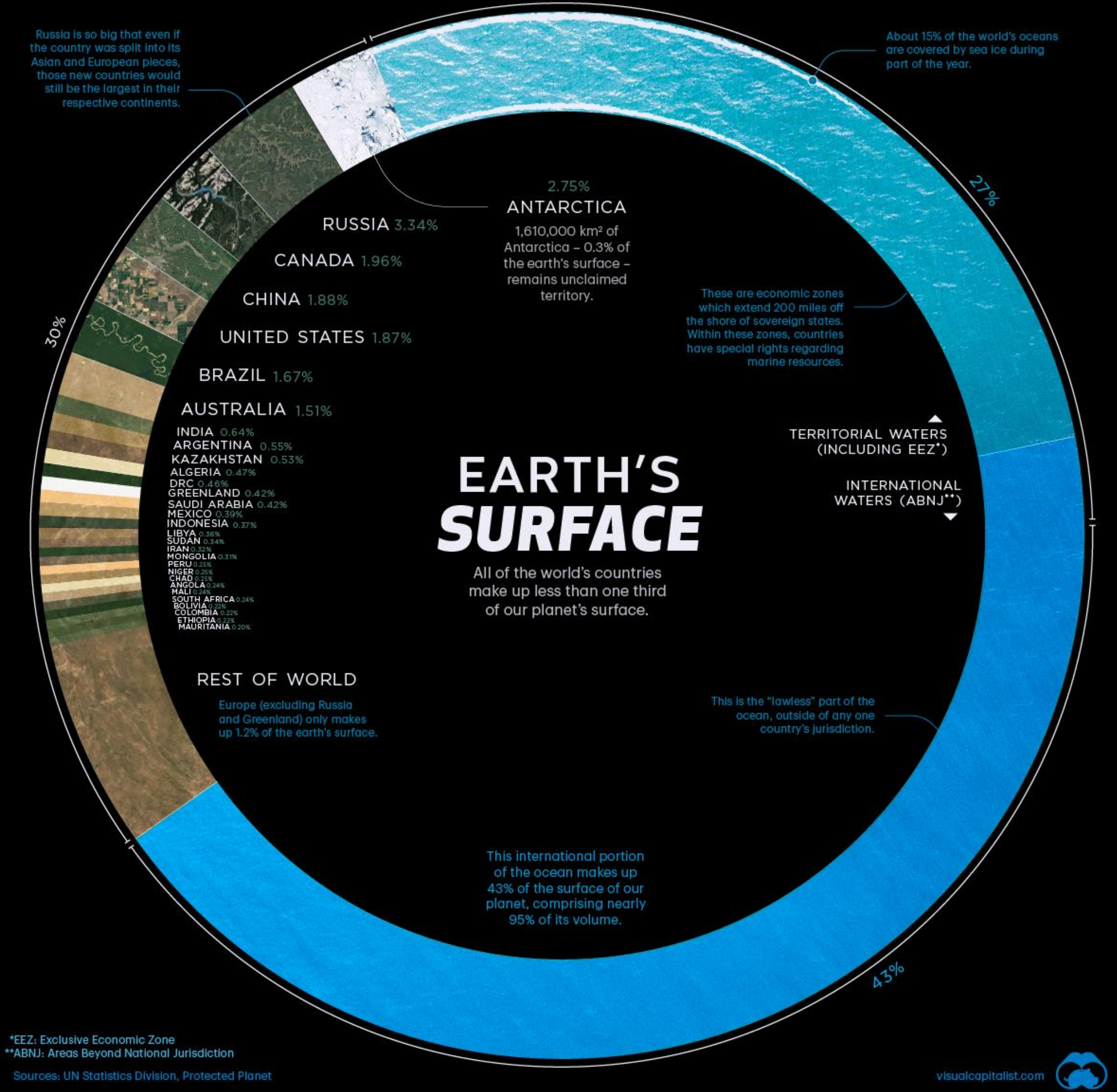
Biological hotspots under threat: Quantifying climate impacts to sentinel features in the California Current

Dan Palance

PhD Candidate UCSC

Beltran Lab & NOAA Ecosystem Services Division Climate & Ecosystems Group

Photo by Jennifer Tackaberry



The ocean is huge!

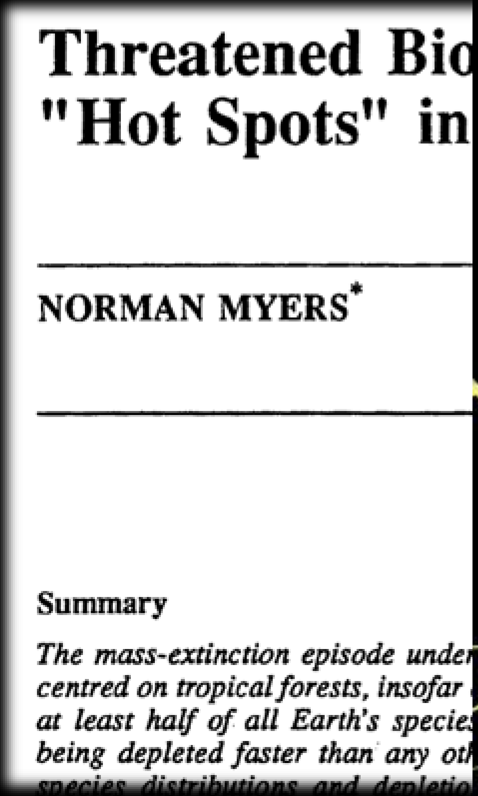
- > 70% of Earth's surface is covered by the ocean
- Marine life is distributed in a patchy mosaic of aggregations with densities 10s-1000s times higher than background levels (Benoit-Bird 2024)

The Knowledge Gap

Where are things concentrated in the ocean? And why?

The Hotspot

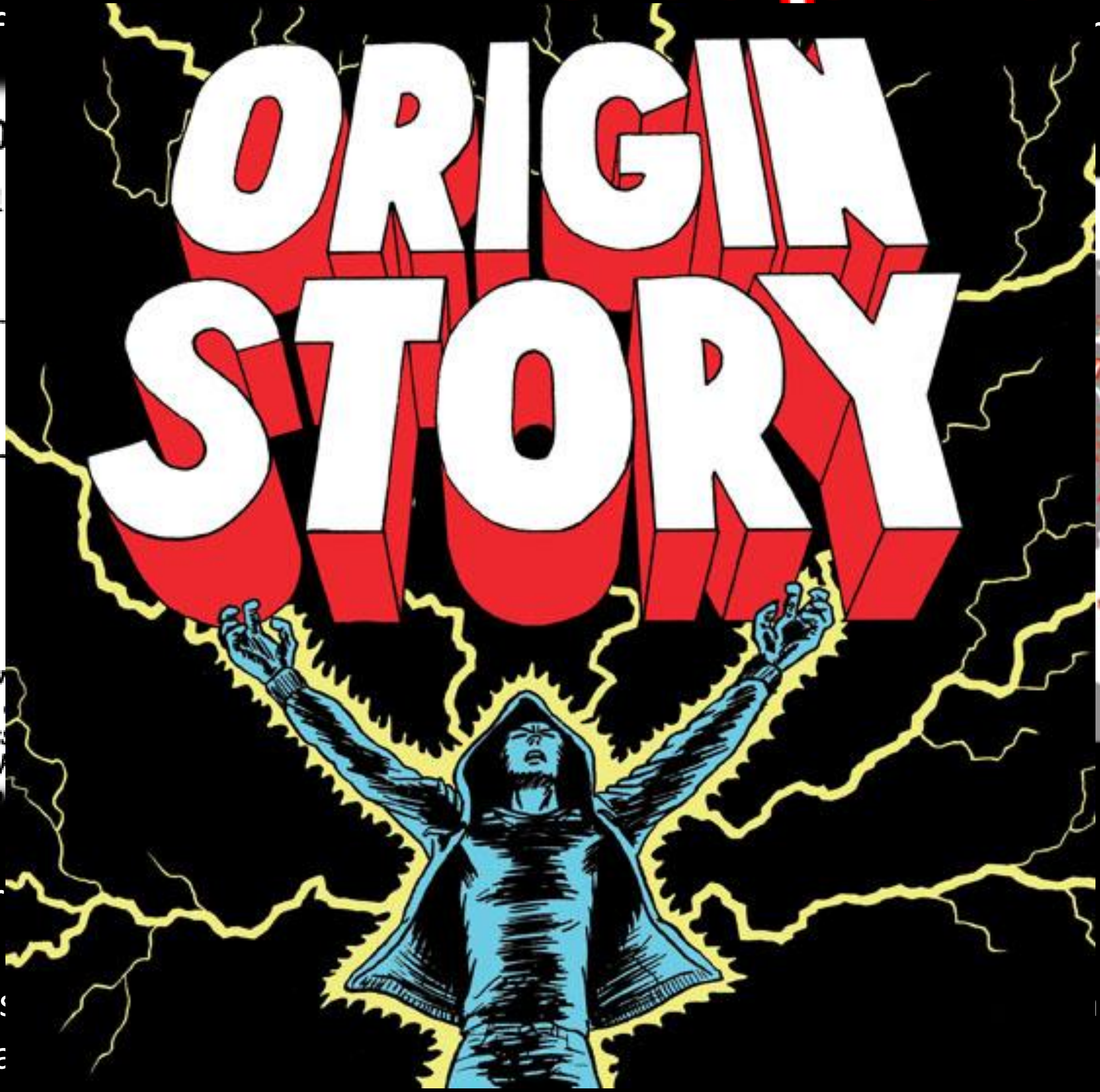
Hotspots – regions of … ıan activity (Myers, 1988)


Threatened Bio…
"Hot Spots" in…

NORMAN MYERS*

Summary

The mass-extinction episode under… centred on tropical forests, insofar … at least half of all Earth's specie… being depleted faster than any oth… species distributions and depletio…



Myers *et al.* 2000

- > 80% of hotspot r…
- The terrestrial hots… …ents due to the dynamic features a…

Filling the gap in hotspot knowledge

Problems	Aims
1. Colloquialism vs scientific concept	1. Synthesize the scope of marine hotspot definitions and examine the concept's evolution
2. Not always integrated effectively into conservation and management	2. Showcase how hotspots of predator and prey habitat could be useful to management applications

The review process

Google Scholar

Web of Science™

Metadata

"Hotspot", "Hot spot" "Marine" "Ocean"

Gather and read papers

Continental Shelf Research 70 (2013) 126–134
Contents lists available at ScienceDirect
Continental Shelf Research
journal homepage: www.elsevier.com/locate/csr

Research papers

Environmental Pollution 292 (2022) 118338

OPEN ACCESS Freely available online
PLOS ONE

...ommunities in Rapidly Warming Fjords

Global Ecology and Conservation 3 (2015) 297–309
Contents lists available at ScienceDirect
Global Ecology and Conservation
journal homepage: www.elsevier.com/locate/gecco

Review paper

Biodiversity hotspots: A shortcut for a more complicated concept

Christian Marchese
Université du Québec à Rimouski, Département de biologie, chimie et géographie, 300 allée des Ursulines, Rimouski (Québec), C... Canada

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Received 9 August 2014
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Keywords:
Climate change
Coldspots
Species richness
Phylogenetic diversity
Ecosystem services

ABSTRACT
In an era of human activities, global environmental changes, ... tinction, conservation strategies are a crucial step toward min... instance, oceans acidification and land use are intensifying i... and often irreversible consequences for biodiversity. Biodive... criticism, have become a tool for setting conservation prioriti... in decision-making for cost-effective strategies to preserve b... to some extent, marine ecosystems. This area-based approa... ographical scale and it is considered to be one of the best a... large proportion of the world's biological diversity. However, ... quantitative criteria along with subjective considerations an... such as coldspots, with other types of conservation value. No... edged that biodiversity is much more than just the number... conservation strategy cannot be based merely on the number... tem. Therefore, the idea that strongly emerges is the need to r... ities and to go toward an interdisciplinary approach through t... partnerships.

Contents

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MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published July 30

Contribution to the Theme Section 'Biophysical coupling of marine hotspots'

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INTRODUCTION

Scales and mechanisms of marine hotspot formation

Elliott L. Hazen[1,2,*], Robert M. Suryan[3], Jarrod A. Santora[4,5], Steven J. Bograd[1], Yutaka Watanuki[6], Rory P. Wilson[7]

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[2]Institute of Marine Sciences, University of California, Santa Cruz, 100 Shaffer Road, Santa Cruz, California 95060, USA
[3]Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, Oregon 97365, USA
[4]Farallon Institute for Advanced Ecosystem Research, 101 H Street, Suite Q, Petaluma, California 94952, USA
[5]Center for Stock Assessment and Research, University of California Santa Cruz, 110 Shaffer Road, Santa Cruz, California 95060, USA
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[7]Biosciences, College of Science, Swansea University, Singleton Park, Swansea SA2 8PP, UK

ABSTRACT: Identifying areas of high species diversity and abundance is important for understanding ecological processes and conservation planning. These areas serve as foraging habitat or important breeding or settlement areas for multiple species, and are often termed 'hotspots'. Marine hotspots have distinct biophysical features that lead to their formation, persistence, and recurrence, and that make them important oases in oceanic seascapes. Building upon a session at the North Pacific Marine Science Organization (PICES), this Theme Section explores the scales and mechanisms underlying hotspot formation. Fundamentally, understanding the mechanisms of hotspot formation is important for determining how hotspots may shift relative to ocean features and climate change, which is a prerequisite for determining management priorities.

KEY WORDS: Hotspot · Ocean features · Aggregations · Bottom-up processes · Biodiversity · Marine conservation

What is a biological hotspot?

The term 'hotspot' is used with increased frequency in marine biology and conservation literature. The concept of a hotspot of biodiversity has a longer history in the terrestrial community, with Myers (1988) defining hotspots as areas featuring both high endemism and risk to habitat (Myers et al. 2000). These concepts translate well to more static marine habitats such as coral reefs and kelp forests, but are less easily applied to pelagic systems, where both boundaries and features are dynamic. Here, we build upon previous studies that have defined pelagic hotspots based on bathymetric variation (Dower & Brodeur 2004) and ocean features in the North Pacific (Sydeman et al. 2006), to identify the biophysical mechanisms that result in hotspot formation. This requires defining the concept of a marine hotspot, particularly when it consists of mobile features.

We have taken a biophysical approach to defining marine hotspots, focusing on their ecological rather than their conservation importance. Understanding mechanisms that result in hotspot formation is critical to identify areas of high ecological importance and ultimately conservation concern. Hotspots in marine systems can be defined by (1) important life history areas for a particular species, (2) areas of high biodiversity and abundance of individuals, and (3) areas of important productivity, trophic transfer, and biophysical coupling (Dower & Brodeur 2004, Sydeman et al. 2006, Santora & Veit 2013, this Theme Section). Areas of high trophic transfer are of particular interest, because predictable and recurrent productivity hotspots often serve as the foundation of pelagic food

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ENDANGERED SPECIES RESEARCH
Endang Species Res
Published January 21

Contribution to the Theme Section 'Geospatial approaches to support pelagic conservation planning and adaptive management'

OPEN ACCESS

NOTE

Are we missing important areas in pelagic marine conservation? Redefining conservation hotspots in the ocean

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[2]Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529, USA
[3]Center for Ocean Solutions, Stanford University, Monterey, CA 93940, USA
[4]Stanford University, Hopkins Marine Station, Pacific Grove, CA 93950, USA
[5]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz Long Marine Lab, Santa Cruz, CA 95060, USA
[6]*Present address:* Stanford University, Hopkins Marine Station, Pacific Grove, CA 93950, USA

ABSTRACT: The protection of biodiversity is one of the most important goals in terrestrial and marine conservation. Marine conservation approaches have traditionally followed the example of terrestrial initiatives. However, patterns, processes, habitats, and threats differ greatly between the 2 systems — and even within the marine environment. As a result, there is still a lack of congruence as to how to best identify and prioritize conservation approaches moving from the static terrestrial and nearshore realm into a more fluid, 3-dimensional pelagic realm. To address this problem, we investigate how the conservation science literature has been used to inform and guide management strategies in the marine system from coastal to pelagic environments. As cumulative impacts on the health of the oceans continue to increase, conservation priorities have shifted to include highly dynamic areas of the pelagic marine system. By evaluating whether priorities match science with current place-based management approaches (i.e. marine protected areas, MPAs), we identify important gaps that must be considered in current conservation schemes. Effective pelagic MPA design requires monitoring and evaluation across multiple physical, biological, and human dimensions. Because many threatened and exploited marine species move through an ephemeral and ever-changing environment, our results highlight the need to move beyond traditional, 2-dimensional approaches to marine conservation, and into dynamic management approaches that incorporate metrics of biodiversity as well as oceanographic features known to promote multilevel, trophic productivity.

KEY WORDS: Hotspot biodiversity · Conservation planning · Dynamic ocean management · Large marine protected areas · Pelagic · Productivity · Terrestrial conservation

INTRODUCTION

There is widespread consensus that we are facing a ...lobal conservation crisis (Pimm et al. 1995, MEA ...005, Brooks et al. 2006, CBD 2010). There has been a substantial decline in both the diversity and abundance of species worldwide, owing to increasing human pressures (Jackson et al. 2001, Myers & Worm 2003, Sala & Knowlton 2006, Halpern et al. 2008, Baum & Worm 2009, Cardinale et al. 2012, Merrie et

Corresponding author: dbriscoe@stanford.edu

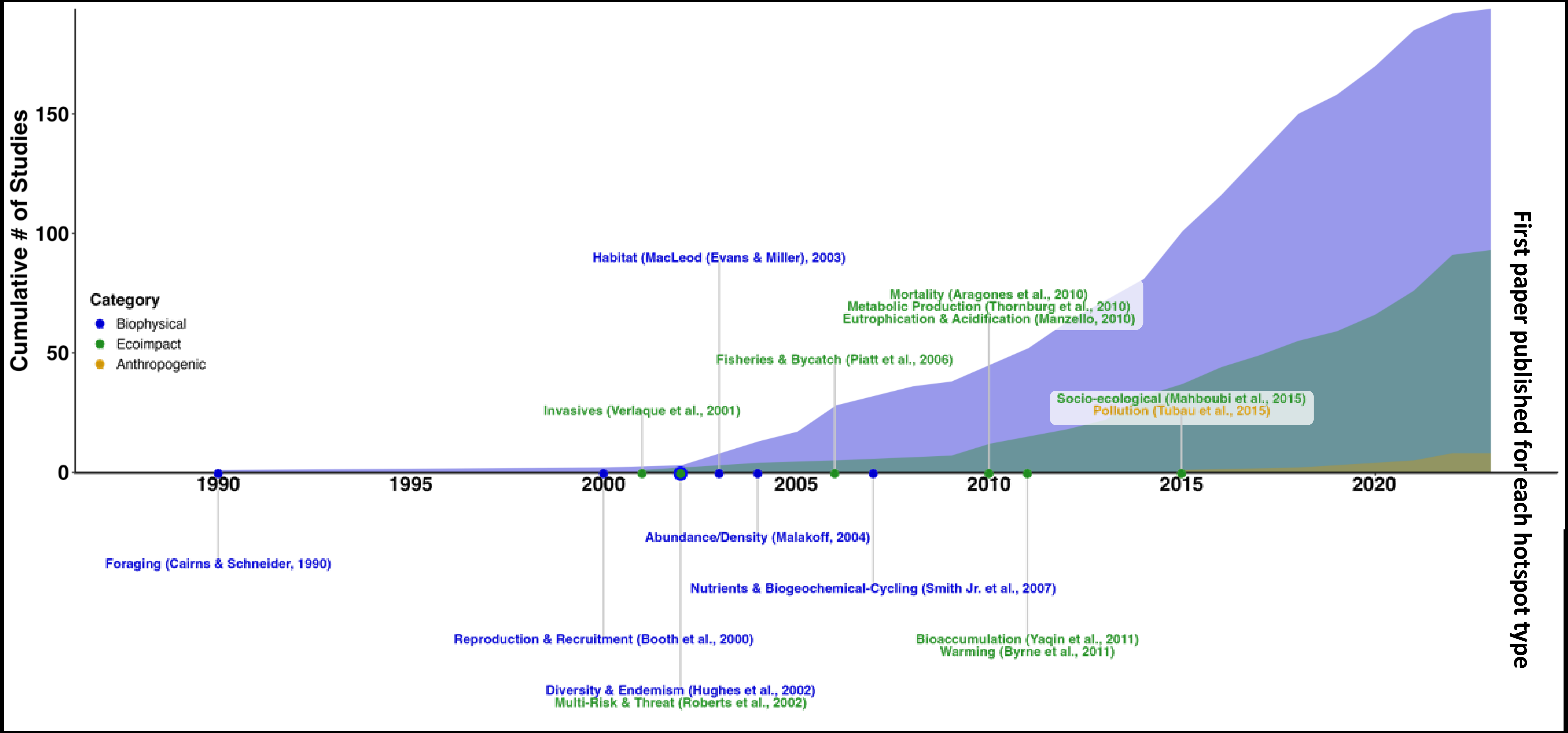
The diversity of the marine hotspot concept

Biophysical (66%, n = 196)
- Abundance/Density (n = 73)
- Foraging (n = 37)
- Habitat (n = 27)
- *Diversity & Endemism (n = 23)
- Nutrients & Biogeochemical Cycling (n = 23)
- Reproduction & Recruitment (n = 9)

Ecological Impact (31%, n = 92)
- Fisheries & Bycatch (n = 24)
- Multi-risk & Threat (n = 20)
- Invasive Species (n = 14)
- Warming (n = 14)
- Bioaccumulation (n = 9)
- Mortality (n = 6)
- Eutrophication & Acidification (n = 4)
- Metabolic Production (n = 3)
- Socioecological (n = 2)

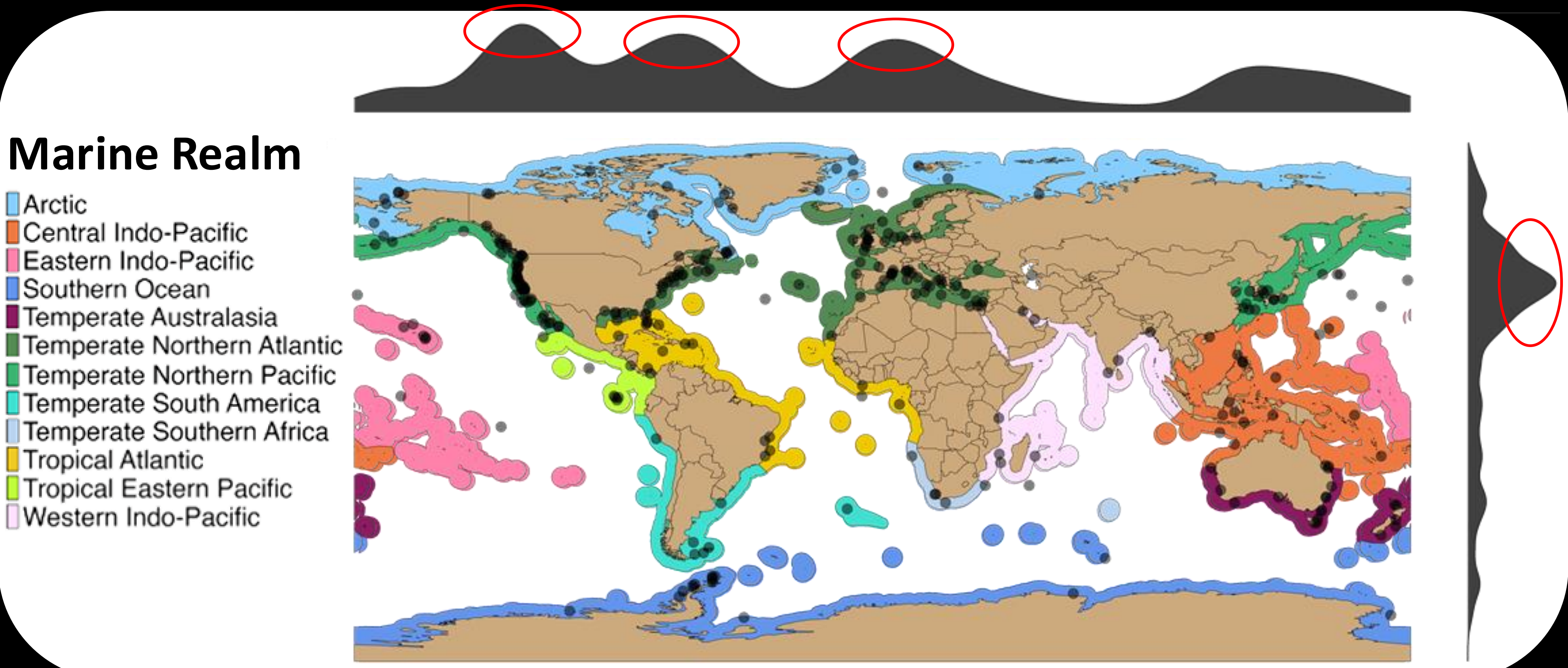
Anthropogenic (3% n = 8)
- Pollution (n = 8)

The evolution of the marine hotspot concept



First paper published for each hotspot type

Geographic biases in hotspot research



Sanctuary Futures

- Species distributions are  r climate change
- We don't know how this … spatial distributions and relationships of migrator… d their prey
- Assess how effective San… e in the future for ~14 managed and protected …

FUTURE co-chair

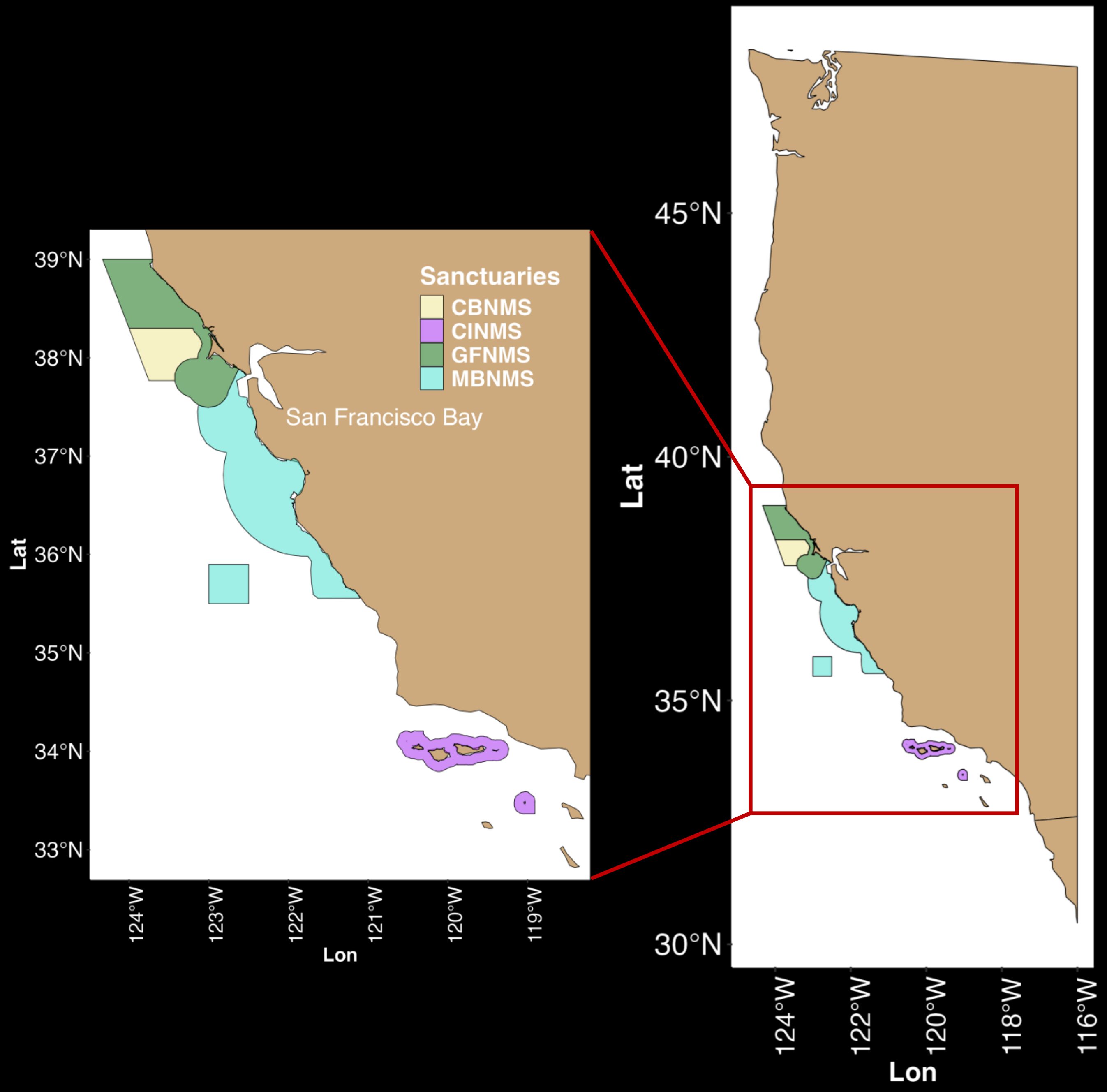
S7 4:20-4:40

S2 12:10-12:30

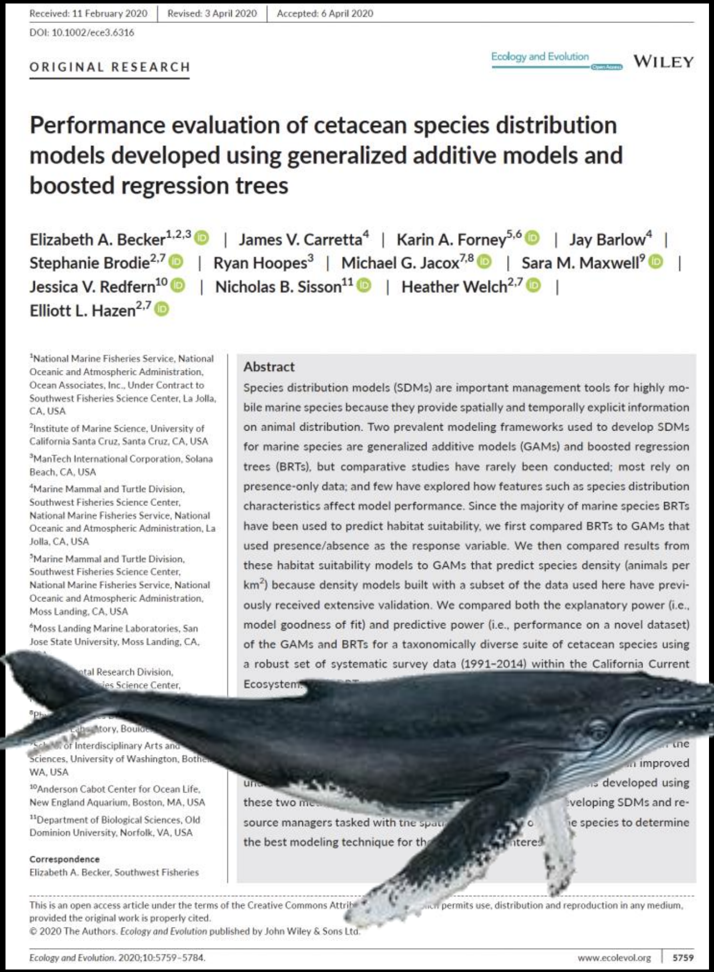
S7 3:40-4:00

California’s National Marine Sanctuaries

- 4 National Marine Sanctuaries (NMS)
  - Greater Farallones (GFNMS)
  - Cordell Bank (CBNMS)
  - Monterey Bay (MBNMS)
  - Channel Islands (CINMS)



Habitat Suitability Models of species in the California Current



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DOI: 10.1002/ece3.6316

Ecology and Evolution WILEY

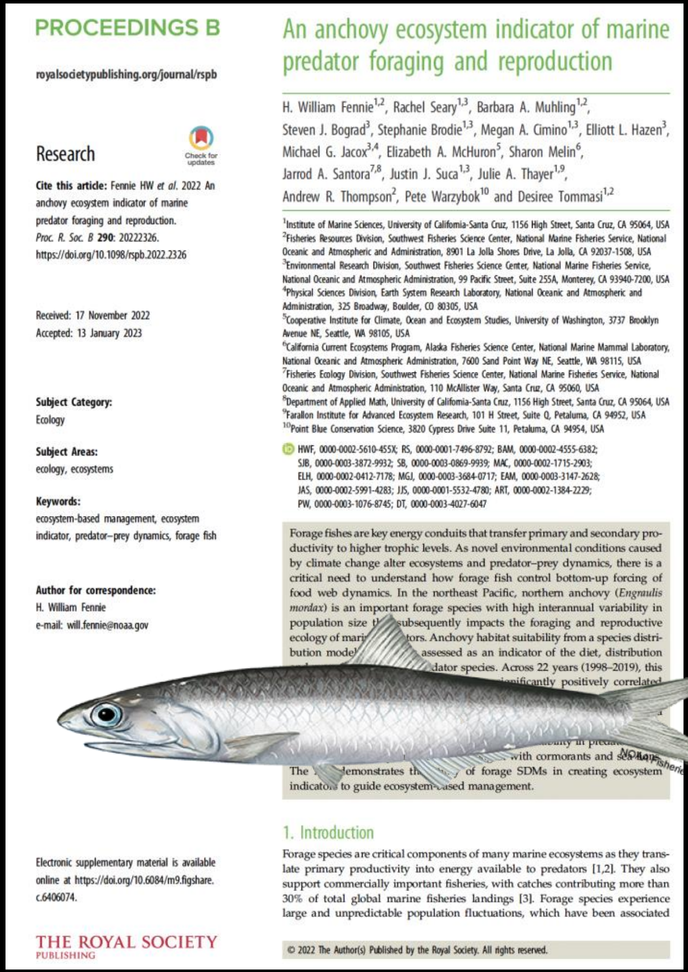
ORIGINAL RESEARCH

Performance evaluation of cetacean species distribution models developed using generalized additive models and boosted regression trees

Elizabeth A. Becker[1,2,3] | James V. Carretta[4] | Karin A. Forney[5,6] | Jay Barlow[4] | Stephanie Brodie[2,7] | Ryan Hoopes[3] | Michael G. Jacox[7,8] | Sara M. Maxwell[9] | Jessica V. Redfern[10] | Nicholas B. Sisson[11] | Heather Welch[2,7] | Elliott L. Hazen[2,7]

Abstract

Species distribution models (SDMs) are important management tools for highly mobile marine species because they provide spatially and temporally explicit information on animal distribution. Two prevalent modeling frameworks used to develop SDMs for marine species are generalized additive models (GAMs) and boosted regression trees (BRTs), but comparative studies have rarely been conducted; most rely on presence-only data; and few have explored how features such as species distribution characteristics affect model performance. Since the majority of marine species BRTs have been used to predict habitat suitability, we first compared BRTs to GAMs that used presence/absence as the response variable. We then compared results from these habitat suitability models to GAMs that predict species density (animals per km²) because density models built with a subset of the data used here have previously received extensive validation. We compared both the explanatory power (i.e., model goodness of fit) and predictive power (i.e., performance on a novel dataset) of the GAMs and BRTs for a taxonomically diverse suite of cetacean species using a robust set of systematic survey data (1991–2014) within the California Current Ecosystem ...



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Research

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Subject Category: Ecology

Subject Areas: ecology, ecosystems

Keywords: ecosystem-based management, ecosystem indicator, predator–prey dynamics, forage fish

Author for correspondence: H. William Fennie e-mail: will.fennie@noaa.gov

An anchovy ecosystem indicator of marine predator foraging and reproduction

H. William Fennie[1,2], Rachel Seary[1,3], Barbara A. Muhling[1,2], Steven J. Bograd[3], Stephanie Brodie[1,3], Megan A. Cimino[1,3], Elliott L. Hazen[3], Michael G. Jacox[3,4], Elizabeth A. McHuron[5], Sharon Melin[6], Jarrod A. Santora[7,8], Justin J. Suca[1,3], Julie A. Thayer[1,9], Andrew R. Thompson[2], Pete Warzybok[10] and Desiree Tommasi[1,2]

Forage fishes are key energy conduits that transfer primary and secondary productivity to higher trophic levels. As novel environmental conditions caused by climate change alter ecosystems and predator–prey dynamics, there is a critical need to understand how forage fish control bottom-up forcing of food web dynamics. In the northeast Pacific, northern anchovy (*Engraulis mordax*) is an important forage species with high interannual variability in population size ...

1. Introduction

Forage species are critical components of many marine ecosystems as they translate primary productivity into energy available to predators [1,2]. They also support commercially important fisheries, with catches contributing more than 30% of total global marine fisheries landings [3]. Forage species experience large and unpredictable population fluctuations, which have been associated

THE ROYAL SOCIETY PUBLISHING

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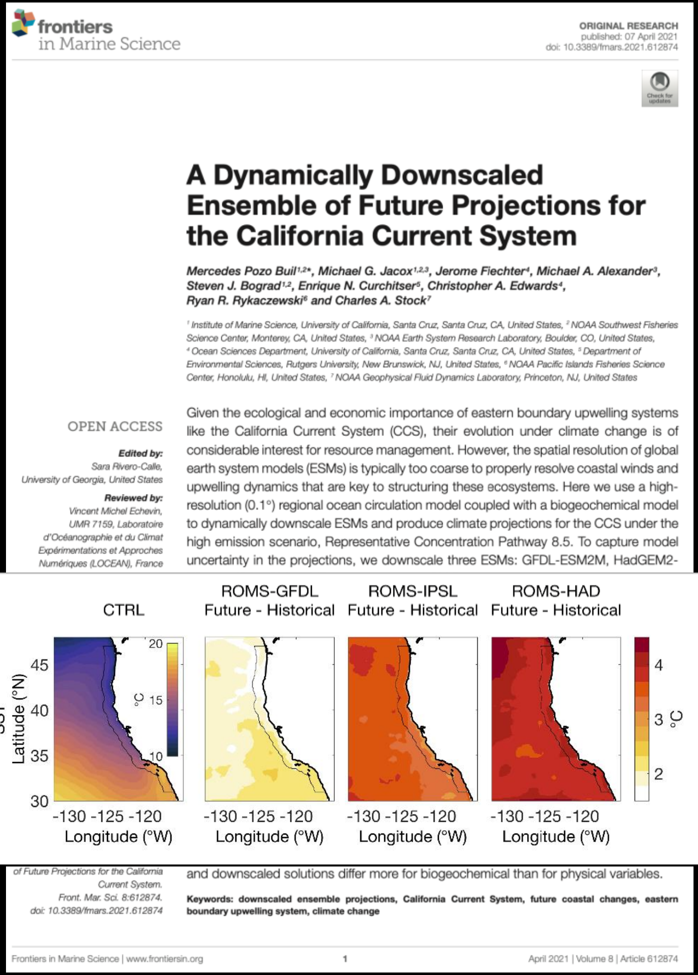


frontiers in Marine Science

ORIGINAL RESEARCH published: 07 April 2021 doi: 10.3389/fmars.2021.612874

A Dynamically Downscaled Ensemble of Future Projections for the California Current System

Mercedes Pozo Buil[1,2*], Michael G. Jacox[1,2,3], Jerome Fiechter[4], Michael A. Alexander[3], Steven J. Bograd[1,2], Enrique N. Curchitser[5], Christopher A. Edwards[4], Ryan R. Rykaczewski[6] and Charles A. Stock[7]

OPEN ACCESS

Given the ecological and economic importance of eastern boundary upwelling systems like the California Current System (CCS), their evolution under climate change is of considerable interest for resource management. However, the spatial resolution of global earth system models (ESMs) is typically too coarse to properly resolve coastal winds and upwelling dynamics that are key to structuring these ecosystems. Here we use a high-resolution (0.1°) regional ocean circulation model coupled with a biogeochemical model to dynamically downscale ESMs and produce climate projections for the CCS under the high emission scenario, Representative Concentration Pathway 8.5. To capture model uncertainty in the projections, we downscale three ESMs: GFDL-ESM2M, HadGEM2- ... and downscaled solutions differ more for biogeochemical than for physical variables.

Keywords: downscaled ensemble projections, California Current System, future coastal changes, eastern boundary upwelling system, climate change

Frontiers in Marine Science | www.frontiersin.org 1 April 2021 | Volume 8 | Article 612874

Core Habitat Threshold:
κ - Cohen's Kappa

Overview

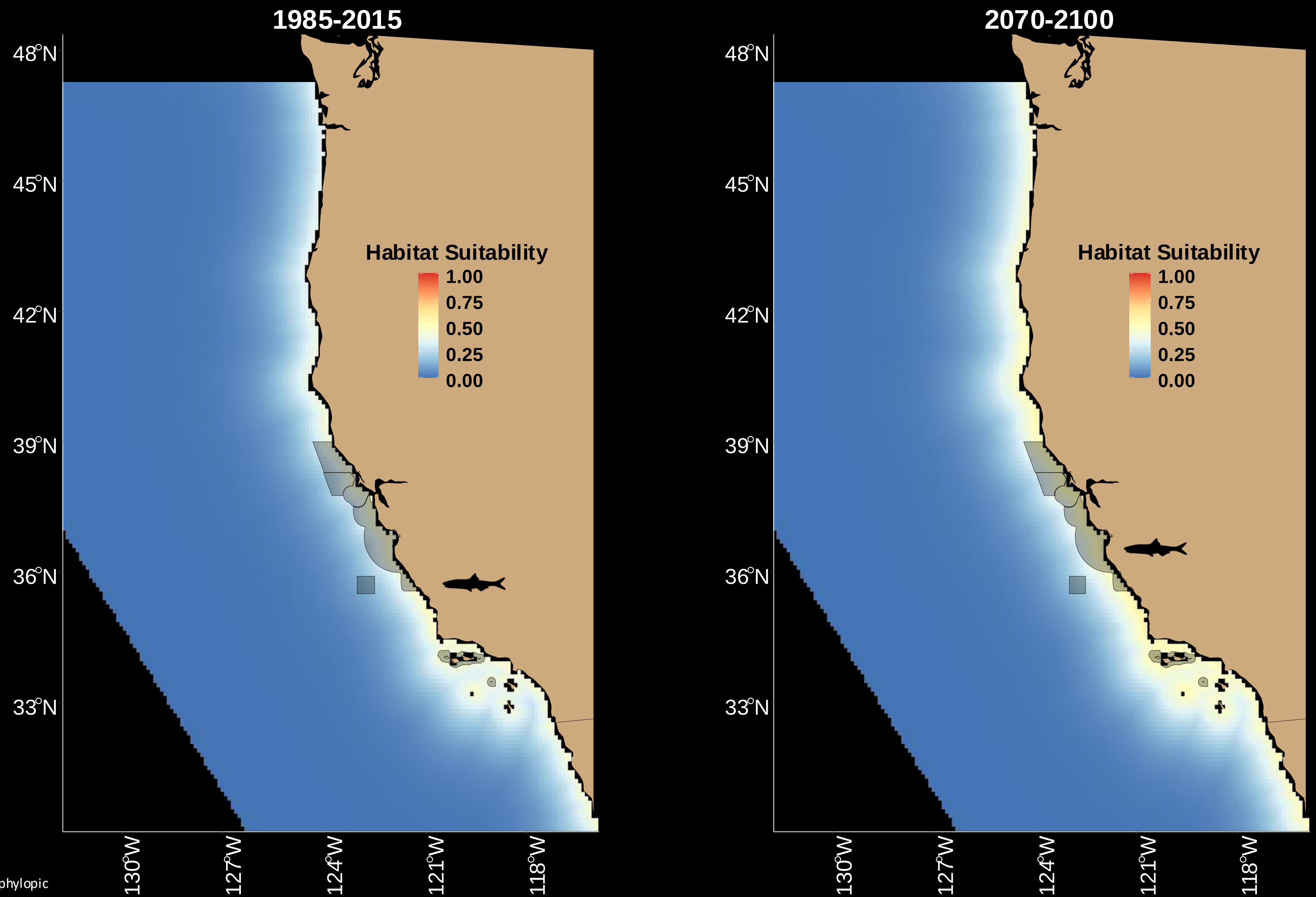
Hotspot Framework

Applying the hotspot concept

Takeaways

Future work

Anchovy habitat shifts NW by ~105 km



Anchovy credit: phylopic

Overview

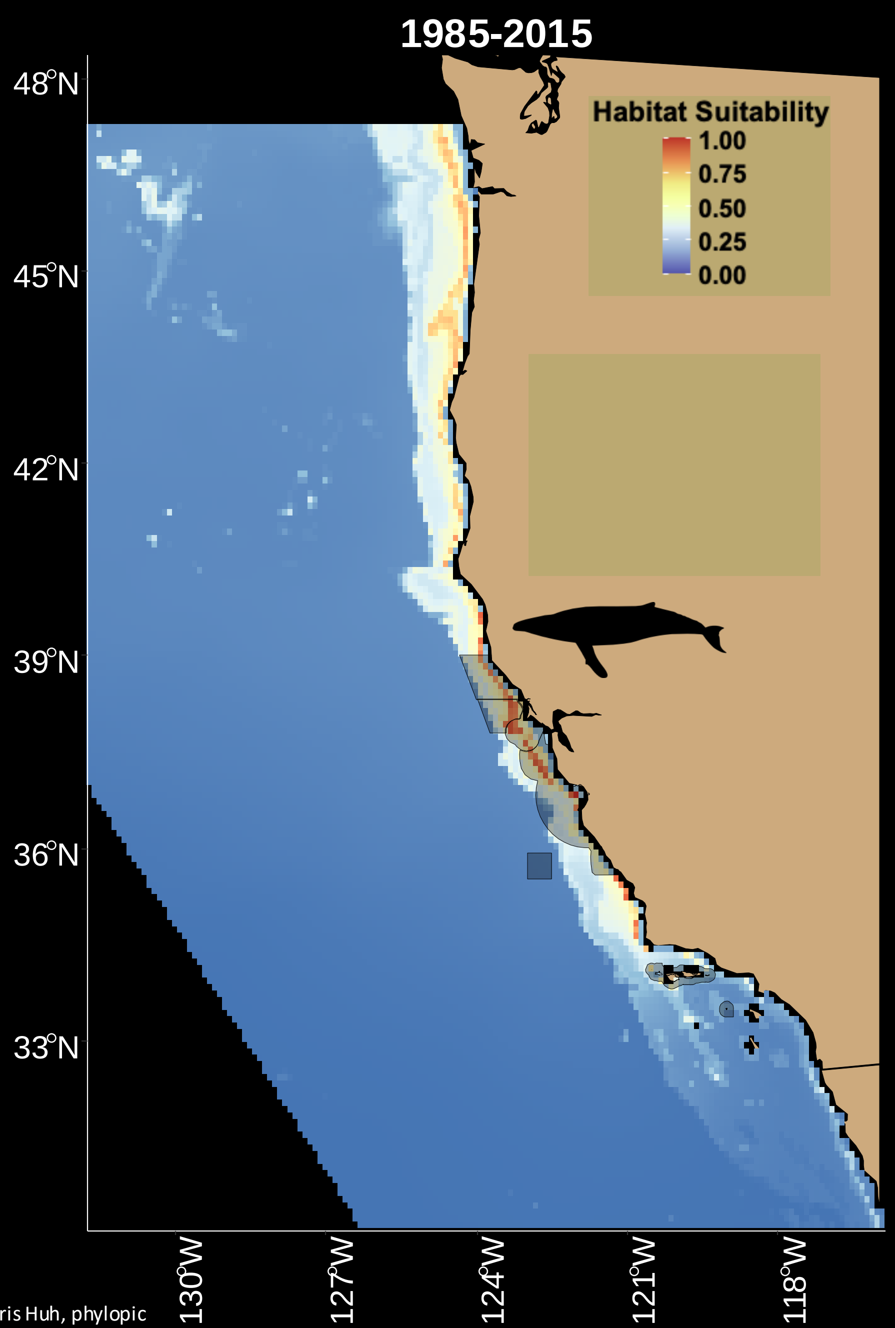
Hotspot Framework

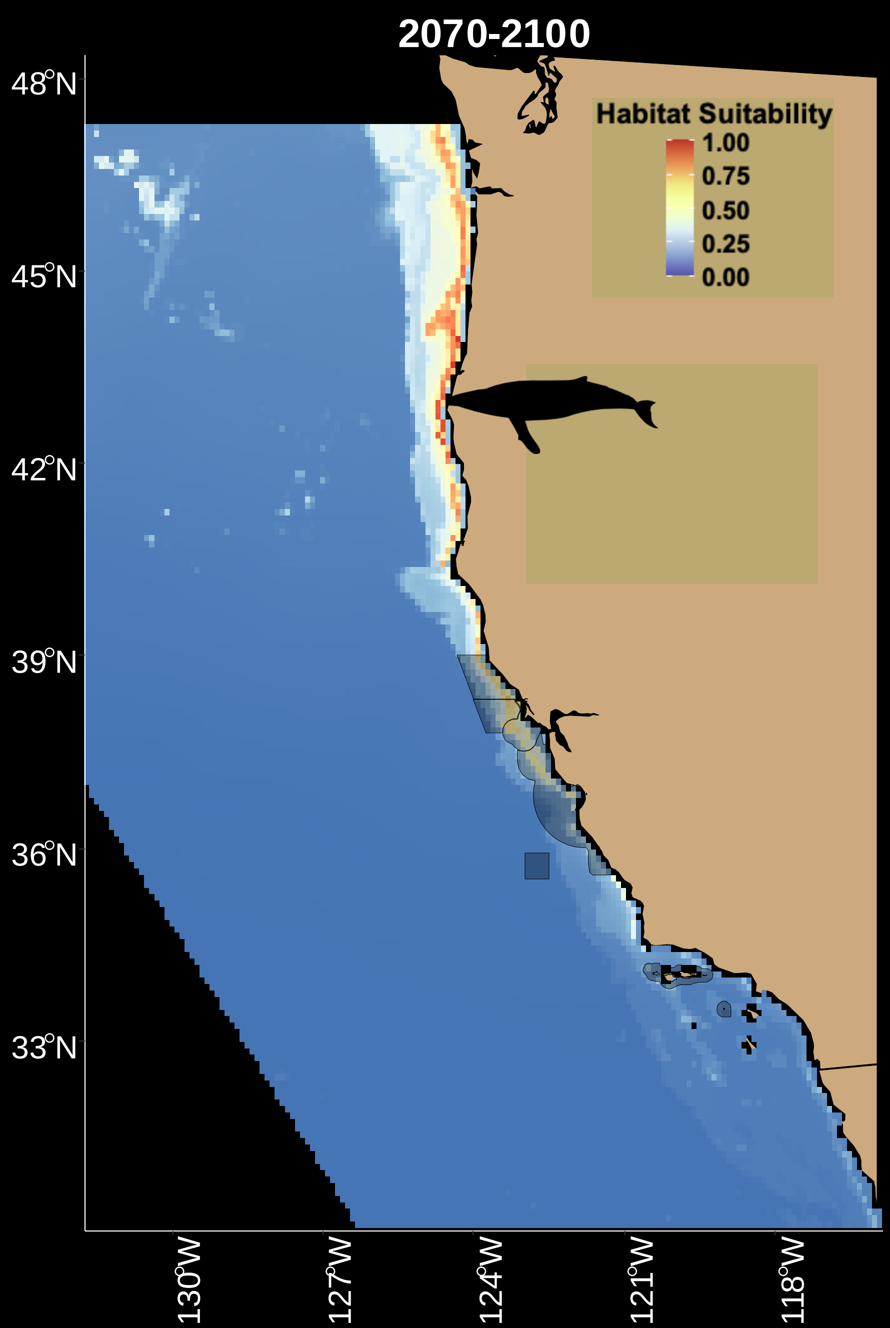
Applying the hotspot concept

Takeaways

Future work

Humpback whale habitat shifts NW by ~408 km





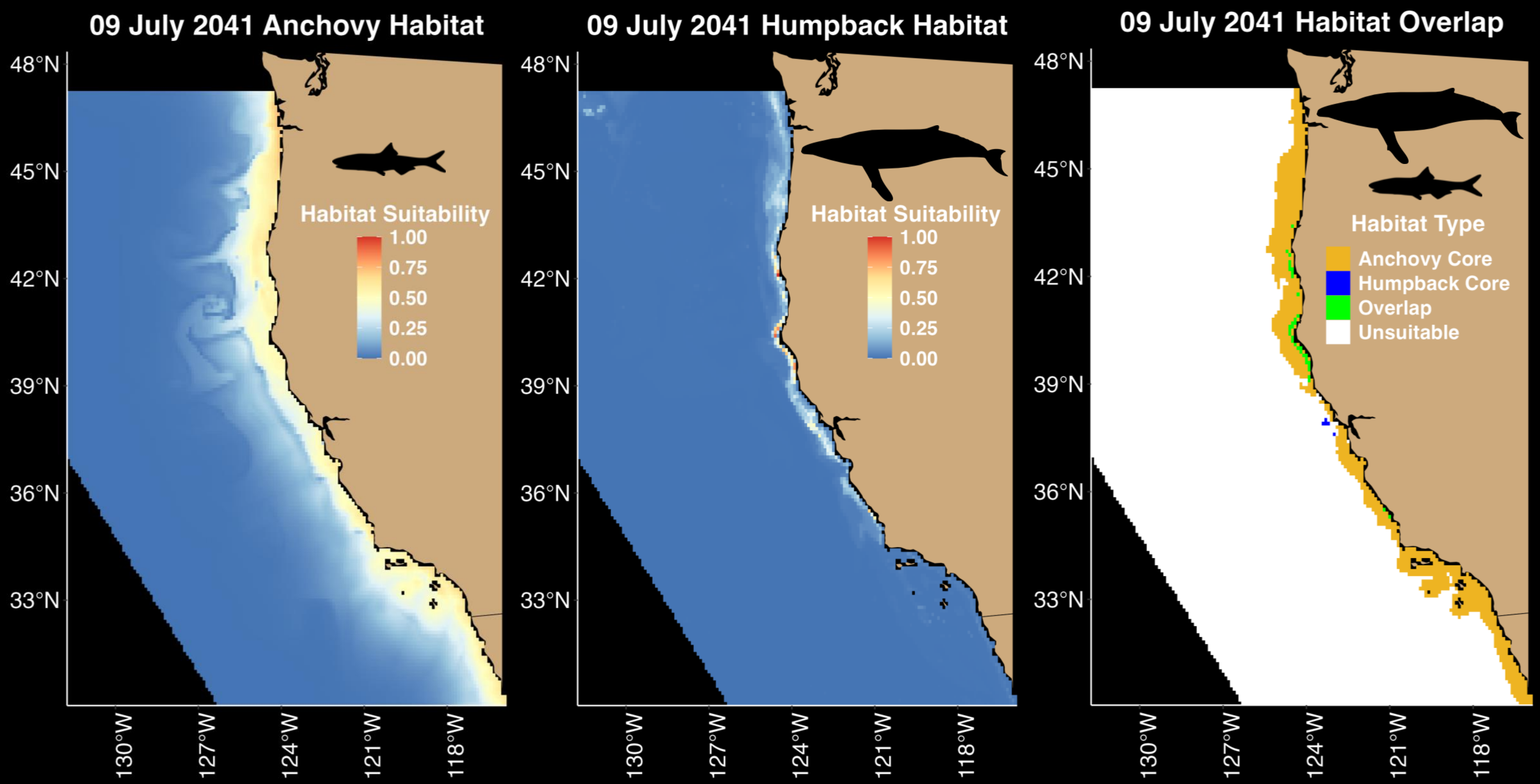
Anchovy credit: Chris Huh, phylopic

Applying the hotspot concept in a changing climate

- **Habitat hotspots** - areas with particular environmental characteristics that have relatively high use/occupancy by an individual, species, or group of species for a variety of biological functions (i.e., breeding, feeding, or migration).

- Identifying Habitat Hotspots:
  - Range Overlap = $A_{pred, prey}/A_{prey}$ (Carroll *et al*. 2019)

Visual representation of Range Overlap metric

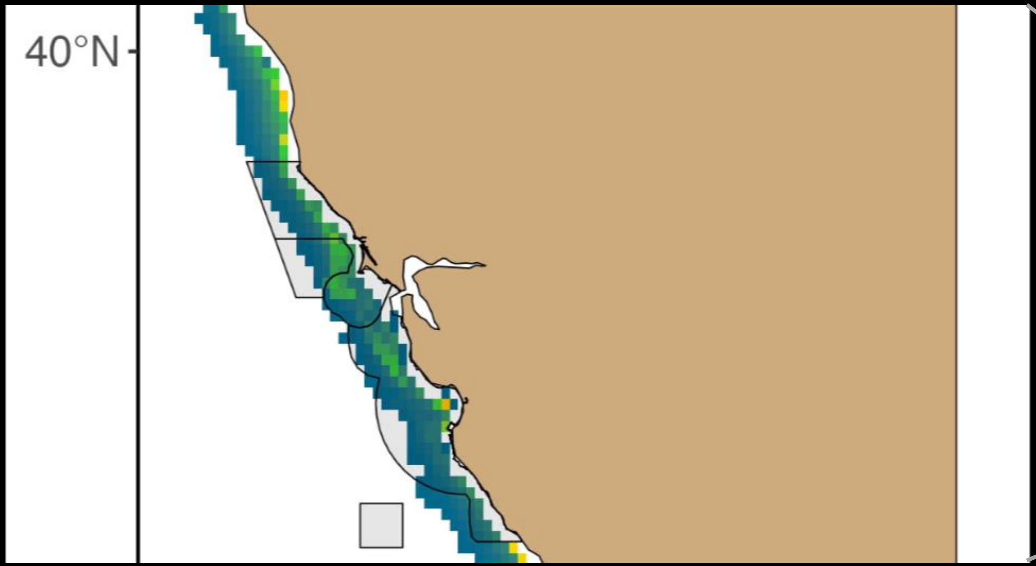


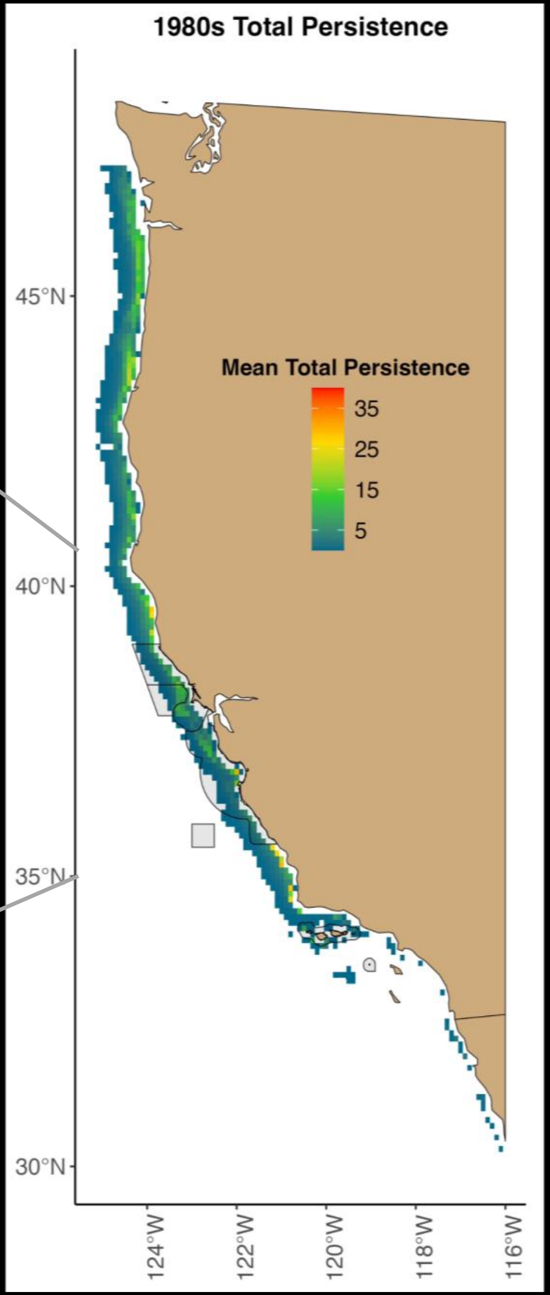
Persistence of overlap

- Lesson from the hotspot review:
  - Few studies examined persistence (13% of ~300 studies)

- To assess persistence of humpback and anchovy overlap
  - Summed the total number of days during the upwelling season (March-August) a grid cell was an overlap hotspot for each climate projection
  - Averaged climate projections for an ensemble mean

Decadal Persistence decreases in the South, increases in the North





Overview

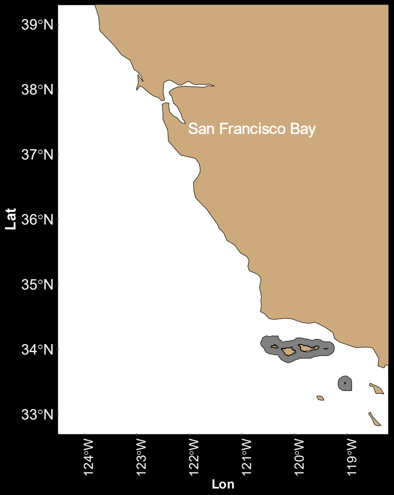
Hotspot Framework

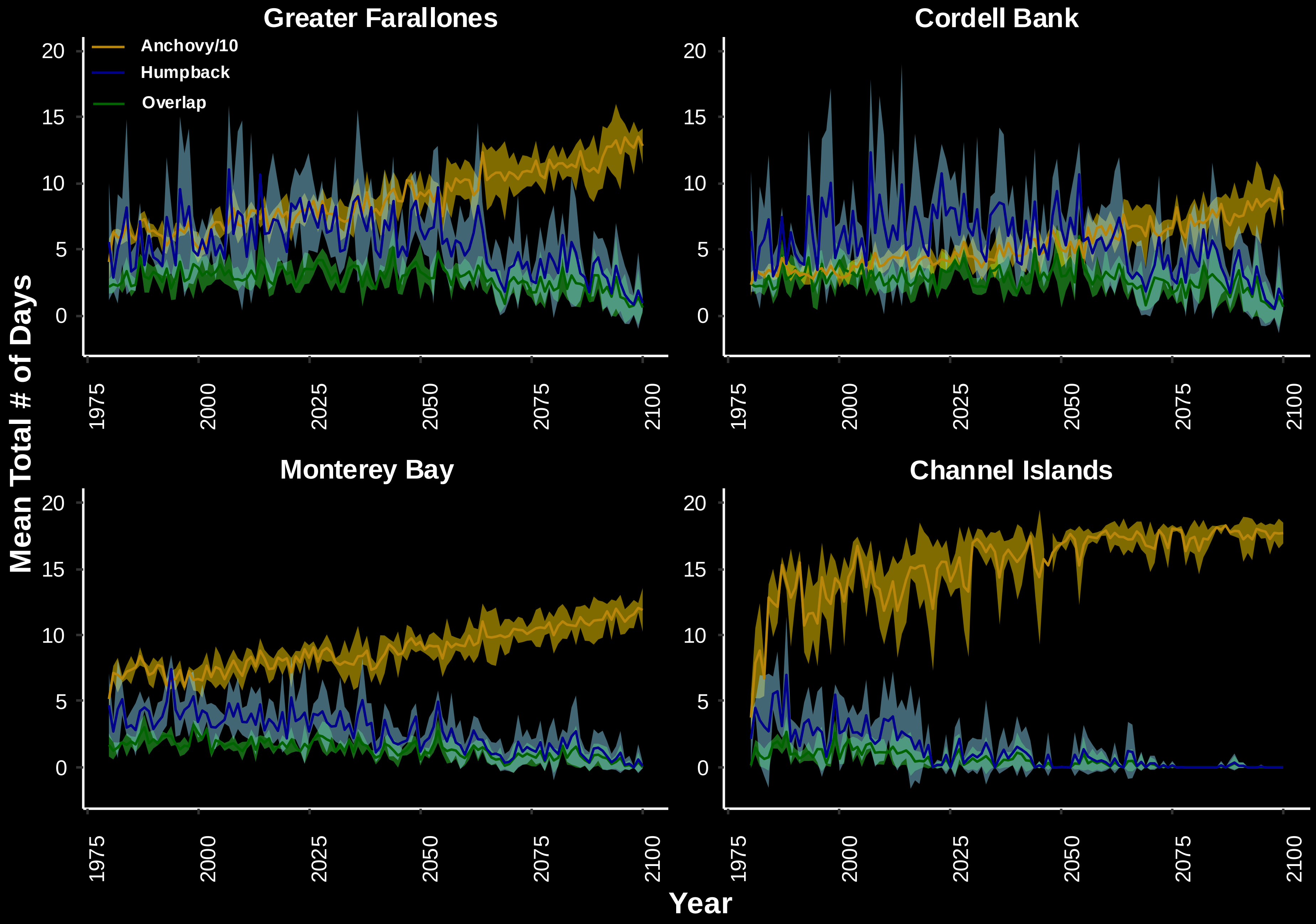
Applying the hotspot concept

Takeaways

Future work

Mean total persistence declines in sanctuaries during upwelling





Overview

Hotspot Framework

Applying the hotspot concept

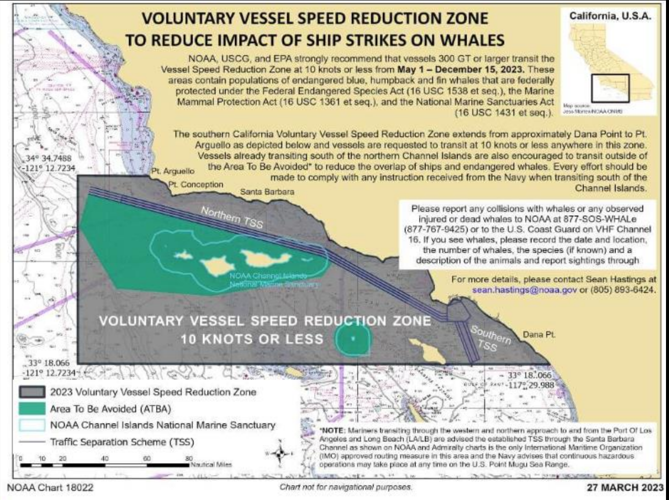
Takeaways

Future work

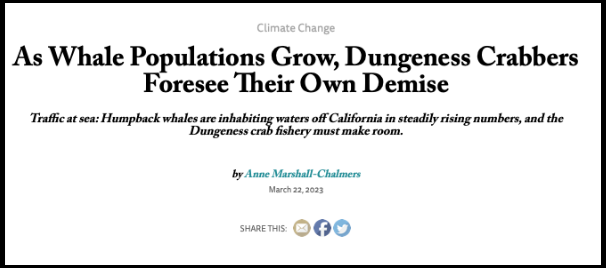
Takeaways

- Make an effort to speak the same language about hotspots via consistent definitions for future work
- Persistence is a useful tool to evaluate how effective protection efforts may be
- Marine spatial planning
  - identify areas best suited for future protections or dynamic management strategies

30x30



Voluntary vessel speed reduction zone southern California Image: NOAA


Climate Change

As Whale Populations Grow, Dungeness Crabbers Foresee Their Own Demise

Traffic at sea: Humpback whales are inhabiting waters off California in steadily rising numbers, and the Dungeness crab fishery must make room.

by Anne Marshall-Chalmers

March 22, 2023

SHARE THIS:

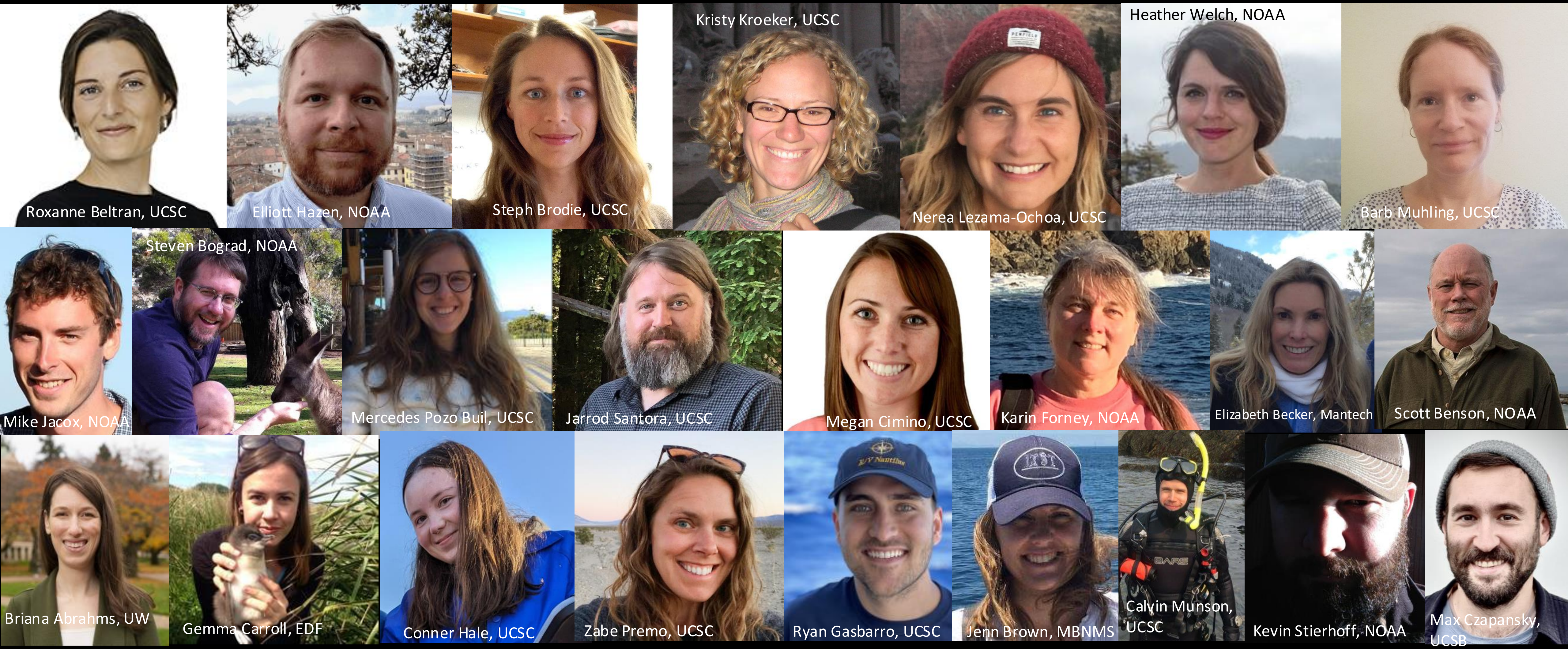
What's next?

- Assess overlap between additional predator-prey couplets:

- Conduct overlap analyses in ecologically significant areas and other oceanographic seasons (Davidson Current & Oceanic)

- Evaluate overlap of habitat hotspots with human use of the ocean

Acknowledgements



Not pictured: Joffrey Jouma

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Office of Naval Research · Science & Technology

Ecology & Evolutionary Biology · UC Santa Cruz

UCSC Bruce Lane Memorial Scholarship


Questions?
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