Application of Climate Predictions to Marine Ecosystem Management

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March 28, 2023 WCRP Symposium Frontiers in Seasonal to Decadal Prediction

Application of Climate Predictions to Marine Ecosystem Management





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Mechanisms of predictability



Forecast tools and methods







Physical Forecast

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Ecological Forecast

Jacox et al. (2020)

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Forecast tools and methods



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Forecast tools and methods





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Regional ocean forecasts

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Regional ocean forecasts

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Forecast configuration

- Forcing from CanCM4
- ROMS California Current domain (0.1° resolution; ~10 km)
- Forecasts initialized twice per year (January and July)
- 1982 to 2010
- 12-month forecasts
- Three ensemble members







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0.5 ACC 0 -0.5 0

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Jacox et al. (in review)



Regional ocean forecasts

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0.5 ACC 0 -0.5 0

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Jacox et al. (in review)





Regional ocean forecasts

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Jacox et al. (in review)

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Connecting physical forecasts to ecological forecasts



Regional ocean forecasts

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Original Articles

Southern California

Heather Welch^{a,b,*}, Elliott L. Hazen^{a,b}, Dana K. Briscoe^{a,c}, Steven J. Bograd^{a,b}, Michael G. Jacox^{b,d}, Tomoharu Eguchi^e, Scott R. Benson^{f,g}, Christina C. Fahy^h, Toby Garfield^e, Dale Robinson^{a,i}, Jeffrey A. Seminoff^e, Helen Bailey^j

Received: 21 December 2018 Revised: 15 April 201 DOI: 10.1111/ddi.12940

BIODIVERSITY RESEARCH

Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species

Briana Abrahms¹ | Heather \ Elizabeth A. Becker^{2,4} | Steven Bruce R. Mate⁵ | Elliott L. Haze



Habitat compression indices for monitoring ocean conditions and ecosystem impacts within coastal upwelling systems

Elliott L. Hazen^{a,b}, Michael Jacox^{a,b}, Steven J. Bograd^{a,b}

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Environmental indicators to reduce loggerhead turtle bycatch offshore of

0	Accontrol 5 May 2010	EDITOR'S
7	Accepted. 5 May 2019	CIUCL

WILEY Diversity and Distributions

Velch ^{1,2} Stephanie Brodie ^{1,2}	Michael G. Jacox ^{1,3}
J. Bograd ^{1,2} Ladd M. Irvine ⁵ 💿	Daniel M. Palacios ⁵ 💿
n ^{1,2}	

PROCEEDINGS B

royalsocietypublishing.org/journal/rspb

Research

Cite this article: Fennie HW et al. 2022 An chowy accountant indicator of mari

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. Bograd³, Stephanie Brodie^{1,3}, Megan A. Cimino^{1,3}, Elliott L. Hazen³, Michael G. Jacox^{3,4}, Elizabeth A. McHuron⁵, Sharon Melin⁶, Jarrod A. Santora^{7,8}, Justin J. Suca^{1,3}, Julie A. Thayer^{1,9}, Andrew R. Thompson², Pete Warzybok¹⁰ and Desiree Tommasi^{1,2}

SCIENCE ADVANCES | RESEARCH ARTICLE

Check fo

ECOLOGY

A dynamic ocean management tool to reduce bycatch and support sustainable fisheries

Elliott L. Hazen,^{1,2,3}* Kylie L. Scales,^{2,4} Sara M. Maxwell,⁵ Dana K. Briscoe,² Heather Welch,² Steven J. Bograd,^{1,2} Helen Bailey,⁶ Scott R. Benson,^{1,7} Tomo Eguchi,¹ Heidi Dewar,¹ Suzy Kohin,¹ Daniel P. Costa,² Larry B. Crowder,⁸ Rebecca L. Lewison⁹

MUHLING ET AL .: DYNAMIC HABITAT USE OF ALBACORE AND THEIR PRIMARY PREY SPECIES IN THE CALIFORNIA CURRENT SYSTEM CalCOFI Rep., Vol. 60, 2019

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Isaac D. Schroeder^{a, D}, Jarrod A. Santora^{c, d, *}, Nate Mantua^c, John C. Field^{D, c}, Brian K. Wells^c

DYNAMIC HABITAT USE OF ALBACORE AND THEIR PRIMARY PREY SPECIES IN THE CALIFORNIA CURRENT SYSTEM

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CHRISTOPHER A. EDWARDS Ocean Sciences Department University of California, Santa Cruz, CA

YI XU Department of Fisheries and Oceans Delta, British Columbia, Canada

> STEPHANIE SNYDER Thomas More University Crestview Hills, KY

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Connecting physical forecasts to ecological forecasts

Application	Region	Key physical variables	Forecast months
Habitat compression (whale entanglement	Central/Northern California	SST	Mar-Nov
TOTAL (loggerhead bycatch)	Southern California	SST	Dec-Jul
WhaleWatch (ship strike risk)	Southern California	Full suite *	May-Nov
Sardine spawning habitat and recruitment	Southern California	SST, SSH	Mar-May
EcoCast (bycatch risk)	Entire Coast	Full suite *	Aug-Jan
Albacore distribution	Oregon/Washtington	Full suite *	Jun-Nov
Anchovy Ecosystem Indicator (top predator foraging and reproduction)	Central/Northern California	Full suite *	Apr-Jul

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<u>*Full suite</u> SST SSH Surface currents (u,v) Wind Stress (u,v,curl) Mixed layer depth Stratification

Jacox et al. (in review)

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<u>*Full suite</u> SST SSH Surface currents (u,v) Wind Stress (u,v,curl) Mixed layer depth Stratification

Jacox et al. (in review)

Habitat compression index (HCI)





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Habitat compression index (HCI)

Habitat Compression Index

Area below threshold = 29177 km^2

Total area = 89418 km^2

$$HCI = \frac{29177 \text{ km}^2}{89418 \text{ km}^2} = 0.33$$

Schroeder et al. (2022)

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Temperature observations to avoid loggerheads (TOTAL) tool

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Temperature observations to avoid loggerheads (TOTAL) tool

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Bycatch dropped significantly, but at large economic cost to the fishery

Temperature observations to avoid loggerheads (TOTAL) tool

Photo copyright: Ralph Pace • Contact for use outside NOAA

Supporting turtle conservation and sustainable fisheries with dynamic ocean management

Turtle Bycatch Overview

Loggerhead turtles from the endangered North Pacific population migrate to the waters off California and Mexico. Higher than normal sea temperatures during spring and summer can bring loggerheads close to the California coast, where they are more likely to be unintentionally captured by commercial fishing vessels. The

Conservation Area Status

In an effort to reduce loggerhead bycatch, the Pacific Loggerhead Conservation Area was established off the Southern California coast. The area is subject to closure to drift gillnet fishing when environmental conditions bring loggerheads into commercial fishing grounds. The Closure Rules page provides backgrounds to the

Historical Data Dashboard

View historical environmental observations for the Southern California coast and the closure status for the Pacific Loggerhead Conservation Area going back to 2003, when the Conservation Area was established. Observation such as sea surface temperature, large temperature deviations and El Niño status are available.

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https://coastwatch.pfeg.noaa.gov/loggerheads/

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Moving TOTAL and HCI from nowcast to forecast

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Observed Forecast

High compression in 2005 could have been predicted 1-2 months in advance.

Persistent habitat compression 2014-2016 was predictable months in advance.

Brodie et al. (in prep)

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Moving TOTAL and HCI from nowcast to forecast

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Observed Forecast

High compression in 2005 could have been predicted 1-2 months in advance.

Persistent habitat compression 2014-2016 was predictable months in advance.

Closures were enacted in the summers of 2015 and 2016.

These closures could have been predicted at least 6 months in advance.

Brodie et al. (in prep)

Moving TOTAL and HCI from nowcast to forecast

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Comparing global and regional forecasts

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Brodie et al. (in prep)

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17.5 15.0 12.5 10.0 7.5

Comparing global and regional forecasts

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Brodie et al. (in prep)

Comparing global and regional forecasts

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Downscaling improves skill, BUT global forecasts are also skillful and can even be better due to availability of much larger ensembles.

Brodie et al. (in prep)

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Widespread impacts of marine heatwaves

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Smith et al. (2021)

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Leveraging forecasts in the North American Multimodel Ensemble...

NMME

Below

Above

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Prob fcst

PAC calib. prob fcst

NMME prob fcst SST IC=202211 for lead 6 2023 May

SON

https://www.cpc.ncep.noaa.gov/products/NMME/

...to create seasonal marine heatwave forecasts

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Example forecasts

Forecast Heatwave Probability

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Jacox et al. (2022)

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Example forecasts

Forecast Heatwave Probability

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Jacox et al. (2022)

Marine heatwave forecast skill

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Jacox et al. (2022)

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Web-based marine heatwave forecasts

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Phys	sical Sciences	Laboratory	/	About	People	Research	Data	Products
Overview	Observation	Forecasts	Large Marine Ecosystems	E	xplore	PSL Papers	Data	News
Initial year		Initial month	Projection	n				
2022	× -	Oct	× 👻 robinsor	n		× -		

Marine Heatwave (MHW) Forecast [Jacox et al., 2022] Derived from : NMME

Lead time = 0.5 months (10/2022)

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	News Events Learn Q					
/S	Links					
	How to use this forecast tool?					
Remove long-term temperature trends?						
	MHW probability • 0-10% • 10-20% • 20-30% • 30-40% • 40-50% • 50-60%					

60-70% 70-80% 80-90% 90-100%

+11.5

Built on output from the North American Multi-model Ensemble

>70-member ensemble, using six global climate models

Forecasts issued monthly

Lead times up to one year

Current and past forecasts online

https://psl.noaa.gov/marine-heatwaves/#forecasts

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Priority advancements in forecasting for marine ecosystem management

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Improve	e mechanistic und	derstanding	
Coastal Waves		Physical Processe Biogeochemical at	es
Persistence Sea-Ice Proce	sses		
Baroclinic Ros	Re-emergence sby Waves		
Advection			
Tropical-Extrat	ropical Connections		
Biogeochemic	al Response to Physical Forcing		
Species Respo	onses to Environmental Change		
	Species Life History		
nonth	6 months	∎ 1 year	2 year

Facilitate uptake of climate information

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