Overview of ocean wildlife conservation issues & emerging responses

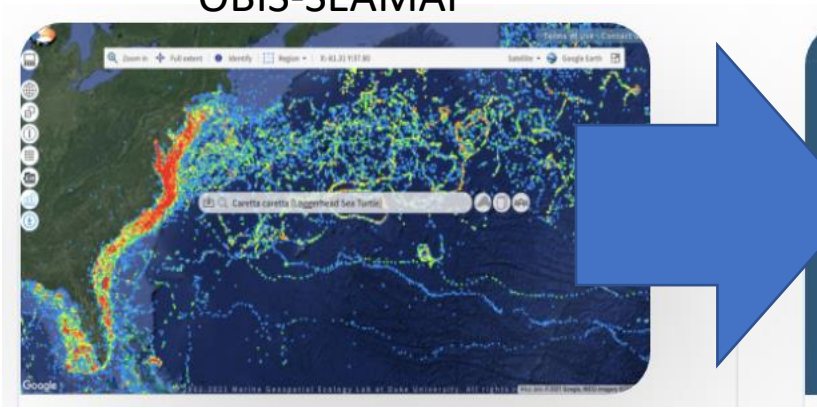
Mid-Atlantic Ocean Forum
Mid-Atlantic Ocean Wildlife: Charting a Course for Biodiversity Conservation

Patrick Halpin
Marine Geospatial Ecology Lab
Duke University
May 18, 2023

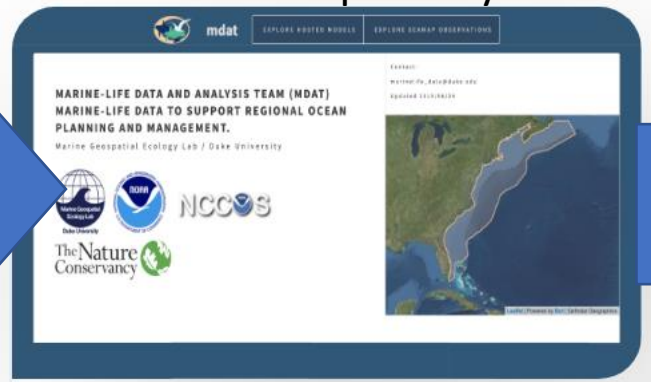
We have a long history of working in the Mid-Atlantic region

Marine Geospatial Ecology Lab · Duke University

OBIS-SEAMAP



Model Repository

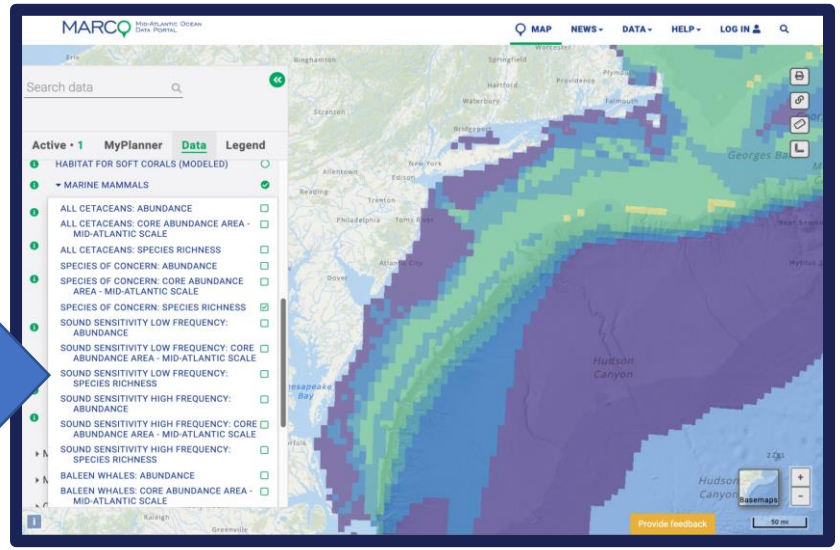


(US Navy, NOAA...)

(CSSF...)

Marinelife Data Analysis Team

MDAT **Mid-Atlantic data portal**



WILDLIFE AND OFFSHORE WIND WOW

(DoE & BOEM)

RWSC

Regional Wildlife Science Collaborative for Offshore Wind

Topics:

Emerging Ocean Wildlife Issues / needs:

- The blue economy / blue acceleration
- Cumulative impacts assessment
- Climate change
- Net gain / net positive impacts

Emerging research directions/products:

- Space/time species overlap & persistence
- Joint models
- Transboundary models
- Near-realtime monitoring/forecasting

PUBLISHED: 24 JANUARY 2017 | VOLUME: 1 | ARTICLE NUMBER: 0017

comment

Making sure the blue economy is green

Jay S. Golden, John Virdin, Douglas Nowacek, Patrick Halpin, Lori Bennear and Pawan G. Patil

Given the growing and seemingly limitless capacity to industrialize the oceans, there is a need to reimagine how to effectively measure, monitor and sustainably manage this seventy-one per cent of the Earth's surface.

*With the rapid acceleration of the Blue Economy in the US Mid-Atlantic we need to **decouple** the past link between increasing ocean use and increasing habitat degradation and wildlife impacts*

of islands for human habitation, our capacity to industrialize the oceans seems limitless.

By 2030, provision of protein for a rapidly growing population will result in two out of three fish on our plates probably farmed at sea; by 2050, seaborne trade will have quadrupled, and marine mining is likely to move from the continental shelf to the deep sea[4,5]. In 1980 offshore oil and gas production provided 20% of consumption needs. By 2014 it had risen to 30% and is expected to grow further as most of the new discoveries globally are primarily offshore, in waters three kilometres deep. Compare this with one kilometre just 20 years ago[6].

As our capacity to industrialize the ocean grows, our capacity to govern ocean use is becoming stretched (Fig. 1). Increased industrialization challenges the traditional paradigm of jurisdictional control of waters and seabed features within national exclusive economic zones (EEZs) 200 nautical miles from the coast and limited controls in international waters known as areas beyond national jurisdiction (ABNJs). This strain is currently becoming apparent in three different spheres: (1) nations' capacity to govern the waters within their EEZs; (2) the international community's

economy is broadly defined and used in a range of different contexts, we refer to the imperative for a sustainable ocean economy, where economic activity is in balance with the long-term carrying capacity of ocean ecosystems[9]. If a blue economy is to emerge, where economic and ecological considerations are much more closely intertwined, we suggest the following policy

extension of EEZ boundaries (for example, the South China Sea) or through extended continental shelf claims (for example, the Arctic and elsewhere). A second response is the development of a new and legally binding implementation agreement for the sustainable management of ocean biodiversity under the Law of the Sea (UNCLOS). In 2015 the UN General

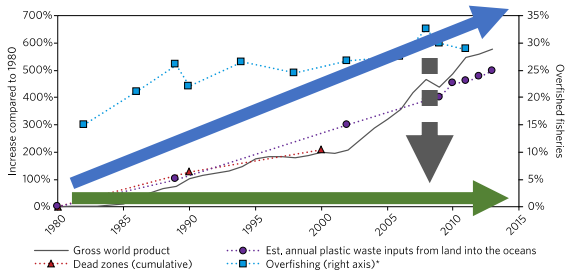


Figure 1 | Can they decouple? Trends in gross world product, overfishing and ocean pollution. *Percentage of assessed fish stocks that are fished at biologically unsustainable levels according to FAO[16,23].

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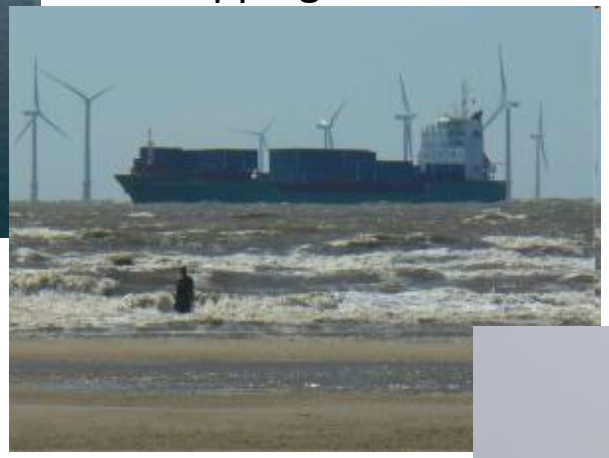
Golden, J., J. Virdin, D. Nowacek, P.N. Halpin, L. Bennear, and P.G. Patil. (*2017*) A Watershed Moment for the Industrialization of Oceans: Making sure the Blue Economy is "Green". *Nature Ecology & Evolution* 1:0017

Marine spatial planning

...but not just multi-sector planning we need to move to a better framework for ***cumulative impact assessments***

Offshore energy sector

Shipping sector



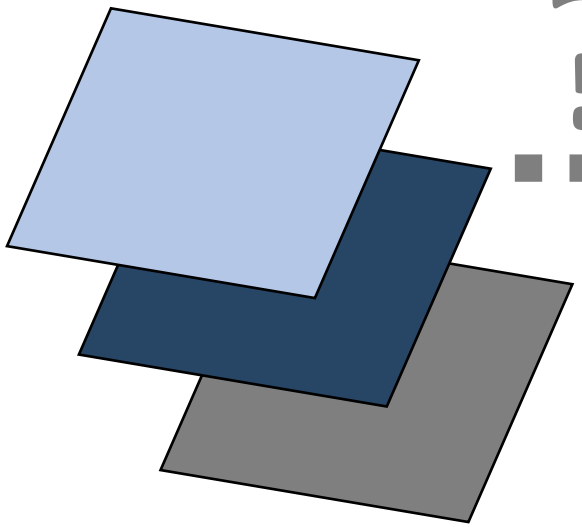
Fisheries sector

...what are the ***new data*** we will need to conduct multi-sector cumulative impacts assessments?

A necessary move from ***single sector*** to ***multi-sector planning***

Cumulative impacts assessment frameworks

Will require detailing the complex linkages between ocean use **pressures** and the **ecosystem components**



Spatial data overlays

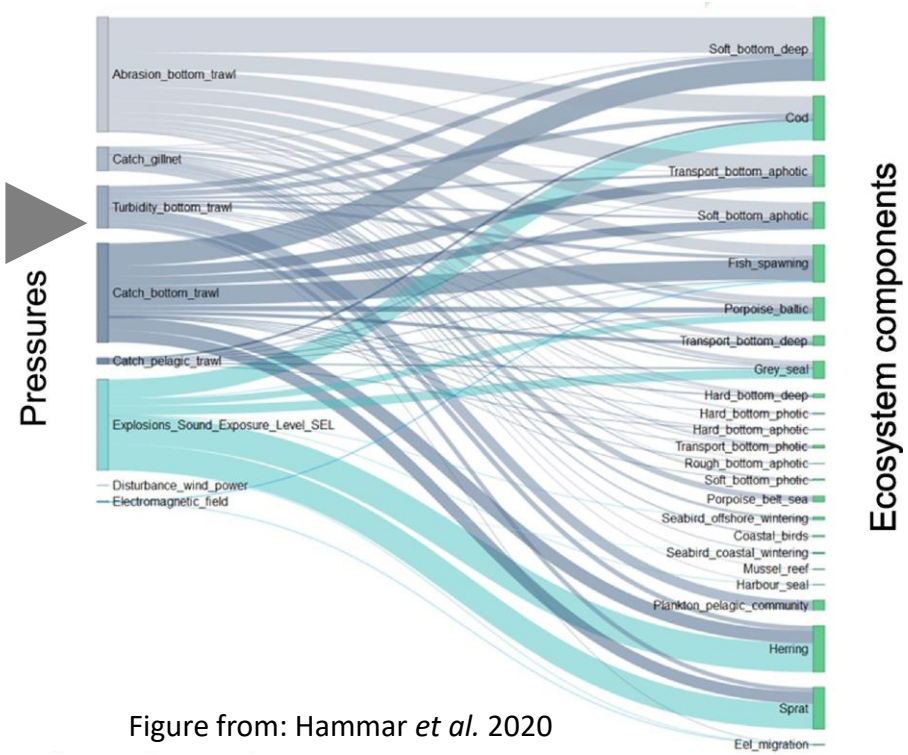


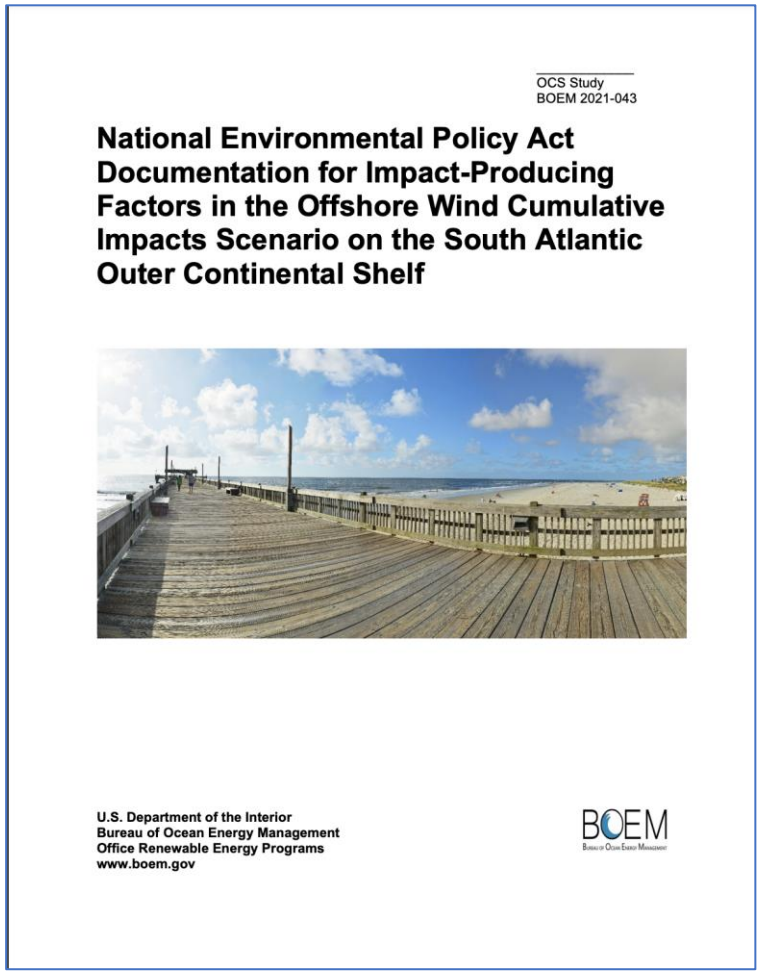
Figure from: Hammar *et al.* 2020

Assessment of the reduction in pressures on ecosystem components for an environmental plan

Cumulative impacts

*We will need move from identifying factors to **quantify** these relationships…*

IPFs = Impact Producing Factors


OCS Study
BOEM 2021-043

National Environmental Policy Act Documentation for Impact-Producing Factors in the Offshore Wind Cumulative Impacts Scenario on the South Atlantic Outer Continental Shelf

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office Renewable Energy Programs
www.boem.gov

BOEM

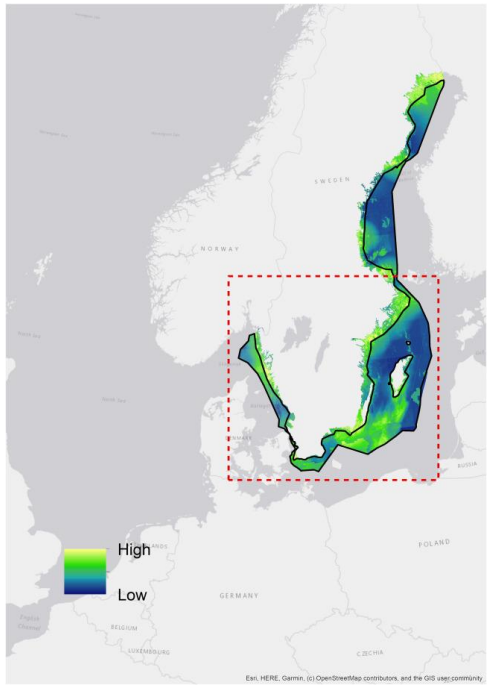
Table 4-11. Cumulative Impacts Scenario IPFs – Marine Mammals

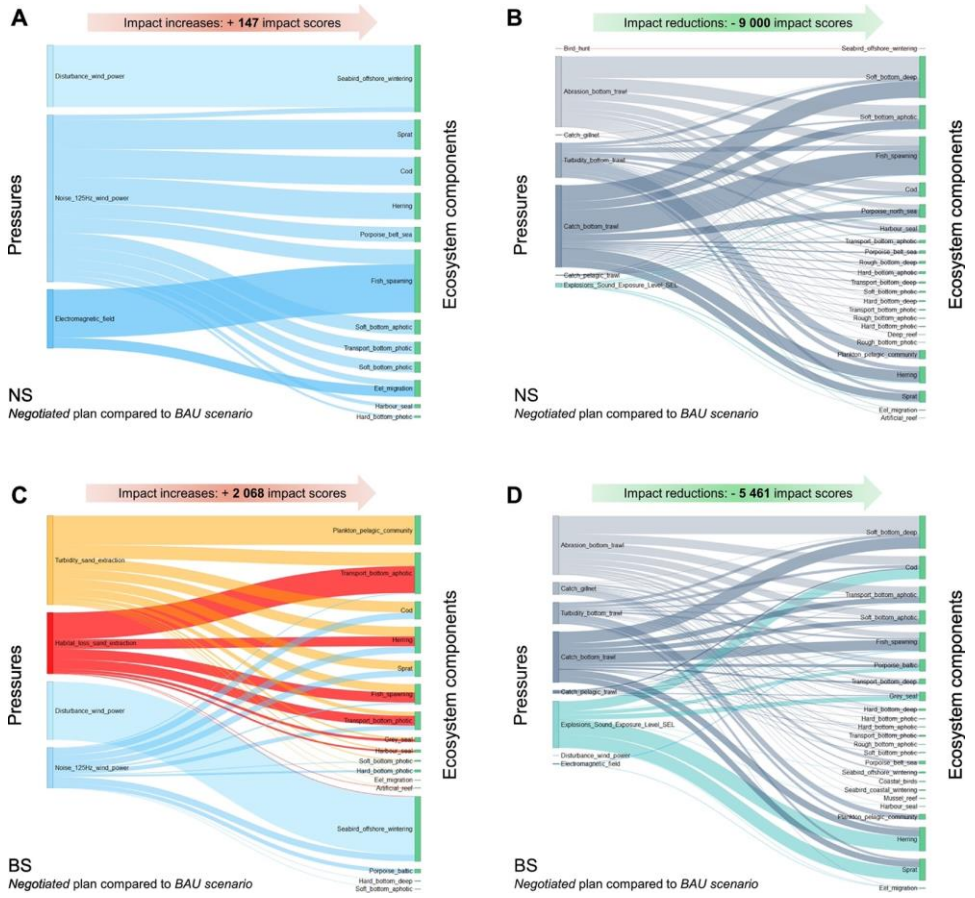
	Dredge Material Ocean Disposal	Commercial and Recreational Fishing	Land Use /Coastal Infrastructure	Marine Minerals Extraction	Marine Transportation, Navigation, and Traffic	Military Ranges & Civilian Space Program Uses	Oil and Gas Surveys and Extraction	Renewable Energy-Wind	Submarine Cables, Lines, & Pipelines	Climate Change
Offshore Wind Energy Development IPFs										
Accidental releases	●	●	●	●	●	●	●	●	●	
Discharges	●	●	●	●	●	●	●	●	●	
Electromagnetic fields								●	●	●
Energy generation, energy security								●		●
Light		●	●		●	●	●	●		
New cable emplacement/maintenance								●	●	●
Noise	●	●	●	●	●	●	●	●	●	
Port utilization	●				●		●	●		●
Presence of structures			●			●	●	●	●	●
Traffic	●	●	●	●	●	●	●	●	●	
Cumulative Impact Scenario, Other IPFs										
Demolition/structure removal						●	●			
Energy stressors/devices/lasers						●				
Gear utilization		●		●		●				●
Ingestion						●				
Ocean acidification										●
Pipeline trenching							●			
Resource exploitation		●								●
Warming and sea level rise										●

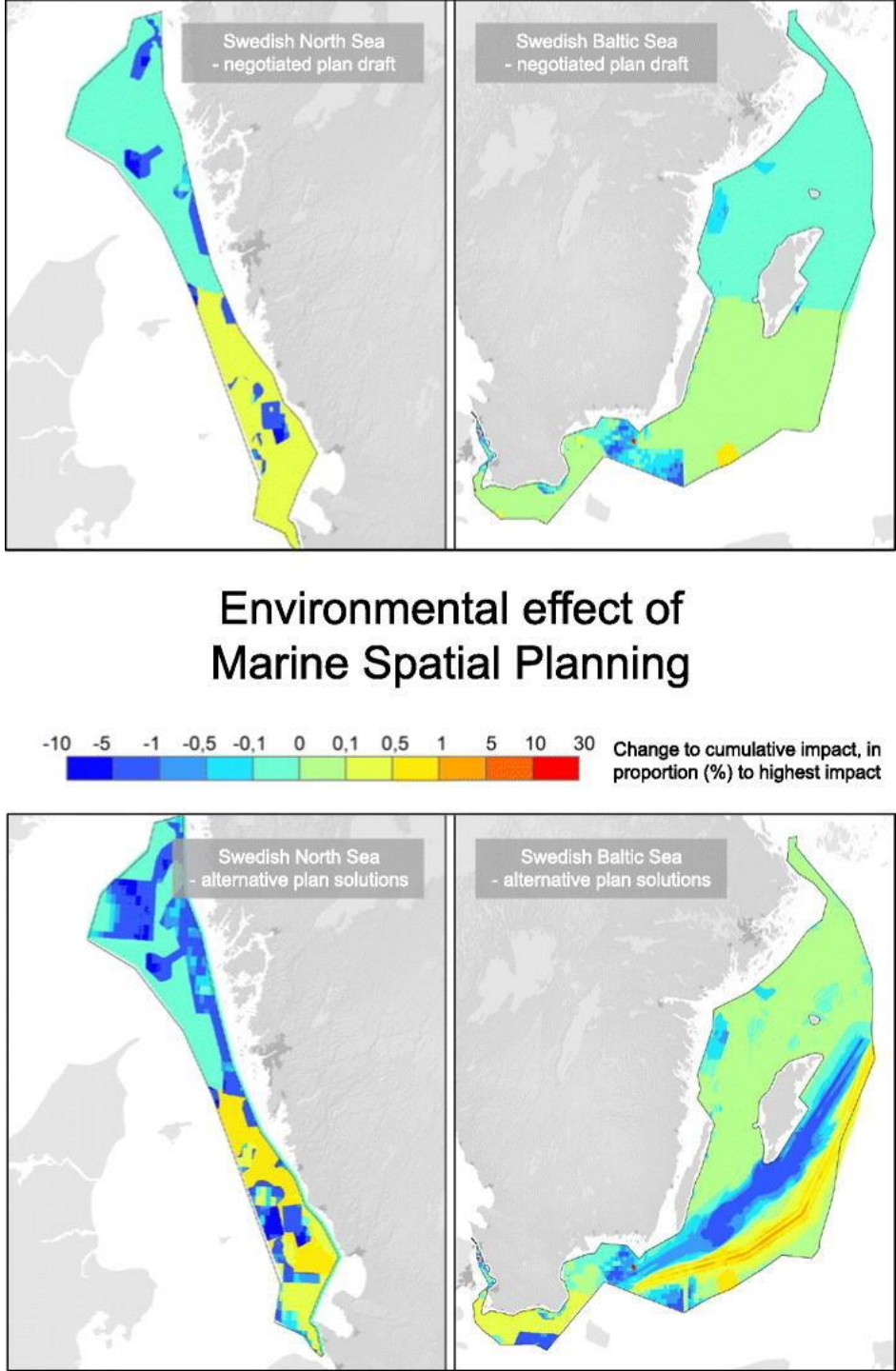
https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Impact-Producing-Factors-in-the-Offshore-Wind-Cumulative-Impacts-Scenario-on-the-South-Atlantic.pdf

Cumulative impacts

Examples emerging from Sweden (North Sea & Baltic Sea) and other regions...







Hammar *et al.* 2020

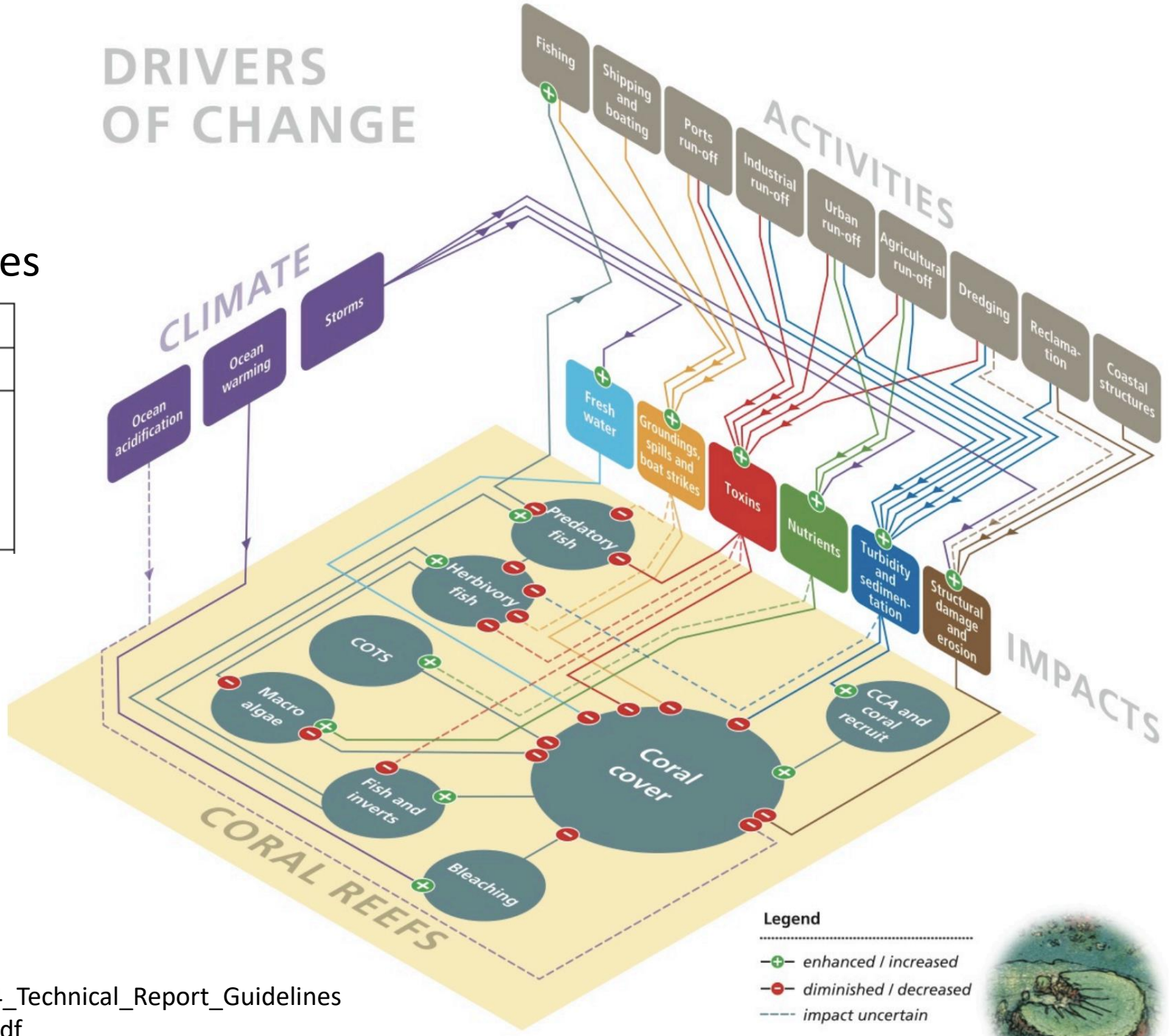
https://www.sciencedirect.com/science/article/pii/S0048969720325419

Cumulative impacts

Directed graph modeling approaches

Complexity of cause-effect relationship				
None[1]	Simple[2]	Directed[3]	Diffuse[4]	Feedback[5]
P = I	P → I	P → V → I	P → V → I, V → I	P → V → I, P → V → I, P → V

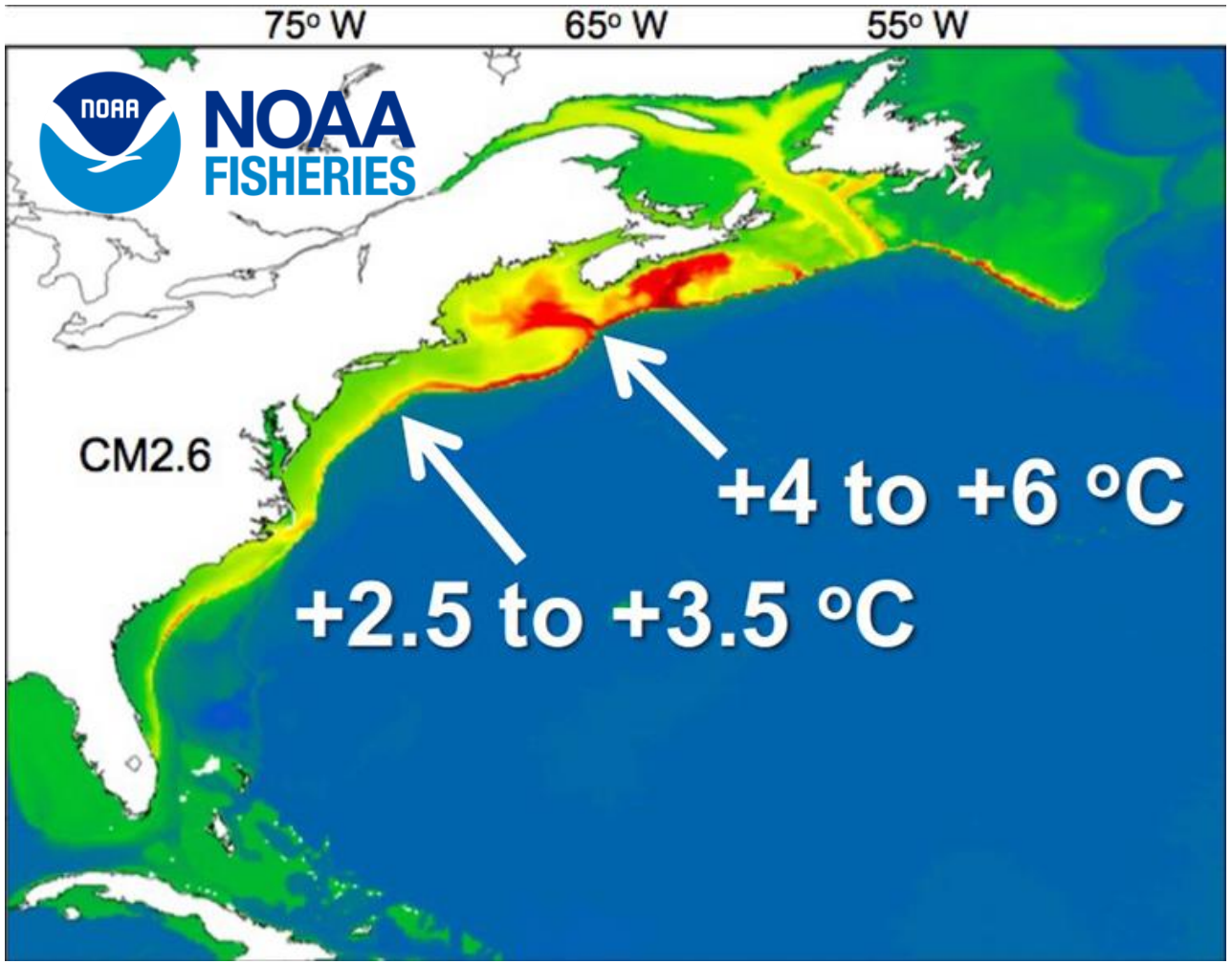
Marine Biodiversity Hub
CSIRO Australia



Dunstan, P. et al. 2021
https://www.nespmarine.edu.au/system/files/Dunstan_E1_M4_Technical_Report_Guidelines_for_analysis_of_cumulative_impacts_updated_Jan%202021.pdf

Climate change

While we need to look at multi-sector, cumulative impacts we will also need to:



- **Anticipate** climatic change impacts on ecosystems & species distributions;
- Cleary **discern** what change is a climatic impact *vs.* an ocean use impact

Example 1: do we now need to model the distribution of North Atlantic Right Whales across both US and Canadian waters?

Example 2: are observed shifts in a species distribution the result of displacement from offshore development or climatic change?

https://www.fisheries.noaa.gov/event/outreach-climate-change-scenario-planning

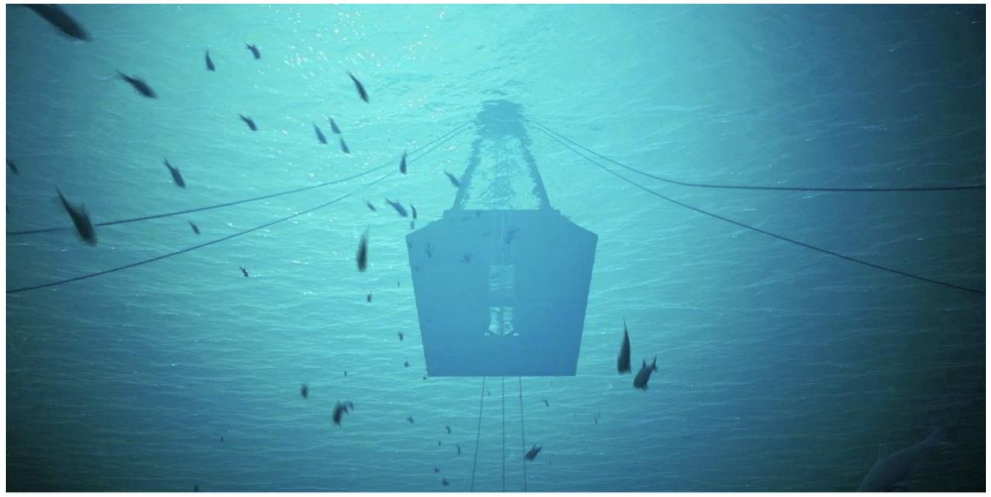
Net gain / net positive

New policy goals…

ECOWind UK program

Net gain – a policy measure defined as "an approach to development that aims to leave the natural environment in a ***measurably better*** state than beforehand".

What data baselines and future analysis frameworks will we need to measure this?



'Net-positive offshore wind key to tackling interlinked energy and climate crises': Orsted-WWF

Roger Williams University School of Law

ACADEMICS ADMISSION STUDENT EXPERIENCE FACULTY WHY RWU LAW?

For COVID-19 information, visit Reopening Roger ›

Home | Events | Marine Law Symposium

Marine Law Symposium

THU APR 20

11:30am - 5:00pm

RWU Law Bristol Campus

Registration Required

Can Offshore Wind Development Have a Net Positive Impact on Biodiversity? Regulatory and Scientific Perspectives and Considerations

Thursday, April 20, 2023 - Program Begins at 11:30 AM

MARINE LAW SYMPOSIUM

Topics:

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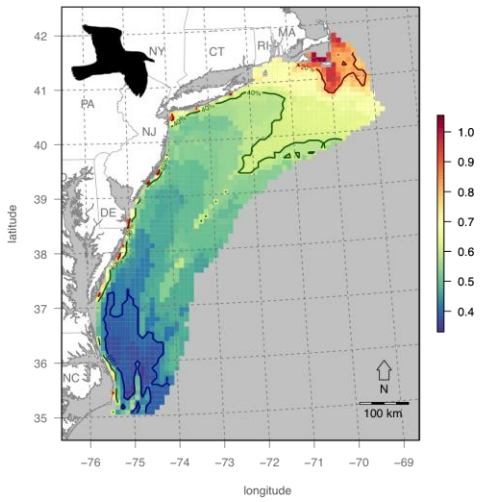
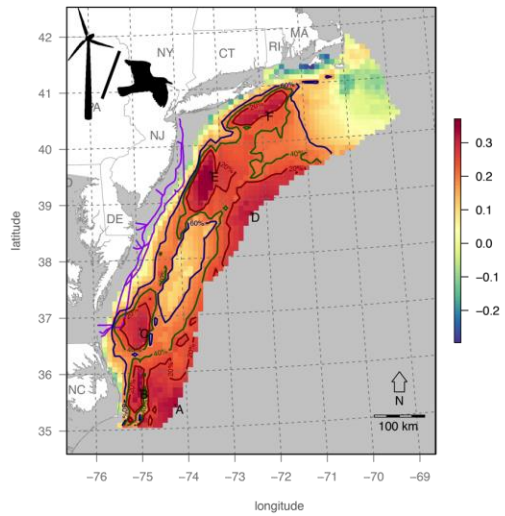
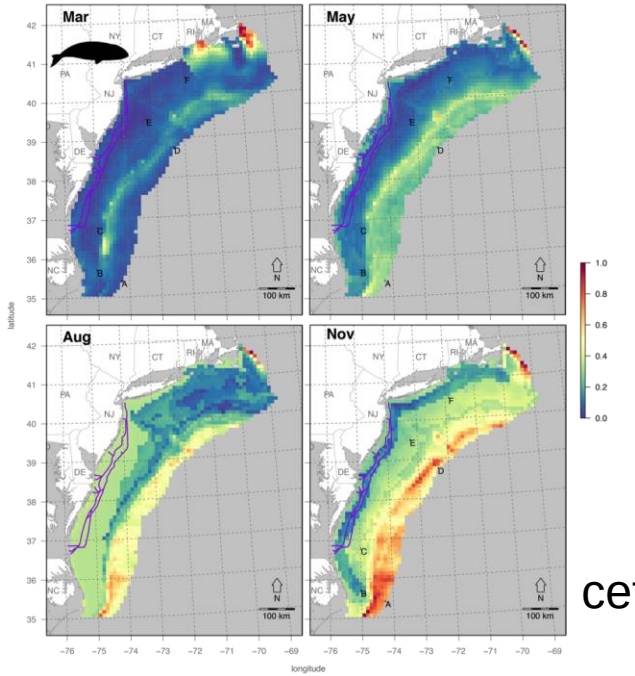
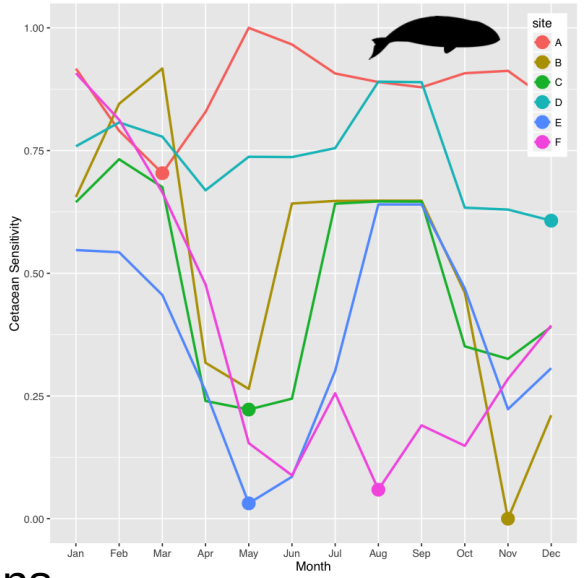
Space/time species overlap & persistence



seabirds: year-round interactions



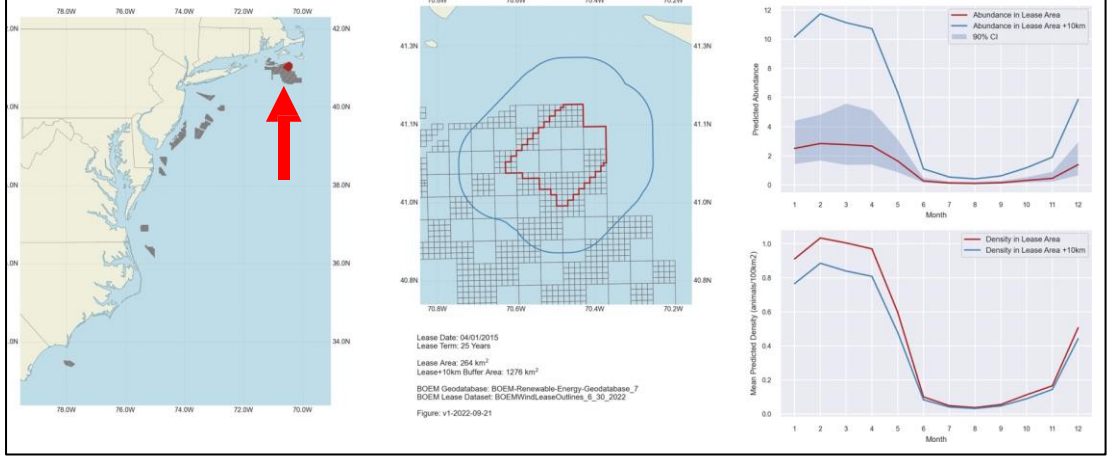




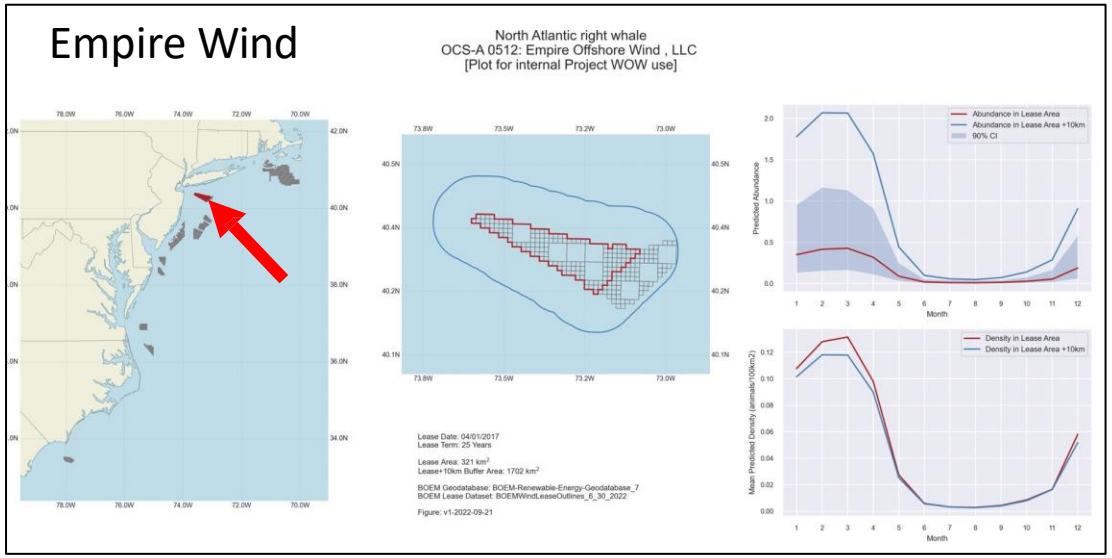
cetaceans: construction interactions

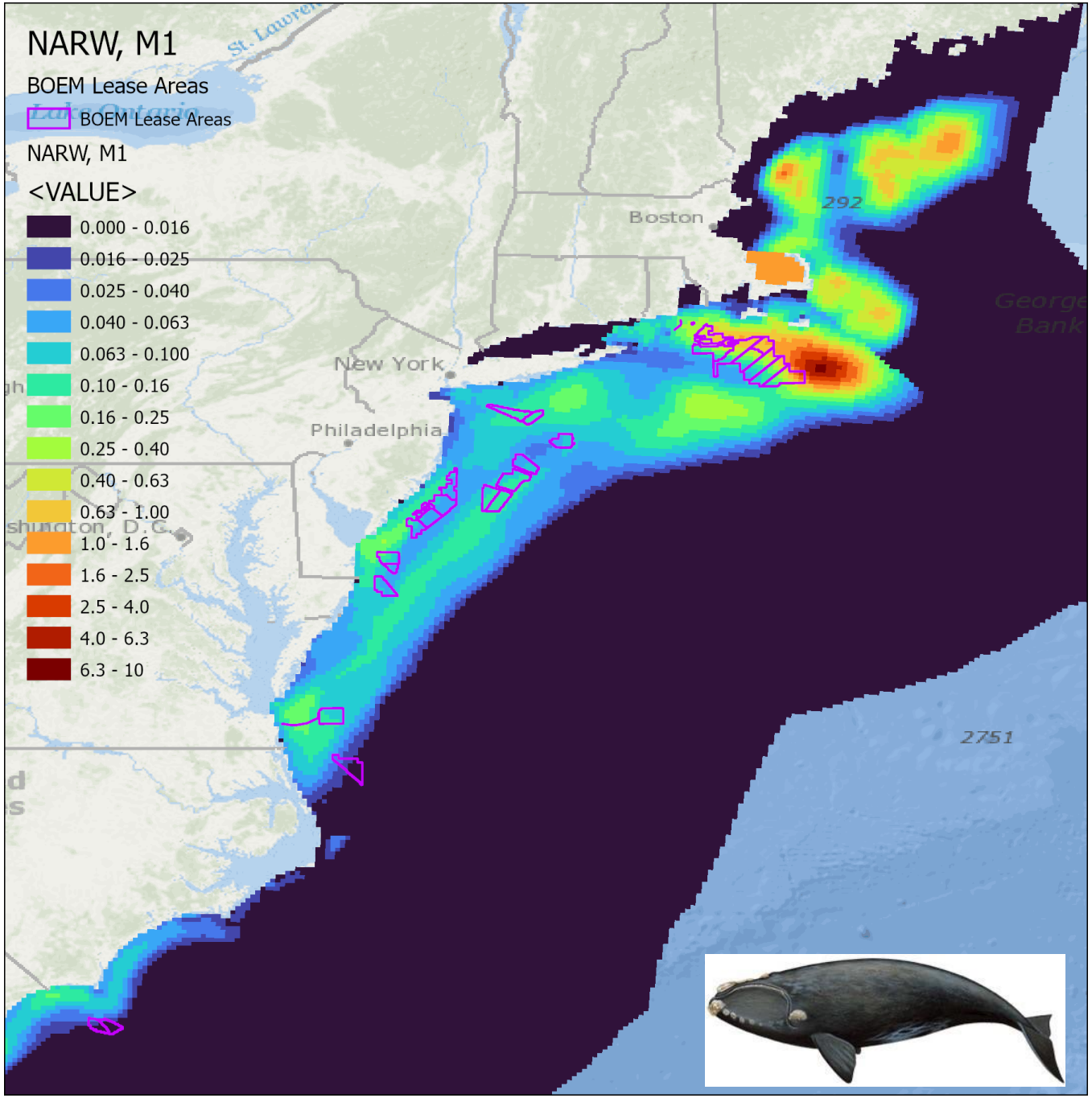
North Atlantic Right Whale

Vineyard Wind



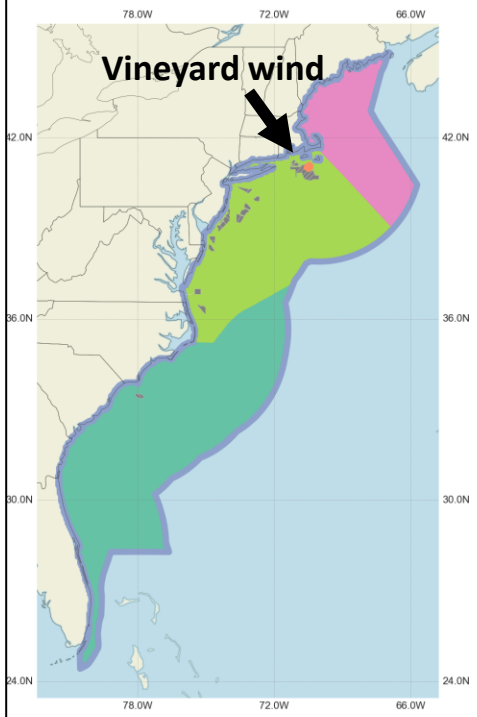
Empire Wind

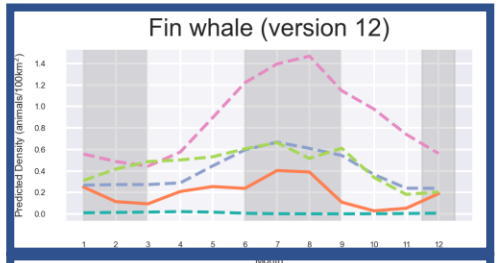


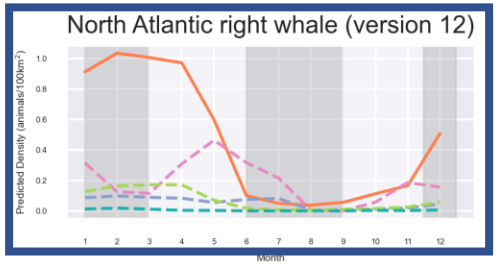


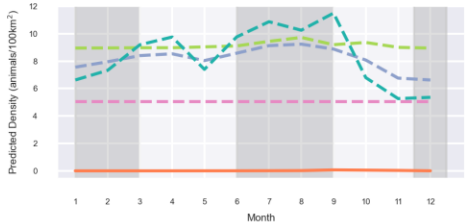
Roberts et al. 2022 in prep

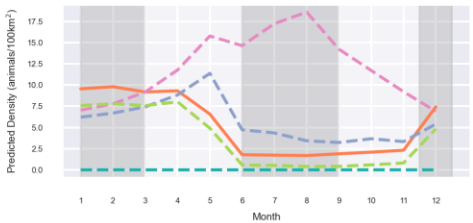
OCS-A 0501: Vineyard Wind 1 LLC
[Plot for internal Project WOW use]
Figure: 2023-03-24

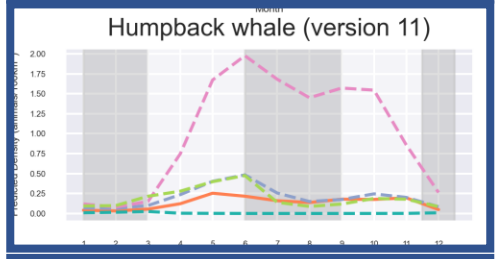


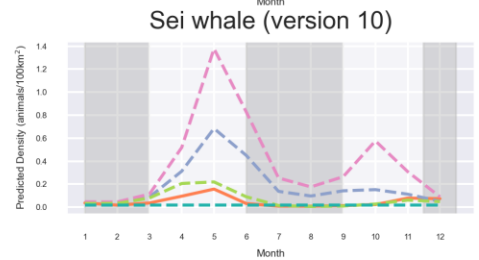


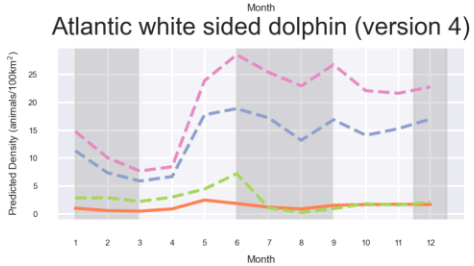


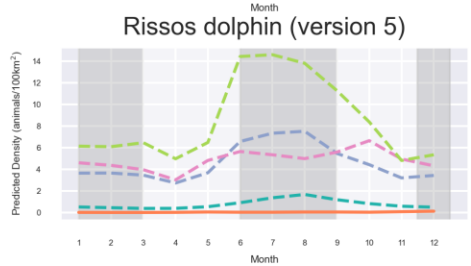


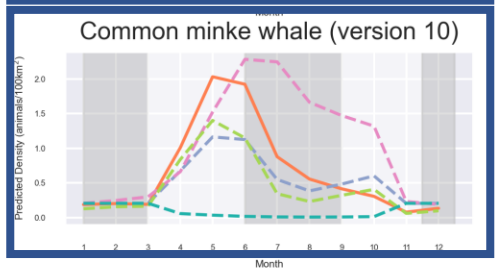


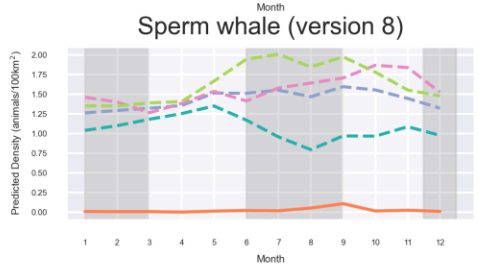


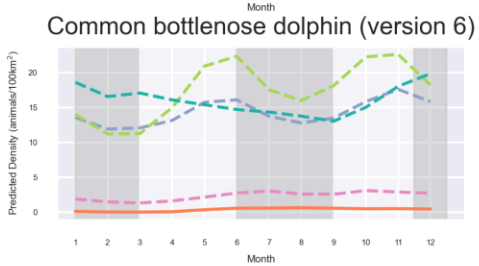


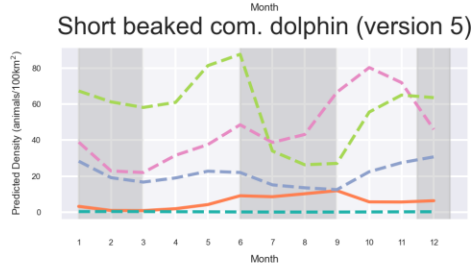


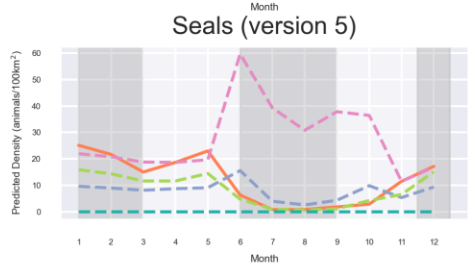












Legend

- Lease Area
- Total Coast 90th Percentile
- Gulf of Maine 90th Percentile
- Mid-Atlantic 90th Percentile
- Southeast 90th Percentile

Lease Date: 04/01/2015
Lease Term: 25 Years
Lease Area: 264 km^2

BOEM Geodatabase: BOEM-Renewable-Energy-Geodatabase_7
BOEM Lease Dataset: BOEMWindLeaseOutlines_11_2_2022

Marine mammal density & abundance data: Duke-MGEL habitat based models
Roberts, J., Best, B., Mannocci, L. et al. Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Sci Rep6, 22615 (2016). https://doi.org/10.1038/srep22615

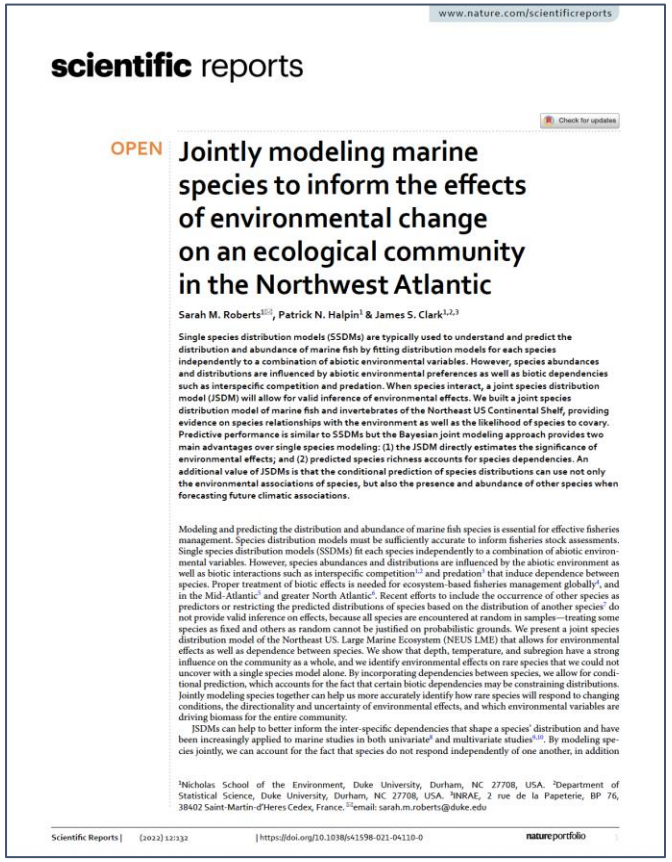
Version # refers to Roberts et al. release version. https://seamap.env.duke.edu/models/Duke/EC/

The boundaries used were provided by J. Roberts and reflect the same partitions used in those models.

WILDLIFE AND OFFSHORE WIND
WOW

Joint modelling

Joint Species Distribution Models (JSDM) of fish species from trawl surveys



www.nature.com/scientificreports

scientific reports

OPEN

Jointly modeling marine species to inform the effects of environmental change on an ecological community in the Northwest Atlantic

Sarah M. Roberts[1,2], Patrick N. Halpin[1] & James S. Clark[1,2,3]

Single species distribution models (SSDMs) are typically used to understand and predict the distribution and abundance of marine fish by fitting distribution models for each species independently to a combination of abiotic environmental variables. However, species abundances and distributions are influenced by abiotic environmental preferences as well as biotic dependencies such as interspecific competition and predation. When species interact, a joint species distribution model (JSDM) will allow for valid inference of environmental effects. We built a joint species distribution model of marine fish and invertebrates of the Northeast US Continental Shelf, providing evidence on species relationships with the environment as well as the likelihood of species to covary. Predictive performance is similar to SSDMs but the Bayesian joint modeling approach provides two main advantages over single species modeling: (1) the JSDM directly estimates the significance of environmental effects; and (2) predicted species richness accounts for species dependencies. An additional value of JSDMs is that the conditional prediction of species distributions can use not only the environmental associations of species, but also the presence and abundance of other species when forecasting future climatic associations.

Modeling and predicting the distribution and abundance of marine fish species is essential for effective fisheries management. Species distribution models must be sufficiently accurate to inform fisheries stock assessments. Single species distribution models (SSDMs) fit each species independently to a combination of abiotic environmental variables. However, species abundances and distributions are influenced by the abiotic environment as well as biotic interactions such as interspecific competition[1,2] and predation[3] that induce dependence between species. Proper treatment of biotic effects is needed for ecosystem-based fisheries management globally[4], and in the Mid-Atlantic[5] and greater North Atlantic[6]. Recent efforts to include the occurrence of other species as predictors or restricting the predicted distributions of species based on the distribution of another species[7] do not provide valid inference on effects, because all species are encountered at random in samples—treating some species as fixed and others as random cannot be justified on probabilistic grounds. We present a joint species distribution model of the Northeast US. Large Marine Ecosystem (NEUS LME) that allows for environmental effects as well as dependence between species. We show that depth, temperature, and subregion have a strong influence on the community as a whole, and we identify environmental effects on rare species that we could not uncover with a single species model alone. By incorporating dependencies between species, we allow for conditional prediction, which accounts for the fact that certain biotic dependencies may be constraining distributions. Jointly modeling species together can help us more accurately identify how rare species will respond to changing conditions, the directionality and uncertainty of environmental effects, and which environmental variables are driving biomass for the entire community.

JSDMs can help to better inform the inter-specific dependencies that shape a species' distribution and have been increasingly applied to marine studies in both univariate[8] and multivariate studies[9,10]. By modeling species jointly, we can account for the fact that species do not respond independently of one another, in addition

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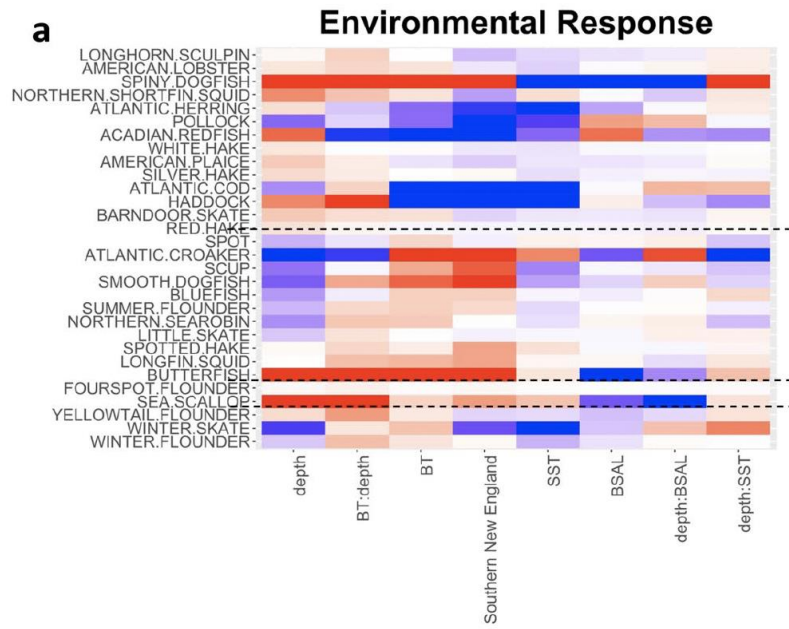
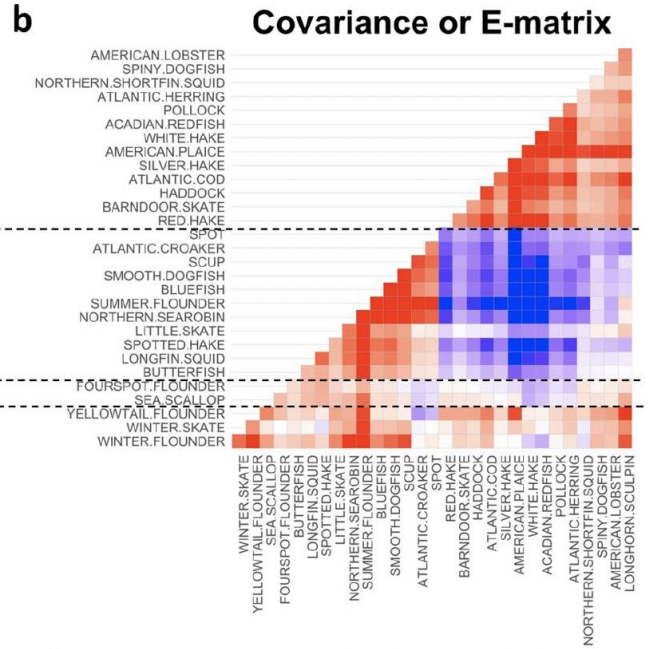
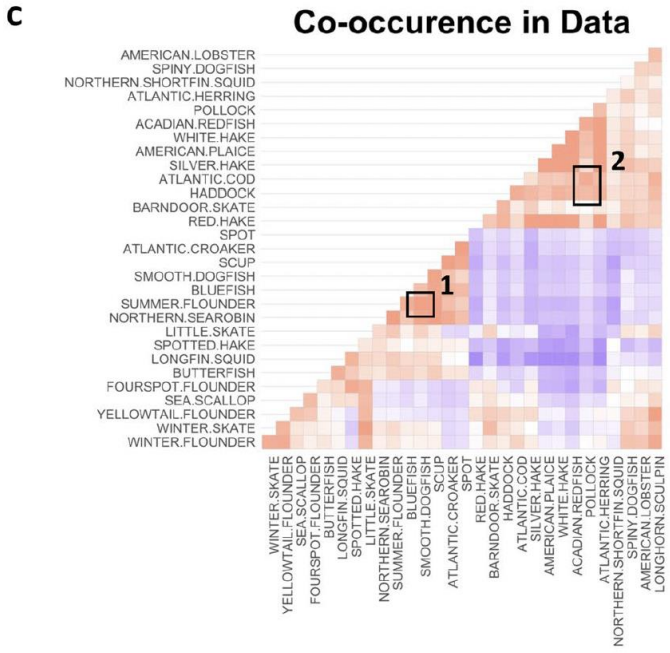
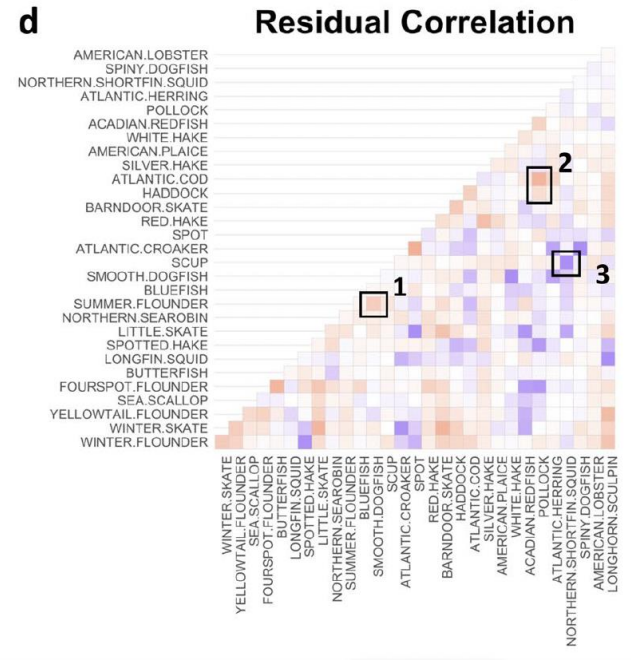
Scientific Reports | (2022) 12:132 | https://doi.org/10.1038/s41598-021-04110-0 nature portfolio









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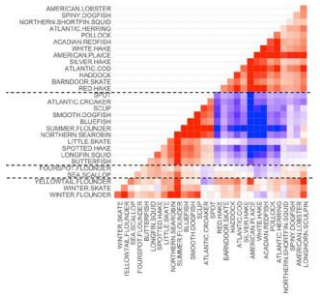
30 species fall & 24 species spring (due to availability of environmental covariates)

Joint modelling



Bayesian joint modeling provides two main advantages:

(1) the JSDM directly estimates the ***significance of environmental effects***; and

(2) predicted species richness accounts for ***species dependencies***.

An additional value of JSDMs is that the conditional prediction of species distributions can use not only the environmental associations of species, but also the ***presence and abundance of other species when forecasting future climatic associations***.

Joint models also allow us to look at ***predator & prey*** interaction across taxa (e.g. linking marine mammals and fish prey)

Roberts, S. et al. (in review) Tight spatial coupling of a marine predator with soniferous fishes: using joint modeling to aid in ecosystem approaches to management

Joint modelling

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Northeast Regional Marine Fish Habitat Assessment

Overview

The Northeast Regional Marine Fish Habitat Assessment (NRHA) is a collaborative, multi-disciplinary effort to describe and characterize estuarine, coastal, and offshore fish habitat distribution, abundance, and quality in the Northeast. The project aims to align habitat science goals and prior
develop habitat science products that support an assessment. The
leadership from the major habitat conservation, restoration, and sc

This project is oriented around four core actions:

1. **Abundance and trends in habitat types in the inshore area.** of habitat types utilized by the focus species and quantify the habitats. It will also compile metrics that may inform an asses
2. **Habitat vulnerability.** This action will involve Council and Co participation in, the NOAA Habitat Climate Vulnerability Asse habitat experts to examine fish habitat vulnerability to climat
3. **Spatial descriptions of species habitat use in the offshore a** empirical approaches to identify, predict, and map habitat us quantify changes in habitat use over time (e.g. seasonal, annu
4. **Habitat data visualization and decision support tool.** Habita publicly accessible decision support tool, making this informa location, extent, and use throughout the region, and provide developed by the assessment.

NRHA joint modeling efforts

CBFM: Community-level Basis Function model

- **Methods manuscript** (MEE)
  - Simulation studies
  - Comparison to LVMs
- **R package**
  - Github repository
  - June Public release

GitHub

Spatio-Temporal Joint Species Distribution Modeling:
A Community-Level Basis Function Approach

Francis K.C. Hui*[1], David I. Warton[2], Scott D. Foster[3], Nicole A. Hill[4], and Christopher R. Haak[5]

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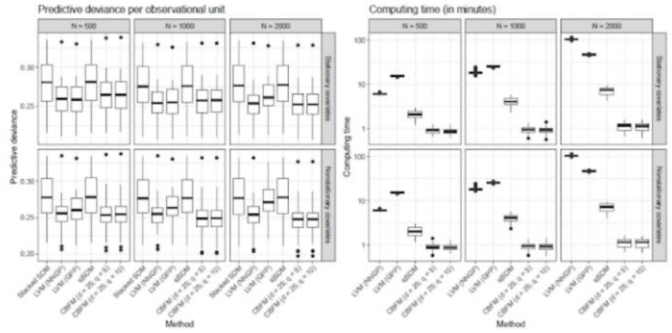
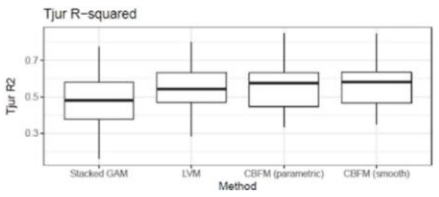
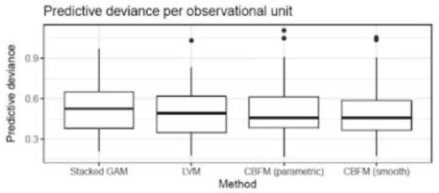




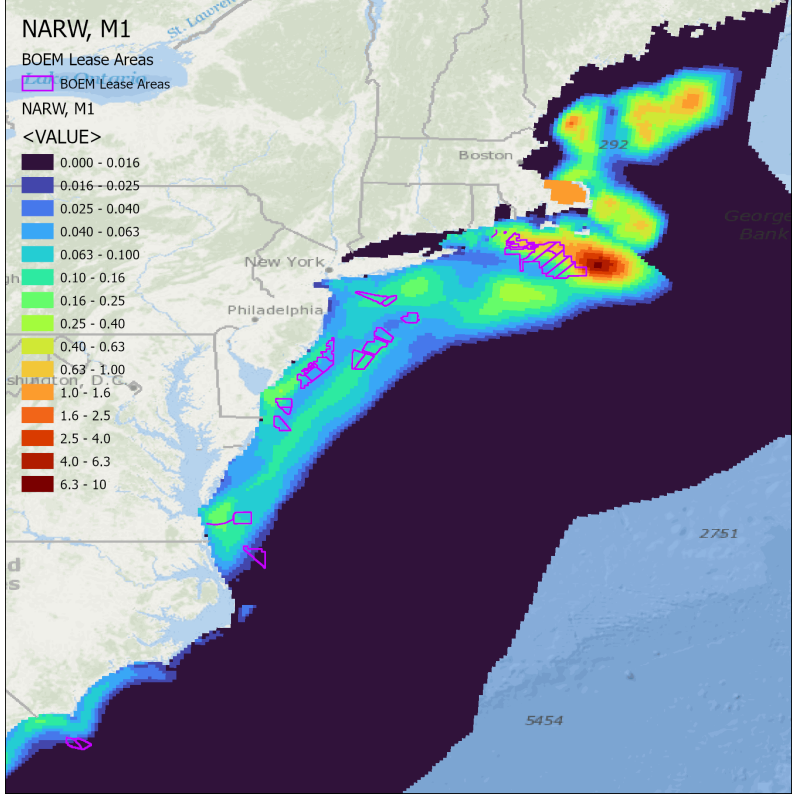


Transboundary Species Distribution Modeling

North Atlantic Right Whale
Transboundary Species Distribution Modeling Workshop

5-7 December 2022, Montreal, Canada

Objective: The overall goal of this workshop is to initiate the development of species distribution models for the North Atlantic right whale that span the full range of the species. This requires collaboration between scientific experts in the U.S. and Canada, and pooling of data collected in both regions into a single model, or, alternatively, the joining of models built independently for both regions. By "species distribution models", we mean empirical models, fitted to data, that yield maps that estimate some numerical parameter such as density (whales km^{-2}) or occupancy (probability one or more whales are present) that quantifies how the population is distributed across the seascape through time (e.g., monthly). Ultimately, we hope to start collaborations that yield models that span the full range of the species distribution across U.S. and Canadian waters.



Research questions:

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Fisheries and Oceans Canada

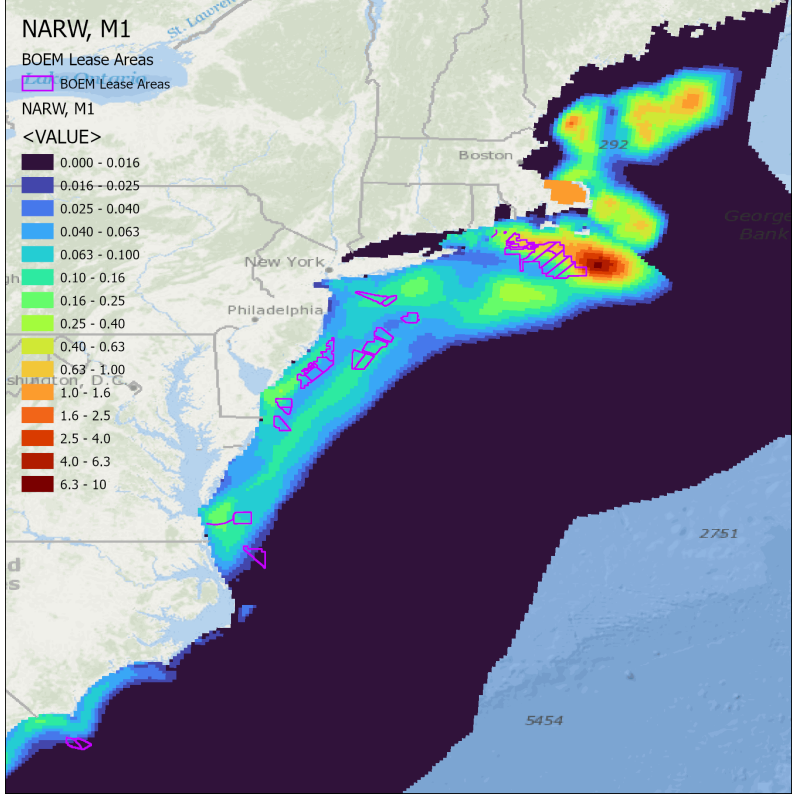
- Density surface models answer management questions that require absolute density estimates. The **"missing whales"** issue can directly help develop more robust density estimates.
- Are there **alternative modeling approaches** that will be more amenable to the current data status across both regions?
- Do we have **comparable data** to support the development of density surface models across each region?
- Are there **significant differences in expected covariates or modeling sub-dom**ains that we would expect to see for different regions in the US and CA?

Nowcasting/short-term forecasting

Current marine mammal (Roberts *et al.* 2022) and seabird (NOAA NCOS 2023 – in review) species distribution models operate at a ***monthly time-step*** (if sufficient data is available).

We are turning our attention to the development of prototypes for ***nowcasting/short-term forecasting*** methods to augment these modeling frameworks for critical marine mammal species.

This new prototype modeling framework will require ***assimilation*** of near-real-time observation data and oceanographic covariates.



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Topics:

Emerging Ocean Wildlife Issues / needs:

- The blue economy / blue acceleration
- Cumulative impacts assessment
- Climate change
- Net gain / net positive impacts

Emerging research directions/products:

- Space/time species overlap & persistence
- Joint models
- Transboundary models
- Near-realtime monitoring/forecasting

What are the ***data needs*** and new ***approaches*** we will need to deploy into the future?

Discussion?