



**NOAA
FISHERIES**

Northeast Fisheries Science Center

Offshore Wind Development and the Structure and Function of Marine Ecosystems

Jon Hare and Andy Lipsky - Northeast Fisheries Science Center

21 September 2023

NOAA National MPA Center and OCTO



NOAA FISHERIES

Acknowledgements

There is large number of people who have contributed to this talk and to the ideas presented. Acknowledgment of these individuals does not imply their endorsement of this presentation.

Elizabeth Methratta

Chris Orphanides

Angela Silva

Kathryn Ford

Sean Hayes

Libby Jewett

Chris Meadows

Lisa Pfeiffer

Karen Abrams

Doug Christal

Nick Sisson

Sue Tuxbury

Diane Borggaard

Jaclyn Daly

Eric Patterson

Katie Renshaw

Scott Farley

Lea Tyhach

Brad Blythe

Brian Hooker

Mike Rasser

Brandon Jensen

Desray Reeb

Jill Lewandowski

Ursula Howson

and many more ...

Outline

1. Offshore Wind Energy Development
2. NOAA Fisheries Role
3. Marine Ecosystem Science
4. Complex Socio-Ecological Systems



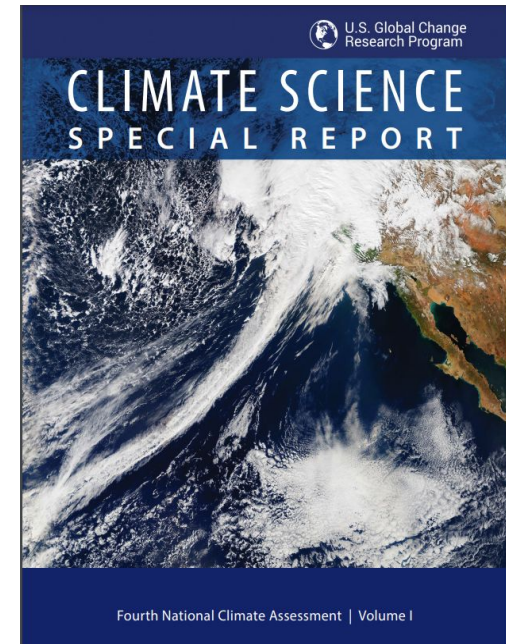
<https://www.vineyardwind.com/press-releases/2023/11/investment-in-us-based-bubble-curtain-supplier>

<https://www.providencejournal.com/story/news/2021/08/14/block-island-offshore-wind-farm-offline-two-months-due-to-maintenance-and-safety-concerns/8122841002/>

Offshore Wind Energy Development

Offshore wind energy development:

- plays an role in mitigating climate change
- represents a domestic renewable energy source
- abundant & located near load centers



<https://science2017.globalchange.gov/>

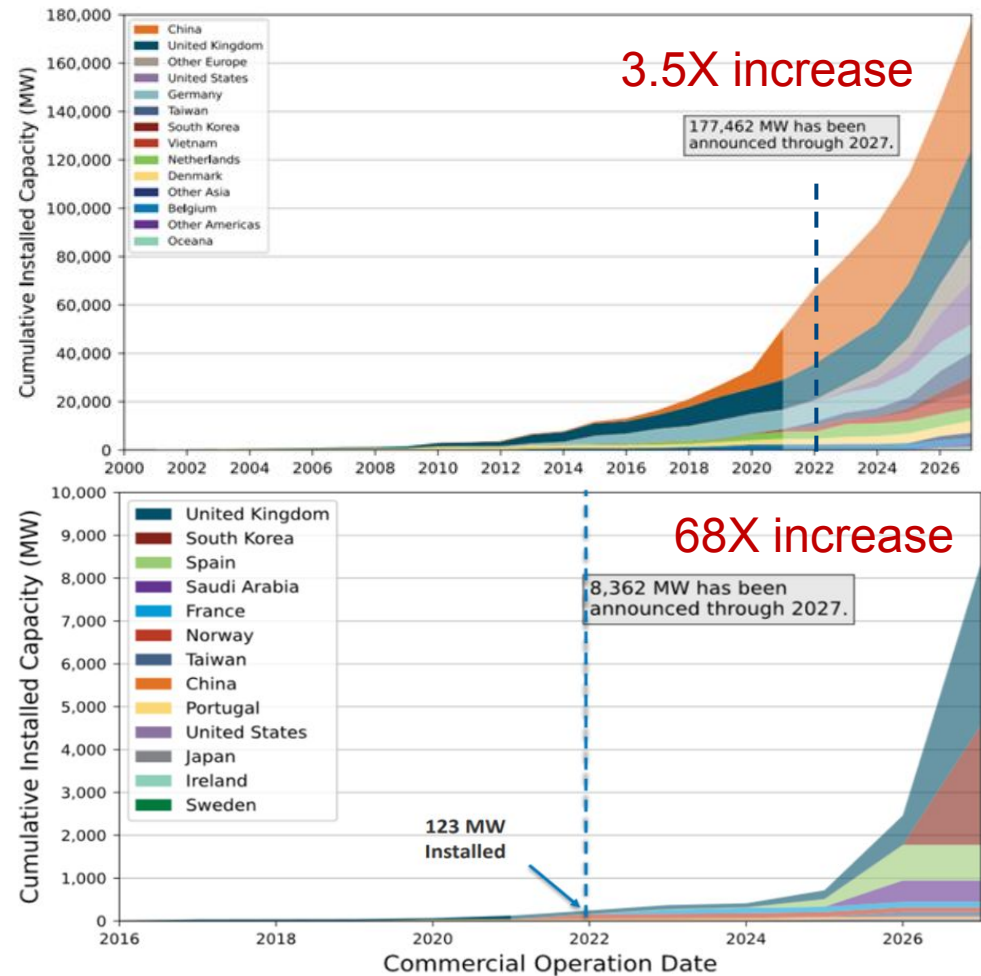
<https://www.boem.gov/renewable-energy/renewable-energy-program-overview>

<https://cleanpower.org/resources/federal-revenue-and-economic-impacts-from-boem-offshore-wind-leasing/>

Offshore Wind Energy Development

Globally:

- capacity from fixed turbines projected to increase 3.5x by 2027
- capacity from floating turbines projects to increase 68x by 2027



https://www.energy.gov/sites/default/files/2022-08/offshore_wind_market_report_2022_ppt_2.pdf

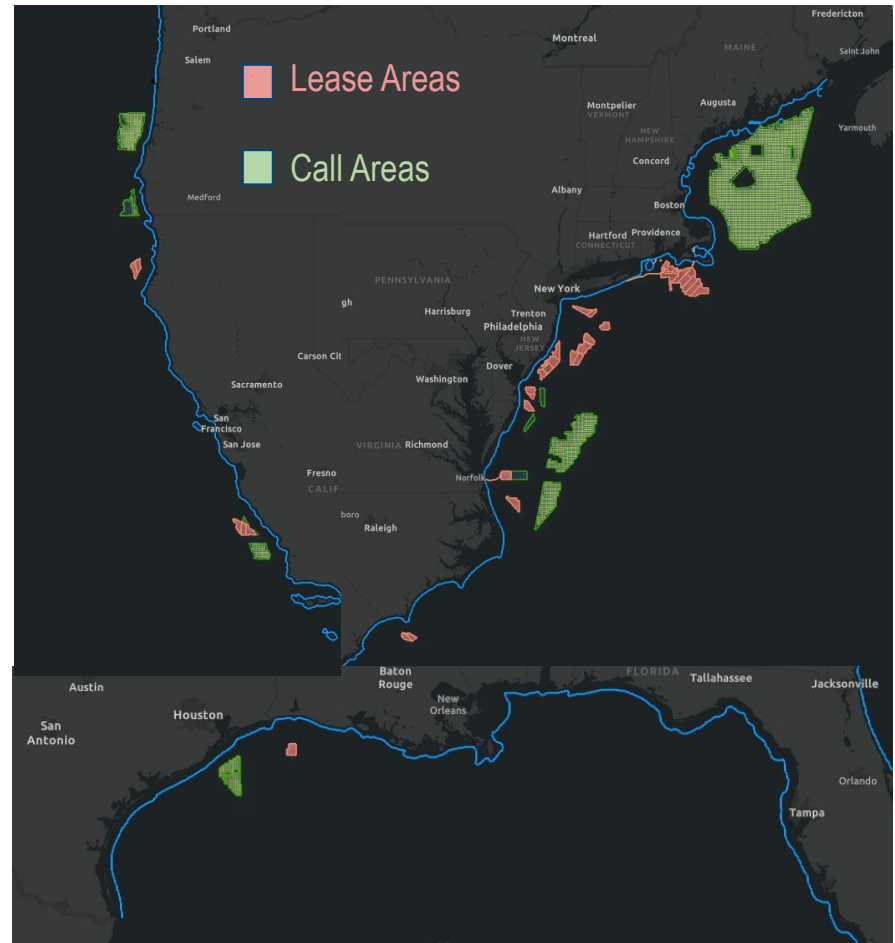
Offshore Wind Energy Development

Nationally:

- development underway or planned in Northeast, Southeast, Gulf of Mexico, and West Coast

Eleven states have committed to 100% clean electricity

How these states are providing new lessons and roadmaps for a future powered by 100% clean energy.



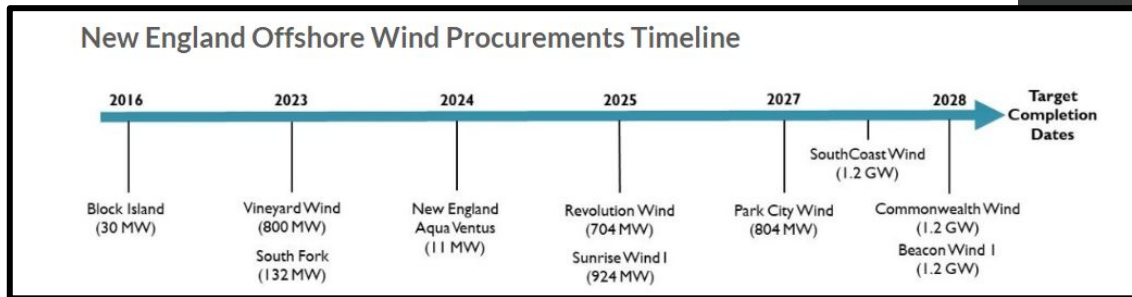
<https://boem.maps.arcgis.com/apps/instant/sidebar/index.html?appid=e2079773d85b43059abf15a16bce7aa7&%3Blocale=en>

<https://environmentamerica.org/articles/eleven-states-have-committed-to-100-clean-electricity/>

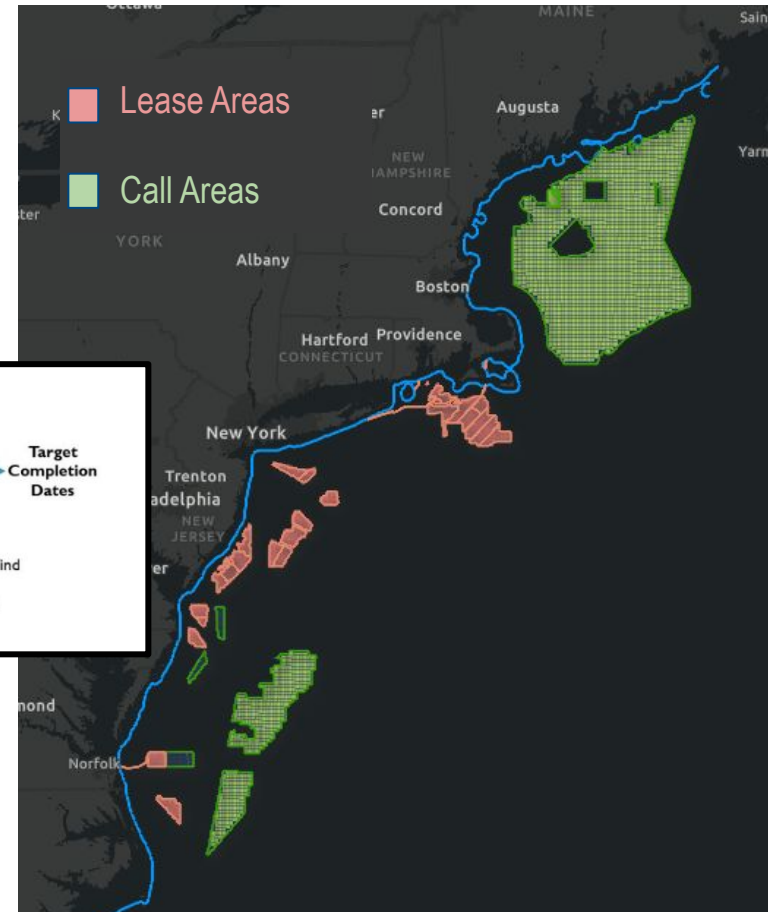
Offshore Wind Energy Development

Northeast Region:

- leading the way for offshore wind energy in the U.S.



Pace and scale is challenging regionally, nationally, and globally



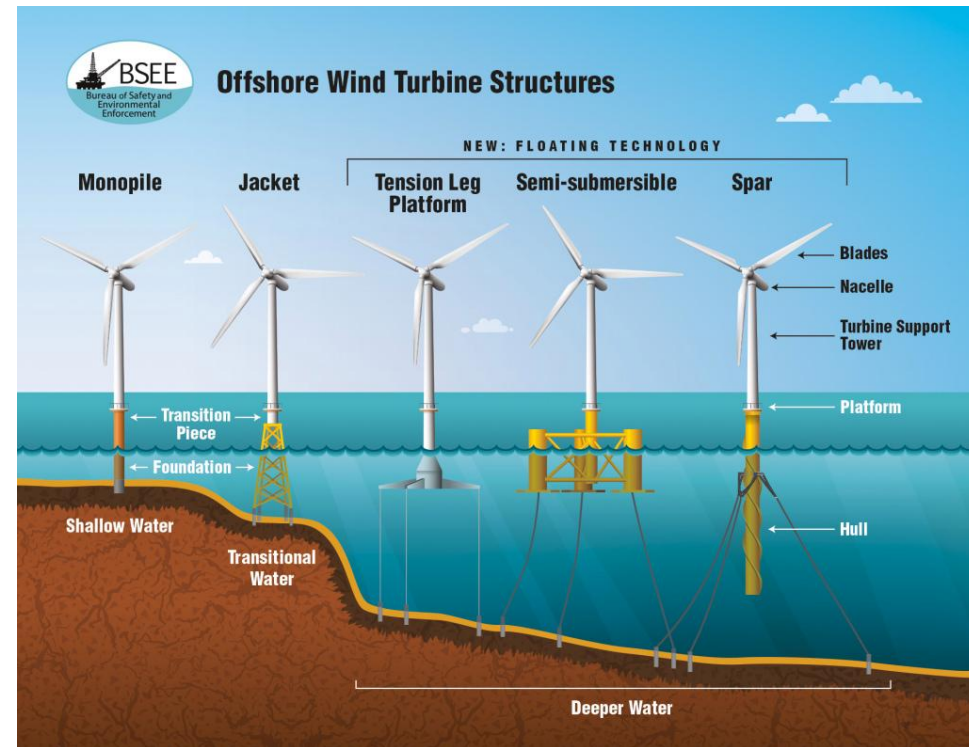
<https://www.northeastoceansdata.org/updated-maps-of-offshore-wind-leases-and-planning-areas/>

<https://www.newenglandforoffshorewind.org/states/overview/>

Offshore Wind Energy Development

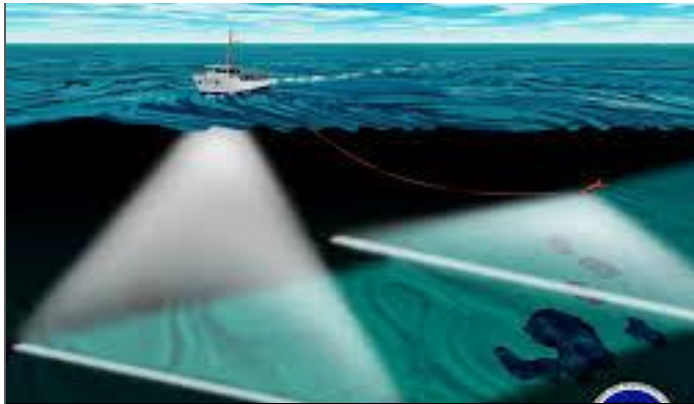
Turbine Technology

- Fixed
 - $\leq 60\text{m}$
 - Monopiles and jackets
 - Currently most common
- Floating
 - $>60\text{m}$
 - planned for West Coast, Gulf of Maine
 - In use in Scotland, Portugal, and Norway



Offshore Wind Energy Development

Stages of Development



Pre-construction - 2-4 years



Construction - 2-3 years



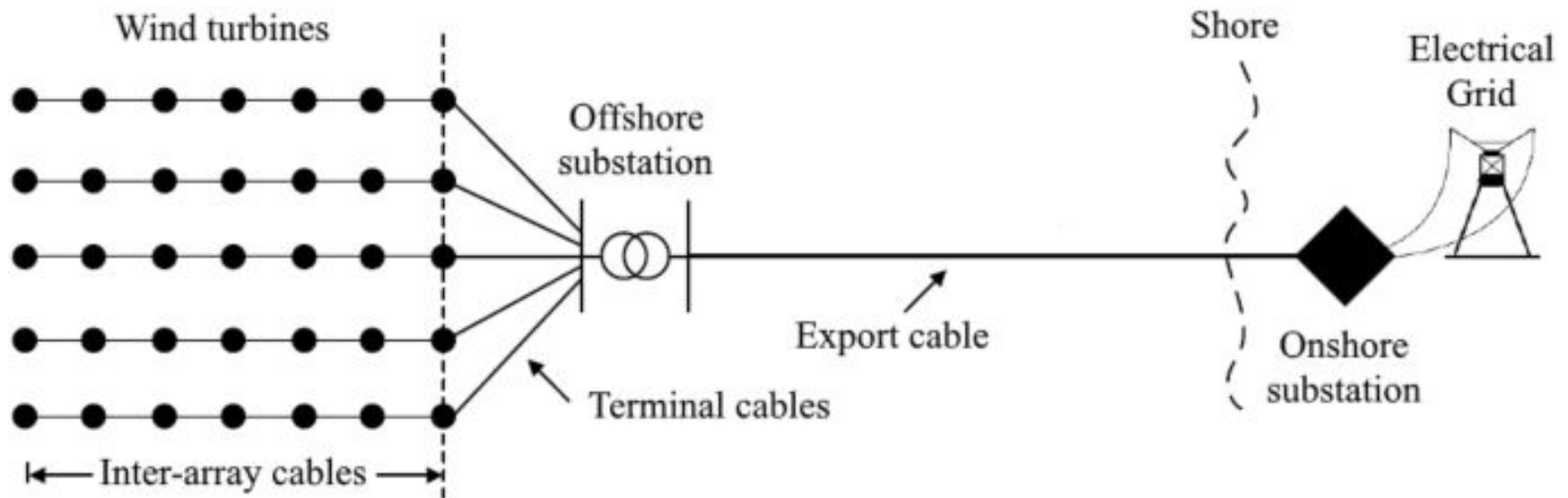
Operations - 25-30+ years



Decommissioning - 2-3 years

Offshore Wind Energy Development

Components of Development (more than just turbines)

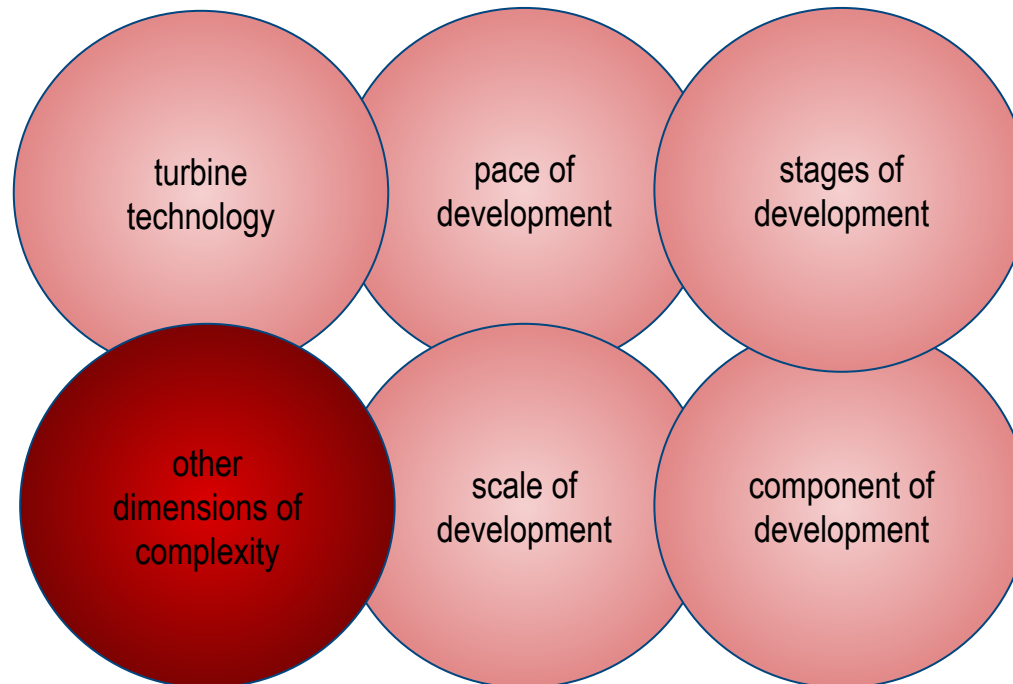


Rentschler et al (2020)

<https://doi.org/10.1007/s40868-020-00071-7>

Offshore Wind Energy Development

Offshore Wind Energy Development is complex



Outline

1. Offshore Wind Energy Development
2. NOAA Fisheries' Role
3. Marine Ecosystem Science
4. Complex Socio-Ecological Systems



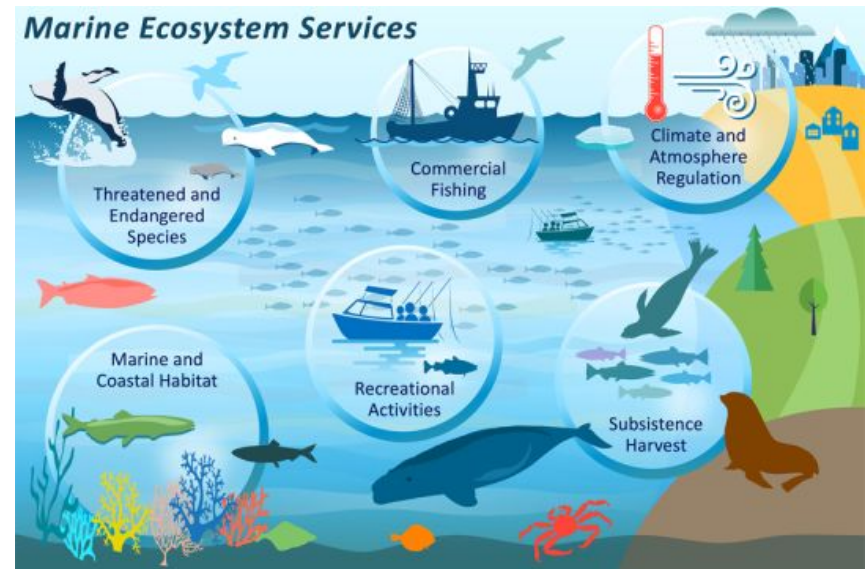
<https://www.fisheries.noaa.gov/species/north-atlantic-right-whale>

<https://www.nationalfisherman.com/national-international/new-bedford-says-wind-boundary-changes-just-a-start>

NOAA Fisheries' Role

NOAA Fisheries is responsible for the stewardship of the nation's ocean resources and their habitat. We provide vital services for the nation, all backed by sound science and an ecosystem-based approach to management:

- Productive and sustainable fisheries
- Safe sources of seafood
- Recovery and conservation of protected resources
- Healthy ecosystems



<https://www.fisheries.noaa.gov/about-us#overview>

<https://www.fisheries.noaa.gov/topic/socioeconomics>

NOAA Fisheries' Role

NOAA's Fisheries authorities come from federal legislation:

- Fish and Wildlife Coordination Act (FWCA)
- National Environmental Policy Act (NEPA)
- Marine Mammal Protection Act (MMPA)
- Endangered Species Act (ESA)
- Magnuson–Stevens Fishery Conservation and Management Act (MSFCMA)
- and more ...



<https://www.fisheries.noaa.gov/feature-story/endangered-species-act-50-years-conserving-species>

<https://www.fisheries.noaa.gov/topic/laws-policies>

NOAA Fisheries' Role

Administration's goal for offshore wind

- To deploy 30 gigawatts (GW) of offshore wind in the United States by 2030, while protecting biodiversity and promoting ocean co-use.



Administration

MARCH 29, 2021

FACT SHEET: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs



▶ BRIEFING ROOM

▶ STATEMENTS AND RELEASES

<https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/>



NOAA FISHERIES

NOAA Fisheries' Role

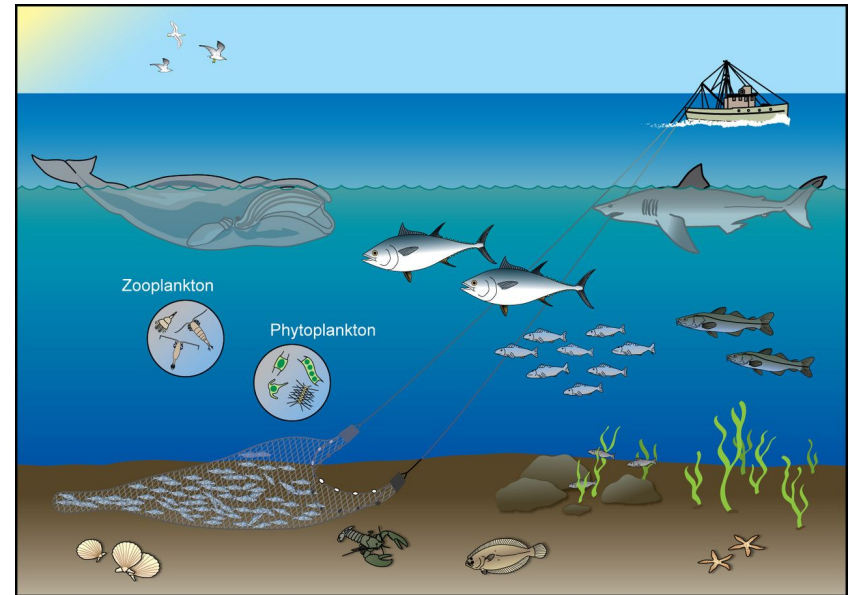
- BOEM is the lead Federal agency and primary decision-maker for offshore wind energy development under the Outer Continental Shelf Lands Act (1953)
- NOAA Fisheries responsible for:
 - Technical Assistance, Comments, Recommendations through **NEPA and FWCA**
 - Section 7 Consultation/Biological Opinion Jeopardy/No Jeopardy decision; if No Jeopardy is found, Incidental Take Statement issued through **ESA**
 - Negligible Impact Determination requirement; when this requirement is met an Incidental Harassment Authorization or a Letter of Authorization is issued through **MMPA**
 - Essential Fish Habitat Conservation Recommendations through **MSFCMA**
 - Scientific support to ensure informed management recommendations and decisions based on best available science in support of **NEPA, FWCA, ESA, MMPA, MSFCMA**

thank you Nick Sisson (NOAA Fisheries) for providing information

NOAA Fisheries' Role

To provide scientific support to ensure informed management recommendations and decisions based on best available science these are the fundamental science questions:

- What are the effects of offshore wind energy development on populations, communities, habitats, and coastal and marine ecosystems - including humans?
- How can this information used in scientific advice and the regulatory process?
- Can adverse effects be avoided, minimized, or compensated?



<https://www.fisheries.noaa.gov/new-england-mid-atlantic/ecosystems/northeast-ecosystem-dynamics-and-assessment-our-research>

NOAA Fisheries' Role

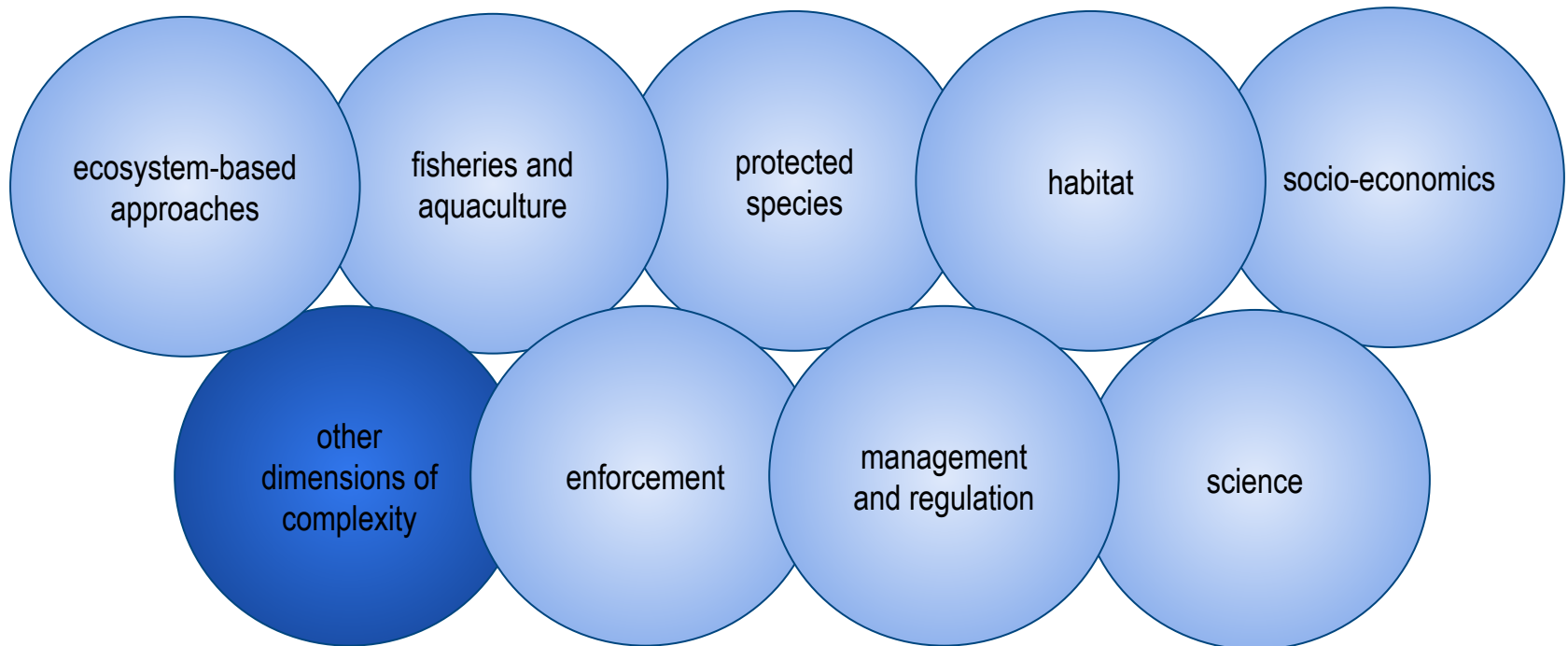
Science to inform Ecosystem-Based Management

- an integrated management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation
- an integrated approach that incorporates the entire ecosystem, including humans, into resource management decisions, and is guided by an adaptive management approach

<https://www.integratedecosystemassessment.noaa.gov/about-iea/ecosystem-based-management>

NOAA Fisheries Role

NOAA Fisheries' Role is complex



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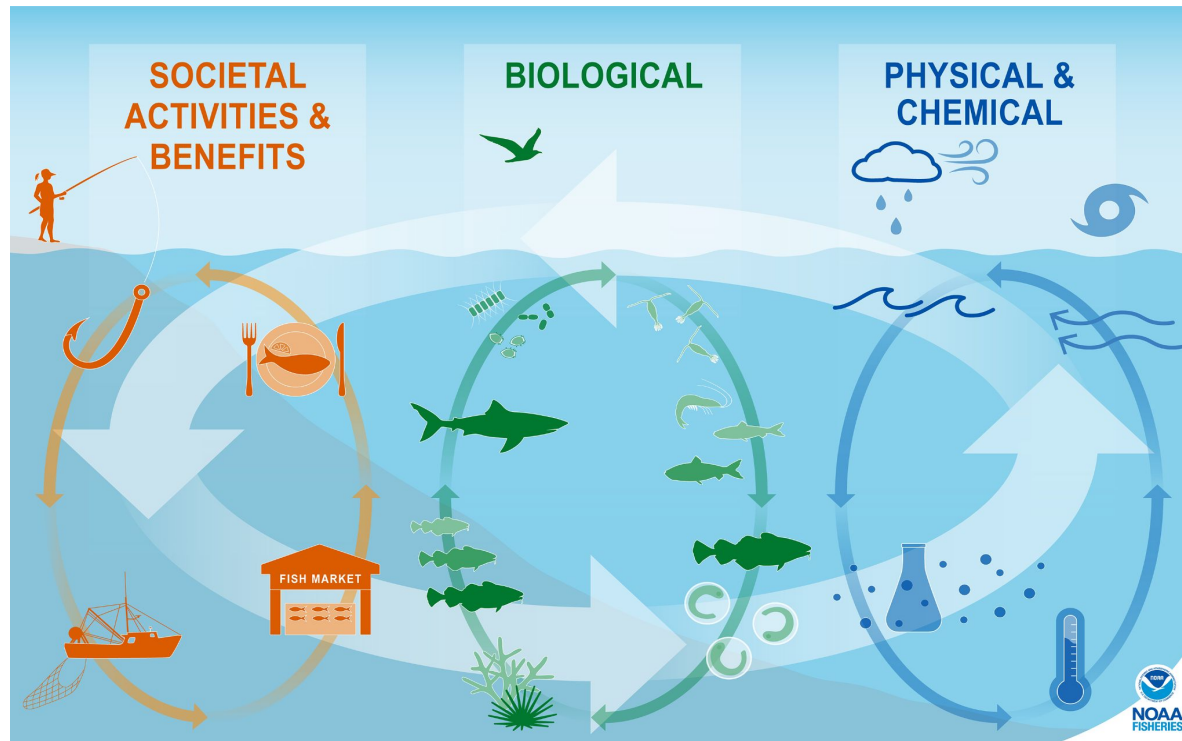


<https://eos.org/features/ocean-terrain-and-the-engineering-challenges-for-offshore-wind-farms>

<https://www.integratedecosystemassessment.noaa.gov/regions/northeast>

Marine Ecosystem Science

Science that promotes an integrated approach that incorporates the entire ecosystem, including humans, into resource management decisions, and is guided by an adaptive management approach



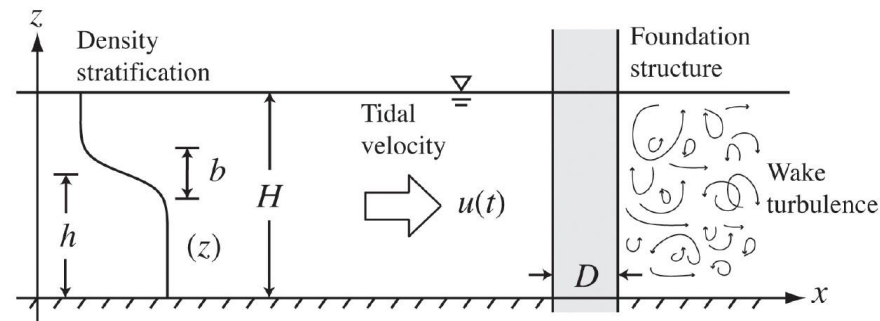
https://noaa-edab.github.io/presentations/20210504_OneNOAA_Bastille.html#6

Marine Ecosystem Science - Physical Effects

Aero- and hydrodynamics effects

Turbines could affect aerodynamics and hydrodynamics - e.g., turbulence, mixing, vertical stratification.

Scale of development related to magnitude of effect



Carpenter et al. 2016

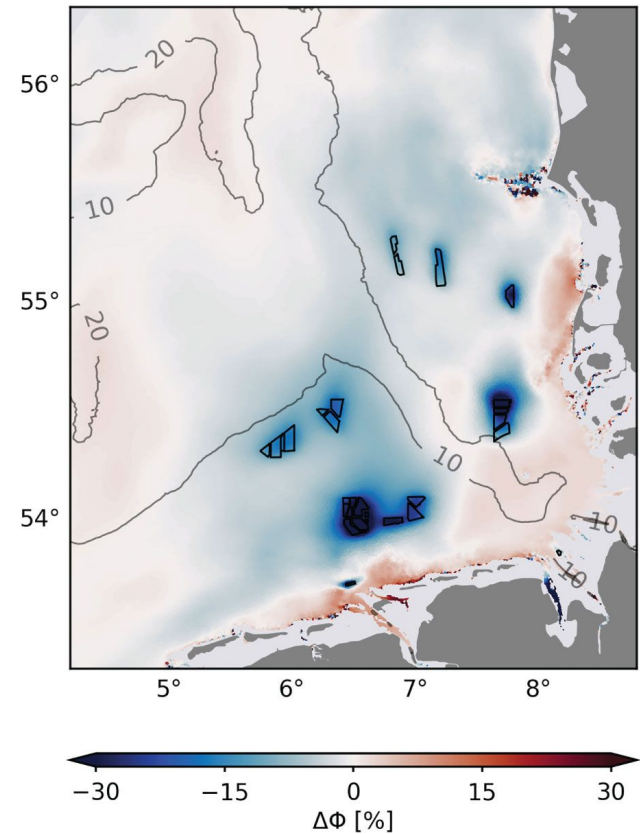
<https://doi.org/10.1371/journal.pone.0160830>



Marine Ecosystem Science - Physical Effects

Hydrodynamic modeling in the North Sea finds an effect of wind energy development on advection, vertical mixing, and stratification

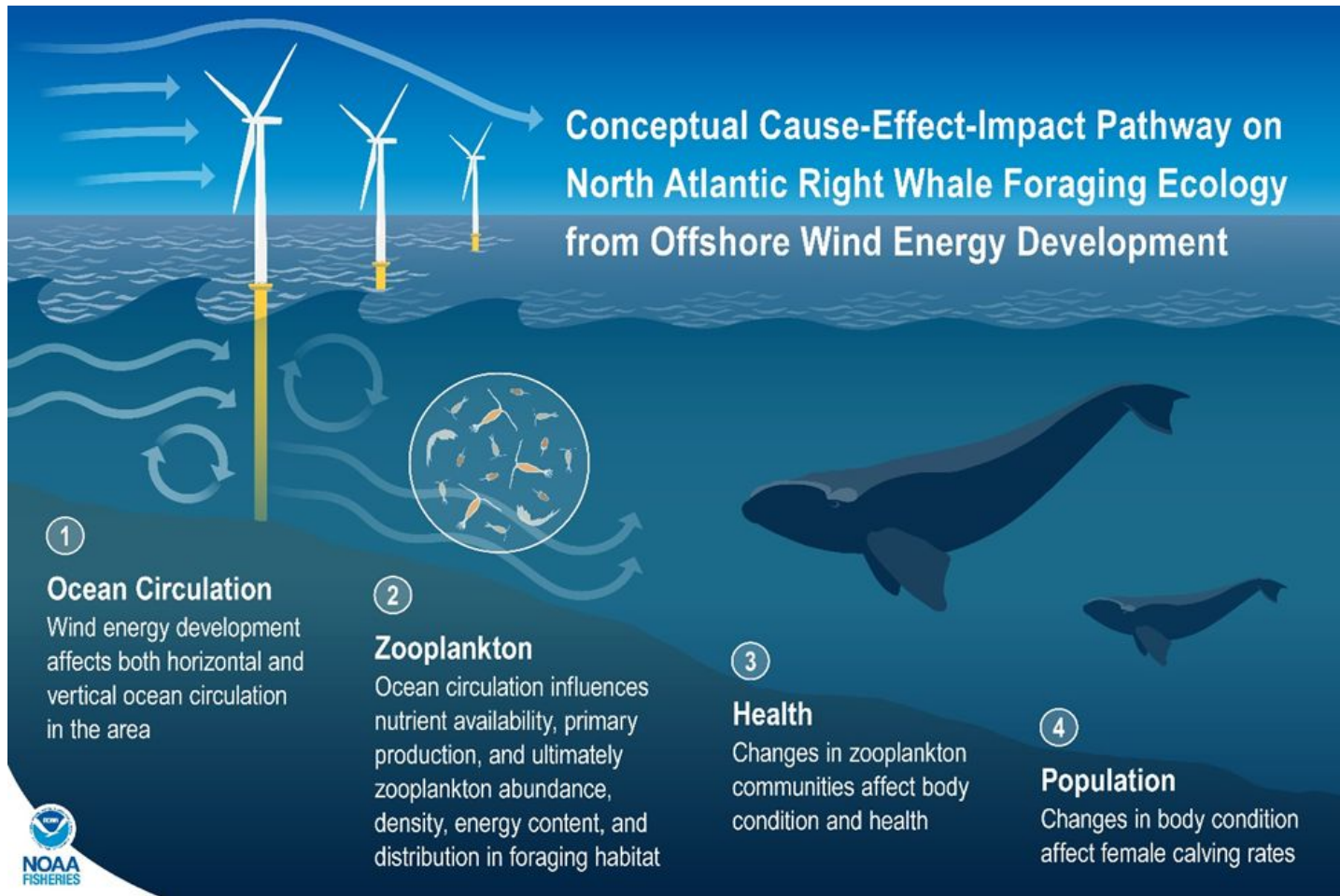
Potential energy anomaly (a measure of stratification) is decreased by 10-15% in wind energy development and decreases by 5% regionally



Christiansen et al. (2023)

<https://doi.org/10.3389/fmars.2023.1178330>

Marine Ecosystem Science - Biological Interactions



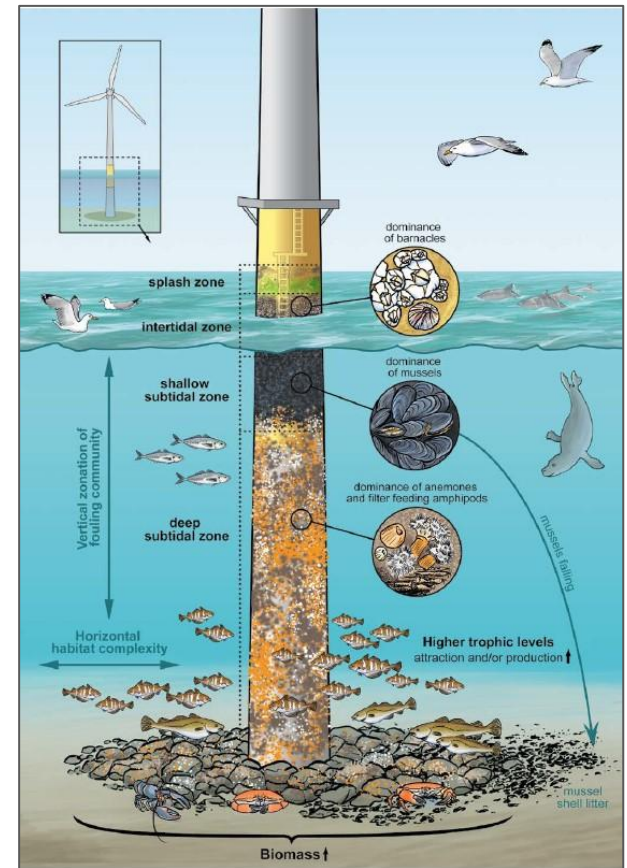
https://www.boem.gov/sites/default/files/documents/environment/BOEM_NMFS_DRAFT_NARW_OSW_Strategy.pdf

Marine Ecosystem Science - Physical Effects

Artificial-reef effect

Turbines represent physical hard-structure that can support a diverse and abundant artificial reef community

Populations affected by changes in availability of food, predators, and shelter



Degraer et al. (2020)

<https://doi.org/10.5670/oceanog.2020.405>

405

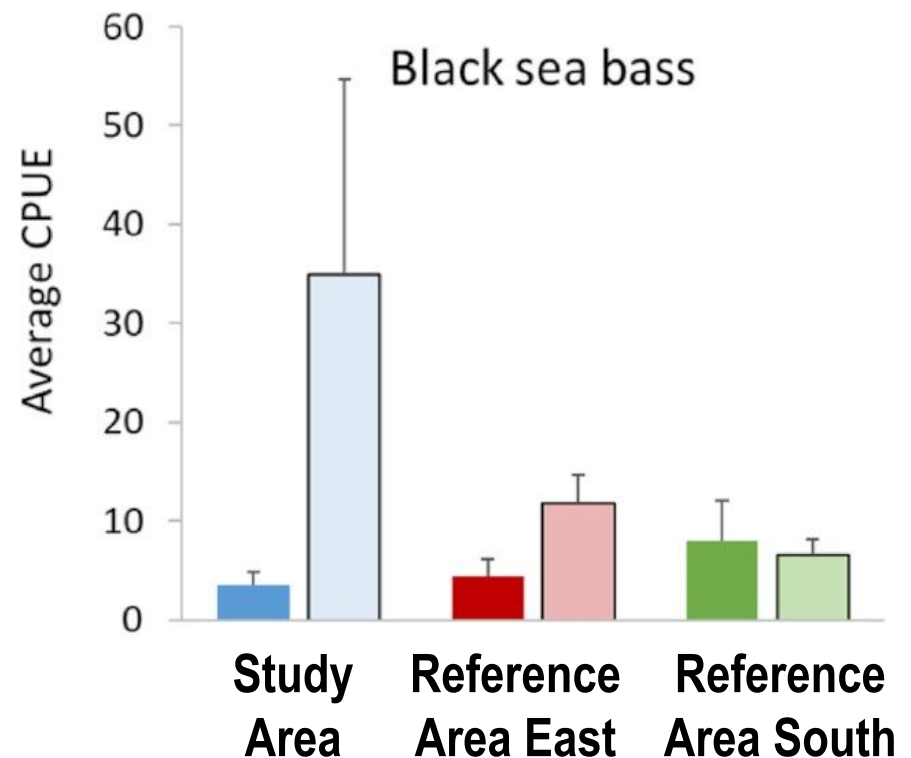
Marine Ecosystem Science - Biological Interactions

Black sea bass abundance at
Block Island Wind

Development increased ~10x

Unknown whether this is
based on attraction or
increase in productivity

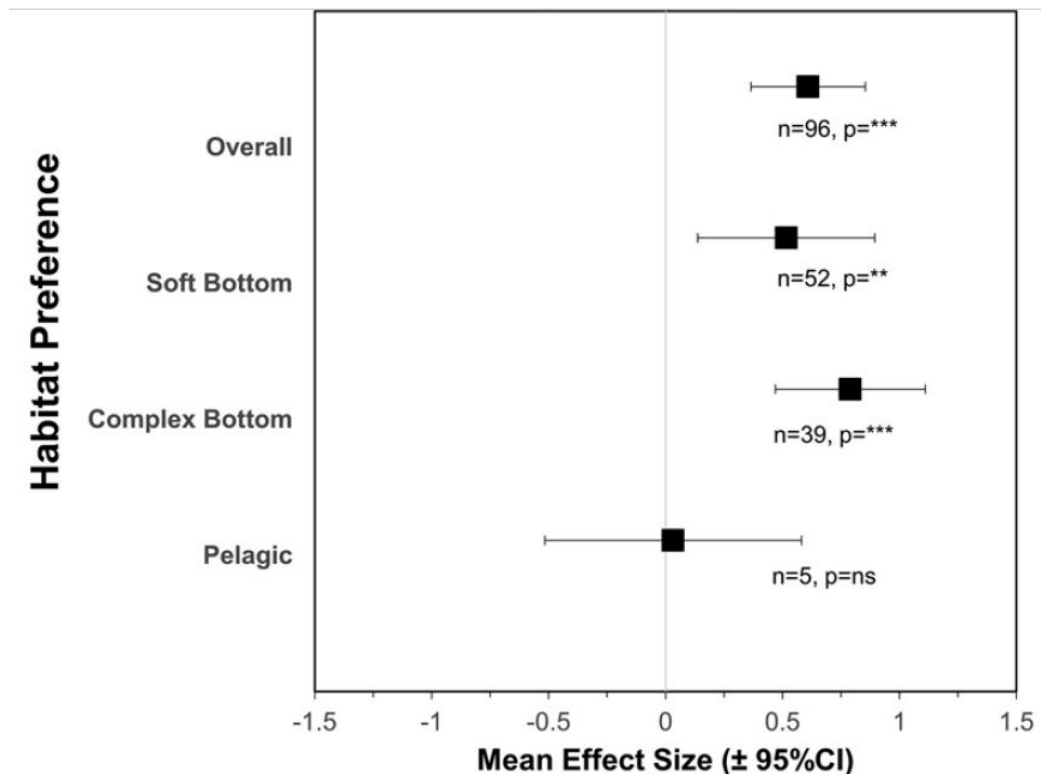
Black sea bass is an
important commercial and
recreational species



Wilbur et al. (2022) <https://doi.org/10.1093/icesjms/fsac051>

Marine Ecosystem Science - Biological Interactions

Meta-analysis of 13 studies found greater abundance of fish inside of wind energy developments



Methratta & Dardick (2019)

<https://doi.org/10.1080/23308249.2019.1584601>

Marine Ecosystem Science - Physical Effects

All phases of wind development produce underwater sound

Data on acoustic impacts are very limited for most life stages, population, and communities

New understanding needs to be integrated into assessments and cumulative impact analyses

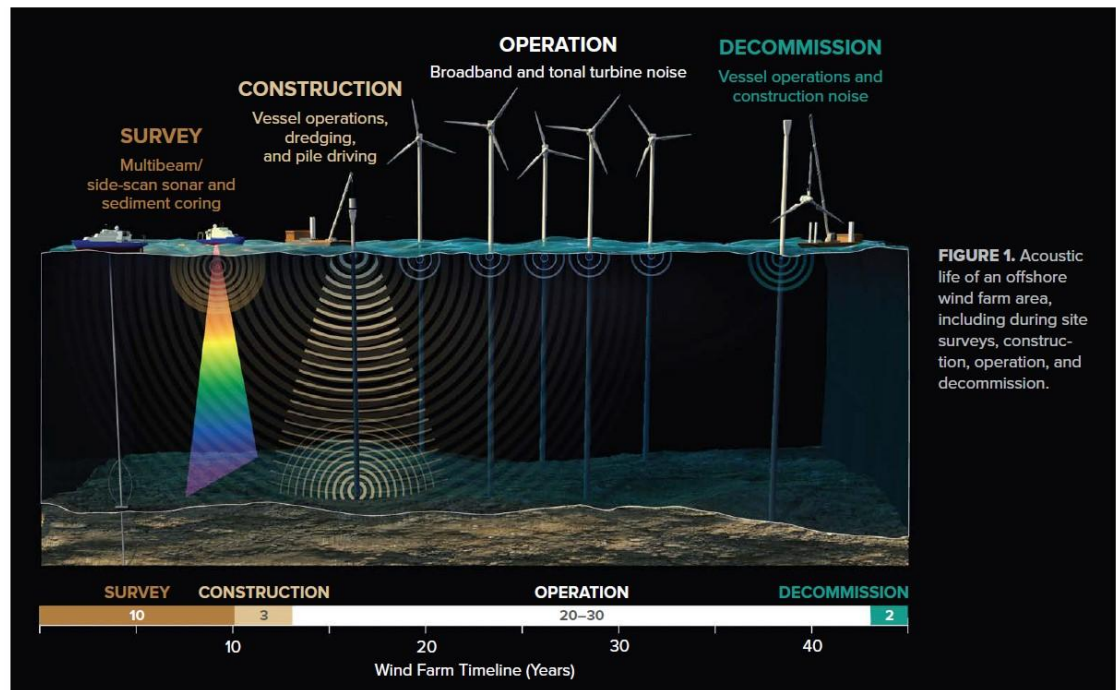


FIGURE 1. Acoustic life of an offshore wind farm area, including during site surveys, construction, operation, and decommission.

Mooney et al. (2020) <https://doi.org/10.5670/oceanog.2020.408>

Marine Ecosystem Science - Physical Effects

Electromagnetic fields created by power cables

Initial assessment is negligible impact

Need to continue to work to understand if there is a population or community level effects

JOURNAL ARTICLE

Magnetic fields produced by subsea high-voltage direct current cables reduce swimming activity of haddock larvae (*Melanogrammus aeglefinus*)

Alessandro Cresci, Caroline M F Durif, Torkel Larsen, Reidun Bjelland, Anne Berit Skiftesvik, Howard I Browman

Cresci et al. (2022)

<https://doi.org/10.1093/pnasnexus/pgac175>

Hutchinson et al (2020)

<https://doi.org/10.5670/oceanog.2020.409>

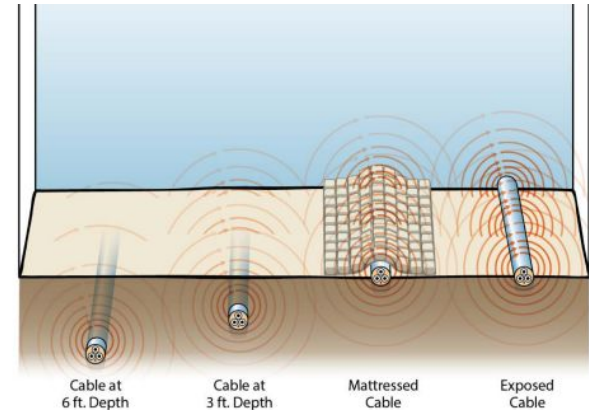


Table ES-1. Significance of potential impacts to fishes and invertebrates in the southern New England area from offshore wind energy projects' AC EMF

Species	Potential Impact	Criteria	Consequence	Likelihood of Exposure	Significance
Pelagic Habitat – Magnetic Fields					
American eel, Atlantic salmon	Impairment of navigation or homing	Nature: Negative Intensity: Low Spatial Extent: Immediate vicinity Duration: Long term	Negligible	Likely	1 – Negligible
Pelagic Habitat – Electric Fields					
Bony fishes: bluefish, striped bass, bluefish and others; Pelagic sharks	Changes in feeding success, mate finding, and evading predators	Nature: Negative Intensity: Low Spatial Extent: Immediate vicinity Duration: Long term	Negligible	Rare	1 – Negligible
Demersal Habitat – Magnetic Fields					
Clearnose skate, little skate, winter skate, bamdoor skate, thorny skate, rosette skate, and smooth skate	Impairment of navigation or homing	Nature: Negative Intensity: Low Spatial Extent: Immediate vicinity Duration: Long term	Negligible	Likely	1 – Negligible
Demersal Habitat – Electric Fields					
Clearnose skate, little skate, winter skate, bamdoor skate, thorny skate, rosette skate, and smooth skate	Changes in feeding success, mate finding, and evading predators	Nature: Negative Intensity: Low Spatial Extent: Immediate vicinity Duration: Long term	Negligible	Likely	1 – Negligible

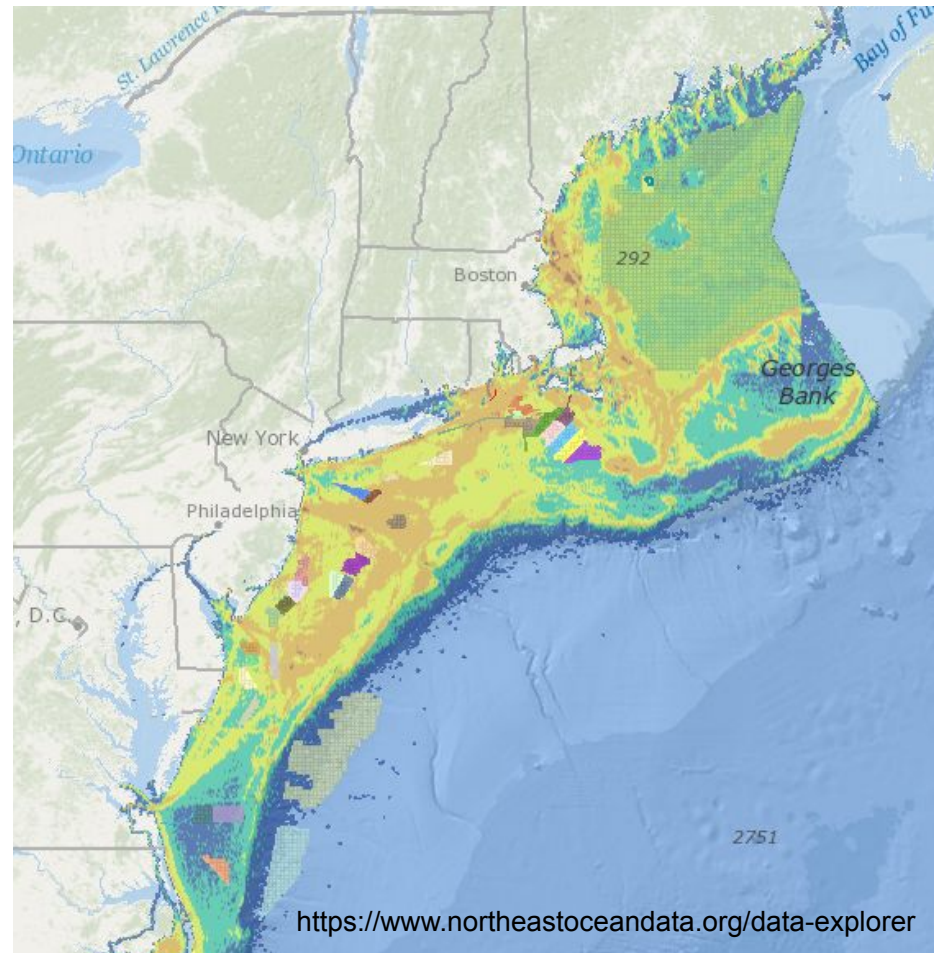
[Snyder et al. \(2019\) OCS Study BOEM 2019-049](#)

Marine Ecosystem Science - Human Interactions

Goal is for co-existence of offshore wind energy development and commercial fishing activities

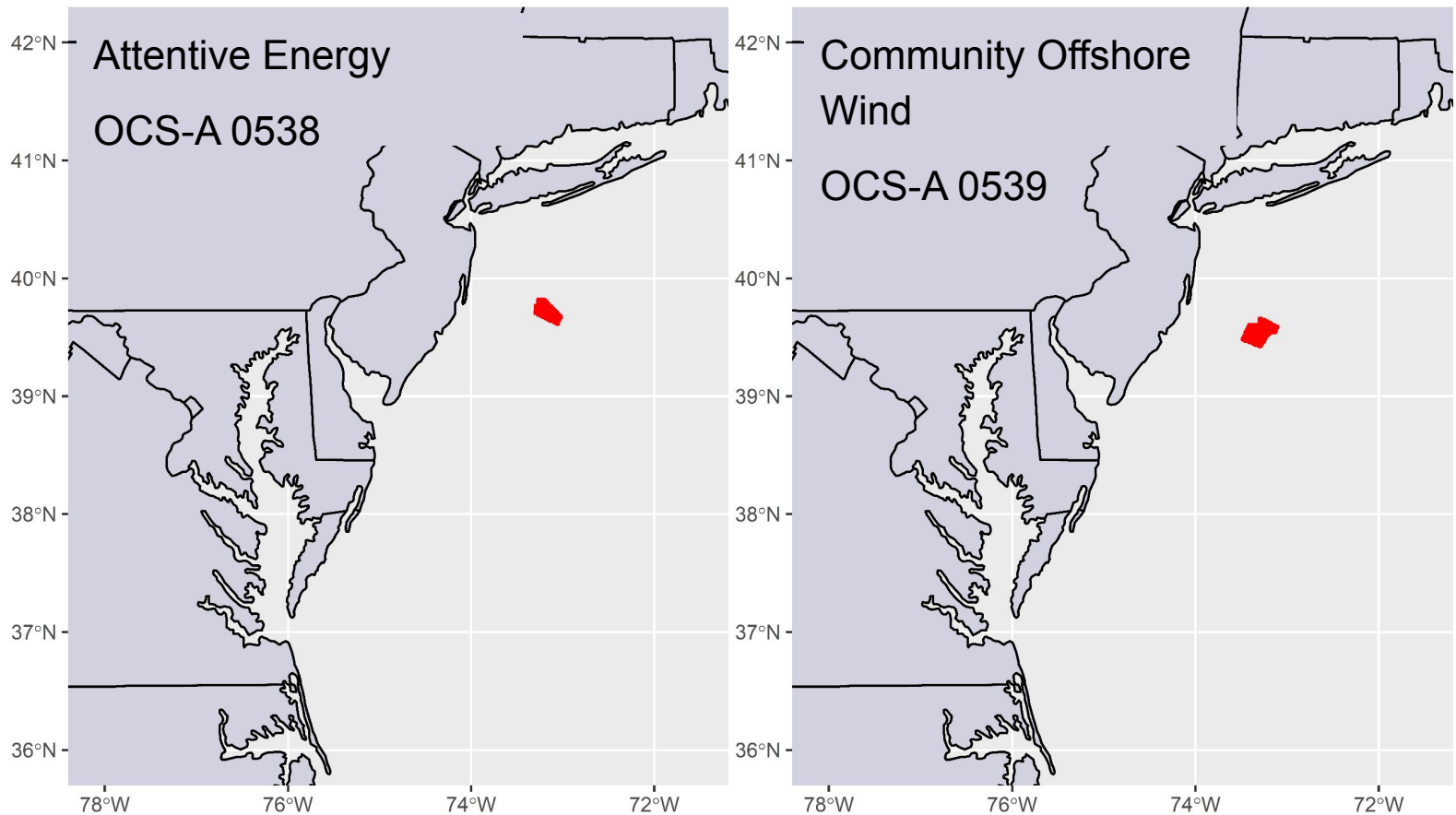
Most offshore wind development is occurring in federal waters - meaning federally permitted fishing vessels

A vessel from Virginia can fish off of Rhode Island; a vessel from Massachusetts can fish off of New Jersey



Marine Ecosystem Science - Human Interactions

Co-existence of wind and fisheries



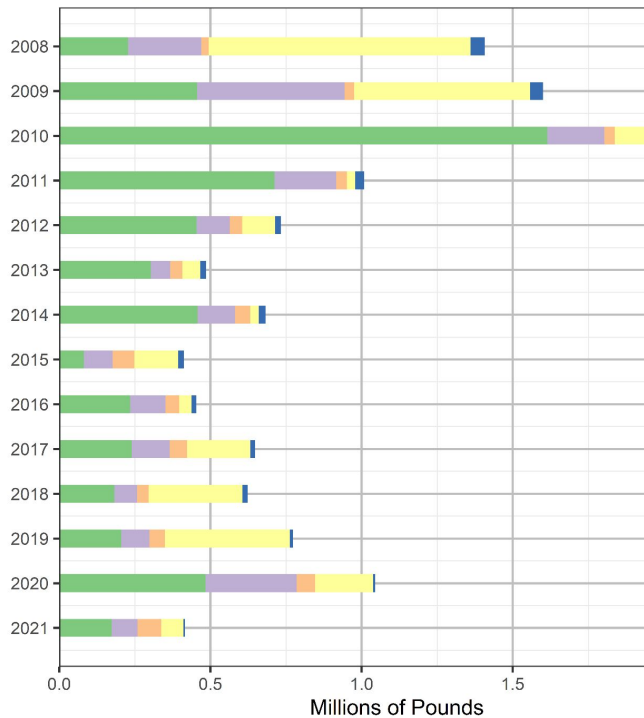
<https://www.fisheries.noaa.gov/resource/data/socioeconomic-impacts-atlantic-offshore-wind-development>

Marine Ecosystem Science - Human Interactions

Co-existence of wind and fisheries

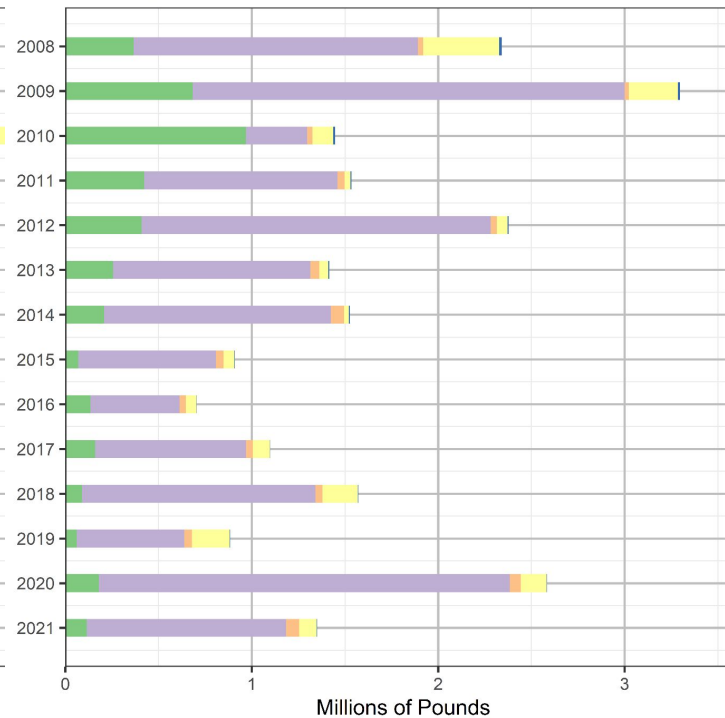
Attentive Energy

Landings from Most Impacted FMPs, OCS-A 0538



Community Offshore Wind

Landings from Most Impacted FMPs, OCS-A 0539



<https://www.fisheries.noaa.gov/resource/data/socioeconomic-impacts-atlantic-offshore-wind-development>

Marine Ecosystem Science - Human Interactions

Different wind energy developments overlap with different fisheries

Fishing effort will be displaced depending on gear

Fishing transits and safety-at-sea

Fishing revenue and fishing communities

Co-existence is both an ocean issue and a land issue

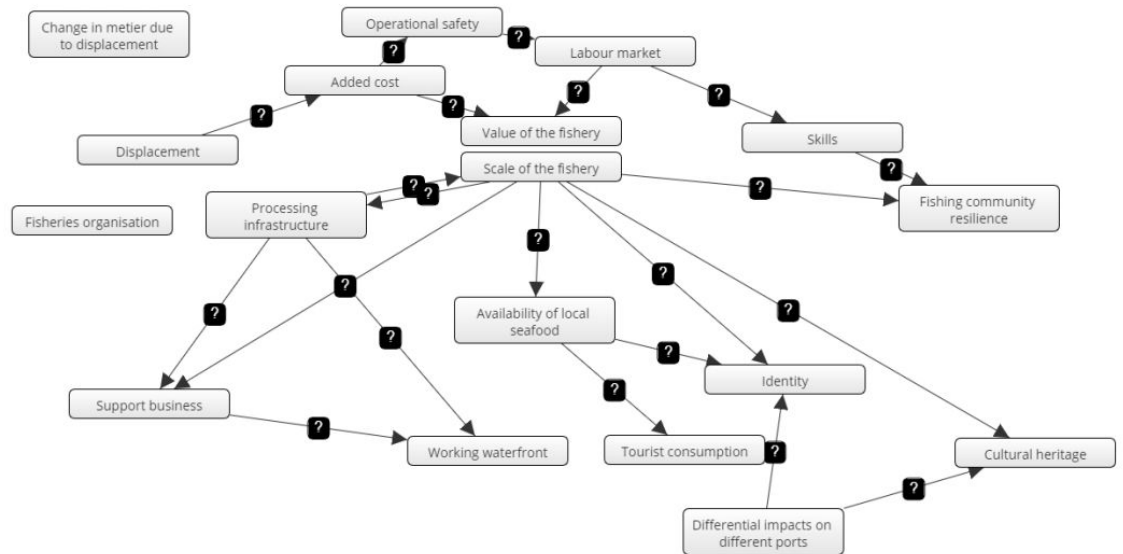


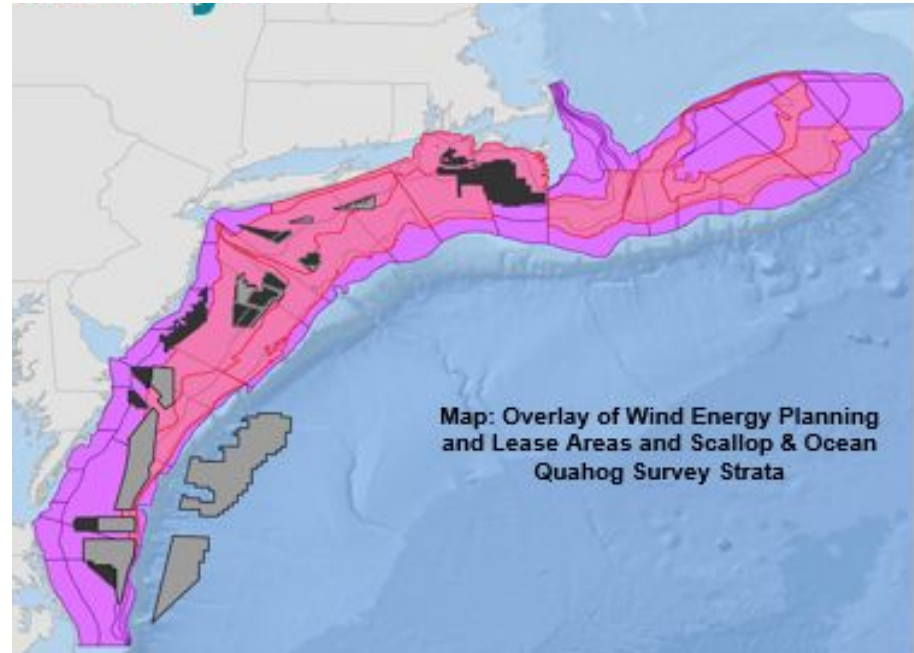
Figure 7. Cause effect map on concerns about possible socio-cultural effects from potential displacement of the surfclam fishery in the US.

ICES (2021) <https://doi.org/10.17895/ices.pub.8115>

Marine Ecosystem Science - Human Interactions

Effects on Scientific Surveys

- Preclusion - displacement by infrastructure
- Statistical Survey Design - stratified random designs need to be redesigned
- Habitat Change - distribution, abundance, and vital rates
- Impacts to sampling - navigation and transits



14 long-term scientific surveys will be impacted by offshore wind energy development

Hare et al (2022) <https://doi.org/10.25923/jqse-x746>

Marine Ecosystem Science - Human Interactions

Effects on Fisheries Management

- Exclusion of fishing from wind development areas (MPA effect)
- Concentration of fishing in non wind energy development areas (Displacement effect)
- Attraction of fishing (Artificial reef effect)
- Changing gear types and selectivity
- Potentially other effects



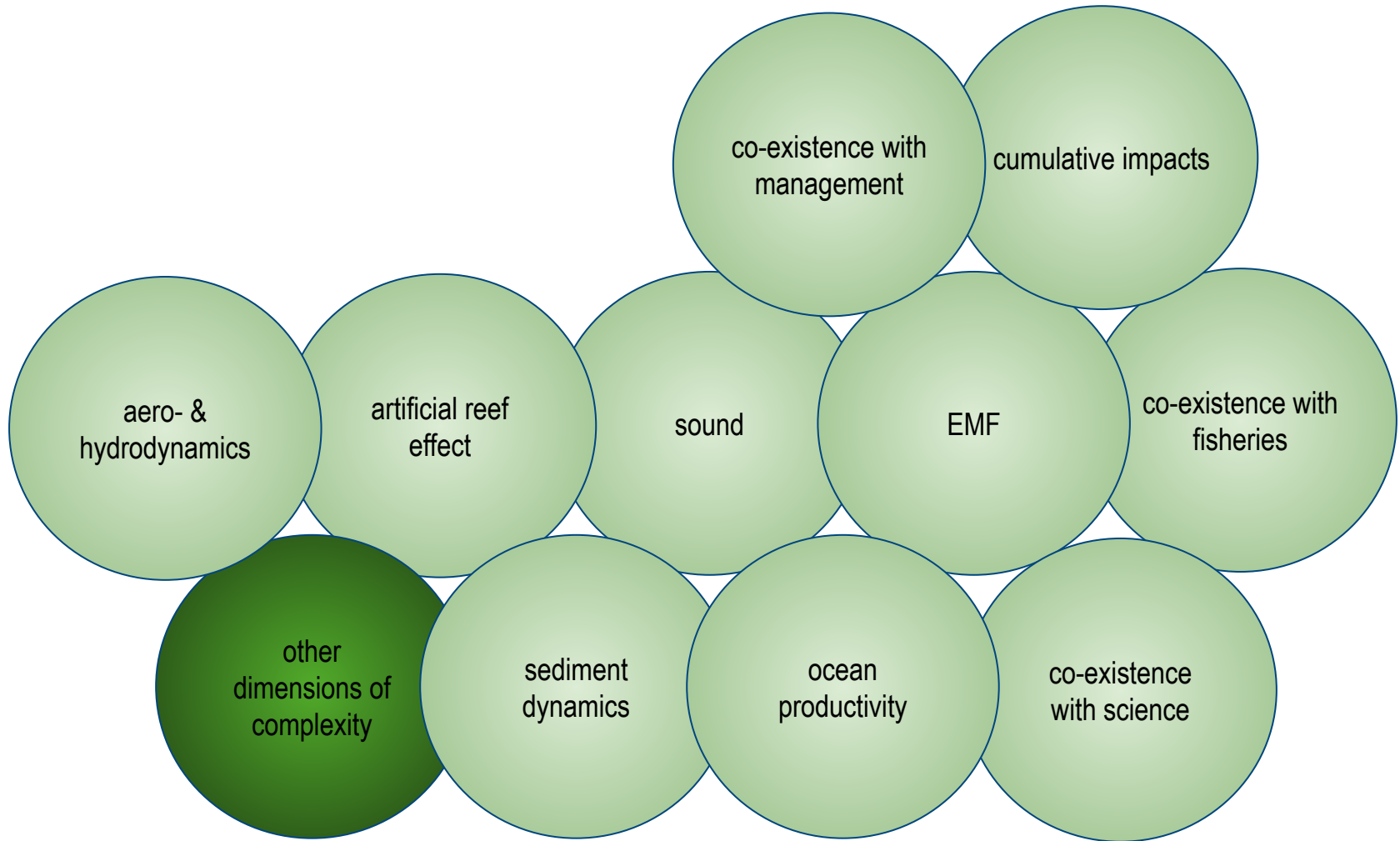
Marine Ecosystem Science

Cumulative Impacts

- multiple wind energy development projects
- multiple scales of biological organization
 - life history stages, individuals, populations, communities, ecosystems
- multiple habitats
 - benthic, pelagic, coastal
- multiple environmental effects
 - physical, chemical, geological
- multiple human interactions
 - fishing, shipping, coastal communities, waterfront

What will the cumulative impact be on [insert a NOAA trust resource]?

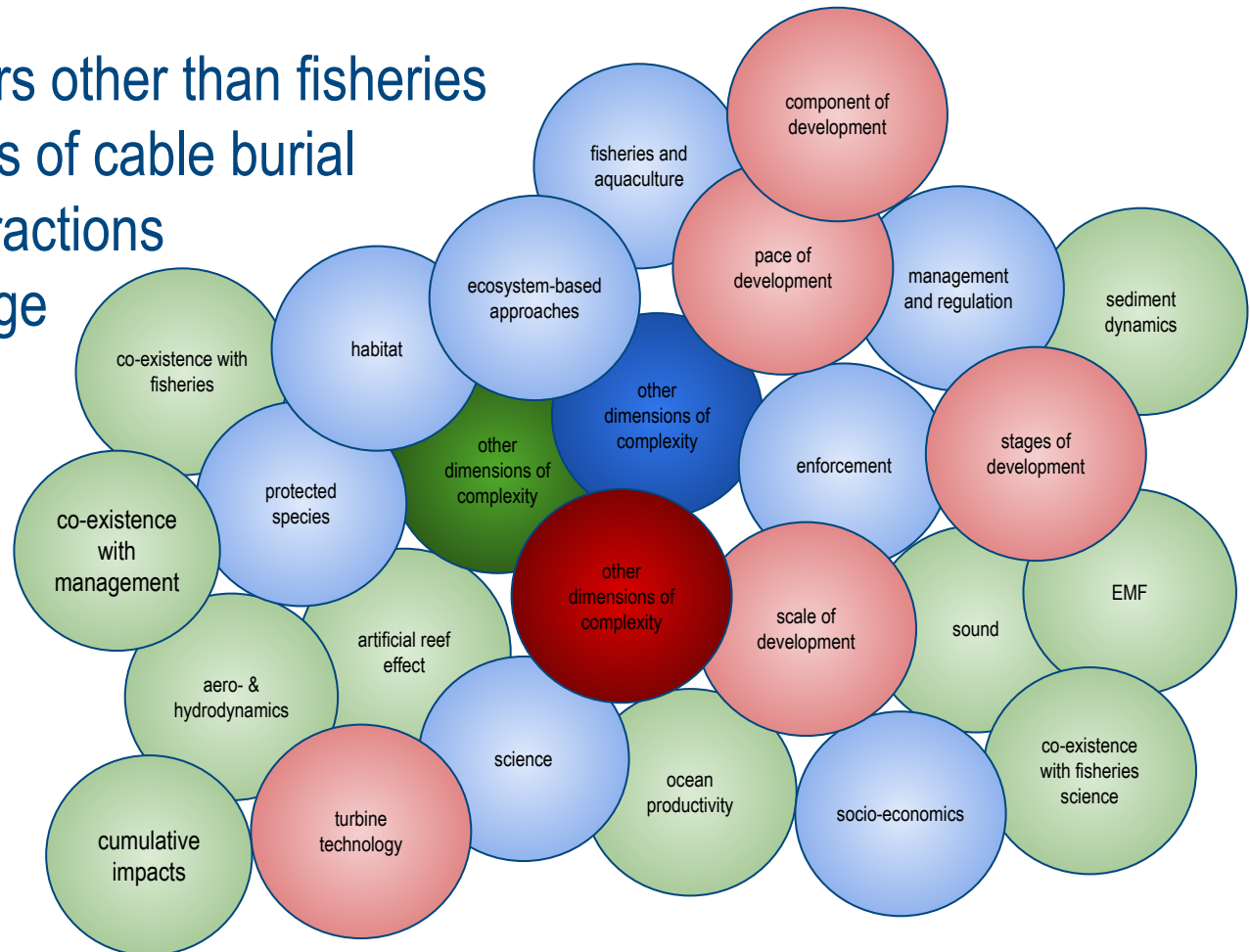
Marine Ecosystem Science



Marine Ecosystem Science - complexity

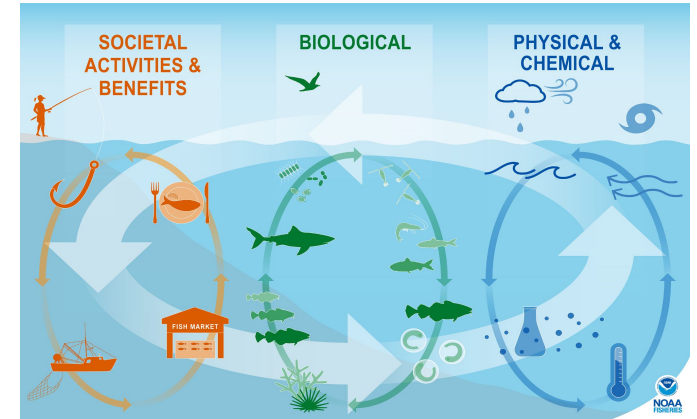
Doesn't include:

- co-use sectors other than fisheries
- habitat effects of cable burial
- sea-bird interactions
- climate change
- and more ...



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Science that promotes an integrated approach that incorporates the entire ecosystem, including humans, into resource management decisions, and is guided by an adaptive management approach

https://noaa-edab.github.io/presentations/20210504_OneNOAA_Bastille.html#6

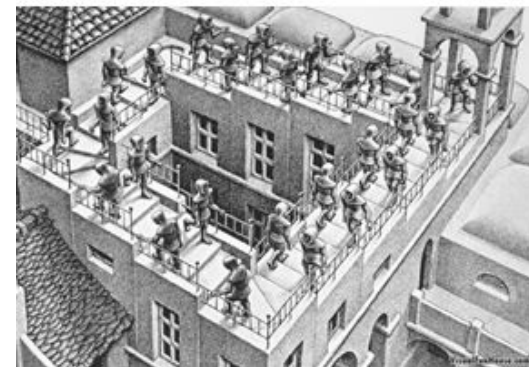
Complex Socio-Ecological Systems

Wicked Problem Traps

- Falsely assuming tame solution
“one solution to rule them all”
- Inaction from overwhelming complexity
“let’s keep doing what we are doing”

[DeFries and Nagendra \(2017\) https://doi.org/10.1126/science.aal1950](https://doi.org/10.1126/science.aal1950)

[Hare \(2020\) https://doi.org/10.1093/icesjms/fsaa025](https://doi.org/10.1093/icesjms/fsaa025)

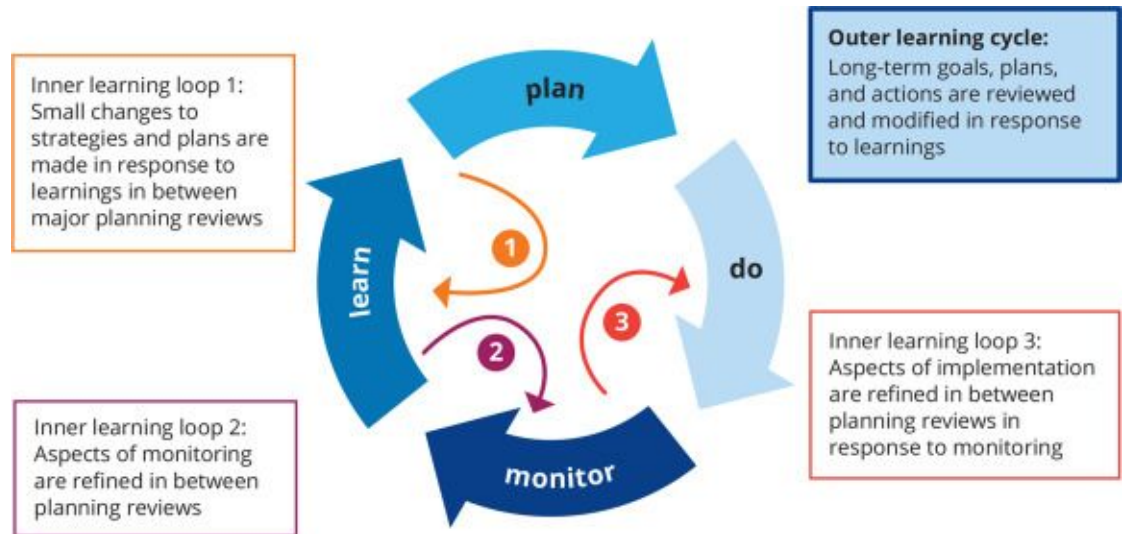


<https://www.cbr.com/lord-of-the-rings-gollum-evolution-explained/>
https://en.wikipedia.org/wiki/Ascending_and_Descending

Complex Socio-Ecological Systems

NOAA Fisheries' Role - Science to inform ecosystem-based management

- ecosystem components
- ecosystem interactions
- physics to people
- integrated approach
- adaptive approach

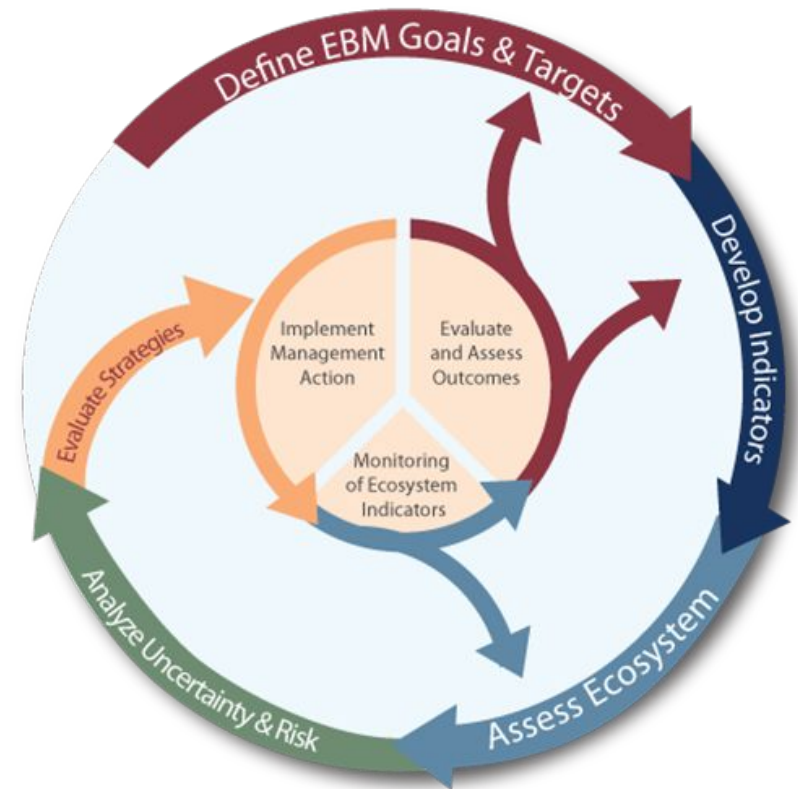


<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/adaptive-management>

Complex Socio-Ecological Systems

Responsible Offshore Development Alliance leading effort in Gulf of Maine with NOAA, BOEM and URI support

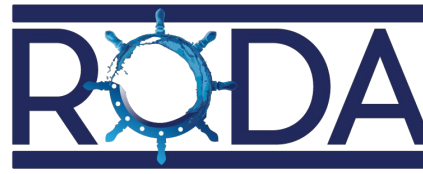
NOAA's Integrated Ecosystem Assessment (IEA) is an approach that integrates all components of an ecosystem to inform a decision-making process so that managers can balance trade-offs and determine what is more likely to achieve their desired goals.



<https://www.integratedecosystemassessment.noaa.gov/about-iea/iea-approach>

Complex Socio-Ecological Systems

Collaboration is key
these and many more ...



Complex Socio-Ecological Systems

Offshore wind energy development is global - also need to work internationally to build and leverage knowledge

The screenshot shows the ICES website header with the logo on the left and navigation links (News, Events, Calendar, Library, SharePoint login, Admin) and a search bar on the right. Below the header is a secondary navigation bar with links: Who we are, How we work, Global cooperation, Project collaborations, ICES Awards, and Jobs at ICES. The main content area features a large orange banner with the heading 'ABOUT ICES' and a list of links: > Our member countries, > Annual Report 2021, > Strategic Plan, > Advisory Plan, and > Science Plan. To the right of this list is a text box containing 'Our Vision: To be a world-leading marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.' and 'Our Mission: To advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals.' Further right is a vertical image of a coastal landscape with snow-capped mountains and a boat in the water, with the text 'Science for sustainable seas' and a link '> Read our Strategic Plan'.

<https://www.ices.dk/about-ICES/Pages/default.aspx>

Complex Socio-Ecological Systems

The questions for NOAA Fisheries

What are the effects of offshore wind energy development on populations, communities, habitats, coastal and marine ecosystems - including humans?

How is this information used in scientific advice and the regulatory process?

Can adverse effects be mitigated: avoided, minimized, or compensated?



<https://ecology.fnal.gov/ecosystem-services/>

<https://teebweb.org/>

Complex Socio-Ecological Systems

Identify research priorities for the Northeast U.S. Continental Shelf Ecosystem from our perspectives as fisheries scientists and managers at NOAA Fisheries who are actively engaged in OSW science

[Check for updates](#)

Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 0:e10242, 2023
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ISSN: 1942-5120 online
DOI: 10.1002/mcf2.10242



CLICK HERE for
Offshore Wind

THEMED ISSUE: OFFSHORE WIND INTERACTIONS WITH FISH AND FISHERIES

Science Priorities for Offshore Wind and Fisheries Research in the Northeast U.S. Continental Shelf Ecosystem: Perspectives from Scientists at the National Marine Fisheries Service

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Methratta et al. (2023) <https://doi.org/10.1002/mcf2.10242>

Further Reading - Offshore Wind Development

[Special Issue on Understanding the Effects of Offshore Wind Energy Development on Fisheries - Oceanography \(2020\)](#)

[Theme Issue Offshore Wind Interactions with Fish and Fisheries - Marine and Coastal Fisheries \(in progress\)](#)

[Theme Set Assessing the impact of expanding offshore wind energy - ICES Journal of Marine Science \(in progress\)](#)

[Fisheries and Offshore Wind Interactions: Synthesis of Science - Hogan et al \(2023\)](#)

[NOAA Fisheries and BOEM Federal Survey Mitigation Implementation Strategy - Northeast U.S. Region - Hare et al. \(2023\)](#)

My work related to using an adaptive / incremental approach

[A perspective on moving forward with Ecosystem Based Fisheries Management](#) - Hare 2022 - NOAA Science Seminar Series

[Using an incremental approach for wicked problems in fisheries management and marine EBM](#) - Hare 2021 - EBM Tools Network Webinar

A Review of River Herring Science in Support of Species Conservation and Ecosystem Restoration - Hare 2021 - <https://doi.org/10.1002/mcf2.10174>

Ten lessons from the frontlines of science in support of fisheries management - Hare 2020 <https://doi.org/10.1093/icesjms/fsaa025>

Atlantic Salmon Recovery Informing and Informed by Ecosystem-Based Fisheries Management - Hare et al. 2019 - <https://doi.org/10.1002/fsh.10262>