# WILDLIFE AND OFFSHORE WIND

# WOW

## A Systems Approach to Research and Risk Assessment for Offshore Wind Development

DOSITS Webinar – June 4, 2025

U.S. DEPARTMENT OF ENERGY

BOEM

Bureau of Ocean Energy Management

Award DE-EE0010287, Offshore Wind Energy Environmental Research and Instrumentation Validation

# THE TEAM & KEY GUIDING RESEARCH QUESTIONS

Generated based on Areas of Research Focus identified by DOE:

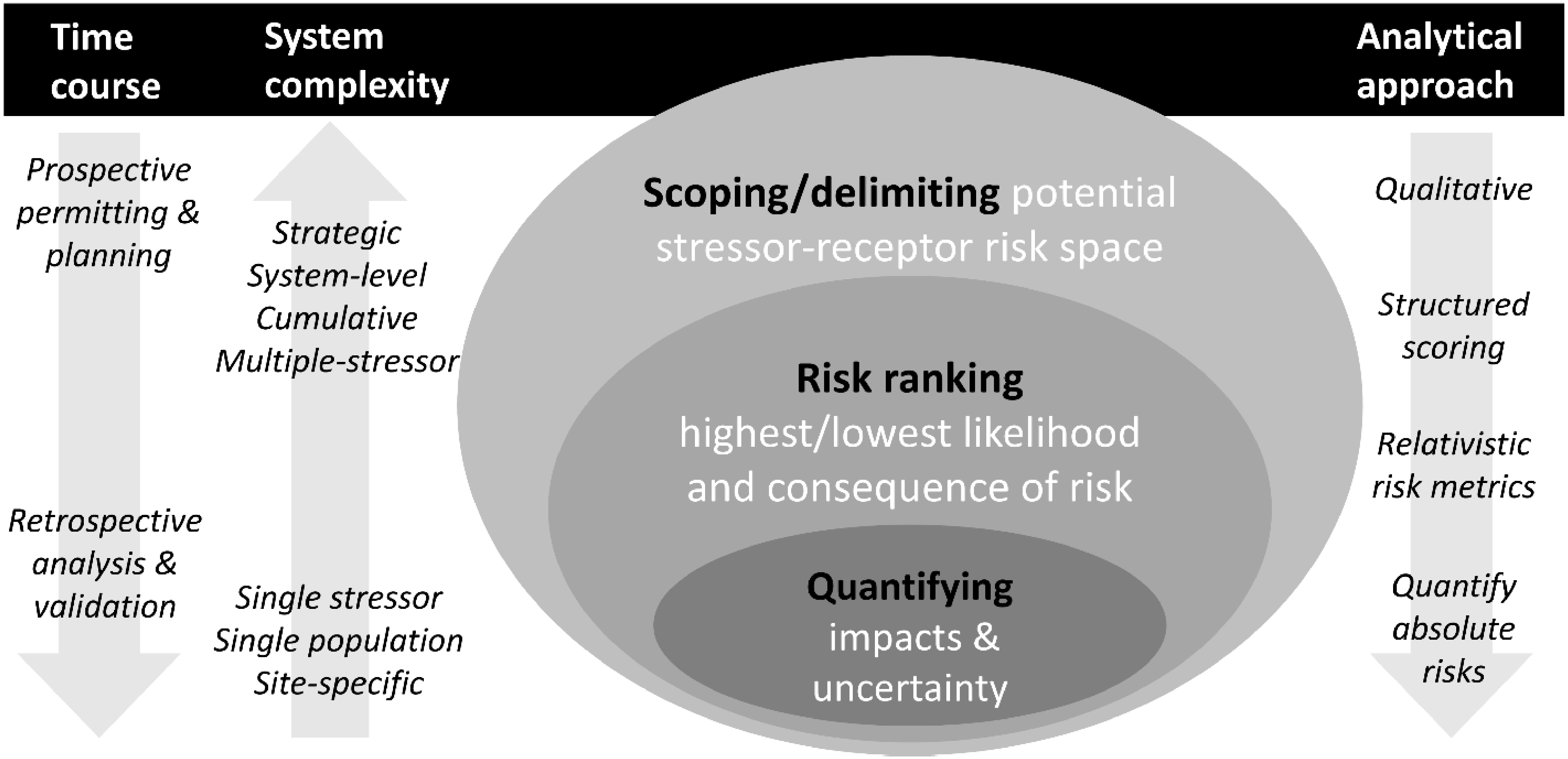
- Research to assess or mitigate impacts of construction noise on marine species
- Changes in habitat and changes in marine species' use of habitat in offshore wind lease areas and surrounding areas
- Research to assess collision risk for birds and/or bats

# TWO PROJECT PHASES

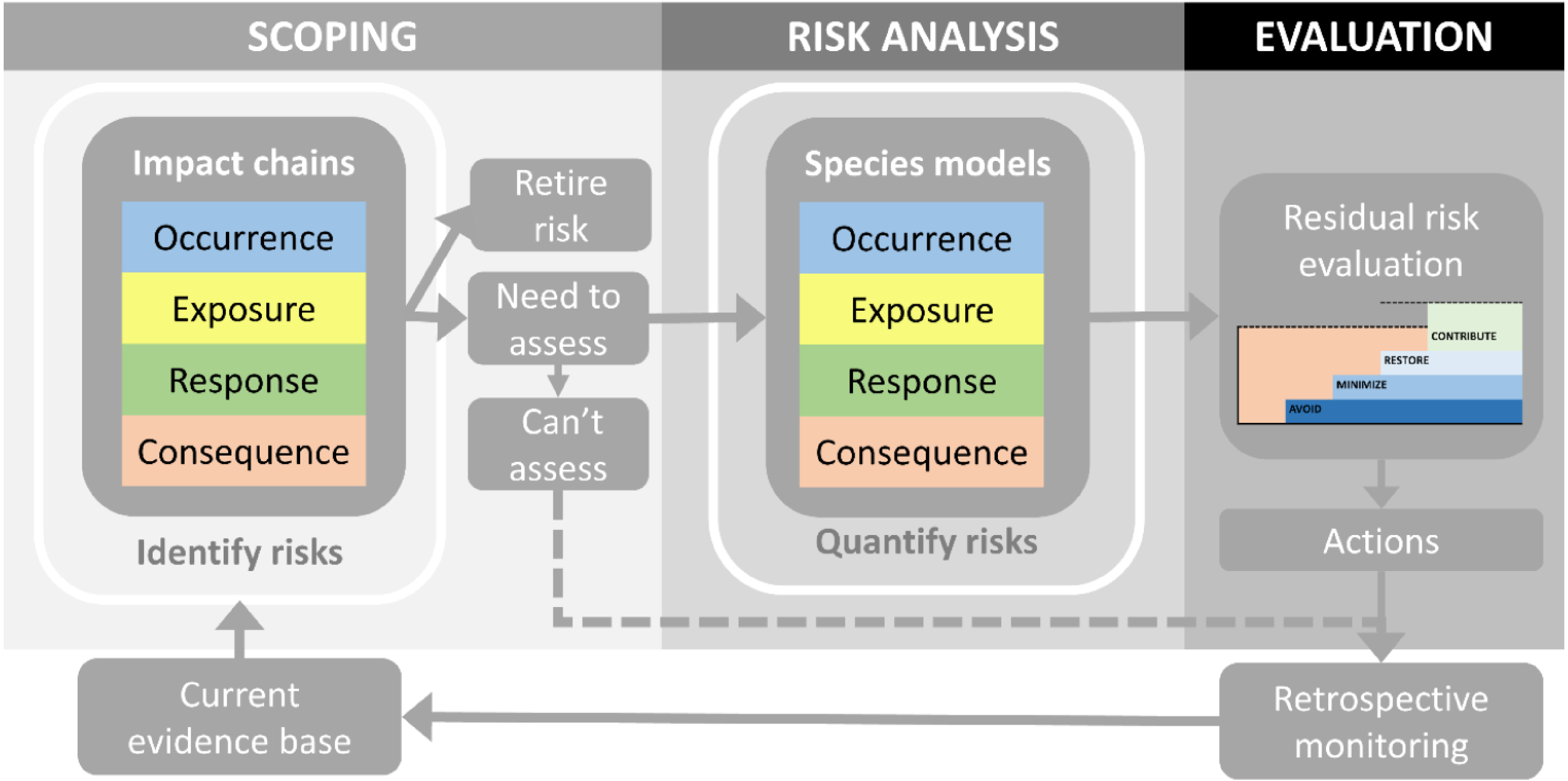
1. Gap Analysis and Framework Development

2. Targeted Data Collection and Technology Validation

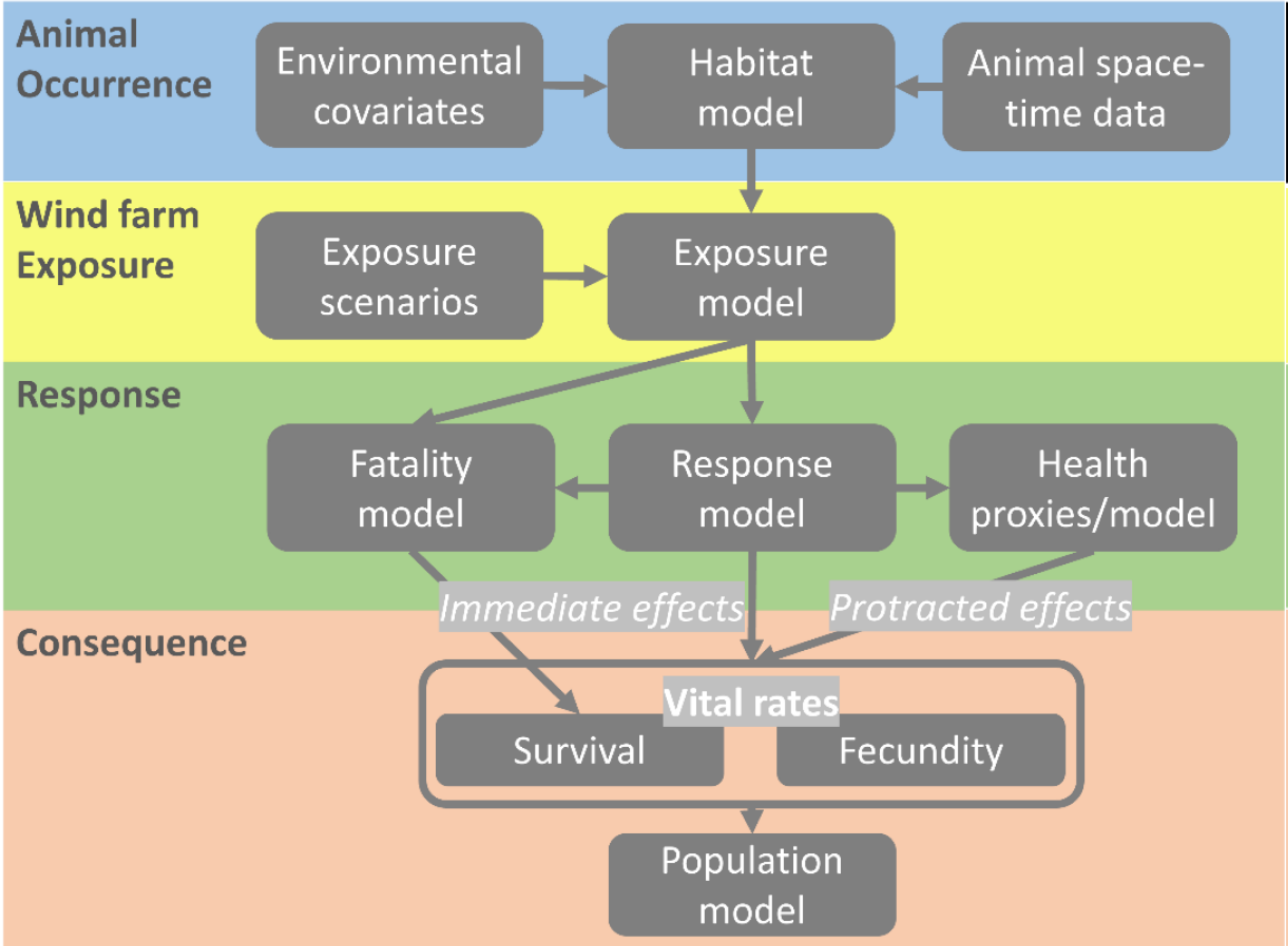
# RISK FRAMEWORK



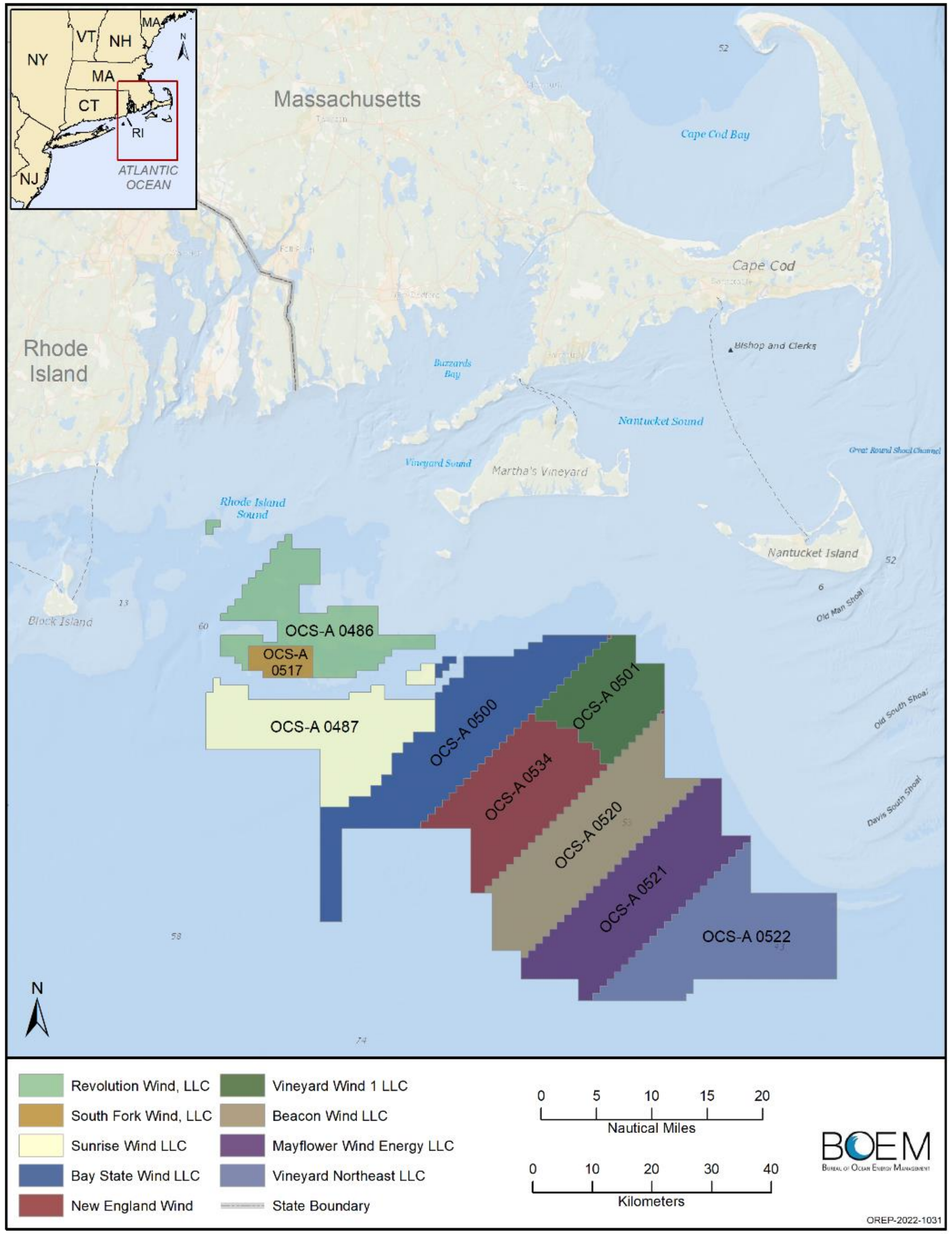
# RISK FRAMEWORK

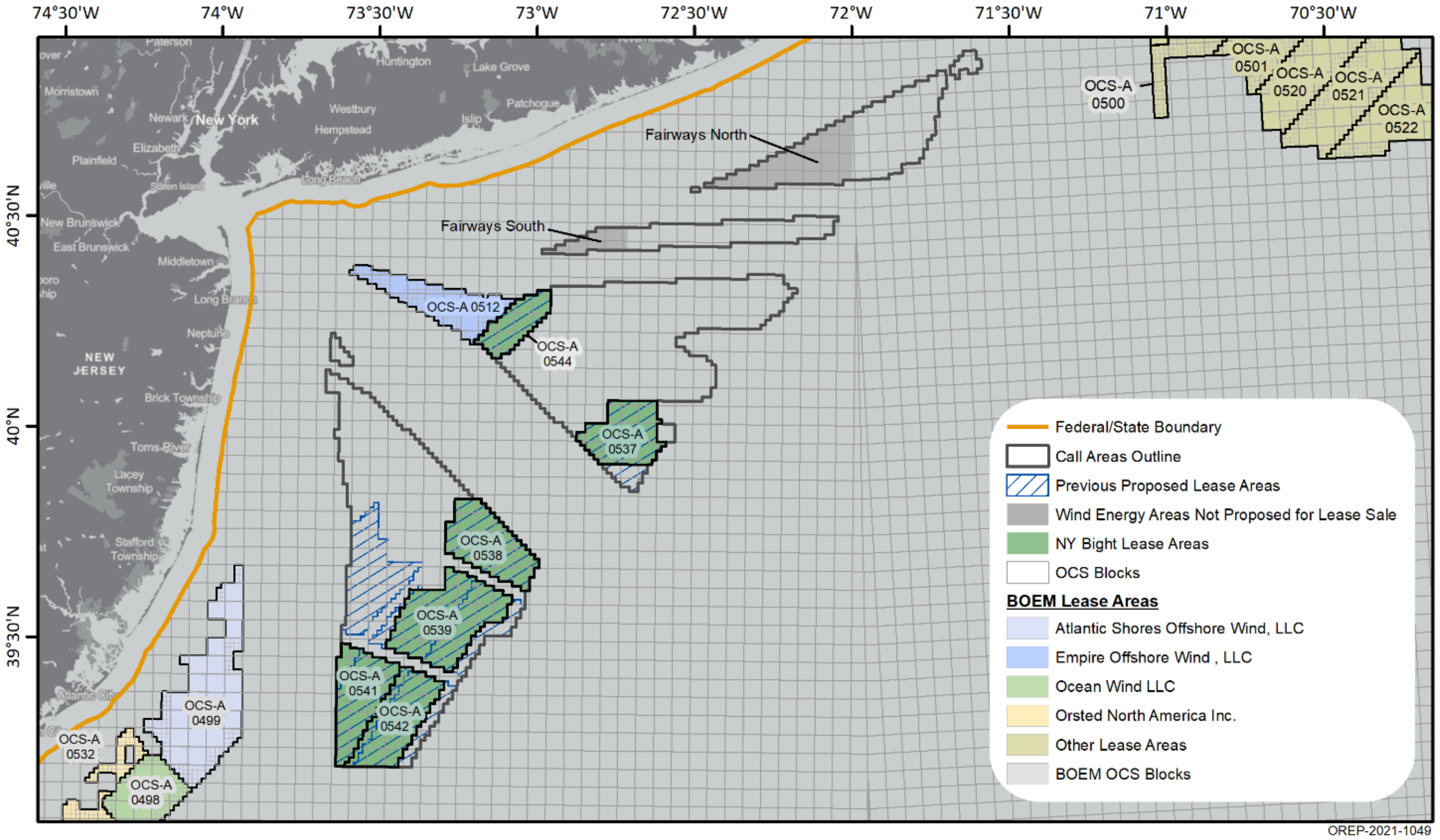


# IMPACT PATHWAYS




| Potential assessment mid- and endpoints |
|---|
| e.g., proportion of habitat within footprint, proportion of individuals within audible range of pile driving |
| e.g., number of takes (e.g., fatalities, number individuals displaced), lost animal time, risk of habitat degradation, health proxies |
| e.g., risk of negative effect on population trajectory, risk of change in ESA-listing/ IUCN status, risk of exceeding potential biological removal, risk of extinction |

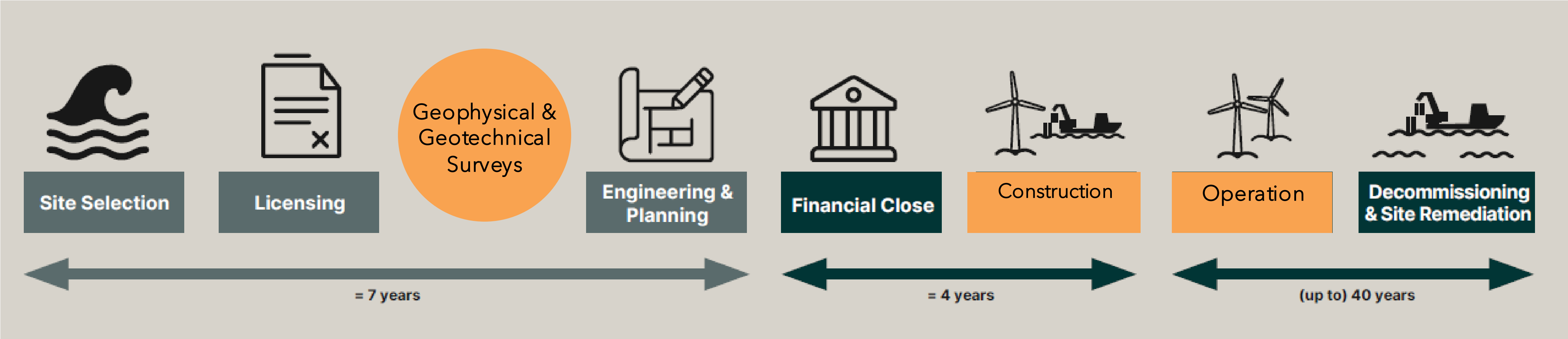



# WOW STUDY SITES

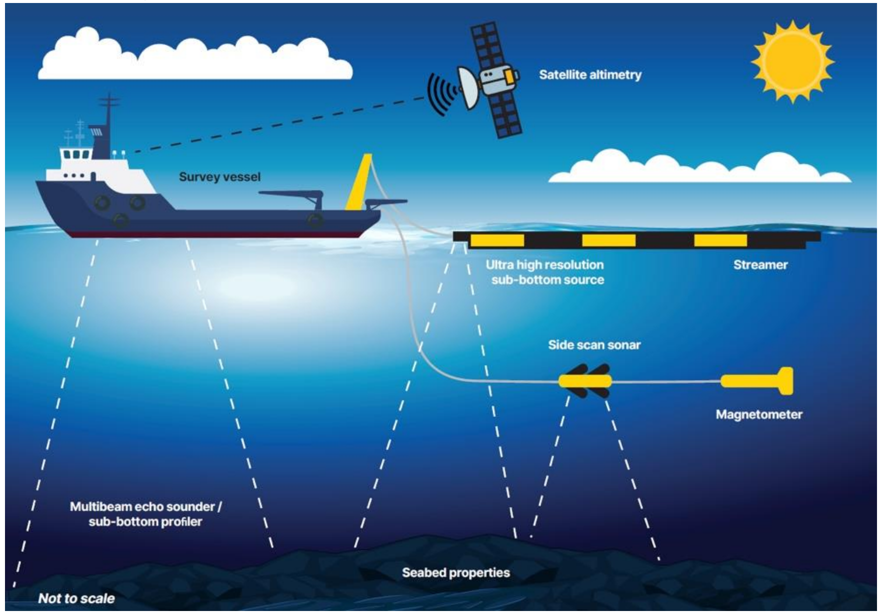
Integrated Regional Ecosystem Studies (IRES)

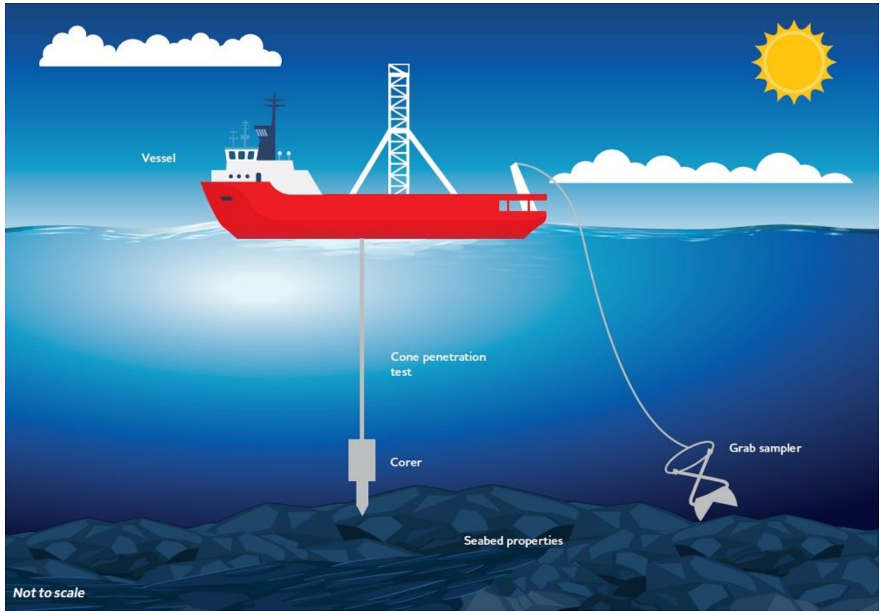
# WINDFARMS & NOISE



# GEOPHYSICAL & GEOTECHNICAL SURVEYS

Clean Energy Council




- Multibeam Sonar
- Side-scan Sonar

- Sediment Coring

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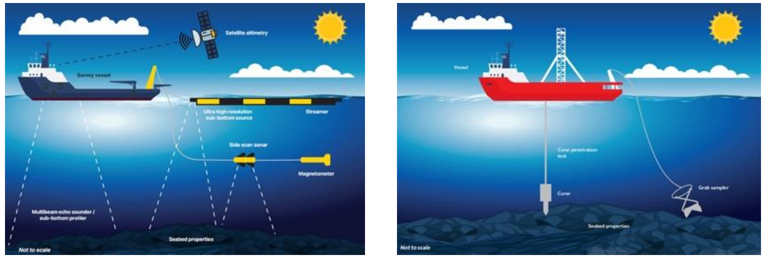
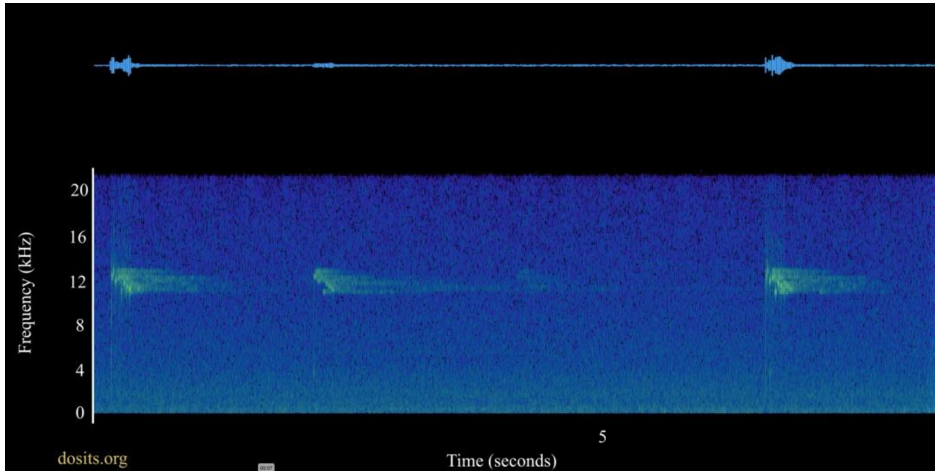
# GEOPHYSICAL & GEOTECHNICAL SURVEYS

Multibeam Echosounder

DOSITS Link



Mooney et al (2020)




INCREASING FREQUENCY

| SEISMIC SOURCE | FREQUENCY RANGE |
|---|---|
| Multibeam | 100–400 kHz |
| Echosounder | 2–22 kHz |
| Chirp sonar | 400 Hz to 24 kHz |
| Pinger | 3.5–7 kHz |
| Boomer | 300 Hz to 6 kHz |
| Sparker | 40 Hz to 1.5 kHz |

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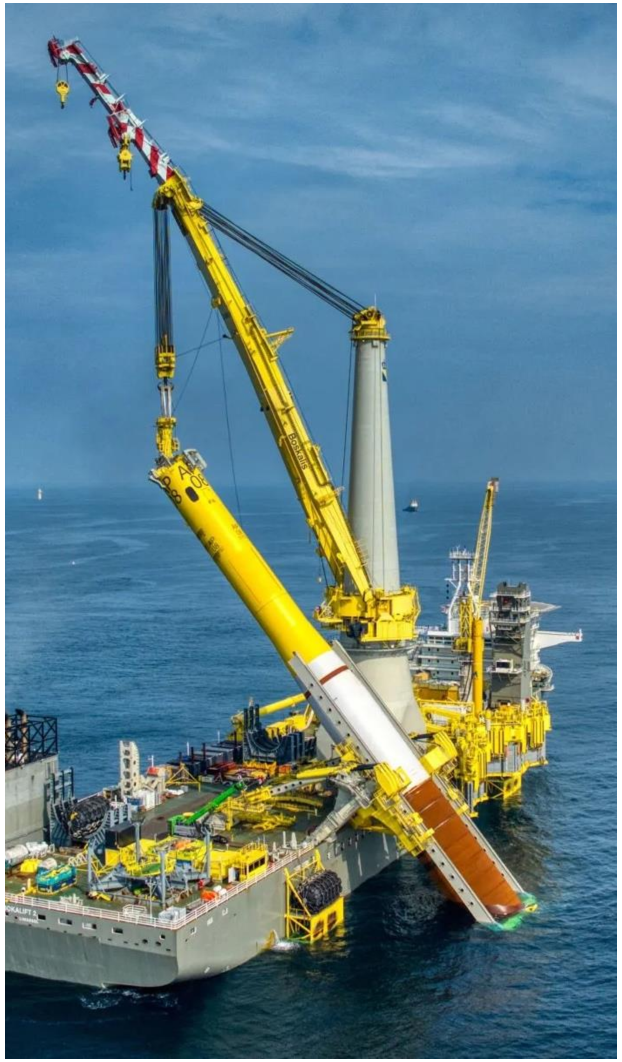
# FOUNDATION INSTALLATION



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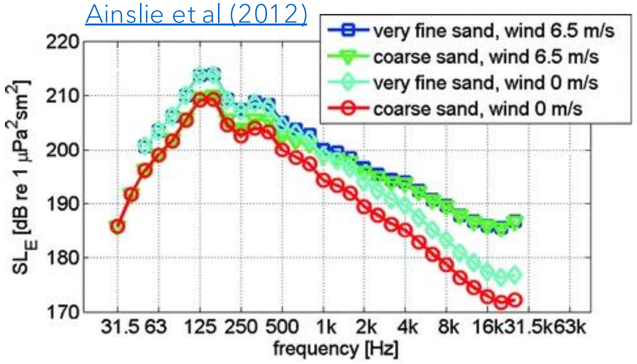
# FOUNDATION INSTALLATION

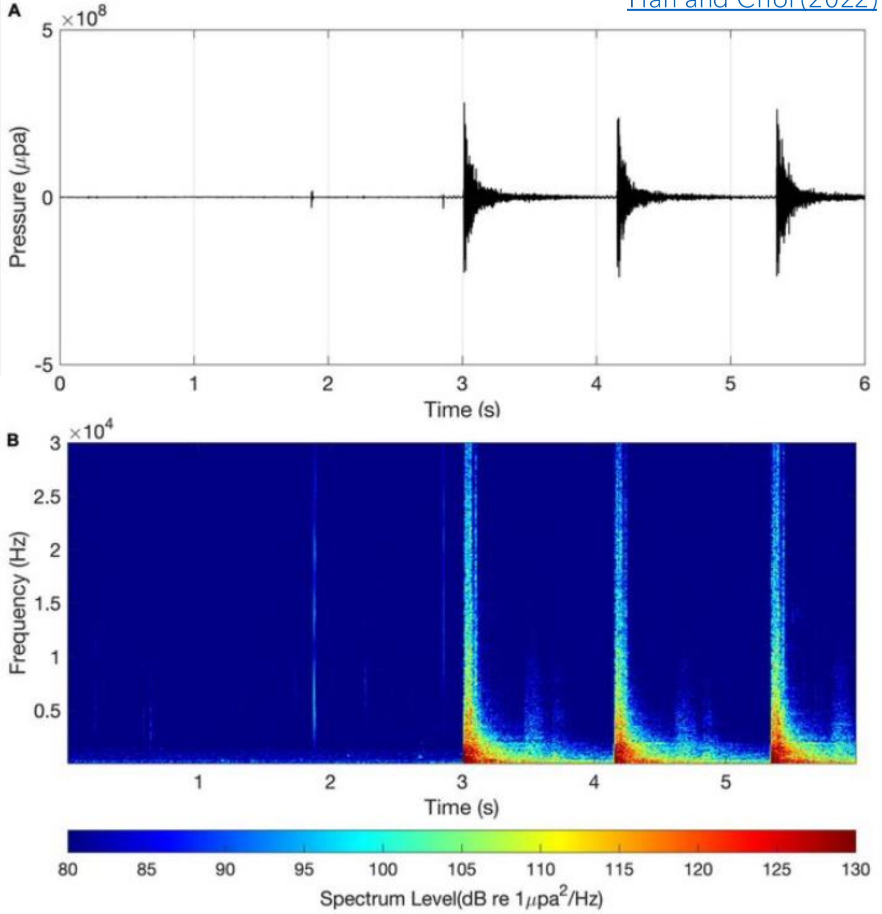
Sources
- Vessel Operations & Dredging

- Pile Driving
Most Energy at <500Hz
Source Level (10m): ~215-220 dB re 1 μPa

Ainslie et al (2012)




Han and Choi (2022)

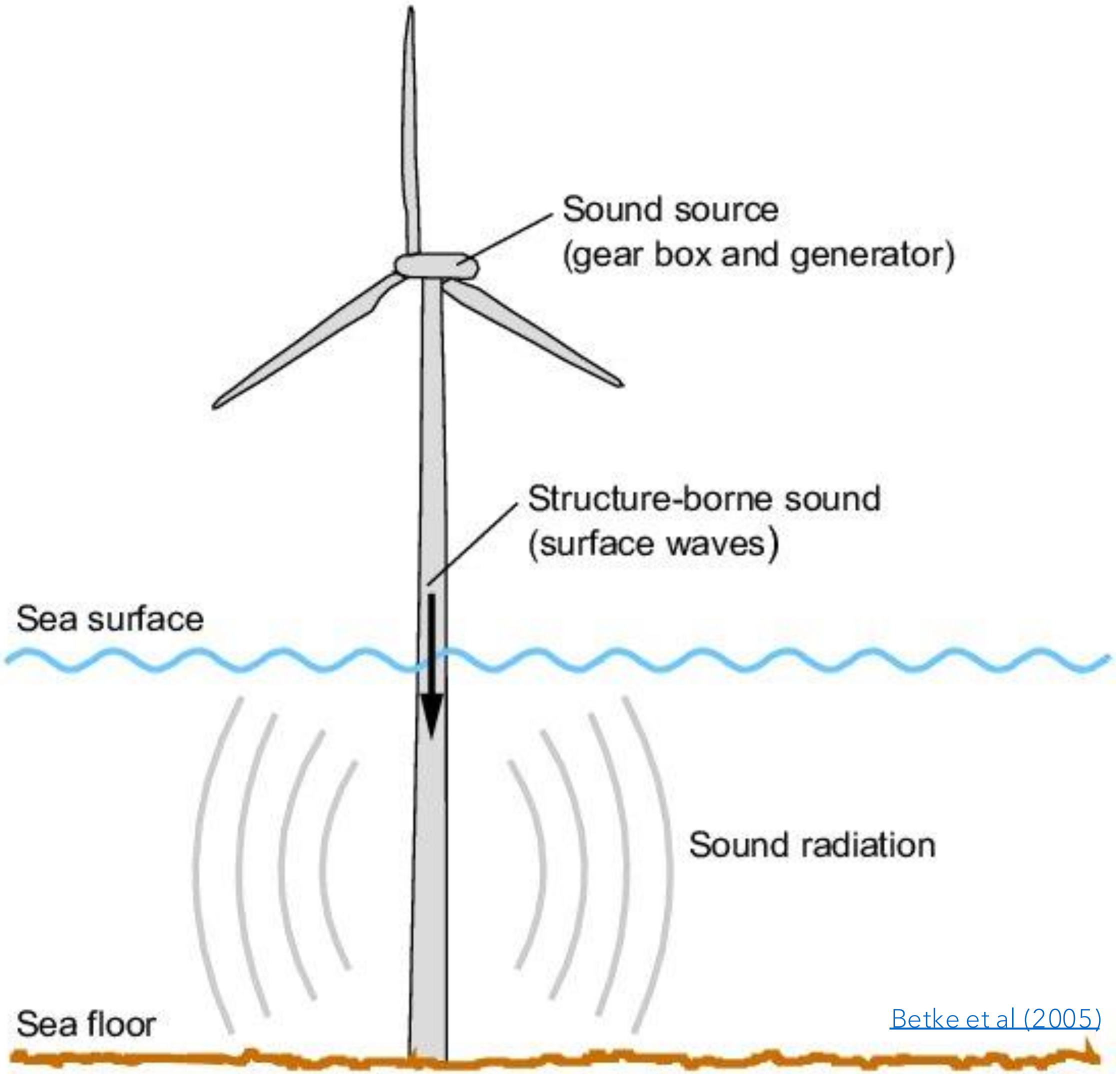



DOSITS Gallery Video Link

# OPERATION

Broadband
& Tonal Turbine Noise

Single Turbine + Collective Farm




Betke et al (2005)

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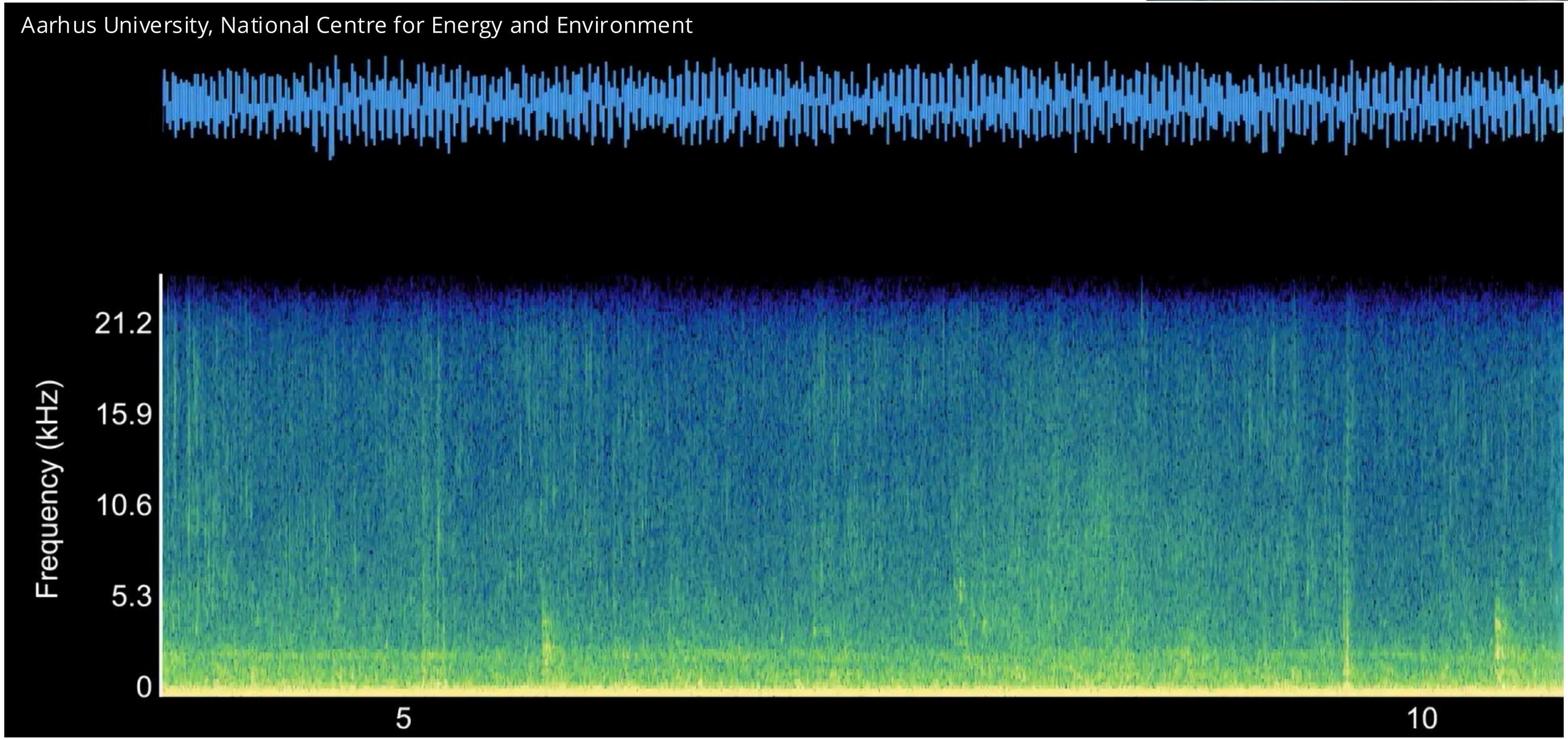
# OPERATION




SL: 153 dB re 1 μPa @ 1m at 16 Hz
Nedwell and Howell (2004)

SPL: 105 – 125 dB re 1 μPa @ 100 m
Tougaard et al (2020)

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# METHODS



- Tagging
- Aerial Surveys
- Photogrammetry
- Archival PAM (detection & localization)
- Real-time PAM (Medusas and Towed-Array)
- Sound propagation modeling
- Sample collection
- Mapping
- Oceanographic sampling
- Covariate analysis
- Risk frameworks

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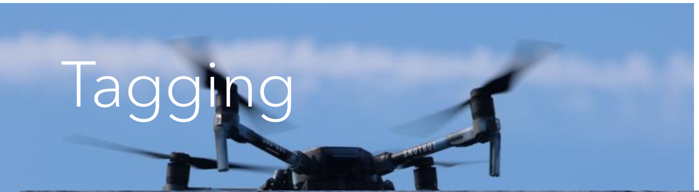
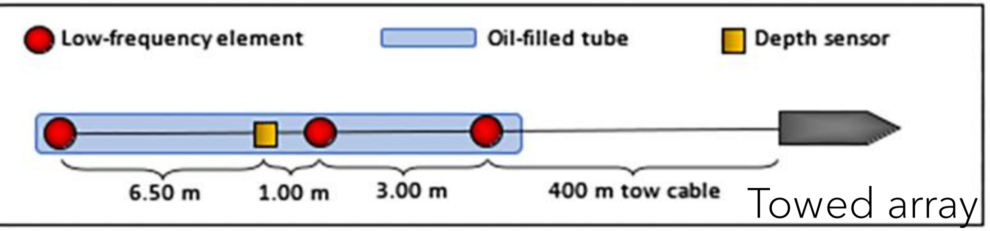
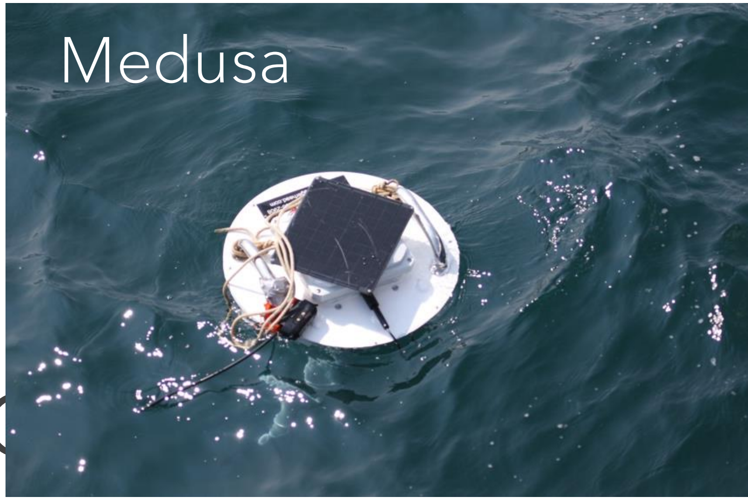
Applications to whales, birds and bats





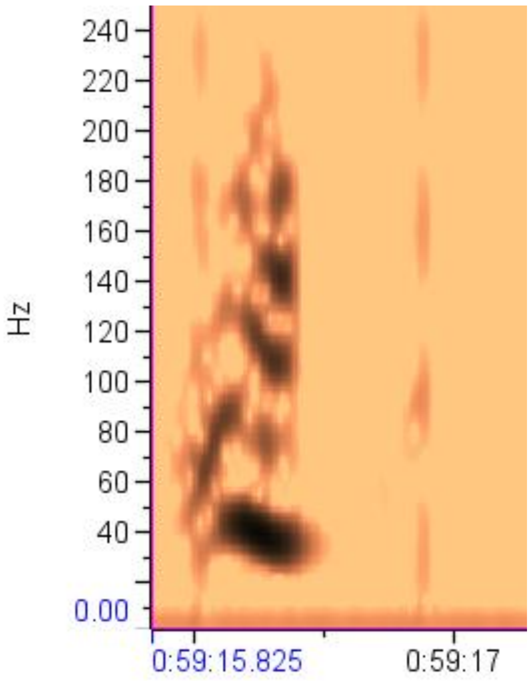



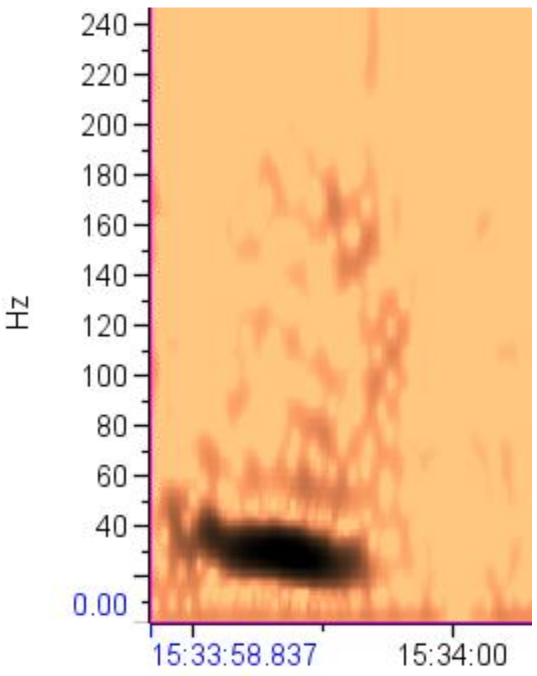

MMAL DATA COLLEC

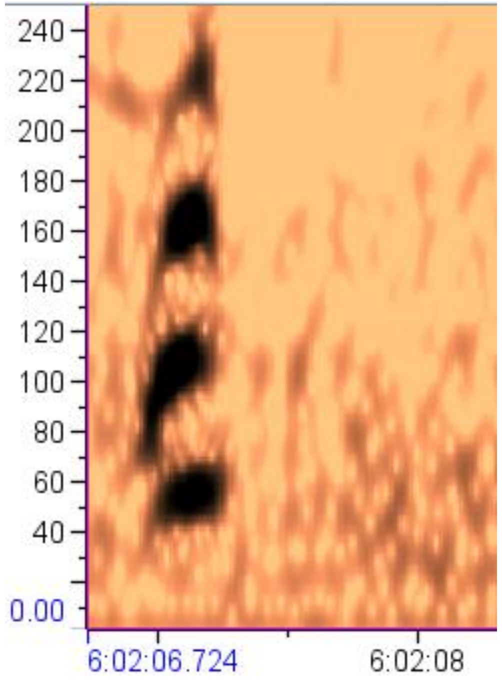


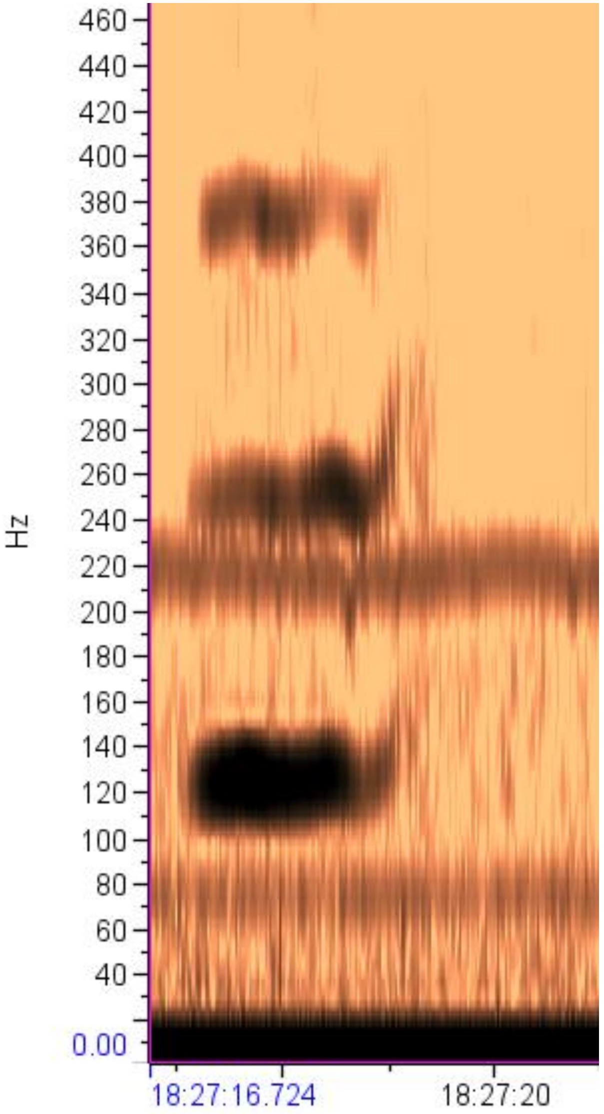
# DRONE TAG DELIVERY AND SNOT COLLECTION!

# FIN WHALE CALLS RECORDED ON TAGS NEAR THE SOUTHERN NE WIND ENERGY AREAS



# DOUBLE-TAGGING

# Medusa (new tech): a low-cost, near-real time passive acoustic drifting or stationary tool

Aran Mooney, Frants Jensen, Nadege Aoki, Nate Formel, Matthew Hyer, and David Mann

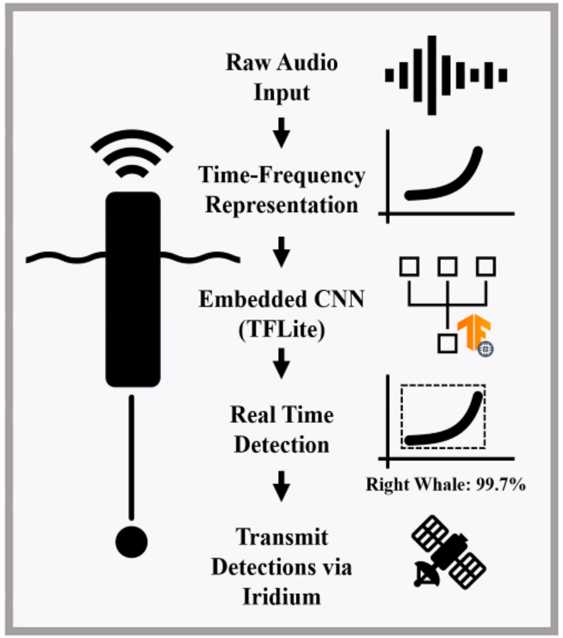
# Medusa NARW detection

**Constraints for NN:** Small (memory limit); fast (inference time)

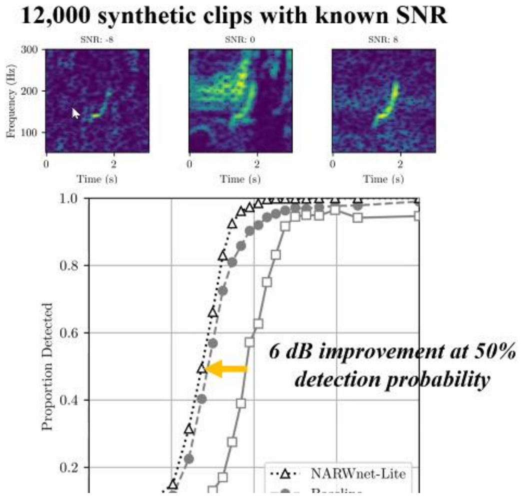
**CNN:** Resnet-50, 75,000 trainable parameters

**Features:** 3s spectrogram, crop to 50-300 Hz range, 64x64 pixel tensor (4 Hz frequency resolution and 50 ms temporal resolution)

**Training objectives:** Robust, highly reliable detection when compressed for real-time inference, even in new noise environments




# Performance as a function of SNR



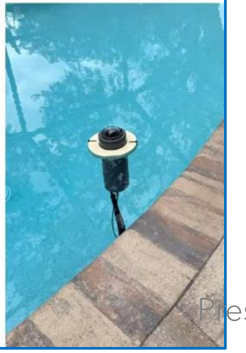

Noise Levels (Bailey et al., 2019)

## MEDUSA UPDATES

# Medusa design split

Two designs going forward:

- Moored buoy, solar powered batteries, sufficient floatation to avoid submergence in rough weather (using medusa "brain", potential for installation of system anywhere)
- Spar drifter buoy, battery powered, no solar but minimalist design/footprint



# Field Validation

*Summers 2023 and 2024*

**2023: Medusa in archival mode:** all analyses done post-processing on desktop

**2024: Medusa with real-time detection:** Detection output compared to post-processed data

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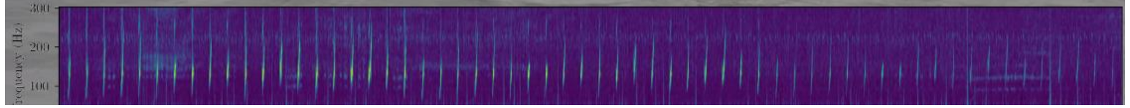
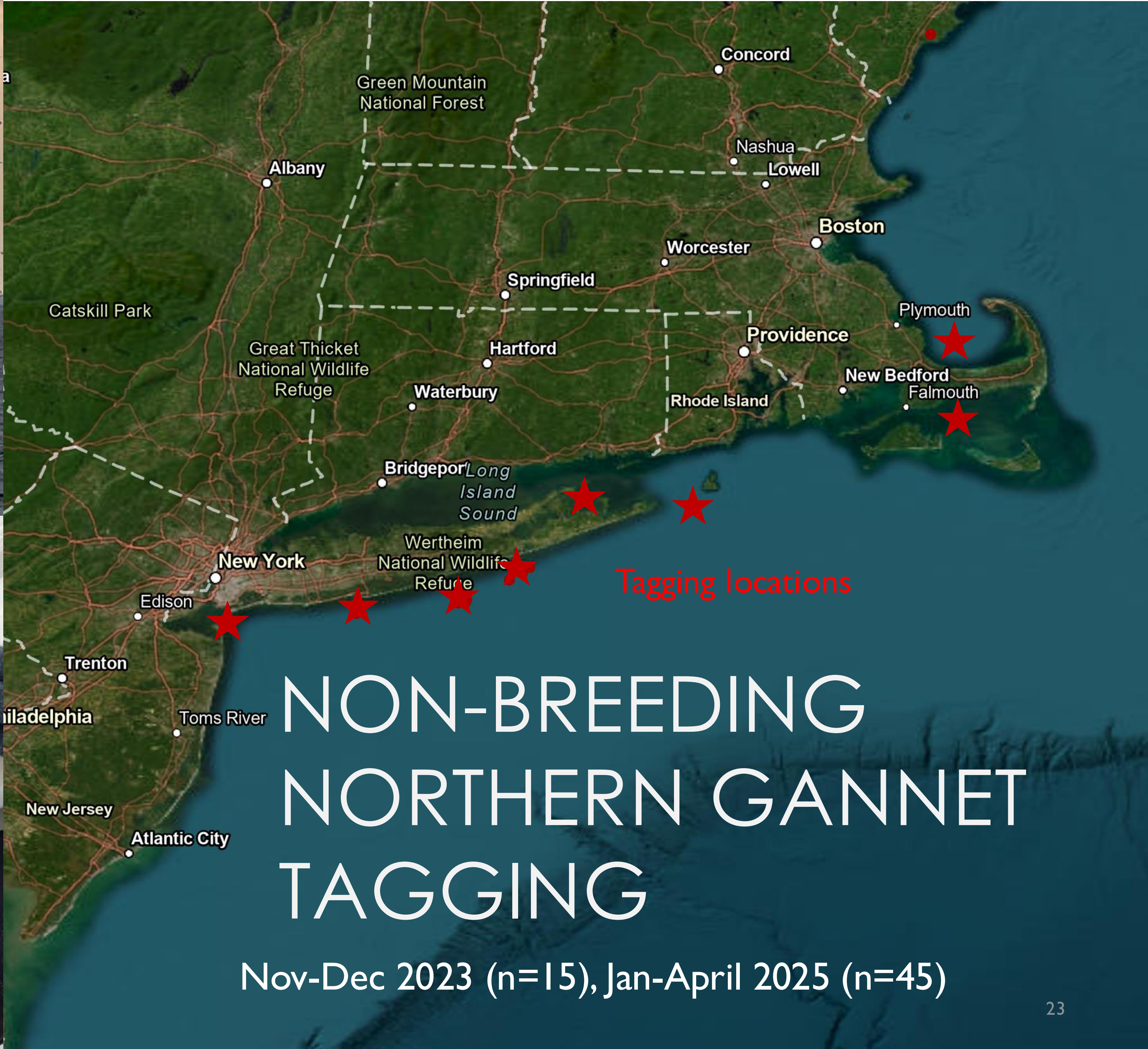
Simulated field operation with four Medusa acoustic buoys and RAPS playback system with corresponding GPS locations

Sequence of 20 upcalls played from speaker (high, medium, and low amplitude transmissions)

Evaluate NARWnet-Lite performance running onboard Medusa acoustic buoy

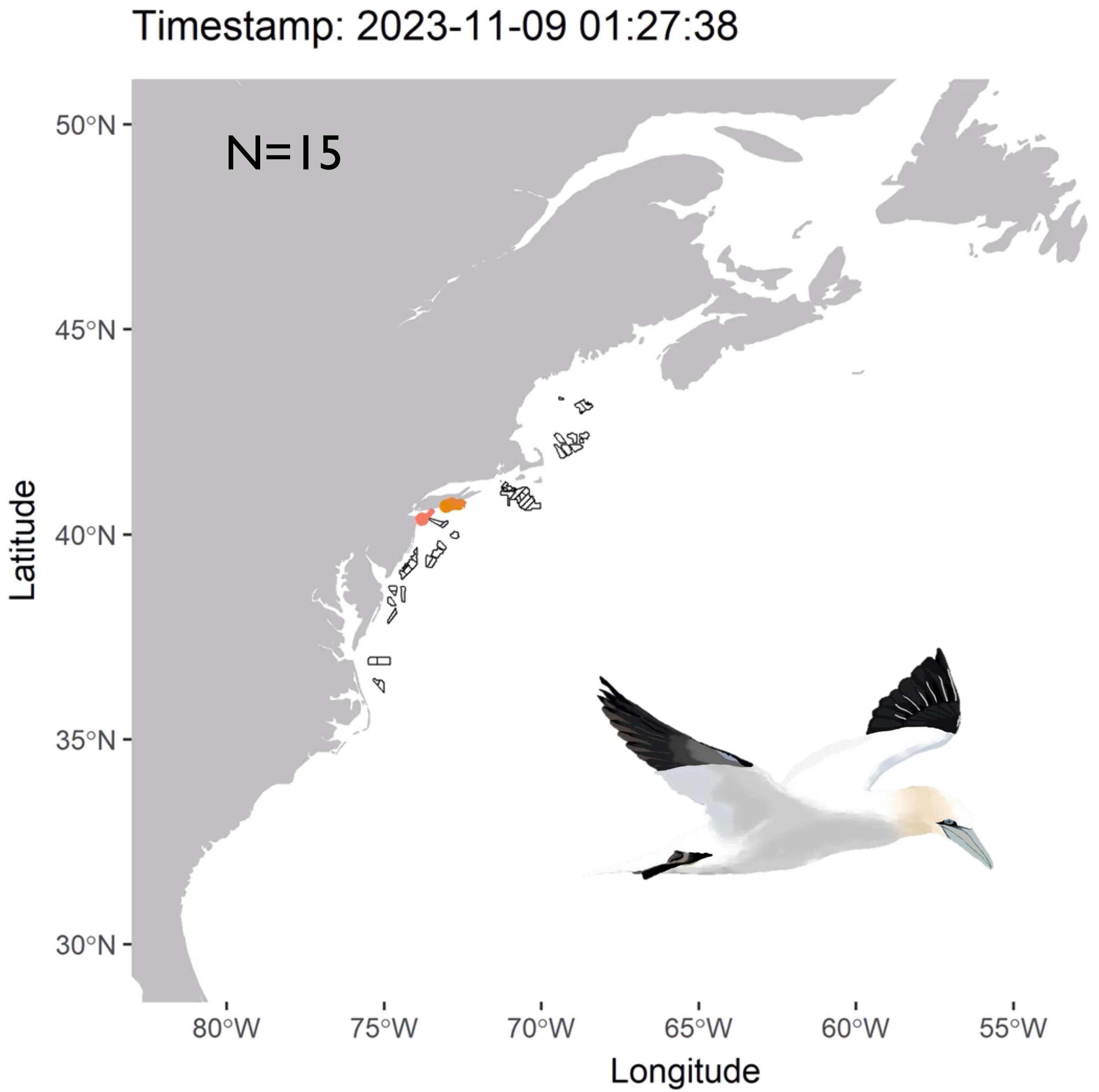


# Project WOW: Tracking Northern Gannets to Understand 3D Habitat Use and Risk from Offshore Wind Development

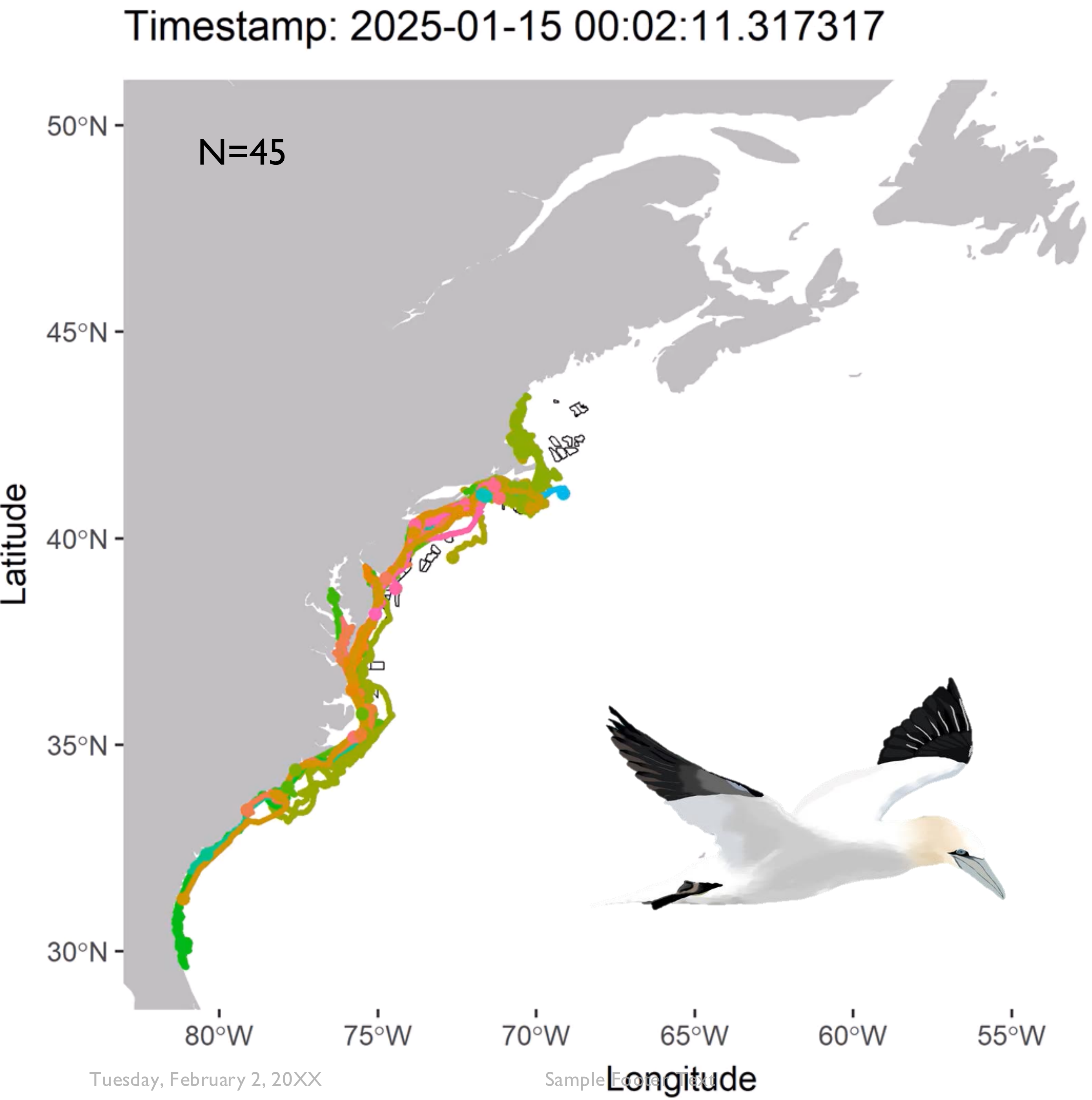



# NON-BREEDING NORTHERN GANNET TAGGING

Nov-Dec 2023 (n=15), Jan-April 2025 (n=45)

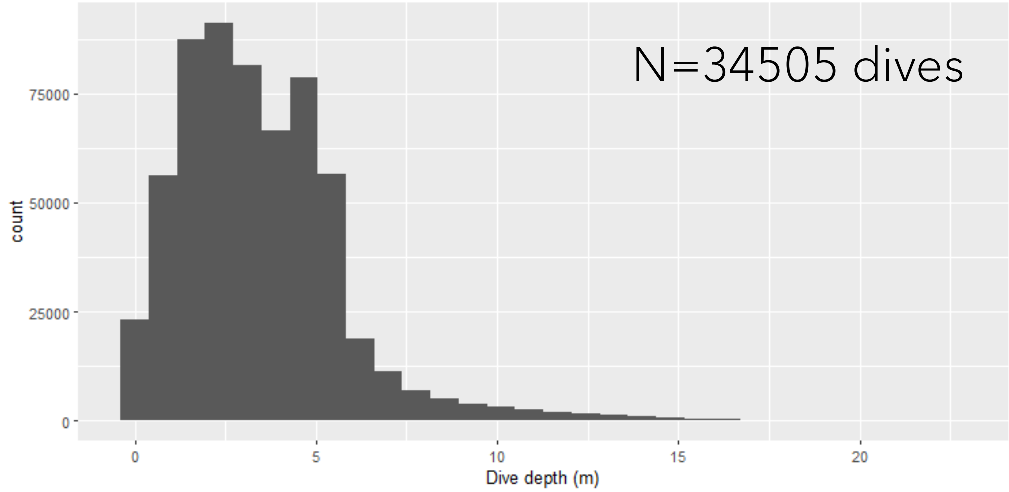


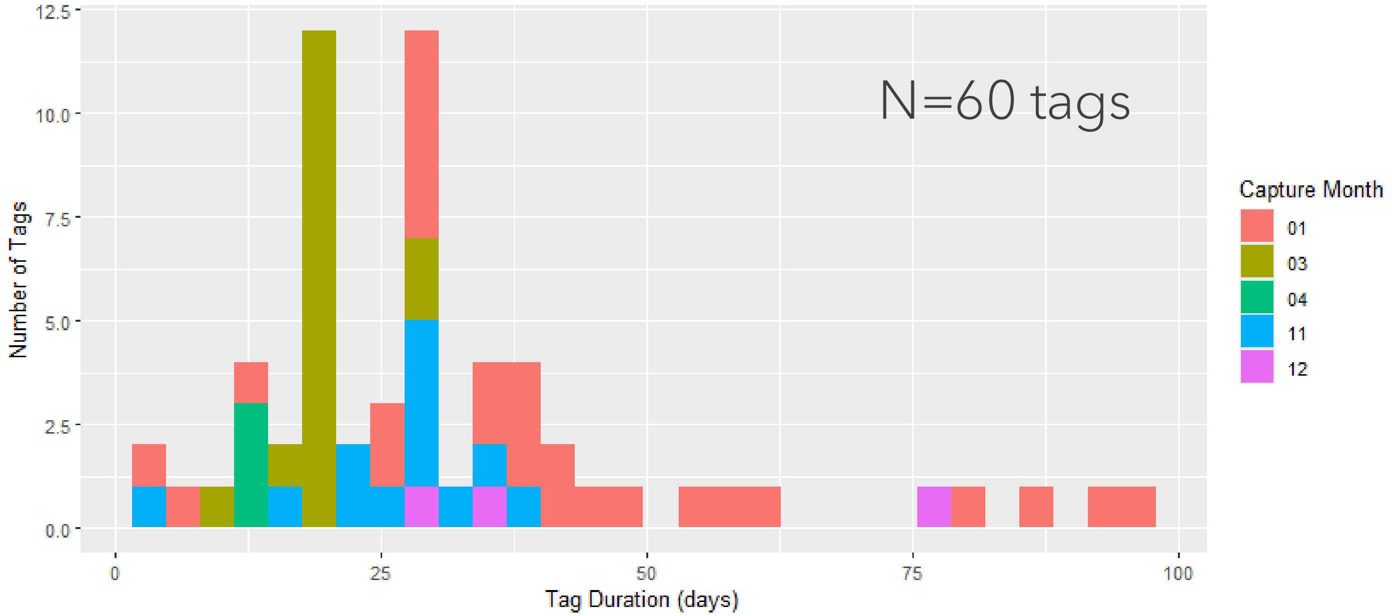

# 2023 Deployments

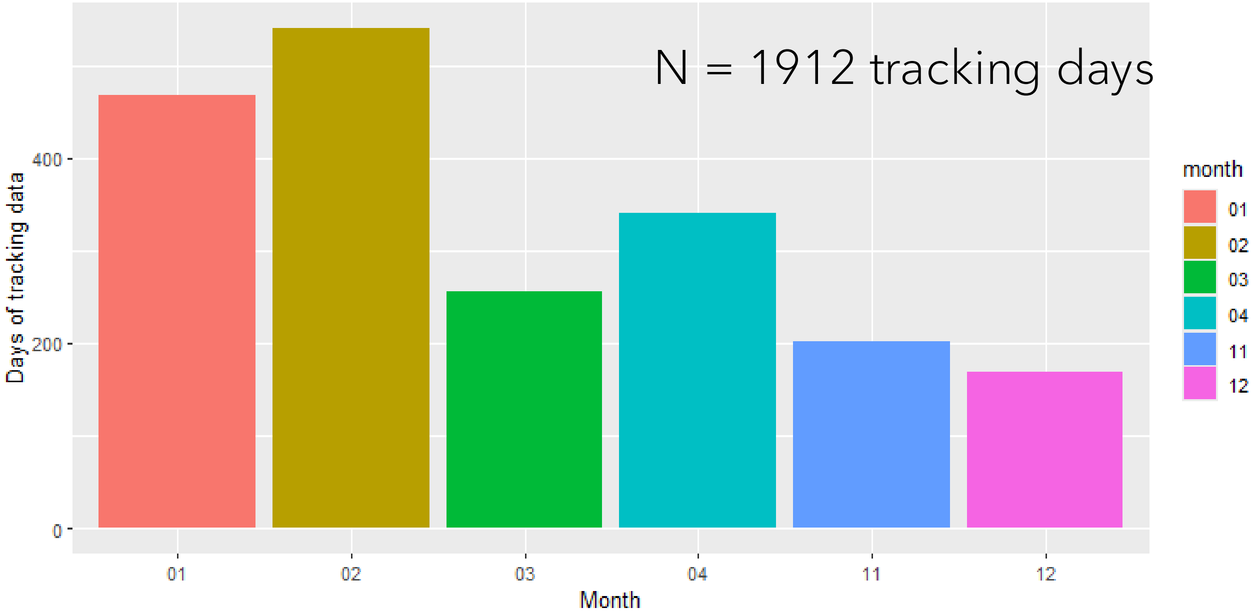


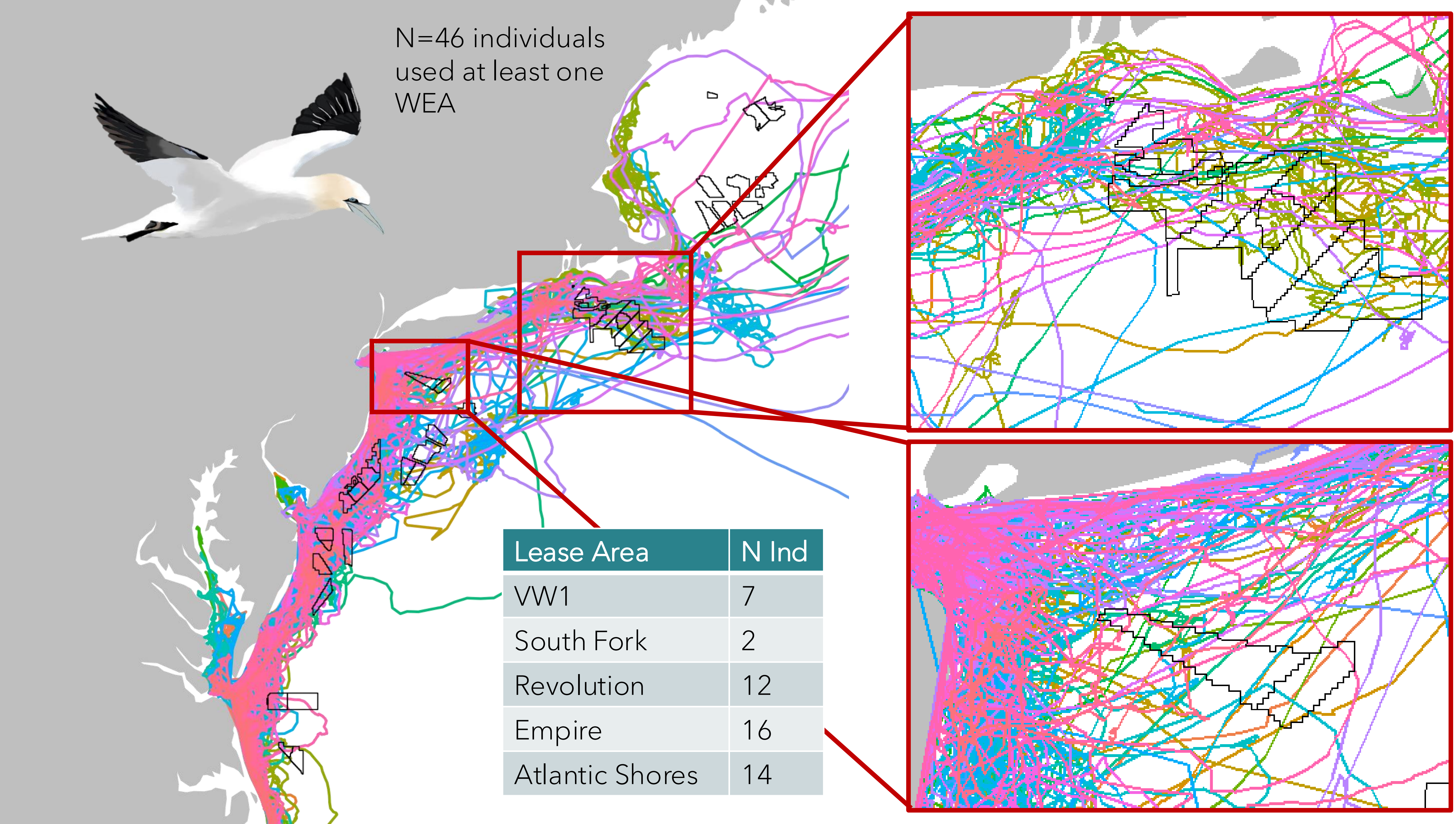

# 2025 Deployments

# SUMMARY STATS





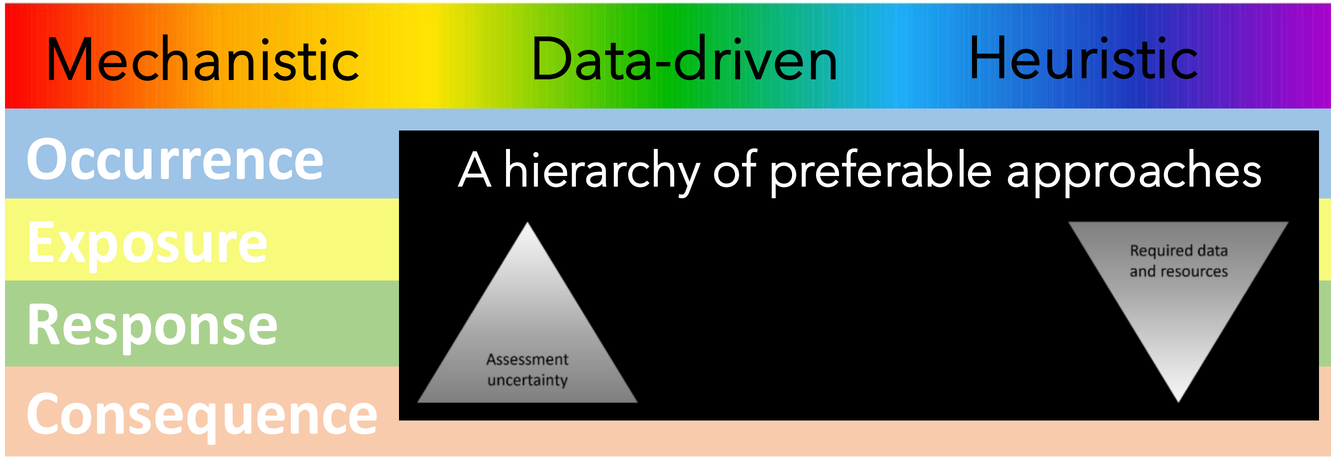

| Lease Area | N Ind |
|---|---|
| VW1 | 7 |
| South Fork | 2 |
| Revolution | 12 |
| Empire | 16 |
| Atlantic Shores | 14 |

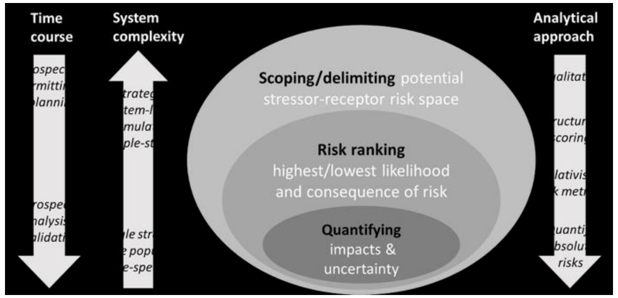
# Next Steps

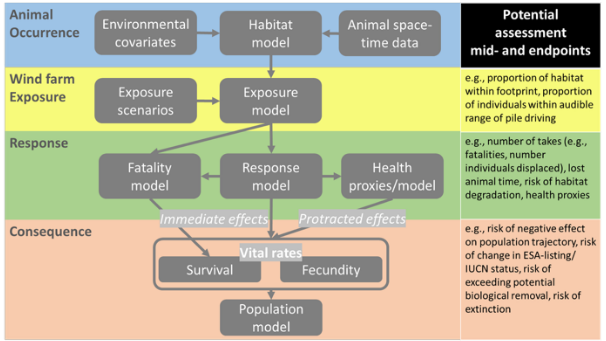
- Modeling to examine environmental factors influencing movement patterns and behavior
- Incorporating dive information to understand where birds are foraging
- Analyzing flight height to improve understanding of collision risk
- For the areas of Southern New England with operational offshore wind turbines we can examine how individuals are responding to these structures

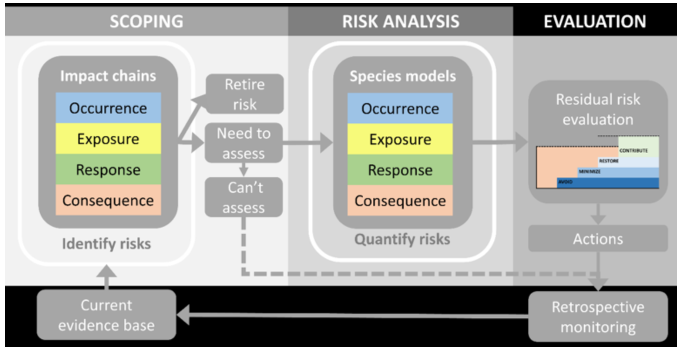
# RETHINKING RISK ASSESSMENT FRAMEWORKS…

I. Conceptual framework that
   I. Provides shared language/ consistency in approach across receptor groups & hazard types
   II. Is scalable and adaptable to a spectrum of analytical approaches/ choices (acknowledging need for simplified & relativistic approaches)
II. Spectrum of approaches, but all should
   I. Define explicit assessment endpoints
   II. Consider (at least conceptually) potential mechanisms driving risks
III. Proxies and heuristic need to be validated
   I. call for cross-validation studies and sensitivity analyses
   II. Real validation requires data – need for monitoring / promising monitoring approaches (why we need simpler assessments in the first place). Especially baseline data for the "Occurrence piece"



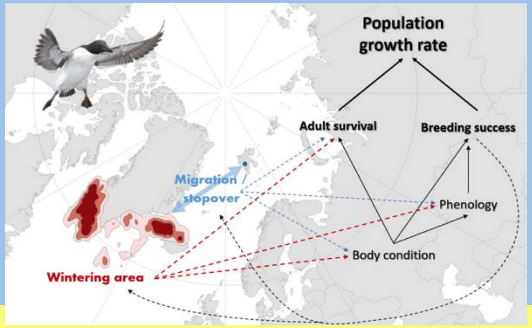




Seabird & collision risk case study
figure TBD

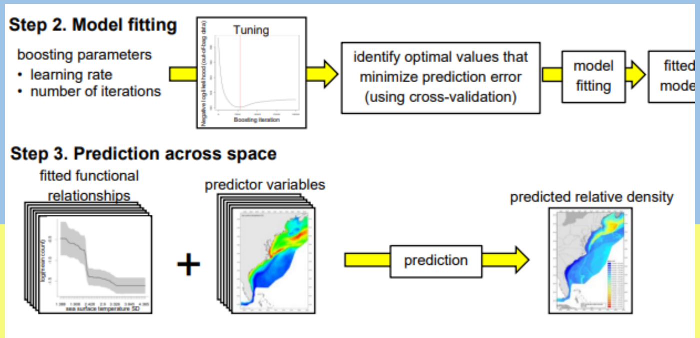
# Mechanistic models | Empirical models | Heuristic algorithms

## Occurrence
*how, where, when, and how long birds **use** sites/spaces*

**Mechanisms:** Availability of resources, breeding and resting sites, accessibility & connectivity between important sites, dispersal, site fidelity

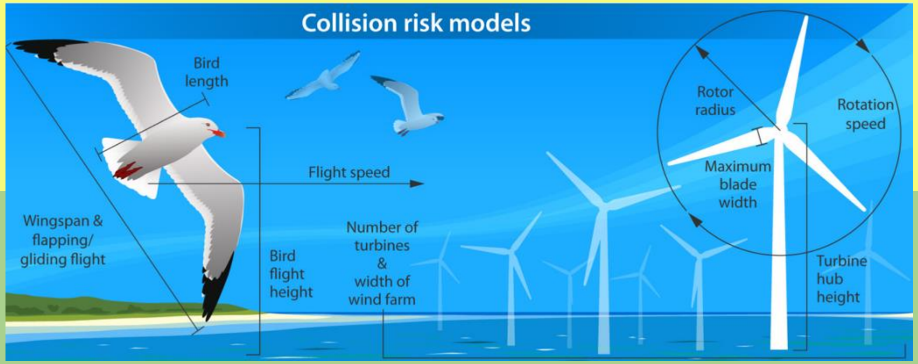



Covariates as proxies for drivers of habitat use, density distribution as a proxy of average usage




## Exposure
*where, when, and how long birds are exposed*

**Mechanisms:** Spatiotemporal co-occurrence with and detectability of turbines in different contexts & scales




Density as a proxy for the number of birds flying through a windfarm footprint

Composite indices of collision risk

Flight altitude score ✖ OR ✚

**Fauchald et al, Kelsey et al:**

**Furness et al 2013:**

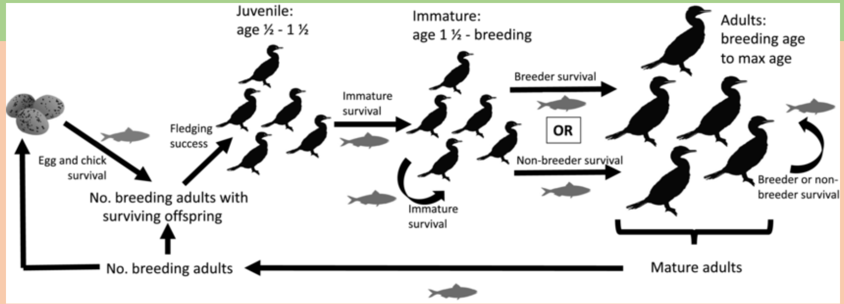
## Response
*the likelihood, type and severity of individual-level response/ effects*

Micro-avoidance calculated as observed (terrestrial) minus predicted by CRM

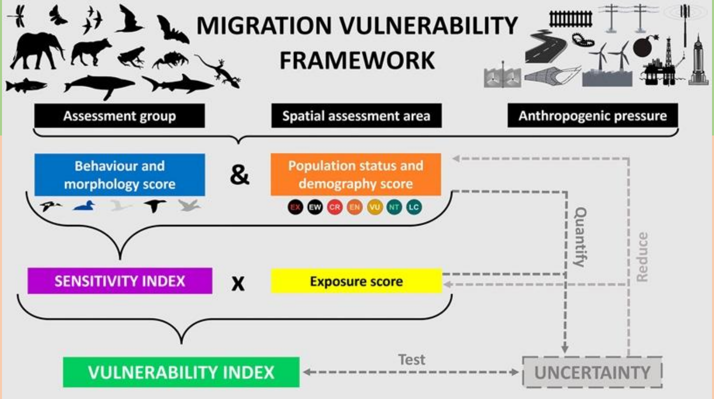
( Flight time score ✚ Nocturnal flight activity ✚ Manoeuvrability score )

**Mechanisms:** threat perception, ability to avoid turbines

## Consequence
*the likelihood and magnitude of population-level impacts*




Potential Biological Removal (PBR)





Green et al 2025
https://www.sciencedirect.com/science/article/pii/S0006320725001557

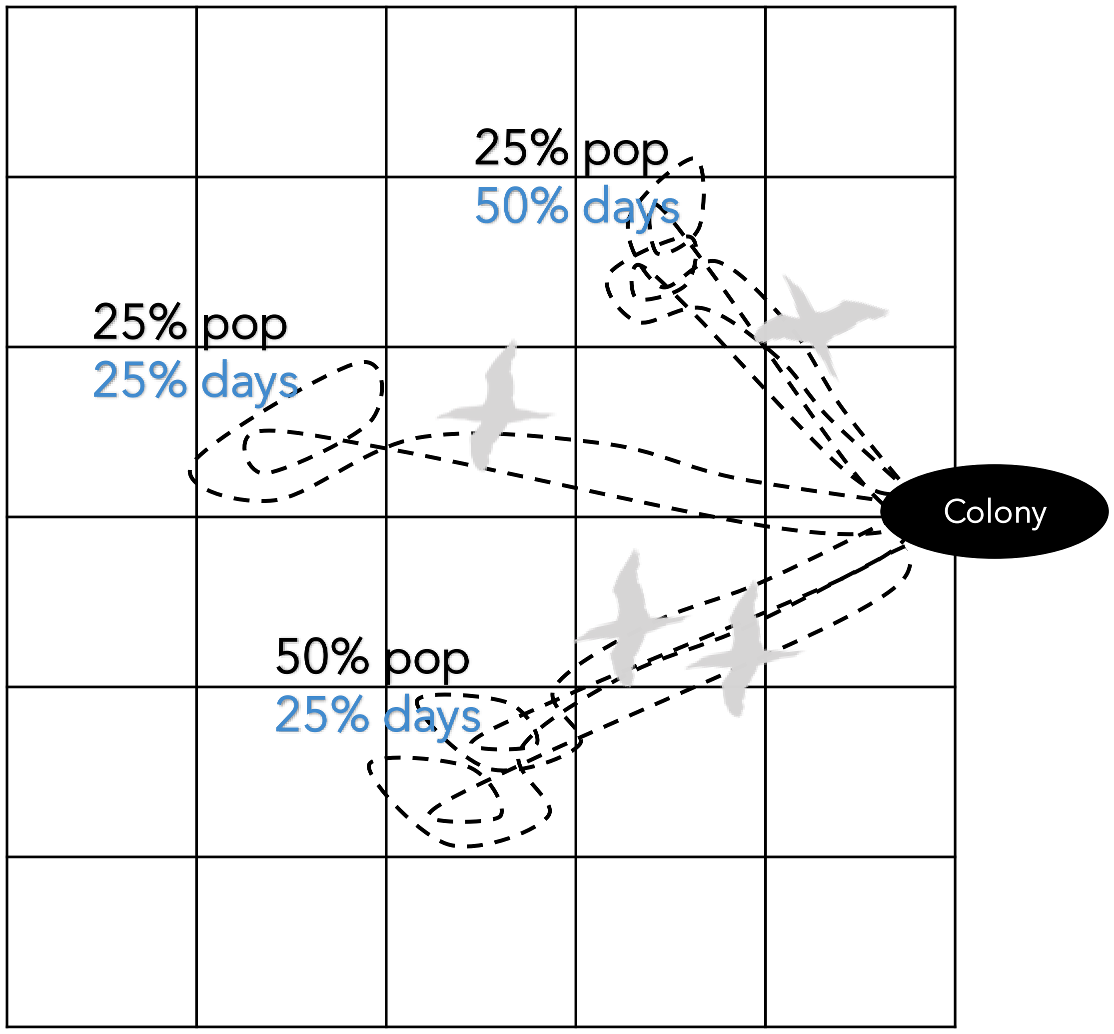
**Mechanisms**: Demographic rates, density dependence, other pressures

# Occurrence, but ideally: usage, especially aggregate usage

*how, where, when,*
*and how long birds*
*use sites/spaces*

Example usage metrics to inform potential exposure in each grid cell:

- Proportion of population using each grid cell
- Proportion of time foraging in each grid cell → aggregate impact of disturbance in the grid cell, if birds keep trying to forage there
  - And possibly displacement, if the baseline time spent scales with the fitness value of the habitat to the birds
- Passage rates → barrier effects, collision risk
- 3D flight paths, speed → collision risk



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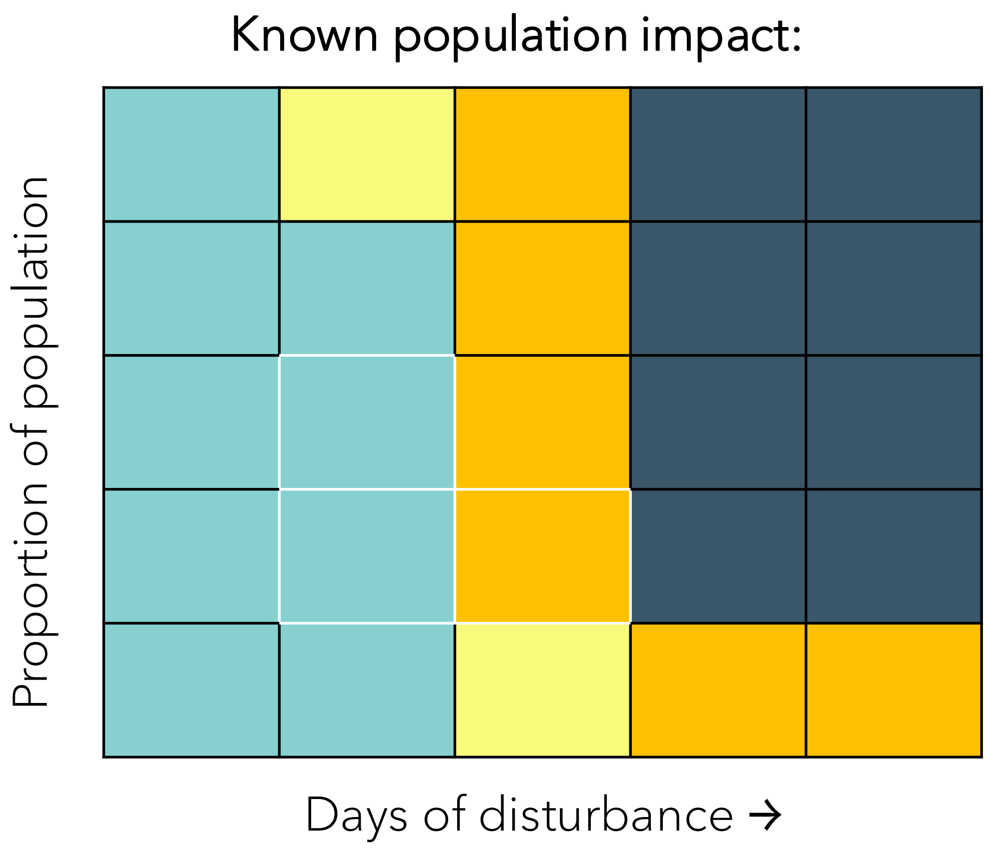


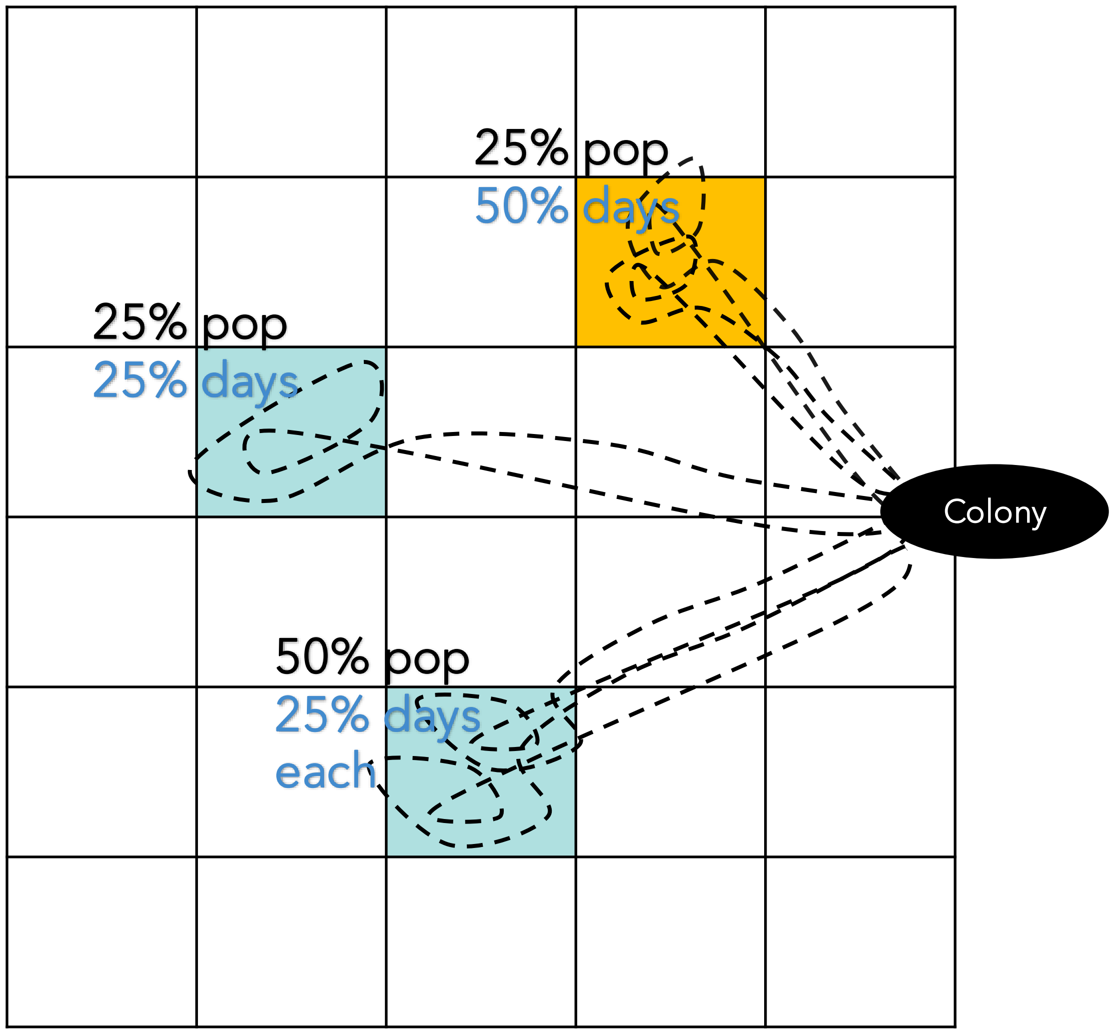

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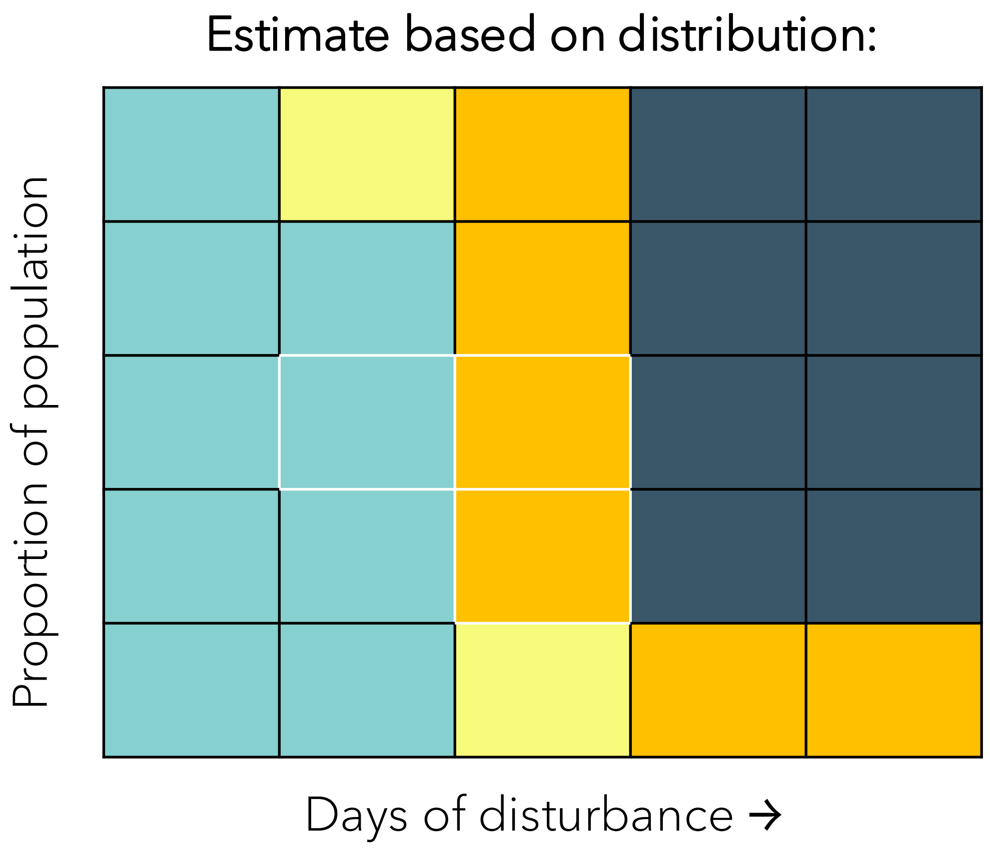
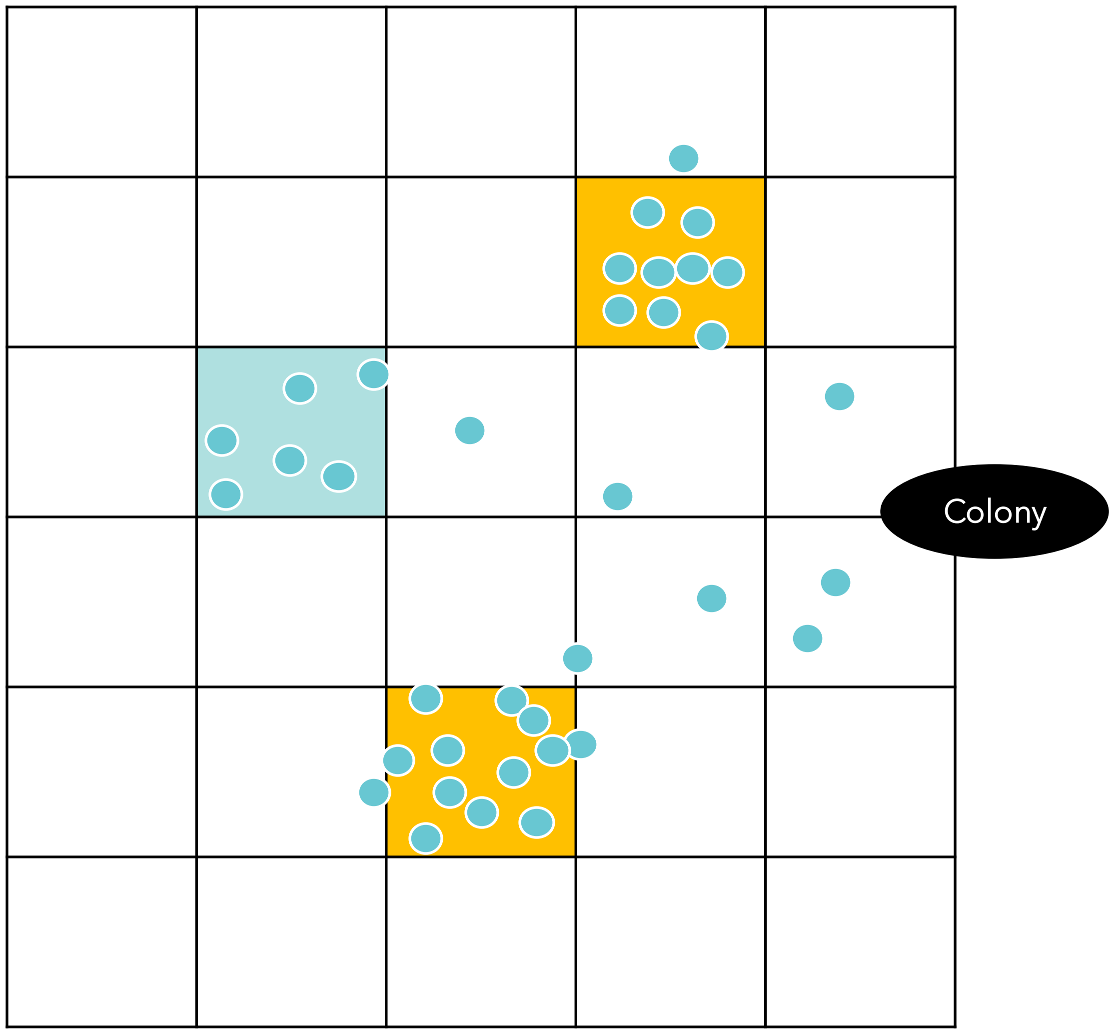
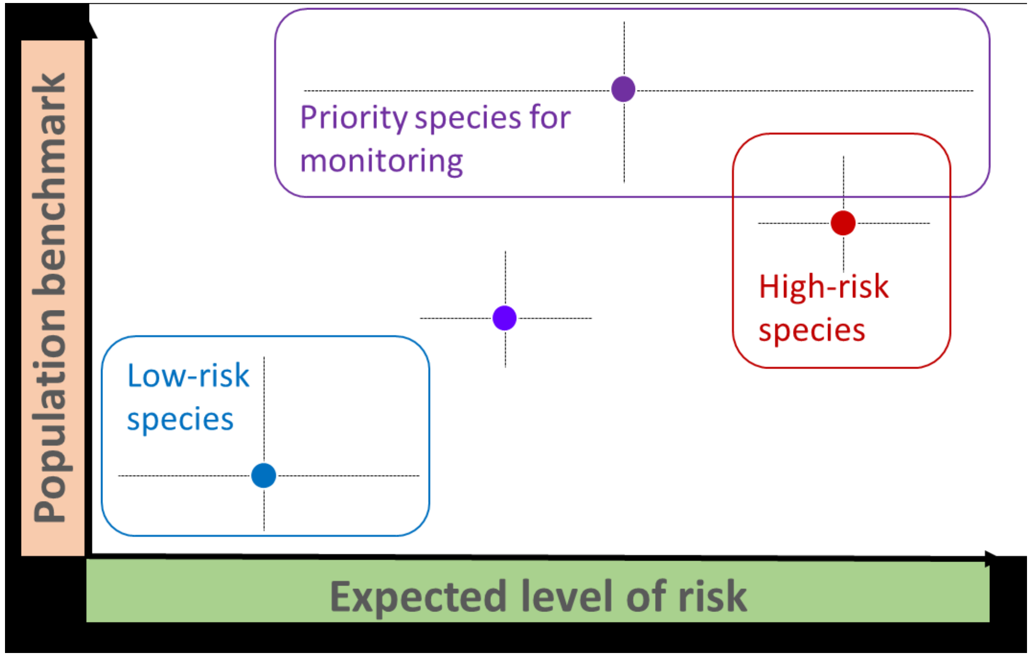


# BENCHMARKING POPULATION-LEVEL RISK

$$Risk\ ratio = \frac{Expected\ risk}{Acceptable\ risk}$$




Some precedent in using risk ratios – e.g., in USGS assessment methodology to evaluate risks to birds and bats from onshore wind farms:

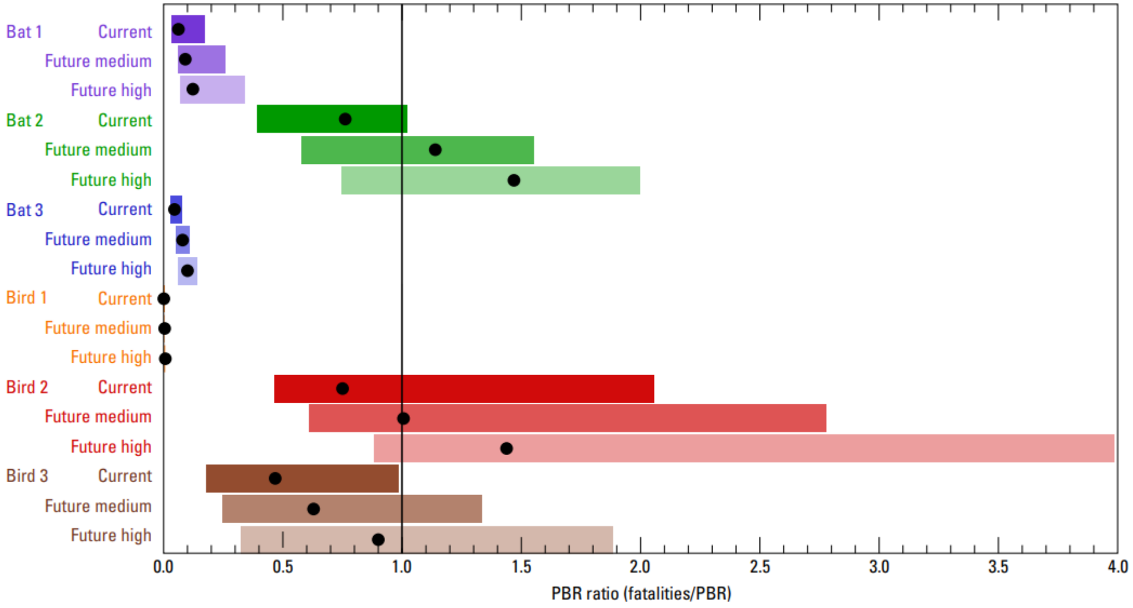



**Figure 8.** Graph showing the ranges of PBR ratios when the recovery factor (*F*) equals 0.5 for three bird species and three bat species at current (2014) levels of installed capacity and for both medium- and high-capacity scenarios for 2025. Each black circle represents the best estimate for the scenario, whereas each colored bar represents the range spanned by the upper and lower confidence intervals. The projected scenarios are as follows, by installed capacity in gigawatts (GW): current (2014), 62.3 GW (American Wind Energy Association, 2014); future medium (2025), 94 GW; future high (2025), 121 GW. PBR, potential biological removal.

https://pubs.usgs.gov/sir/2018/5157/sir20185157.pdf

# NYB SATELLITE TAGGING EFFORT

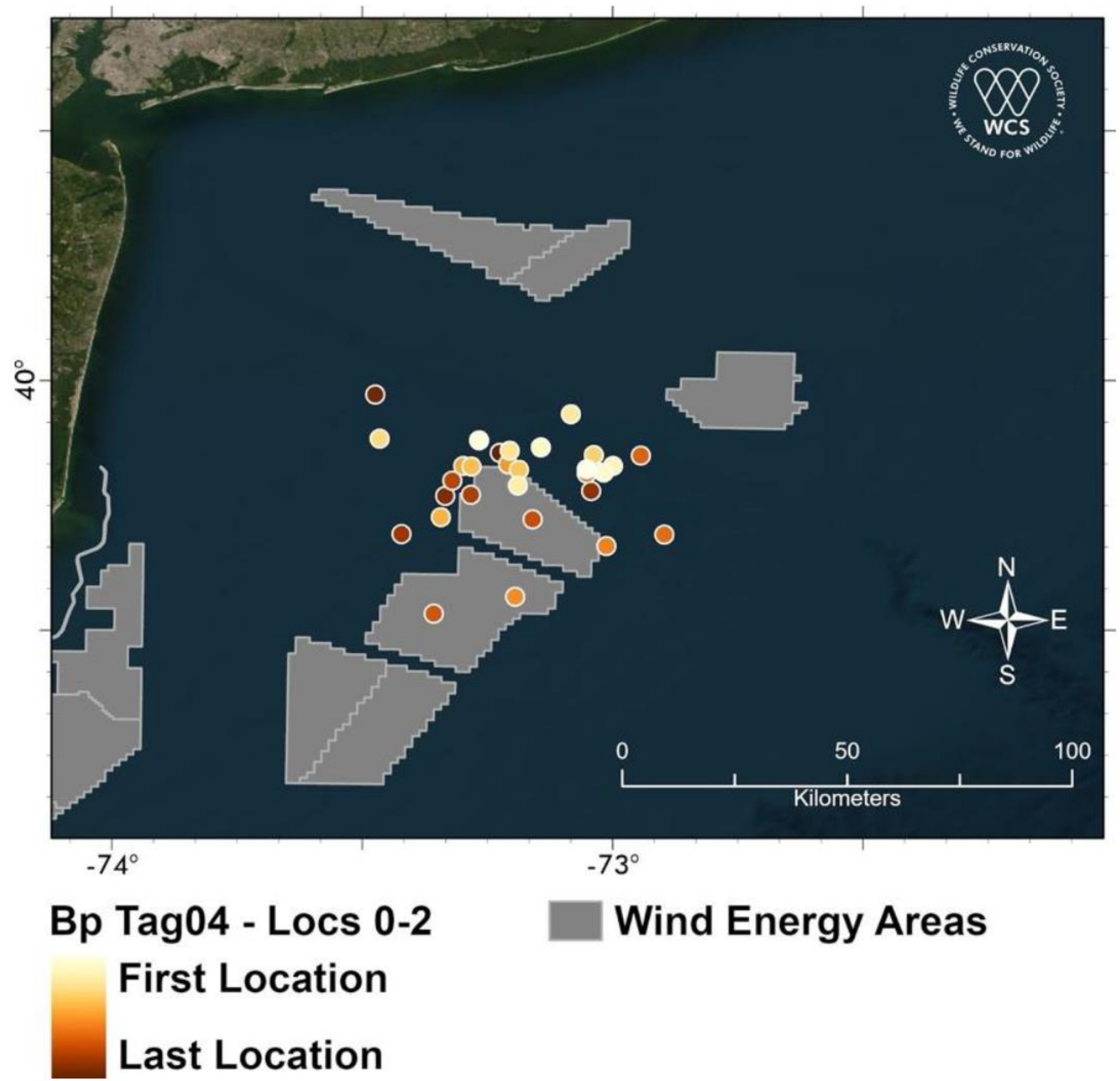
## 2023 & 2024 Seasons

Dr. Howard Rosenbaum, Dr. Brandon Southall, Dr. Will Cioffi, Carissa King-Nolan & Sarah Trabue
Wildlife Conservation Society
Southall Environmental Associates

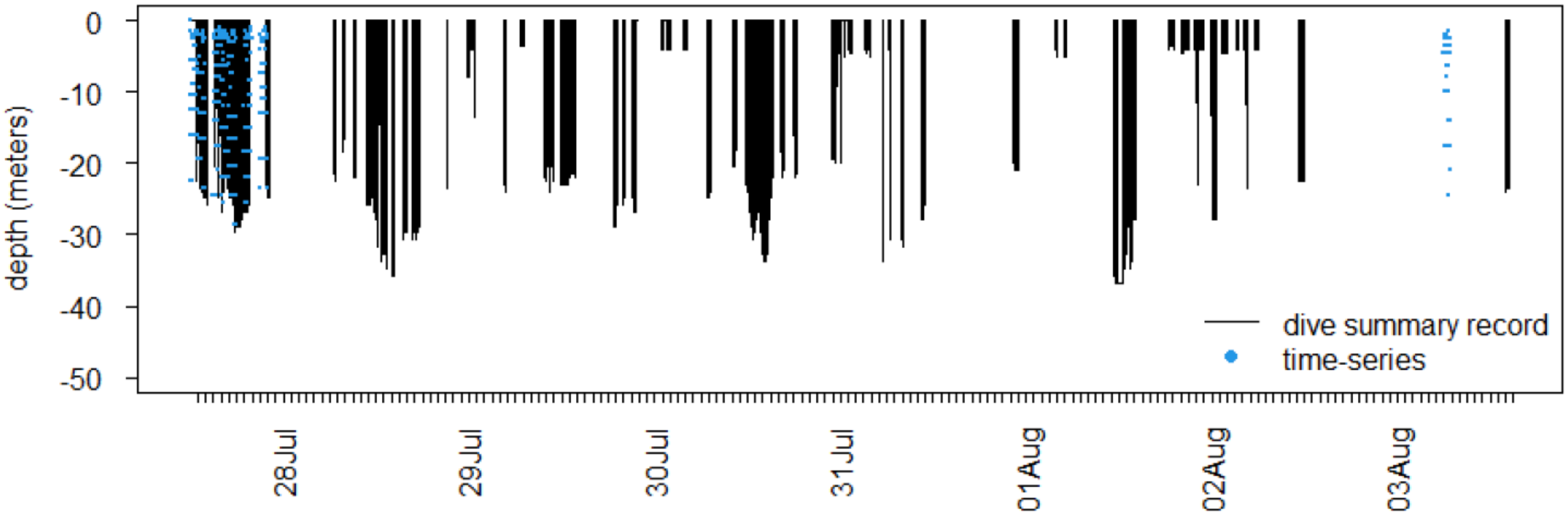
# TAGGING RESULTS



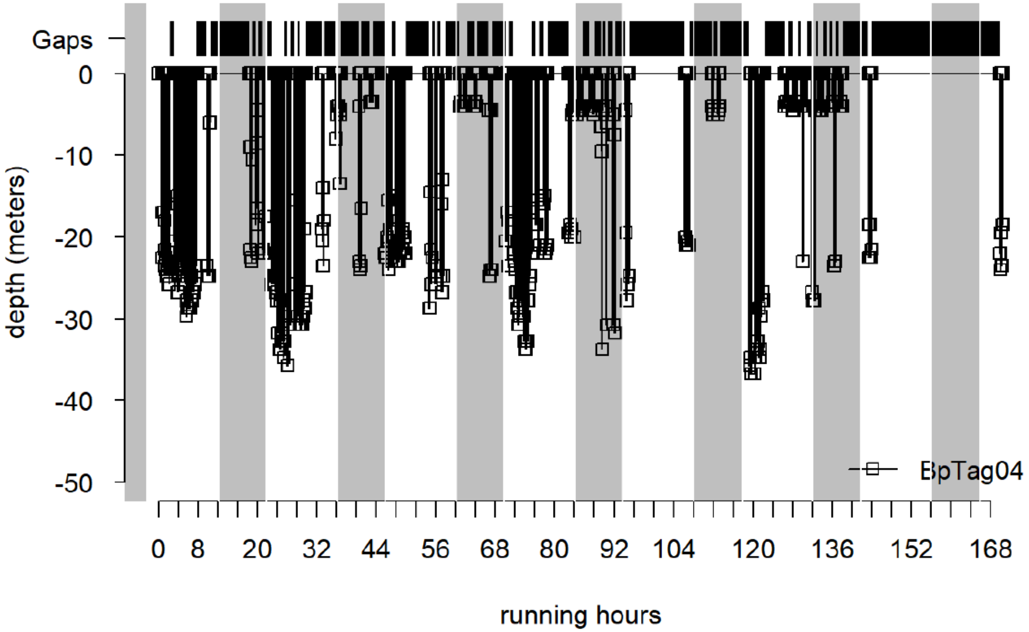
Aarhus University, Natic



# TAGGING RESULTS

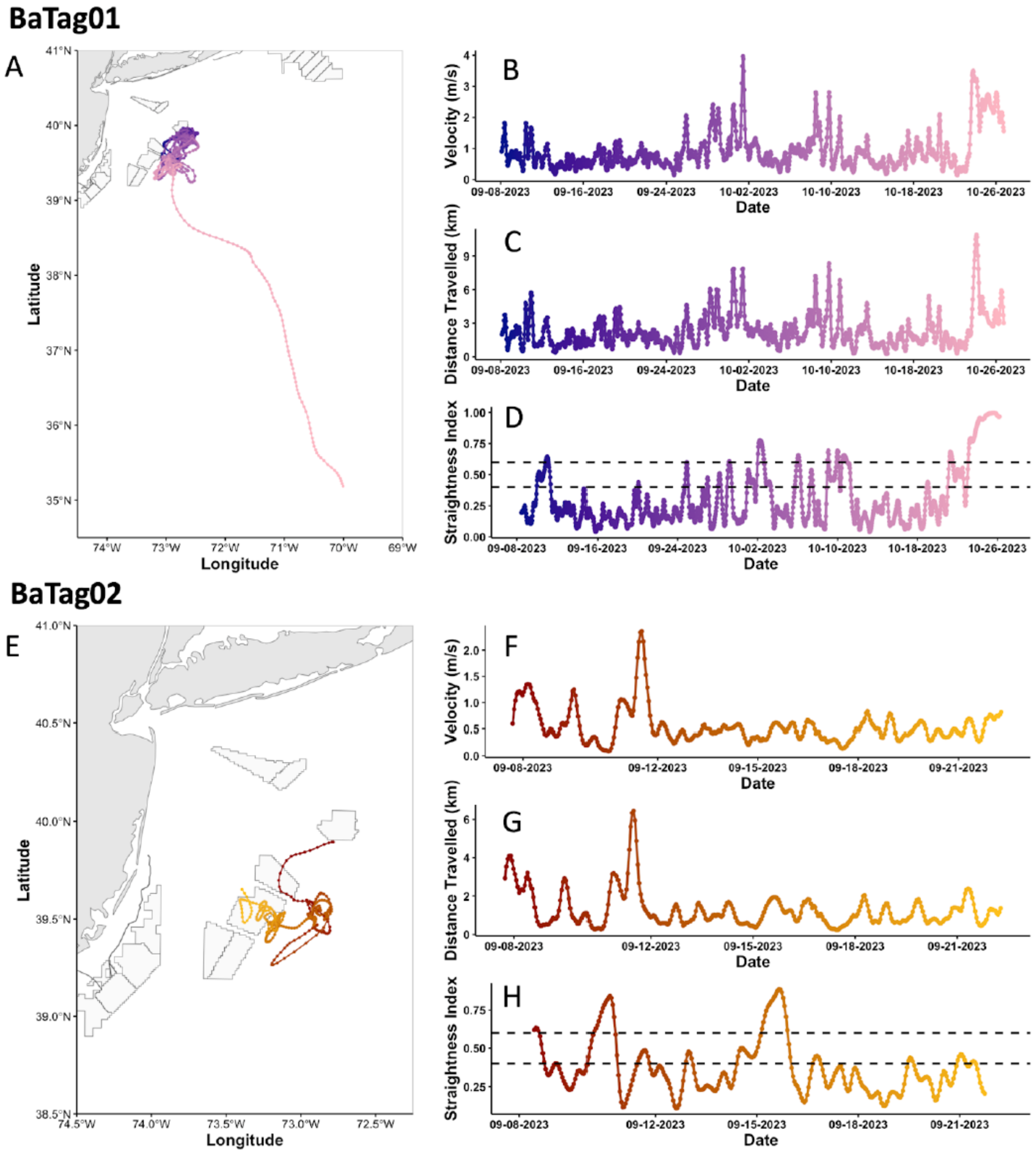



Dive behavior

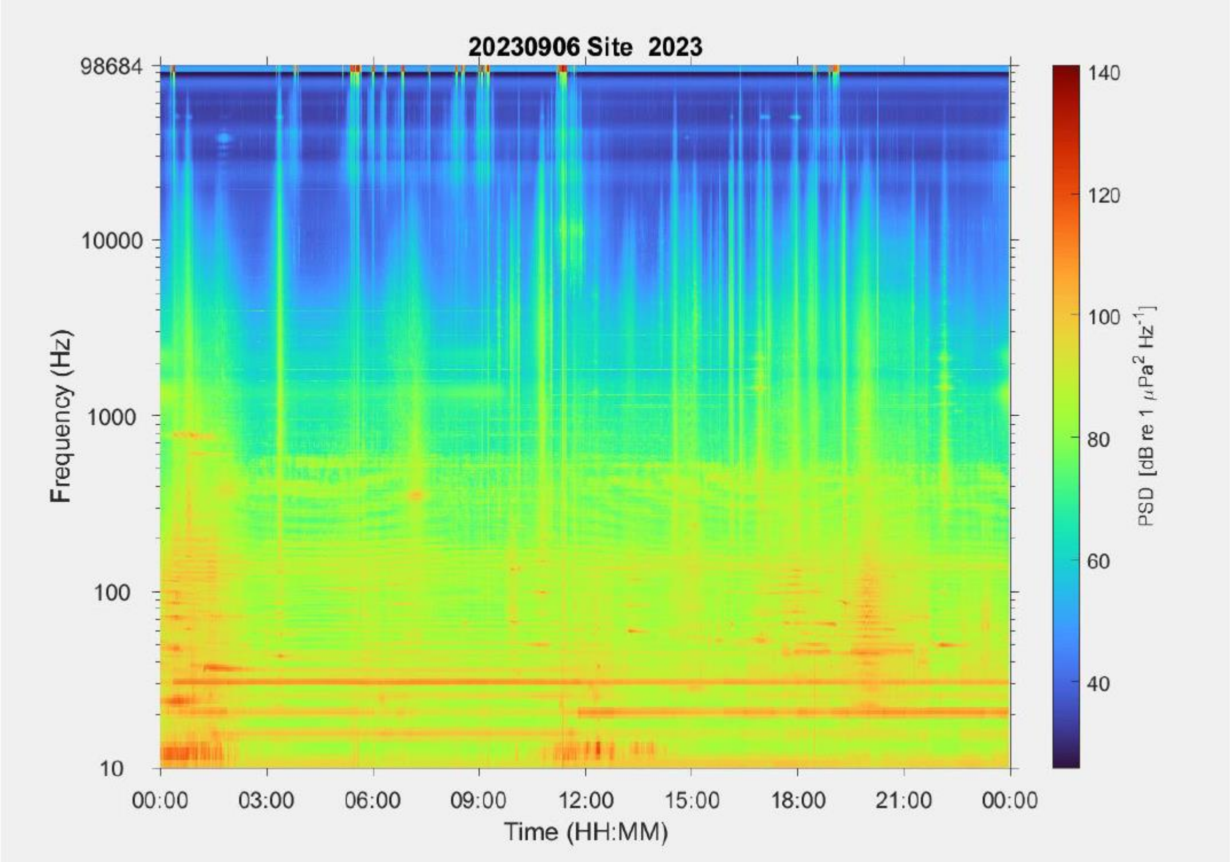


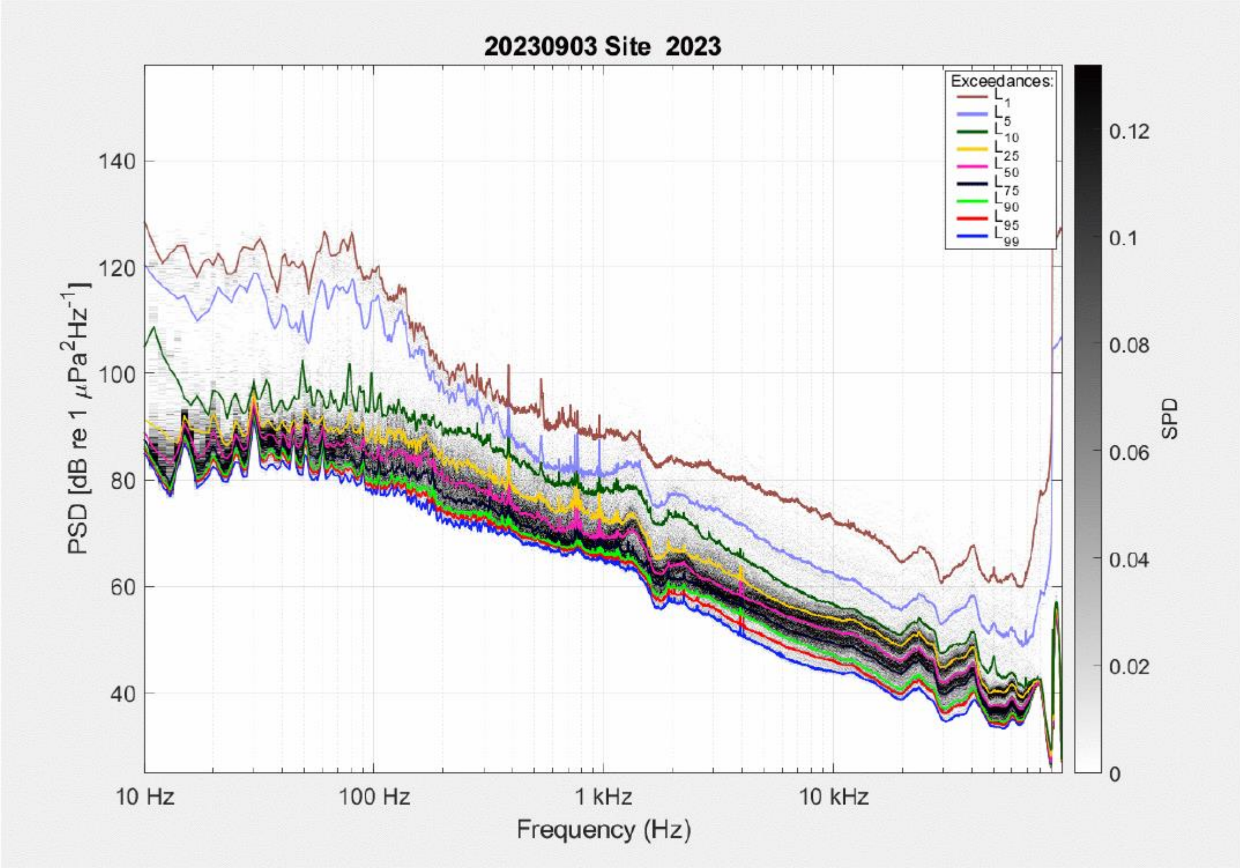
# TAGGING RESULTS

Aarhus University, Natio



# AMBIENT NOISE



# THANK YOU!

Douglas P. Nowacek – dpn3@duke.edu

Aaron N. Rice – arice@cornell.edu

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WILDLIFE AND OFFSHORE WIND

WOW

A Systems Approach to Research and Risk Assessment for Offshore Wind Development

# WOW PROJECT UPDATES

- 'Opportunistic BRS' – in motion!
- Medusa updates/upgrades
- NOGA tagging
- Revisiting & updating RA frameworks

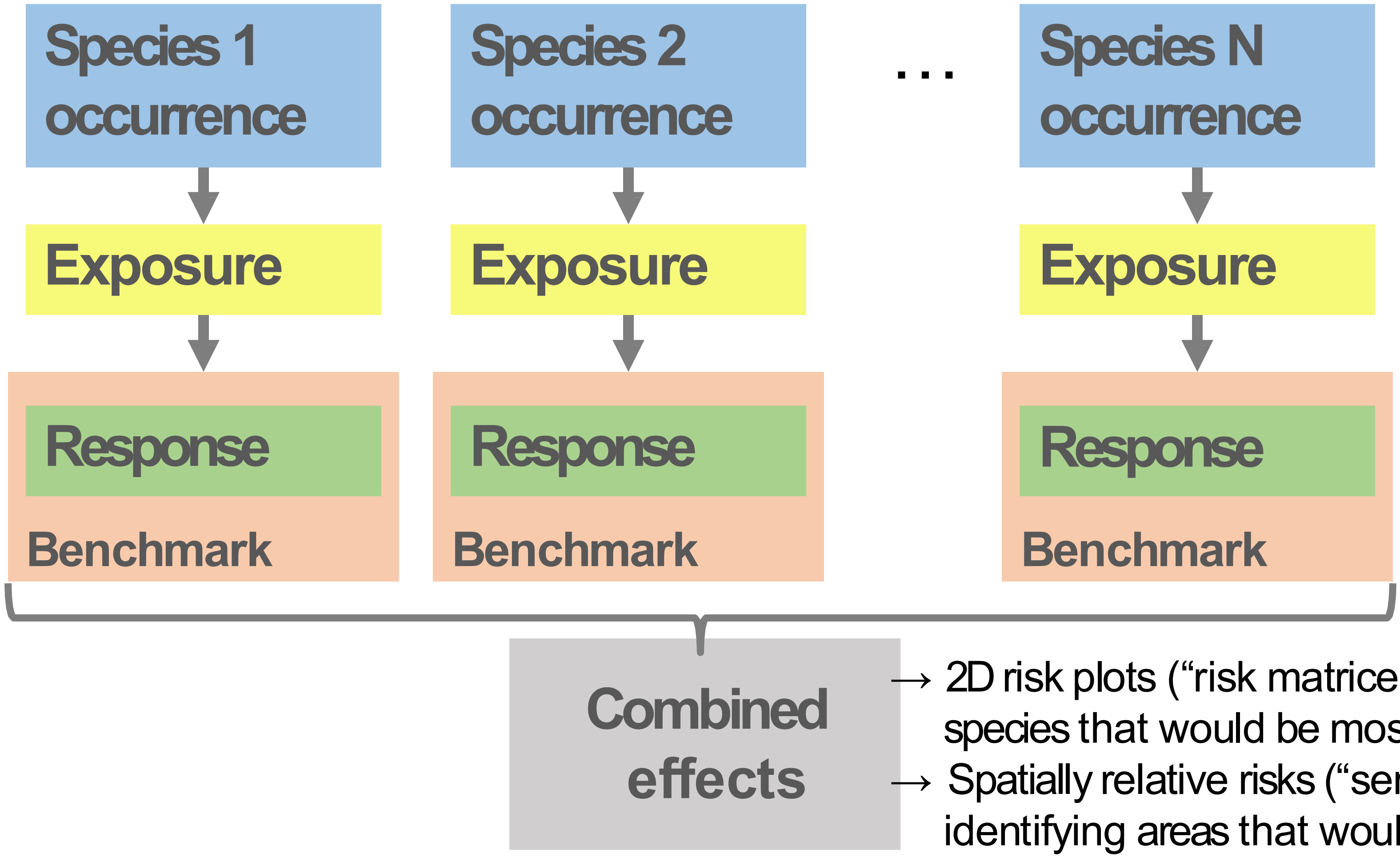
# MULTI-SPECIES ASSESSMENT

***Risk*** *= likelihood x consequence of an outcome*

**Relative species risk:**

$$Risk\ ratio = \frac{E(effects)}{Acceptable\ effects}$$

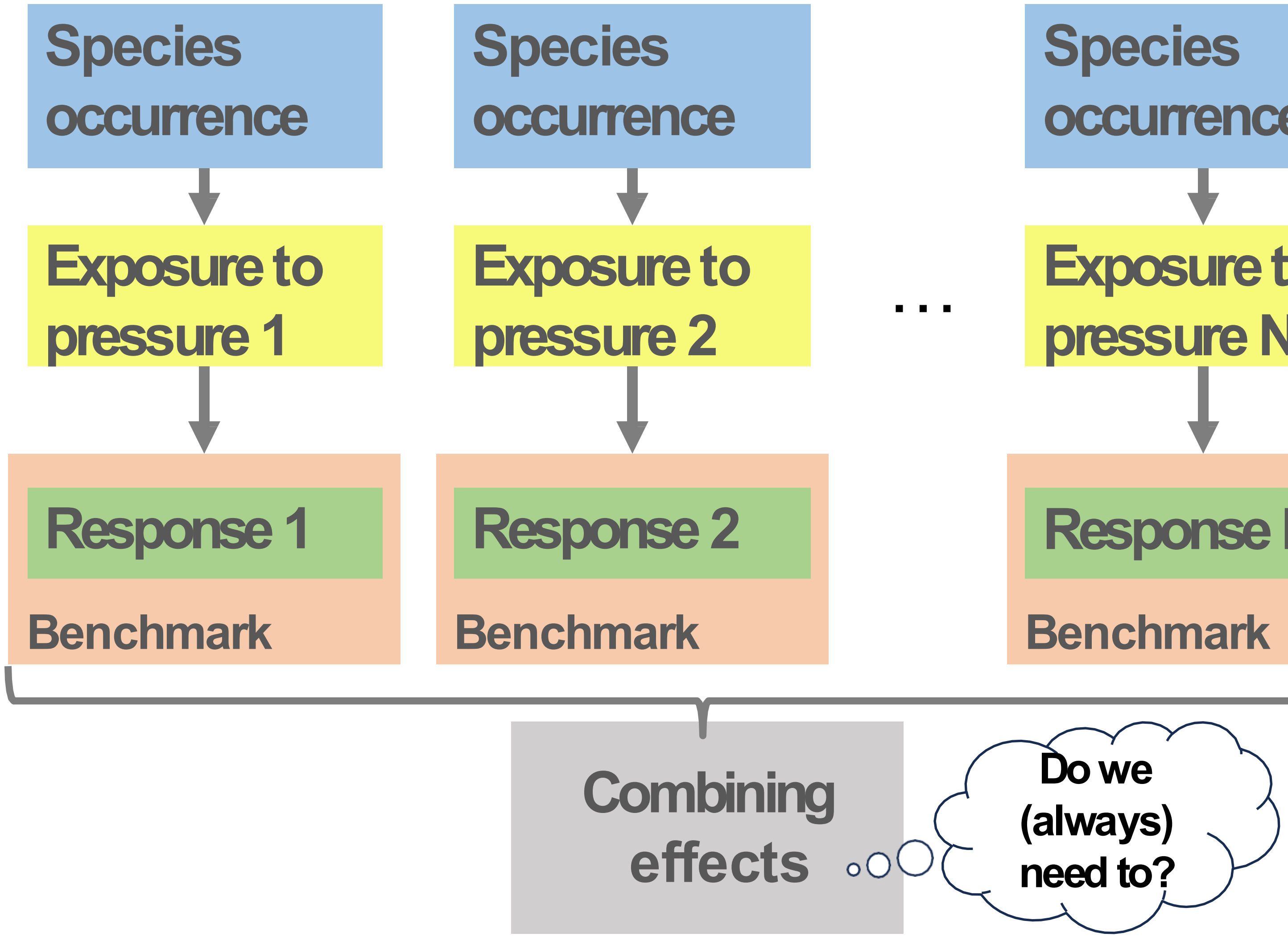
$$= \frac{E(effects)}{1 - target\ protection}$$



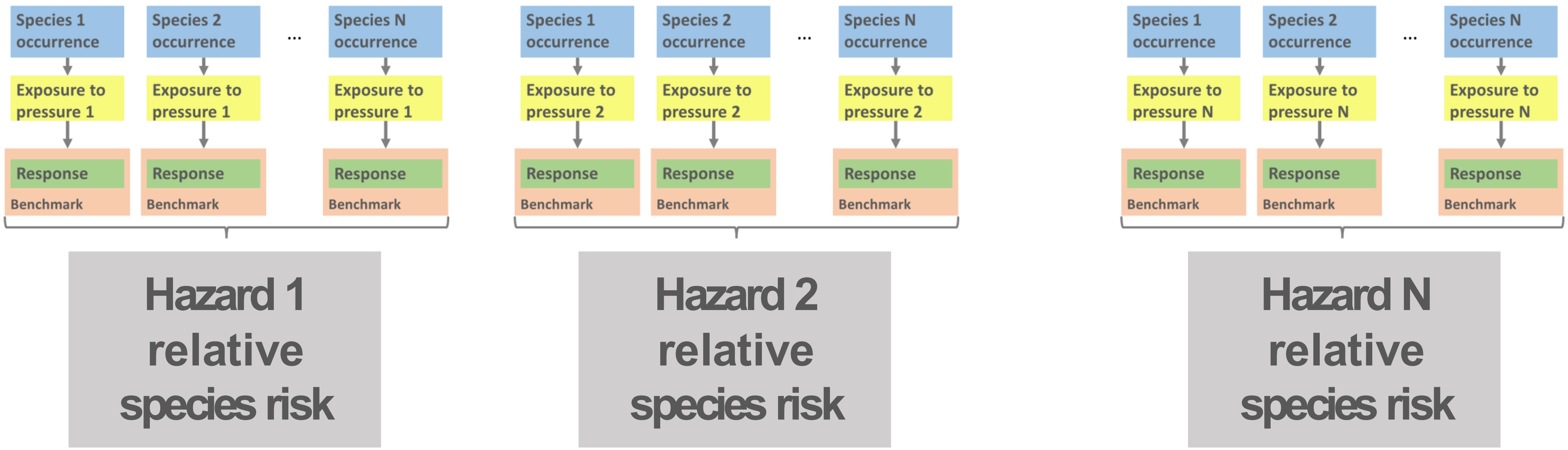

→ 2D risk plots ("risk matrices") identifying species that would be most/least at risk

→ Spatially relative risks ("sensitivity maps") identifying areas that would present most/least risk to assessed species

# MULTI-PATH ASSESSMENT (MULTIPLE STRESSORS/PRESSURES/DRIVERS/IMPACTORS, WHICHEVER WE WANT TO CALL THEM!)



# → MULTI-PATH, MULTI-SPECIES RELATIVE RISK ASSESSMENT



| | **Minimum data needs** (relative risk to populations / static) | **Ideal-world data needs** (absolute risk to populations / dynamic) |
|---|---|---|
| **O** | • Important habitat areas for critical life stages<br>• Relative density distributions<br>• Seabirds/bats: use of blade sweep area (averaged across contexts) | • Important habitat areas for critical life stages<br>• Dynamic (e.g., seasonal) density distribution maps<br>• Habitat preference (-> proxy for habitat value)<br>• Forage distributions/ prey fields<br>• Seabirds/bats: use of blade sweep area – flight heights and speeds in different contexts (e.g., day vs night, different wind speeds and weather variables) |
| **E** | • Wind farm development areas or exposure scenarios<br>• Planned construction phases<br>• Marine mammals/turtles: hearing thresholds | • Detailed development plans, existing and added vessel traffic<br>• Turbine size and blade speed (as a function of wind)<br>• Source level, duration and timing for driving each pile<br>• 3D oceanographic data for sound propagation models<br>• Marine mammals/turtles: audiograms, ambient levels -> sensation levels<br>• Seabirds/bats: detectability of turbines in different contexts |
| **R** | • Distance-response functions or effective response radii → expected magnitude (e.g., avoidance, collision rate) and spatial extent of effects (e.g., displacement) | • Relevant context/stage-specific dose-response or distance-response functions for behavioral responses<br>• Detailed movement model parameters (e.g., state-dependent speed, turning), Seabirds/bats: manoeuvrability around turbine blades<br>• Detailed bioenergetic model parameters (e.g., daily energy expenditure, available reserves and their depletion, relationship between reserves and fecundity)<br>• Marine mammals/turtles: entanglement and vessel collision risk data |
| **C** | • Benchmarks, or target protection levels, for each assessment endpoint (i.e., acceptable level of impact) | • Current, and trends in, abundance<br>• Population structure (apportioning)<br>• Stage-specific survival, added other anthropogenic mortality<br>• Stage-specific fecundity, a function of covariates as appropriate<br>• All reproductive parameters (e.g., recruitment, inter-birth-int., clutch sizes) |