Pacific Northwest NATIONAL LABORATORY

ES ENVIRONMENTAL

Investigating Displacement of Marine Animals as a Potential Effect of Marine Renewable Energy Development

Lenaïg Hemery

Lysel Garavelli

Andrea Copping

Hayley Farr

Kristin Jones

U.S. DEPARTMENT OF ENERGY BATTELLE

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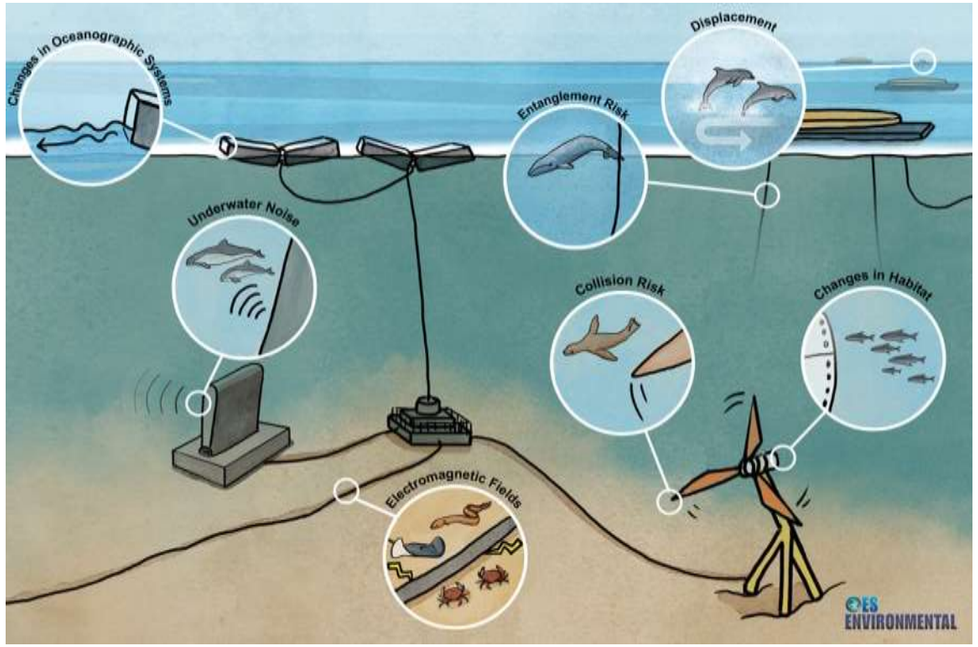
Environmental effects of marine renewable energy: stressors, receptors, and interactions

- Stressors – MRE devices, systems that may cause harm
- Receptors – marine animals, habitats, ecosystem processes



- Priority stressor-receptor interactions:

Collision risk

Mooring line encounter

Underwater noise

Changes in oceanographic systems

Electromagnetic fields

Displacement

Habitat changes

What is displacement, in the MRE context?

"potential for the **loss of habitat due to disturbance or barrier effects**. This may be in the form of redistribution from an area or complete avoidance of an area"

(Long 2017)

"the **movement of animals away** from the area within or immediately adjacent to an area in which an anthropogenic activity is occurring or has occurred"

(Sparling et al. 2020)

"an array of MRE devices placed in a line or large installation might cause a **disturbance that acts as a barrier**, causing resident fish to **move away** from the area and/or migratory fish to **modify their routes**"

(Copping et al. 2021)

"marine energy arrays may displace animals, fully or partially, from foraging or breeding habitats if the arrays are located in those areas or are **perceived as barriers to access**. Displacement could also **lengthen migration routes**, thereby increasing energetic costs and changing access to prey; all of these factors could lead to population-level effects. Under this definition, displacement is **caused by the presence of an array of devices** as distinguished from related noise, EMF, or other stressors"

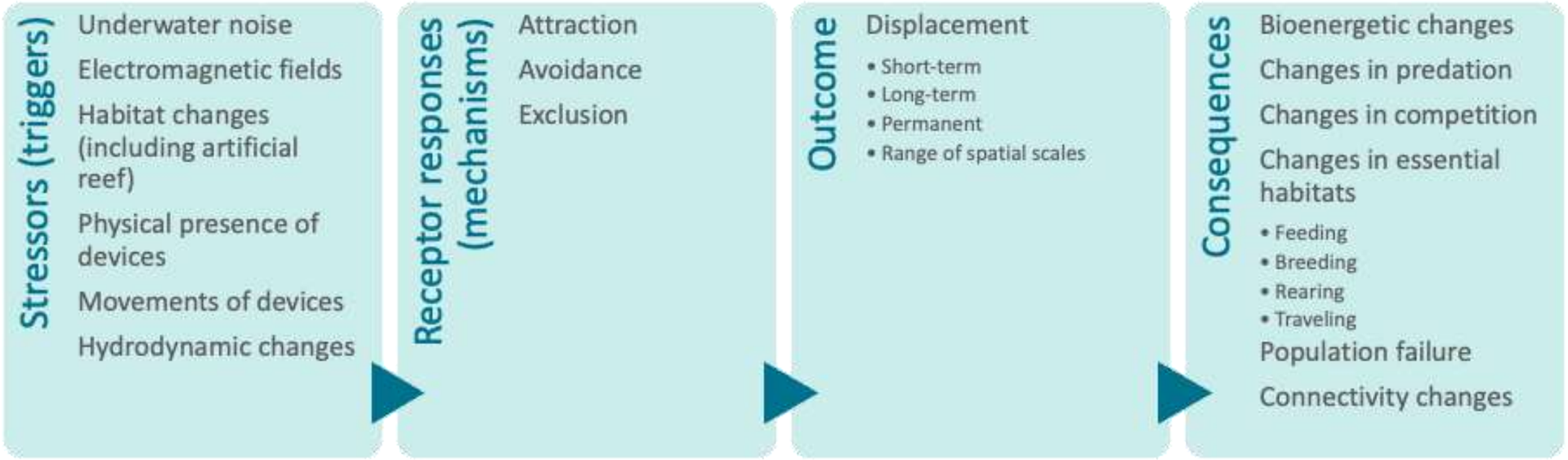
(Buenau et al. 2022)

Proposed definition of displacement

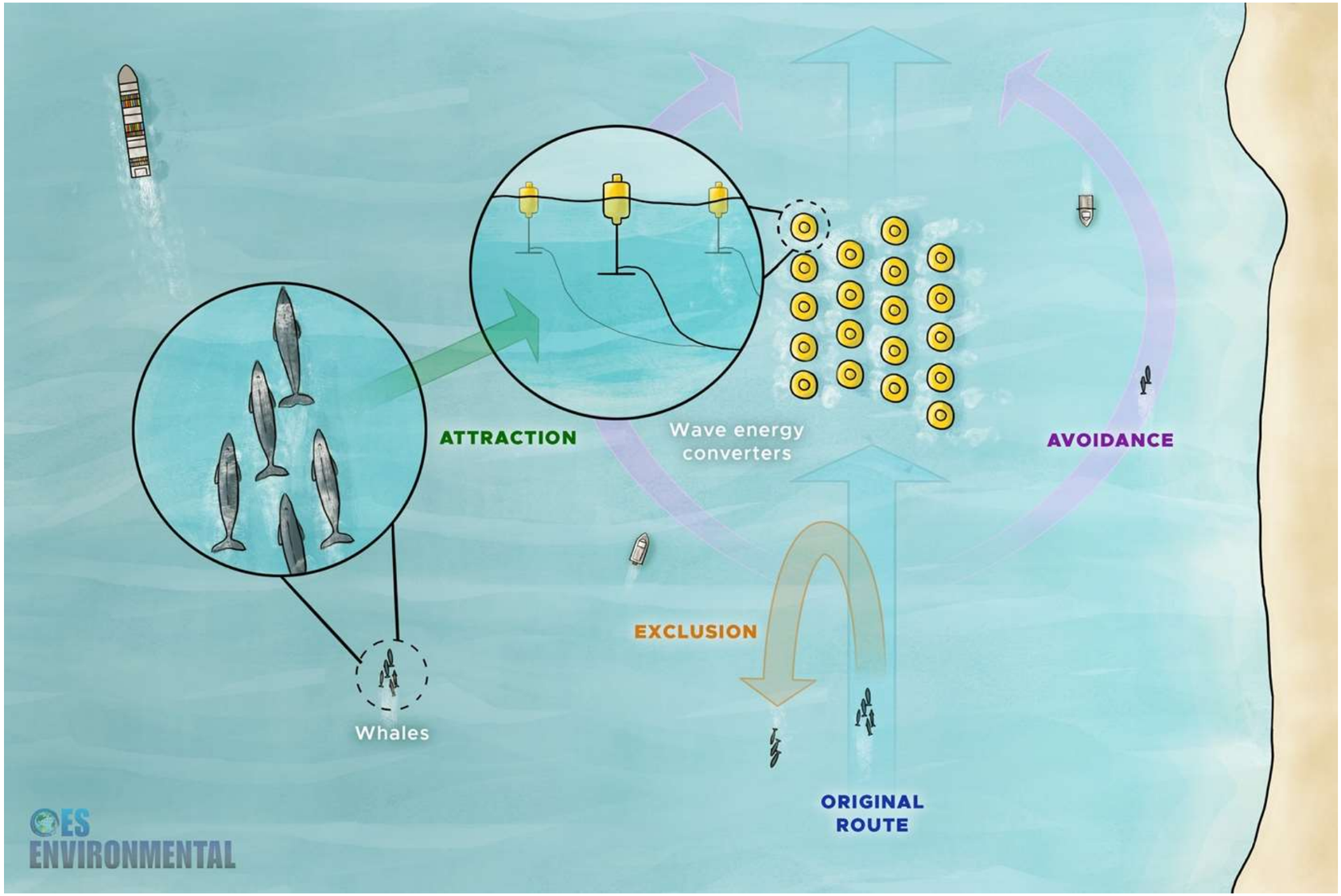
Displacement is the outcome of one of three mechanisms:

- Attraction
- Avoidance
- Exclusion

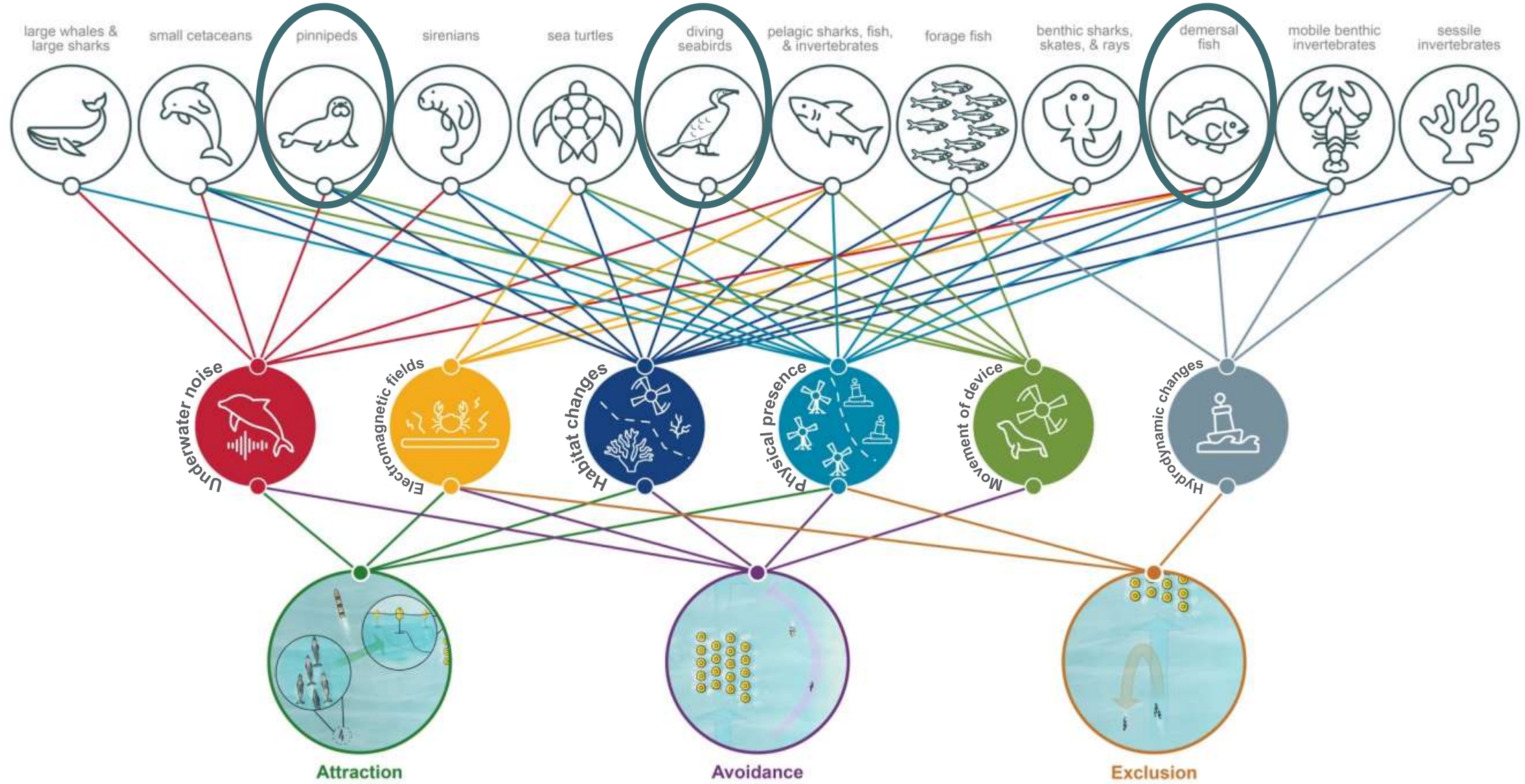
triggered by a receptor's response to stressors, with the potential for a range of consequences on marine animals that span from effects on the individual to effects on populations.



Causes, effects, and consequences of displacement



Marine animals most susceptible to displacement

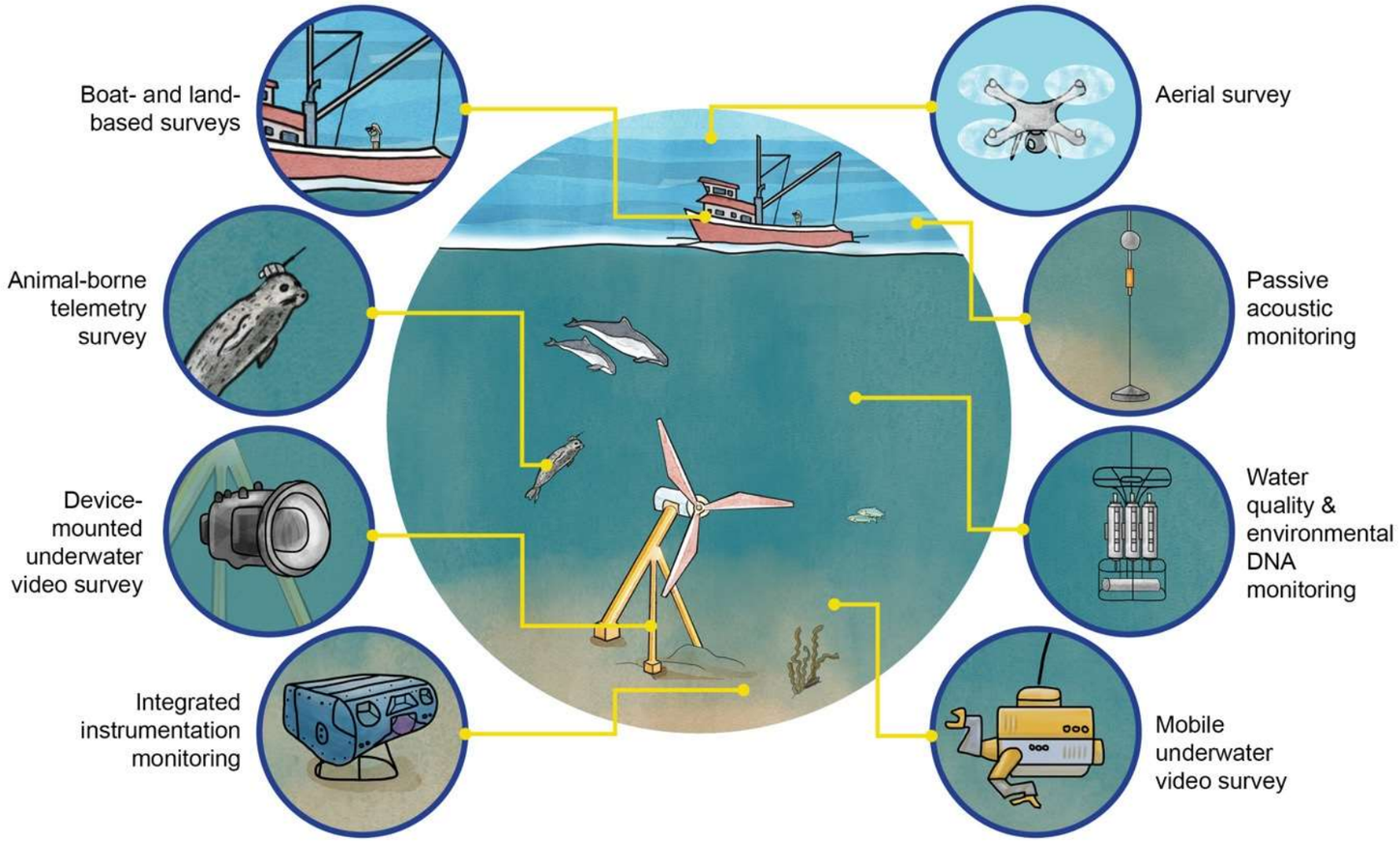


Methods of investigation

Numerical models

- **Agent-based models:** for animal movement around MRE devices and their spatial distribution over time
- **Species distribution models:** for probability of species occurrence based on habitat characteristics and physical features
- **Interim population consequences of disturbance (iPCoD) framework:** for population consequences of disturbances
- **Dynamic energy budget models:** for bioenergetic consequences of a disturbance at the individual to population levels

Field data collection

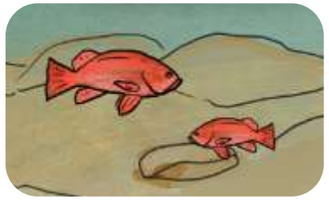


Remaining knowledge gaps

Gaps specific to <u>marine animals</u> include

- Which **species** that are most likely to be affected by displacement
- How those species **behave** and how they **use** their habitats
- What the **triggers**, **mechanisms**, and **consequences** of displacement are for each species, or at least functional groups

- How behaviors and biological rates differ among **life stages**, **individuals**, or **populations** within a species
- What **spatiotemporal scales** of displacement are relevant to each species and life stage
- How **consequences** of displacement of individuals translate to the population or species levels

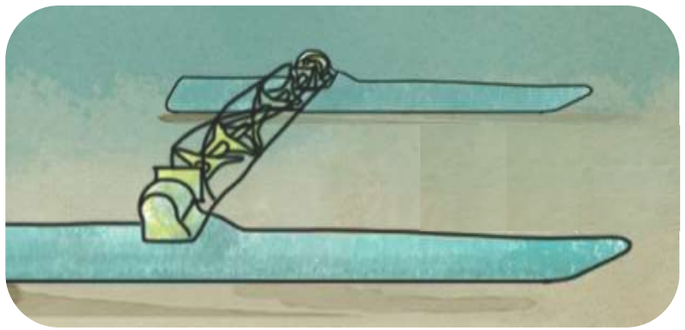


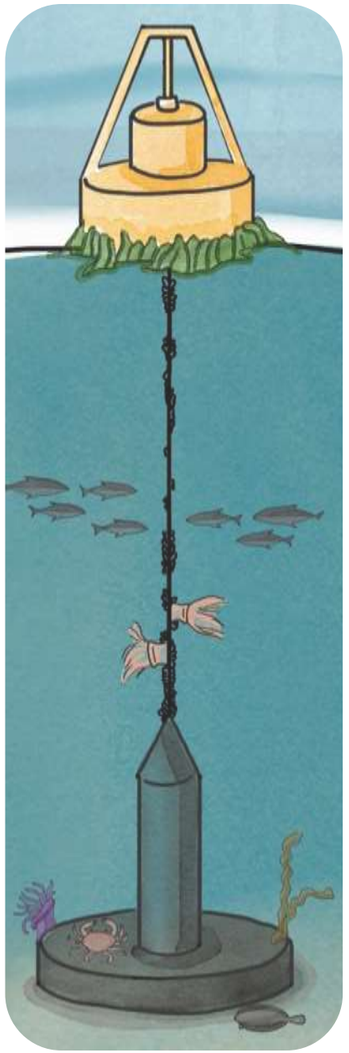
- How to understand displacement in the context of **climate change** and other **cumulative effects**

Remaining knowledge gaps

Gaps specific to MRE technologies include

- Which **array configurations** (e.g., size, geometry, spatial coverage, cable route) and/or **device types** are most likely to cause displacement and in which type of environment
- How will underwater noise and/or EMF emissions **scale up with arrays**
- Which **surrogate** marine and/or terrestrial activities may inform this interaction

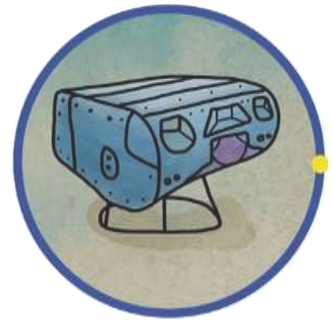




Remaining knowledge gaps

Gaps specific to <u>monitoring displacement</u> include

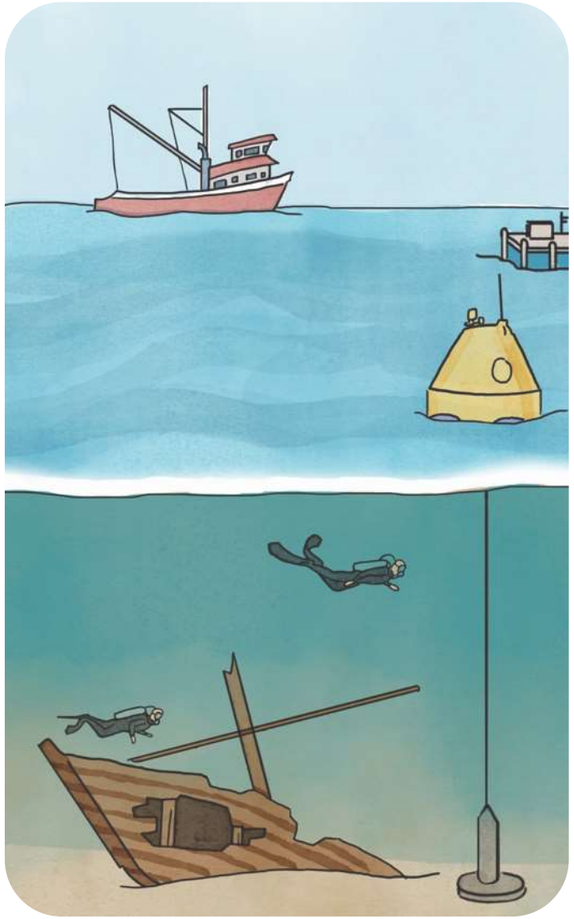
- Which **commercial-off-the-shelf** monitoring technologies are most suitable for each species and how to adapt them to different sites and MRE technologies
- Whether existing observation technologies can be **modified** or new technologies need to be **developed**
- What **spatiotemporal scales** should the monitoring surveys cover for each species and MRE technology
- How to monitor displacement in the context of **climate change** and other **cumulative effects**



Remaining knowledge gaps

Gaps specific to the <u>regulatory context</u> include

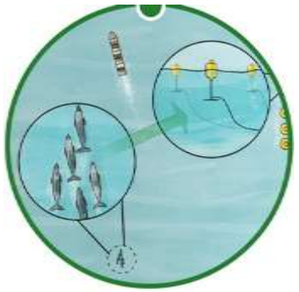
- Which **existing** specific national or international **regulations or statutes** apply to displacement of marine animals (related to MRE and/or other sectors)
- Under which **common regulations** that already **protect** species and populations could these interactions fall into
- Whether any **actions** regarding displacement are **required** by law or recommended

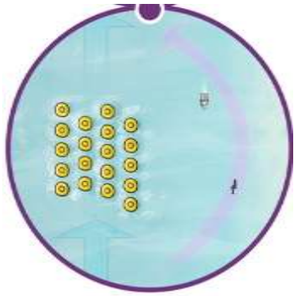


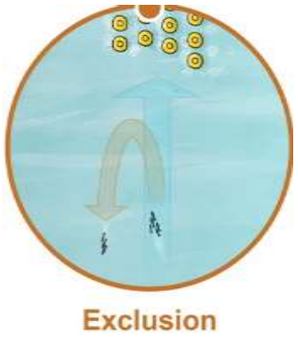
Recommendations

Displacement is unlikely to be a priority concern until the deployment of large MRE arrays; however, it is important to:

- Agree on the definition of displacement
- Understand the potential mechanisms that cause displacement and the possible consequences to marine animals
- Generate realistic models of such consequences
- Identify how to best monitor and mitigate these changes
- Start collecting meaningful field data with the deployment of MRE arrays in mind







Hemery LG, Garavelli L, Copping AE, Farr H, Jones K, Baker-Horne N, Kregting L, McGarry LP, Sparling C, Verling E. (under review). Animal displacement from marine energy development: mechanisms and consequences. Submitted to Science of the Total Environment

Thank you!

Lenaïg Hemery
lenaig,hemery@pnnl.gov