Introduction to the Assessment of Research Activities

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Outline: Ecological Risk Assessment Process

- What are the stressors?
- What is the probability of exposure?
- How does exposure relate to potential effects?
- What can be done to mitigate potential effects?
- What is the risk of potential effects?

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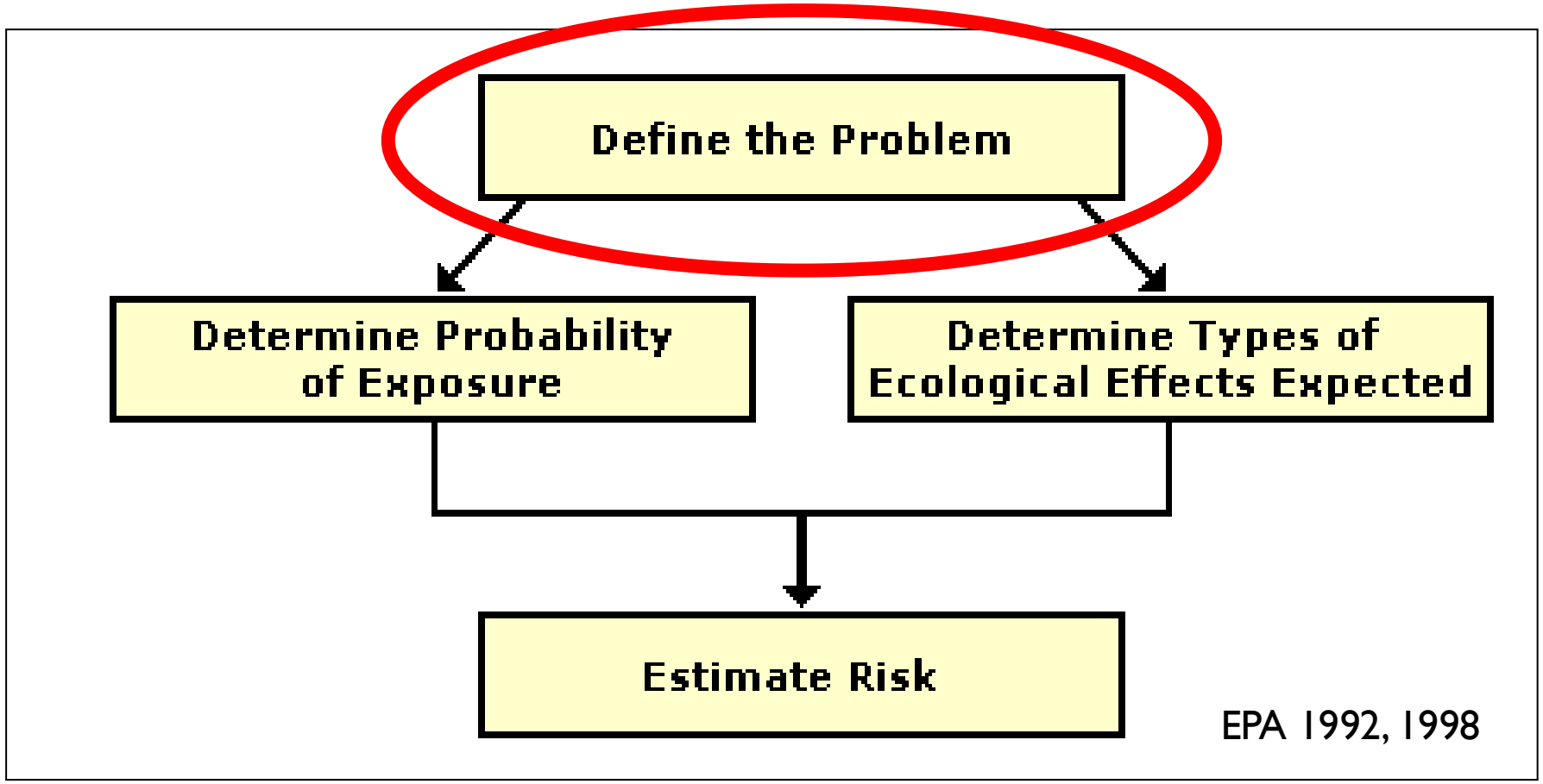
Ecological Risk Assessment Process



Define the Stressor(s) of Experiment

- Emissions
  - Waste treatment
  - Air emissions
  - Equipment left behind
  - Light
  - Acoustics
- Climate Impacts
  - Fuel consumption
  - Break up of ice
- Economic Impacts
  - Commercial shipping
  - Commercial or recreational fishing
- Governance/Location Sensitivities
  - E.g., Svalbard waters, Marine Protected Areas (MPAs)

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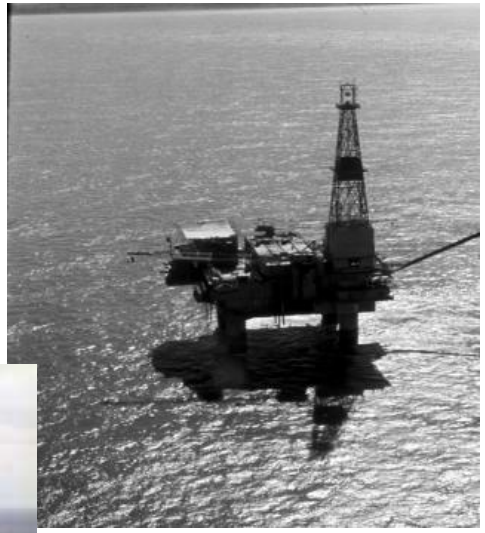
What is the Problem?

- Underwater sound can affect marine animals



Examples of Regional or International Regulations

- E.U. Marine Strategic Framework Directive
  - Requires Member States to achieve Good Environmental Status (GES) as measured by eleven descriptors
  - One descriptor is energy, which includes underwater sound

There are two indicators of GES for underwater sound:

1. Distribution in time and space of **loud impulsive sounds**
   - Proportion of days and their distribution within a calendar year within the frequency band of 10 Hz to 10 kHz.
2. **Continuous low-frequency sound** (habitat quality)
   - Average sound level over a year within the 1/3 octave bands centered at 63 and 125 Hz.

Examples of Federal Regulations

- U.S.: National Environmental Policy Act (NEPA) / Executive Order 12114
  - Any major project that involves work performed by the federal government, or receives federal funding or permits issued by a federal agency must consider environmental issues

- Germany: Federal Nature Conservation Act
  - Prohibits the willful disturbance of animals and requires projects to assess potential impacts to habitat

https://dosits.org/decision-makers/ocean-policies/

Examples of Federal Regulations

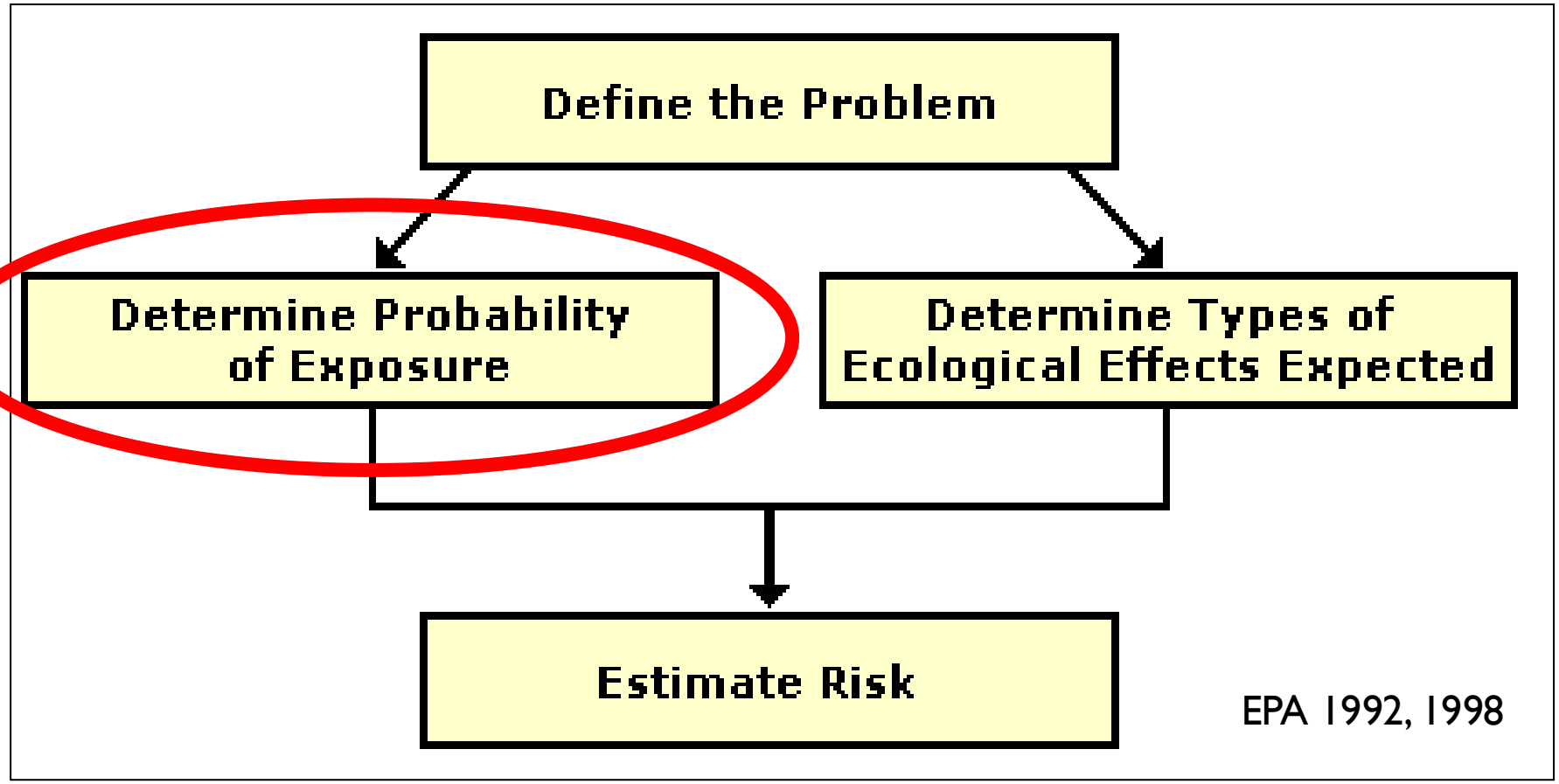
- U.S. Endangered Species Act

  – Species listed as “endangered” (imminent threat of becoming extinct) or “threatened” (likely to become endangered in the foreseeable future)
  – Critical habitat can be designated
  – “take”: harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or any attempt to…
  – National Marine Fisheries Service (NMFS): Jurisdiction over 163 E&T marine species: 14 whale, 5 dolphin/porpoise, 7 seal/sea lion species (https://www.fisheries.noaa.gov/species-directory)

Examples of Federal Regulations

- U.S. Marine Mammal Protection Act (MMPA)
  - "take": harass, hunt, capture, or kill, or attempt to…
  - "harassment": any act of pursuit, torment, or annoyance that has the potential to:
    (1) injure (Level A)
    (2) disrupt behavioral patterns, such as migration, breathing, nursing, breeding, feeding, or sheltering (Level B)
  - Exceptions to take prohibitions
    - Commercial fisheries
    - Scientific research
    - Incidental take authorizations

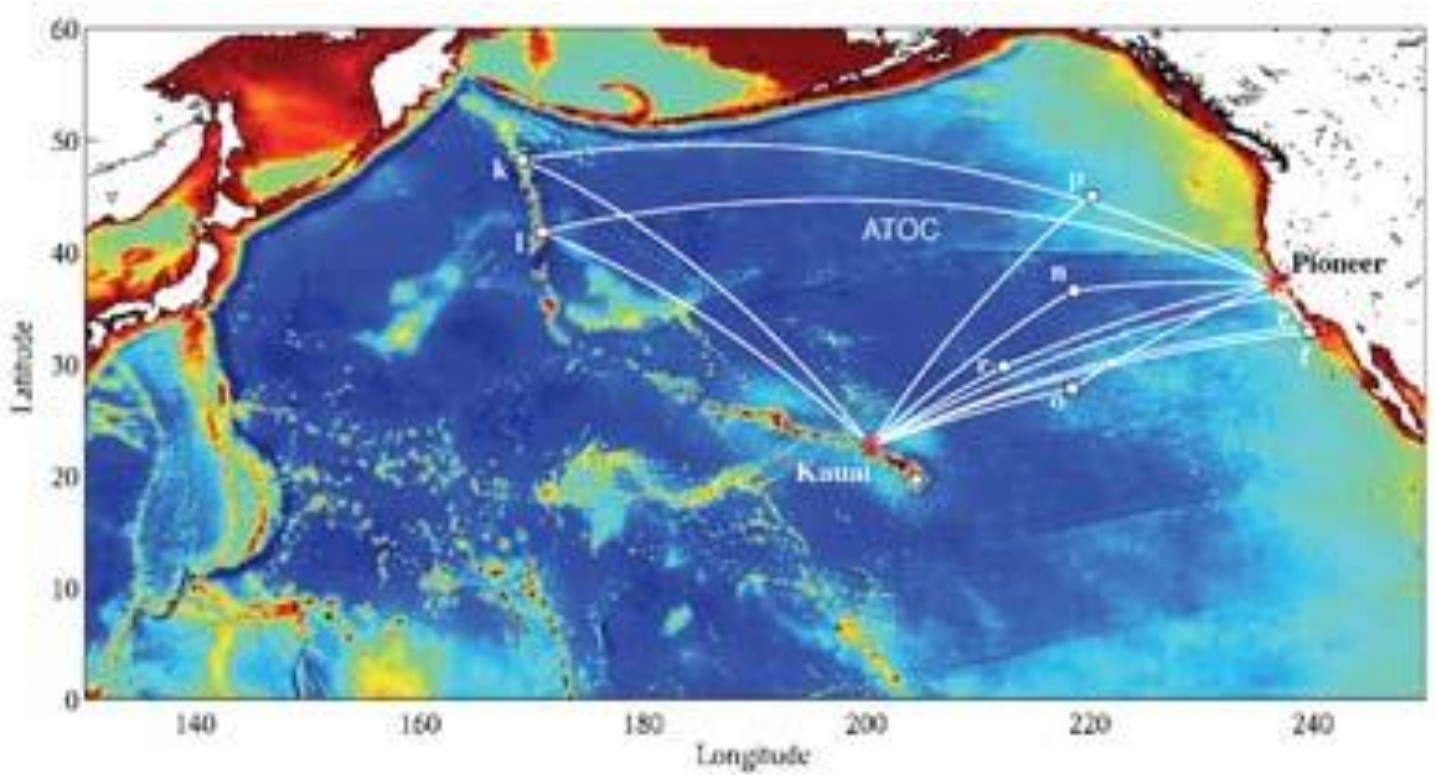
Ecological Risk Assessment Process



How to Determine Probability of Exposure?

Example: North Pacific Acoustic Laboratory (NPAL) or the Acoustic Thermometry of Ocean Climate (ATOC) source off the north shore of Kauai, Hawaii.

• Use travel time data obtained from a few acoustic sources and receivers located throughout the North Pacific basin to study temperature at the largest scale

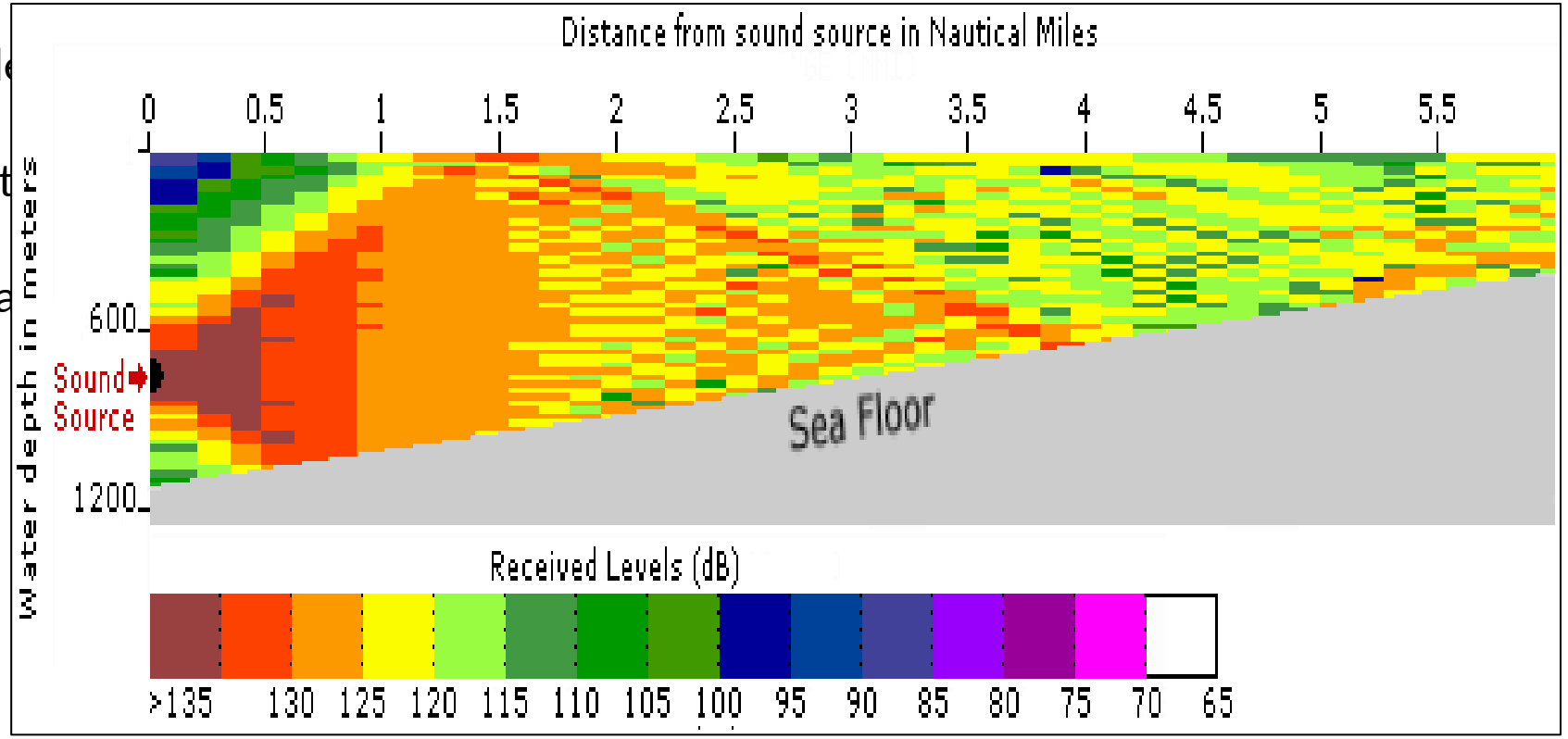


How to Determine Probability of Exposure?

1. Calculate 3D sound field

Exposure levels (received sound levels) at different distances and depths

- location and season
  - sound speed profile
- source components
  - number of element
- signal characteristics
  - SL, frequency, dura

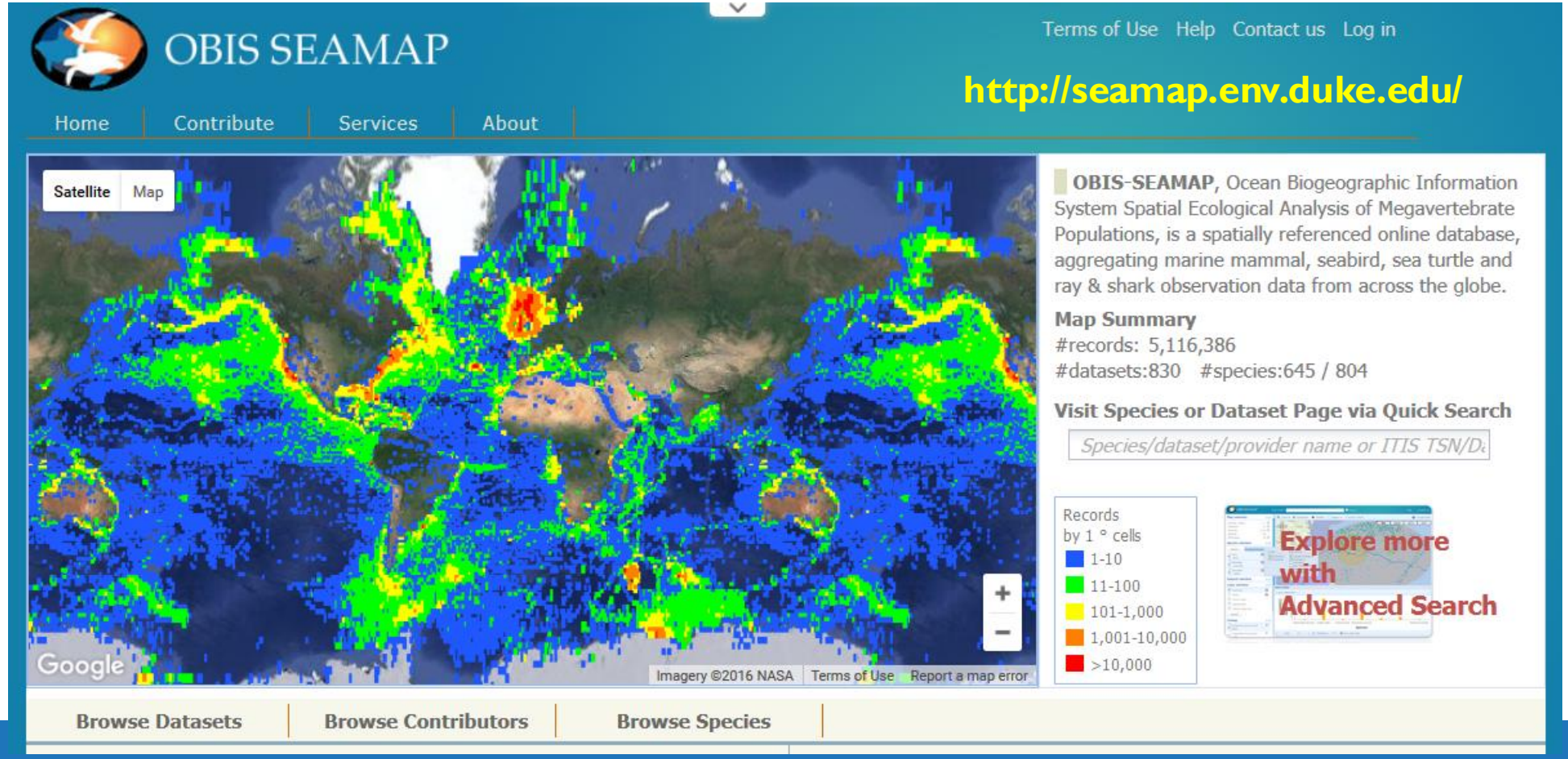


How to Determine Probability of Exposure?

2. Where are animals likely to be located relative to the source?

A. Species screening

1. Is the species found in the area of the sound field at that time of year?

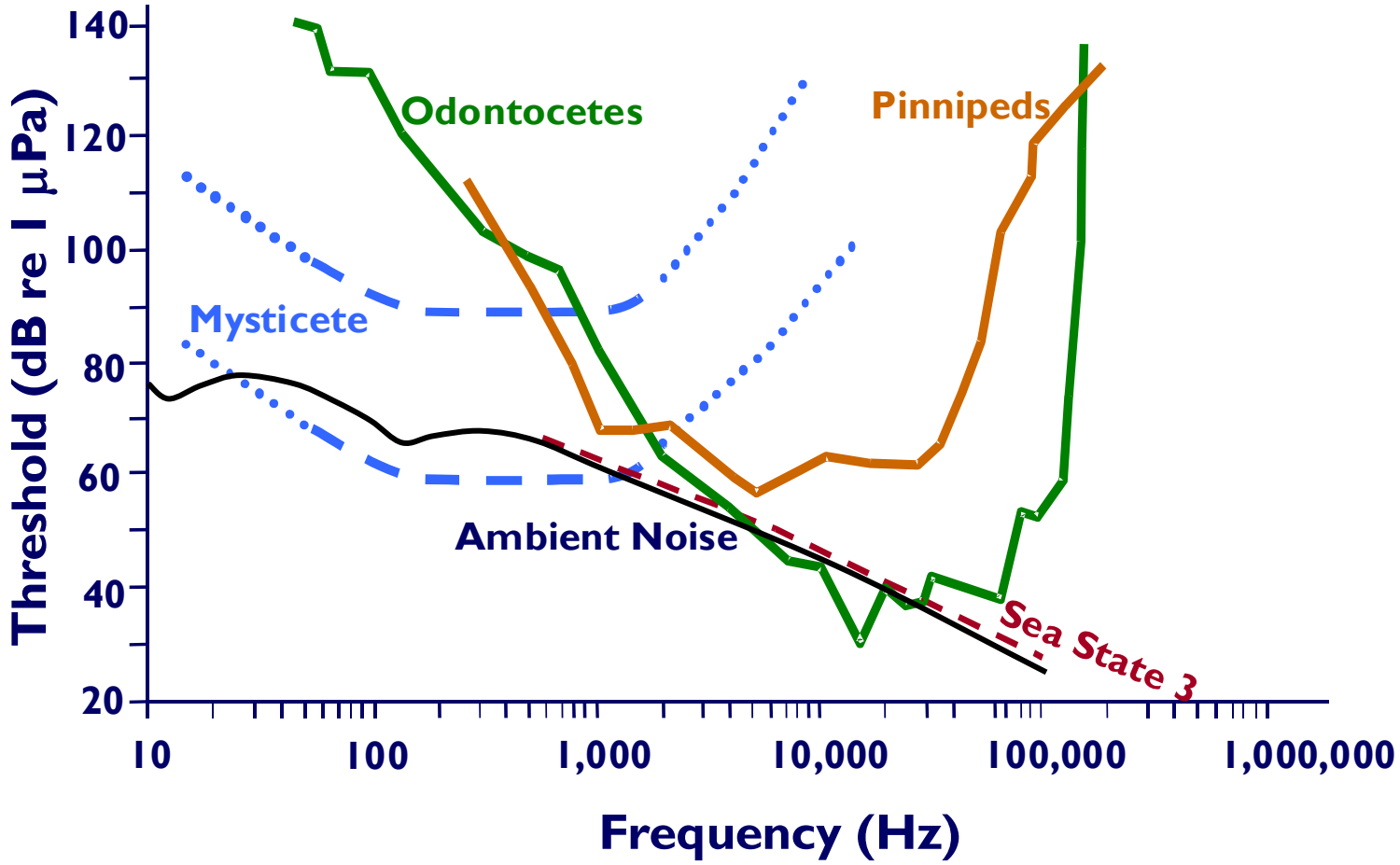


How Do We Determine Probability of Exposure?

2. Where are animals likely to be located relative to the source?

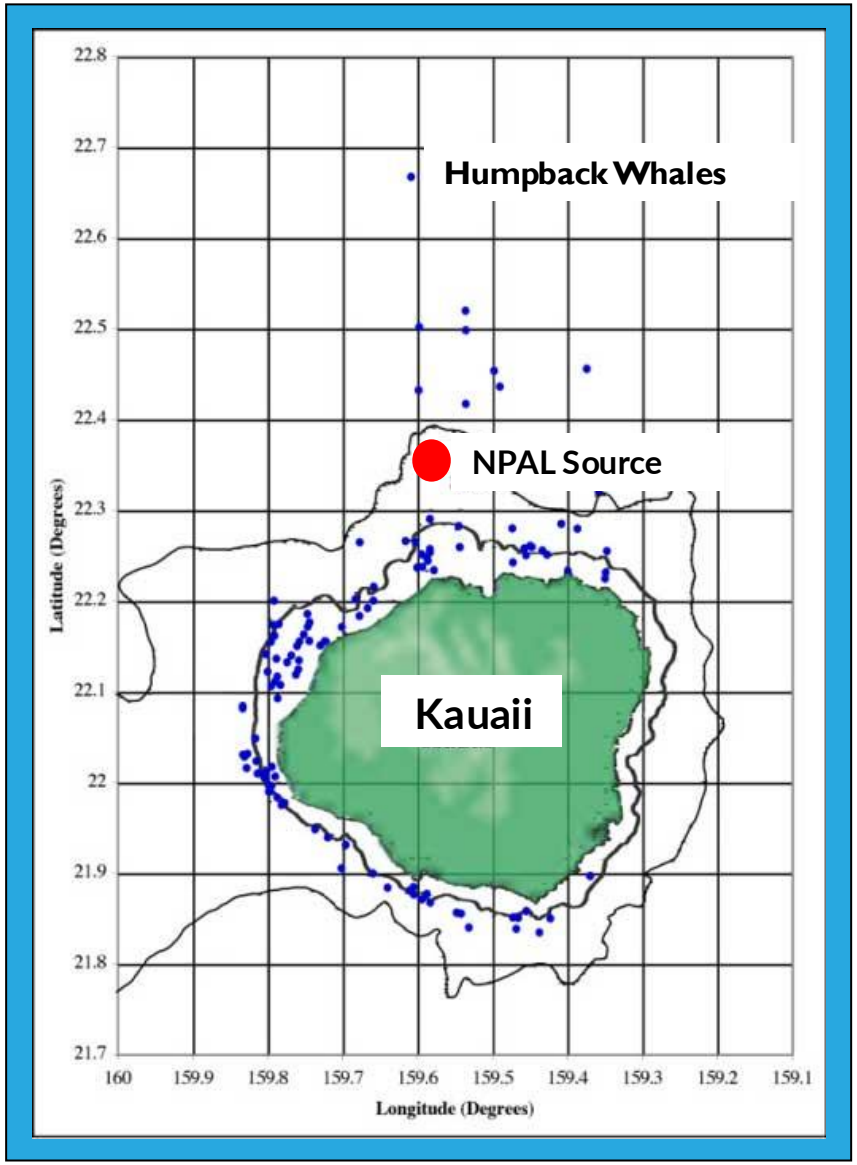
A. Species screening

2. Is the species sensitive to sounds at that frequency?



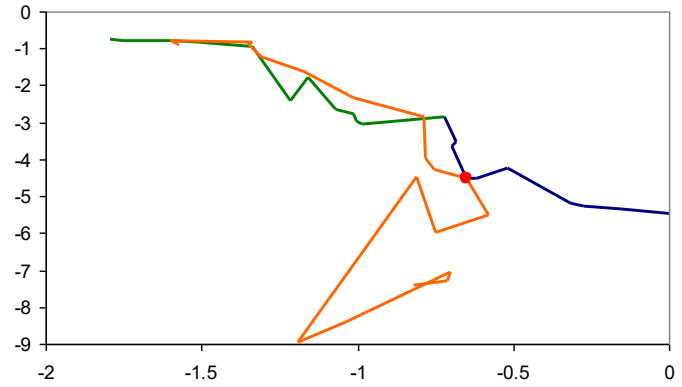
How to Determine Probability of Exposure?

2. Calculate 3D animal field.
   A. Species screening
   B. Where are animals located relative to the source:
      - distribution pattern
      - density/abundance

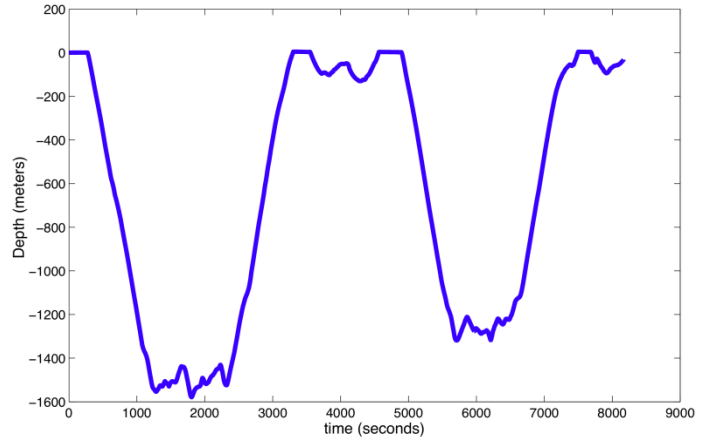


How to Determine Probability of Exposure?

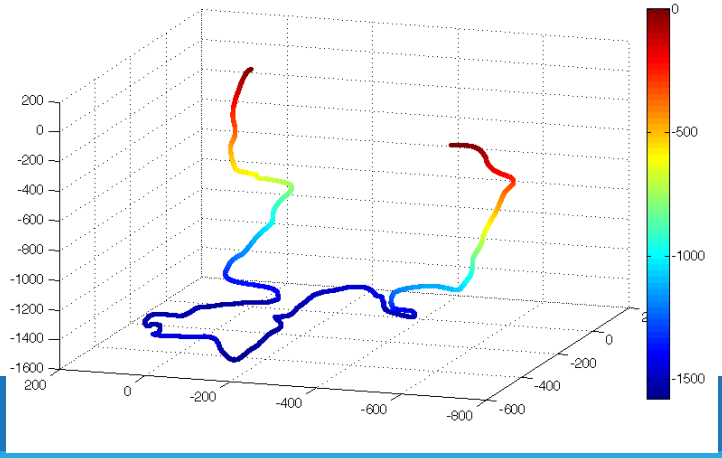
2. Calculate 3D animal field.
   A. Species screening
   B. Where are animals located relative to the source:
      - distribution pattern
      - density/abundance
      - swim speed
      - movement pattern
      - dive pattern



Track animals from shore



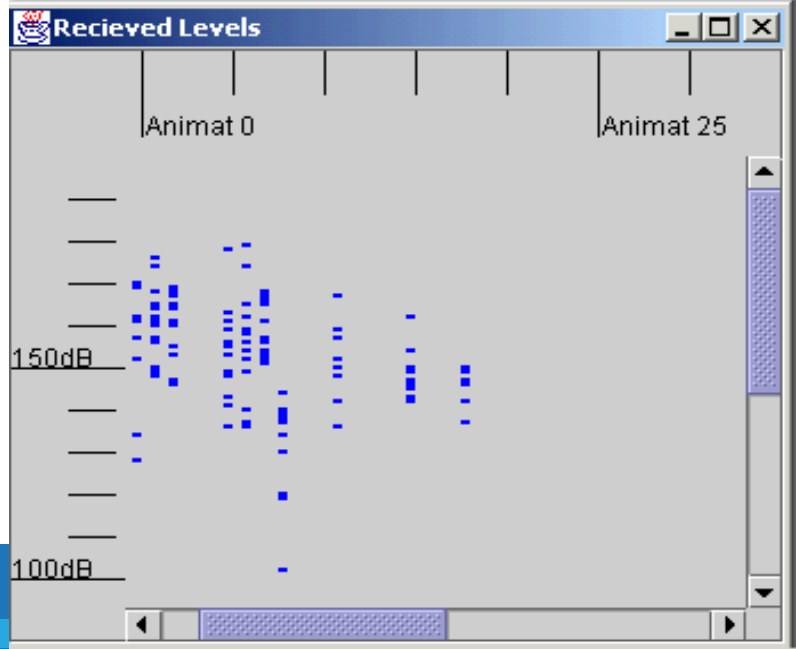
Time-depth recorder on animal

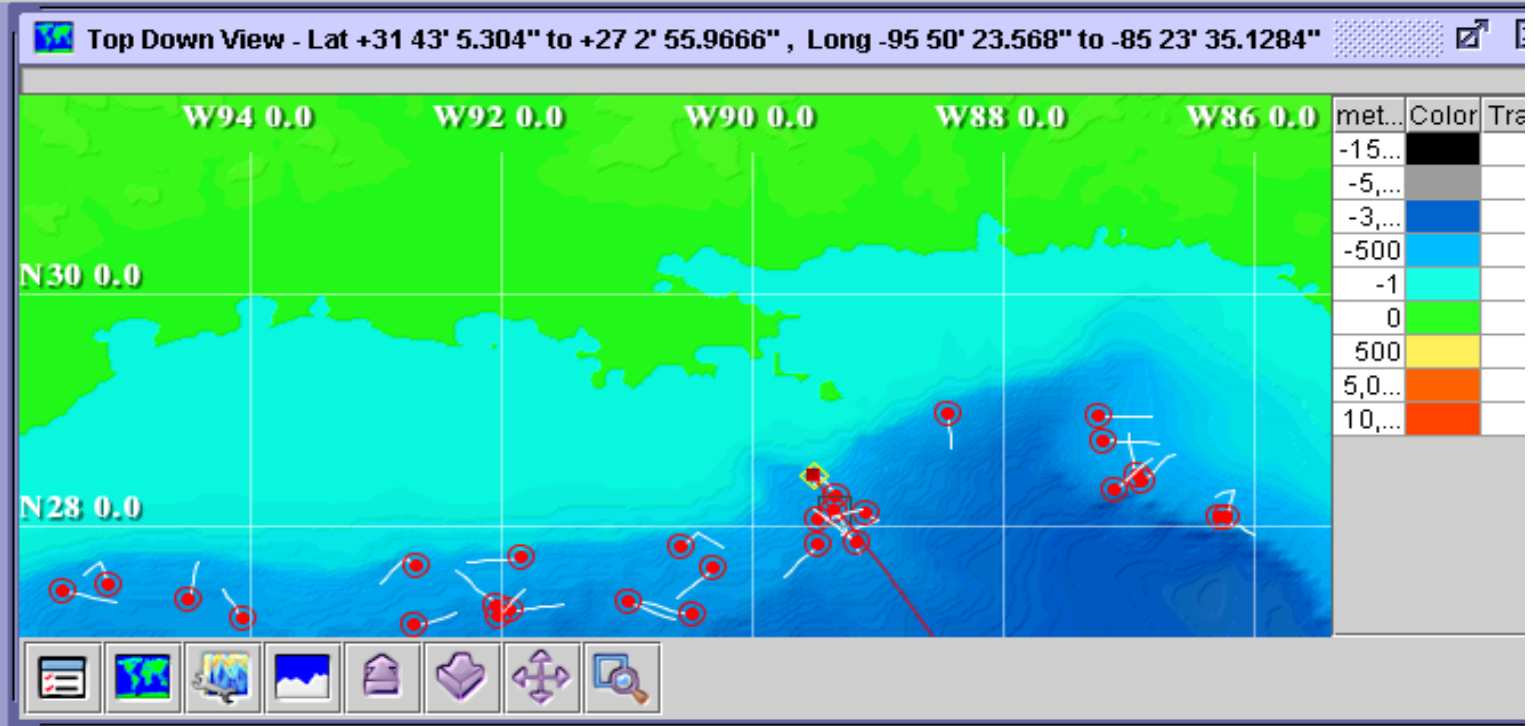


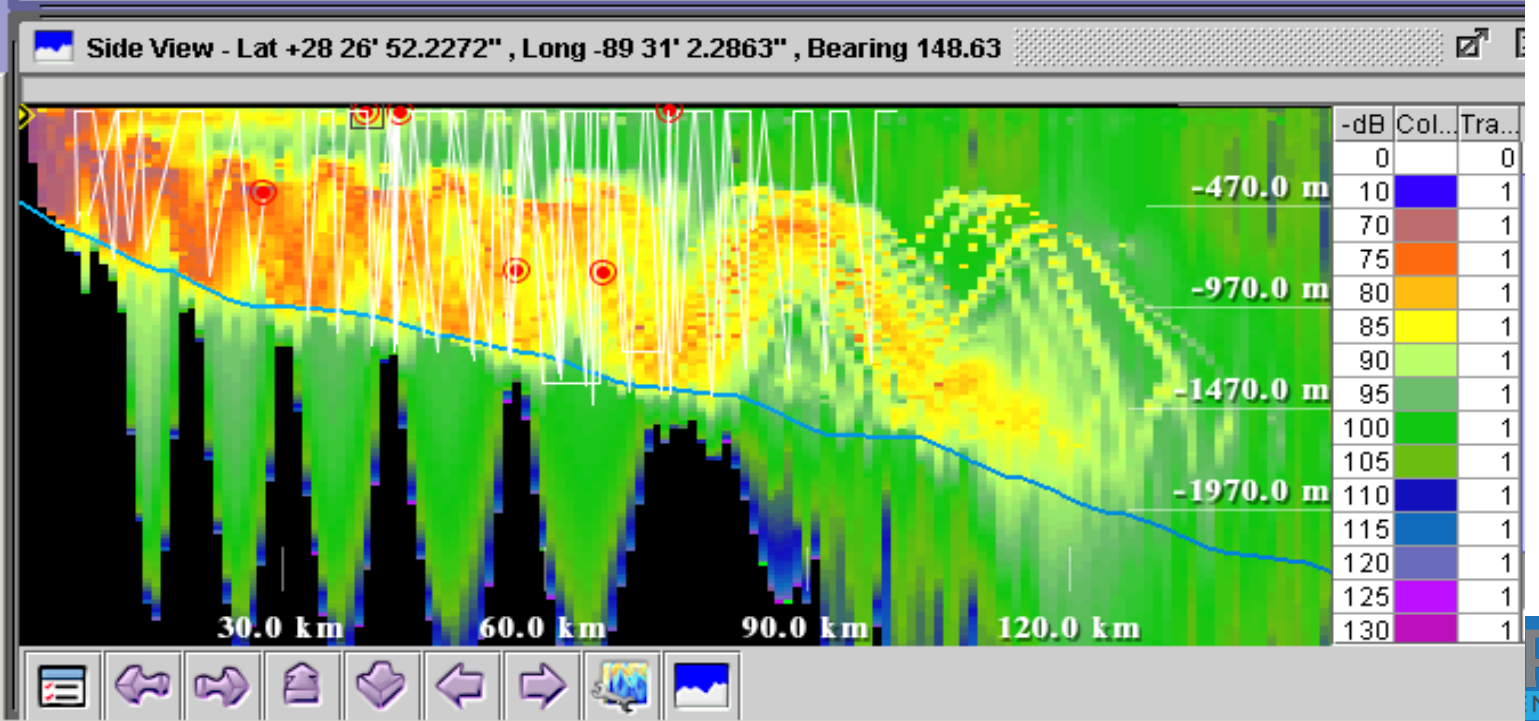
3D tag on animal

Estimate Probability of Exposure through Modeling/Calculations

- Integrate sound field and animal field to estimate the exposure of individual animals
- Results: Received sound levels over time







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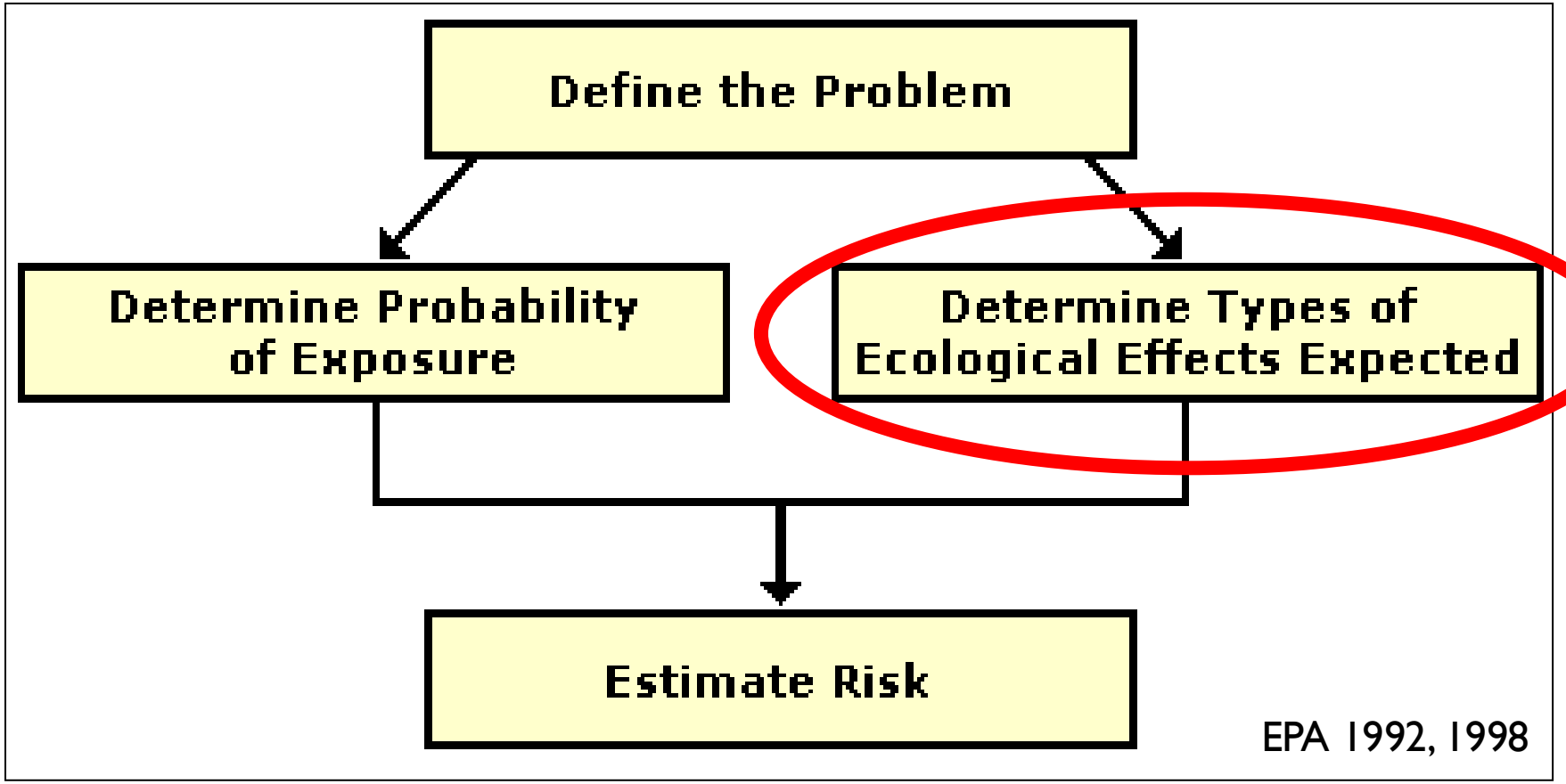
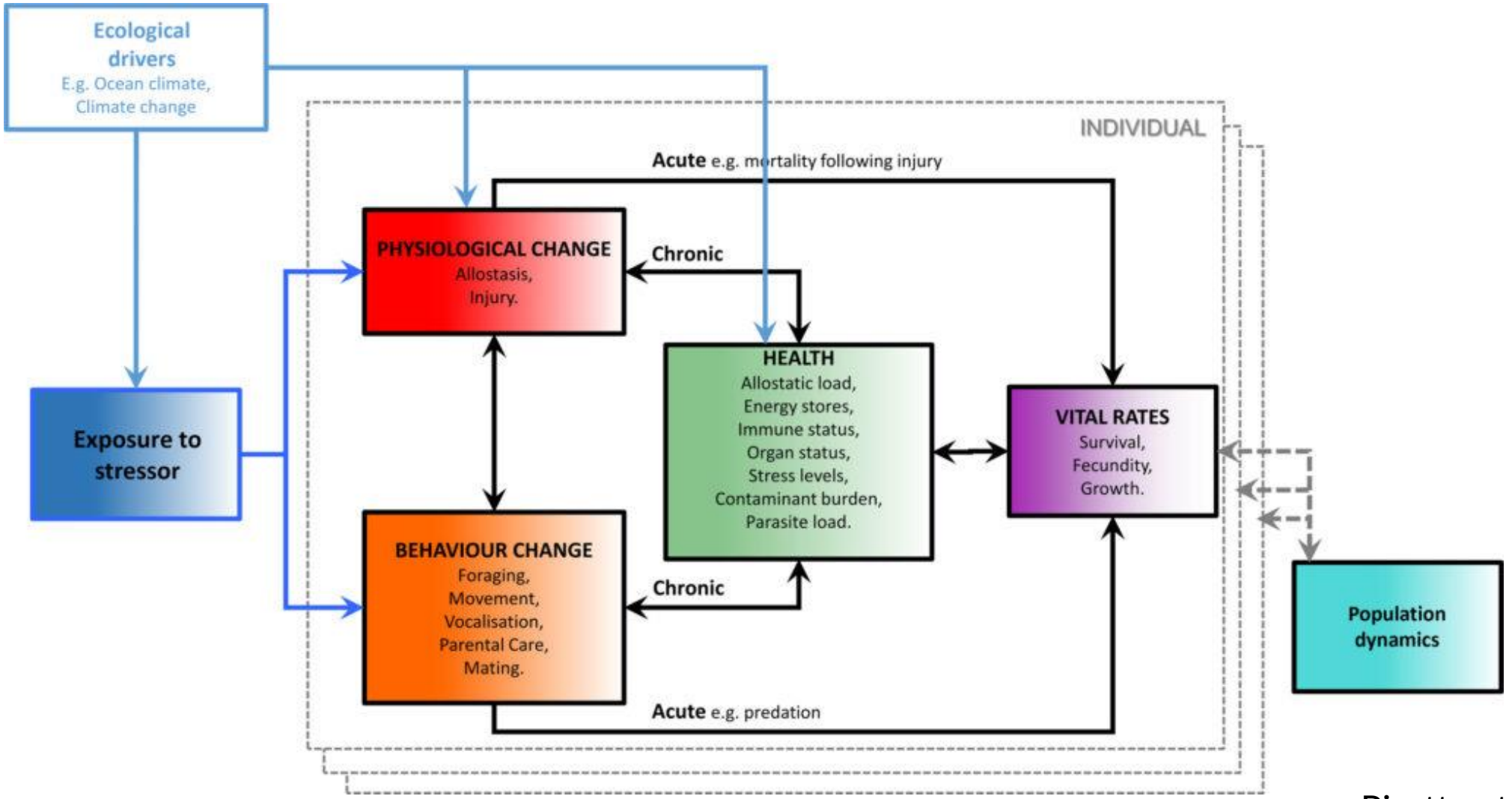


What are the Potential Effects of Underwater Sound on Marine Animals?

- Strandings
- Hearing loss
- Masking
- Behavioral changes

Discovery of Sound in the Sea
http://www.dosits.org

Population Consequences of Disturbance (PCoD)



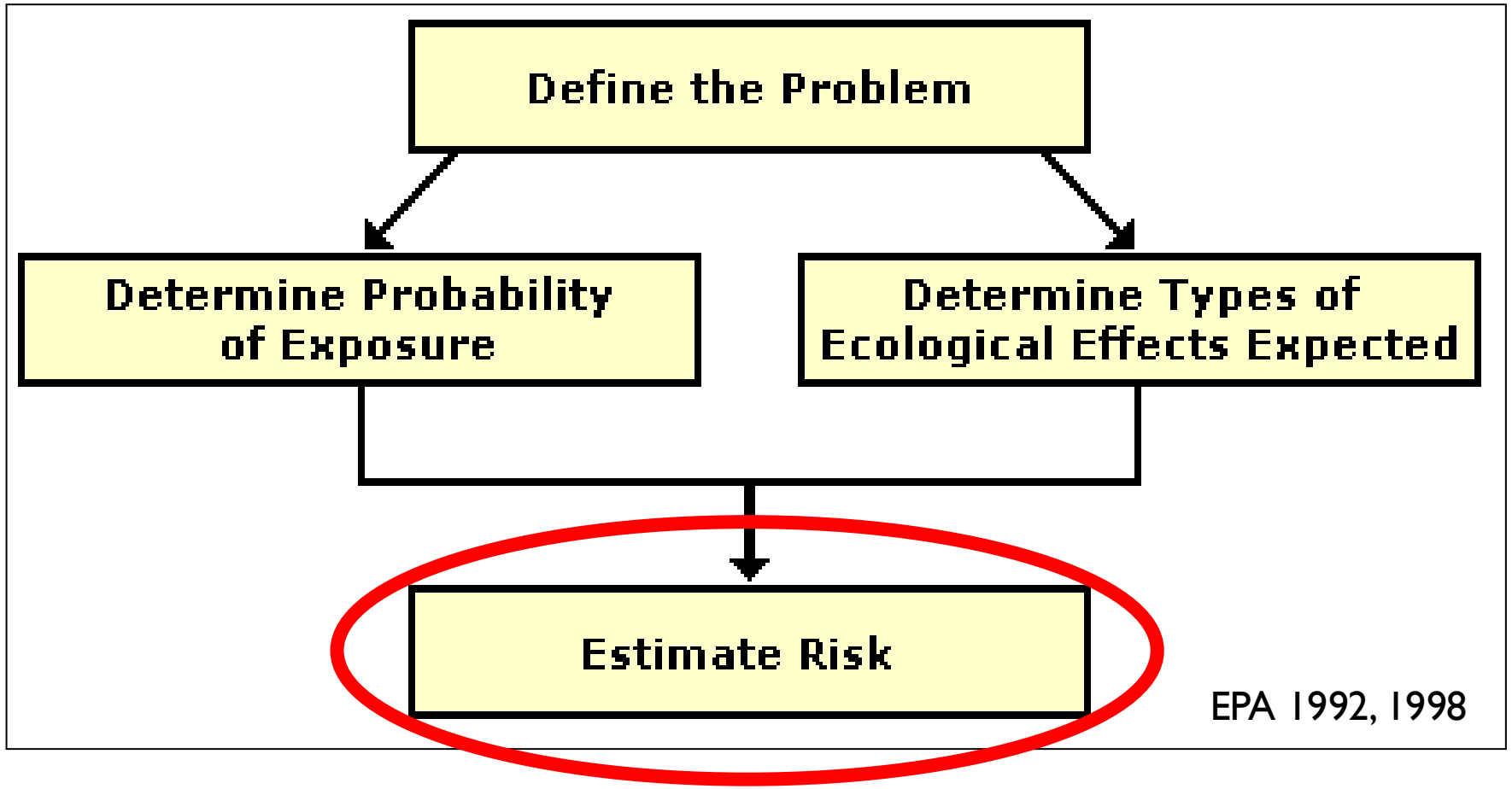
Pirotta et al. 2018

Mitigation: Actions to reduce or prevent effects

Considerations:

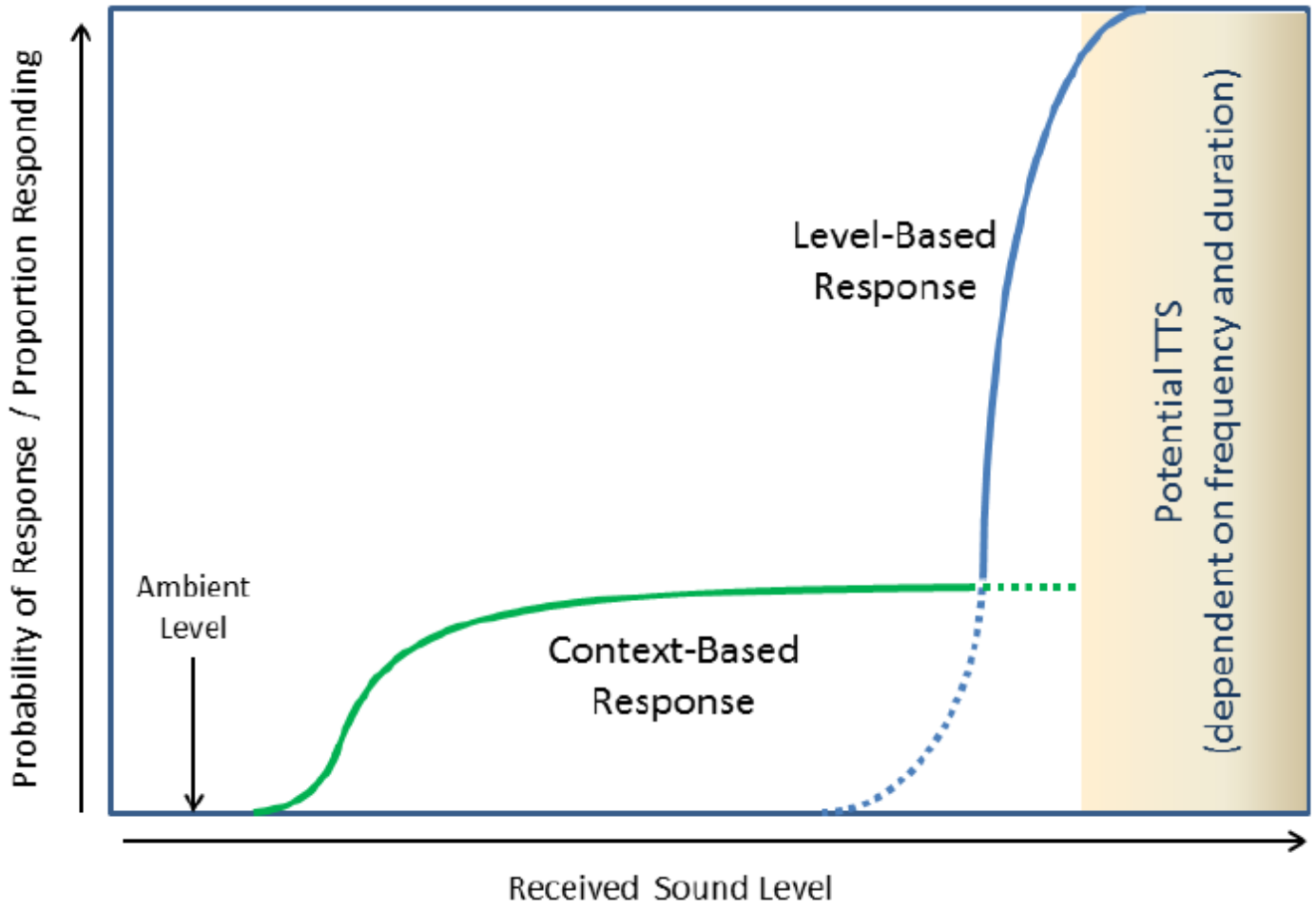
- Geographic
  - Can the experiment be conducted in areas away from sensitive animals? Or areas where sensitive animals are at lower densities?
- Timing
  - Can the experiment be conducted at times when sensitive animals are not present? Or times when animals are not engaged in biologically important activities?
- Operational
  - Can the source level ramp-up so animals having warning of activity?
  - Could the sound source be shut down if animals come within a predetermined range of activities?

Ecological Risk Assessment Process



Estimating risk of behavioral response to acoustics

Conceptual bi-phasic behavioral response function



Finneran, 2017

Conclusion: Ecological Risk Assessment Process

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