Chemical Exposures for Cook Inlet Beluga Whales

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Introduction

- Cook Inlet Belugas may be exposed to hundreds of chemicals in food, water and sediment
- Could these chemicals affect population recovery?
- Can we identify which chemicals might have the potential to affect CIBs and which ones can be dismissed?

Goals and Objectives

- Assist NMFS with evaluation of chemical exposures potentially affecting the Cook Inlet beluga whales (CIBs)
- Identify the wide range of chemical groups and sources that may be relevant to CIB exposures
- Create narrowed list of chemicals of potential concern (COPCs) that are recommended for additional evaluation

Methodology

- Literature review – focus on breadth over depth
- Risk-based approach – chemical source > CIB exposure > toxicity
- Focus on toxic effects relevant to reproductive success
- Only highlights presented today

What are the Chemicals?

- Legacy Chemicals
- Emerging Chemicals
- Some overlap exists

Chemical Groups of Concern

- Conventional chemicals – “legacy chemicals” that constitute most of available toxicological literature

Pesticides

PCBs

Heavy metals

Legacy Chemicals

- Chlorinated pesticides, Organophosphates
- Triazines, pyrethroids
- PCBs, dioxins, furans
- PAHs, hydrocarbons
- Phthalates, phthalate esters
- Metals (mercury, selenium)
- More

Chemical Groups of Concern

- Emerging chemicals – broad and diverse category; least understood due to fewer available studies

Triclosan

Musk

Estradiols

Nanomaterials

Emerging Chemicals

- Pharmaceutical and personal care products (PPCPs)
- Flame retardants (PBDEs, PBDDs, HBCD)
- Fluoropolymer coatings (PFOS, PFOA)
- Alkylphenol cleaners (APEs)
- Nanomaterials
- Prions
- More

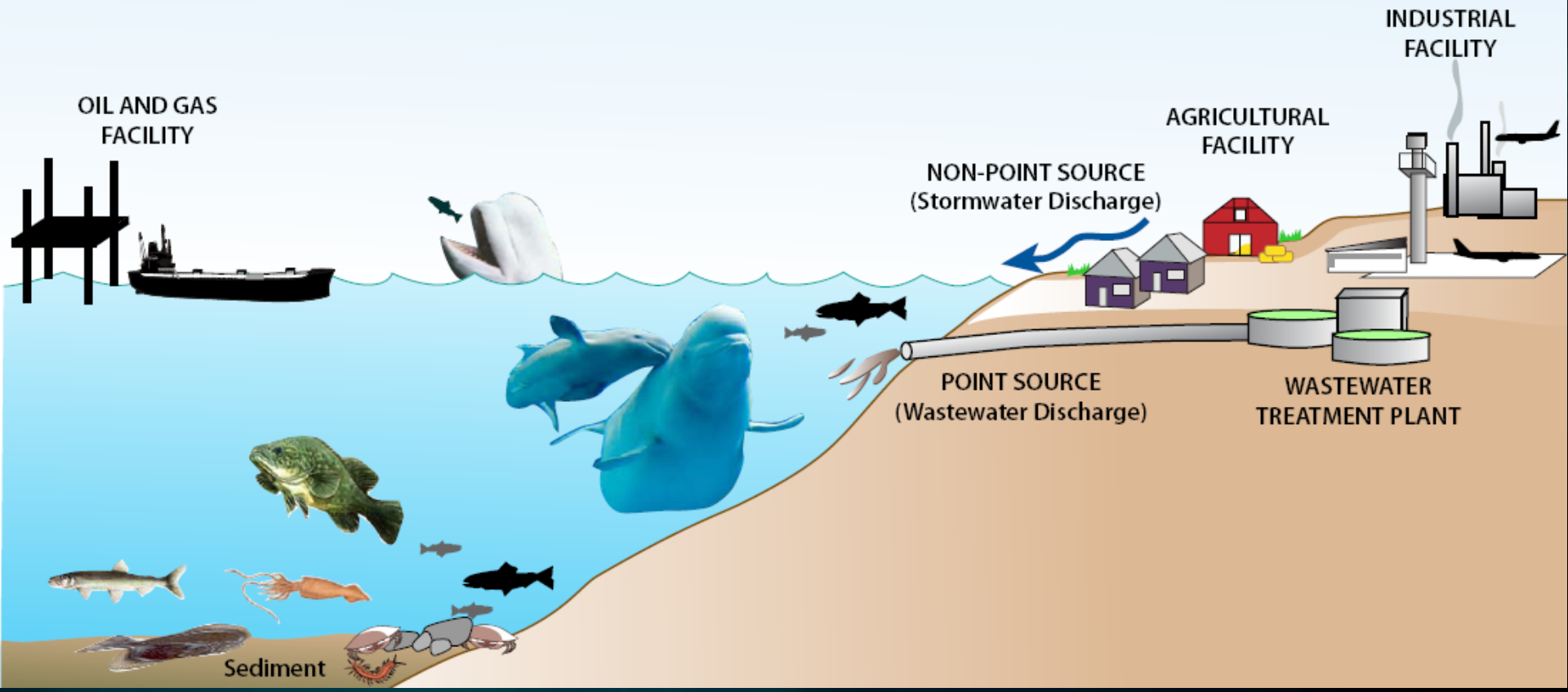
Emerging Chemicals

- Pharmaceutical and Personal Care Products (PPCPs)
  - Residues from prescription and OTC drugs
  - Dietary supplements, nutraceuticals
  - Consumer products (soaps, cosmetics, fragrances)
  - Consumer plastics (BPA)
  - Natural and synthetic hormones
  - Nanoparticles

How does exposure occur?

- Chemicals are associated with sources
- Release and transport from sources
- Exposure media and exposure to CIBs
- Source-specific and cumulative dose
- **“The dose makes the poison”**

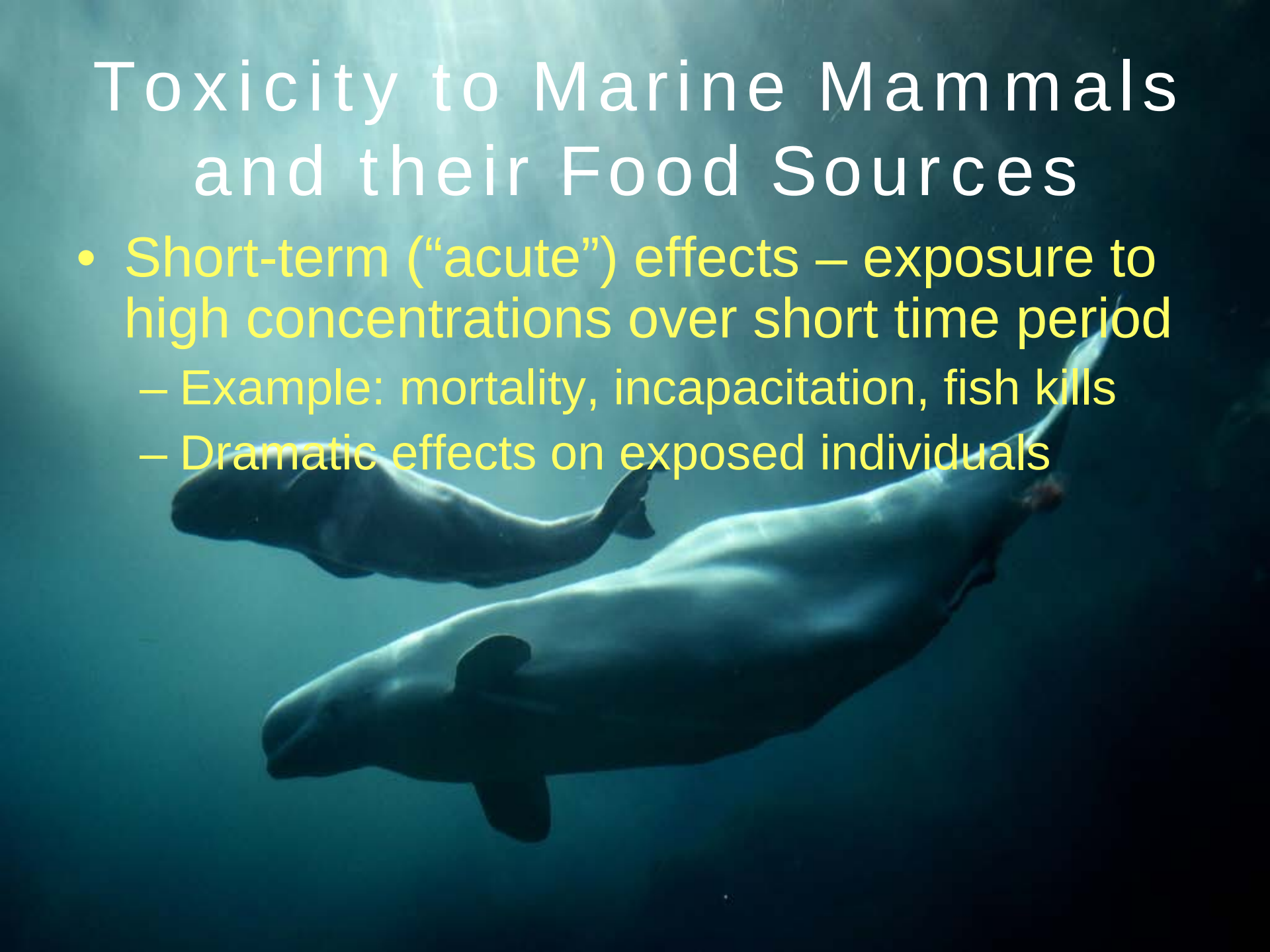
Conceptual Exposure Model



Not to scale

Toxicity to Marine Mammals and their Food Sources

- Short-term (“acute”) effects – exposure to high concentrations over short time period
  - Example: mortality, incapacitation, fish kills
  - Dramatic effects on exposed individuals



Max, A., 2010

Toxicity to Marine Mammals and their Food Sources

- Long-term ("chronic") effects – exposure to low concentrations over long time period; sensitive life stage or multigenerational exposure
  - Example: alterations in development, growth, reproductive success
  - Tumors, lesions and immunosuppression reported as possible effects in St. Lawrence belugas
  - Current evaluation focus on chronic effects

Bearzi, M., S. Rapoport, J. Chau, and C. Saylan, 2009

General Findings – Exposure Dose

- Source-related chemical information was very limited for CI
- Discharge characterization is limited – narrow suite of analytes
- Cumulative exposure - little data for CI water, sediment, prey
- Tissue data specific to CIBs very limited but is expanding

General Findings – Exposure Dose

- Most data available for legacy chemicals (e.g., PCBs, pesticides, mercury)
- Very sparse data for emerging chemicals
- Could not identify any “smoking gun” chemicals for CIBs

General Findings – Toxicity

- Some screening level toxicity threshold values available for organochlorines and a few metals
- Toxicity basis is for other marine mammals
- Uncertainties in high dose to low dose extrapolations and species variability

General Findings – Toxicity

- Very little toxicity threshold information on other chemical groups including:
  - Dioxins/furans
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Polybrominated compounds (PBDDs, PBDEs)
  - Perfluoronated compounds (PFOA, PFOS)
  - Phthalates, PPCPs
- But cellular and organismal toxicity data exist

Findings – Detected in CIBs

Organochlorines

- Legacy sources and airborne deposition
- Potential effects on growth and reproduction: endocrine disruption, premature parturition, compromised lactation
- Effects on individual health: immunosuppression, thyroidal dysfunction, and carcinogenesis

Findings – Detected in CIBs

Organochlorines

- PCBs and chlorinated pesticides detected in blubber of CIBs at lower concentrations than other Arctic belugas
- Endocrine effects threshold for marine mammals reported at 1.3 mg/kg lipid (Kannan et al 2000, Loseto et al 2009).
- Concentrations in CIB blubber 1.49 0.70 mg/kg in males and 0.79 0.56 mg/kg in females (Becker 2000)

Findings – Detected in CIBs

Heavy Metals

- Multiple sources - industrial, non-point, mining
- Low acute toxicity at environmental concentrations
- Reproductive, developmental and systemic effects with chronic exposure

Findings – Detected in CIBs

Mercury

- Total mercury, methyl mercury, selenium, silver, vanadium and cadmium detected in liver of CIBs at lower concentrations than other Arctic belugas
- Total mercury in CIB (16.3 mg/kg) lower than toxicity threshold level (60 mg/kg)

Findings – Detected in CIBs

Heavy Metals (cont.)

- Copper concentrations higher in liver of CIBs compared to other Arctic belugas
- Mean copper level (160 mg/kg in CIB liver) higher than levels reported for renal damage (29 mg/kg) in Australian bottlenose dolphins (Lavery et al 2009).

Findings – Detected in CIBs

Zinc

- Zinc in CIBs (102 mg/kg) are intermediate between low and high renal damage range (73 – 178 mg/kg) reported for bottlenose dolphins (Lavery et al 2005).
- High uncertainty in all these comparisons

Findings – Literature Review

- **Chemicals of Potential Concern (COPCs) designated as Probable, Possible or Unlikely as to whether there is reason for further evaluation**

- Note: Terms do not refer to likelihood of adverse effects in CIBs, only reason to evaluate further

Findings – Literature Review

- **Probable –** reported in CI water or sediment, CIB tissues, likely sources present, persistent, potential toxicity includes effects on reproduction and growth
  - Organochlorines (PCBs, chlorinated pesticides)
  - PAHs
  - Copper, zinc (atypical)
  - Recommended for extensive evaluation

Findings – Literature Review

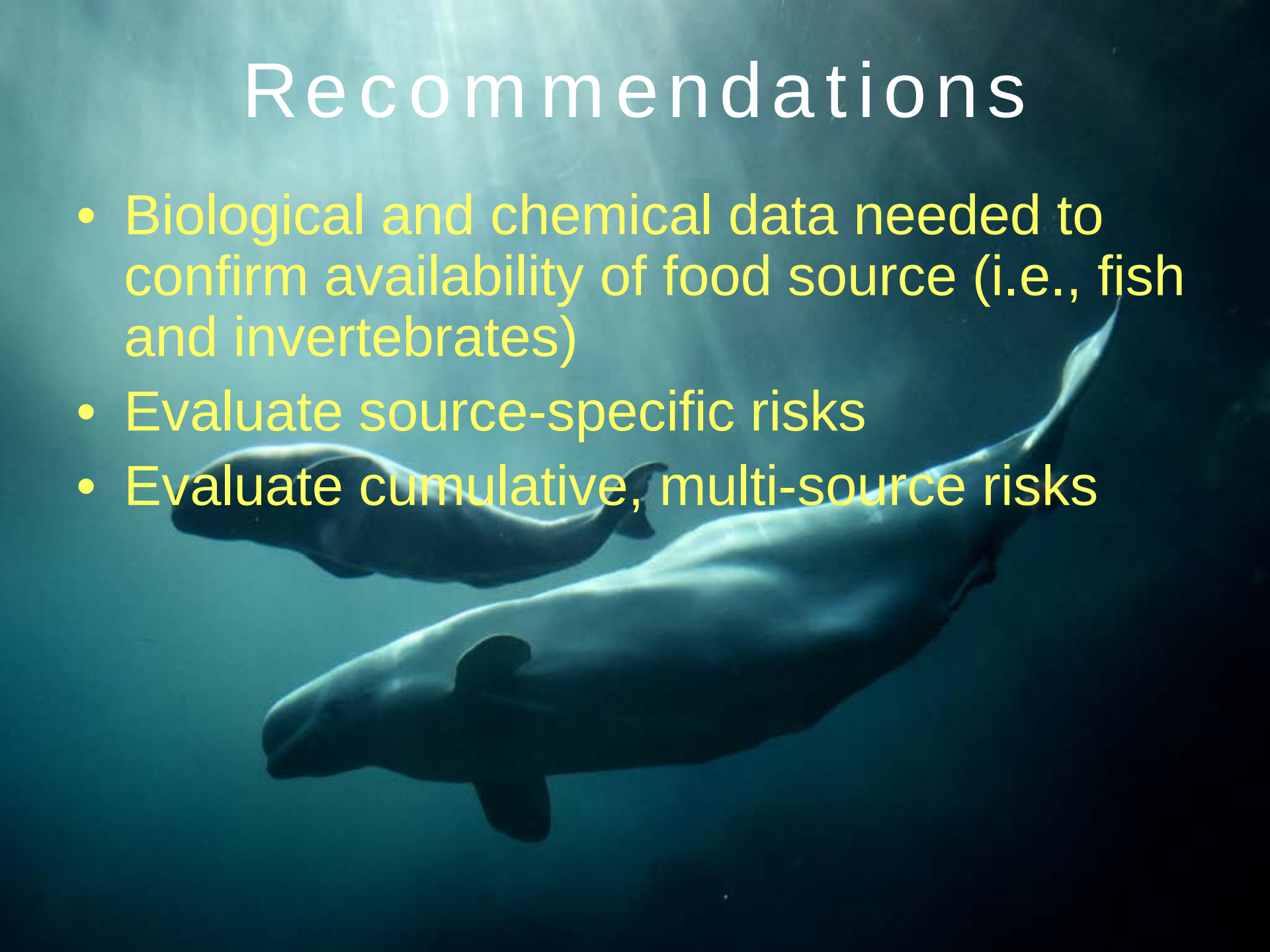
- **Possible COPCs** – Potential toxic effects to marine mammals or their prey but insufficient evidence of their occurrence in CI or CIBs
  - Polybrominated and perfluoronated compounds
  - Phthalates, Pesticides
  - Pharmaceuticals and hormones
  - Recommended for further evaluation

Findings – Literature Review

- **Unlikely COPCs** – Low toxicity to marine mammals and aquatic biota, non-persistent, toxicity unknown but environmental concentrations appear to be very low or localized
  - Non-PAH hydrocarbons
  - Glycols
  - Some types of PPCPs
  - Nanoparticles, prions
  - Recommended for exploratory evaluation

Recommendations

- Biological and chemical data needed to confirm availability of food source (i.e., fish and invertebrates)
- Evaluate source-specific risks
- Evaluate cumulative, multi-source risks



Summary

- What we know is far less than what we don’t know for most chemicals
- Site-specific data gaps can be addressed by additional sampling
- Toxic effects data gaps require more information search, research and interpretation
- For more details, please refer to the report