Conceptual Models of the Potential Ecological Impacts of MHK Arrays

M. Grippo and I. Hlohowskyj
Environmental Science Division
Argonne National Laboratory

Marine and Hydrokinetic (MHK) Technology

- Commercial MHK development has potential to affect biotic resources of high ecological value and public interest.

- Regulatory agencies will require evaluations of potential impacts to such resources
  - Federal Energy Regulatory Commission
  - Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)
  - U.S. Army Corps of Engineers
  - National Oceanic and Atmospheric Administration

- Evaluations may be conducted under one or more federal statutes
  - Clean Water Act - Endangered Species Act
  - Marine Mammal Protection Act - Essential Fish Habitat
  - Coastal Zone Management Act

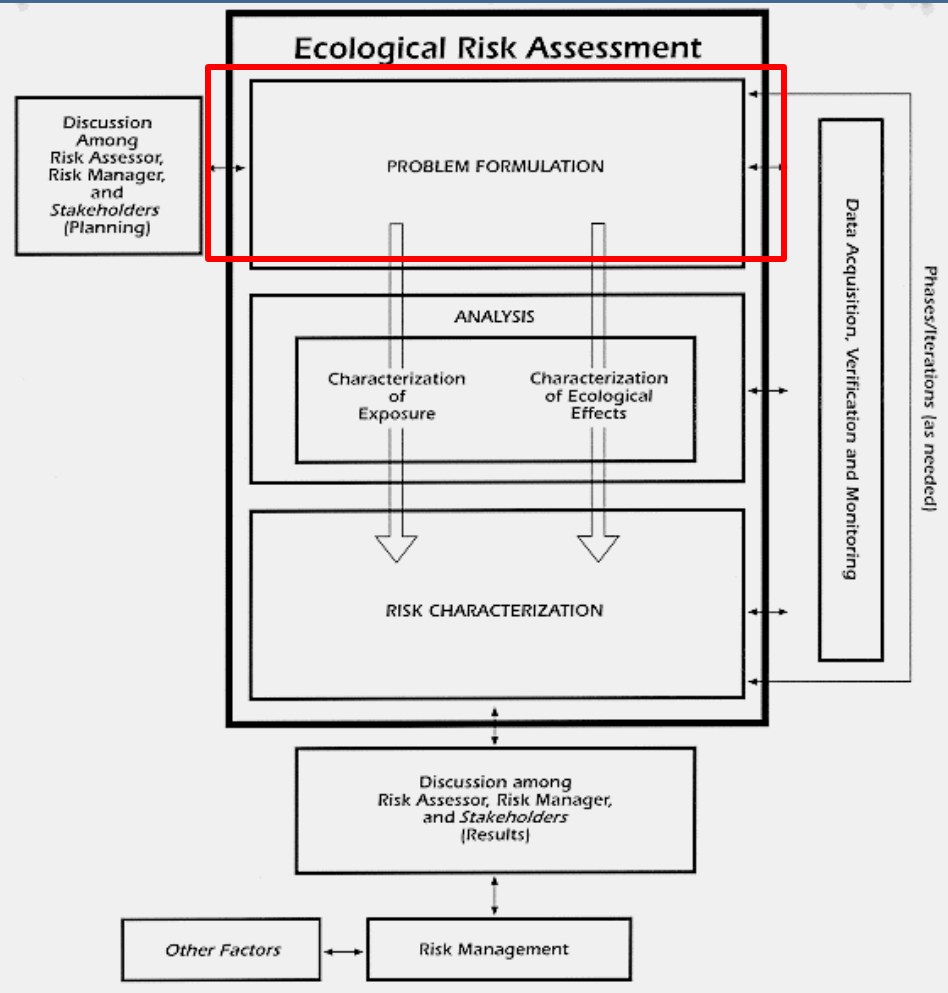
National Environmental Policy Act

MHK and NEPA

- MHK projects will likely be implemented under a NEPA framework
- Description of existing resources and an analysis of impacts under each development alternative.
- Multi-lab effort funded by DOE to examine physical and biological effects of MHK devices
- Argonne's role:

  -Use field and laboratory data in ecological risk analysis of MHK technologies

  -Aid developers in meeting NEPA requirements by addressing stakeholders concerns about MHK technology



EPA RISK ASSESSMENT

Problem Formulation

-Conceptual models (CM):

- -Diagrammatic representation of receptor and stressor linkages
- -Identifies potential risks
- -Excellent communications tool
- -Identify data gaps and research needs
- -CM shows **POTENTIAL EFFECTS**

Source:Guidelines for Ecological Risk Assessment (EPA, 1998)

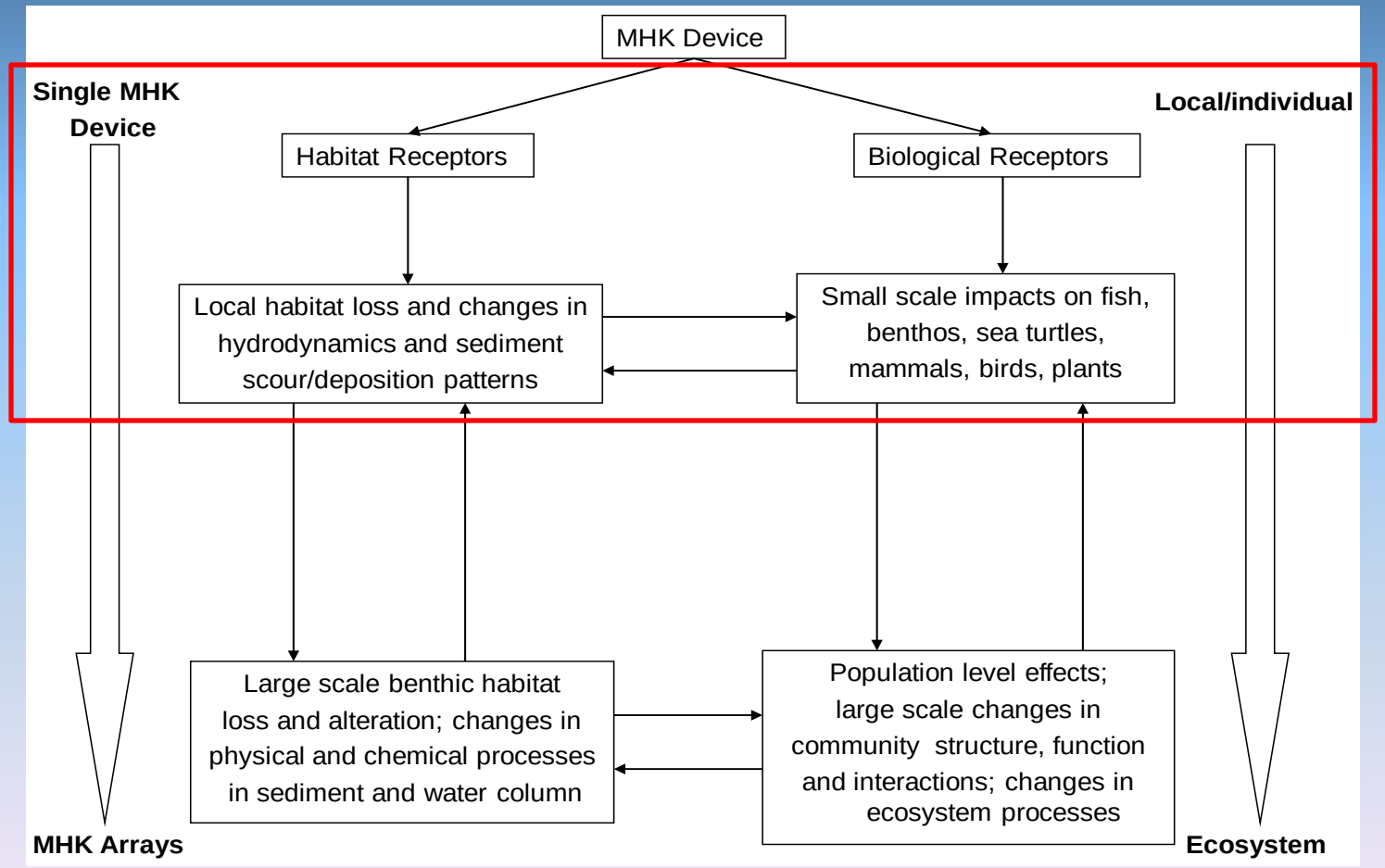
MHK development must consider:

- The incremental increases in impacts from a single MHK device to large-scale commercial developments
- Interaction of the MHK device with existing impacts from other anthropogenic stressors

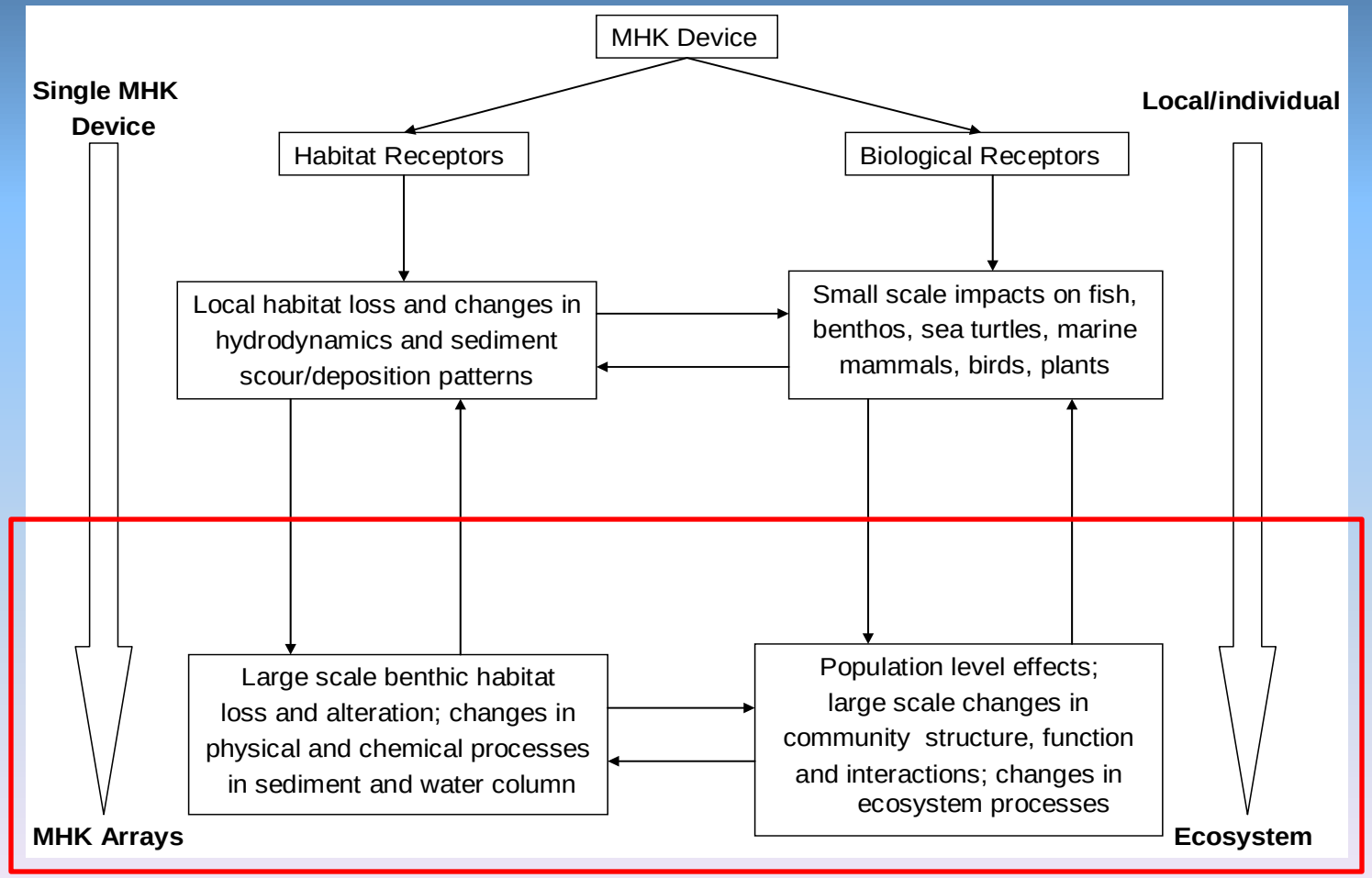
MHK development must consider:

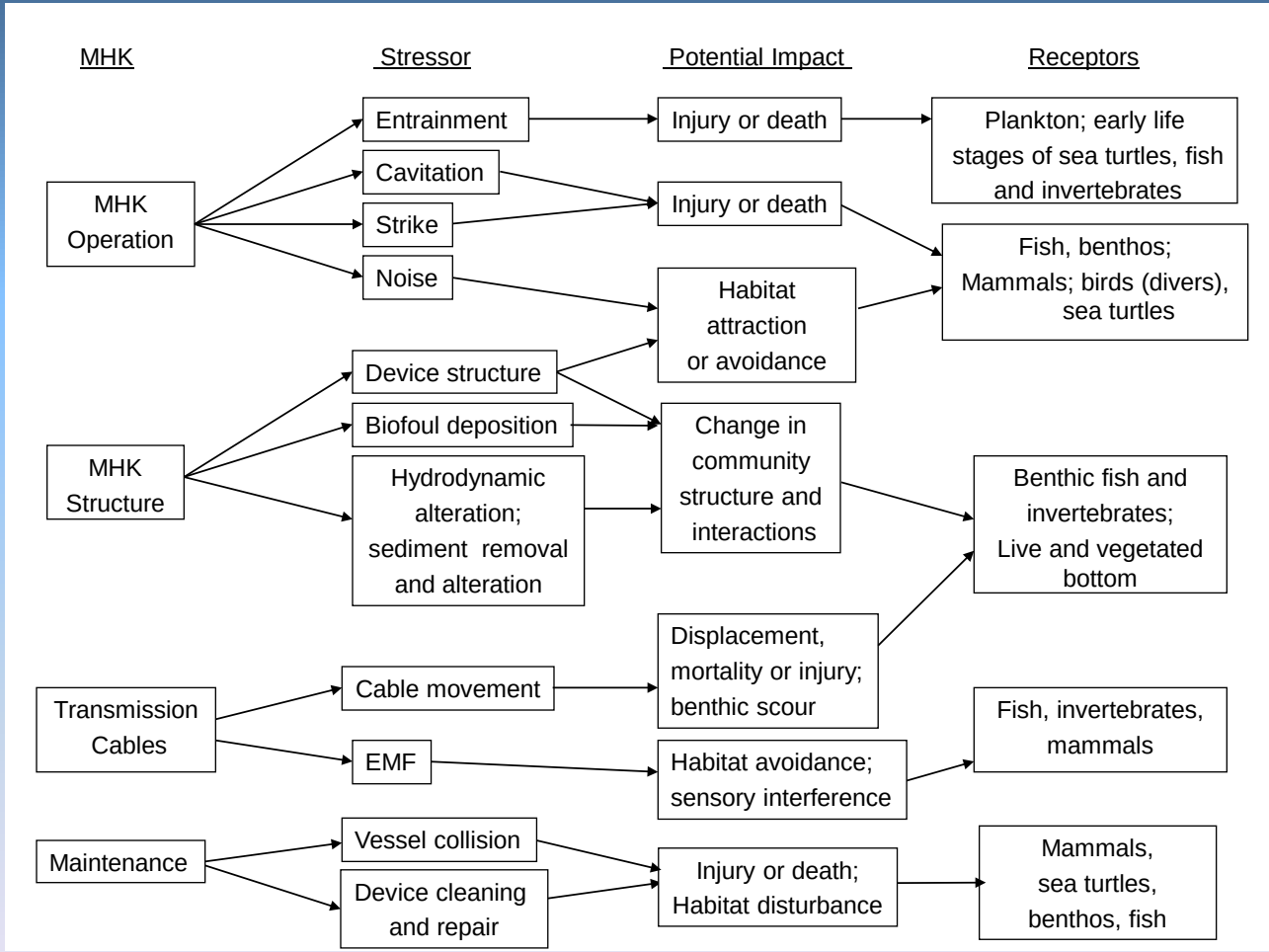
- **The incremental increases in impacts from a single MHK device to large-scale commercial developments**
- Interaction of the MHK device with existing impacts from other anthropogenic stressors

Single MHK Vs. MHK Array Deployments



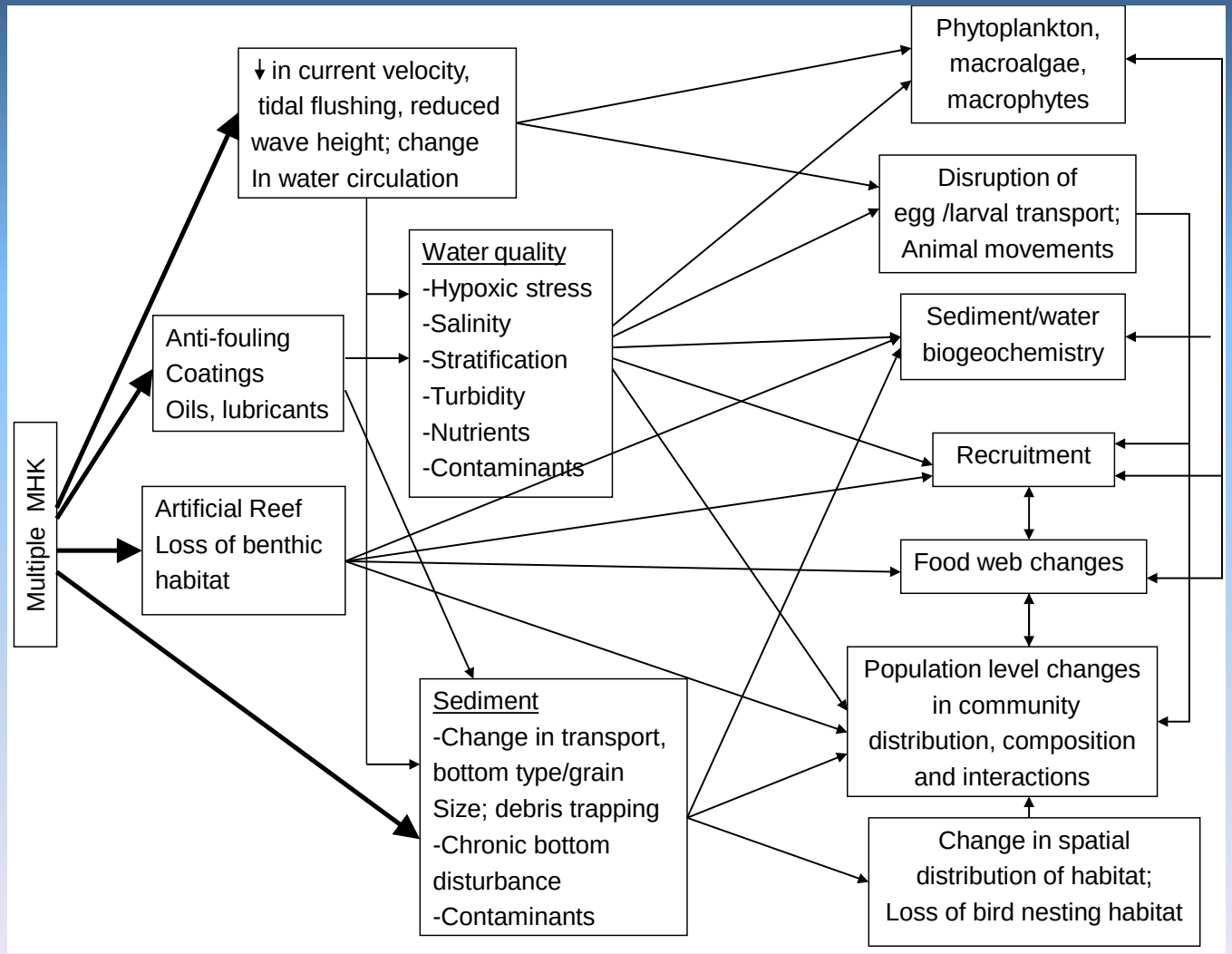
Single MHK Vs. MHK Array Deployments



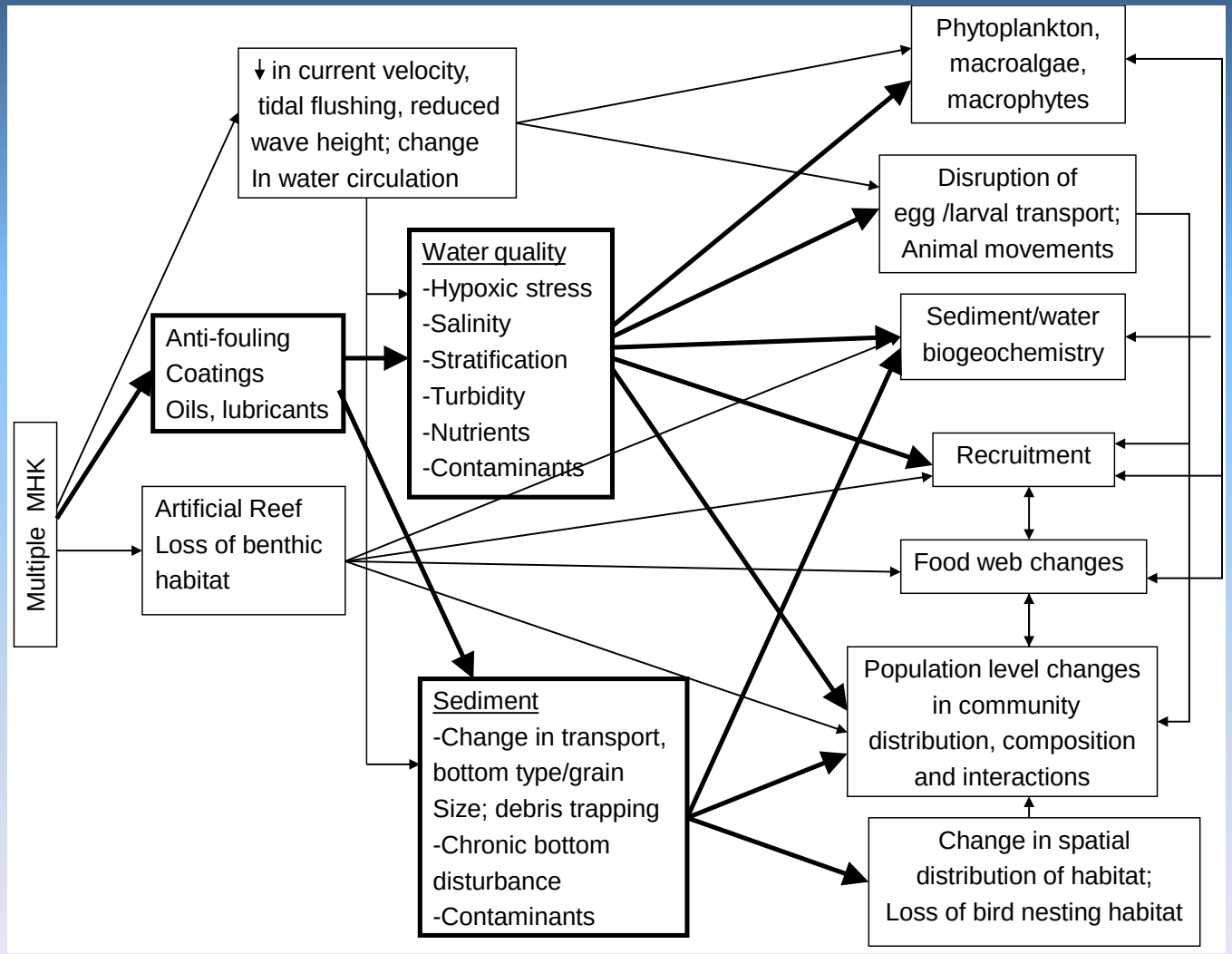


Potential effects of a single MHK device

Increase in magnitude MHK arrays

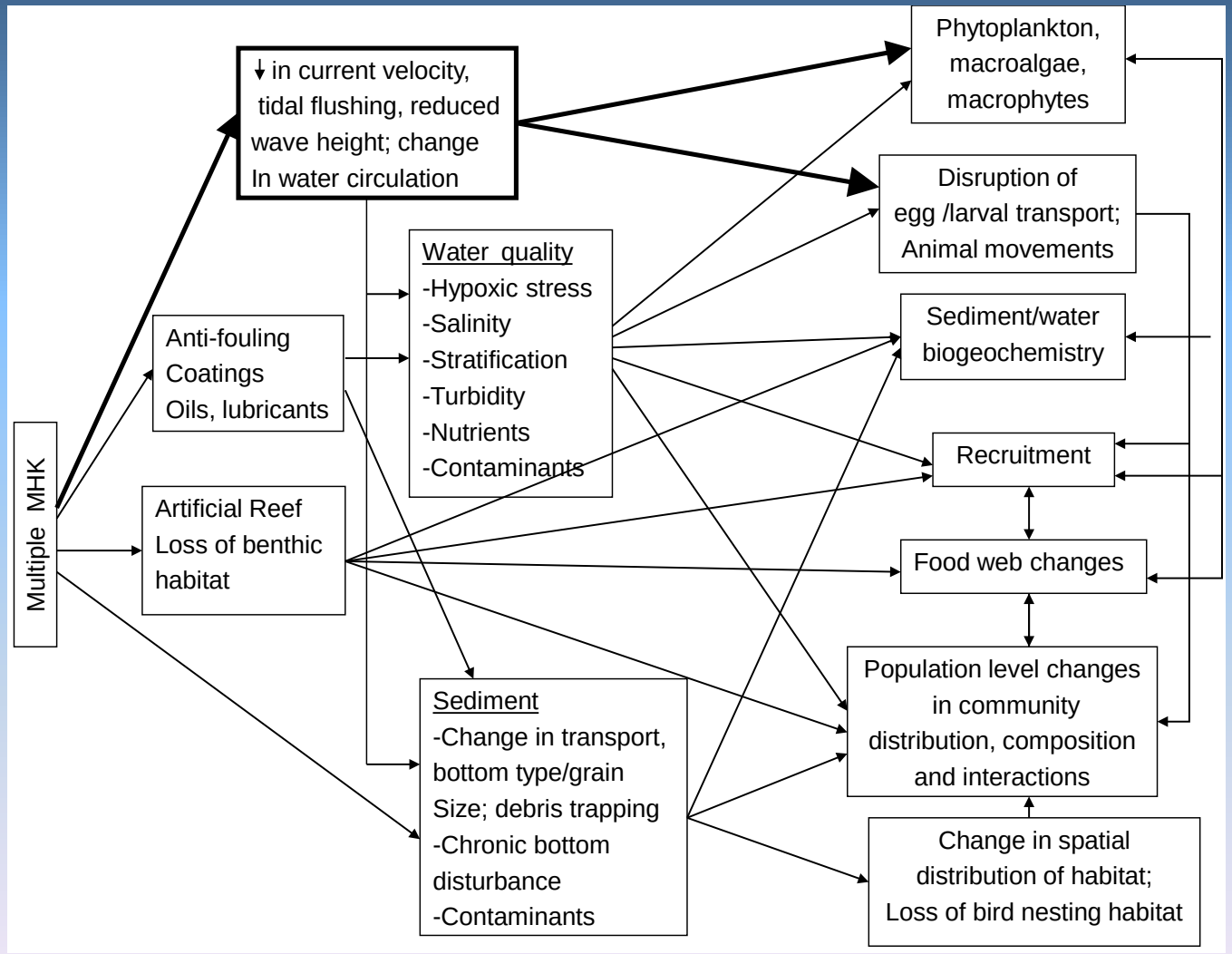


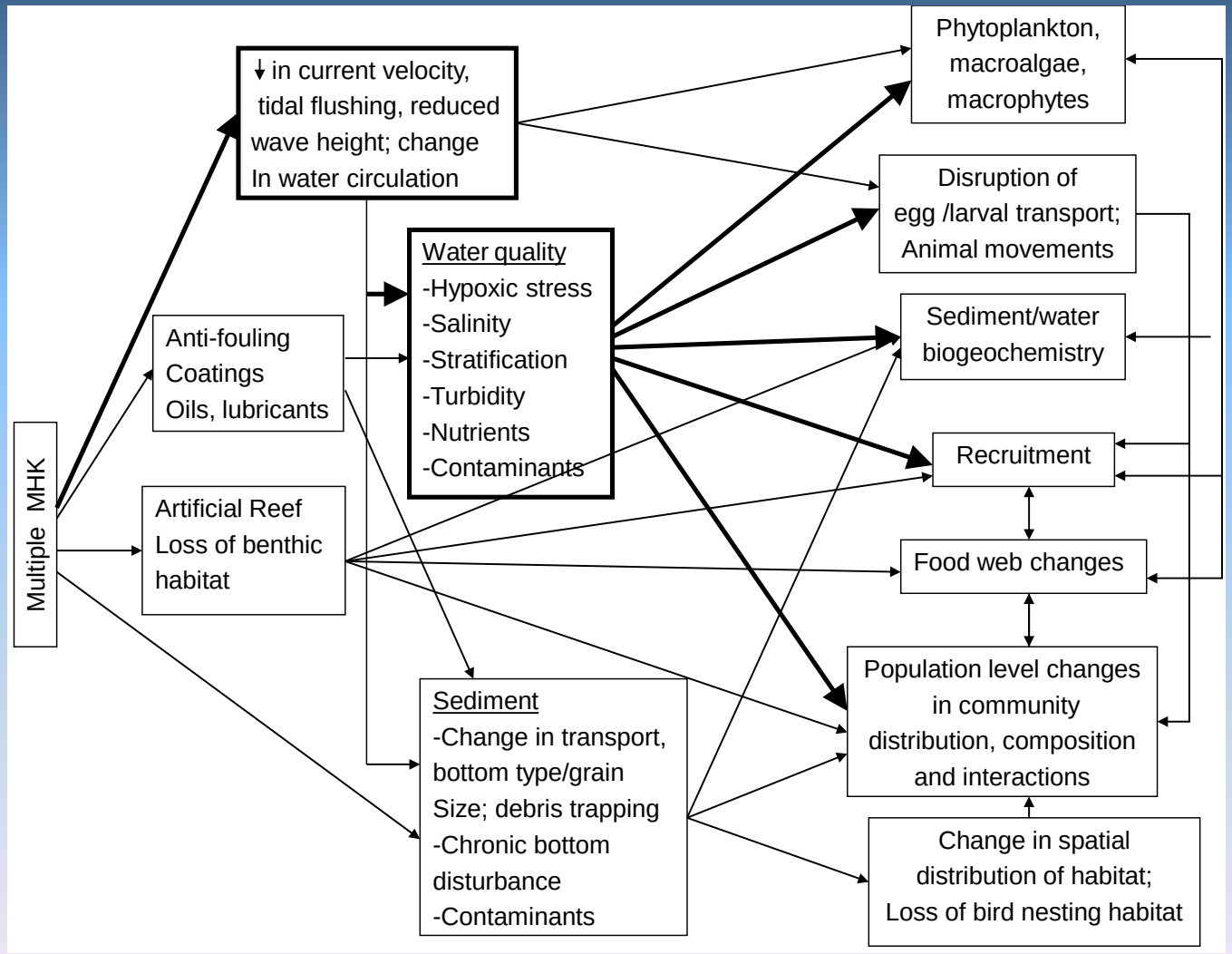
Habitat mediated impact routes from MHK arrays



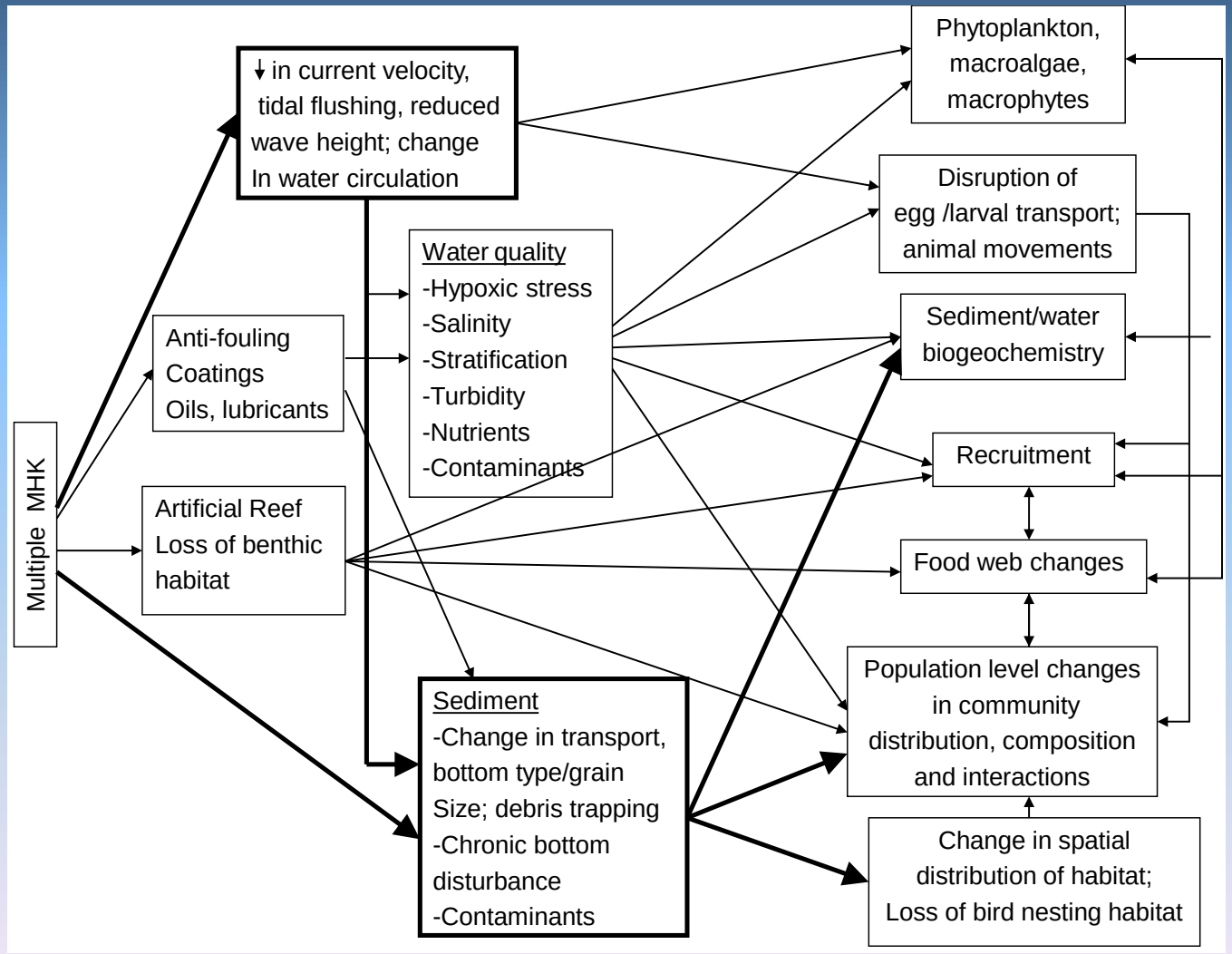
Contaminants

Hydrology

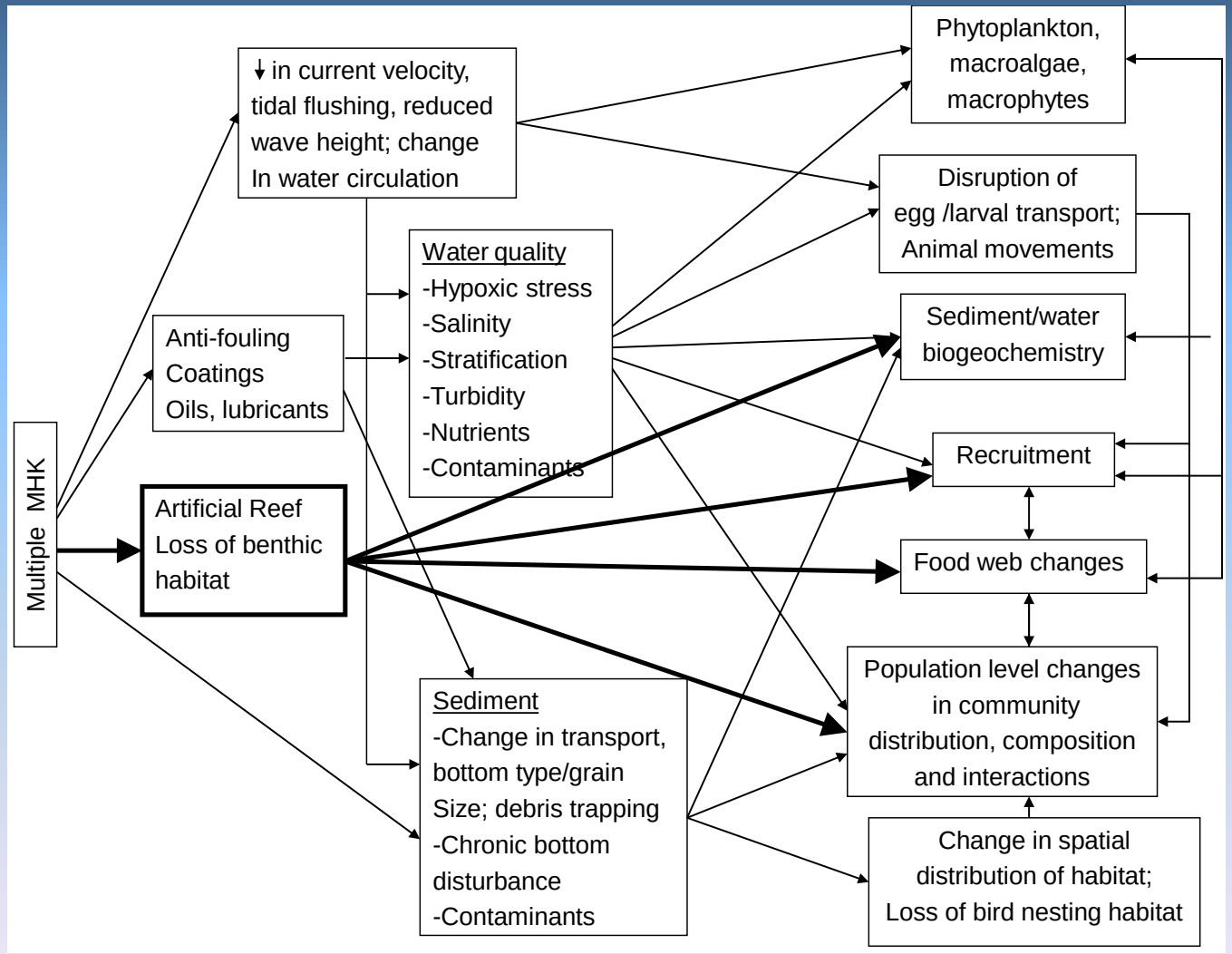

Multiple MHK
↓ in current velocity, tidal flushing, reduced wave height; change In water circulation
Anti-fouling Coatings Oils, lubricants
Artificial Reef Loss of benthic habitat
Water quality
-Hypoxic stress
-Salinity
-Stratification
-Turbidity
-Nutrients
-Contaminants
Sediment
-Change in transport, bottom type/grain Size; debris trapping
-Chronic bottom disturbance
-Contaminants
Phytoplankton, macroalgae, macrophytes
Disruption of egg /larval transport; Animal movements
Sediment/water biogeochemistry
Recruitment
Food web changes
Population level changes in community distribution, composition and interactions
Change in spatial distribution of habitat; Loss of bird nesting habitat



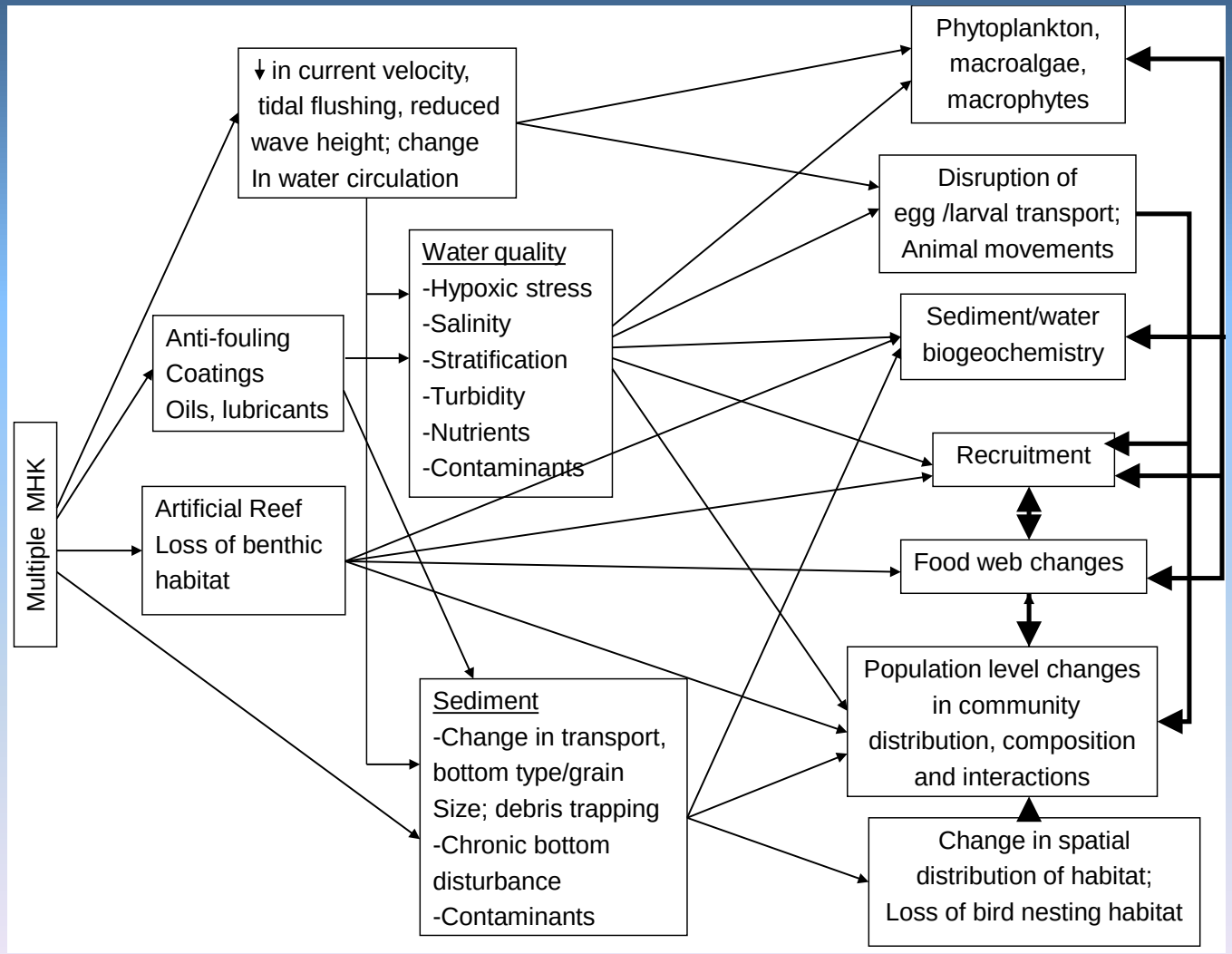
Water chemistry



Sediment and geomorphology



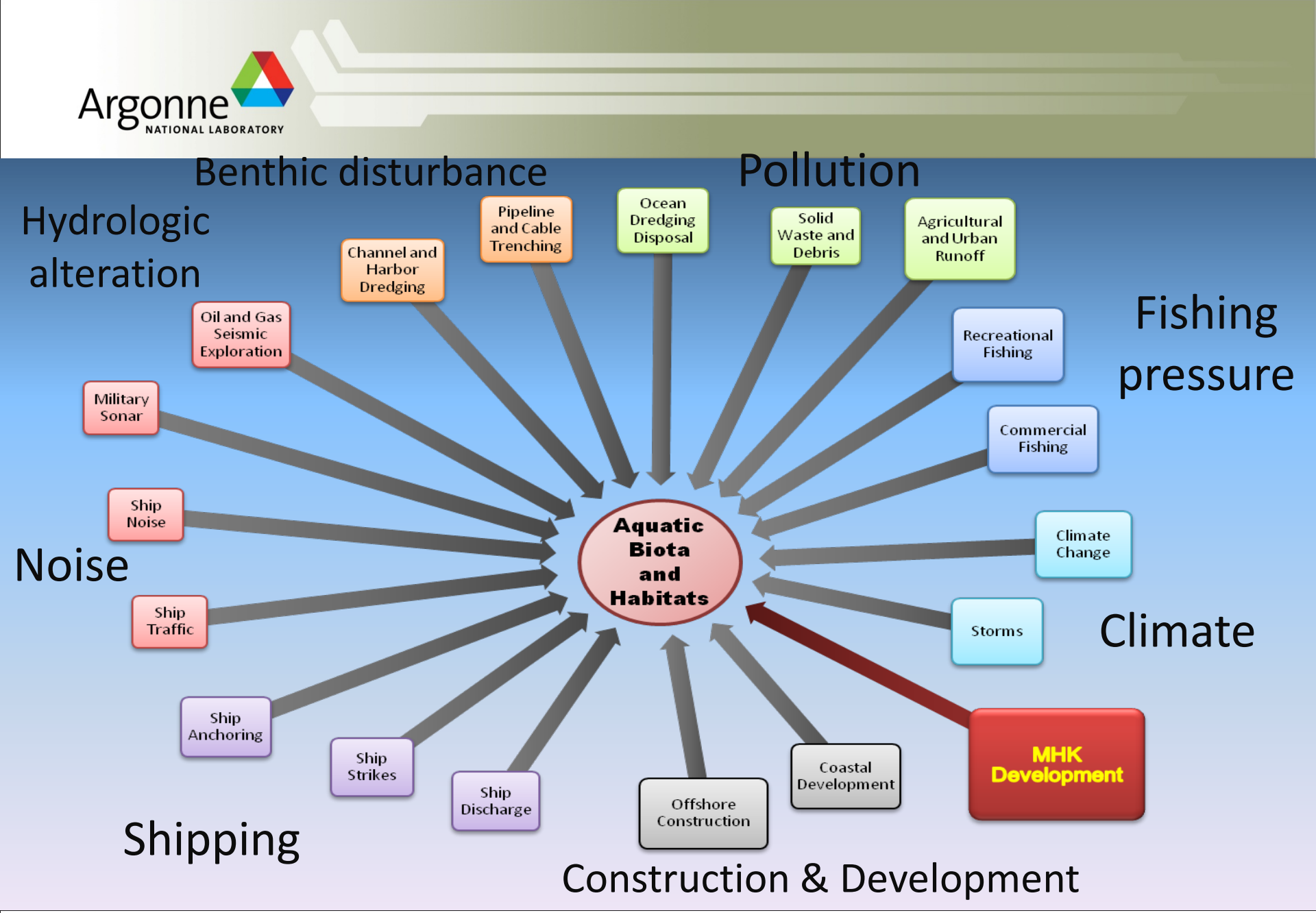
Habitat Effects



Complex interaction Between ecosystem compartments

MHK development must consider:

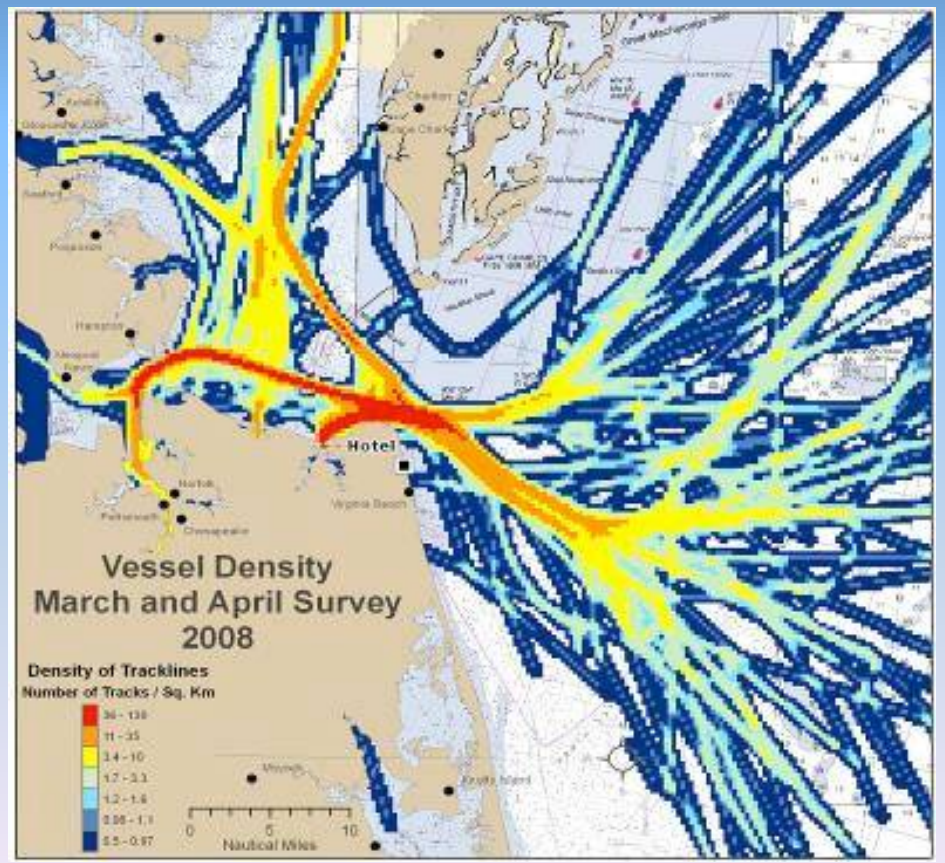
- The incremental increases in impacts from a single MHK device to large-scale commercial developments
- **Interaction of the MHK array with existing impacts from other anthropogenic stressors**

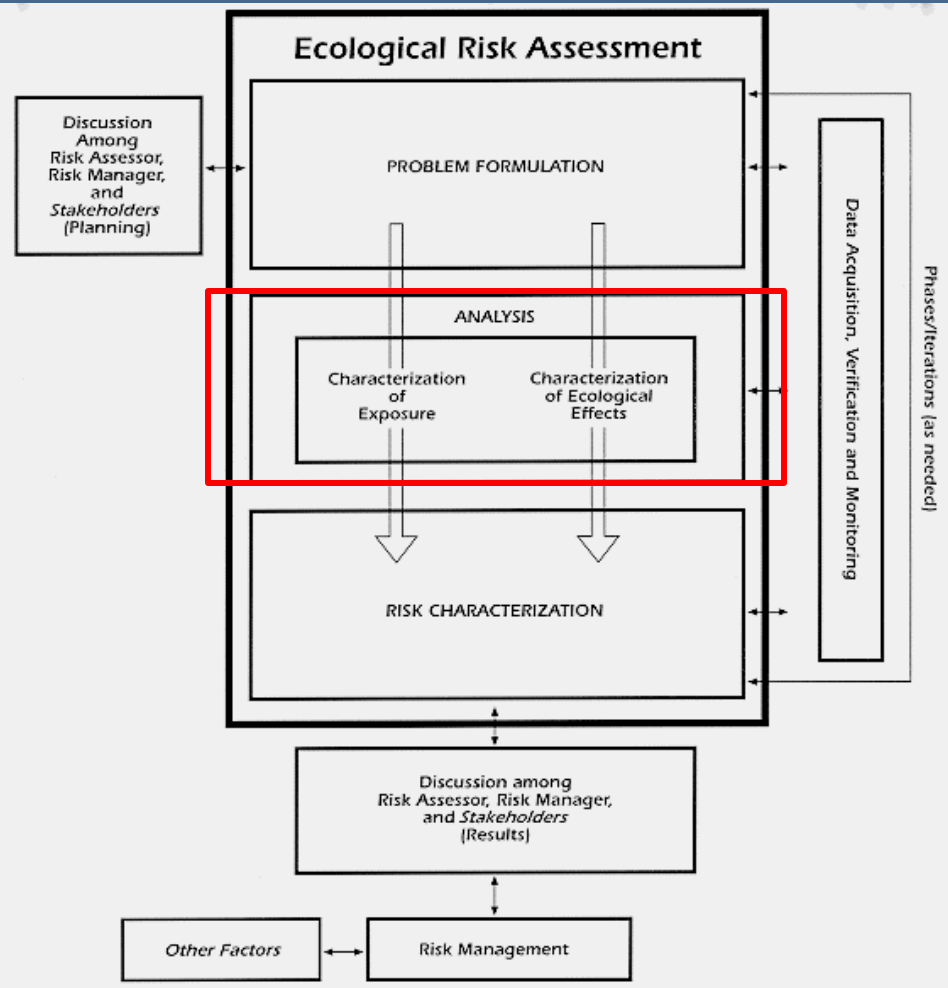

Benthic disturbance
Pollution
Hydrologic alteration
Channel and Harbor Dredging
Pipeline and Cable Trenching
Ocean Dredging Disposal
Solid Waste and Debris
Agricultural and Urban Runoff
Fishing pressure
Oil and Gas Seismic Exploration
Recreational Fishing
Military Sonar
Commercial Fishing
Noise
Ship Noise
Aquatic Biota and Habitats
Climate Change
Ship Traffic
Storms
Climate
Ship Anchoring
MHK Development
Ship Strikes
Coastal Development
Ship Discharge
Offshore Construction
Shipping
Construction & Development

Cumulative Impact

- Multiple existing human uses

- Challenging to evaluate cumulative impacts
  - Little information on ecological impacts of MHK technologies
  - Resources and potential impacts vary by technology and project location
  - Interaction of MHK technology with existing stressors not well understood
  - Could be additive, synergistic, or offsetting



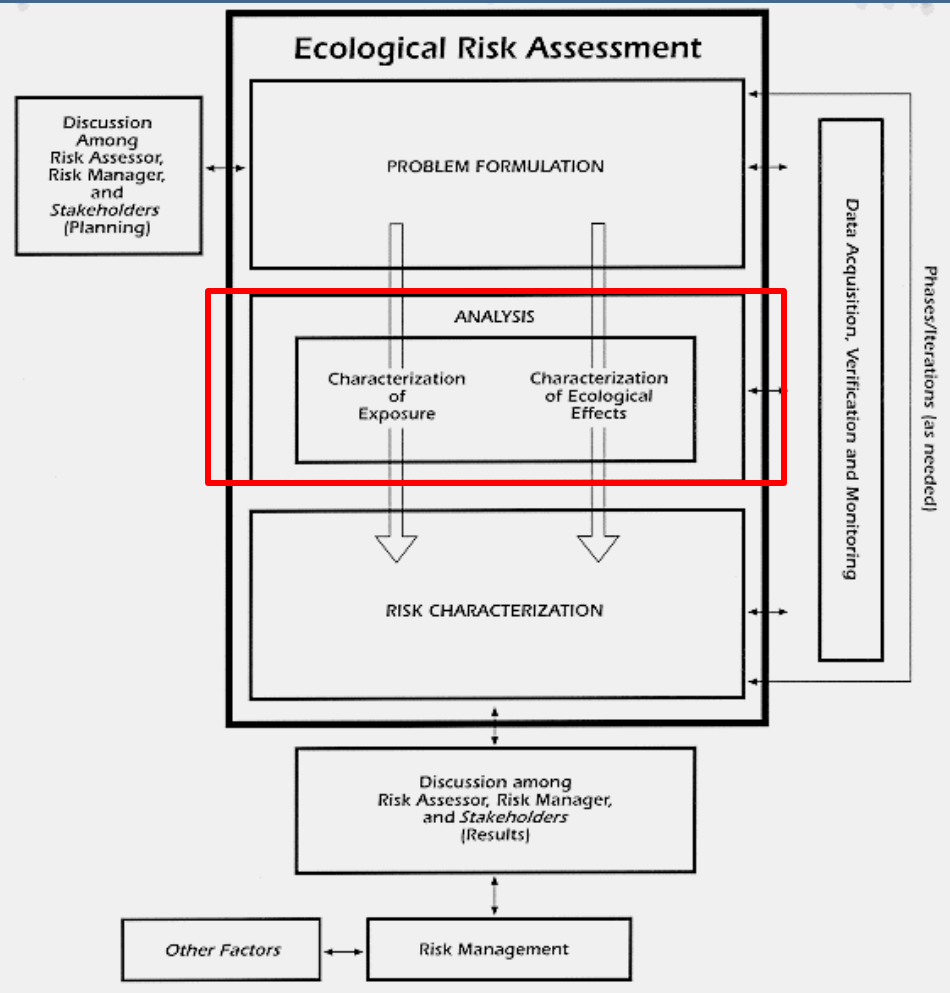


EPA RISK ASSESSMENT
Analysis Phase

Characterization of Exposure

1. Spatial and temporal extent of potential stressor(s) identified in CMs
   - -Must be data informed
   - -Work by other labs will quantify exposures and changes in key environmental processes (EMF, hydrology, sediment dynamics)

Source:Guidelines for Ecological Risk Assessment (EPA, 1998)



Source:Guidelines for Ecological Risk Assessment (EPA, 1998)

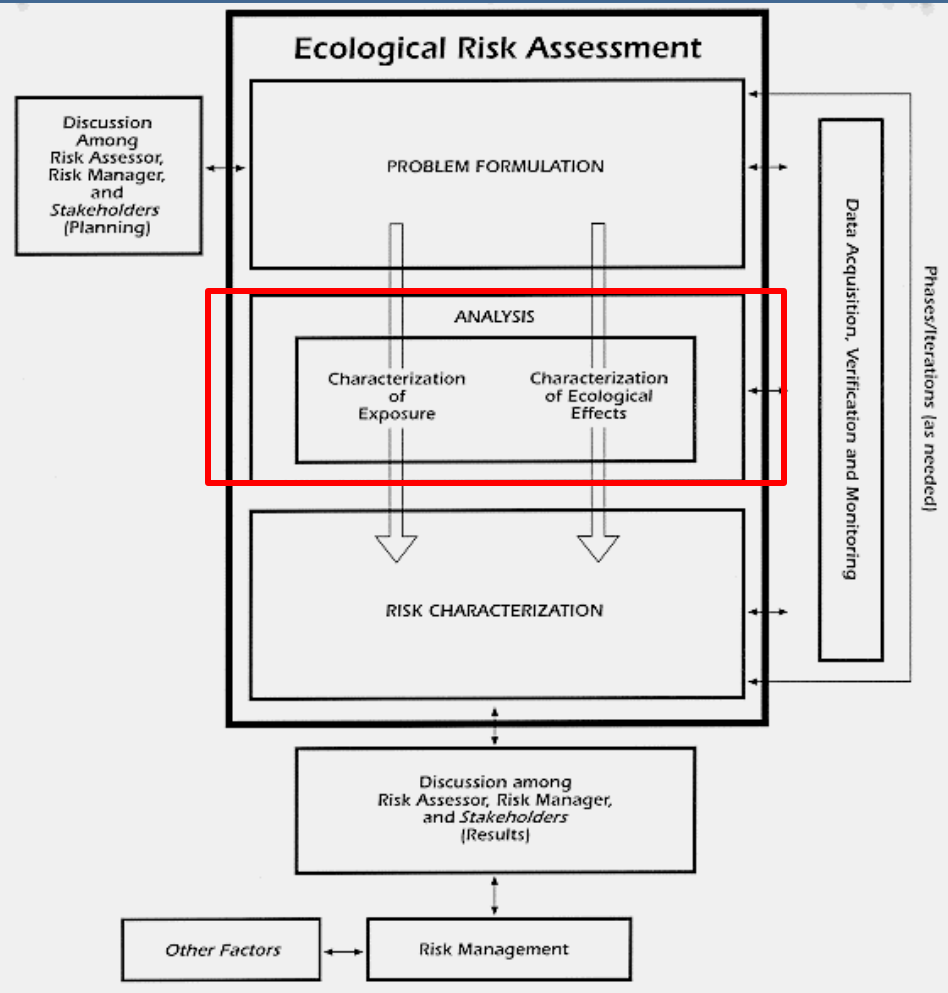
EPA RISK ASSESSMENT

Analysis Phase

Characterization of Exposure

2. Contact with ecological receptors based on species life history and ecology

Impacting Factor	Analytical Method
Device-animal interactions	Models of animal movement
Noise EMF	Movement modelling; Acoustic Integration Model©; GIS based krieging
Toxicants	Probabilistic exposure models; FR-M (USACE); Aquatox (US EPA)

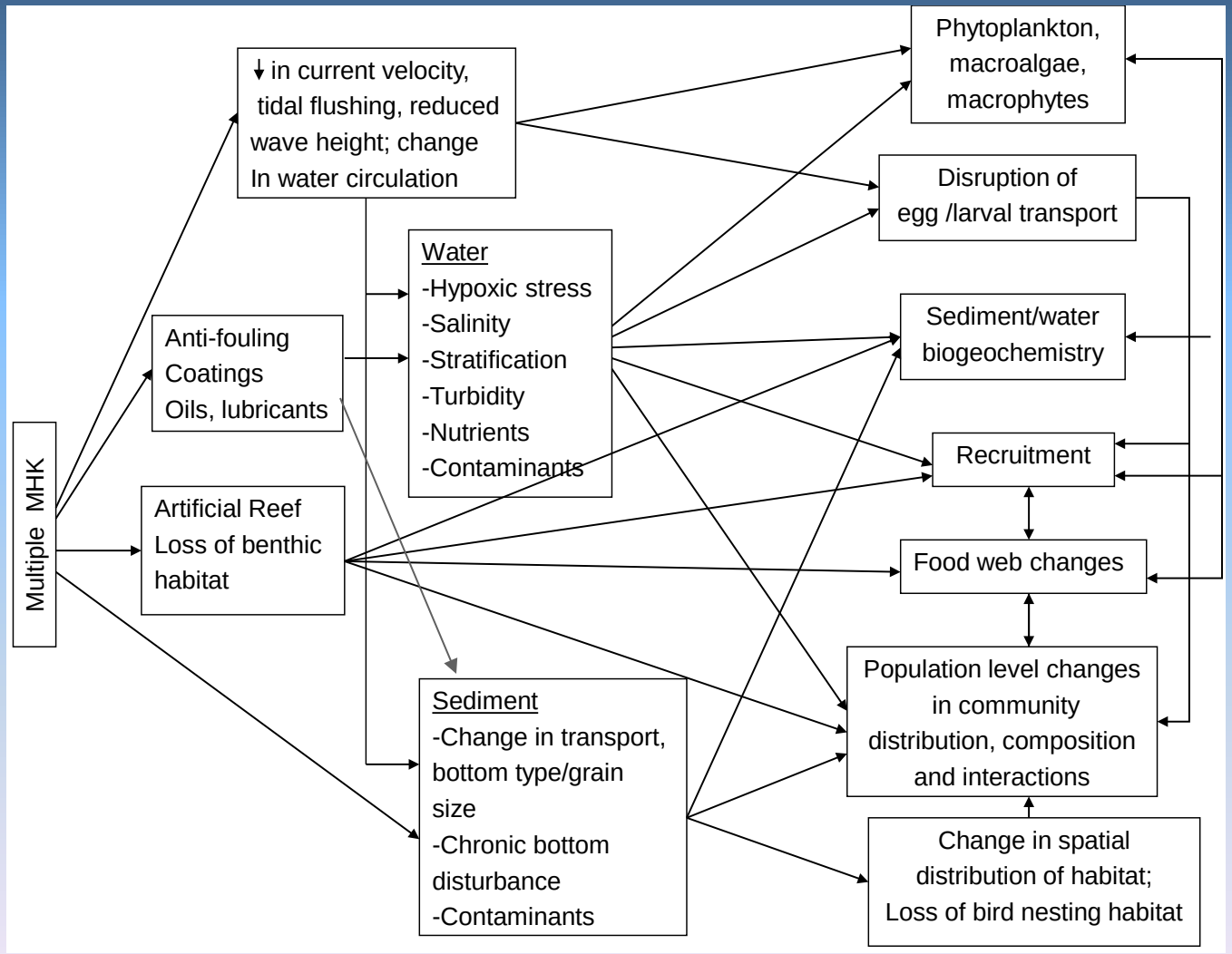


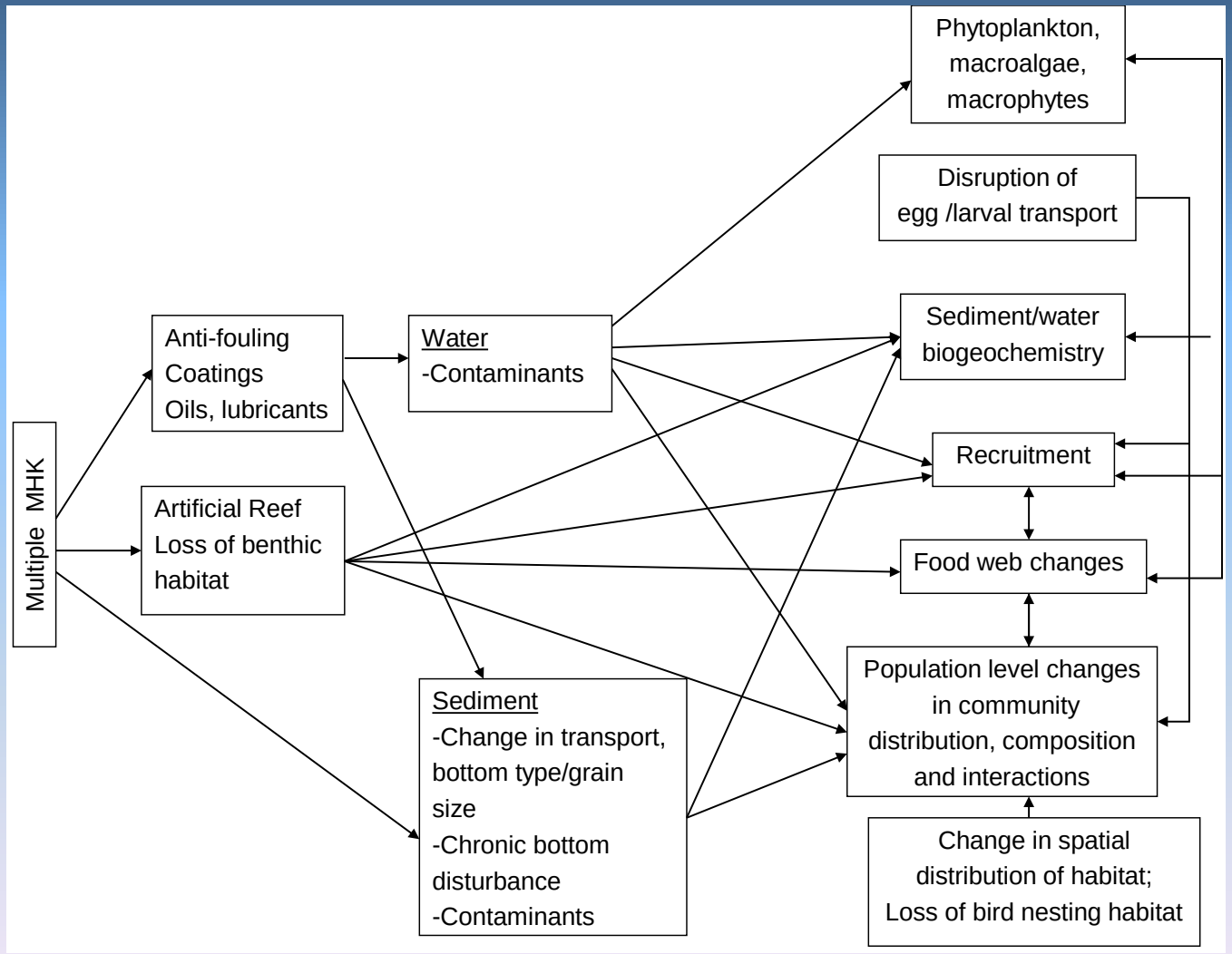
EPA RISK ASSESSMENT
Analysis Phase

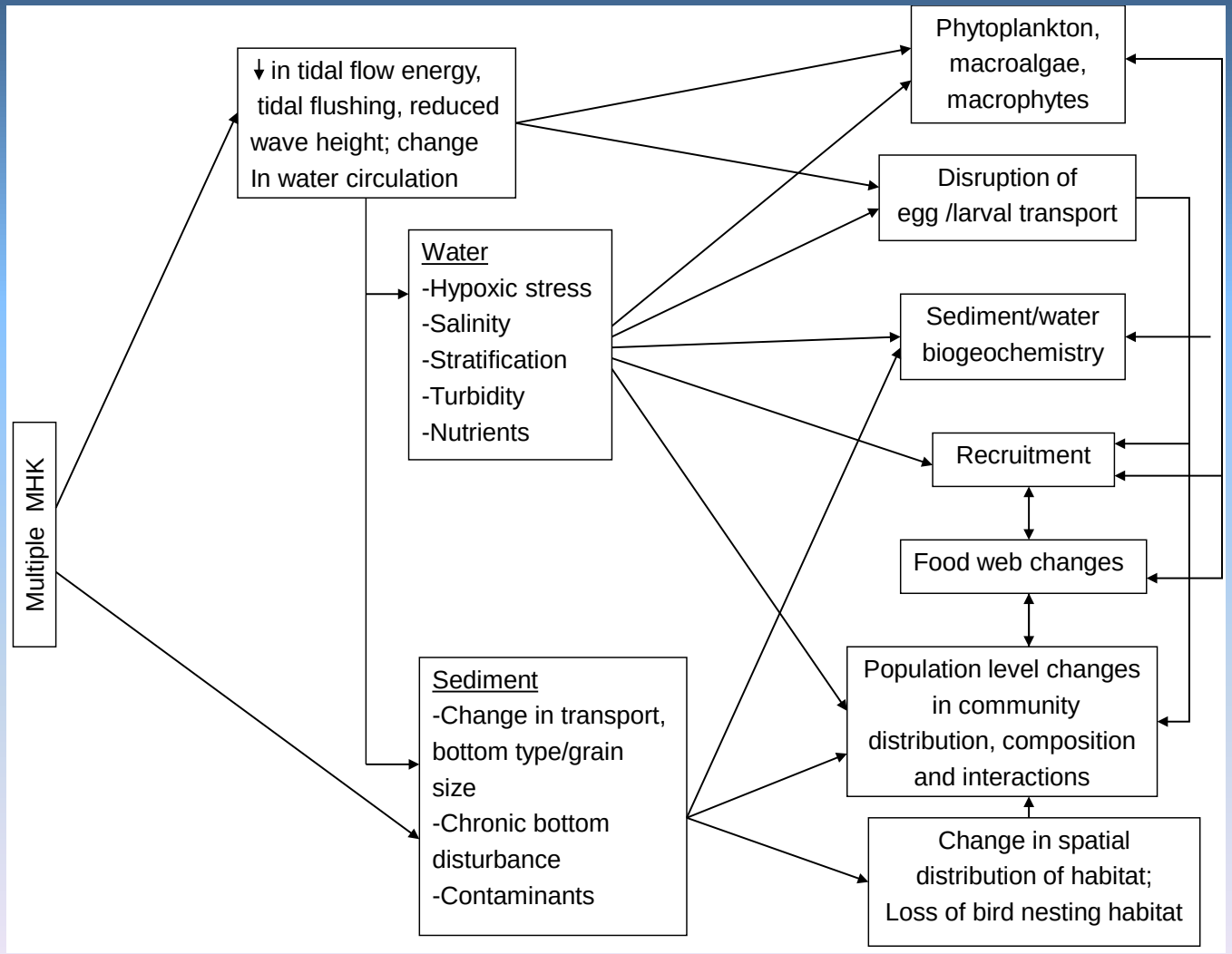
Characterization of Ecological Effects

-What are the potential ecological effects that can be expected based on the level of exposure

Source: Guidelines for Ecological Risk Assessment (EPA, 1998)


Multiple MHK
↓ in current velocity, tidal flushing, reduced wave height; change In water circulation
Anti-fouling Coatings Oils, lubricants
Artificial Reef Loss of benthic habitat
Water
-Hypoxic stress
-Salinity
-Stratification
-Turbidity
-Nutrients
-Contaminants
Sediment
-Change in transport, bottom type/grain size
-Chronic bottom disturbance
-Contaminants
Phytoplankton, macroalgae, macrophytes
Disruption of egg /larval transport
Sediment/water biogeochemistry
Recruitment
Food web changes
Population level changes in community distribution, composition and interactions
Change in spatial distribution of habitat; Loss of bird nesting habitat


Multiple MHK
Anti-fouling
Coatings
Oils, lubricants
Artificial Reef
Loss of benthic
habitat
Water
-Contaminants
Sediment
-Change in transport,
bottom type/grain
size
-Chronic bottom
disturbance
-Contaminants
Phytoplankton,
macroalgae,
macrophytes
Disruption of
egg /larval transport
Sediment/water
biogeochemistry
Recruitment
Food web changes
Population level changes
in community
distribution, composition
and interactions
Change in spatial
distribution of habitat;
Loss of bird nesting habitat


Multiple MHK
↓ in tidal flow energy, tidal flushing, reduced wave height; change In water circulation
Water
-Hypoxic stress
-Salinity
-Stratification
-Turbidity
-Nutrients
Sediment
-Change in transport, bottom type/grain size
-Chronic bottom disturbance
-Contaminants
Phytoplankton, macroalgae, macrophytes
Disruption of egg /larval transport
Sediment/water biogeochemistry
Recruitment
Food web changes
Population level changes in community distribution, composition and interactions
Change in spatial distribution of habitat; Loss of bird nesting habitat

Acknowledgements

US Department of Energy

Sandia National Lab

Pacific Northwest National Lab

Oak Ridge National Lab