Fish and fisheries research considerations for understanding impacts of deep-sea mining

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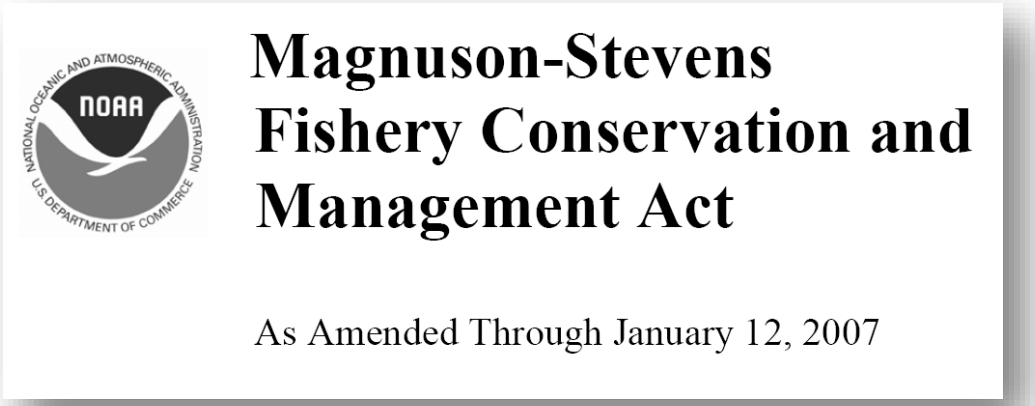
Primary topics

- Habitat
  - Legislative mandate
  - Essential Fish Habitat and Habitat Areas of Particular Concern categorizations
- Fish biology
  - Physiology
  - Behavior
  - Food webs
- Fisheries
  - Access
  - Productivity
- Some proposed preliminary research questions



"*The most important fish (economically, culturally and socially) in the Pacific are oceanic and pelagic*"
-NPFMC Pelagic Fish EFH

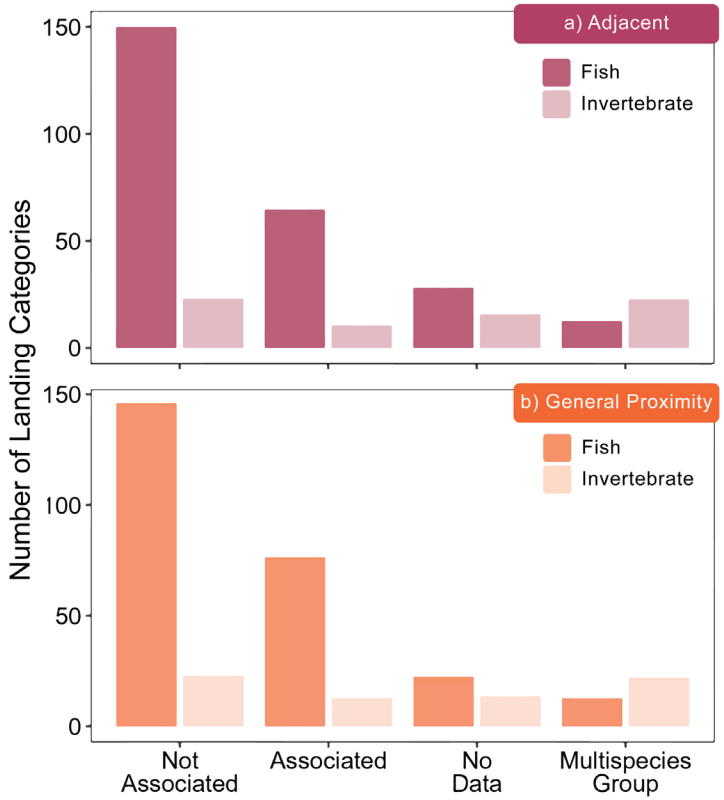
Essential Fish Habitat (EFH)

Defined by the Magnuson-Stevens Fishery Conservation Act amendments of 2007 as, “those waters and substrate necessary for spawning, breeding, feeding or growth to maturity”.

- “Waters” include aquatic areas and their **associated physical, chemical, and biological properties** that are used by fish and may include aquatic areas historically used by fish where appropriate;
- “Substrate” includes **sediment, hard bottom, structures underlying the waters, and associated biological communities;**
- “Necessary” means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and
- “Spawning, breeding, feeding, or growth to maturity” covers a species' full life cycle

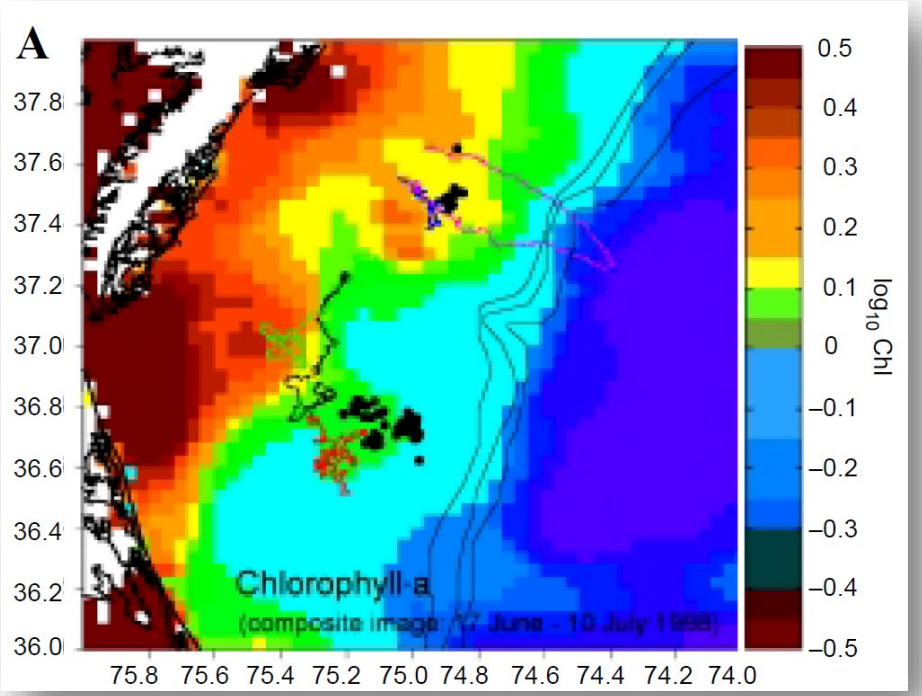
Habitat considerations -benthic

- Benthic Habitat (for reef/groundfish)
  - EFH needs to be defined for managed species
  - Additional protections primarily through Habitat Areas of Particular Concern (HAPC) designation
    - Seamounts are protected habitat or HAPC (e.g., PFMC and WPFMC)
    - Deep sea corals are HAPC designated (e.g., PFMC and SAFMC)
    - Methane seep carbonates are HAPC designated (e.g., PFMC and SAFMC)
    - Hydrothermal vents not currently considered but likely important
  - Selgrath et al (2025): ~30% of commercial fish categories in California associated with deep sea coral & sponge habitat



Habitat considerations -pelagic

- Pelagic Habitat (for highly migratory species)
  - EFH also needs to be designated and typically describes water column physical and biological properties
  - Most pelagic species, including many commercially and/or culturally important species are associated with:
    - Areas of sharp thermal gradients
    - High clarity waters
    - Areas of chlorophyll contrast
    - Areas of O_2 minima
    - Light isolumes



Physiology and behavior of pelagic fishes

- Physiology
  - Some pelagic species have specialized tissues to deal with cold water (swordfish, tuna, lamnid sharks)
  - Many species have adaptations for high visual acuity in deep, low turbidity waters (e.g., Brill et al 2001)
  - Some species are acoustically sensitive, but poorly understood (e.g., Puig-Pons et al 2021)
  - Physiological performance driven by bioenergetics
- Behavior
  - Lateral movement
    - HMS move into and out of different EEZs and therefore different FMC jurisdictions, both U.S. domestic and international, often directly tied to thermal fronts, chlorophyll, and water clarity (WPFMC EFH designation and references therein)
  - Vertical movement
    - Many HMS (swordfish, bigeye tuna, opah, various sharks) forage at great depths (Mather 1976; Carey and Robison 1981; WPFMC EFH), often tied to light levels

Food webs

- Pelagic food webs include both epipelagic and mesopelagic productivity
  - Deep scattering mesopelagic layer of lanternfishes, squids, etc. (Dr. Drazen's work)
  - Predators and their prey fields move with changing light levels and are influenced by temperatures, light levels, and clarity
  - Alterations to movement and/or productivity in this system would affect pelagic fish and fisheries
- Fish life history is complex
  - Larvae have substantially different foraging needs than adults
  - Larvae tend to be more tropical while adults are more wide ranging

Initial research recommendations –part 1

- Need better understanding of the relationships between commercially exploited demersal fishes and deep-sea habitats (e.g. Selgrath et al 2025)
  - Seafloor mining will directly remove habitat
    - How does loss of deep sea benthic physical and biogenic habitats have direct or indirect impacts on population productivity
- Need broad understanding of movement and behavior across life stages for pelagic species in response to environmental change
  - How does alteration to both lateral and vertical thermal structuring due to cold, deep sea water release into warm surface or mesopelagic waters affect:
    - Vertical and horizontal movement patterns of predators
    - Vertical movement patterns of prey
  - How does altered turbidity from plume water release affect:
    - The depth distribution of isolumes?
    - Movement patterns of predators?
    - Movement patterns of prey?
    - Foraging success of predators?
- Need to understand anthropogenic noise impacts on pelagic fishes
  - Bluefin tuna respond to artificial sounds introduced into their environment (e.g., Puig-Pons et al 2021), but this appears to be a poorly studied area

Initial research recommendations -part 2

- Need to understand sublethal effects (likely through targeted research and modeling) on fish from altered habitat, environmental conditions, behavior, and prey field dynamics
  - Foraging success determined by availability, abundance, and predation event success
  - If energetic costs increase due to increased movement or decreased foraging success, do we see
    - Decreased growth in pelagic fishes?
    - Reduced reproductive capacity in pelagic fishes?
- Alterations to fishery access and success
  - If either the vertical or horizontal distribution of fishes changes, what are the impacts to harvest capacity?
  - How might fleet dynamics, including time at sea, fuel consumption, and profit margins change if fish redistribute?
  - How might reductions in growth rate or reproductive success impact stock productivity and therefore harvest quota?
- Likely cannot extrapolate across species, life history stages, ocean basins, or mesopelagic domains given the global diversity of mesopelagic systems
- Likely cannot extrapolate across fisheries