Deepwater fish and fisheries: Issues and opportunities for DOOS

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Outline

• Deepwater fisheries: sustainability and impacts on vulnerable marine ecosystems

• Mesopelagic fishes
  – Forage-fish base of pelagic marine food webs
  – Impacts of deoxygenation and links with climate
  – As EOVs: a “prêt-à-porter” opportunity for a global ecological DOOS network
Distribution & characteristics of deepwater fisheries

- Iconic deepwater fisheries occur on seamounts, deepwater plateaus & coral reefs
- ~23 species aggregate on seamounts for feeding, reproduction
- Global distribution of fisheries for different species, e.g. orange roughy, pelagic armorhead
- Highly valued but typically slow-growing, episodic recruitment, extreme longevity (75 – 100 yr), highly vulnerable on seamounts
- Fisheries characterized by boom & bust within 5-10 yr, little recovery after 10+ yr
- Total seamount catch to date: ~2 million tonnes (Clark 2009), generally 0.2% global landings
  - 11 nations involved: 60% EU, 40% Spain (Gianni 2004)
Deepwater fishery impacts on benthic habitats

- Trawl fisheries on seamounts sweep the benthos clear of its benthic fauna
  - Coral bycatch (e.g. S Tasman Rise) was 44% of the orange roughy catch in the early years
  - Impacts are long-lasting (beyond decades) (Althaus et al. 2009)
- 30-50% of *Lophelia* reefs off Norway already destroyed by trawling when first surveyed
  - Since 1999, Norway has protected 6 sites including its largest reefs: Sula & Røst
How can we sustainably observe deep-sea communities?

• CalCOFI ichthyoplankton time series, 1951-2010
  – Monthly/quarterly sampling
  – CTD casts to 500 m: T, S, nutrients, O₂, chl
  – Oblique net tows to 210 m depth, fish eggs/larvae removed, identified, enumerated (~500 taxa)
  – Effectively samples most mesopelagic fishes as larvae
  – Annual means over consistently sampled region provide proxies for spawning biomass

• Ichthyoplankton time series available globally but vary in spatial & temporal coverage, taxonomic resolution
  • Can cover a single critical season (e.g. Alaska) (but consistently!)
  • Can be based on a single transect (but best if a range of habitats covered, e.g. shelf, slope, deep water)
  • All taxa identified & enumerated around North America but mostly restricted to commercial taxa elsewhere
CalCOFI PC 1: Mesopelagics and the impact of midwater O₂ concentration

PC 1 (20.5% var explained):
24/27 taxa with loadings > 0.5 mesopelagic from 10 families:
  - Myctophidae
  - Gonostomatidae
  - Sternoptychidae
  - Stomiidae
  - Phosichthyidae
  - Scopelarchidae
  - Argentinidae
  - Microstomatidae
  - Paralepididae
  - Bathylagidae
Includes vertical migrators & non-migrants, plankton feeders & predators

63% decline in abundance, 1951-65 & 1999-2008 vs 1966-99
Linked to midwater O₂ concentrations

(Koslow et al 2011, MEPS)

<table>
<thead>
<tr>
<th></th>
<th>PC 1</th>
<th>O₂ (200-400 m)</th>
<th>PDO</th>
<th>MEI</th>
<th>NPGO</th>
<th>SST</th>
<th>Upwelling</th>
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<tbody>
<tr>
<td>R</td>
<td>0.75*</td>
<td>0.56**</td>
<td>0.47*</td>
<td>-0.23</td>
<td>0.45?</td>
<td>-0.25</td>
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The relative importance of the mesopelagic fauna

- Relative acoustic backscatter per ping, daytime averaged over 6 CalCOFI transects, January 2010
- Pelagics dominant near coast, mesopelagics offshore
Planktivore larval abundance from CalCOFI surveys, 1951-2011
Planktivore biomass in the California Current

(Davison et al 2013, in press)

Mean biomass, 1951-2011 (MT)
Sardine: 0.38
Anchovy: 0.32
Scomber: 0.25
Trachurus: 0.91
Migrators: 6.61
Non-migrators: 2.59
Planktivore consumption in the California Current

Estimated from aR=M + G
M&G: Childress et al (1980)

Non-commercial species dominate the biomass and prey consumption of plankton feeders in the CC
Dramatic changes over time

<table>
<thead>
<tr>
<th>Group</th>
<th>Consumption (MT y⁻¹)</th>
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<tbody>
<tr>
<td>sardine</td>
<td>4.9</td>
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<tr>
<td>anchovy</td>
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<td>pac mack</td>
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<tr>
<td>jack mack</td>
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<td>VM</td>
<td>27.1</td>
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<tr>
<td>NM</td>
<td>2.5</td>
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The way forward: enhanced use of fish-based EOVs based on ichthyoplankton time series

- There is a global network of ichthyoplankton time series, some with and some without mesopelagic fish sampling
- Only CalCOFI has analyzed potential changes in mesopelagic fish abundance
- But it is now possible to assess potential changes in mesopelagic fishes in relation to climate change, including deoxygenation
- Because ichthyoplankton time series are a key fisheries assessment tool, there is strong stakeholder support with potential for sustained operation but need to resolve all, not just commercial taxa
Questions?