Response of seafloor ecosystems to abrupt global climate change

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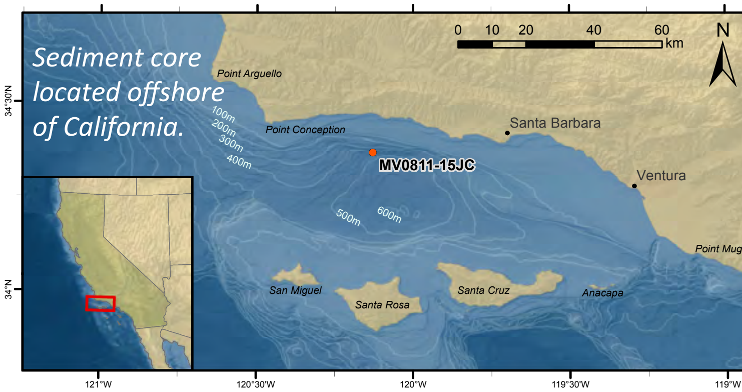
Extensive oxygen loss in the deep-sea is a fundamental component of climate warming.

Previous events of abrupt global climate warming, such as the recent transition out of a glacial climate (17,000-10,00 years ago), are laboratories to understand how ecosystems respond and recover to climate change

Here we investigate the ecological consequences of abrupt, climate-forced oxygen loss using a marine sediment core.



***What we found*: Climate disturbance to the deep sea, in the form of oxygen loss, can catastrophically disturb seafloor biodiversity, on 10-100 year timescales. Biological recovery, however, takes over >1,000 years. We illustrate how, on human timescales, climate-forced disturbance to marine ecosystems commits them to essentially permanent change. Our investigation demonstrates the extreme sensitivity, and timescales of potential recovery, of whole seafloor ecological communities to climate-forced oxygen loss.

Sampling the marine sediment core for seafloor biodiversity assessment.

- This investigation presents the first record of the **disturbance** and **recovery** of seafloor ecosystem biodiversity in response to abrupt climate change.
- Unlike terrestrial ecosystems and their associated pollen and vertebrate assemblages, **marine ecosystem reconstructions** have been largely restricted to **single-celled organisms**.
- We demonstrate here that ocean sediments harbor **metazoan** fossil material that can be used to reconstruct the **response of seafloor biodiversity** to global-scale **climate** events.

The **DEGLACIATION** was accompanied by some fundamental features of abrupt climate warming:

- Atmospheric CO_2 increase
- Sea level rise
- Surface ocean warming
- Extensive oxygen loss in the deep sea

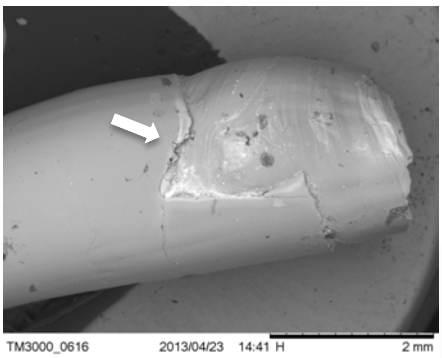
Events of abrupt warming (<100 years) and ephemeral cooling provide the opportunity to document ecological **disturbance** and **recovery**.

Author SE Moffitt analyzing marine sediment fossils

What we did: Reconstruction of seafloor ecosystem with >5,400 fossils and trace fossils of marine invertebrates, including Mollusca, Echinodermata, Arthropoda and Annelida, using a marine sediment core. The record, from 16,000 to 3,400 years ago, reveals that seafloor ecosystems are subject to major biological turnover in response to relatively minor changes in dissolved oxygen (1.5-0.5 ml/L [O_2]).

Core MV0811-15JC from Santa Barbara Basin, California: an exquisite biological record of seafloor community sensitivity to changes in dissolved oxygen.

- Archive reveals previously undescribed sensitivity of deep sea biodiversity to abrupt (10-100 year) warming and oxygen loss.



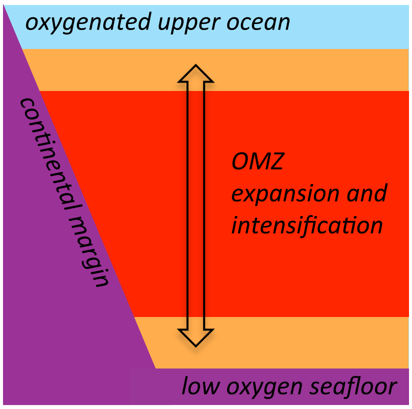
*Scanning Electron Microscope Image of breakage point on scaphopod tusk, **trace fossil** evidence of crustacean predation.*

- Research expands ecological recovery rates by order of magnitude, from <100 years to >1,000 years, revealing ecological timescales of climate commitment.

Considering climate "commitment"

There is a need to assessment what essentially **permanent change** (on human timescales) looks like for **ecosystems** and associated **economies** that we depend upon.

Bivalve (top)
Gastropod (middle)
Scaphopod (bottom)



Schemata of Oxygen Minimum Zones (OMZ; red and orange) in the modern ocean, from the surface ocean to the deep sea.

Climate disturbance in the modern ocean: documenting *essentially permanent* changes

*Compressed oxygenated upper ocean: major loss of habitat for **fisheries** and an enormous habitat loss to the balance of the ocean's **biodiversity**.*

*Permanent ecological change in the **deep sea** to communities dominated by low-oxygen tolerant, **single-celled** organisms.*

WHY IS THIS IMPORTANT?

- *This investigation clearly demonstrates that, on human timescales, climate-forced disruptions to ocean ecosystems are essentially permanent.*
- *As well, this research adds to the very large body of evidence linking climate change with catastrophic risks to ecosystems and associated economies.*