Monitoring deep-sea ecosystem functions to address vulnerabilities in the context of climate change & human activities

Seafloor in situ laboratories using new intrumented plateforms

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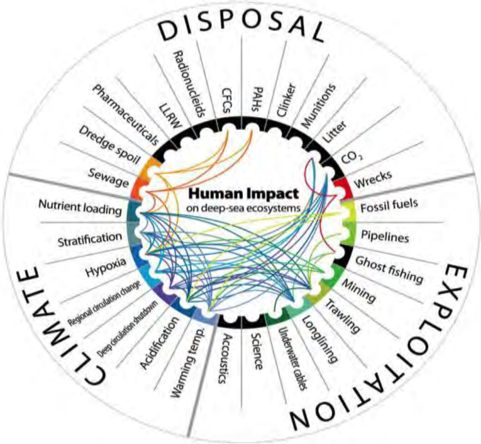
Climate change in the deep-sea: new challenges for biodiversity conservation and environmental protection

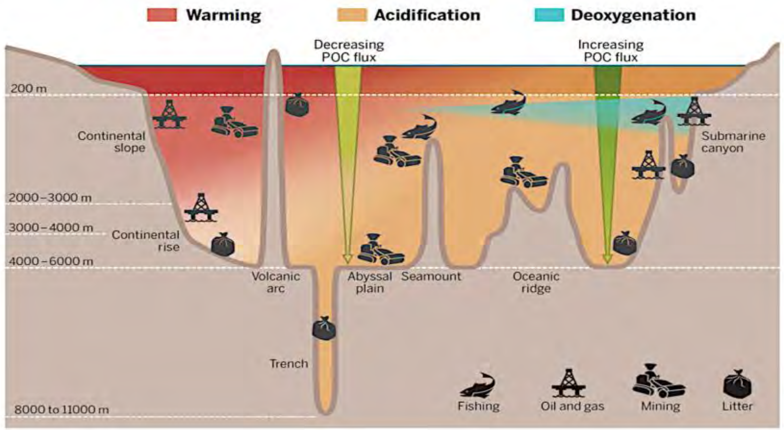
Human imprint in the deep-sea is rapidely growing

Lack of knowledge of ecosystem functionnal dynamics at depth

Concerns about our capacity to ensure effective mitigation of cumulative impacts.

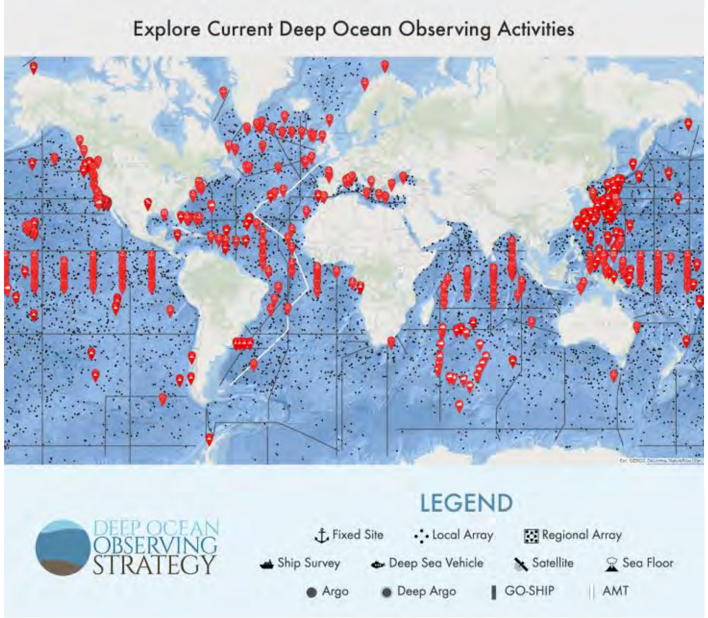


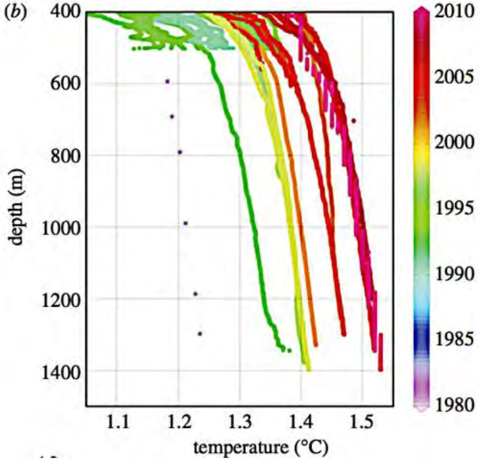
Ramirez et al. 2011



Levin and Le Bris 2015

Monitoring time series are documenting rapid changes in the deep-ocean (200-2000m and beyond)

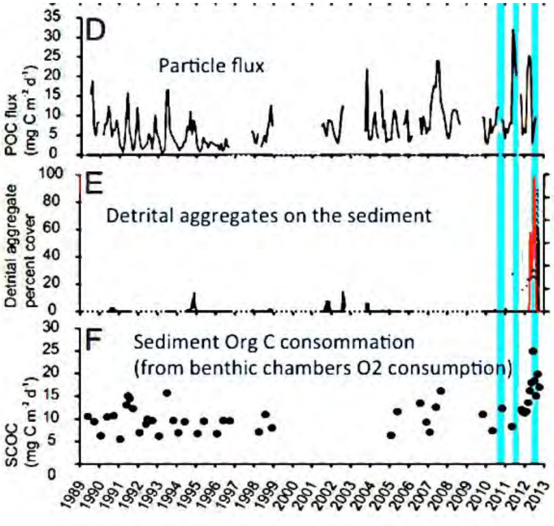




Warming of deep waters, Antarctic margin and macrofauna community changes - Smith et al. 2011

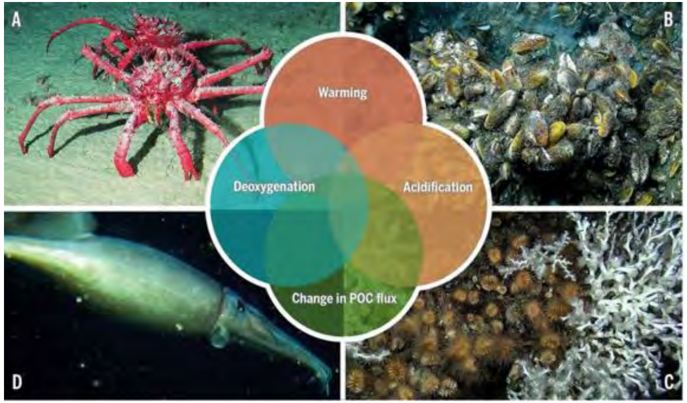
Increase of POC fluxes to abyssal sediments and Corg. consumption

- Smith et al. 2013

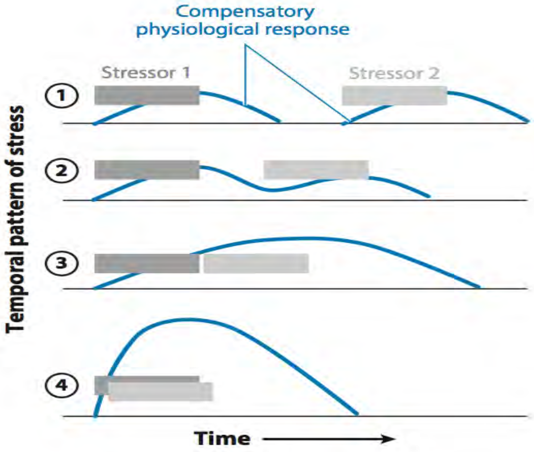


The key question is: how climate-change stressors combination will affect key species & related-ecosystem functions

Any impact assessment at great depth should be able to address stressor combination on relevant timescales in order to identify their potential synergistic effects



Levin and Le Bris 2015



Attenuation

Amplification

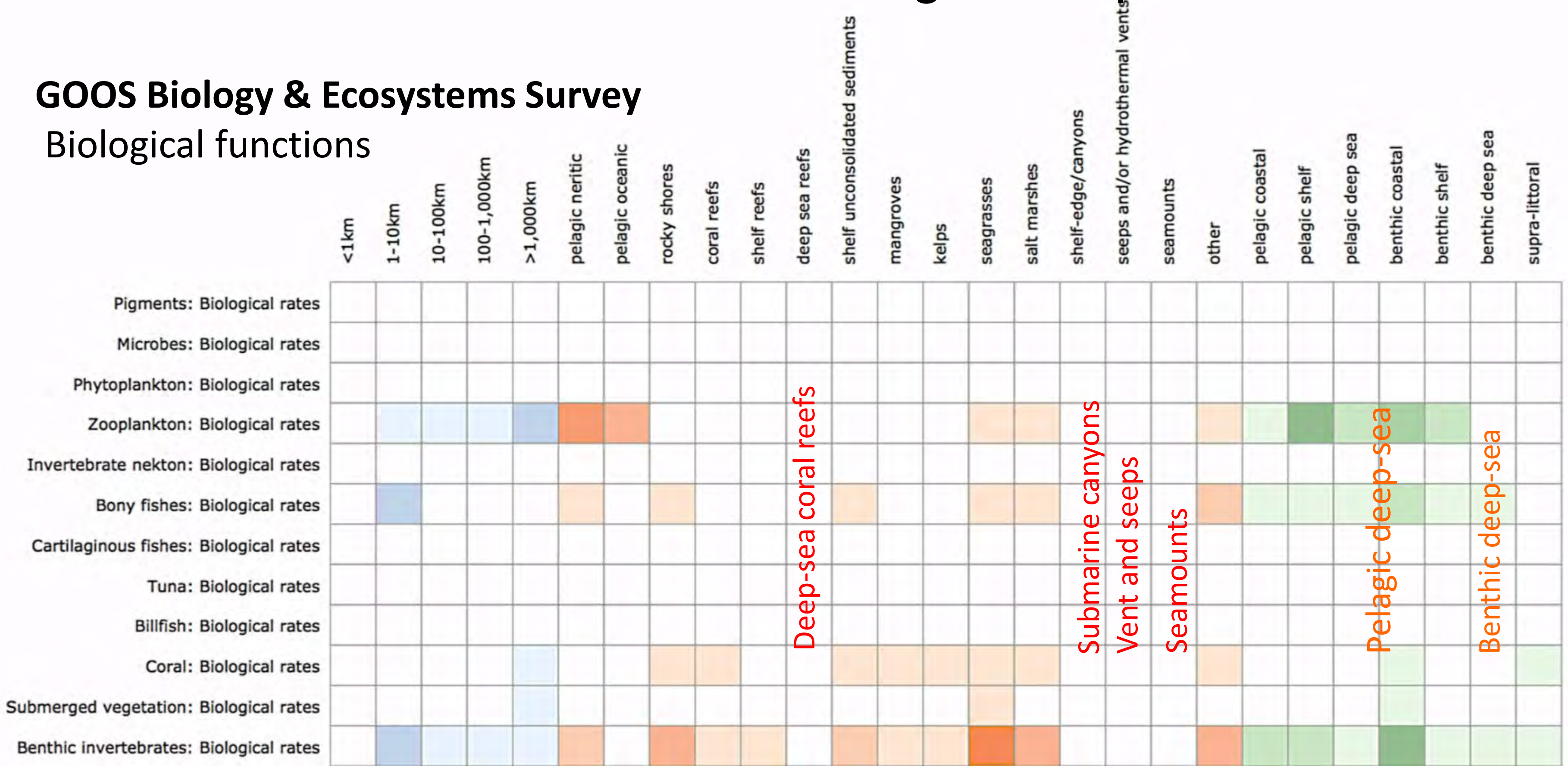
Gunderson et al. 2016

- Local combination of stressors
- Timing and magnitude of events driving stress responses
- Species responses (behavioral and physiological)

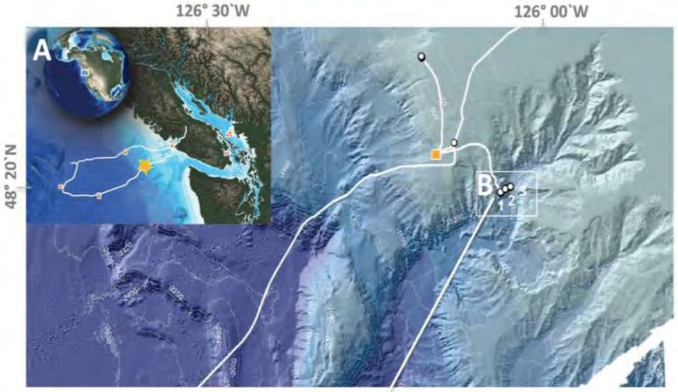
Limited knowledge of biological activities & fonctionnal rates at great depht

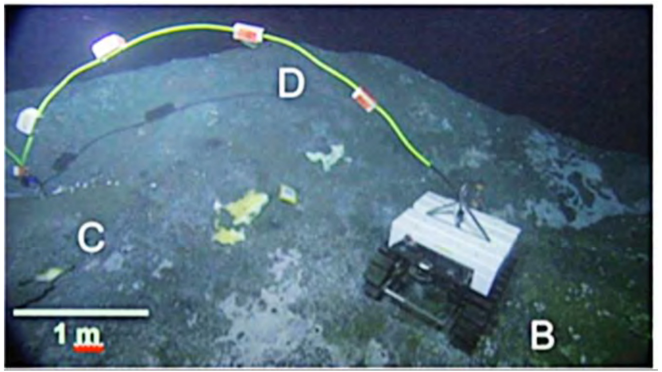
GOOS Biology & Ecosystems Survey

Biological functions



Novel seafloor monitoring strategies are shedding light on biological rates in response to environmental variability





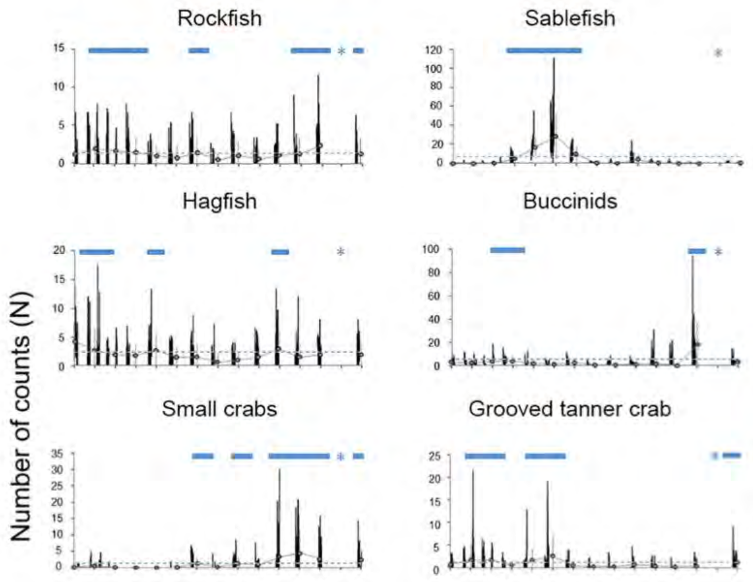
Internet-operated mobile crawler on Neptune Canada cabled-network enable to monitor Barkley **canyon hydrate benthic community** since 2010

Thomsen et al. 2016

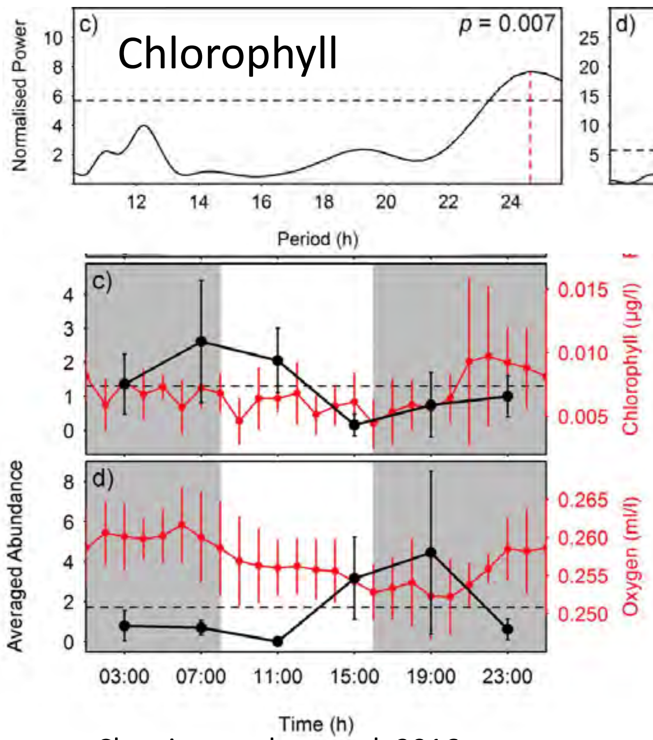
20m video transects / every 4h have documented changes in:

- hydrate mound size,
- microbial mats extend
- seasonal variation in abundance of dominant megafauna taxa
- Reproduction cycle cues

Doya et al. 2016



Animal activity rhythms correlation with short-term fluctuations in environmental conditions



Chatzievangelou et al. 2016

Diurnal change in major parameters in Dec. 2013 (850m depth) due to local currents

Abundances peaks of hagfish and crabs are shifted by 12h.
Hagfish more abundant at dawn, following a peak of chlorophyll at night.
Juvenile crabs more abundant in the early night, when oxygen is minimum.

In the aphotic deep-sea, diel rhythms s are mainly driven by <u>locally and regionally varying oceanographic pattern.</u>

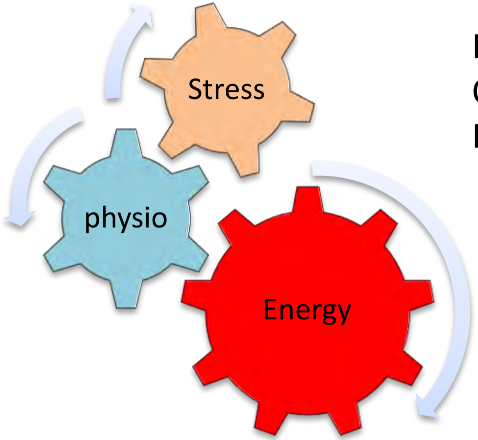
Species behavior and interaction are directly related to environmental cycles

We critically lack of understanding of how ecological systems respond to environmental variability in the deep-sea

Habitat variability

Functionnal rates

Growth of habitat-builders
Respiration & org. matter processing,
Chemoautotrophic production



Hydrodynamic cycles and extremes
Organic matter export
Physical disturbance

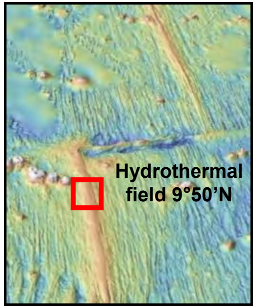
Community dynamics

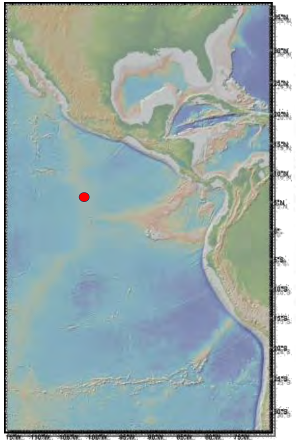
Microbial successions
Larval dispersal and settlement
Species trophic and non-trophic interaction

We need function-oriented experimental approaches to account for the interplay of habitat-ressource & biological dynamics that could be included in impact studies

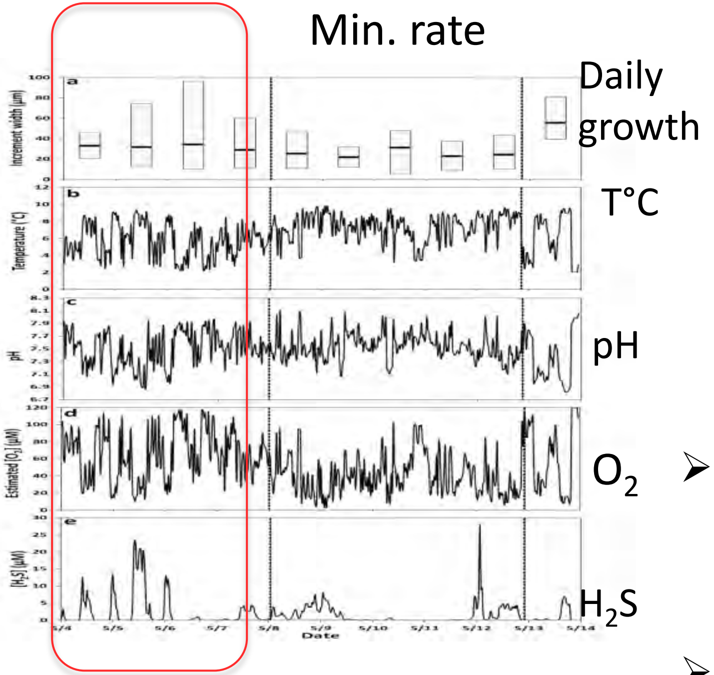
In situ dynamics of mussel growth in vent habitats

How fast do they growth and how daily growth relates to the combination of abiotic factors ?

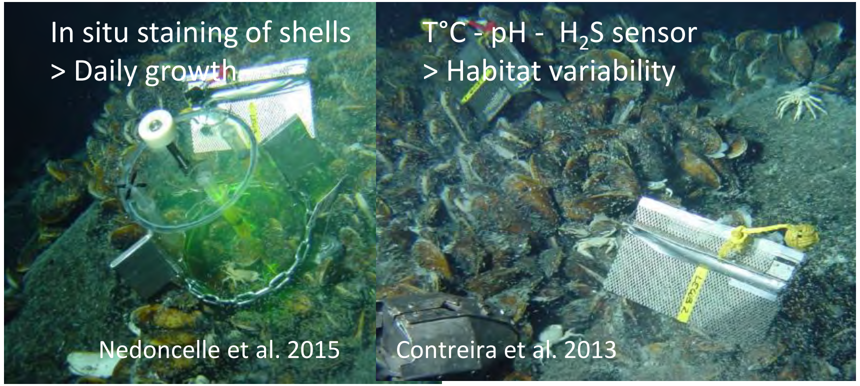




East Pacific Rise –
9°50N hydrothermal vent field, 2500 m depth



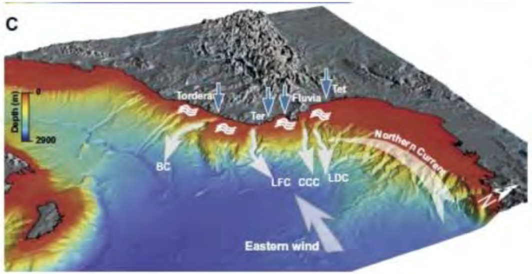
10-day experiment

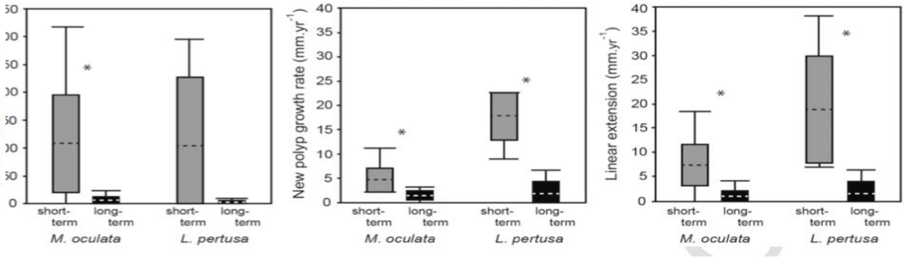


- Bottom currents are to be accounted to define habitat suitability as they drives the amplitude of tidal abiotic fluctuations at local scale
- Sentivity to change in atmospheric regime (extreme events)

In situ tracking of transient habitat-resources conditions favoring growth of cold-water corals

What are the drivers of peaks in coral growth in relation to canyon hydrodynamics ?





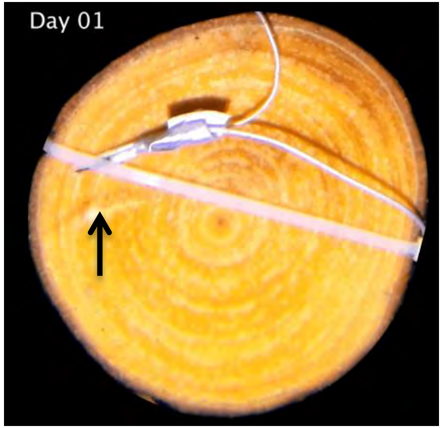
Short = 2.5Mo (April to July 2013), Long = 16Mo (July 2013 to Oct. 2014)

Lartaud et al. 2017

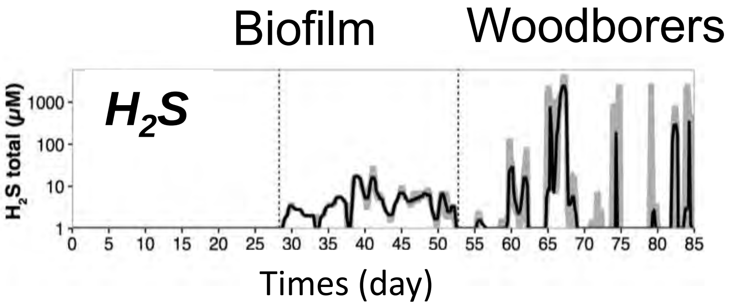
Coral growth experiments equiped with an autonomous camera allow to monitor coral behavior (530m depth) in response to currents and particle load fluctuations

Le Bris, Peru et al. in prep.

Experimental strategies allow to document transient stages in the interaction of fauna with biogeochemical processes in deep-sea habitats



Cost-effective modular macro and micro-observing platforms equipped with autonomous cameras and sensors are shedding light on temporal and spatial heterogeneities that are key to the understanding of biodiversity and ecosystem dynamics



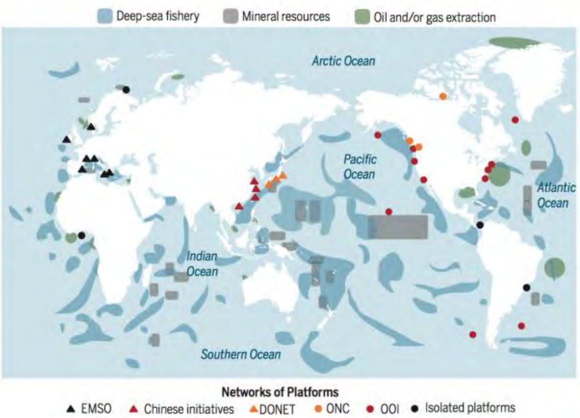
Rapid colonization/degradation of wood falls in relation to microbial H_2S production - *Kalenitchenko et al. 2018*

Time also counts in the deep sea…

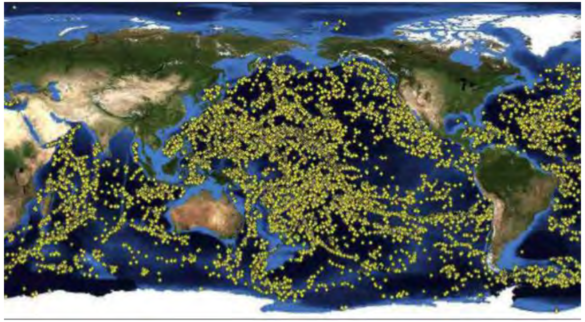
To adress the impact of climate change stressor combination, we need to <u>capture short-term events that drives ecological responses.</u>
Monitoring *at relevant temporal scales (tidal, diurnal, seasonal, multiannual) are required* to assess potential impacts and better constraint the extrapolation of climate-change models on the seafloor.

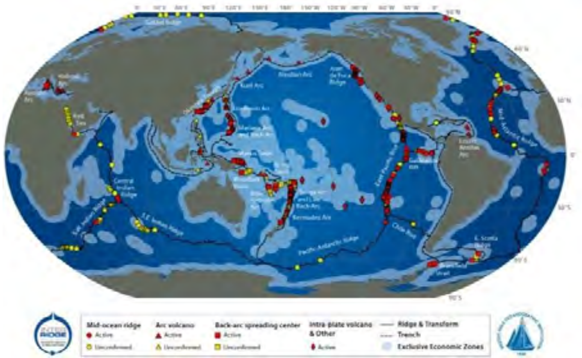
- *Developing autnomous tools to monitor environmental variables at the seafloor (EOVs) over long-terms at high-frequency (e.g. weeks / days).*
- *Developing 'functional observation' and use u***nstable environments as 'Natural laboratories' to understand how deep-sea ecosystem respond to disturbance**

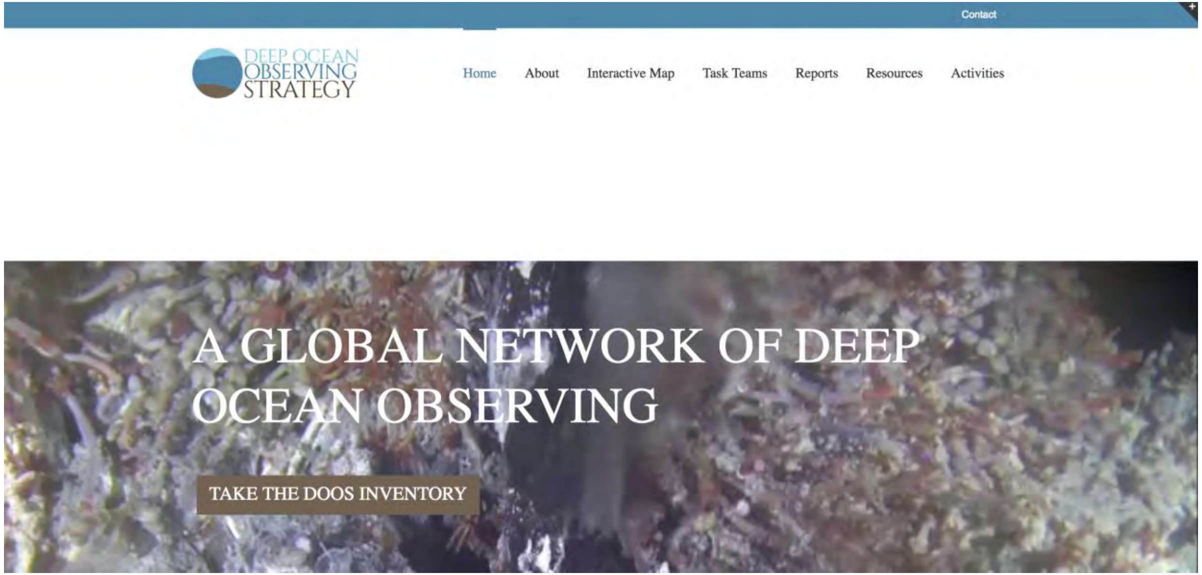
Expanding observations to fully adress the full range of environmental dynamics & ecological responses in vulnerable habitats of the ocean floor is required



- Deep-sea observatories allow to downscale regional oceanographic features on specific habitats/locations, but areas in needs of monitoring are rarely accessible from expensive large infrastructures.
- Specific topographies generate local hydrodynamic features
- Opportunities are raised by newly available autonomous sensor and robotic technologies to expand monitoring capacities to a broad range deep-sea vulnerable/protected areas







http://www.deepoceanobserving.org/

www.dosi-project.org

http://dosi-project.org/working-groups/climate-chang

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