Beyond the last frontier: the deep ocean and why it matters

National Marine Sanctuaries
Webinar Series
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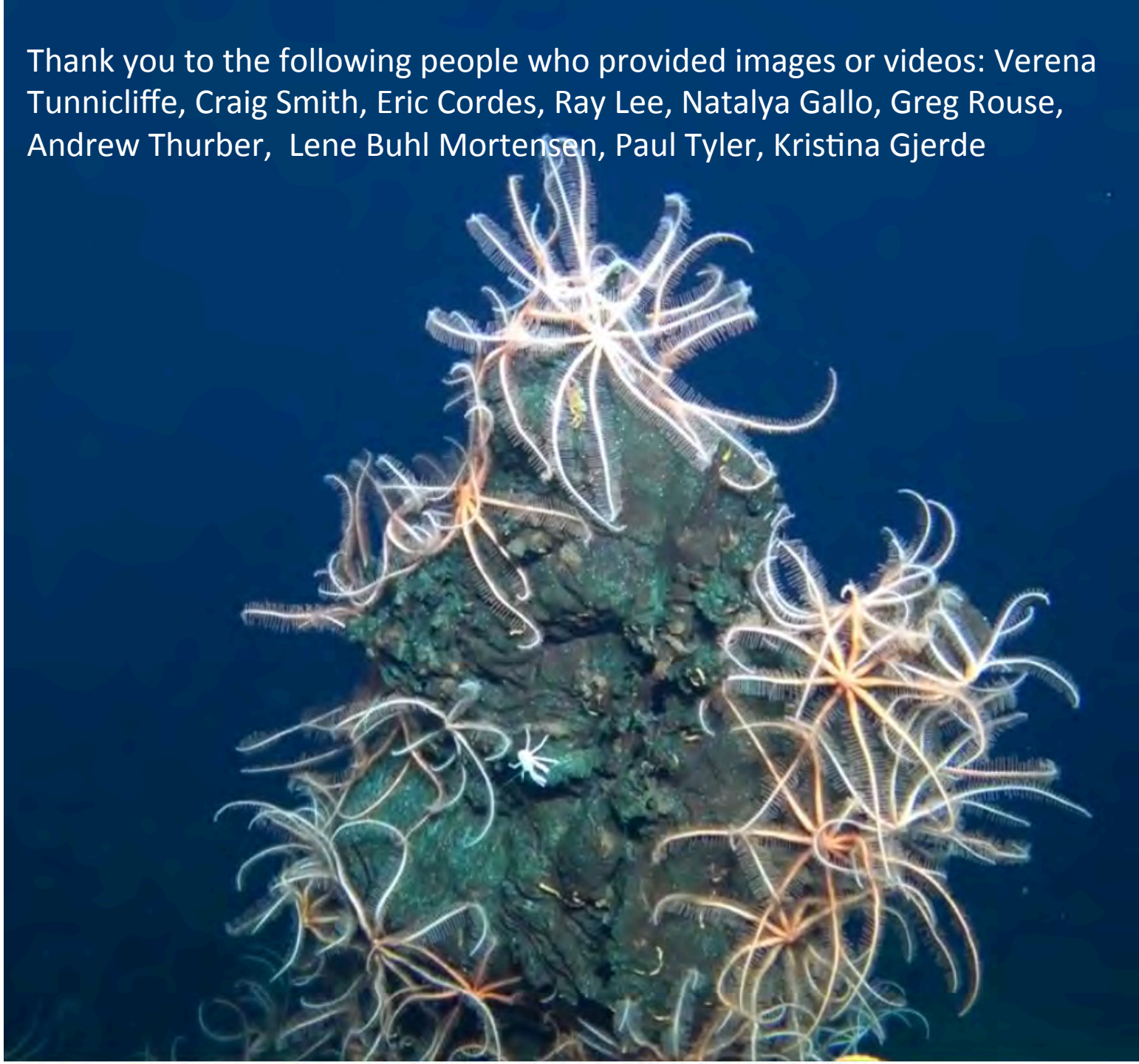
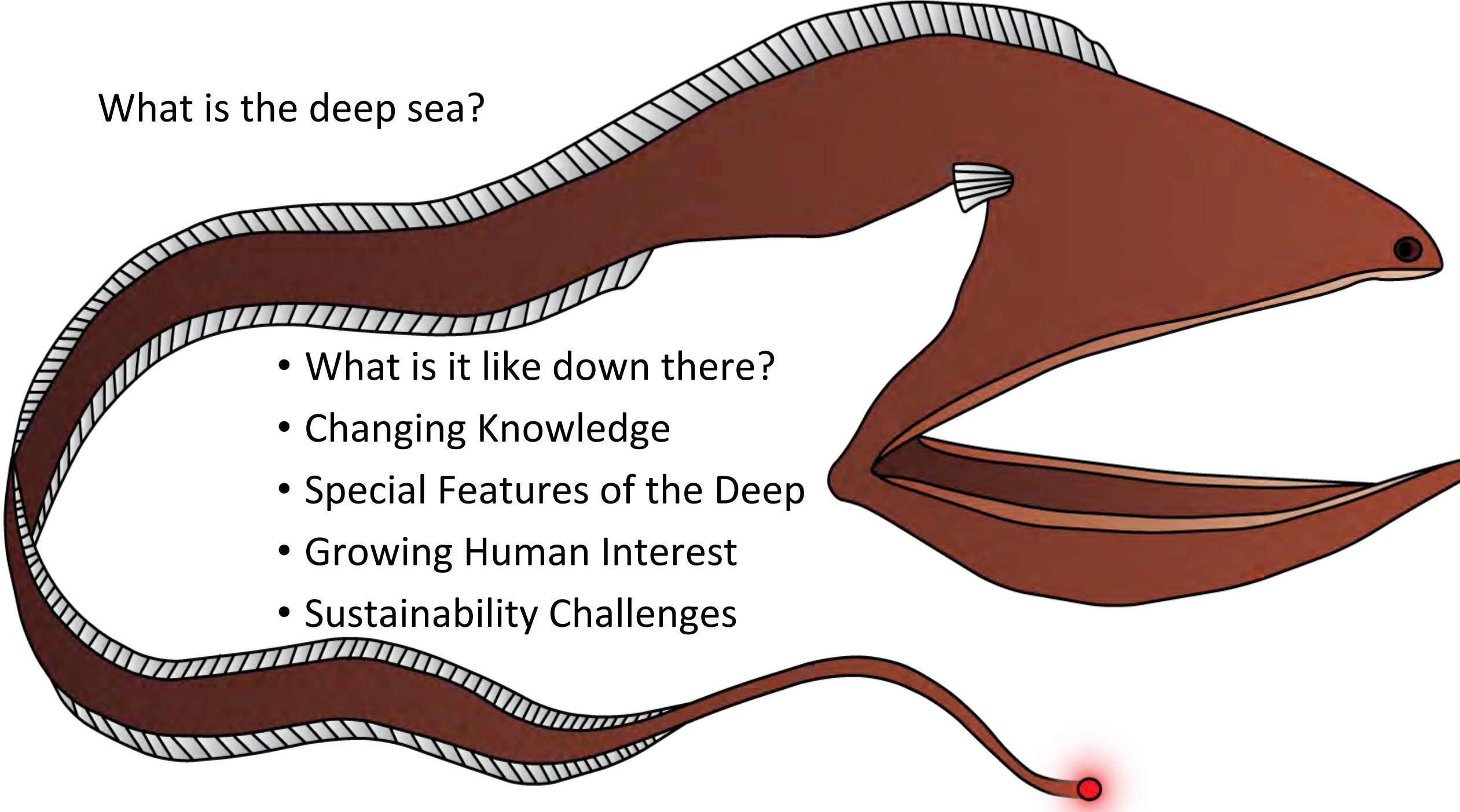
Thank you to the following people who provided images or videos: Verena Tunnicliffe, Craig Smith, Eric Cordes, Ray Lee, Natalya Gallo, Greg Rouse, Andrew Thurber, Lene Buhl Mortensen, Paul Tyler, Kristina Gjerde



What is the deep sea?



- What is it like down there?
- Changing Knowledge
- Special Features of the Deep
- Growing Human Interest
- Sustainability Challenges

Defining the Deep… How deep?

a. Deeper than you can scuba dive

b. > 200 m

c. > 1000 m

d. > 2000 m

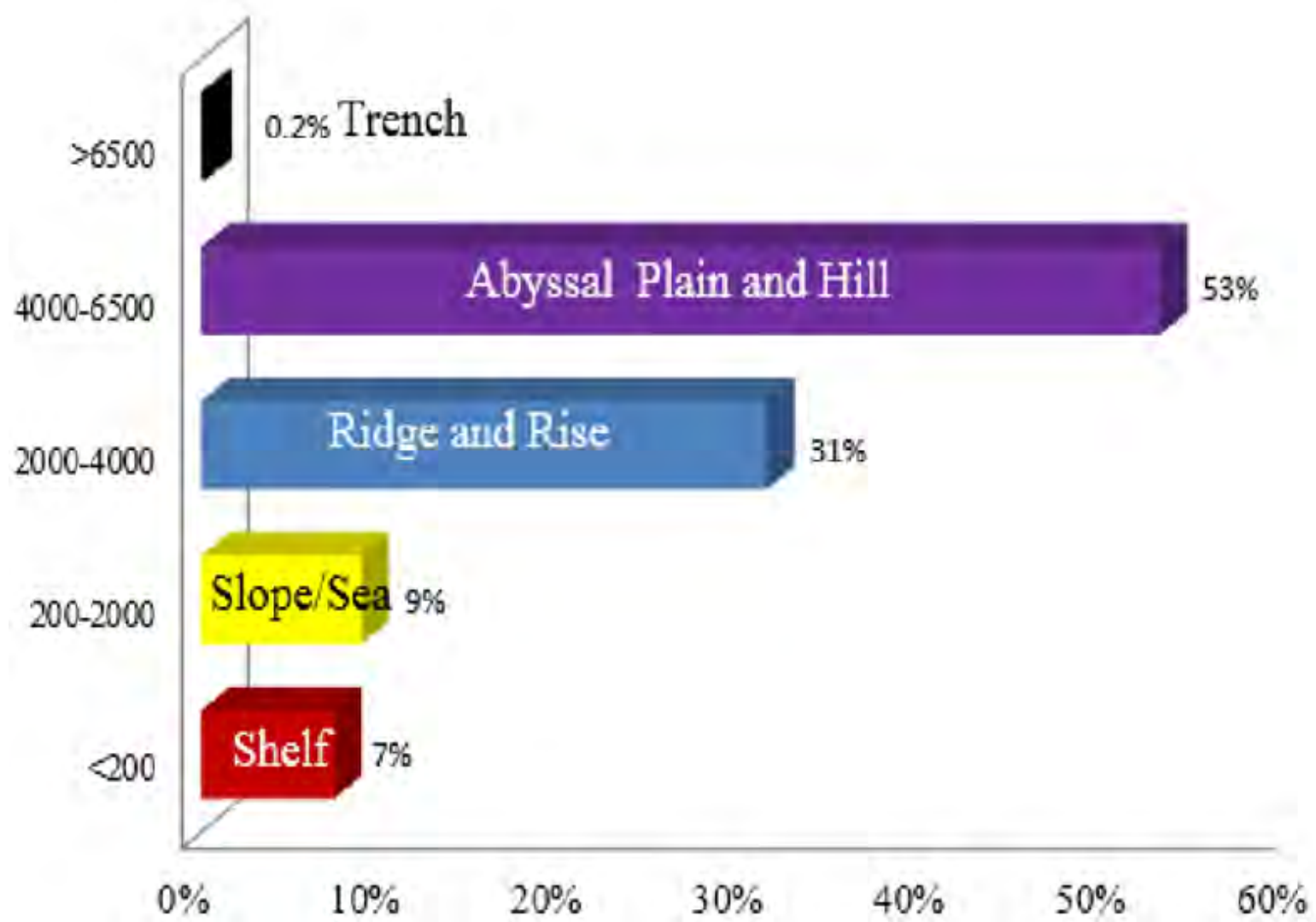
How much of the ocean floor is deep sea (> 200 m)?

a. 3%

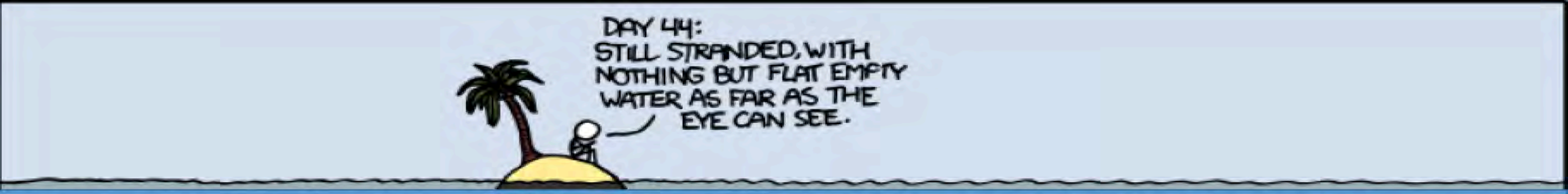
b. 50%

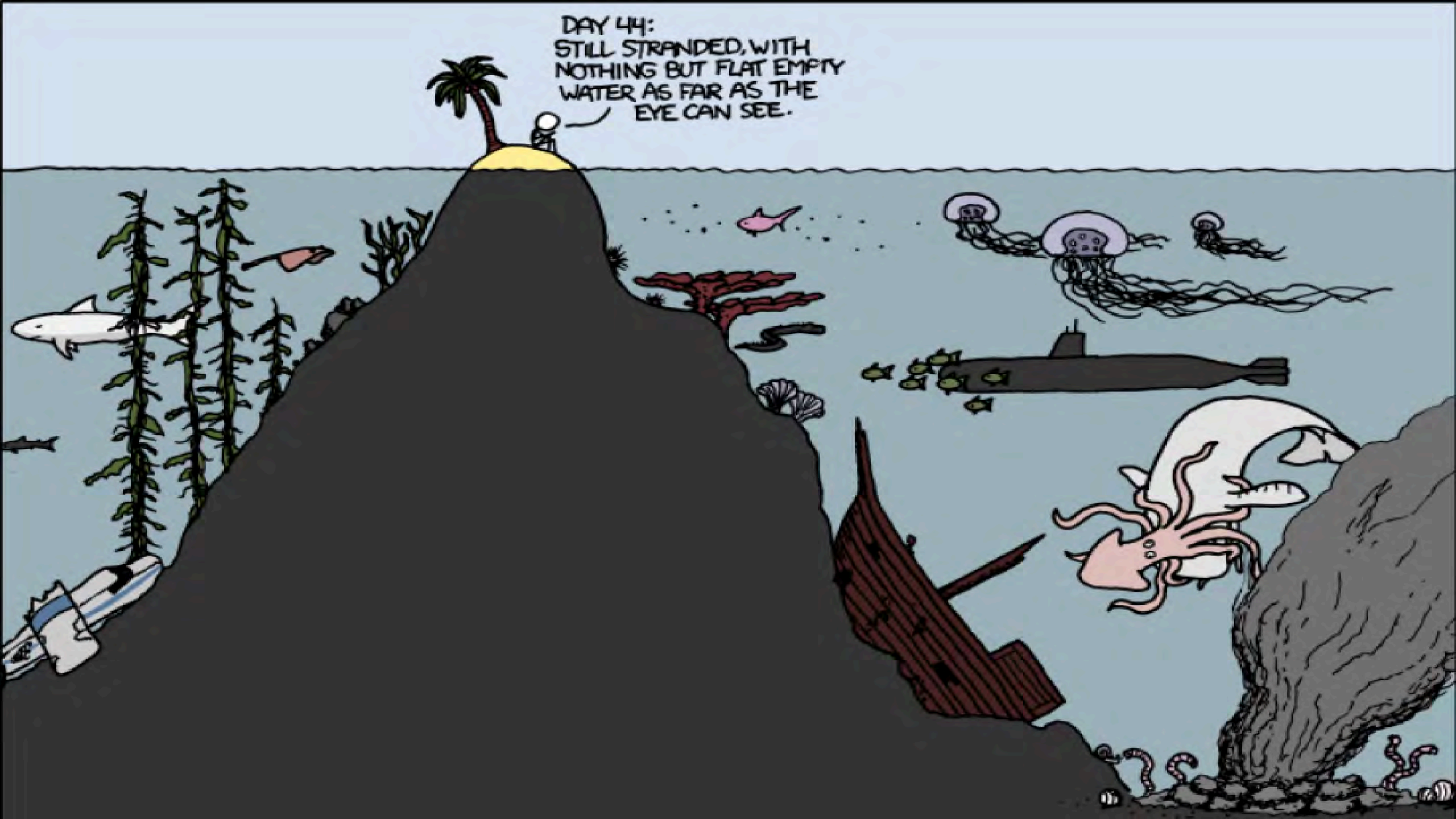
c. 93%

d. 100%



We are limited by our perceptions

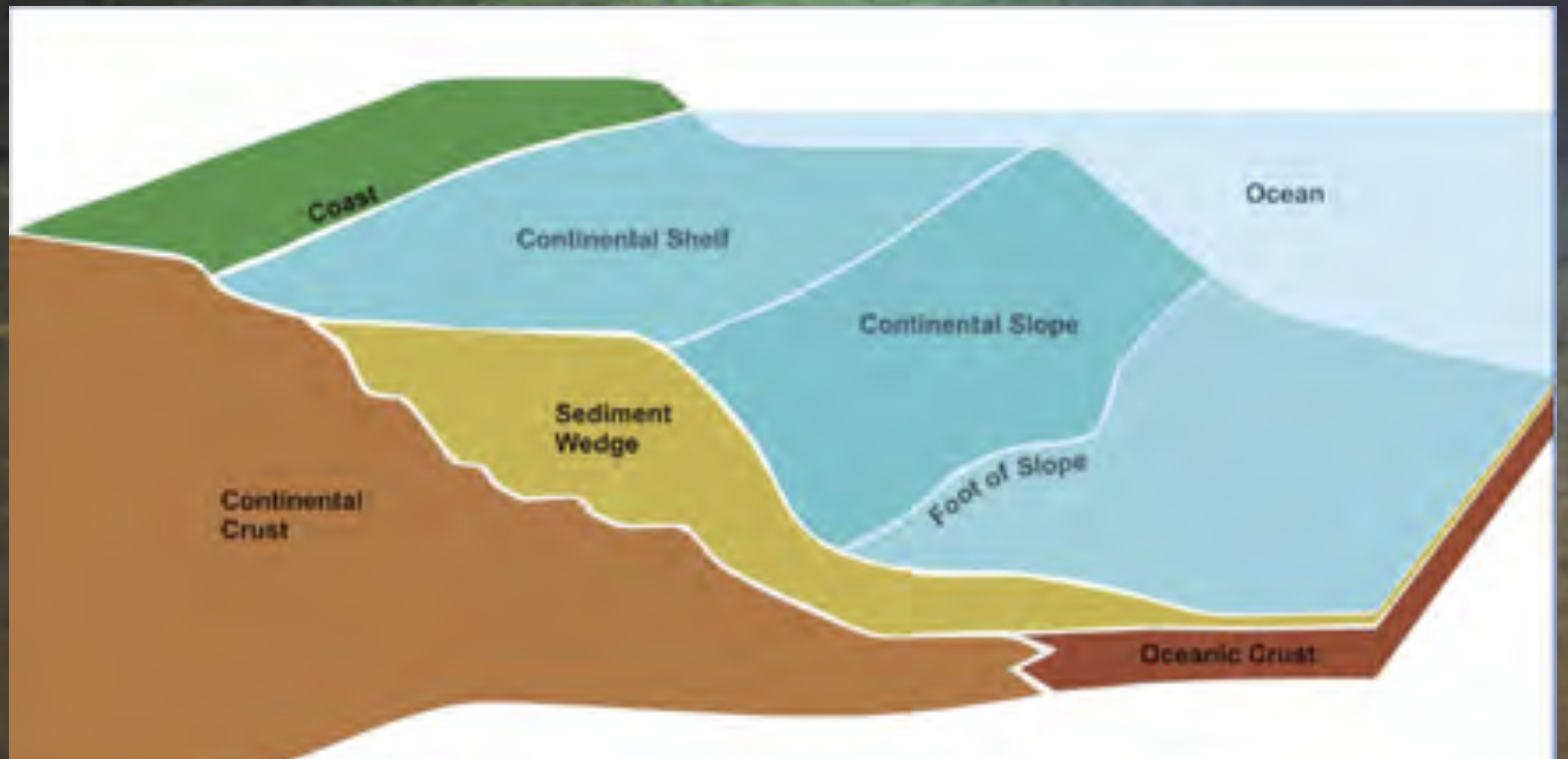

DAY 44:
STILL STRANDED, WITH NOTHING BUT FLAT EMPTY WATER AS FAR AS THE EYE CAN SEE.


DAY 44:
STILL STRANDED, WITH NOTHING BUT FLAT EMPTY WATER AS FAR AS THE EYE CAN SEE.

The First 100 years

- Cold (2-4^{o} C)
- Dark (no sunlight)
- Salty (34.8)
- High Pressure (1 atm/10 m)

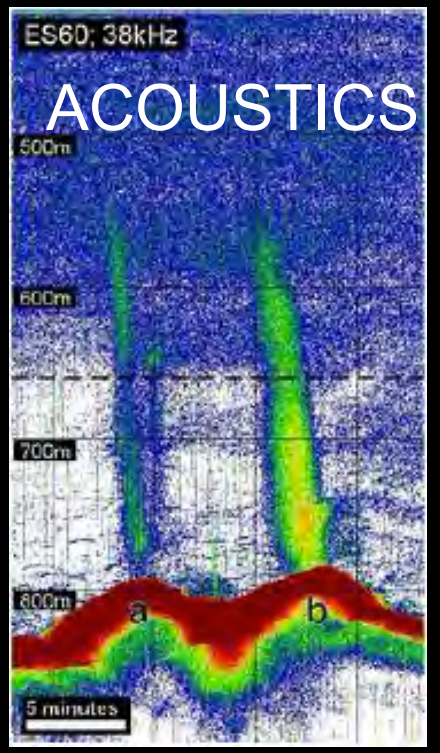
- Muddy
- Homogeneous
- Stable
- Quiescent
- Food Limited



New exploration tools have revealed a wealth of heterogeneity in water properties, shape of the seafloor and life forms.

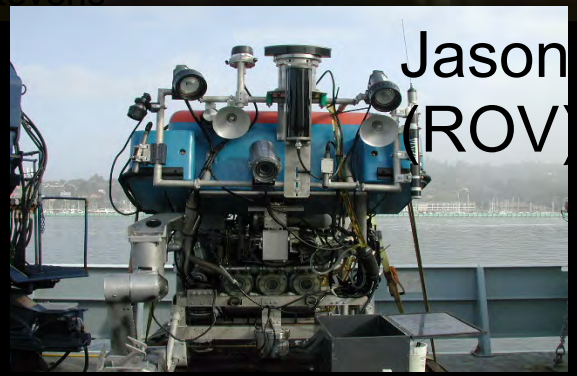
MULTI BEAM SONAR

Photo:D. Stevens

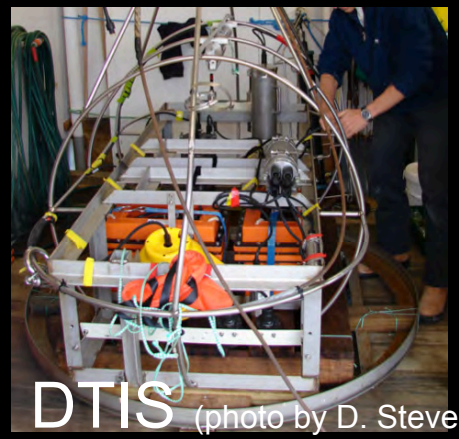


ACOUSTICS

HOV



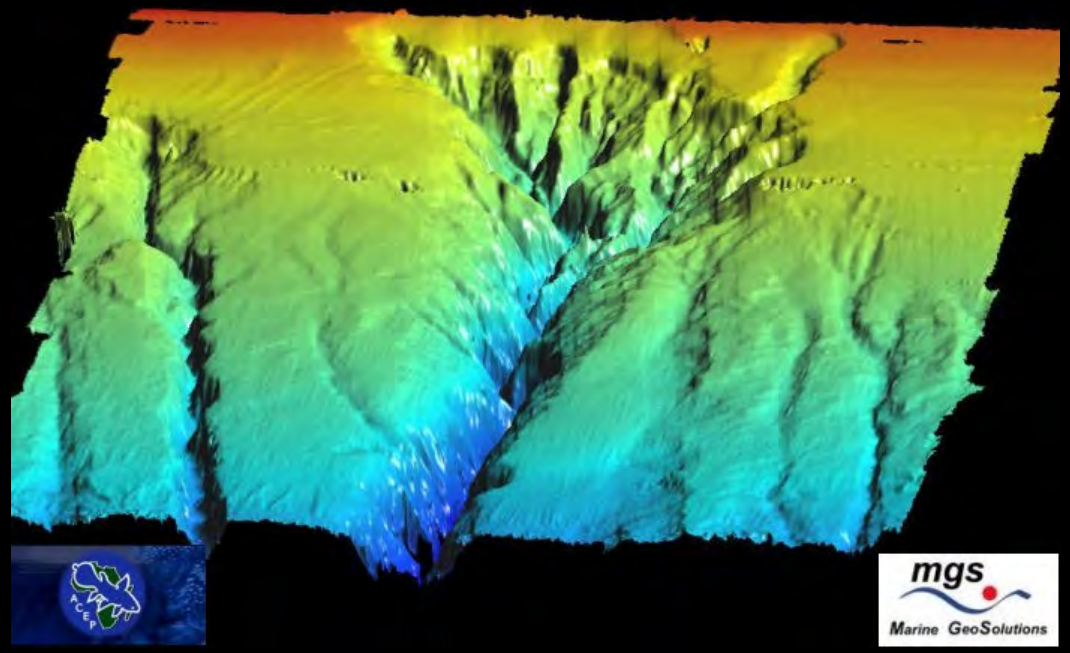
Jason (ROV)



DTIS (photo by D. Stevens)

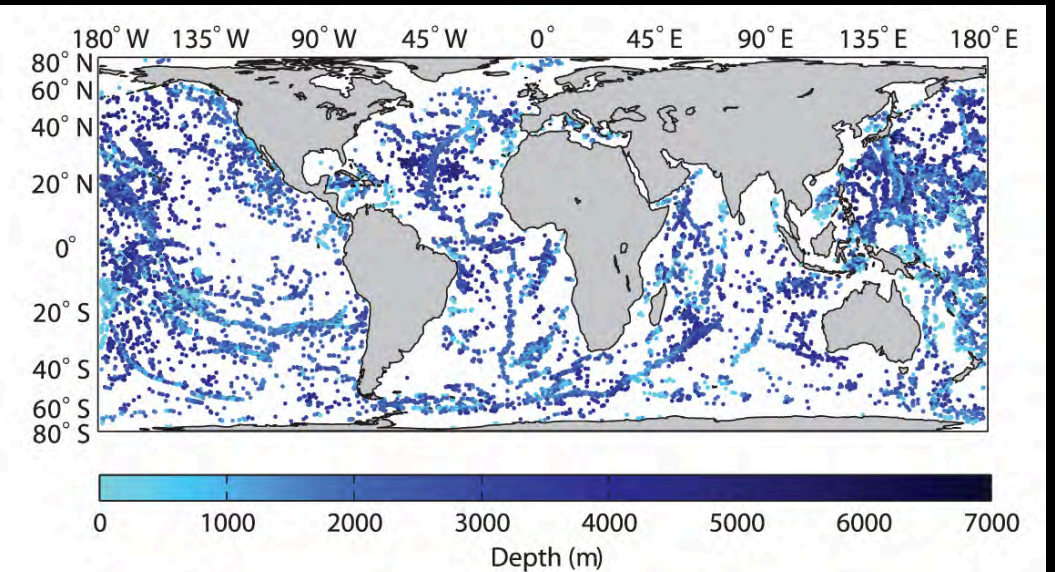
AUV

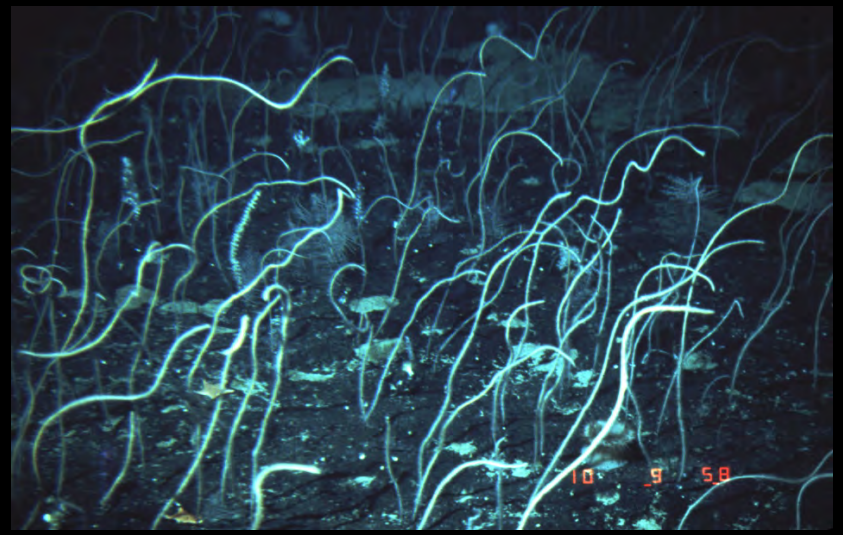
AUV)



CANYONS (thousands)

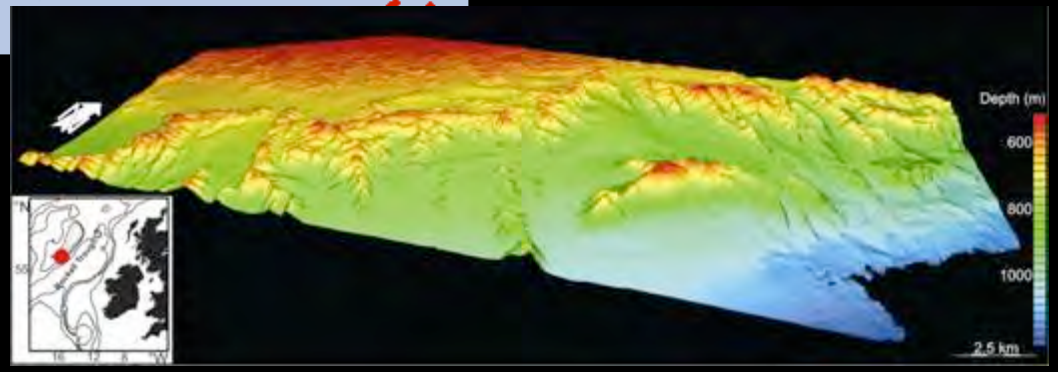
SEAMOUNTS (10s of thousands)





http://inanoctopussgarden.blogspot.com/2011/03/mountains-under-sea.html

DEEP CORAL REEFS



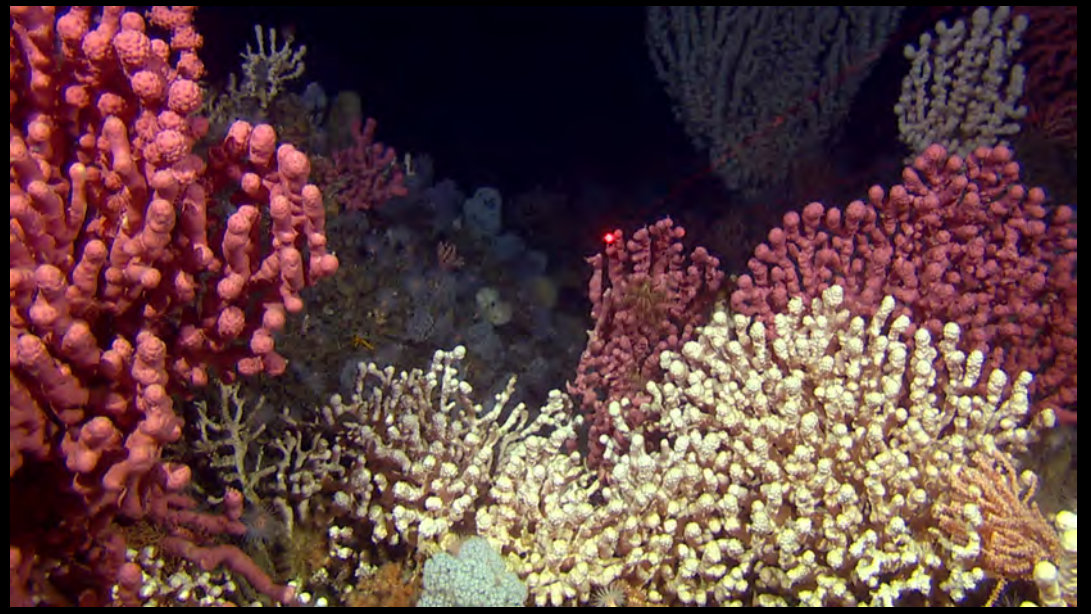
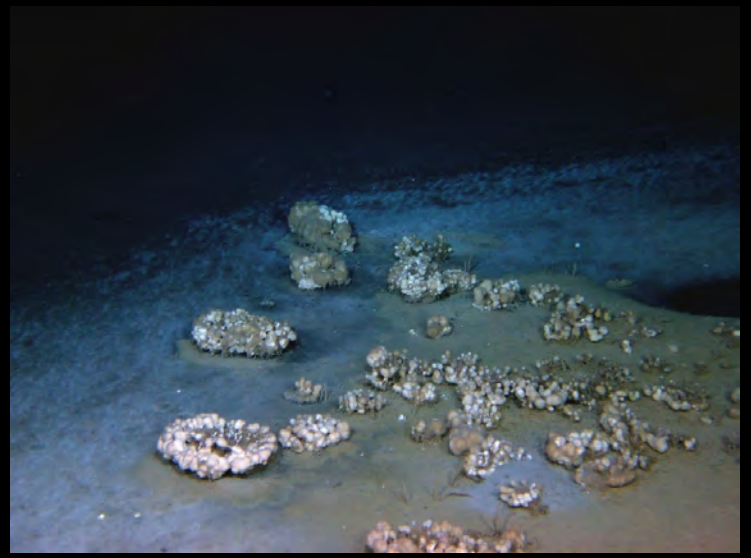


Photo by L. Buhl Mortensen/ MAREANO

SPONGE REEFS

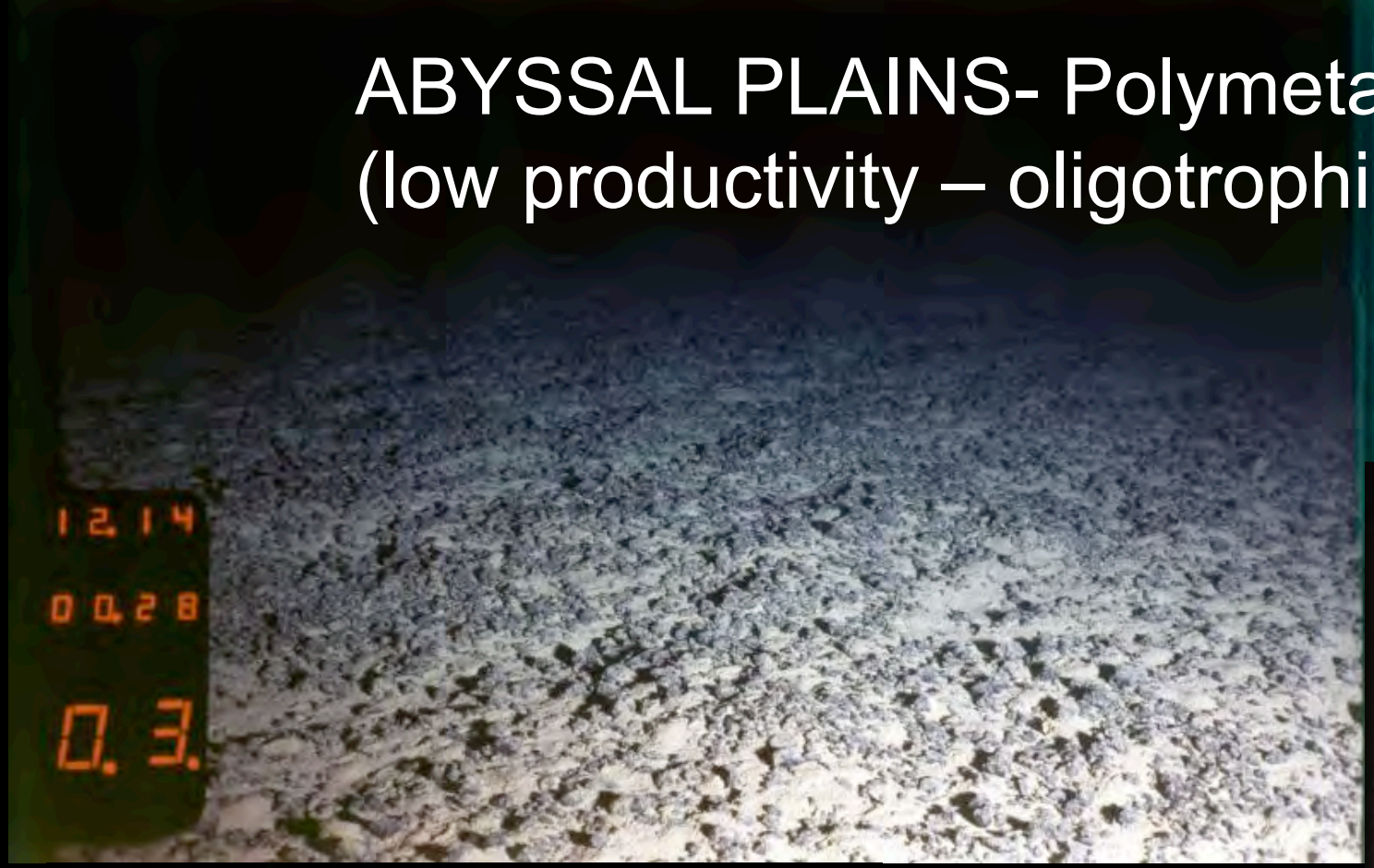


MEDECO/FREMER

Natural Resources Canada

ABYSSAL PLAINS- Polymetallic Nodule Fields (4000-60
(low productivity – oligotrophic regions)

Is it really a desert? Mid north Pacific ~4000m



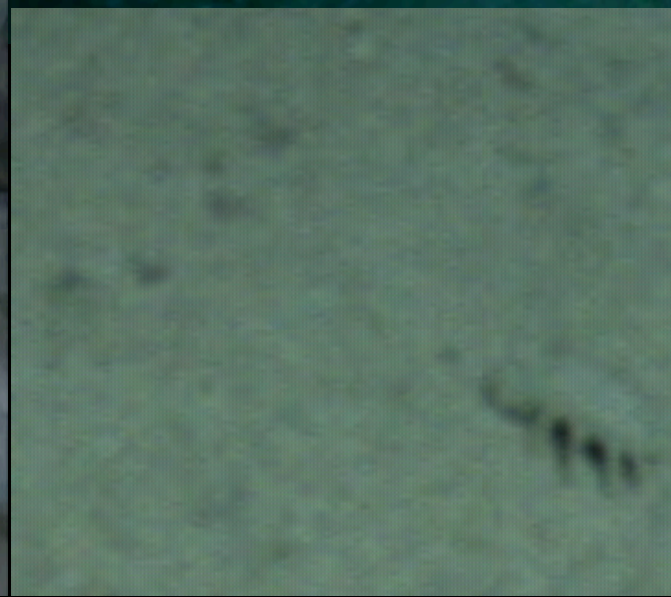
Credit: Craig McClain

Trenches

6,000- 10,980 m deep

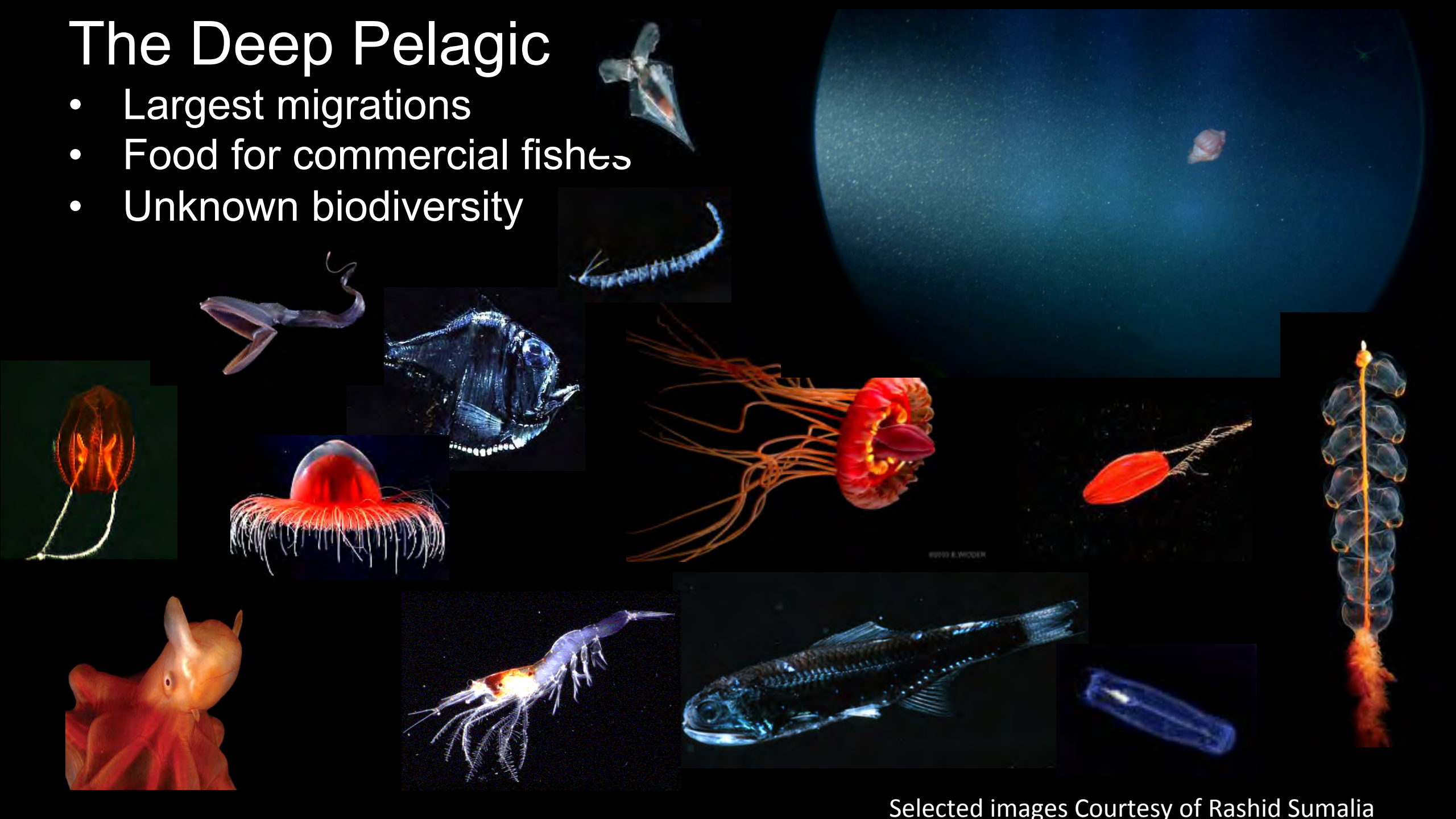
over 1,000 atm pressure

New Britain Trench 8.2 km



The Deep Pelagic

- Largest migrations
- Food for commercial fishes
- Unknown biodiversity

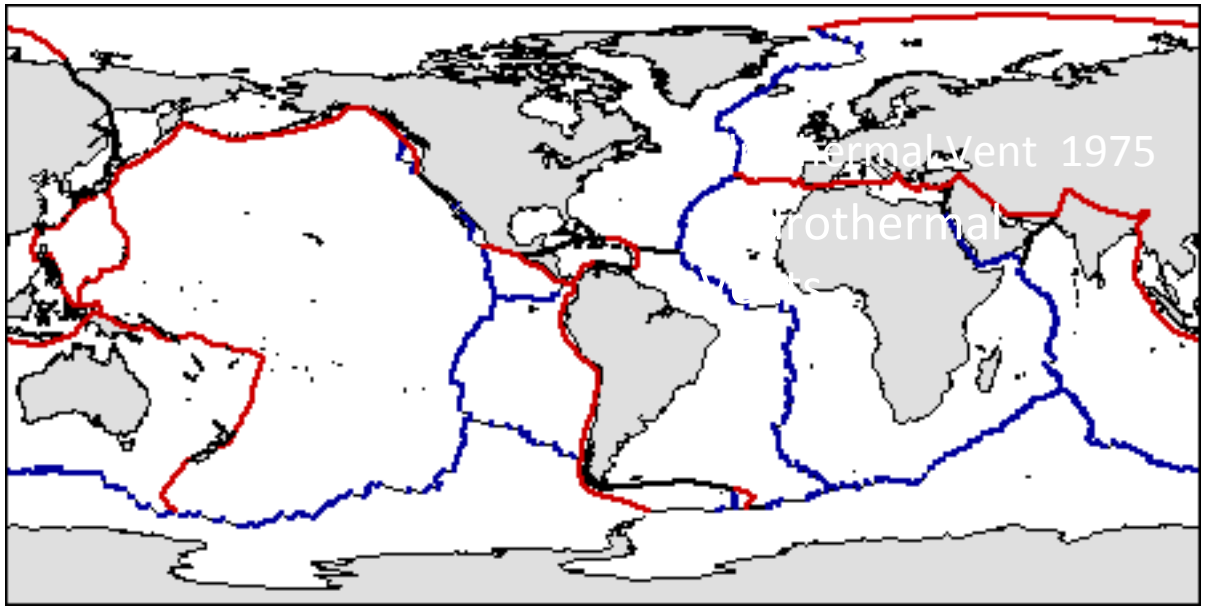


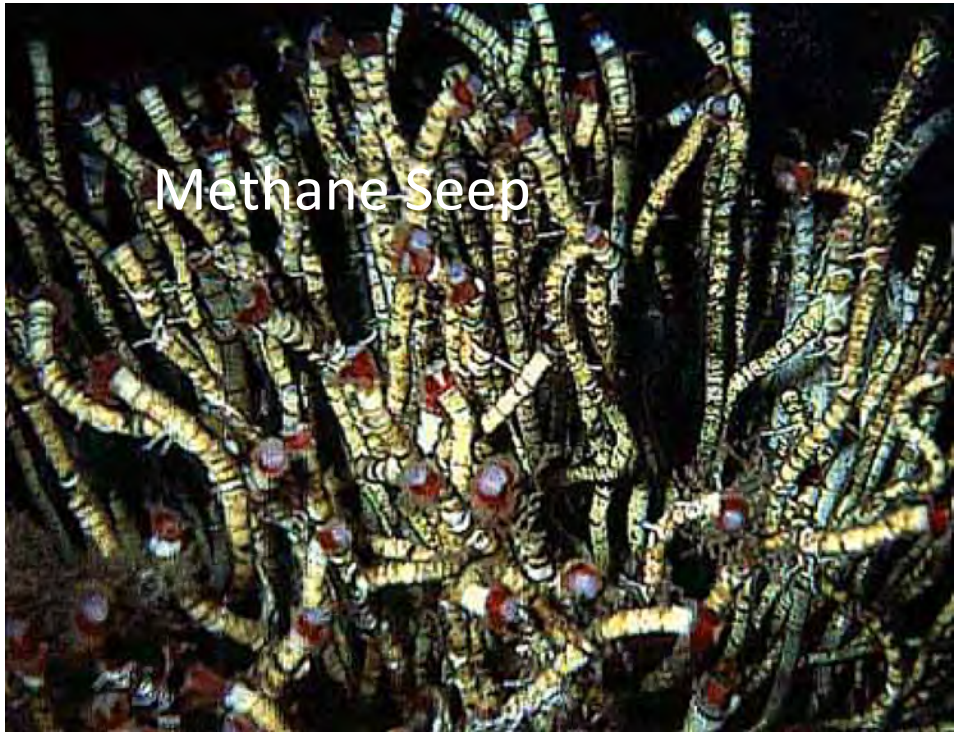
Selected images Courtesy of Rashid Sumalia

Life without sunlight.

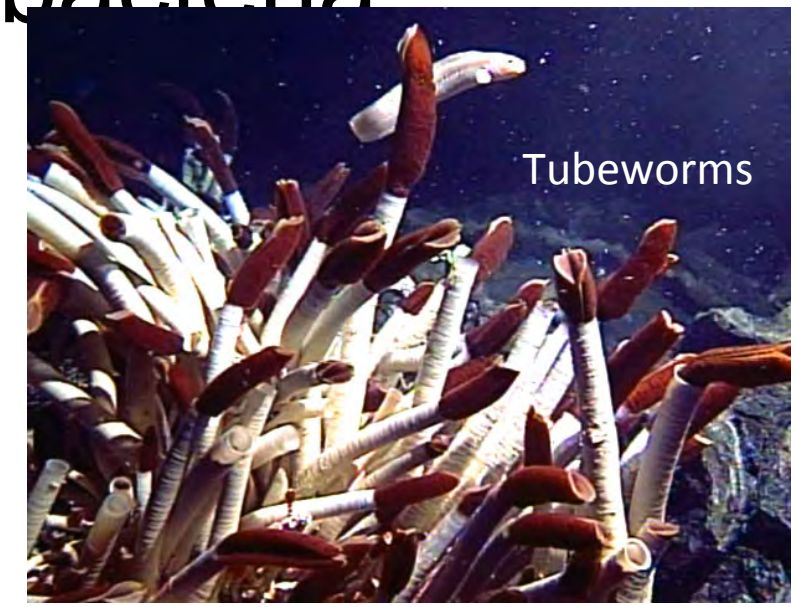
Chemosynthetic ecosystems are found at:

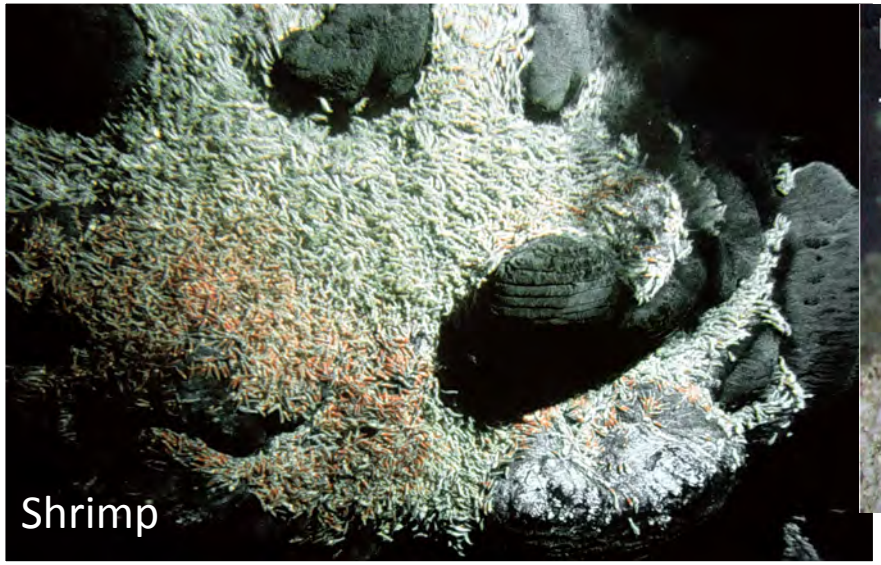
Mid ocean ridges (blue)
Subduction Zones (red)

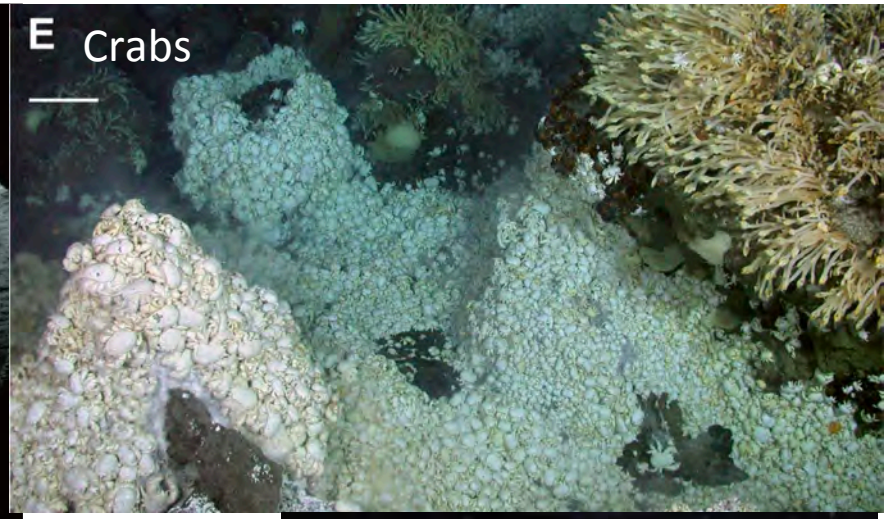




Hydrothermal Vent and Seep animals reliant on bacteria



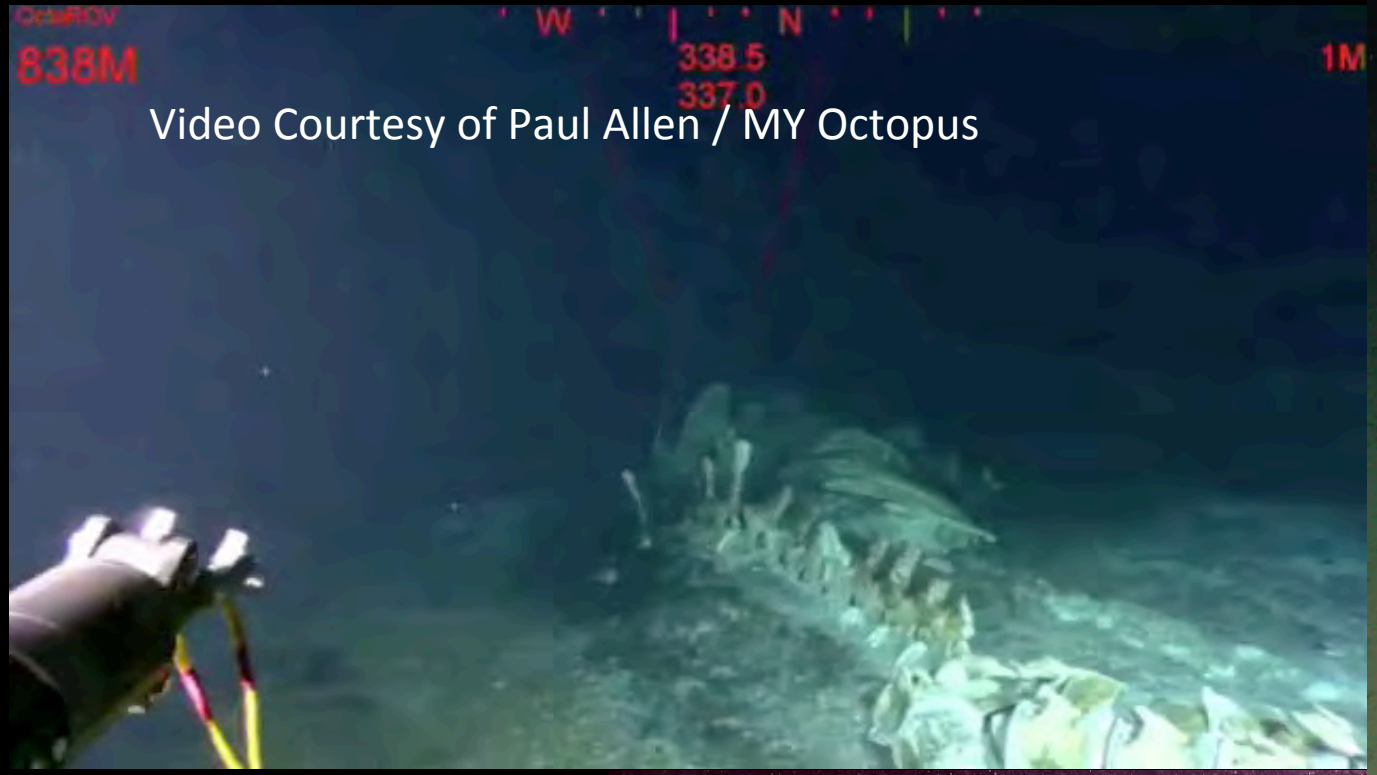




Yeti Crab

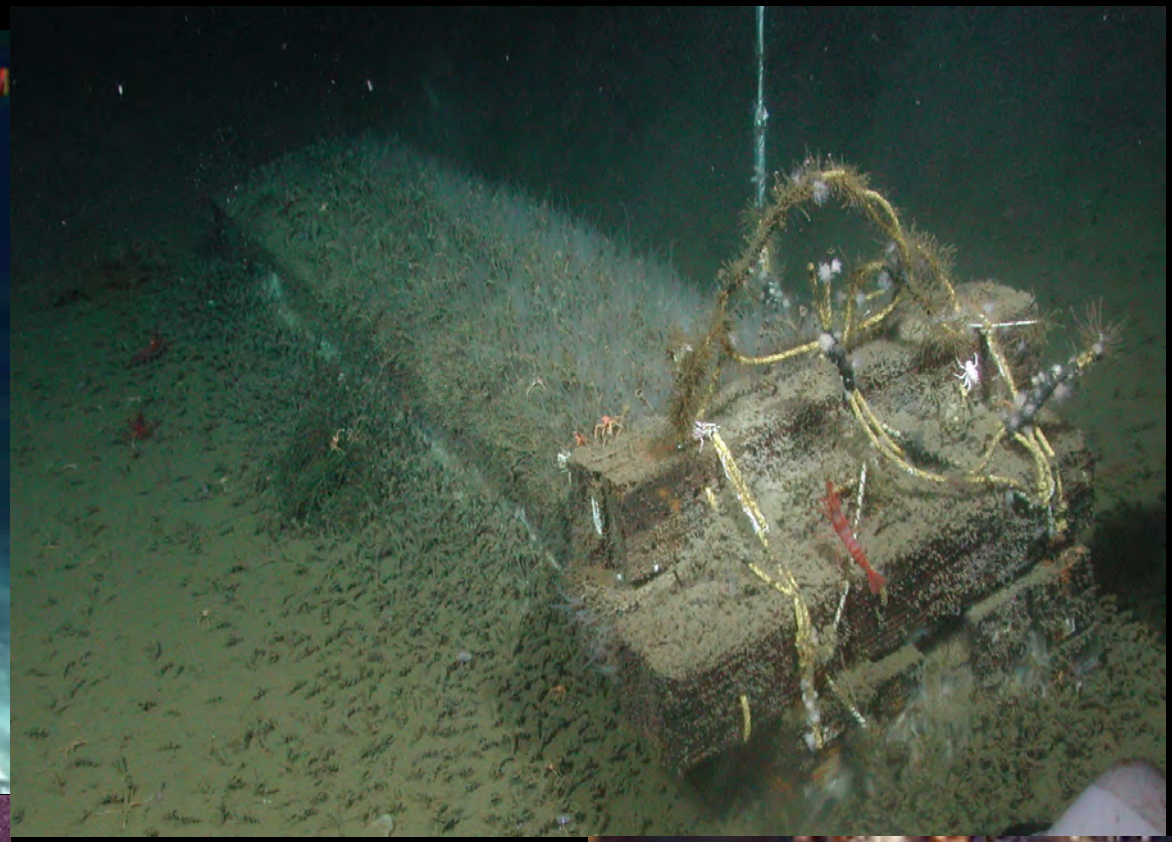
Mussel

Whale-Falls



Video Courtesy of Paul Allen / MY Octopus

Wood Falls

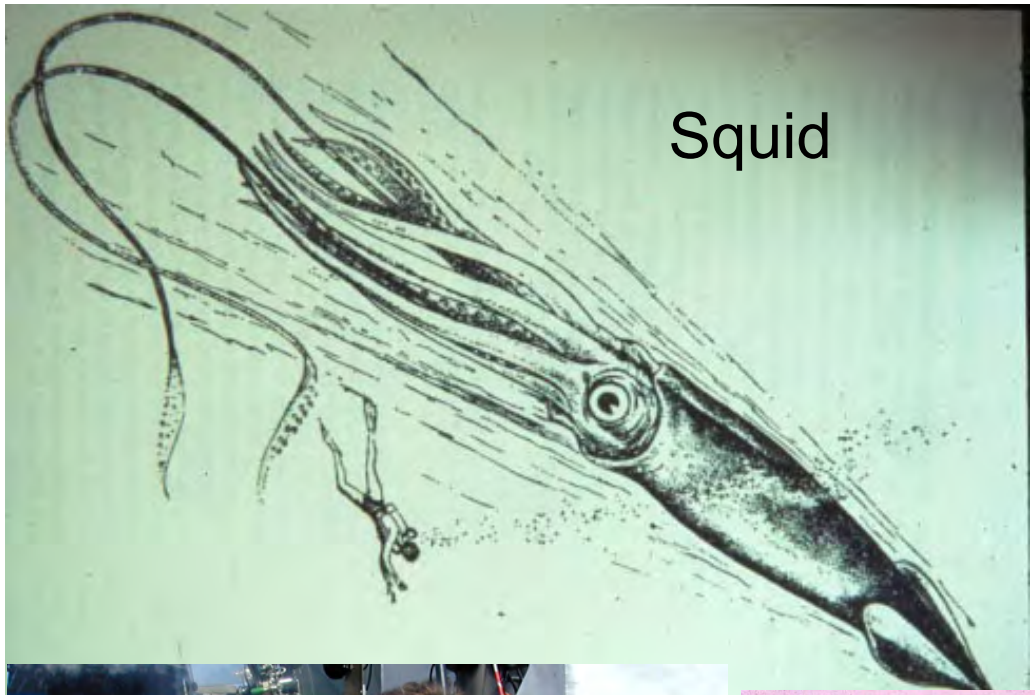


Xylophaga has cellulose-digesting symbionts

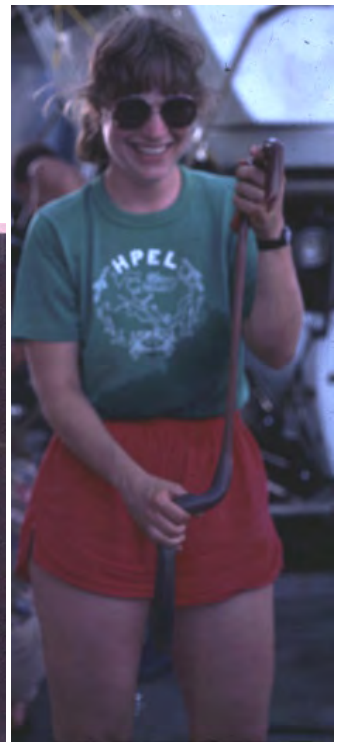
It prepares the substrate for later colonizers

Trends in the deep sea

Gigantism (to find food)



tubeworms



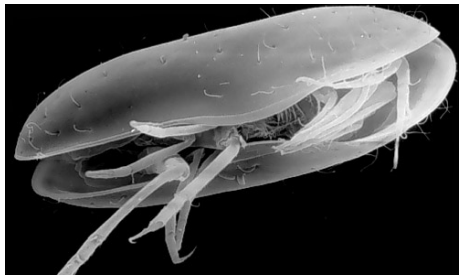
Dwarfism (to cope with low food)

Nematodes

Foraminifera

Harpacticoid copepods

Ostracods

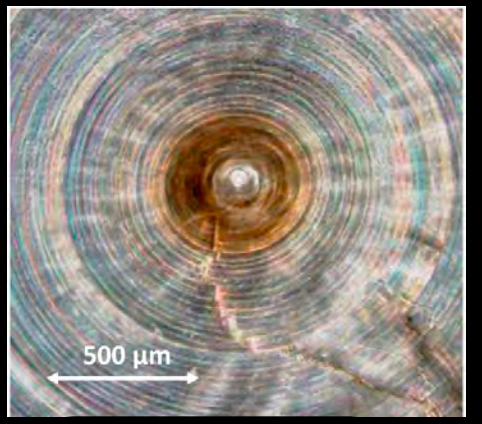


Exceptional Longevity, Slow Growth

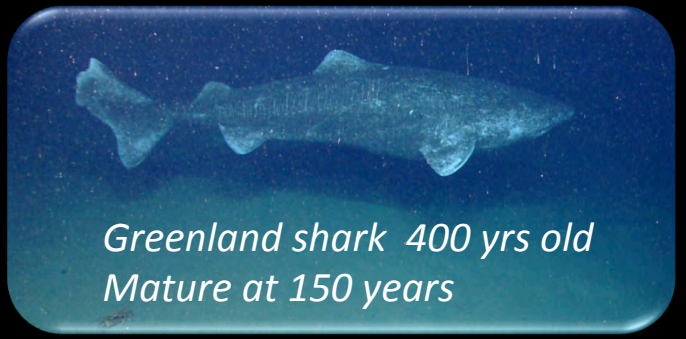
Smooth oreo dory – 100 y

Black Oreo-153 y

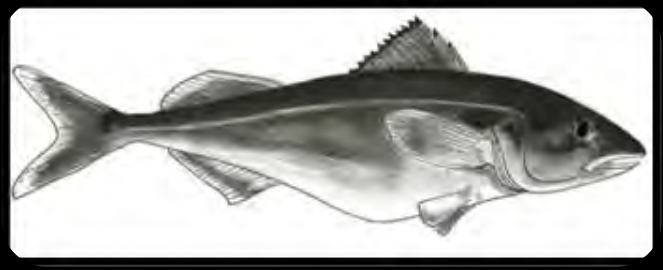
Orange Roughy - 149 y



17,000 y old
Monorhaphis chuni



Greenland shark 400 yrs old
Mature at 150 years



Sablefish – 114 y

2,320 years old
Garrardia sp.

Seep tubeworms at least 300 yrs old

Images NOAA and MBARI

Leiopathes sp.

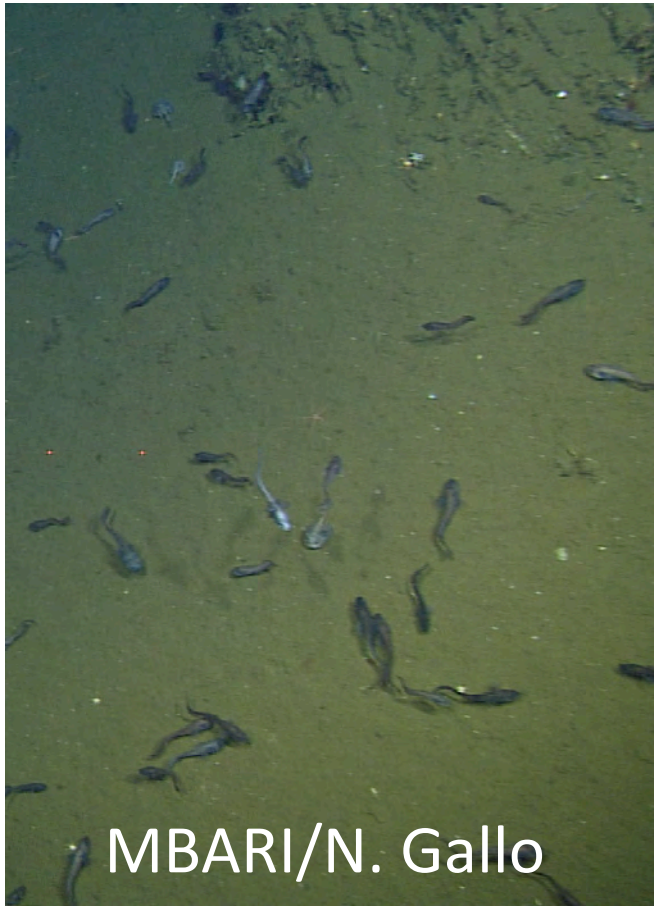
4,265 years old

Adaptation to extremes

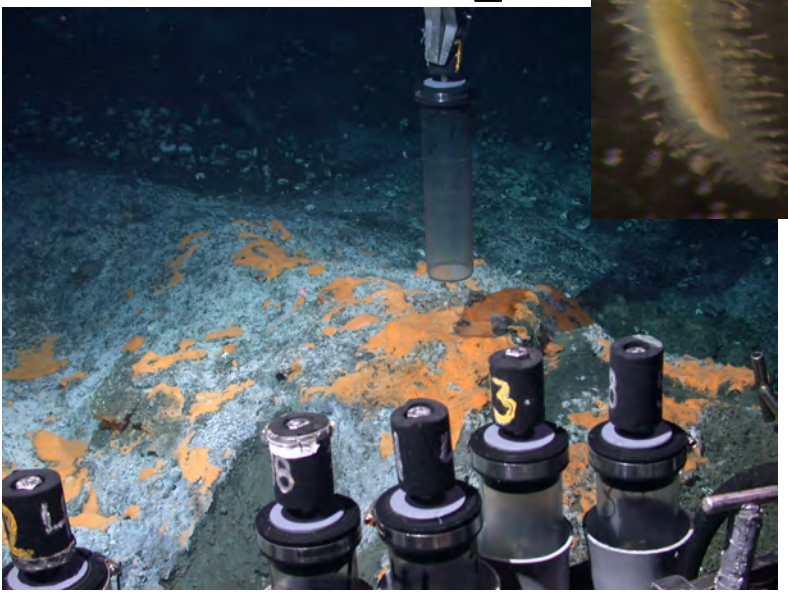
- **High Temperature**
- **Low Oxygen**
- **Hydrogen Sulfide**
- **High Pressure**

55°C

1% O_2 Saturation



5 mM H_2S



800 atm.

WHY SHOULD WE CARE

about the deep ocean?

The ocean is our greatest climate mitigator

Heat

93%

CO_2

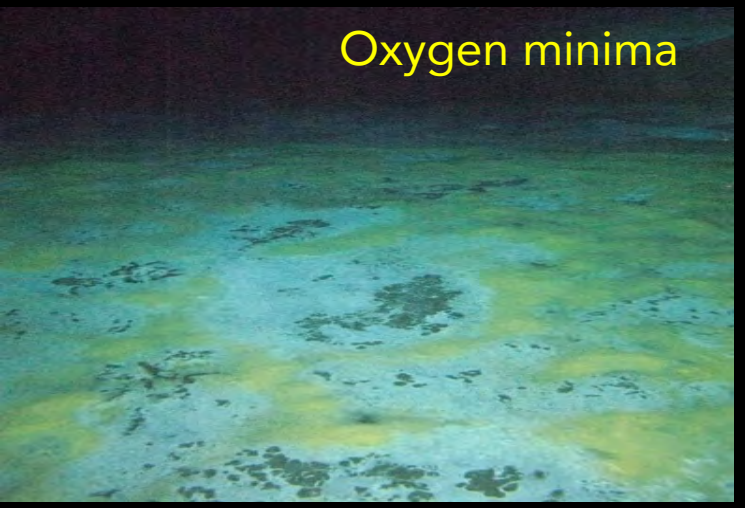
26%

PLASTIC
CONTAMINANTS

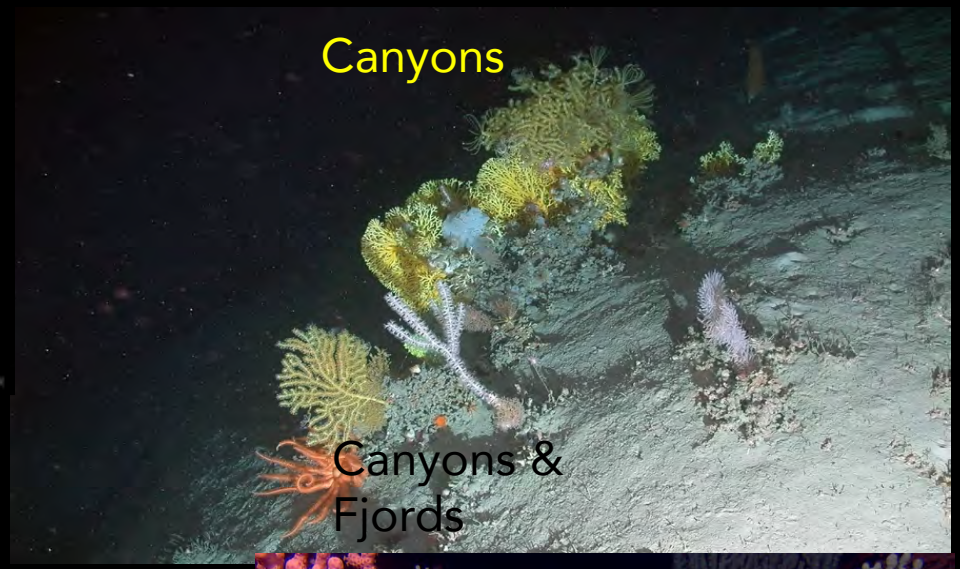
NUTRIENT REGENERATION

CARBON BURIAL

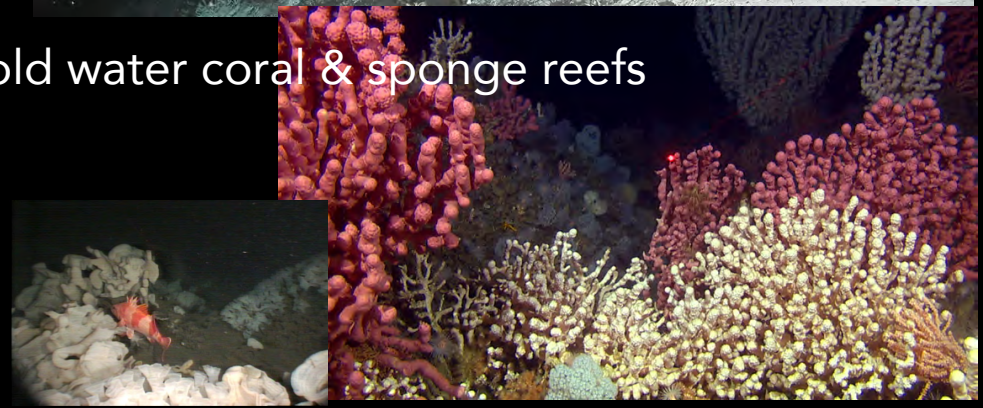
Heterogeneity Begets Biodiversity



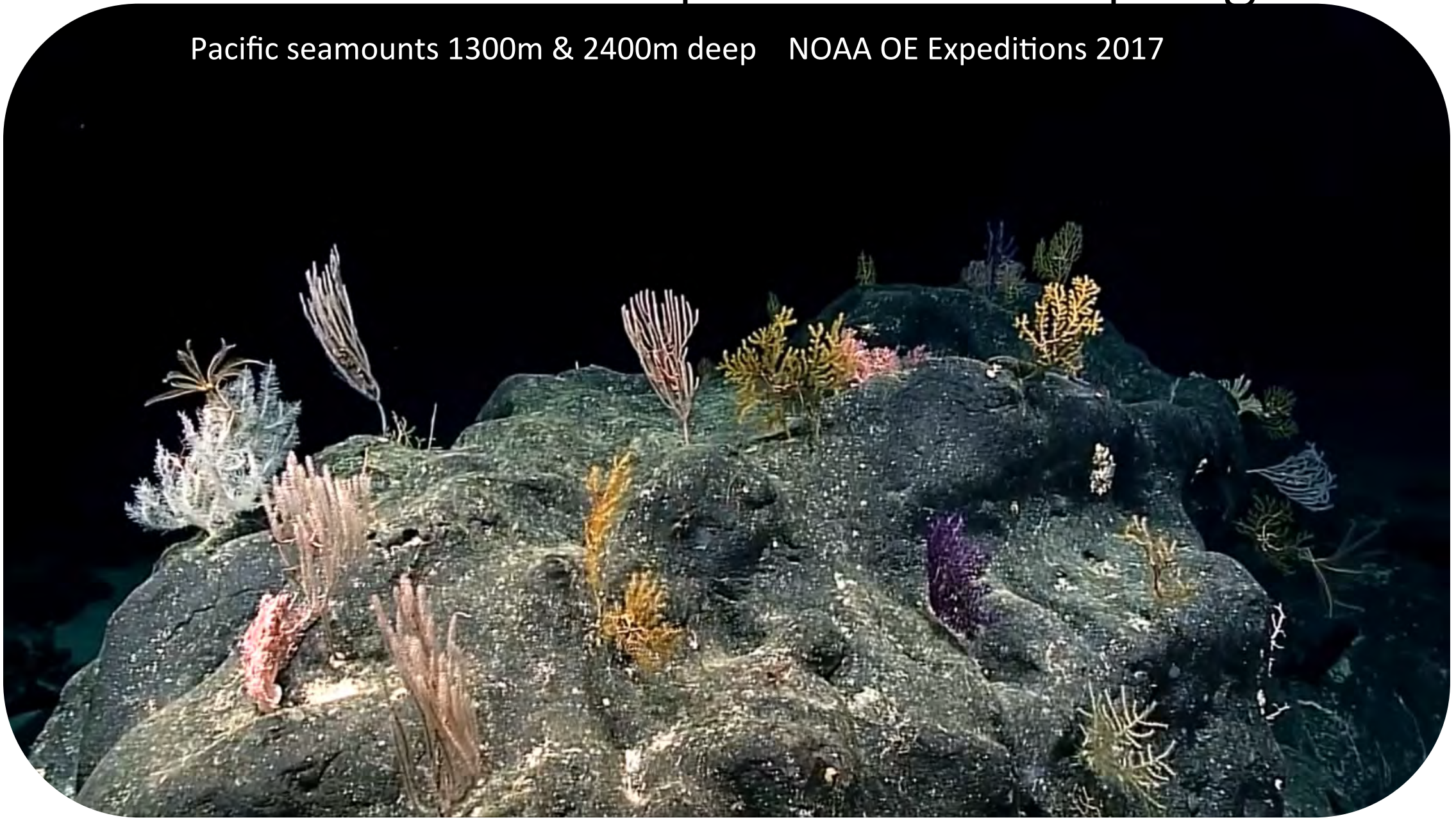
Mesopelagic



Cold water coral & sponge reefs



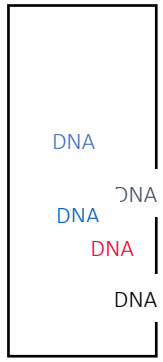
Rainforests of the deep: corals and sponges



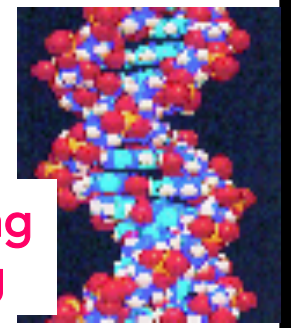
Pacific seamounts 1300m & 2400m deep NOAA OE Expeditions 2017

Biodiversity as a service: Examples from Hydrothermal Vents

MOLECULAR REVOLUTION
Polymerase enzymes

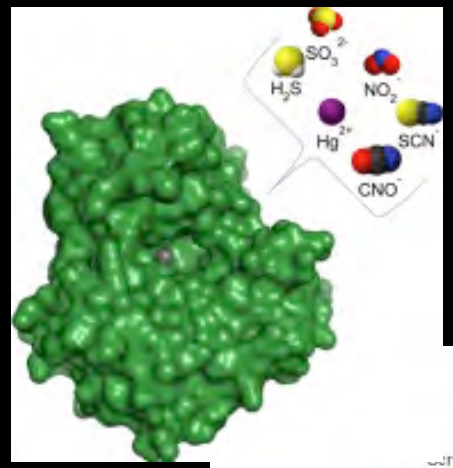


Polymerase chain reaction(PCR)
>85˚C



- DNA fingerprinting
- Genome mapping

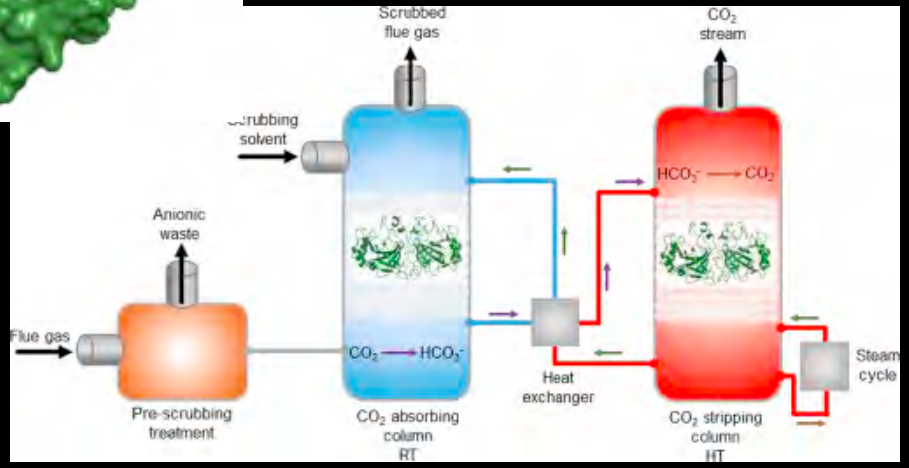
30% of $500M annual market



Diaz-Torres et al. 2015

SCRUBBING CO_2
Thiomicrospira crunogena XCL-2
industrial removal of CO_2

Sulfide oxidizing gammaproteobacteria
Thermally stable carbonic anhydrase

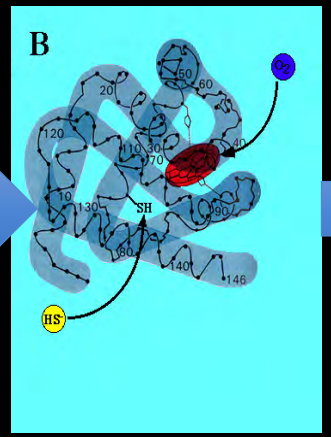


Mahon et al. 2015

NATURAL ARMOR
Crysomallon Squamiferum as Inspiration for stronger materials for airplane hulls, cars, and military equipment

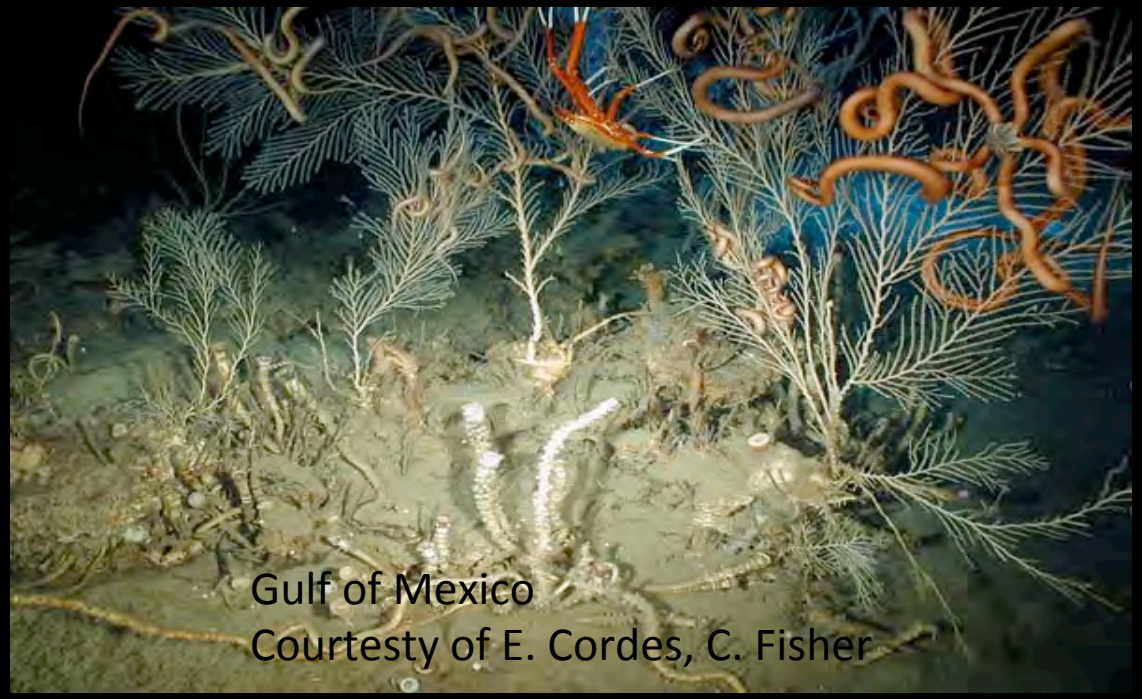
ARTIFICAL BLOOD

Tube worm haemoglobin as a template

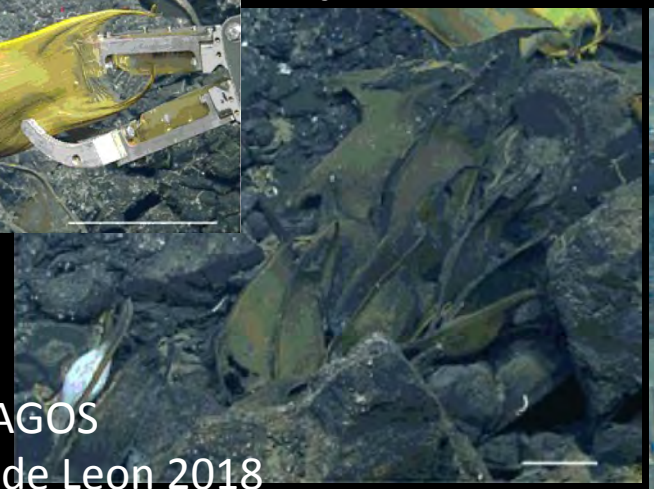


Supporting Services: New-Found Nurseries

http://blog.sylviaearlealliance.org/2011_06_01_archive.html



Hydrothermal vents and methane seeps as skate and ray nurseries

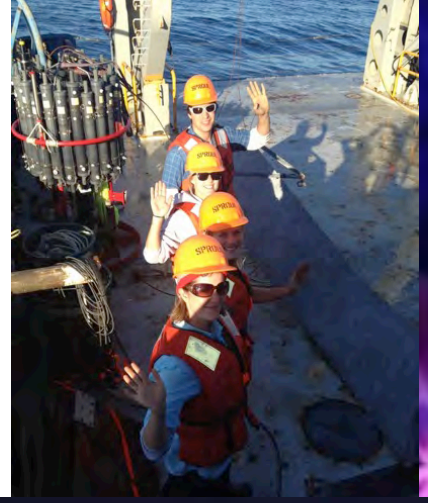


GALAPAGOS
Salinas de Leon 2018

Cultural Services:

Education

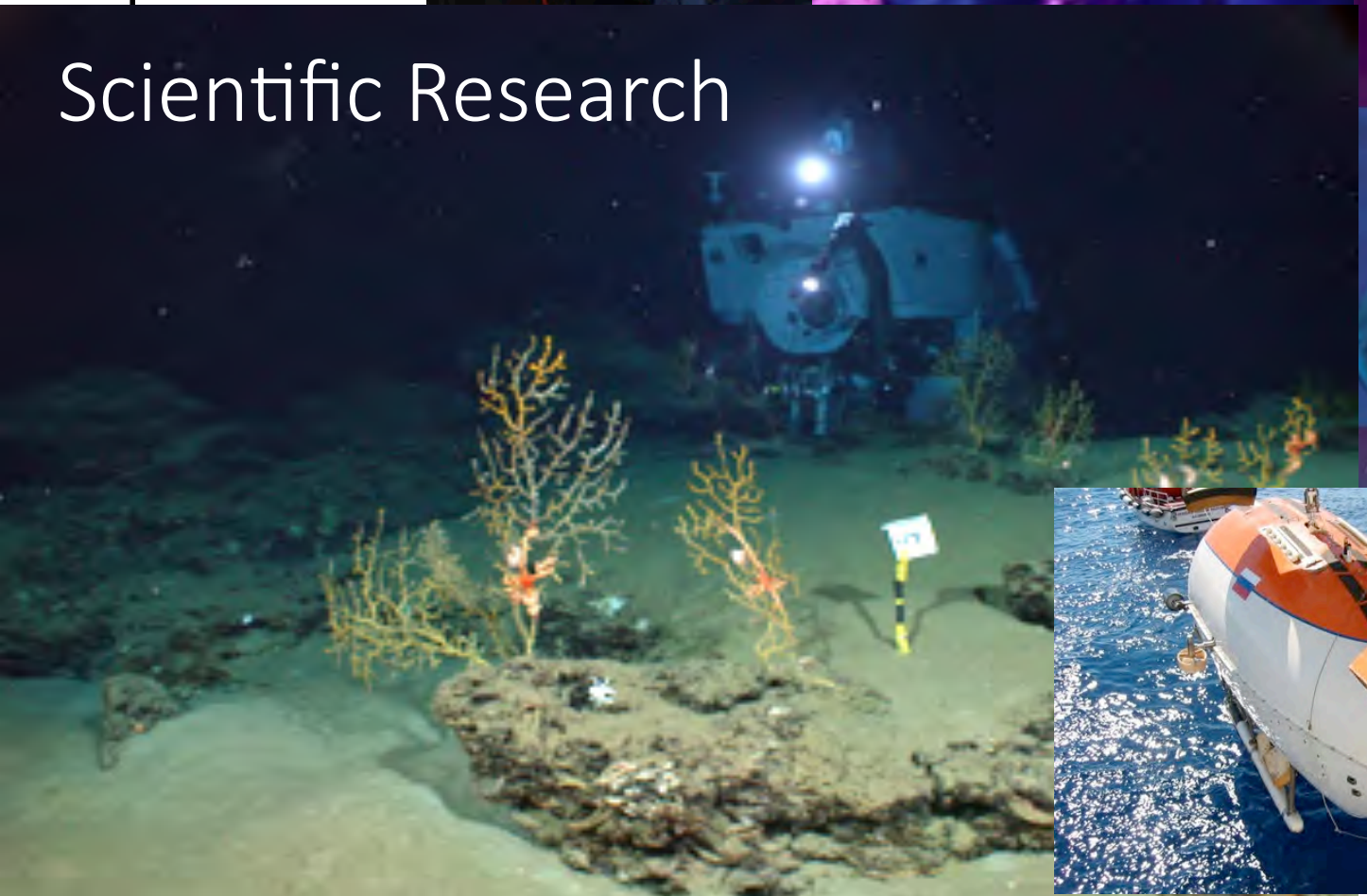
Inspiration

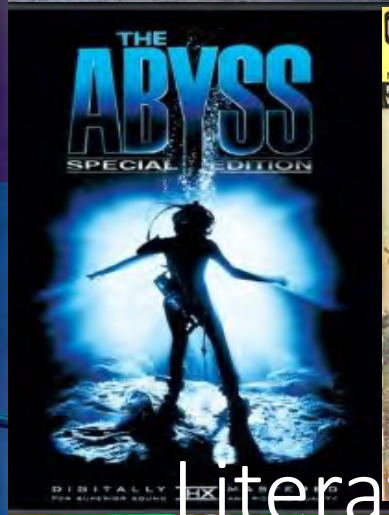


Film

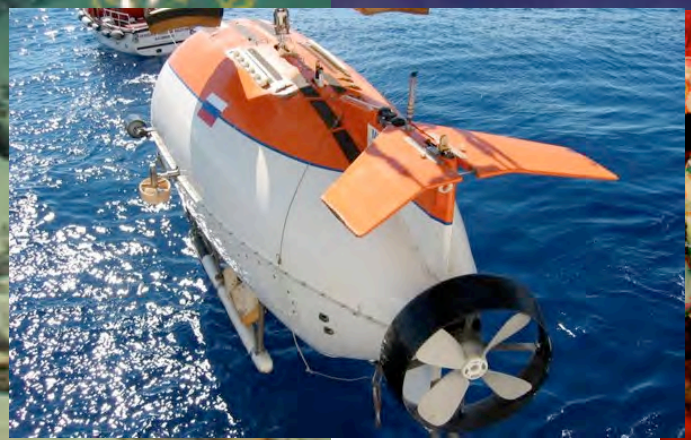
Communication cables

Scientific Research



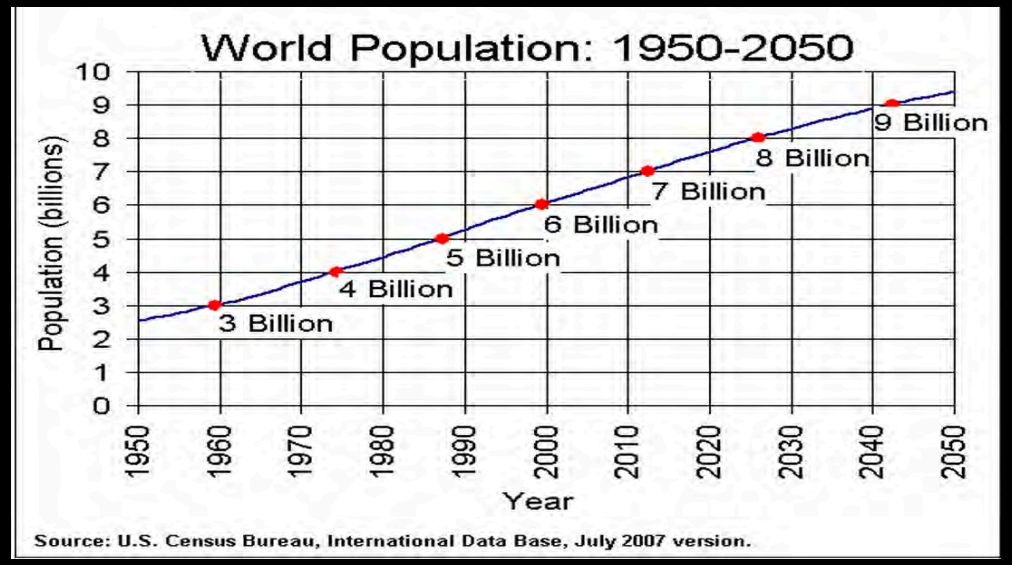


Literature



Art

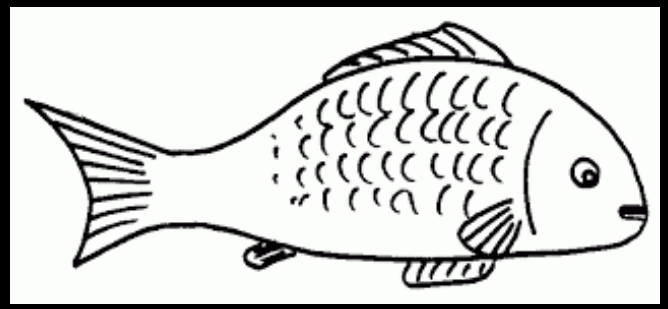
A Growing Demand for Resources



A growing population

Demanding more:

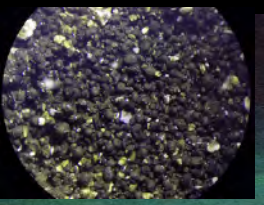
FOOD



TRACE & RARE EARTH ELEMENTS

ENERGY

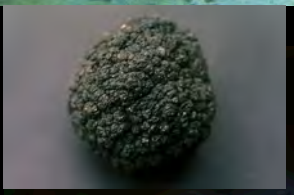
RAW MATERIALS



Oxygen minima

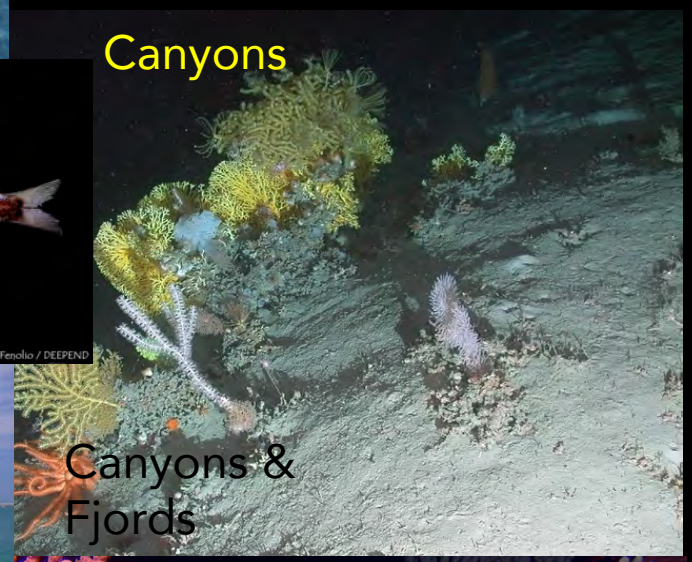
Biodiversity
Generates
Resources

Seamounts



Abyssal Plains

Mesopelagic

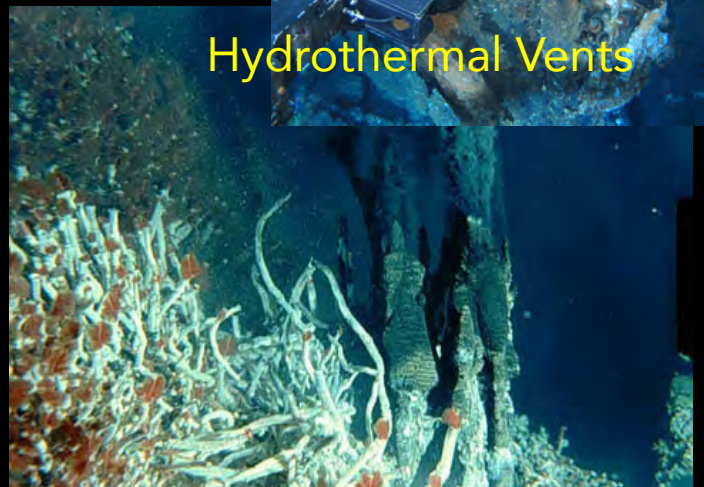


Canyons

Hydrothermal Vents

Canyons &
Fjords

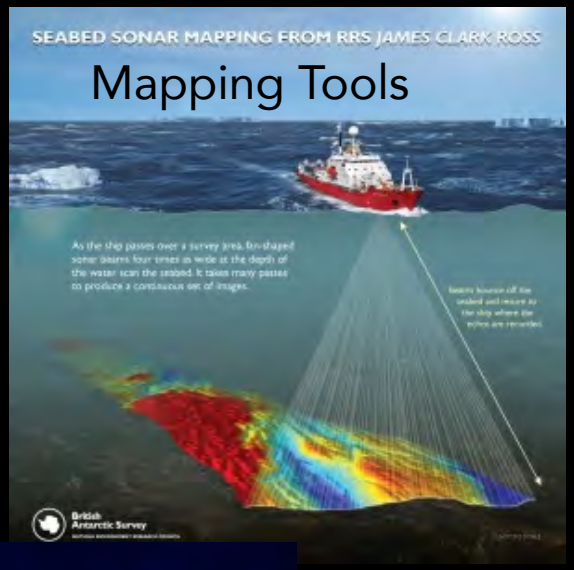
Methane Seeps



Cold water coral & sponge reefs

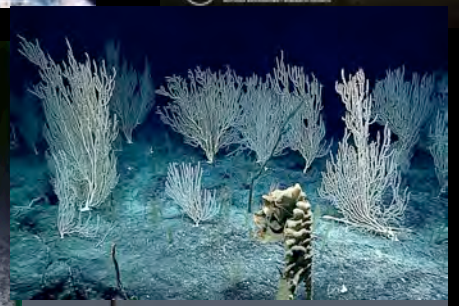
Growing Human Resource Extraction

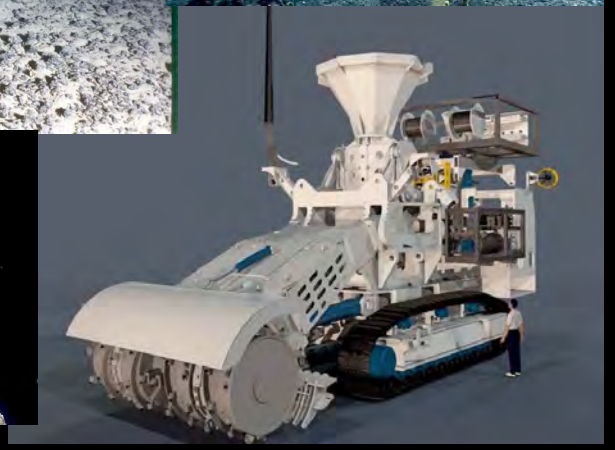
Satellite guided GPS



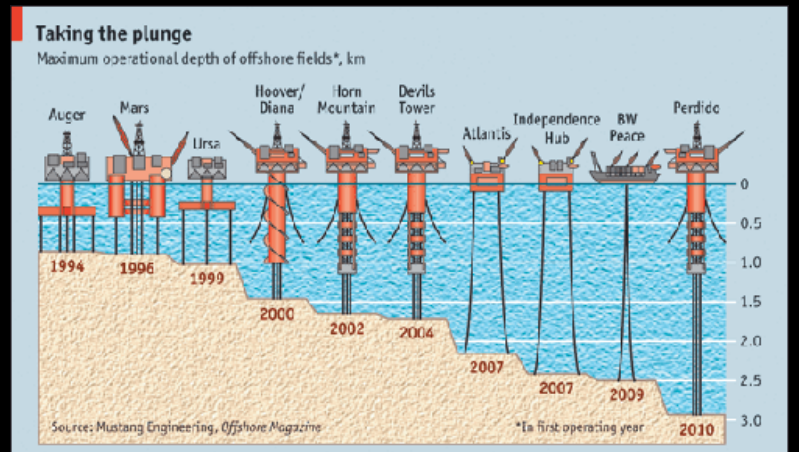
Fishing Deeper

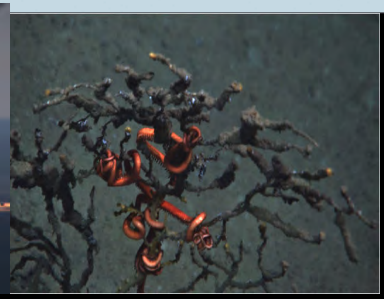
Seabed mining



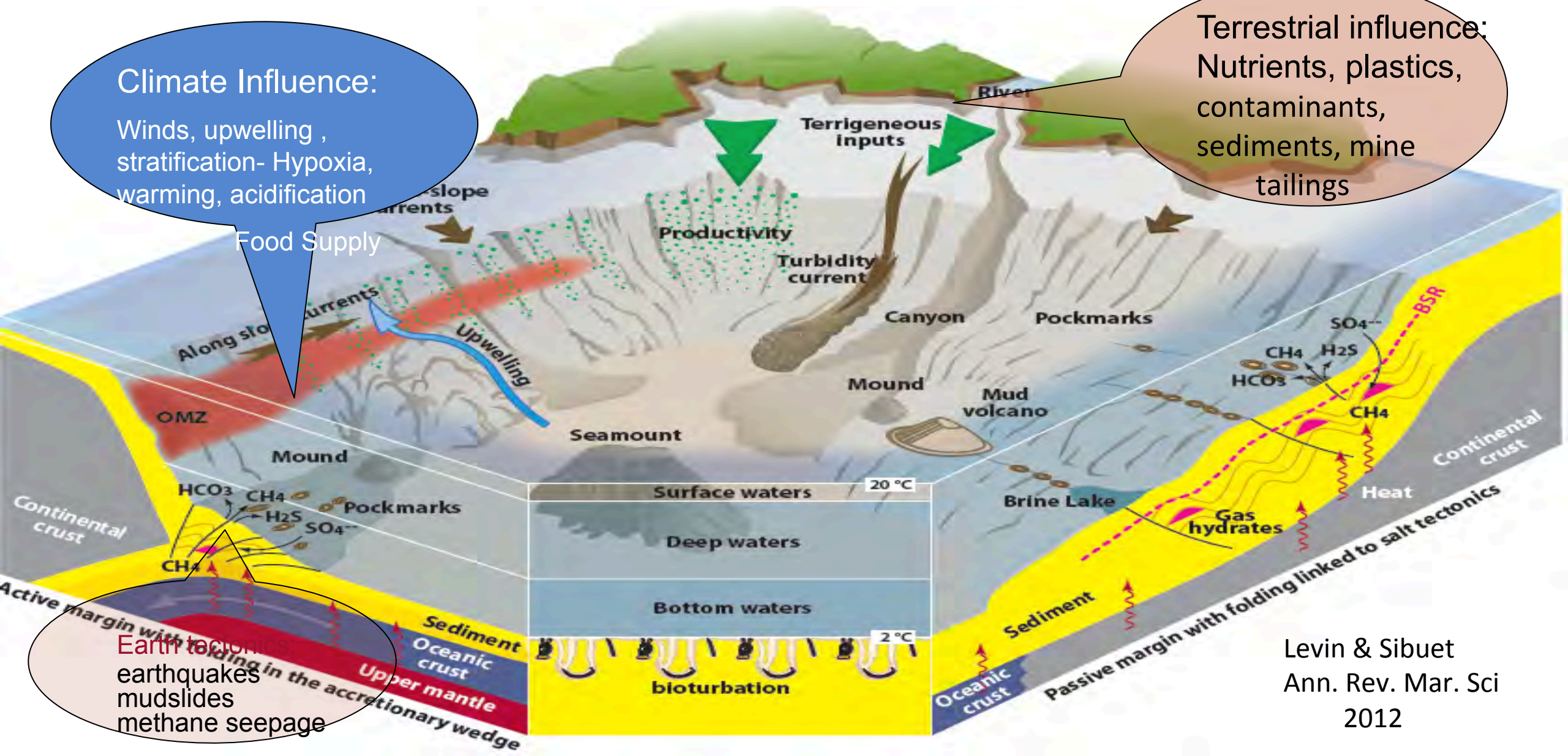


Oil and Gas at Depth





Humans can influence the deep ocean by what they put in

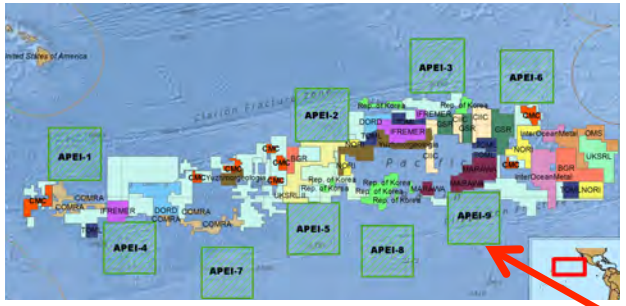


Earth tectonics:
earthquakes
mudslides
methane seepage

Levin & Sibuet
Ann. Rev. Mar. Sci
2012

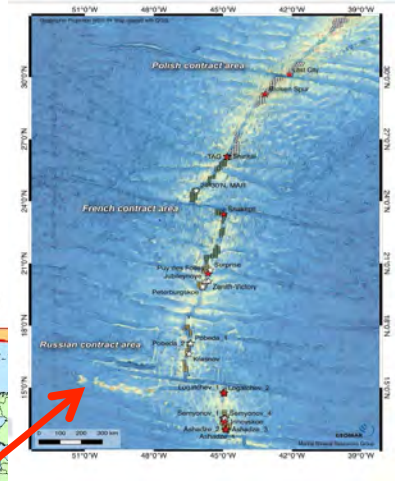
Who Owns the Ocean?

Exclusive Economic Zones (148 countries)

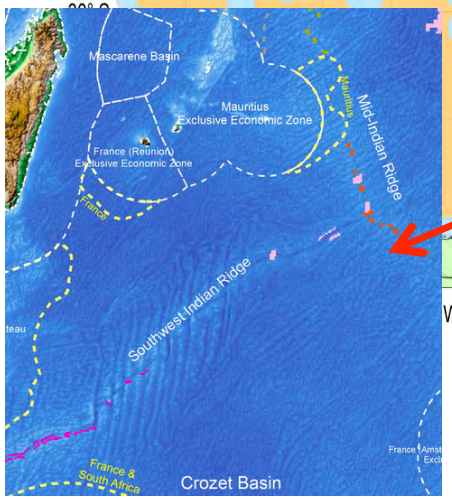


UK, Singapore, China, Japan, Korea, France, Germany, Belgium, Korea, Tonga, Norway, Russia, Nauru, Kiribati, Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia

Extended Continental shelf



Poland
Russia
France



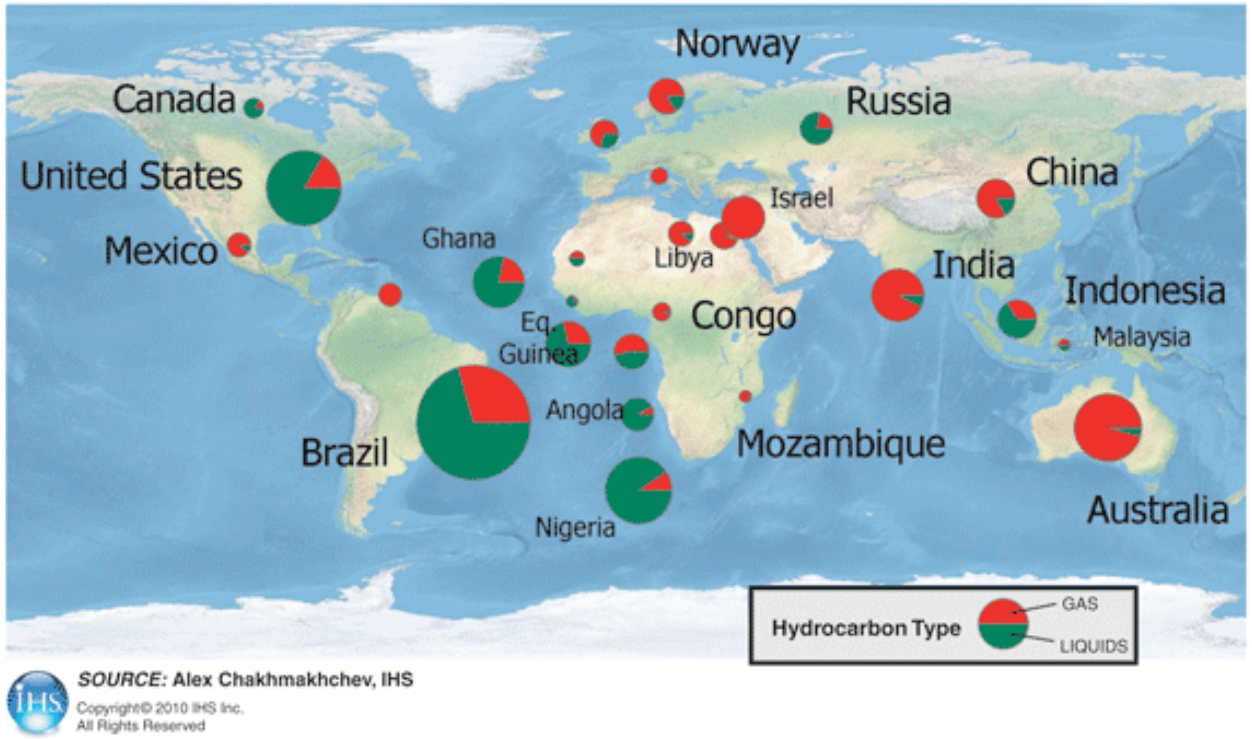
India
Korea
Germany
China

International Seabed Authority "The Area" (Minerals)

International FAO (Fish)

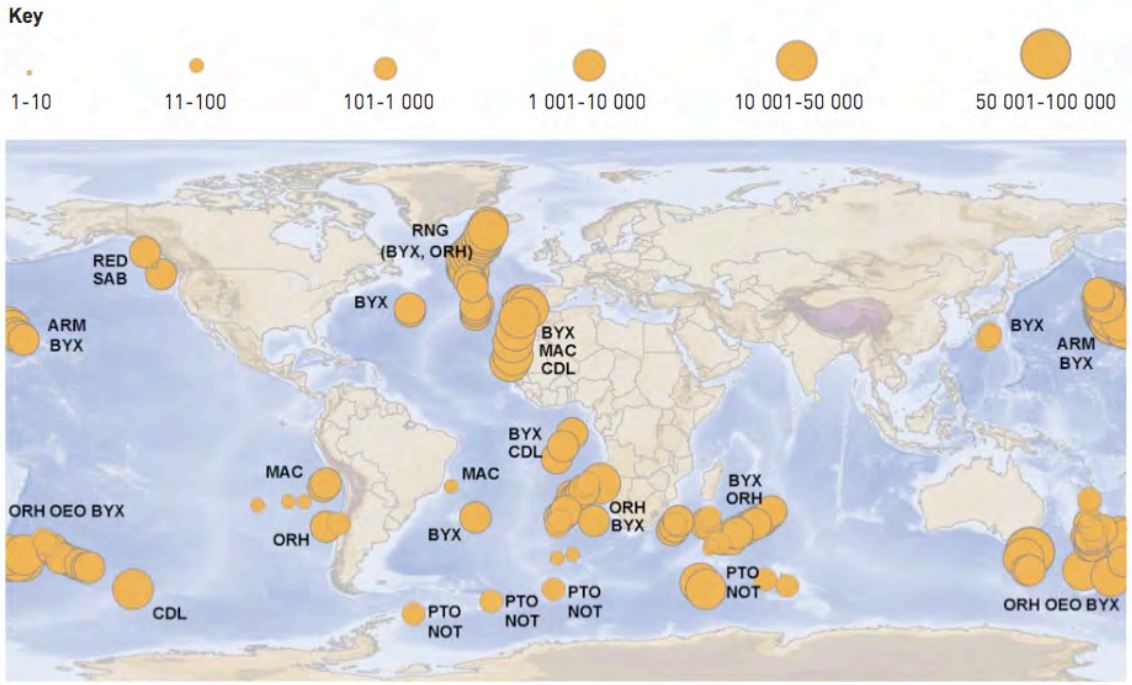
Slide courtesy Michael Lodge, ISA

Deep-water Oil & Gas



http://www.aogr.com/magazine/editors-choice/independents

Deep-water Fisheries



http://thefishproject.weebly.com/deep-sea-fisheries.html

Sustainability Challenges in the Deep Ocean

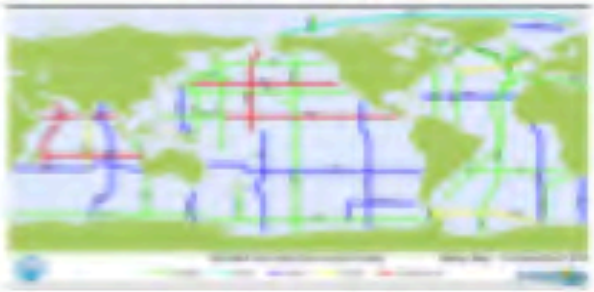
- Studying the deep ocean is expensive and difficult. Areas are vast and difficult to access.
- We still have documented very little of the biodiversity.
- Deep-sea environments are changing via climate influence.
- Life-history traits of deep-sea organisms suggest they will recover from disturbance very slowly.
- > 148 countries managing their own deep waters
- The deep ocean is managed separately by sectors (e.g., energy, fishing, seabed mining) with gaps (biodiversity).
- Increasing human demand for resources creates a new imperative for expanded **science** and **conservation** of deep-ocean ecosystems and their services.

DEEP OCEAN OBSERVING STRATEGY

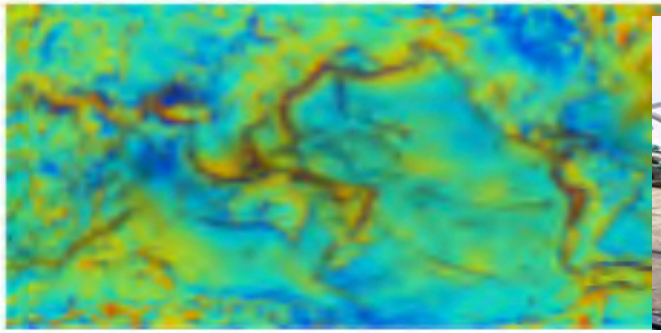
www.deepoceanobserving.org

Coordinate Global Observing Systems to address scientific and societal questions.

GO SHIP



SPACE OBSERVATIONS



Deep Argo Argo BGC Argo

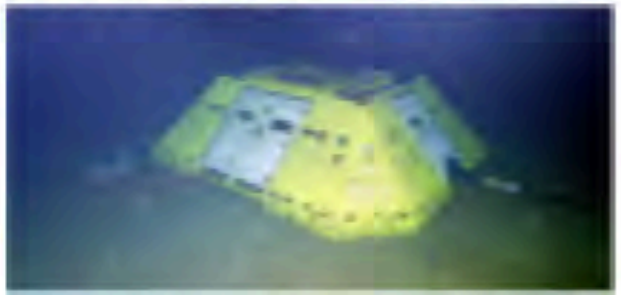
TIME SERIES

MOORINGS

SMART CABLES

GLIDERS

OBSERVATORIES



SUBMERSIBLES

ROVS

AUVS

ANIMAL TAGS

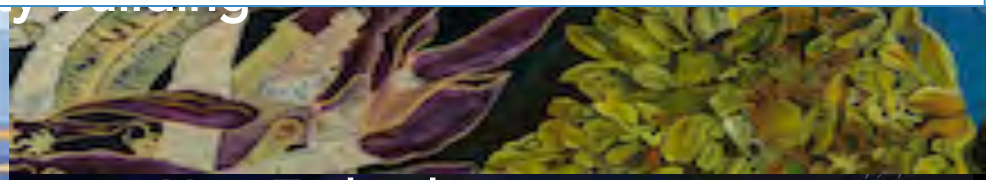
PASSIIVE ACOUST

DOSI

DEEP-OCEAN STEWARDSHIP INITIATIVE

Mission Statement

DOSI seeks to integrate science, technology, policy, law and economics to advise on ecosystem-based management of resource use in the deep ocean and strategies to maintain the integrity of deep-ocean ecosystems



www.dosi-project.org

Artwork by Tanya Young


Thank You!
Questions?
Artwork by Tanya Young