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°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.
CANYONS (thousands)

SEAMOUNTS (10s of thousands)

Photo by P. Tyler

ABYSSAL PLAINS- Polymetallic Nodule Fields (4000-6000 m)
(low productivity – oligotrophic regions)

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

~ 1 metre long enteropneust

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

- Tubeworms
- Shrimp
- Yeti Crab
- Scaly-foot Snail
- Crabs
- Mussels
- Alvinellid worm

Massive Sulfides
- Gold
- Silver
- Copper
- Lead
- Zinc

Kiwa puravida sp. nov.
Whale-Falls

Wood Falls

Video Courtesy of Paul Allen / MY Octopus

*Xylophaga* has cellulose-digesting symbionts

It prepares the substrate for later colonizers
Trends in the deep sea

**Gigantism** (to find food)
- Squid
- Amphipod
- Isopod
- Tubeworms

**Dwarfism** (to cope with low food)
- Nematodes
- Foraminifera
- Harpacticoid copepods
- Ostracods

*Images showing examples of these organisms.*
Exceptional Longevity, Slow Growth

Smooth oreo dory – 100 y
Black Oreo-153 y
Orange Roughy - 149 y
Greenland shark 400 yrs old
Mature at 150 years
Sablefish – 114 y
Seep tubeworms at least 300 yrs old
Leiopathes sp.
2,320 years old
Garrardia sp.
17,000 y old
Monorhaphis chuni

4,265 years old

Images NOAA and MBARI
Adaptation to extremes

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

55°C

1% O₂ Saturation

5 mM H₂S

800 atm.

MBARI/N. Gallo
WHY SHOULD WE CARE about the deep ocean?
The ocean is our greatest climate mitigator

- Heat: 93%
- CO₂: 26%
- Nutrient Regeneration
- Plastic Contaminants
- Carbon Burial
Heterogeneity Begets Biodiversity

- Oxygen minima
- Abyssal Plains
- Methane Seeps
- Hydrothermal Vents
- Seamounts
- Canyons
- Canyons & Fjords
- Cold water coral & sponge reefs
- Mesopelagic
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)
  - DNA fingerprinting
  - Genome mapping

30% of $500M annual market

**SCRUBBING CO₂**
Thiobacillus crunogena XCL-2
industrial removal of CO₂

Sulfide oxidizing gammaproteobacteria
Thermally stable carbonic anhydrase

Mahon et al. 2015
Diaz-Torres et al. 2015

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

**ARTIFICIAL BLOOD**
Tube worm haemoglobin as a template
Supporting Services: New-Found Nurseries

Aleutian Sponge as Rockfish Nursery

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

Fish larvae in sea pens

Baillon et al. 2012

Gulf of Mexico
Courtesy of E. Cordes, C. Fisher

Hydrothermal vents and methane seeps as skate and ray nurseries

GALAPAGOS
Salinas de Leon 2018

CHILE
(Treude et al. 2011)

Mediterranean
Cultural Services:
Education
Inspiration
Scientific Research

Film
Communication cables

Literature
Art

THE BLUE PLANET
a natural history of the oceans
NARRATED BY DAVID ATTENBOROUGH

THE ABYSS
SPECIAL EDITION
A Growing Demand for Resources

A growing population demanding more:

- FOOD
- ENERGY
- RAW MATERIALS
- TRACE & RARE EARTH ELEMENTS

Graph: World Population 1950-2050

Source: U.S. Census Bureau, International Data Base, July 2007 version.
Biodiversity Generates Resources

Seamounts
Canyons & Fjords
Oxygen minima
Abyssal Plains
Canyons
Mesopelagic
Canyons & Fjords
Hydrothermal Vents
Methane Seeps
Cold water coral & sponge reefs
Growing Human Resource Extraction

Satellite guided GPS

Mapping Tools

Fishing Deeper

Seabed mining

Oil and Gas at Depth
Humans can influence the deep ocean by what they put in

Climate Influence:
Winds, upwelling, stratification- Hypoxia, warming, acidification

Food Supply

Earth tectonics:
Earthquakes, mudslides, methane seepage

Terrestrial influence:
Nutrients, plastics, contaminants, sediments, mine tailings

Levin & Sibuet
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

- India
- Korea
- Germany
- China

**Extended Continental shelf**

**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.
Coordinate Global Observing Systems to address scientific and societal questions.

SPACE OBSERVATIONS

Deep Argo  Argo  BGC Argo

TIME SERIES

MOORINGS

SMART CABLES

GLIDERS

OBSERVATORIES

SUBMERSIBLES

ROVS

AUVS

ANIMAL TAGS

PASSIVE ACOUSTICS

www.deepoceanobserving.org
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.
Thank You!
Questions?