

# Zoogeography

Lesson 8

# The Trenches

## Hadalpelagic Zone (6000-11000m)

More people have been to the Moon than the Hadal Zone of the deep.

Most of the Hadal Zone lies in deep sea trenches.

These form by 'subduction' where the Earth's tectonic plates meet and push together.

5,900m

6,700m

The extreme conditions make survival difficult. Thus, life here is sparse.

So little is known about life in the Abyss. Almost every expedition uncovers new species.

6,800m

8,200m



## HADAL SNAILFISH

This flabby, translucent creature is the deepest dwelling fish on Planet Earth.

9,400m



## HADAL AMPHIPOD

10,500m

Amphipods can and do consume just about anything that falls to the seafloor, filling an important ecological function by recycling nutrients from even hard-to-digest material back into the environment. The hadal amphipod even has microbes in its gut that can digest wood.

On January 23rd, 1960, about 9 years before the moon landing, humans went where they never had before.



Two men, Jacques Piccard and Don Walsh, onboard the submarine Trieste slowly descended into the Mariana Trench.

And even at these depths, they could see creatures in the dark beyond.

Following 4 hours and 47 minutes of fear, anxiety and claustrophobia, they reached  
**Ocean's deepest point 11,000m**



10,900m



Yeti crabs, *Kiwa hirsuta*, were discovered relatively recently, in 2015, during the expedition to the deep-sea hydrothermal vents

- These crabs can be found at the bottom of the sea, around hydrothermal vents in the Pacific, and close to Antarctica. Yeti crabs are yellowish-white in color, with prominent front pincers.
- All of their appendages are covered in long hair called setae, and the hair layer is incredibly thick on the front pincers.
- The scientists have observed that the crabs occasionally sit at the vents' openings, waving their hairy pincers above them.
- It was also established that the **hair contains a large number of bacteria**. It is supposed that the crabs support these bacterial colonies, providing them with nutrients emitted by the vents, and these bacteria are used as a supplemental food source.



The Pacific blackdragon is a deep-water fish. It has an elongated body with a long fin along the upper part of the body.



- It has a large head with prominent, sharp, and curved teeth.
- This fish is a predator.
- Unlike anglerfish that bait the potential prey, the blackdragon prefers to wait in an ambush. Unfortunately, this strategy can be problematic even in the deep sea.
- Though this species lives on the levels where there is no natural light, multiple species have bioluminescence.
- This means that there is enough light for potential prey to see their predators. The black dragons have an ingenious solution to this problem.
- Like many sea species, these fish have the black pigment-melanin. Melanin is stored in unique structures called melanosomes.
- In Pacific blackdragons, these melanosomes are very tightly packed, which is usually quite rare.
- Due to this melanosomes organization, the Pacific Blackdragons can absorb bioluminescent light almost wholly, dissolving into the darkness – and attacking their prey entirely unexpectedly.

# Agony of a whale



Biologicamente

Smith, C. R., Glover, A. G., Treude, T., Higgs, N. D., & Amon, D. J. (2015). Whale-fall ecosystems: recent insights into ecology, paleoecology, and evolution. *Annual review of marine science*, 7, 571–596.  
<https://doi.org/10.1146/annurev-marine-010213-135144>



26 mt for 77-81 tons

unexploded explosive



launched from a Japanese whaler



After three days it's gone

The carcass swells due to the gases released by decomposition



The carcass floats on the surface of the water and becomes a hearty meal for seagulls and other sea birds for a while.

A blue shark then arrives and takes off a large piece and the whale begins its descent into the depths of the sea



The whale sinks, taking with it all the carbon stored in its body



The carcass sinks towards the abyss, along with **billions of organic particles** falling from the other like snowflakes. Kilometre after kilometre, it reaches the dark, almost inhospitable depths, seemingly devoid of life



The carcass crosses the bathypelagic zone (between 1,000 and 4,000 m), lies on the seabed and raises a new layer of sediments.

Thanks to her in this cold and dark place, **spring has come**





Missinae dig tunnels in the carcass, octopuses (*Muusoctopus spp*) consume the soft tissues of the whale, together with fish of the Macrouridae family



giant isopods, crabs and holothurians, colonise sediments enriched with new organic matter



polychaete worms (*Osedax* genus) penetrate the skeleton and through root-like extroversions form small white tubes from which tufts of red fringes emerge. They feed on collagen and lipids thanks to the presence of symbiotic bacteria that are able to metabolise these highly nutritious and precious substances.

## 50 years later...

Sulphur-depleting and sulphide-oxidising bacteria, along with methanogenic and methanotrophic archaea, fish, crustaceans, molluscs, and echinoderms, have ravaged the whale's carcass, breaking down its bones and consuming the organic compounds embedded in the surrounding sediment.



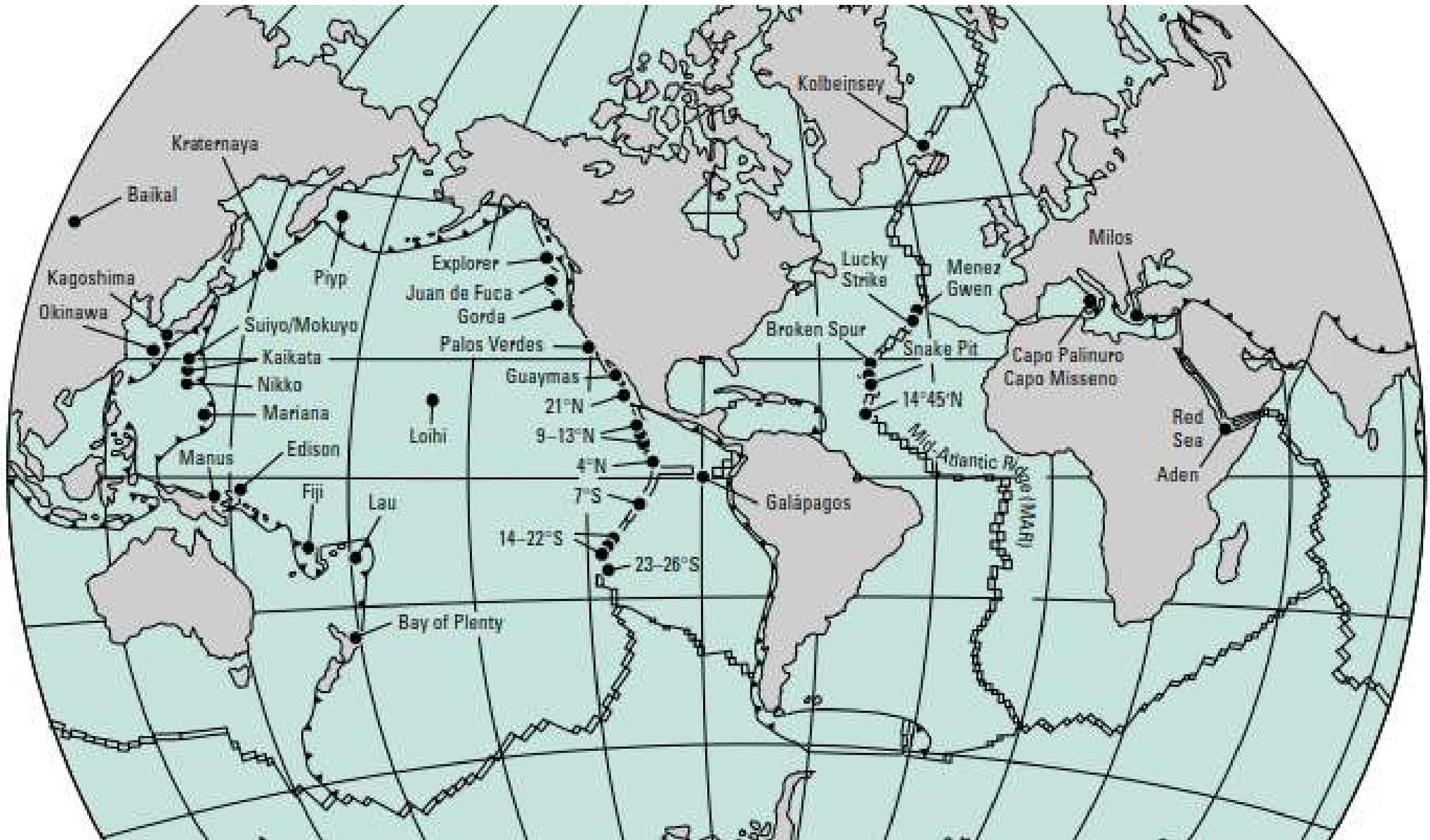
The whale is not just yet another victim of ruthless and senseless hunting, it is not just a whale shot with **defective weapons**; instruments that in no way guarantee a quick and dignified death

The whale become a new and temporary ecosystem!

# Saltwater in the deep sea

- Concentrations of 'saltwater' often occur at deepwater and cold water sites.
- They accumulate above submarine oil deposits. In some cases they are surrounded by vast mussel beds,
- probably dependent on methane released from hydrocarbons, which is fixed by bacteria within the tissues of the bivalves themselves.





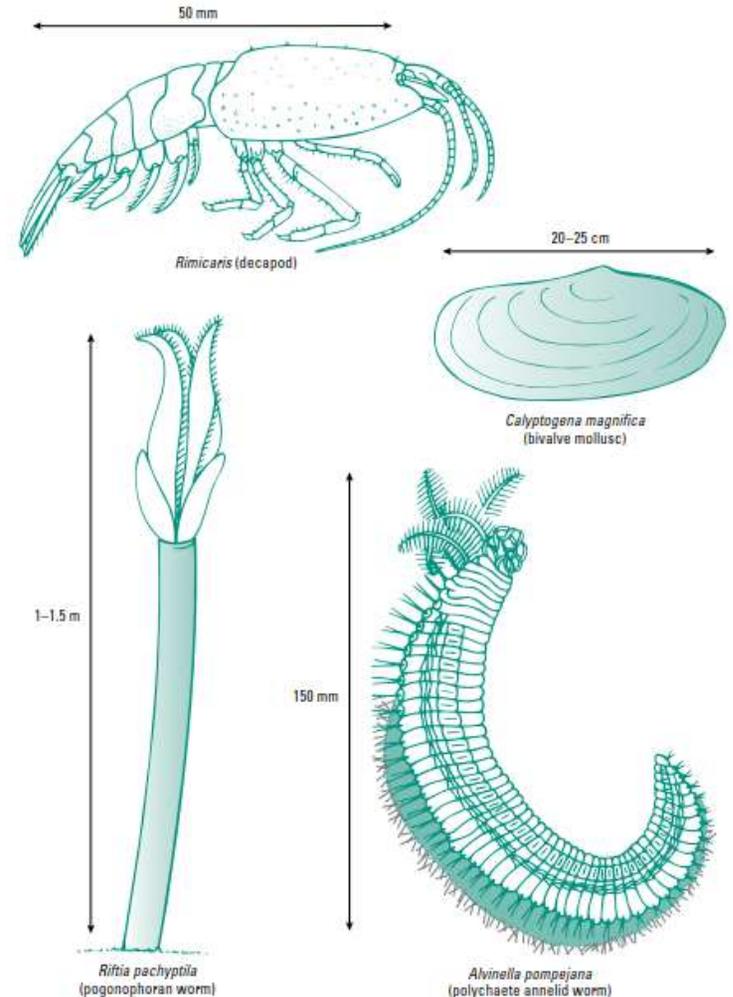
# Hydrothermal Vents

Superheated  
pressurized water  
(**up to  
350°C**) then  
forces up through  
the crust to  
emerge as  
“hydrothermal  
Vents»



# Fauna of hydrothermal vents

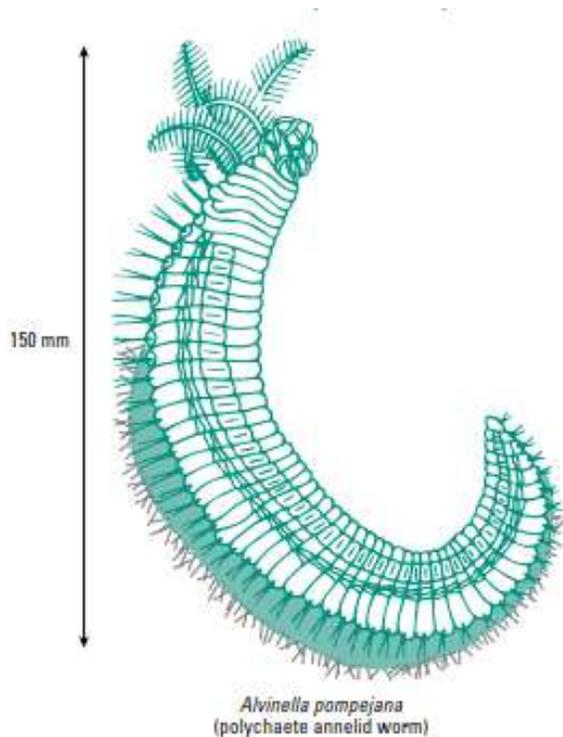
- Prokaryotes present at the boiling T°C of H<sub>2</sub>O. The enzymes of these 'extremophile' organisms are rich in disulphide bridges
- In the vicinity of the chimneys, the air interacts with the surrounding water and produces an environment around 30°C with hydrogen sulphide concentrations of less than 400 μm
- Fauna associated with hydrothermal chimneys have been discovered since 1977



- 250-300 discovered species of macrofauna
- Of these 200 were new spp never before identified



- The composition of fauna associated with hydrothermal vents is variable, but can be predictably dictated by their age and site in relation to larval recruitment and dispersal.



This polychaete lives in a range of Temp 68-81°C.

Around the mouth the temperature is 22°C with a gradient up to 60°C along the length of the body.

To date, the functioning mechanisms of the proteins and membranes of these worms are unknown.

- *Rimicaris exoculata* (Decapoda) does not have eyes except for a 'thoracic eye' adapted to low-light vision. It is probably used to detect the low radiation emitted by the very warm water of the mouths.



- Studies conducted on crabs inhabiting these environments reveal that high pressures accompanied by high temperatures cause less structural damage (pressure: reduces membrane fluidity, but temperature: increases membrane fluidity)



## Living in the Oil

In some parts of the world, bodies of water become contaminated by spills from nearby oil deposits, and hydrocarbon spills support various metazoans.

These fluids contain ( $H_2S$ ,  $HS^-$  and  $S^2$ ) and toxic hydrocarbons ( $C_xH_x$ ) as well as C and N

# Nutrition and respiration in the presence of sulphuric acid

- Sulphur compounds are potentially toxic
  1. They bind the Heme group of Cyt c by inhibiting cell resp.
  2. They can reduce the S-S of proteins (structural instability)

DETOXIFICATION MECHANISMS



Haemoglobin

*Riftia pachyptila*



Plasma proteins

*Calyptogenia magnifica*

These proteins transport free sulphide into the general circulatory system where it is strongly bound, and thus achieve three important functions:

- 1 The preservation of aerobic respiration.
- 2 The prevention of sulphide precipitation in the blood (could impede circulation).
- 3 The transport of sulphide to internal centres where the symbionts exploit it for energy production

# Symbiotic relationships

- The nematode, *Eubostrichys dianeie*, houses sulfur-oxidizing bacteria in a mucus web over the exterior of its body.
- The worm, *A. pompejana*, maintains an epithelial “fur” of fine projections densely packed with sulfur-containing filamentous bacteria.
- Bivalves have specific intracellular (endosymbiotic) strains of sulfur bacteria housed in their gills in modified cells called bacteriocytes; gastropods also have bacteriocytes in their gills
- In pogonophoran worms, sulfide oxidation occurs in the “trophosome”, an internal organ that fills much of the coelomic cavity and contains extremely high concentrations of sulfide-oxidizing bacteria.



# Bivalves

*Calyptogena magnifica* possesses a mouth and intestine although the digestive system is very small.

- The enlarged gills contain sulphur-oxidising chemolithoautotrophic bacteria that provide the clams' main source of energy and weigh on average 17% of the bivalves' wet weight.
- Sulphates appear to be taken up by the foot and transported by a serum factor that binds sulphate and is present in the blood to the gills. Clam serum can reversibly bind to sulphates [8 mM], with a significantly higher concentration than in the seawater environment

# Phogonophora



- Most sulphate oxidative processes occur in the 'trophosome'. Worms lack a mouth and intestine, and the tentacle plume serves as the primary site of gas and solute exchange with ambient seawater.
- abundant haemoglobin (up to 26% of the worm's wet mass) present in the vascular and coelomic spaces carries both oxygen and sulphate to the trophosome
- Bacteria are therefore able to fix CO<sub>2</sub> by involving the ribulose enzyme 1,5-biphosphate carboxylase, providing reduced carbon compounds that in *Riftia* sp. account for almost 100% of the worm's C demand

# Crustaceans



- The crab *Bythograea thermydron* shows a high tolerance for sulphuric acid and high temperatures
- Like molluscs, it has been shown to oxidise H<sub>2</sub>S to thiosulphate, this time in the hepatopancreas.
- In this species, thiosulphate has an additional adaptive function that increases the affinity of the respiratory pigment (haemocyanin) for oxygen (present at low concentrations)