

# Why is the sea so diverse?



Begoña Vendrell-Simón & Josep-Maria Gili  
Institut de Ciències del Mar (ICM-CSIC)  
GIFT Workshop, EGU, Wien 2011

# BIODIVERSITY: what is it?



Genetics  $\longrightarrow$  SPECIES  $\longleftarrow$  Ecology

# BIODIVERSITY: why is it important?

Aesthetic

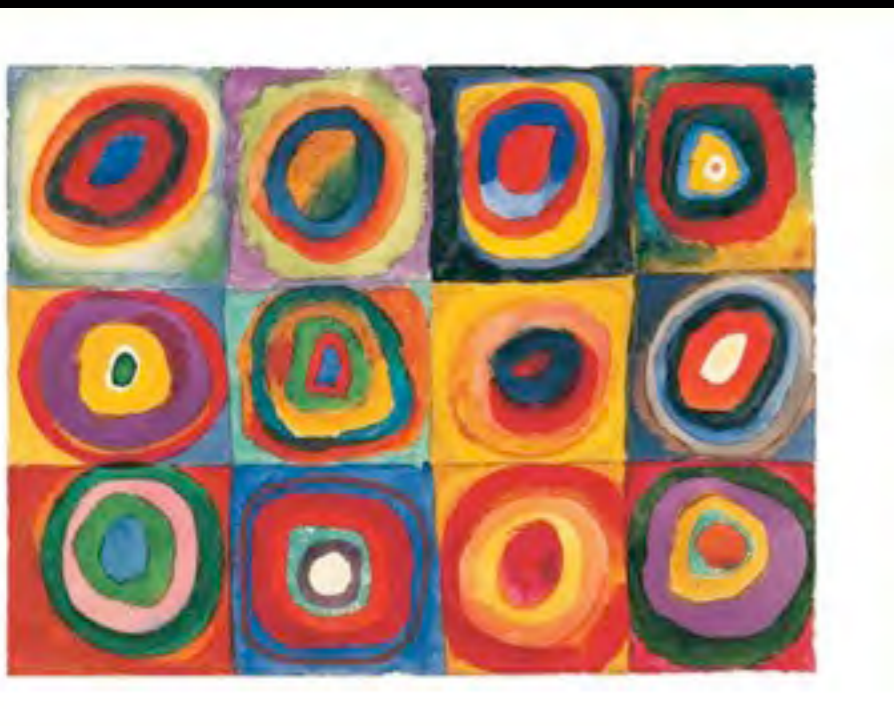
Scientific

Knowledge

Complementarity

Precaution

... and even Economic!





# THE OCEAN

> 70% of the Earth's surface is covered by seawater

3800 m mean depth

$1370 \times 10^6 \text{ Km}^3$  of the Earth's volume

97% of the water in the planet





# THE OCEAN

> 70% of the Earth's surface is covered by seawater

3800 m mean depth

$1370 \times 10^6 \text{ Km}^3$  of the Earth's volume

97% of the water in the planet



... and yet, we don't know much about it!

# Life originated in the primitive Ocean:



3500 m.y.	anaerobic bacteria, archaea
2500 m.y.	aerobic bacteria
2000 m.y.	eukaryotes
670 m.y.	metazoans
500 m.y.	terrestrial metazoans
400 m.y.	plants and terrestrial arthropodes
360 m.y.	amphibians
300 m.y.	gymnosperms, reptiles
200 m.y.	mammals
175 m.y.	birds
125 m.y.	flowering plants



# Life originated in the primitive Ocean:



- |           |                                    |
|-----------|------------------------------------|
| 3500 m.y. | anaerobic bacteria, archaea        |
| 2500 m.y. | aerobic bacteria                   |
| 2000 m.y. | eukaryotes                         |
| 670 m.y.  | metazoans                          |
| 500 m.y.  | terrestrial metazoans              |
| 400 m.y.  | plants and terrestrial arthropodes |
| 360 m.y.  | amphibians                         |
| 300 m.y.  | gymnosperms, reptiles              |
| 200 m.y.  | mammals                            |
| 175 m.y.  | birds                              |
| 125 m.y.  | flowering plants                   |

## Terrestrial environment: 1375000 species

Plants: 345000 species (78% flowering plants)

Animals: 1030000 species (>85% insects)

## Marine environment: 207000 species

Plants: 7000 species

Animals: 200000 species



**Terrestrial environment: 1375000 species**

Plants: 345000 species (78% flowering plants)

Animals: 1030000 species (>85% insects)

**Marine environment: 207000 species**

Plants: 7000 species

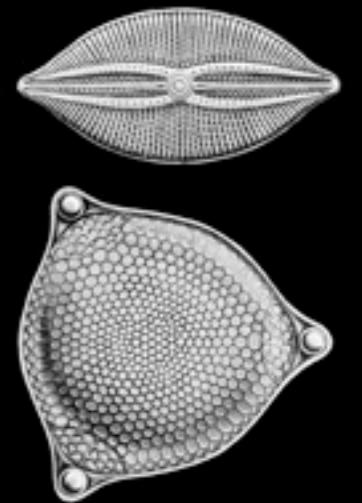
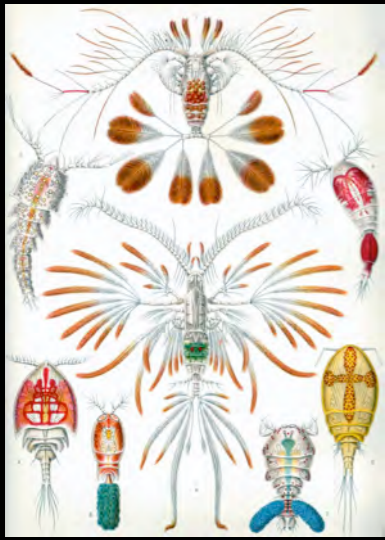
Animals: 200000 species



**Which means that marine biodiversity  
represents only a 13% of total biodiversity!**  
(although there's 300 times more space!)



# Diversity of life forms is greater in the marine environment





# WHY?:

## Speciation Ocean vs Land

- great dispersal capacity
- extense geographic areas
- low speciation rates
- no co-evolution plant-insect
- great stratigraphic longevity
- low extinction rates
- LACK OF KNOWLEDGE



Mean evolutionary longevity of different groups:

### MARINE

Corals 25 m.y.  
Bivalves 20 m.y.  
Bryozoa 12 m.y.  
Gastropods 10 m.y.  
Echinoderms 7 m.y.

### NON-MARINE

Monocots 4 m.y.  
Artiodactyla 4 m.y.  
Dicots 3 m.y.  
Birds 2.5 m.y.  
Mammals 1.7 m.y.  
Insects 1.5 m.y.  
Primates 1 m.y.



## Of the 34 great phyla of metazoans:

Exclusively terrestrial: 1 (Onicophores)  
Exclusively marine: >16



# Where do these marine organisms live?:

- 90% benthic species
- 80% of the species live above 200 m
- 71% live in coastal areas of tropical seas
- 30% live in coral reefs





# Where do these marine organisms live?:

- 90% benthic species
- 80% of the species live above 200 m
- 71% live in coastal areas of tropical seas
- 30% live in coral reefs



50% of the planet's surface is DEEP SEA (and only 0.0001% has been explored).

New habitats: hydrothermal vents, cold seeps and pockmarks, deep trenches, seamounts, canyons, deep-coral communities, whale pitfalls





# Where do these marine organisms live?:

- 90% benthic species
- 80% of the species live above 200 m
- 71% live in coastal areas of tropical seas
- 30% live in coral reefs



50% of the planet's surface is DEEP SEA (and only 0.0001% has been explored).

New habitats: hydrothermal vents, cold seeps and pockmarks, deep trenches, seamounts, canyons, deep-coral communities, whale pitfalls



approx. 1800 new species/year  
perhaps 1-10 million species exist in the Ocean!

# Which clues do we have for foreseeing the still hidden diversity of the Ocean?

## The Ocean is

- a very old and stable system
- a living system which receives energy from its external boundaries and with an enormous capacity of generating new production
- a system moving continuously
- a heterogeneous system (different habitats)
- a system full of internal boundaries

a system with high physical and biological heterogeneity



# Why are the oceans so unknown?

Until relatively recently, studying the Ocean meant almost...



Until the HMS *Challenger* expedition (1872-1876) we believed there was no life in the Ocean under 800 m depth!



# Why are the oceans so unknown?

Until relatively recently, studying the Ocean meant almost...



Until the HMS Challenger expedition (1872-1876) we believed there was no life in the Ocean under 800 m depth!

# Technology is recent

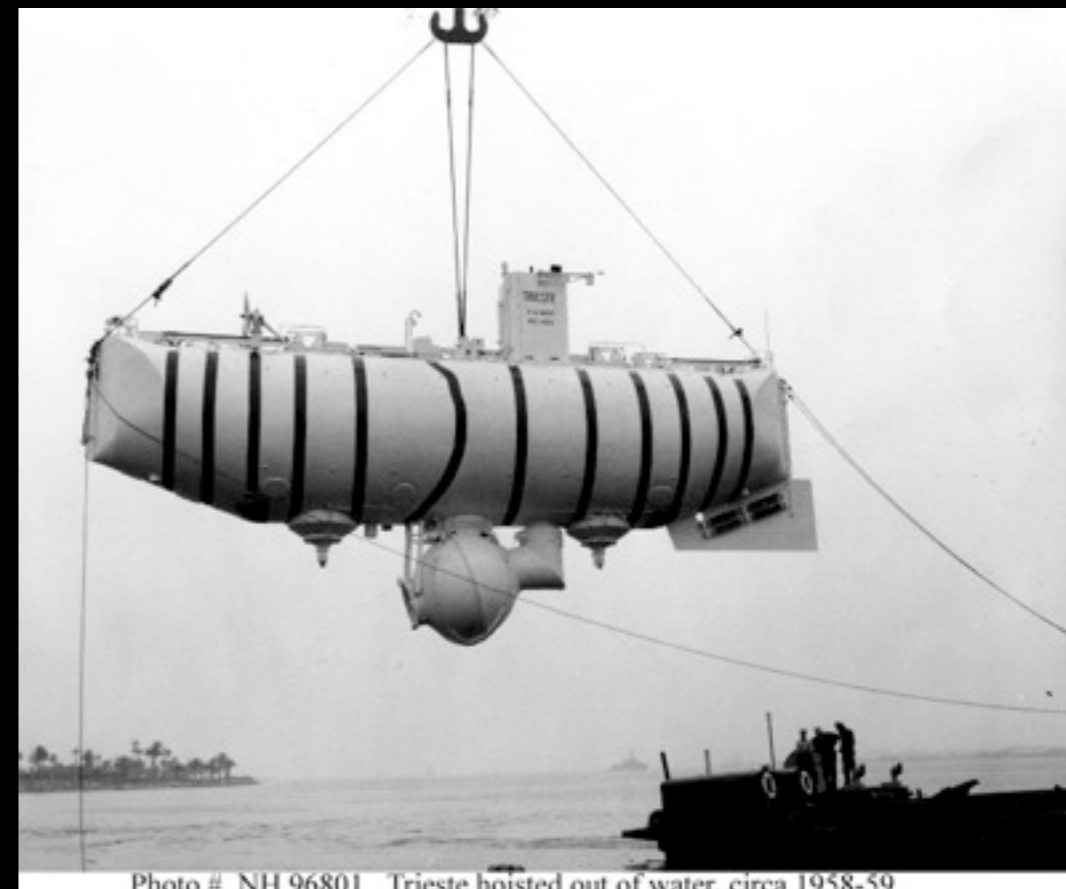
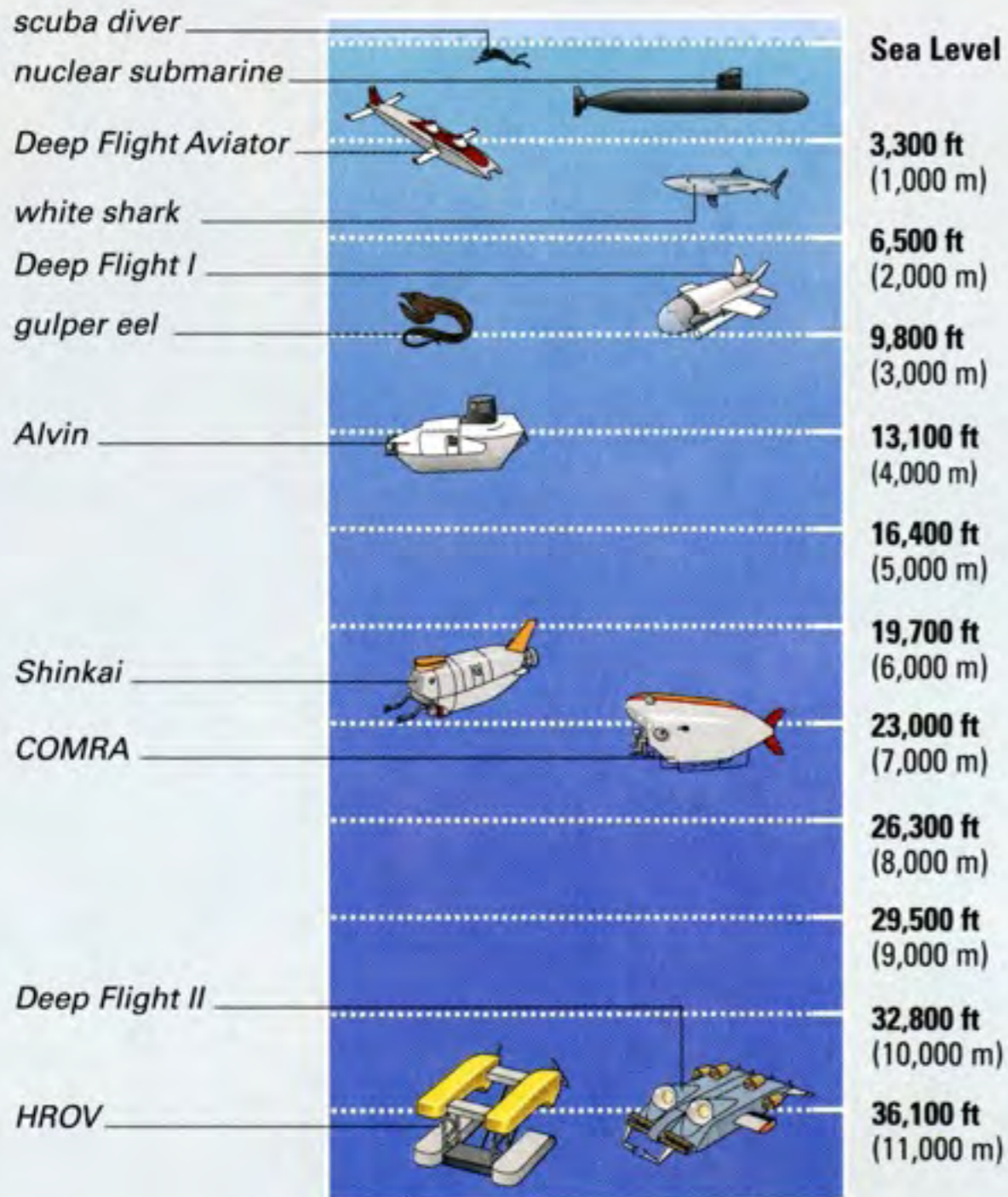
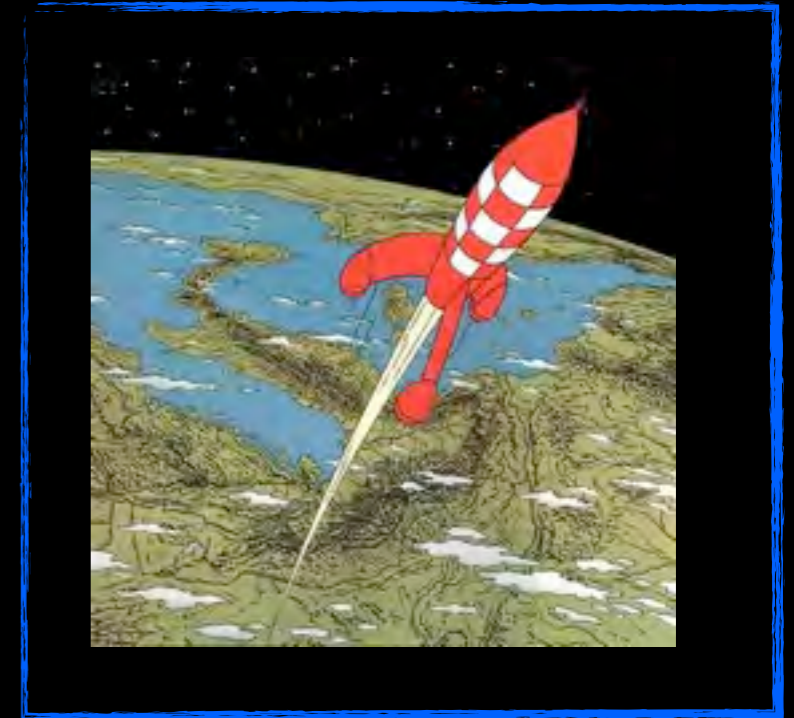
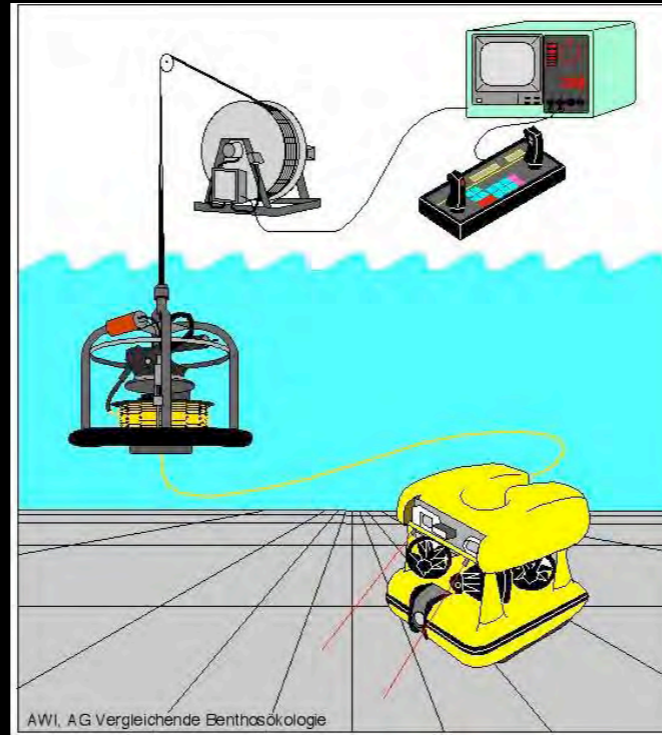
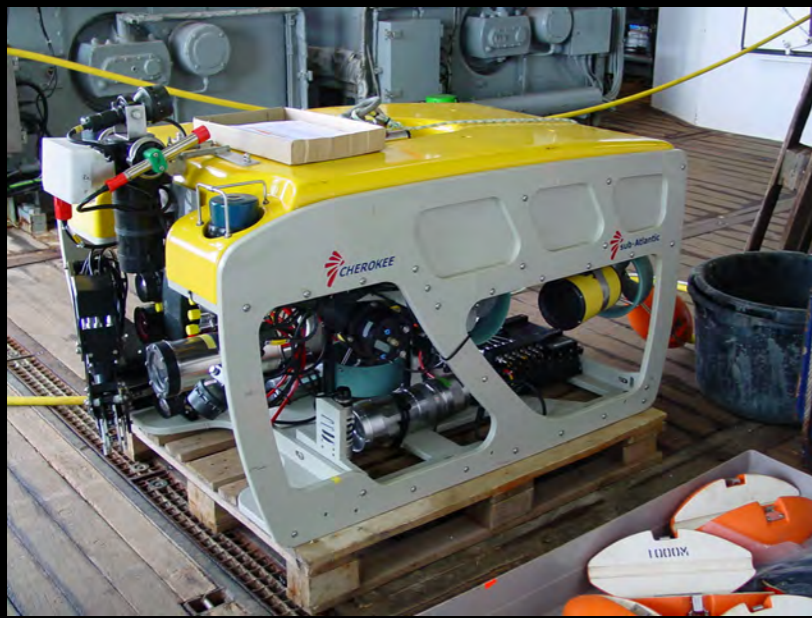


Photo # NH 96801 Trieste hoisted out of water, circa 1958-59

(1960 Trieste I 1000 m)



# We need technological advances







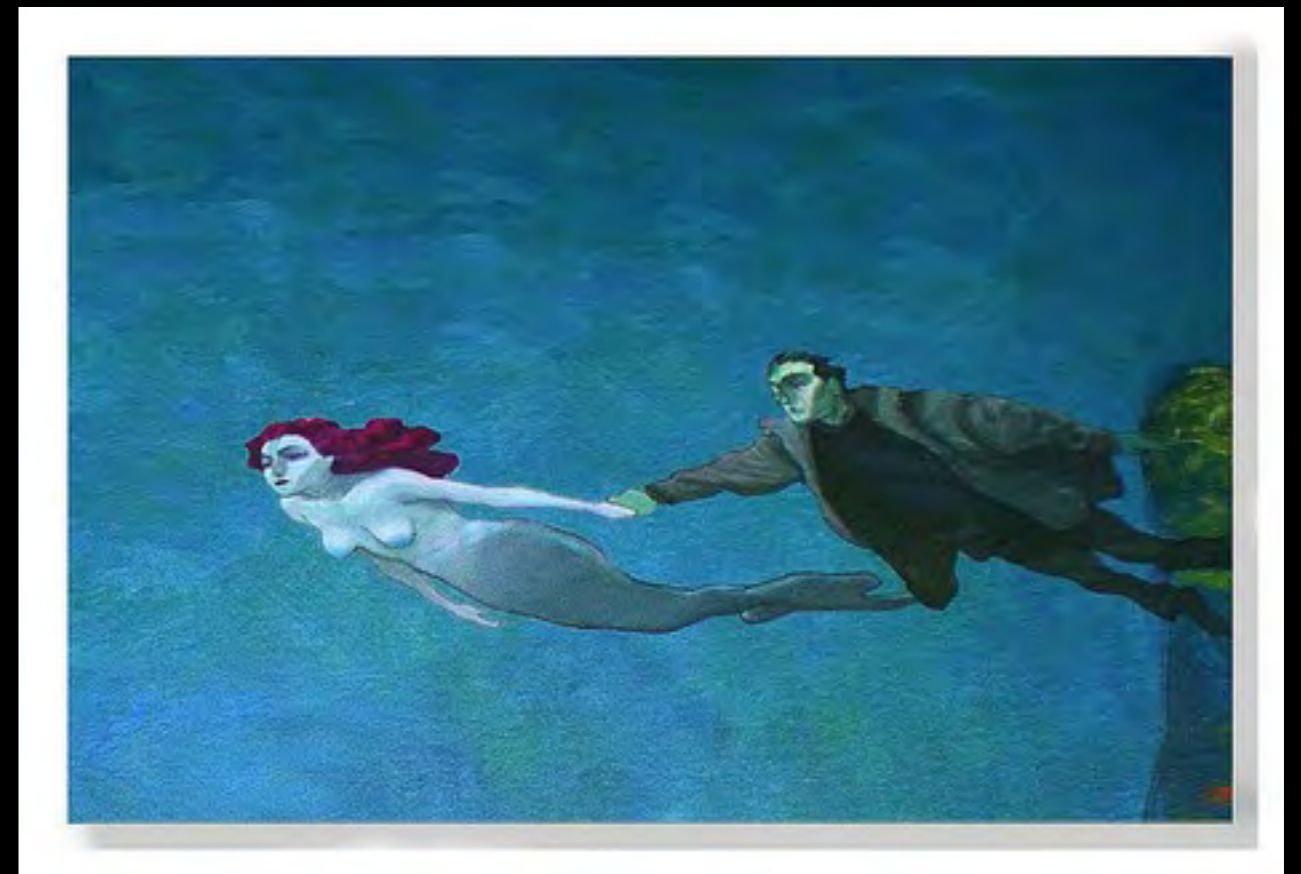
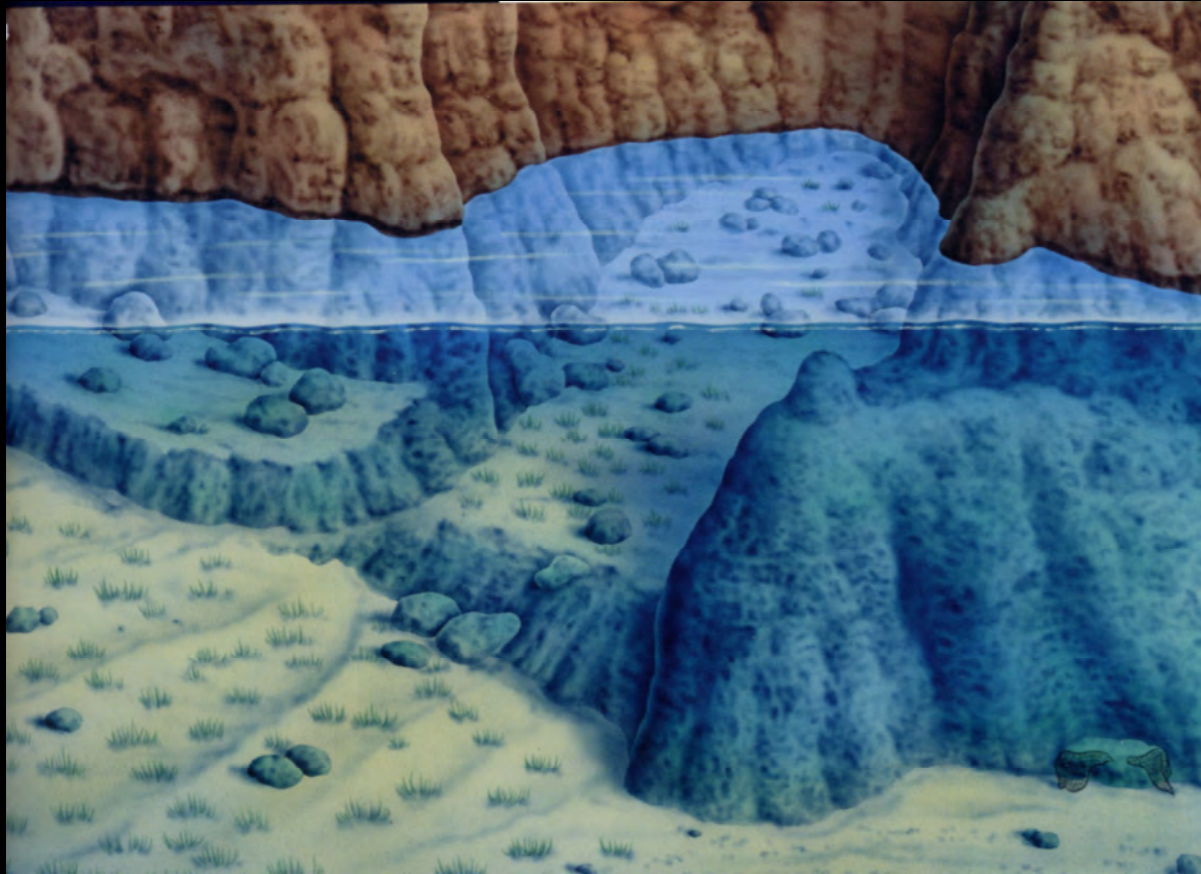








Imagine all you see...



... is covered by water



# Marine forests



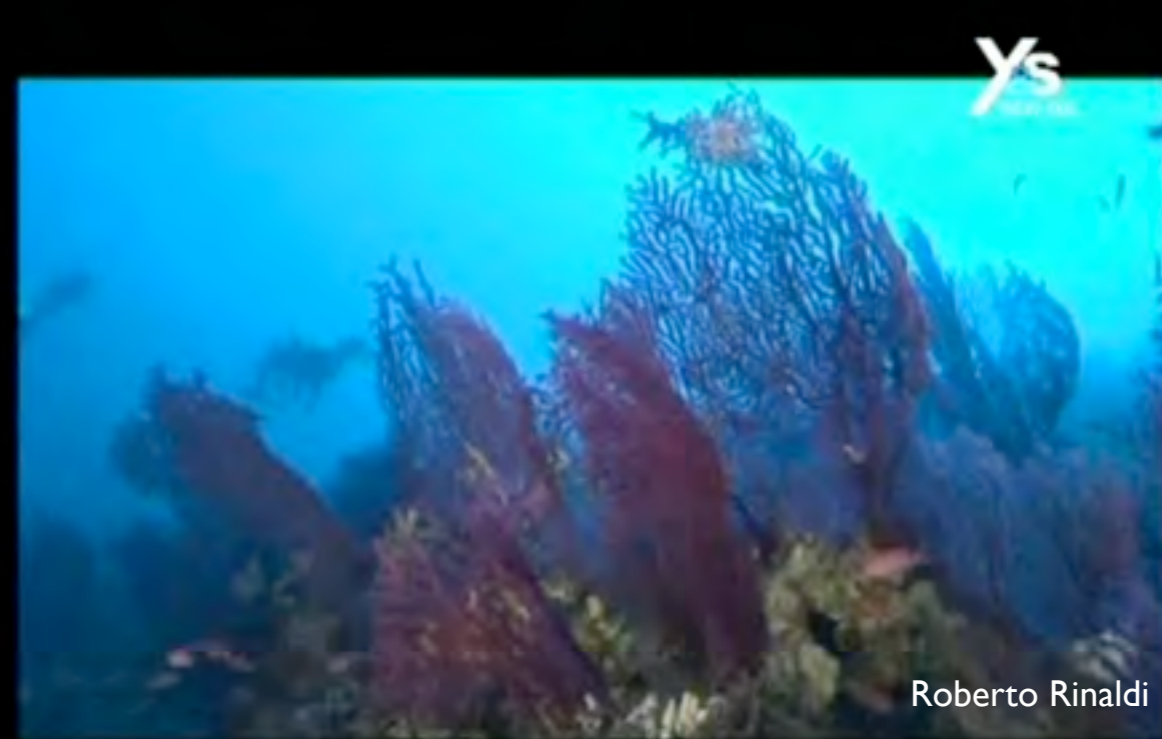


# The world of darkness

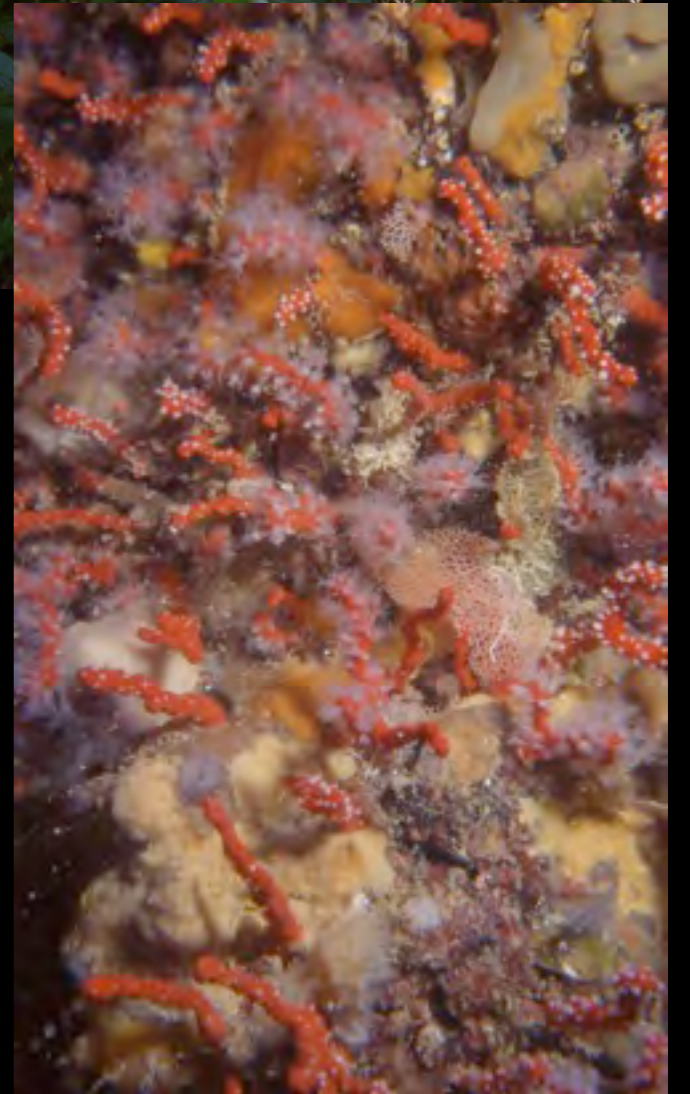
*La luz  
en el mar*

JM Gili

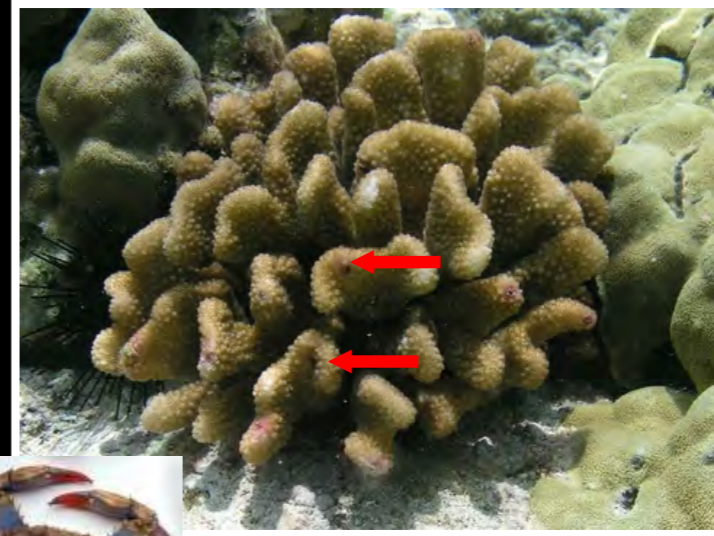
# The Earth's forests: on land and in the sea











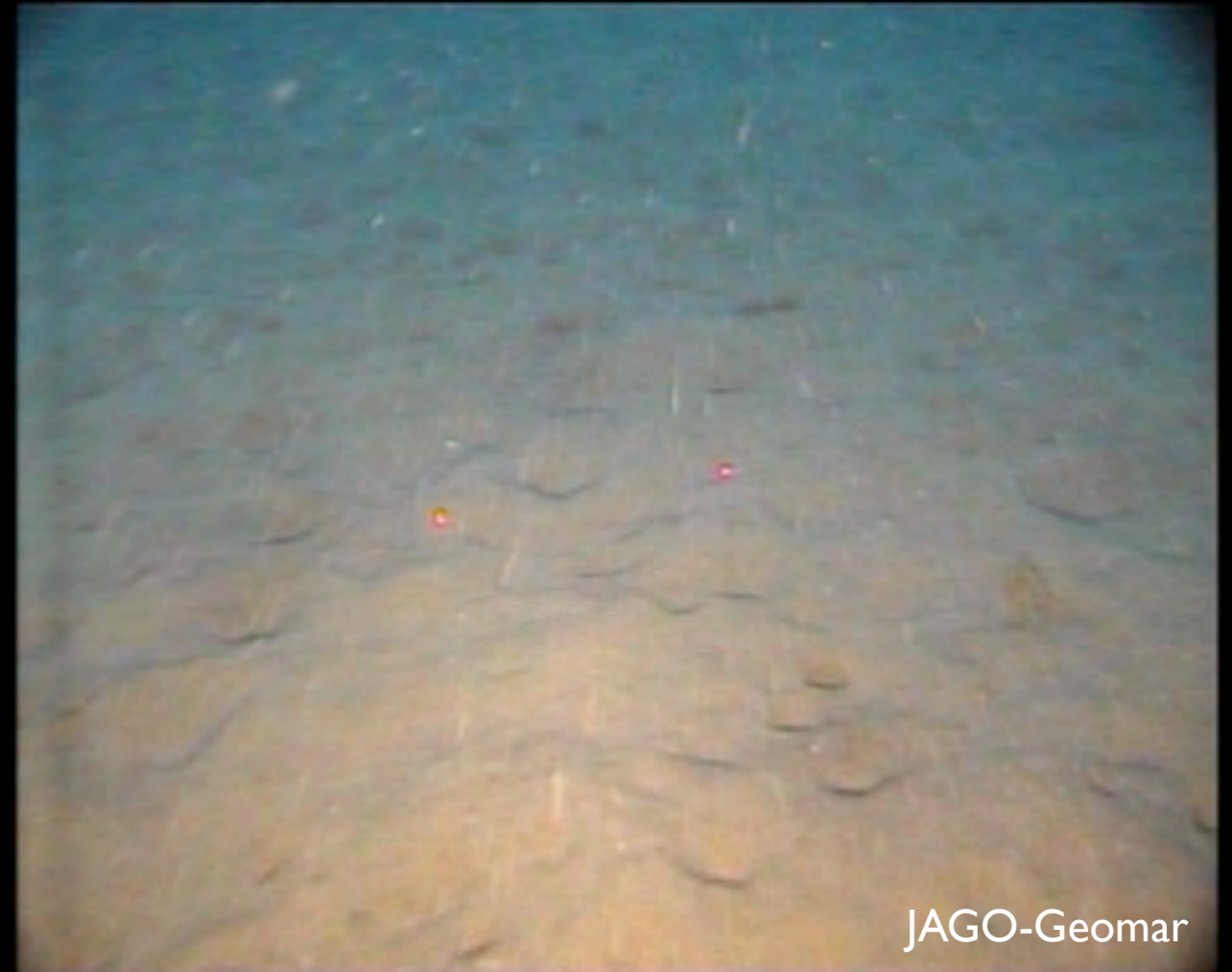




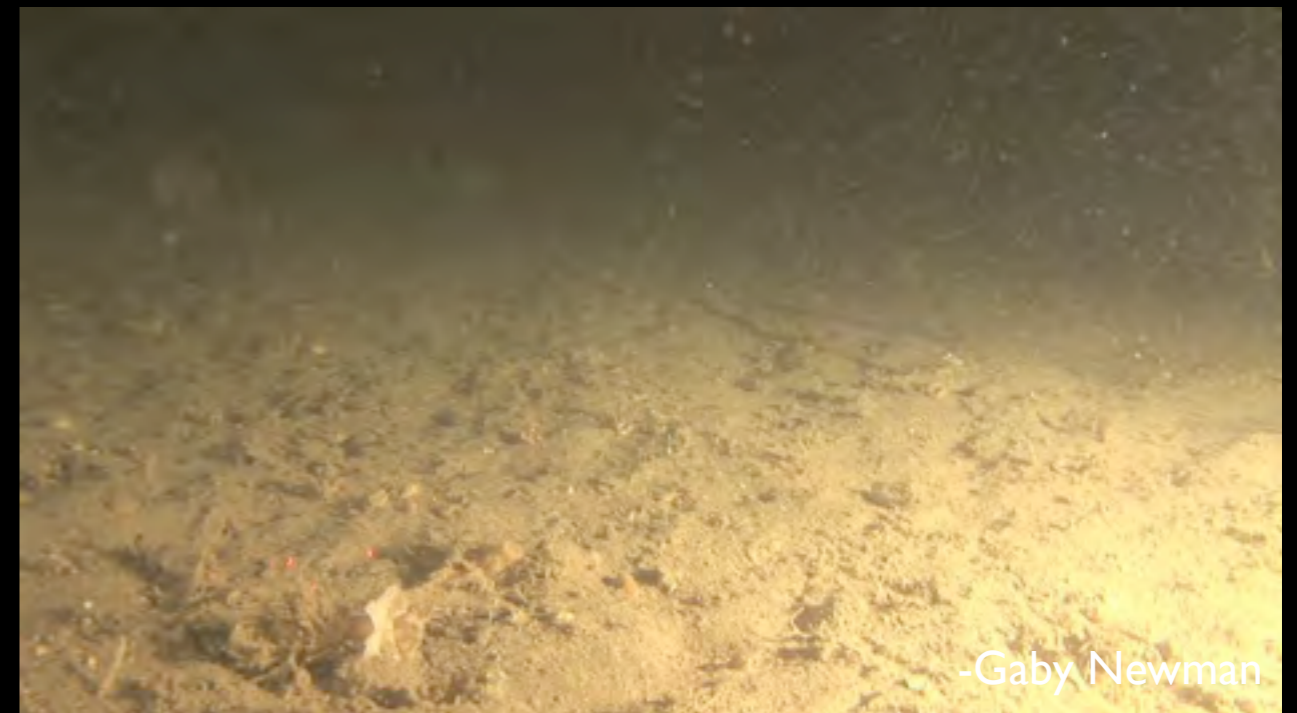
© P. Schuchert



# Holes: signs of biological activity

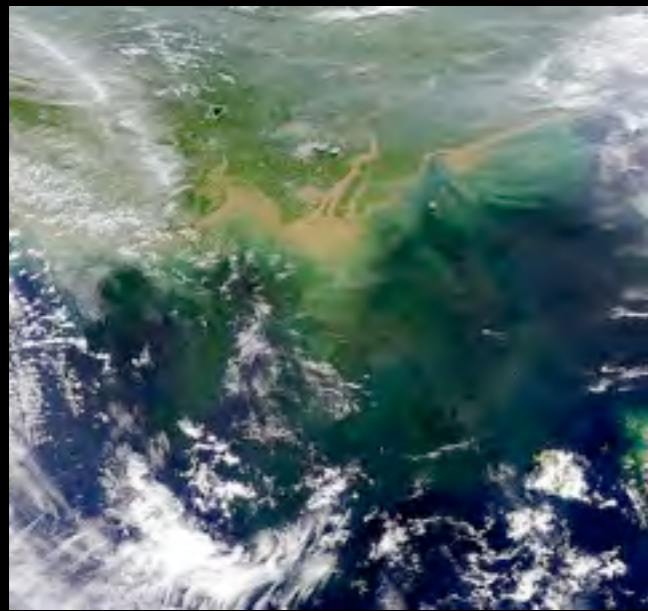


JAGO-Geomar

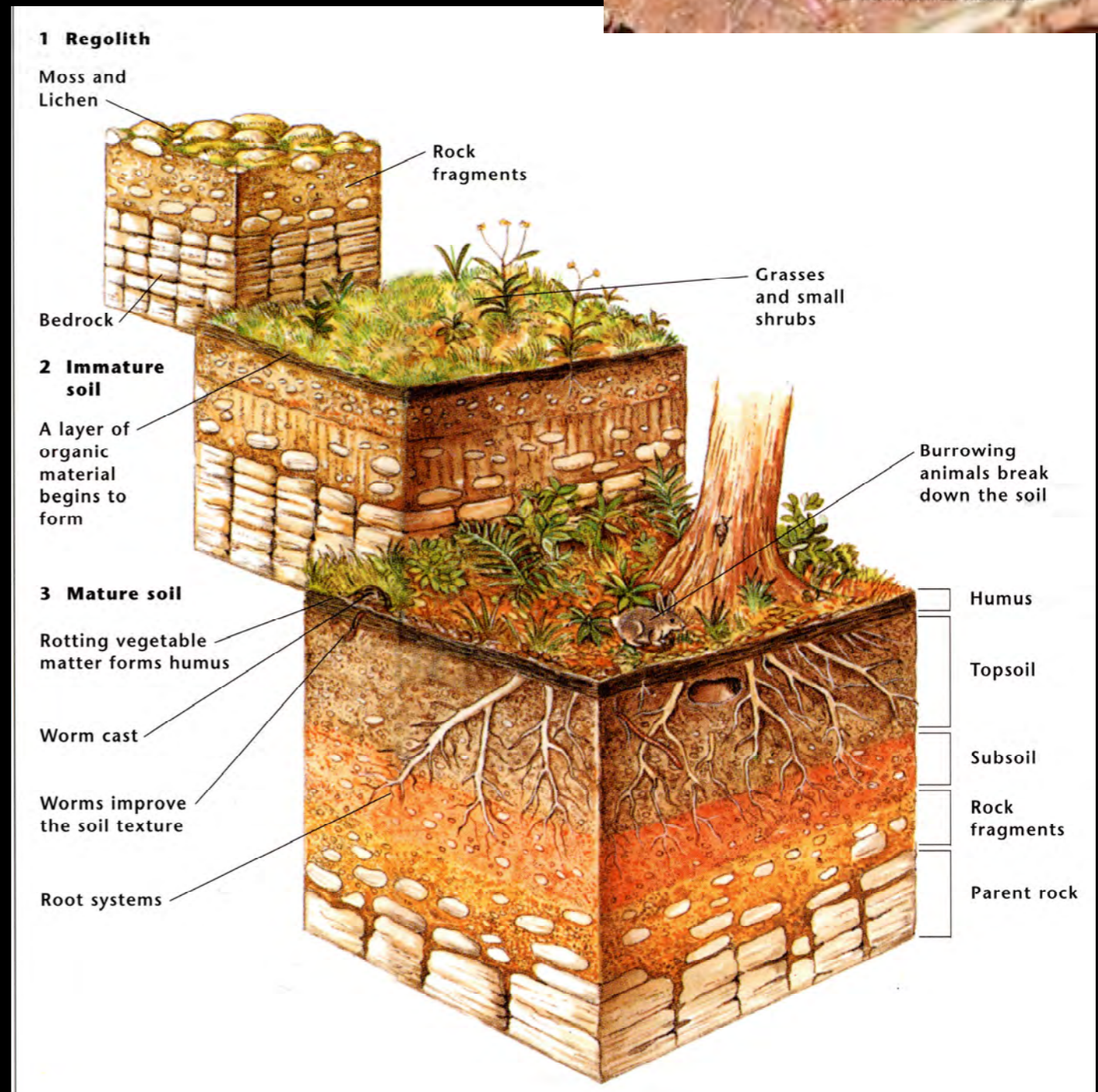
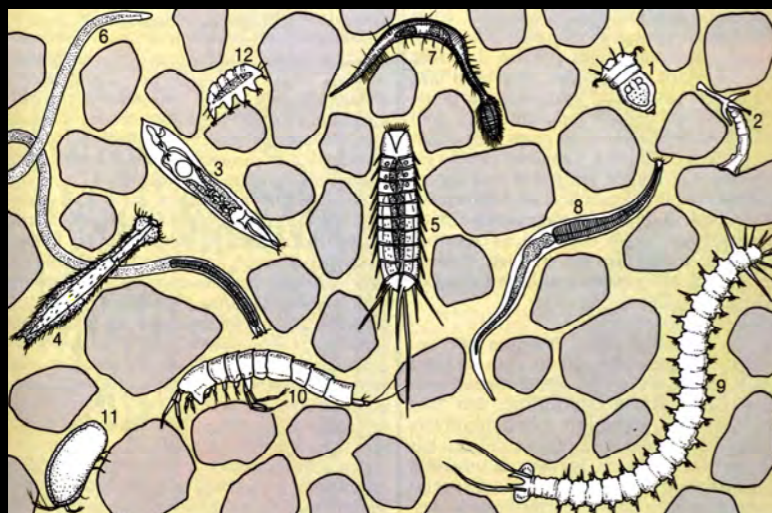
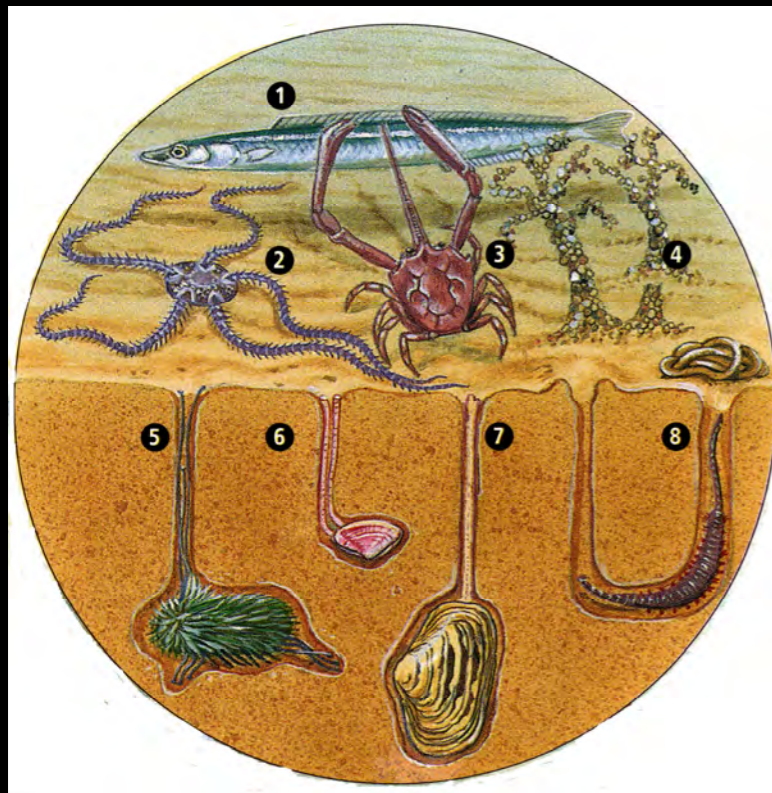


-Gaby Newman





# A new habitat



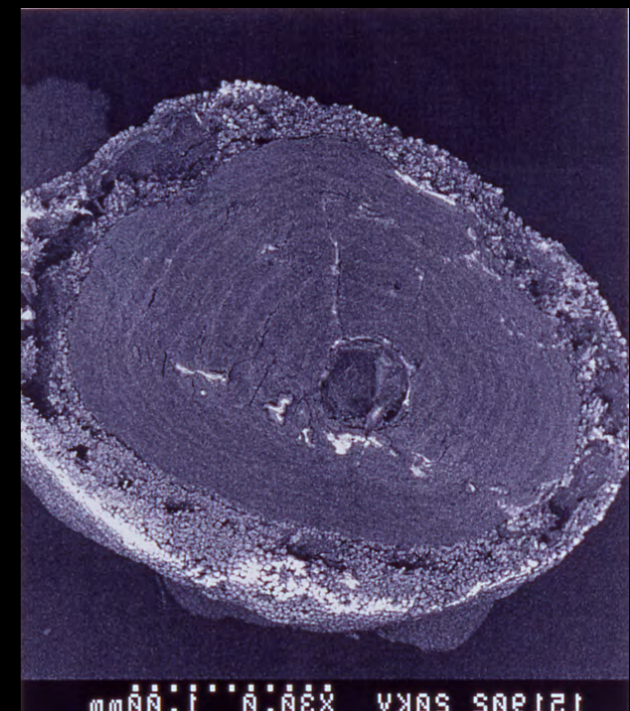


# Animals that grow like plants



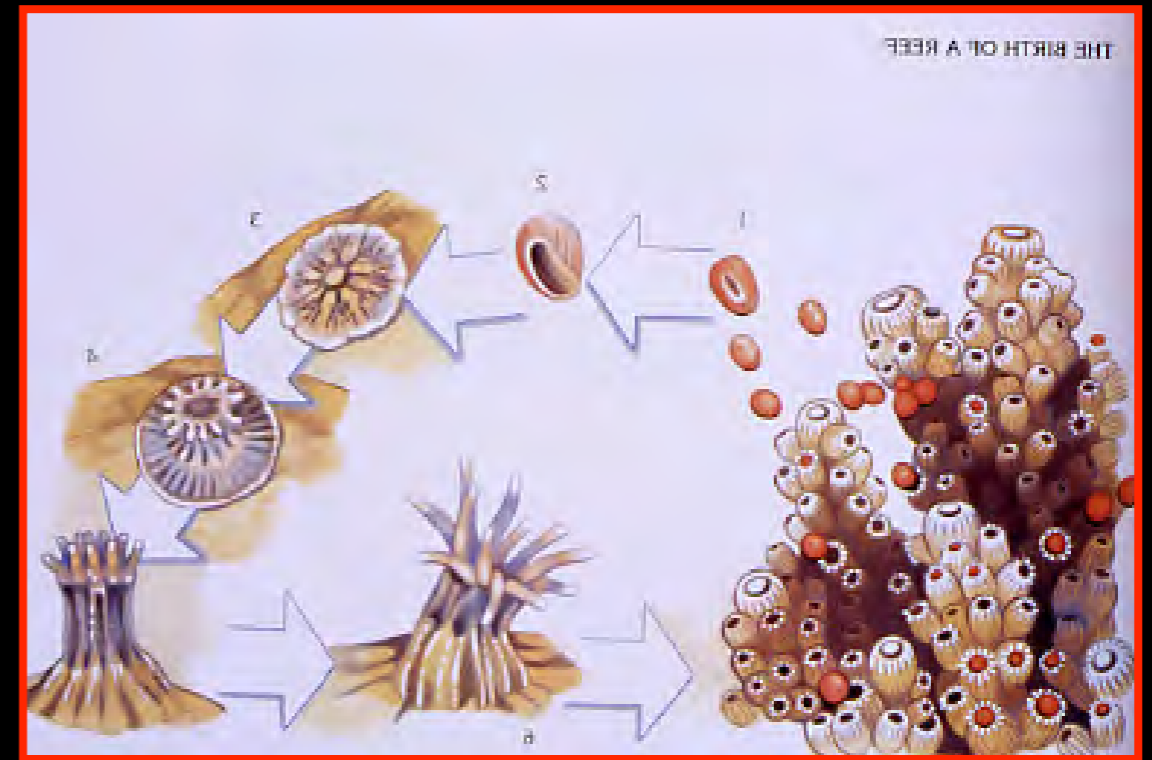


# Animals that grow like plants





# Animals that reproduce like plants

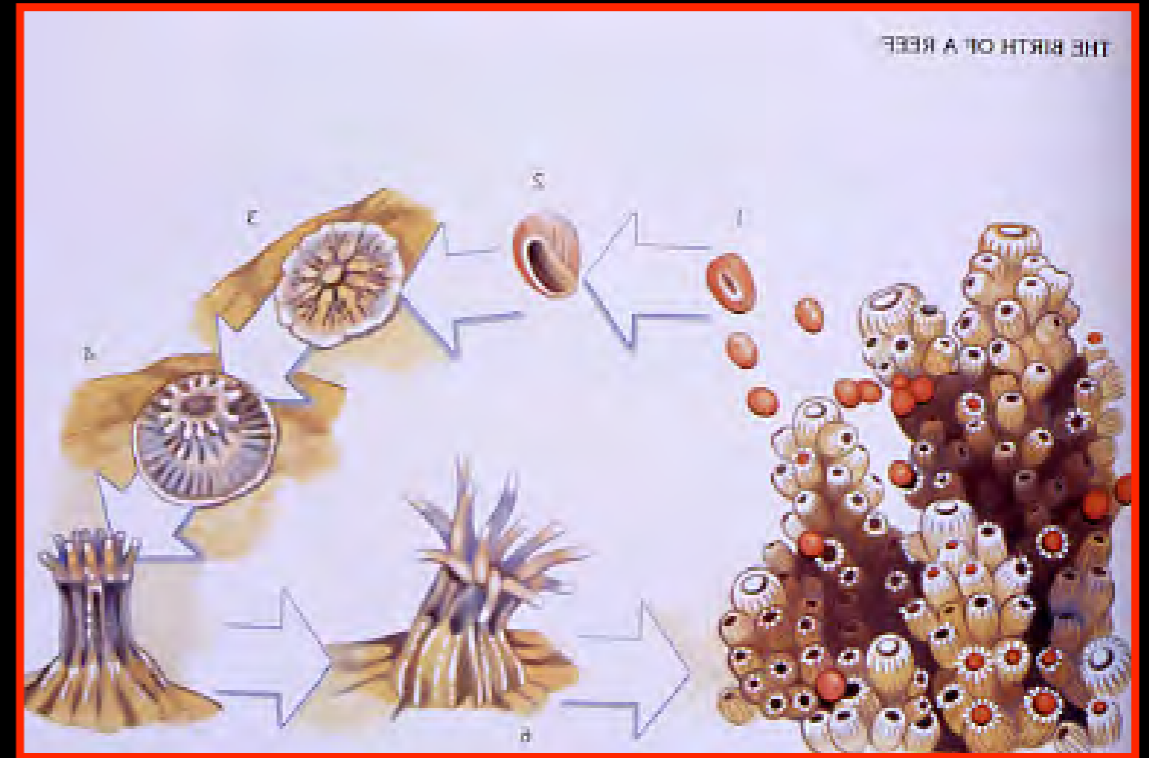




# Animals that reproduce like plants



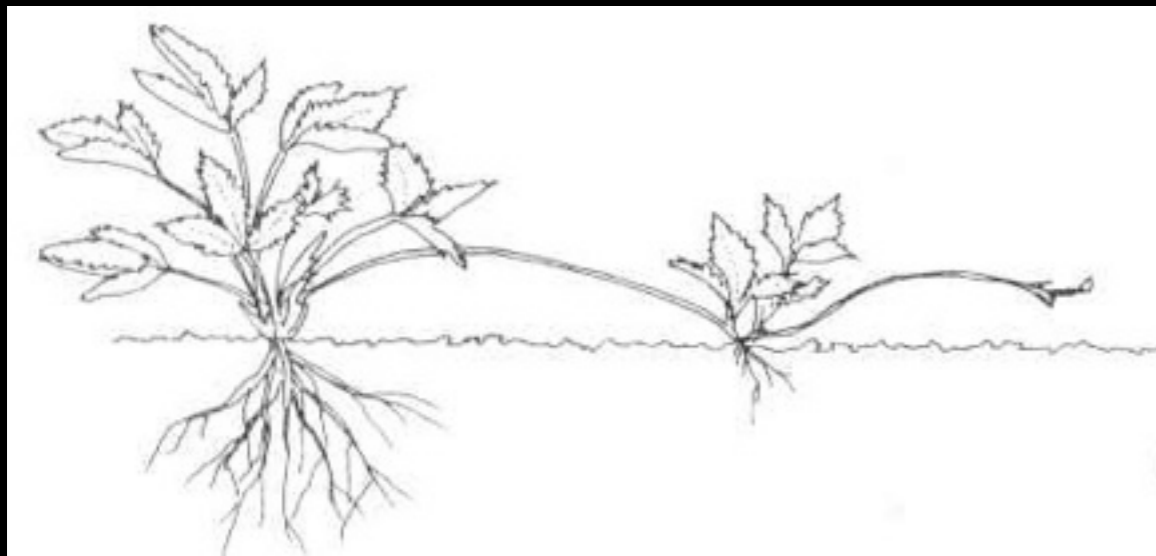
Coral Sea Dreaming



Natural Sciences Museum Barcelona

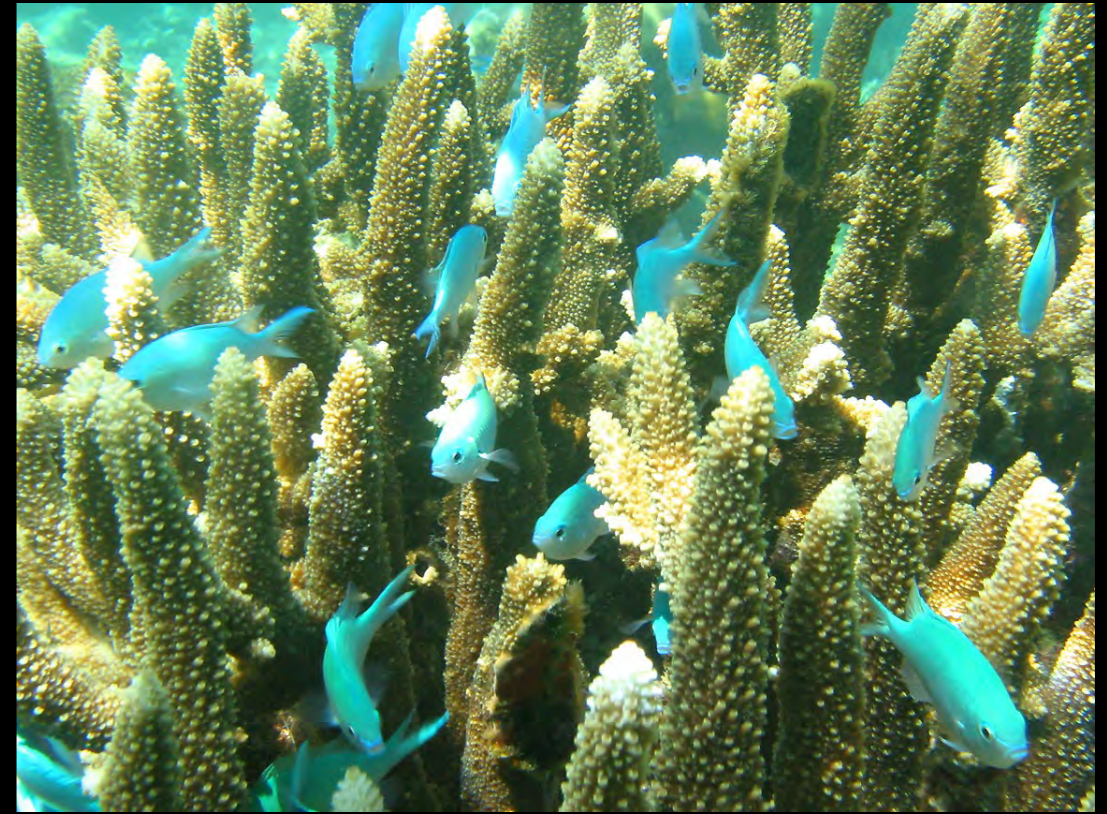








# Forests and prairies have similar functions







AWI



# Living in swarms



Deep Blue

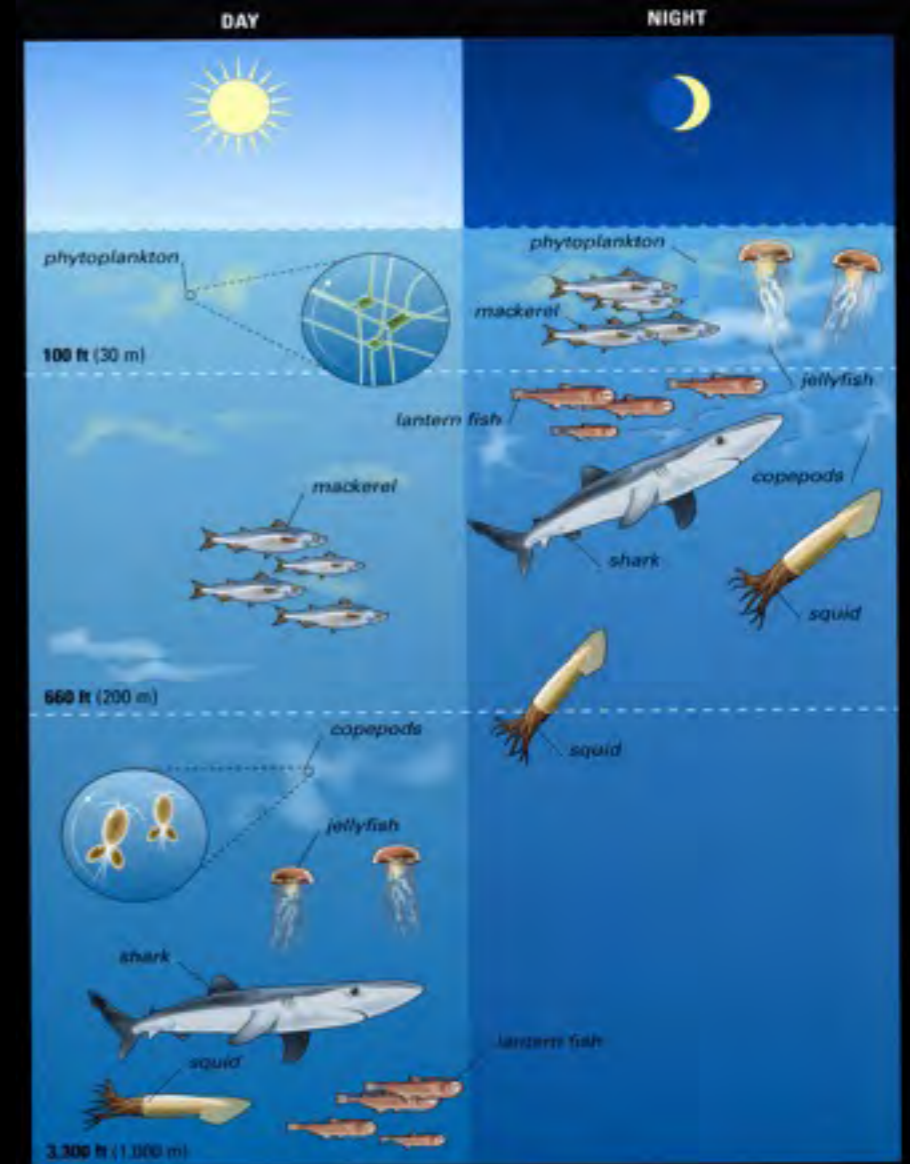


# Living in swarms



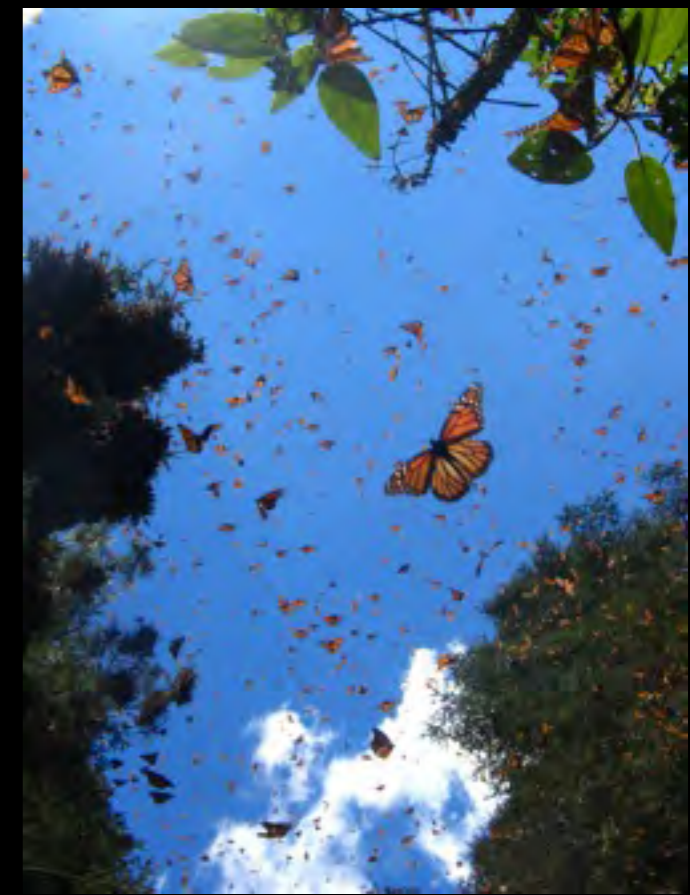


# Migrations in both systems





# Metamorphosis



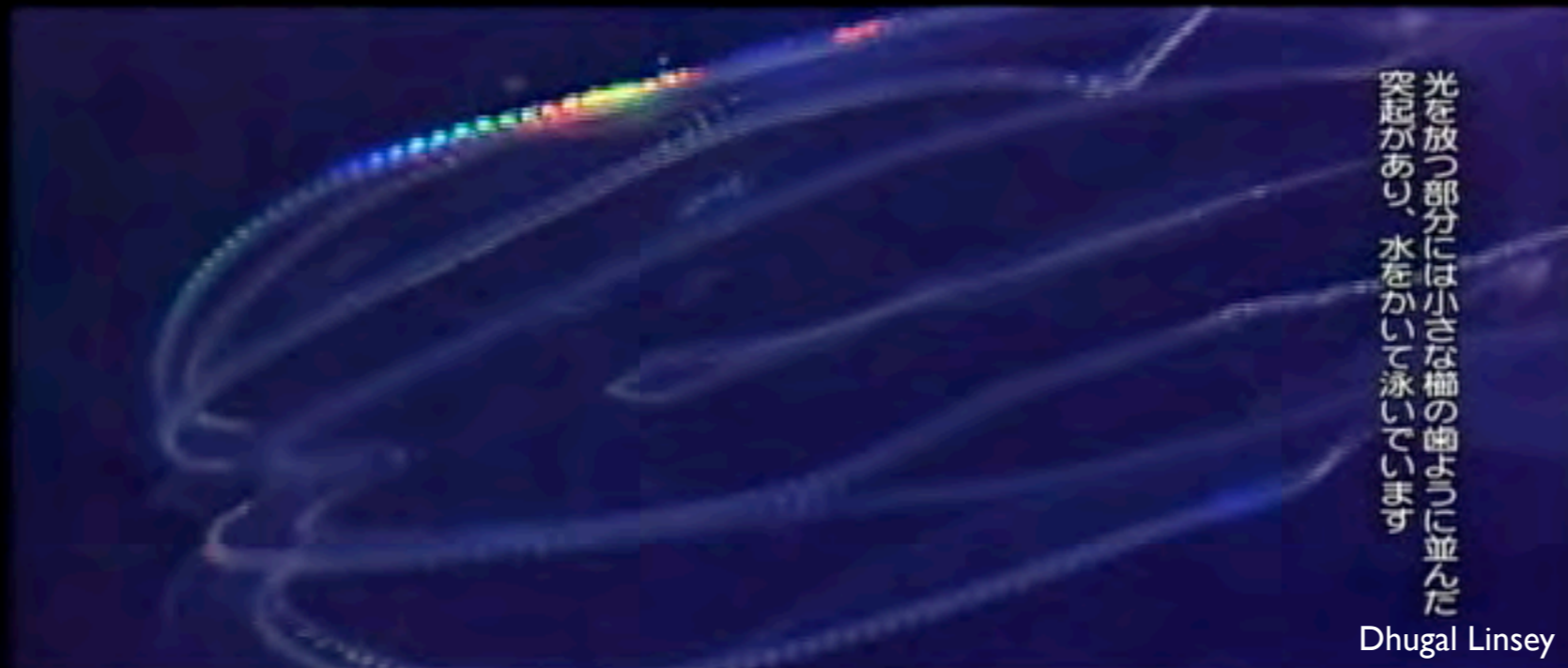


# Metamorphosis



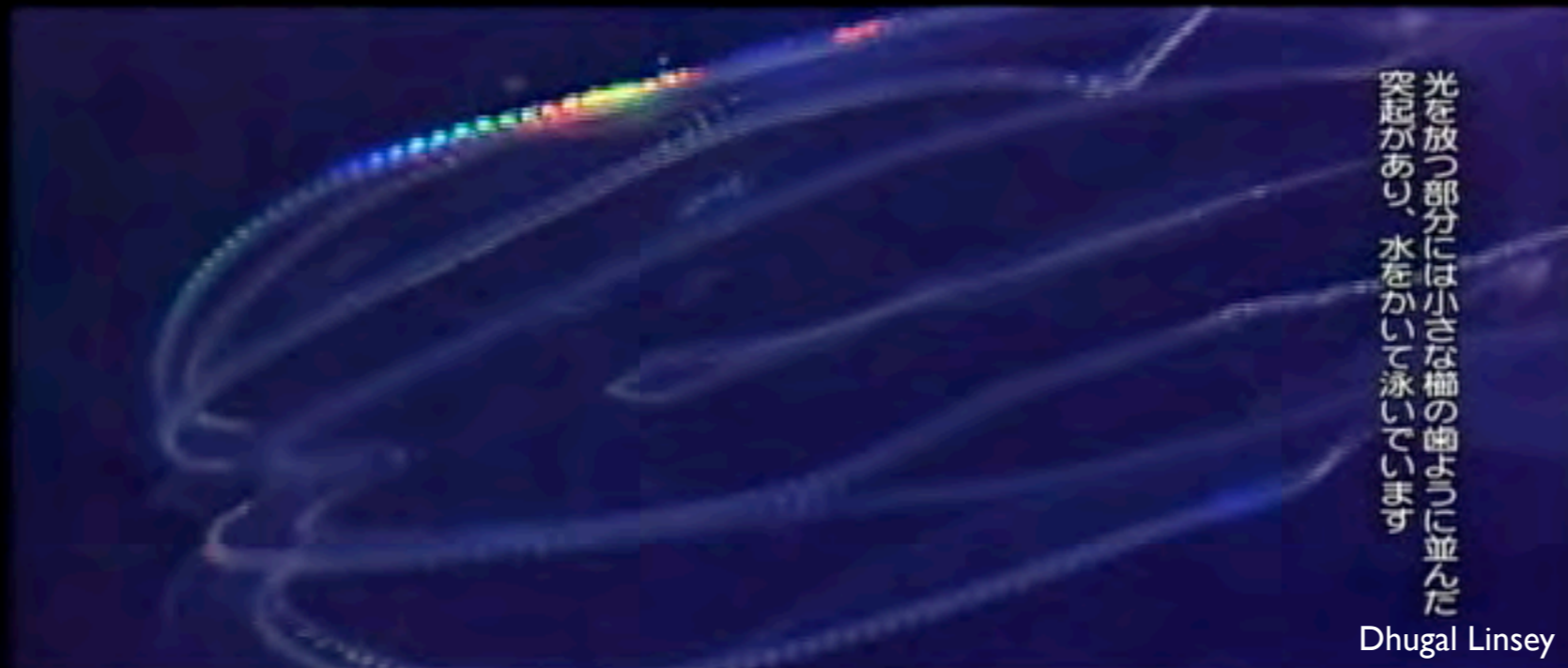


# Bioluminescence



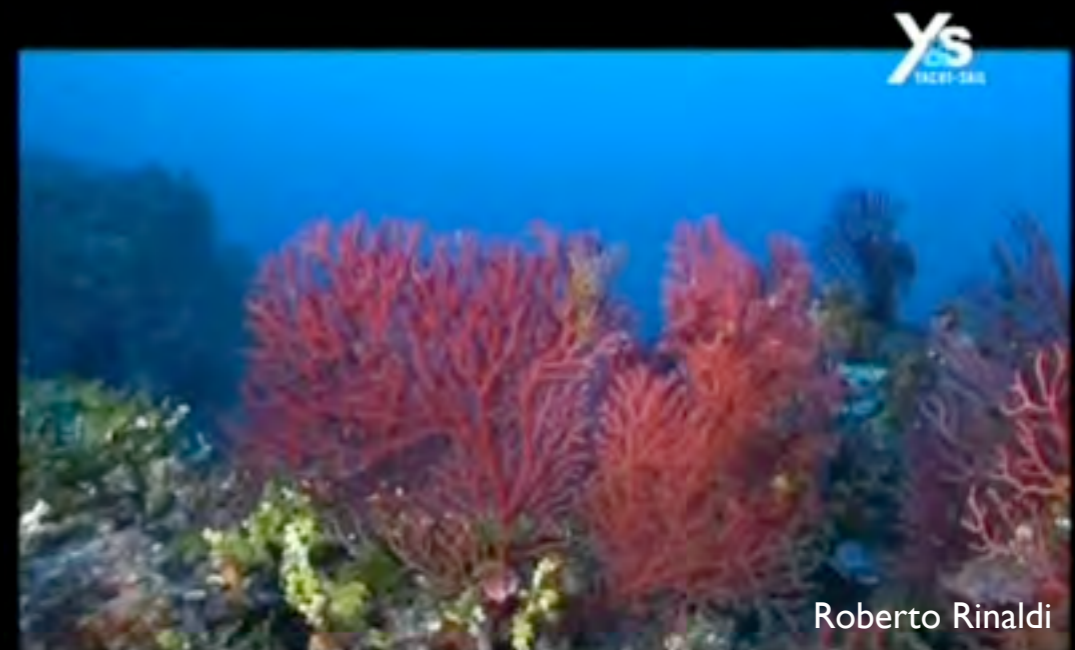


# Bioluminescence

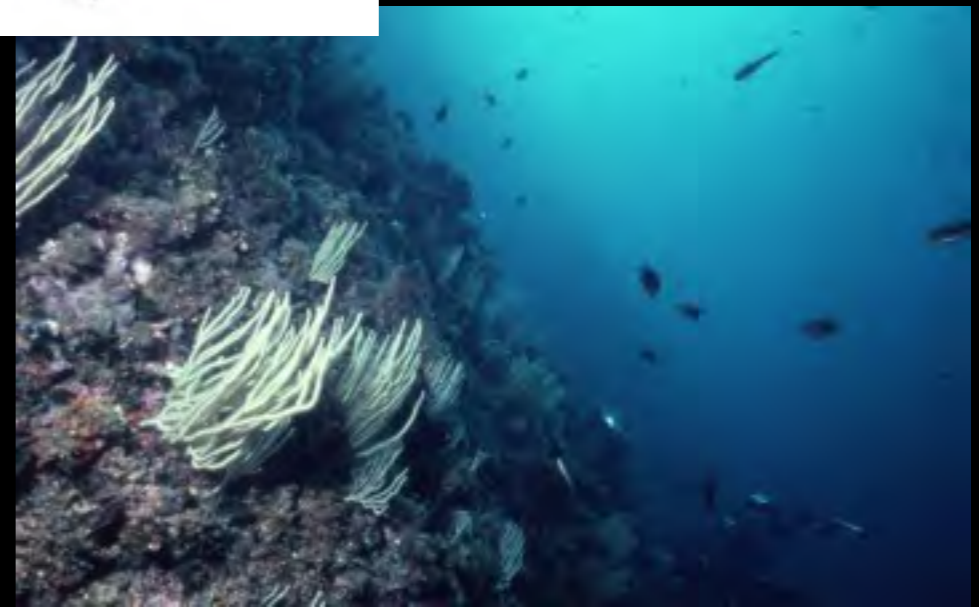
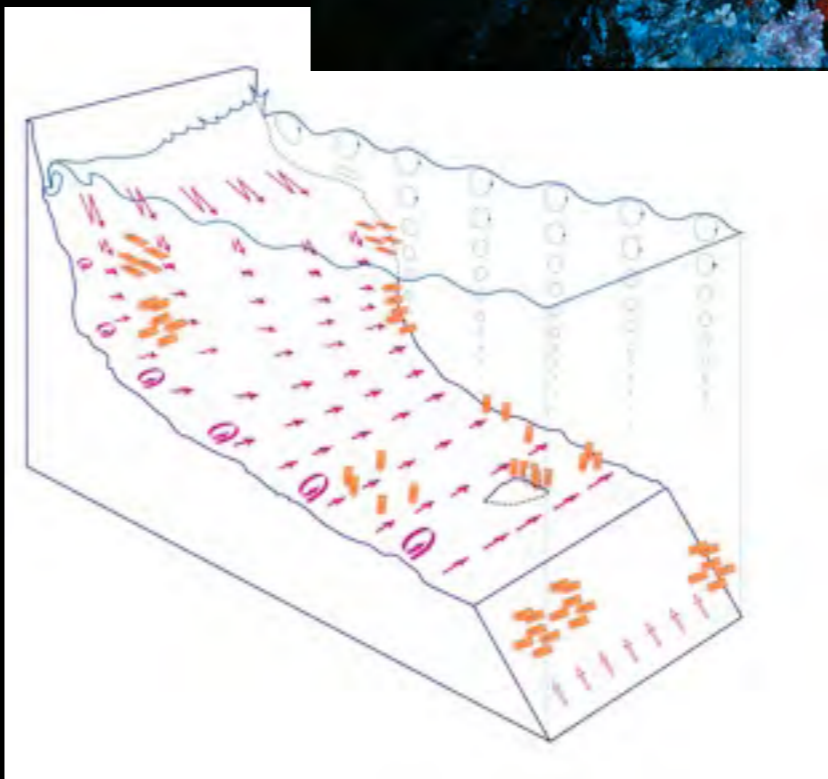




# A world of movement: wind and currents












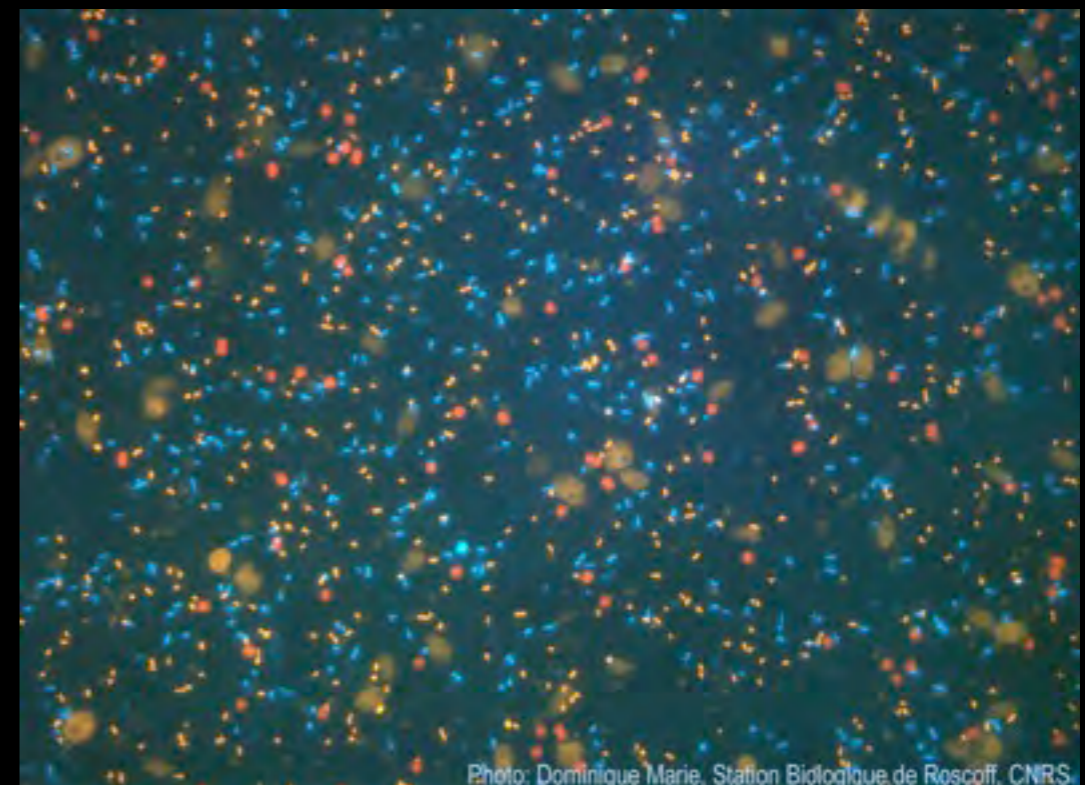


# The sea is like a big soup!

## Recepta del dia **Sopa de mar**

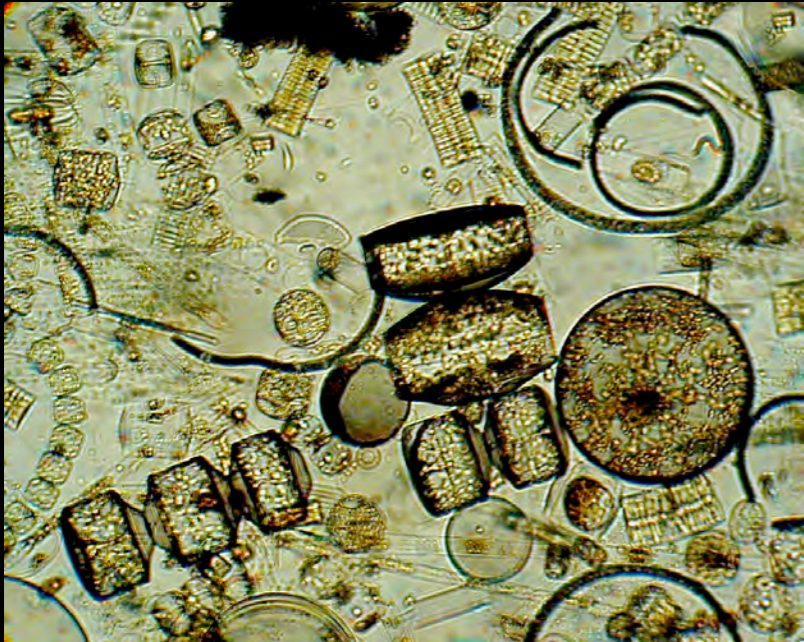
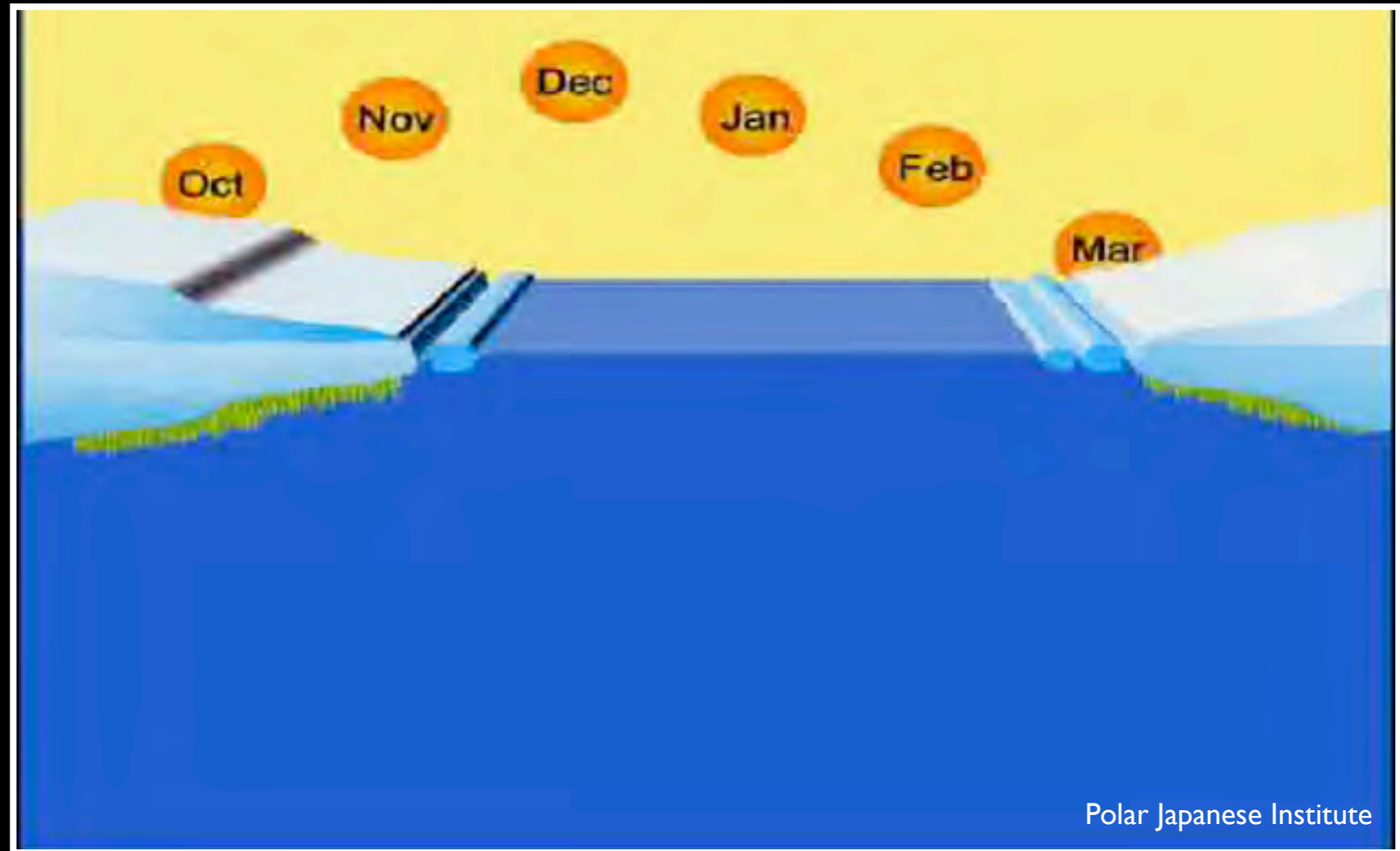
Per 1 ml d'aigua de mar cal posar:

10.000.000	virus	0,02 - 0,2 $\mu\text{m}$	
1.000.000	bacteris	0,2 - 2 $\mu\text{m}$	
1.000	algues petites	2 - 20 $\mu\text{m}$	
10	algues grans	20 - 200 $\mu\text{m}$	
1	ciliats	20 - 200 $\mu\text{m}$	
0.1	crustacis petits	2 - 200 mm	

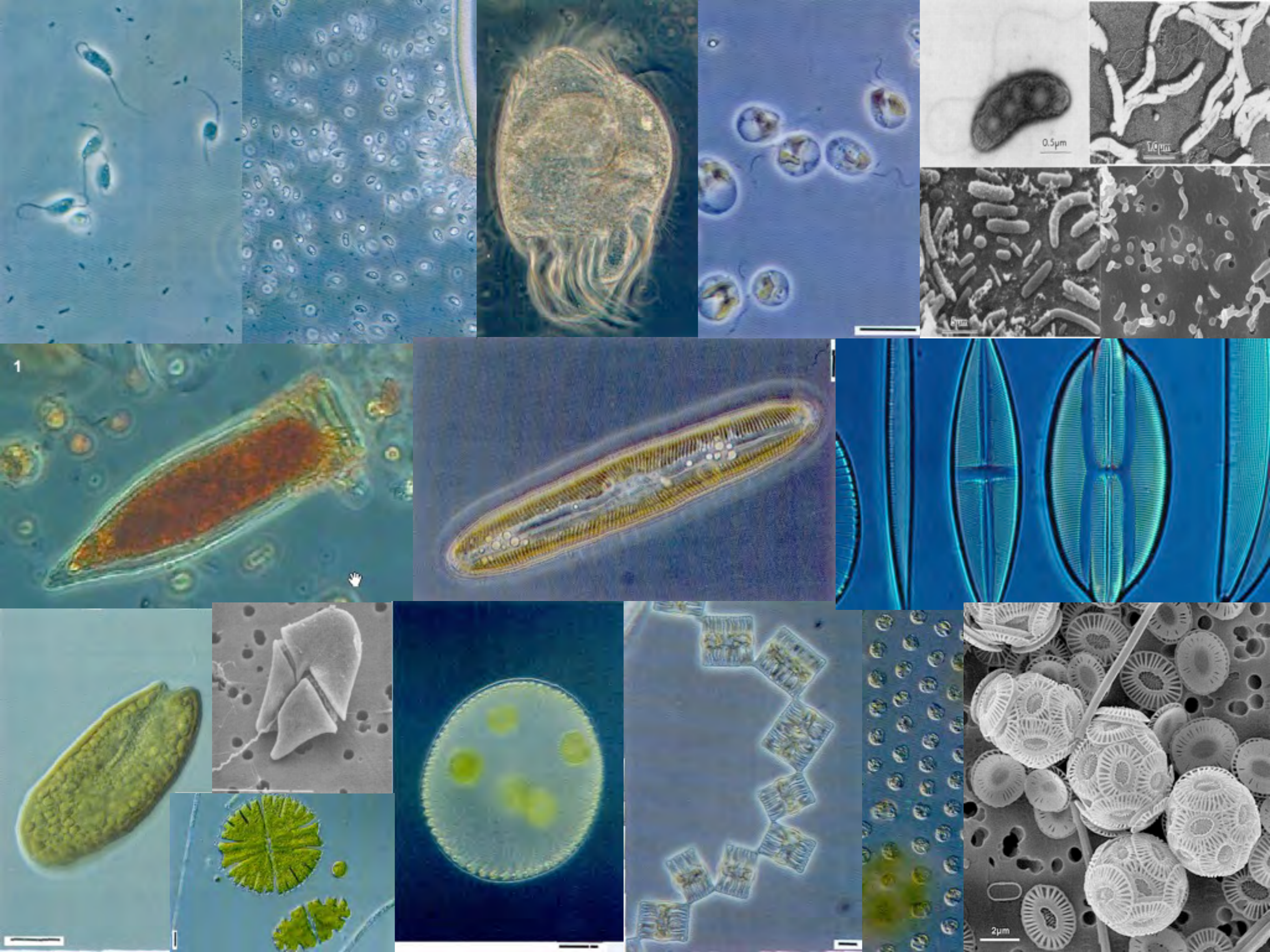




# Life starts with primary producers

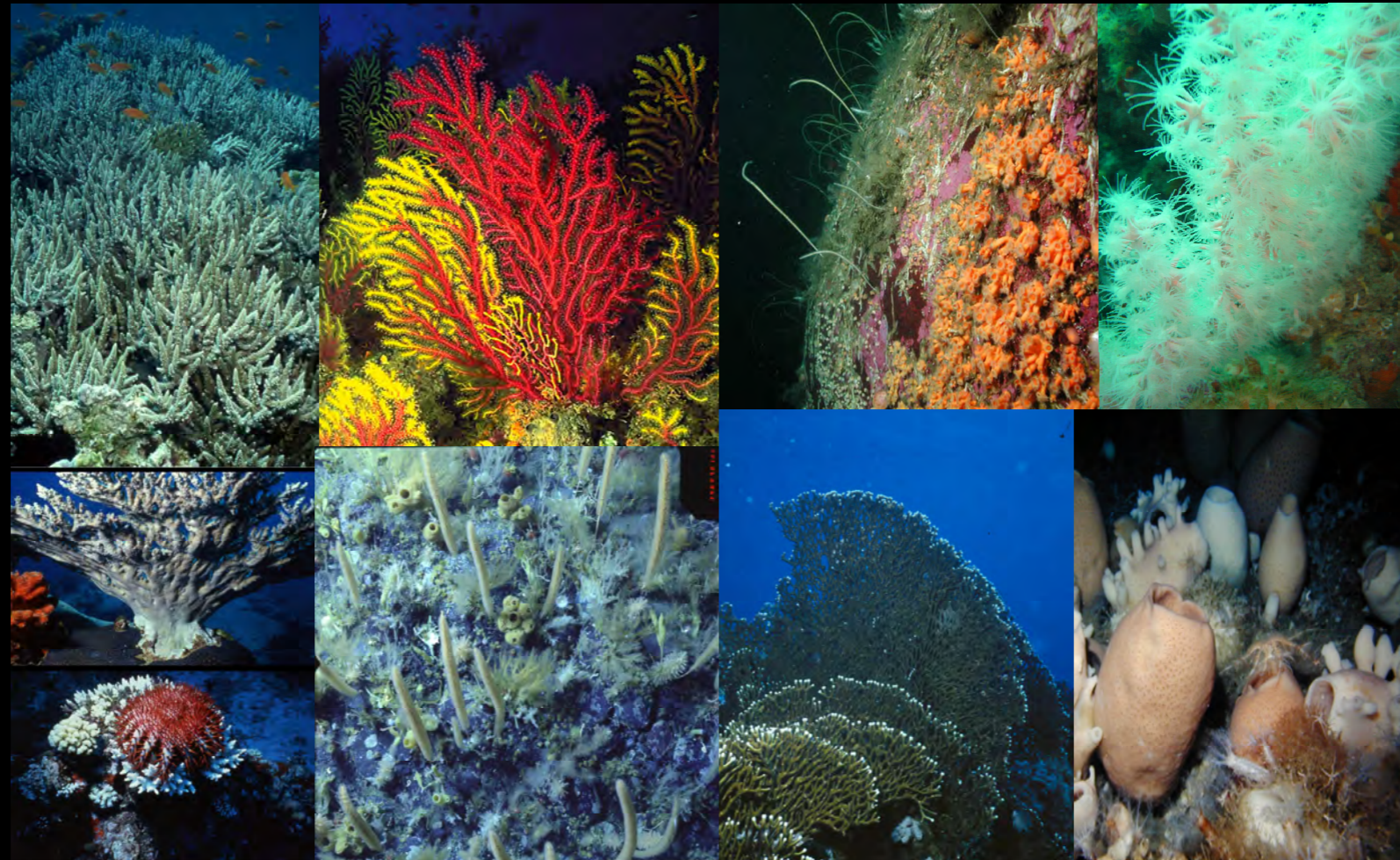








# Capturing particles: strategy of success in the oceans

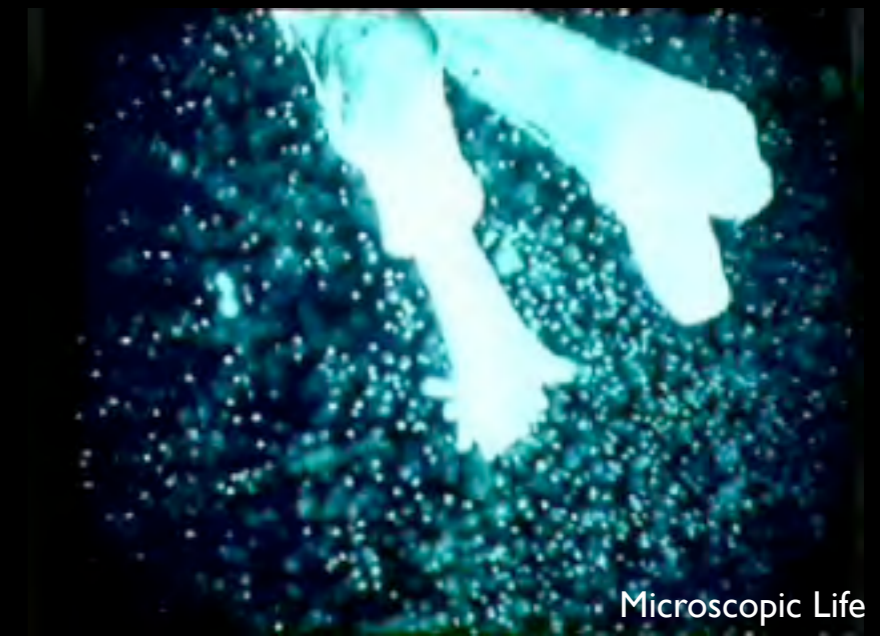






09.10.2005 11:14:53 CORAL 2 39 239.9 m

ICM-CSIC



Microscopic Life

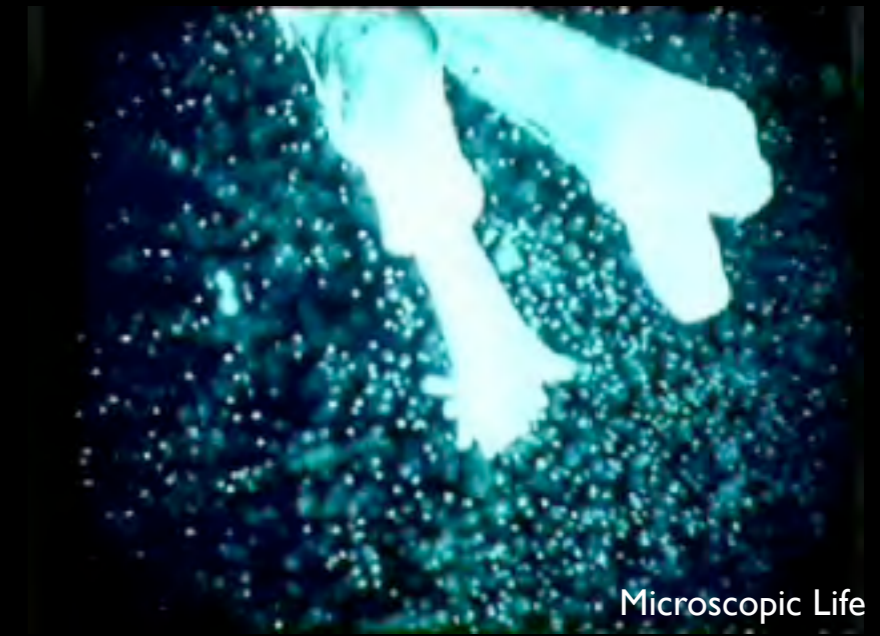






09.10.2005 11:14:53 CORAL 2 39 239.9m 280

ICM-CSIC

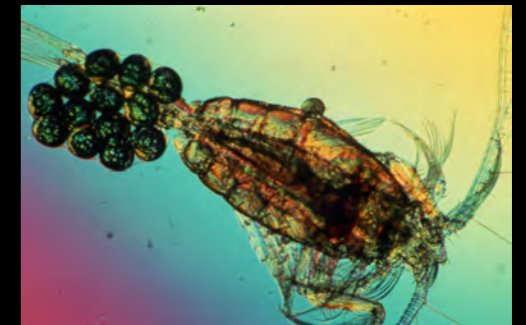
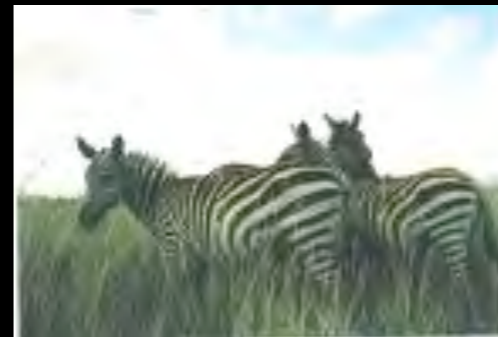
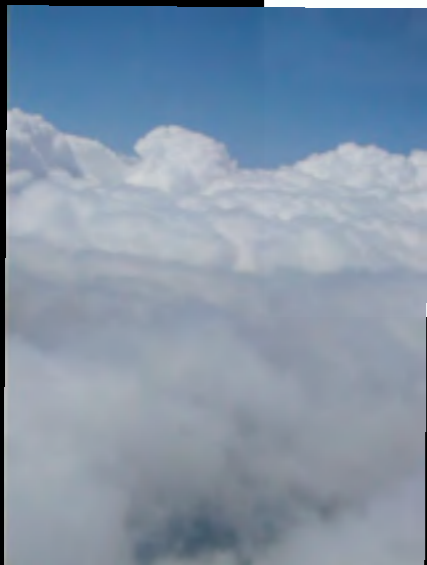
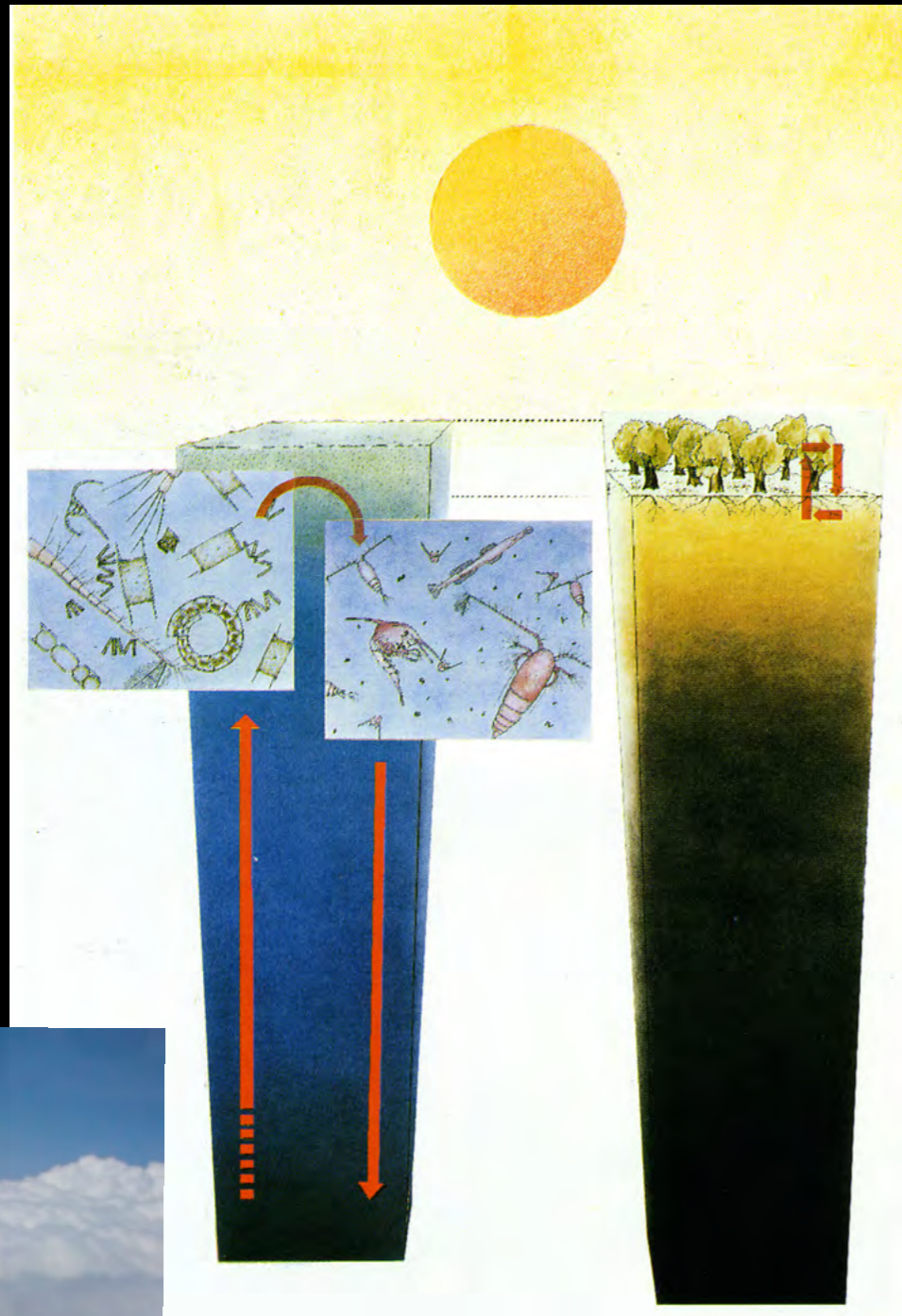


Microscopic Life



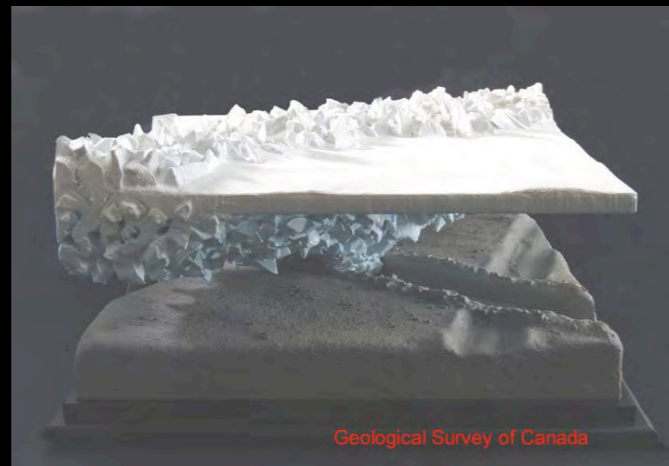
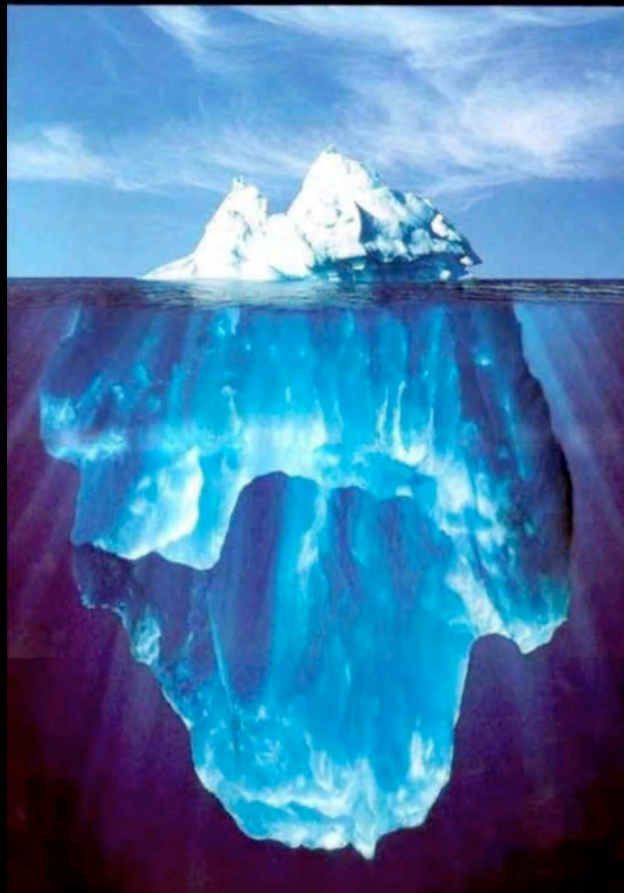


# Differences?: A matter of scale...





# Natural Perturbations





# Lack of knowledge has lead to the Ocean's destruction..



David Díaz

... before we know and understand it



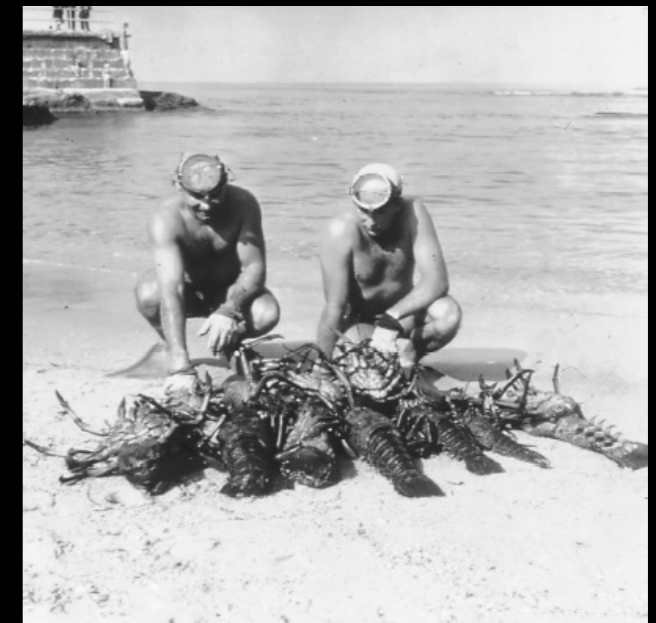
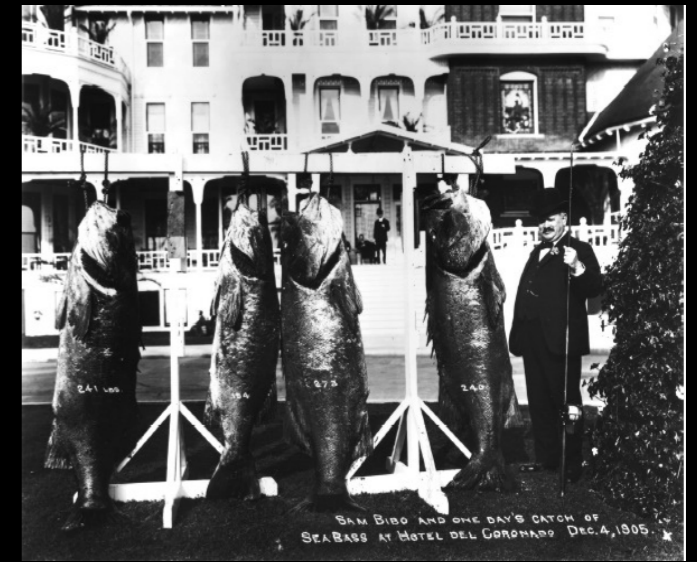
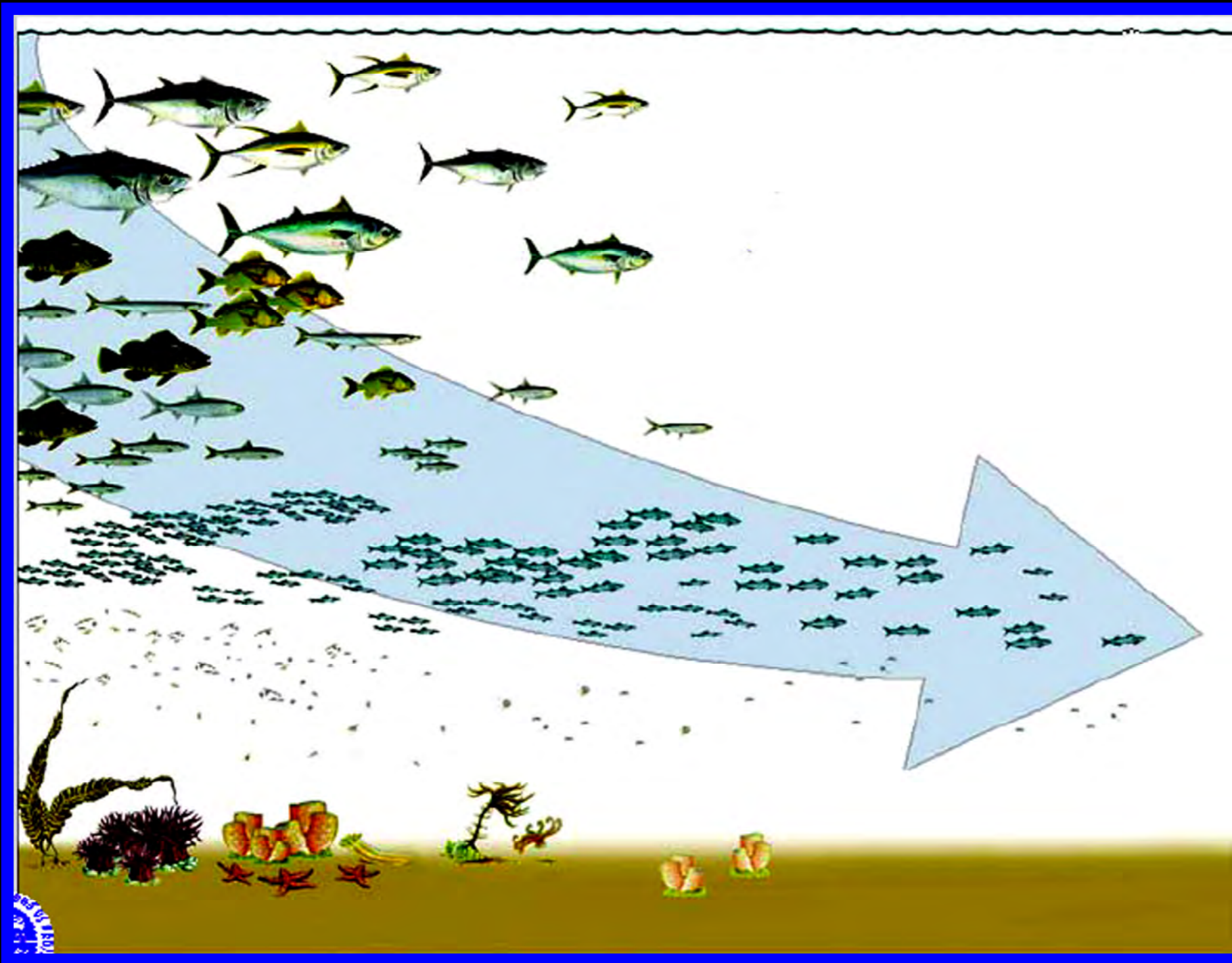
WWF



WWF

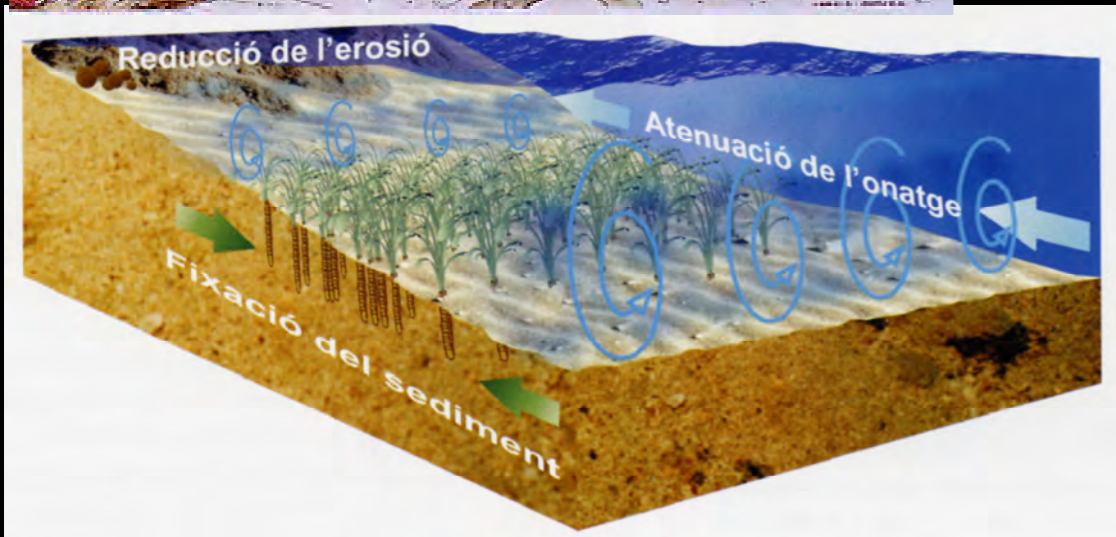


# “Fishing down the foodweb”





# The Ocean has its own protection systems





We don't like to see our woods full of rubbish





We don't like to see our woods full of rubbish





# Many years ago, man discovered a world of darkness



*El clan del oso cavernario*





# Now we can discover another one

GALAPAGOS RIFT  
PACIFIC OCEAN  
8600 FEET

Volcanoes



Dhugal Lindsay



JAGO-Geomar



# Imagine you arrive too late to the discovery of a treasure





In order not to arrive so late in an unknown world,  
we need knowledge and creativity



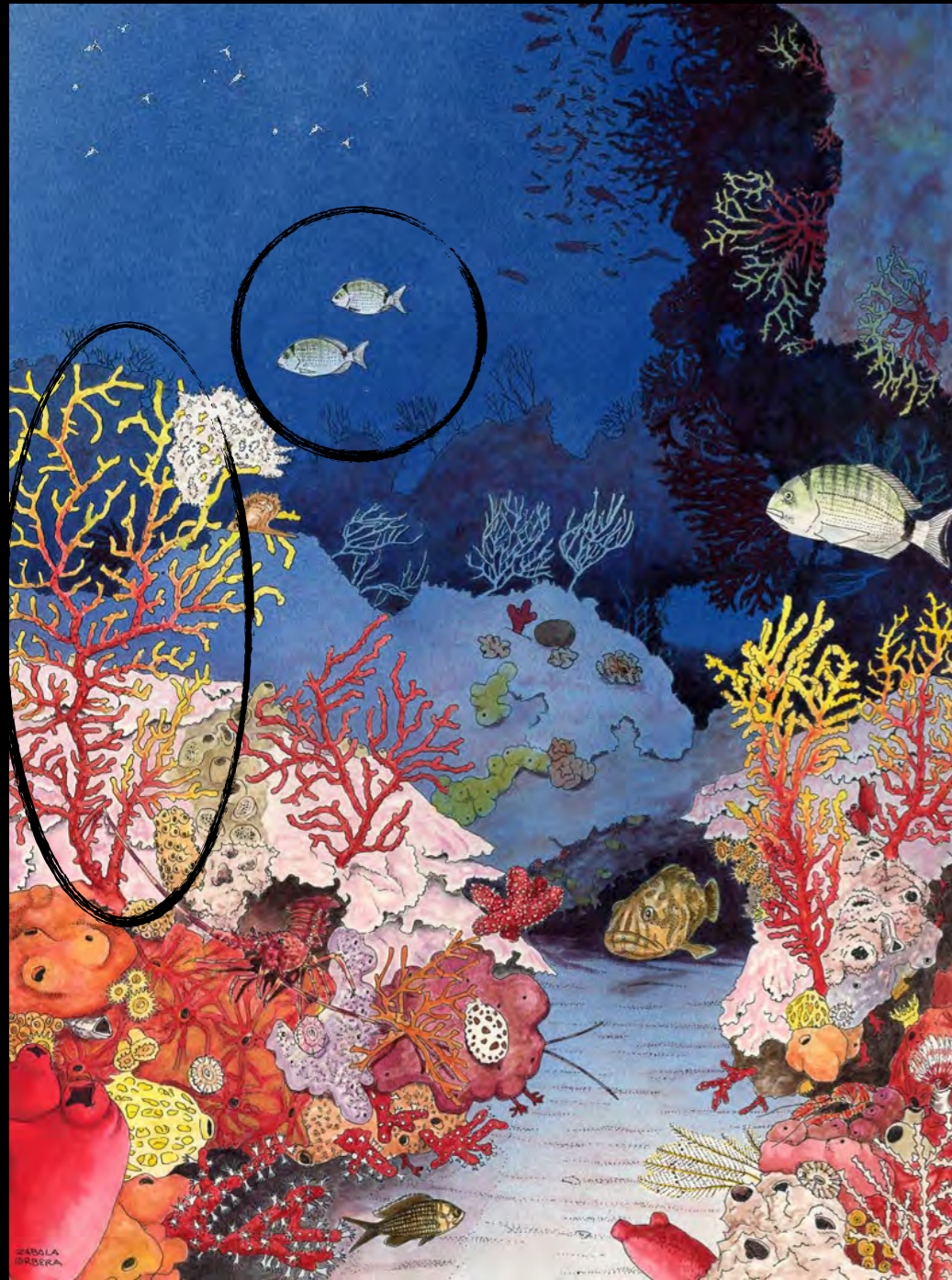


In order not to arrive so late in an unknown world,  
we need knowledge and creativity

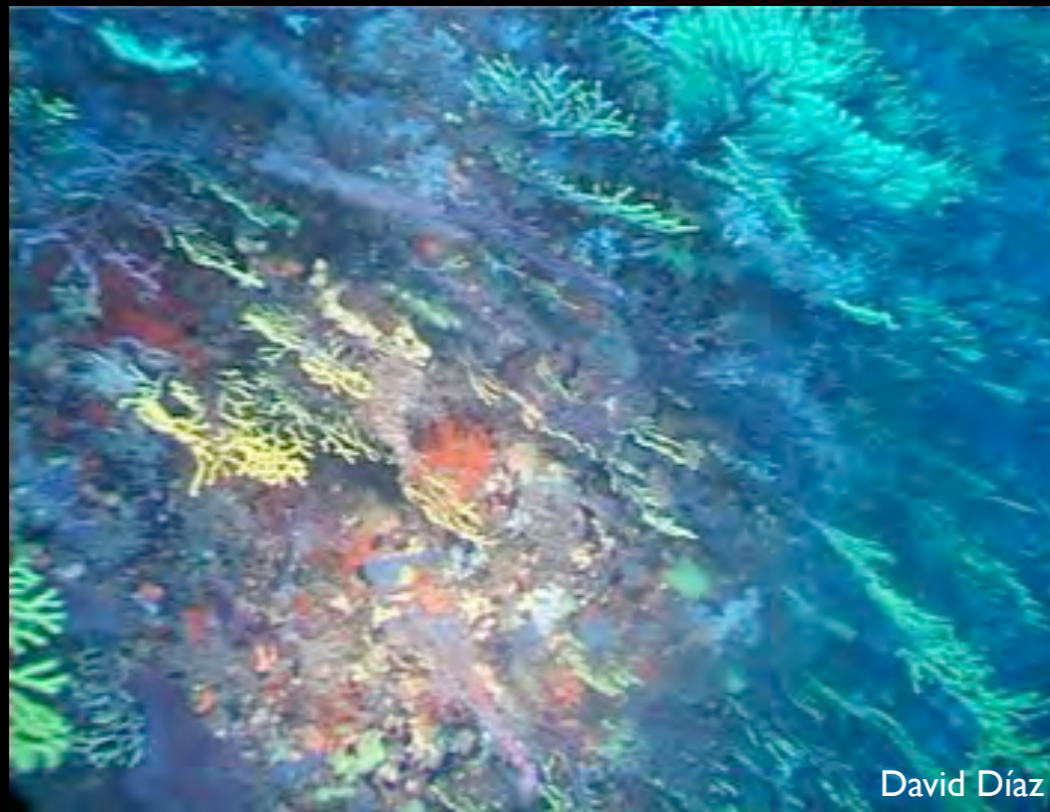




In order not to arrive so late in an unknown world,  
we need knowledge and creativity



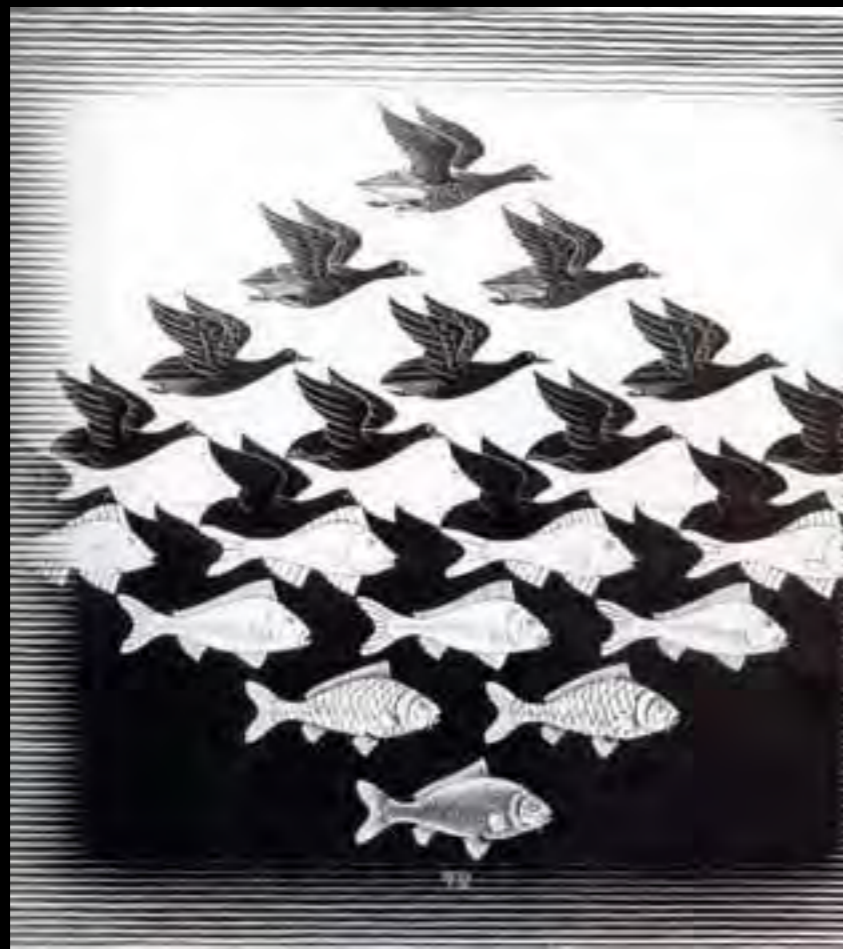




*"La recerca ha de ser un joc, perquè només jugant som feliços"* Ramon Margalef 1984

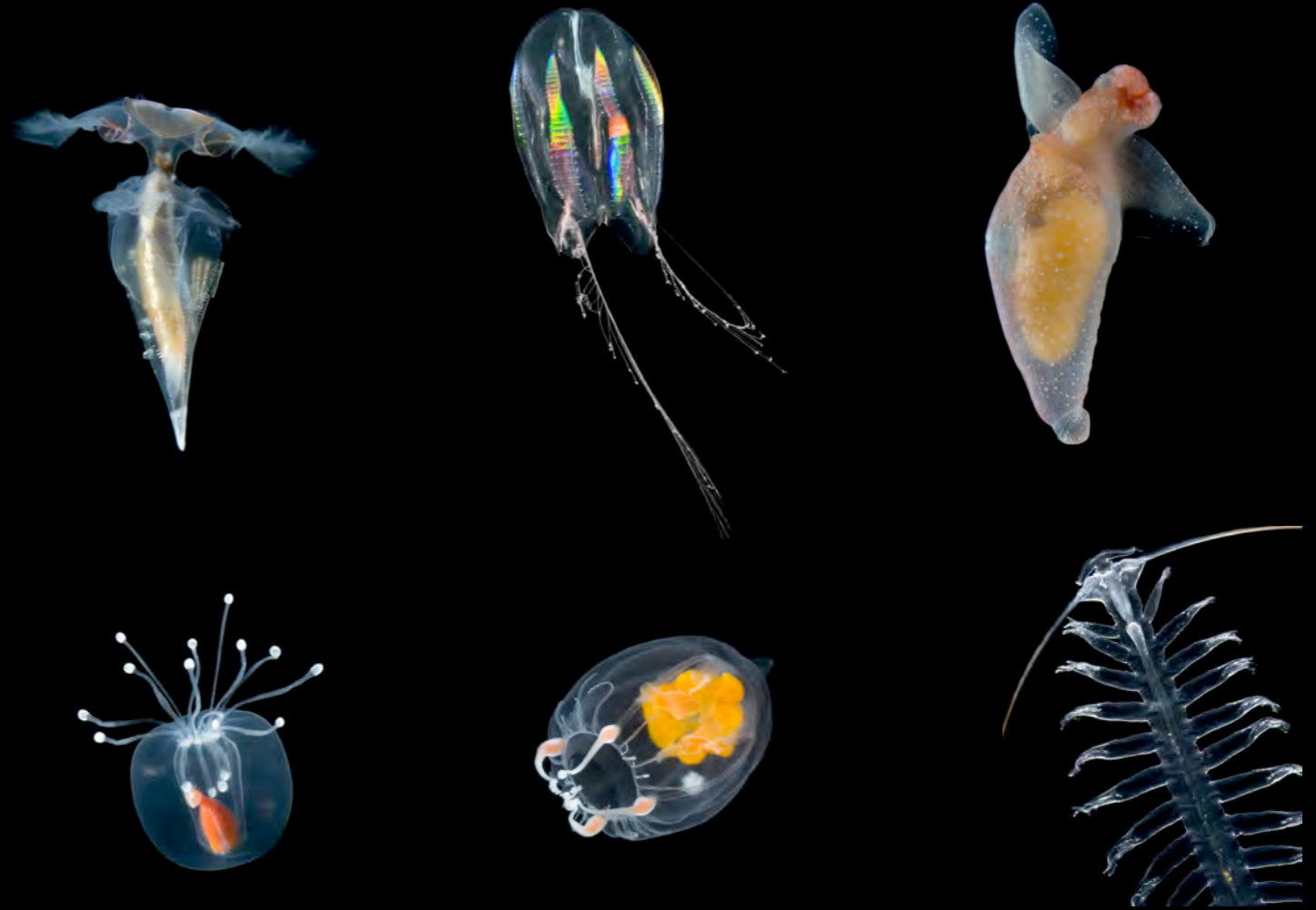


*“The surface of the sea is a mirror, reflecting divergent evolutionary paths. Up above, the creatures of air; down below, those of water. One planet, containing two worlds”.*  
Jeffrey Eugenides, *Middlesex*





# And the future?... An ocean of mysteries!





Thank you!

