The Association for Science Education, Liverpool: 6th January 2012

The Original Olympic Pool

Geoff Boxshall

The LINNEAN SOCIETY of London

NATURAL HISTORY MUSEUM

The oceans are the largest habitable space on the planet..

..covering 71% of the surface to an average depth of 3.7km.

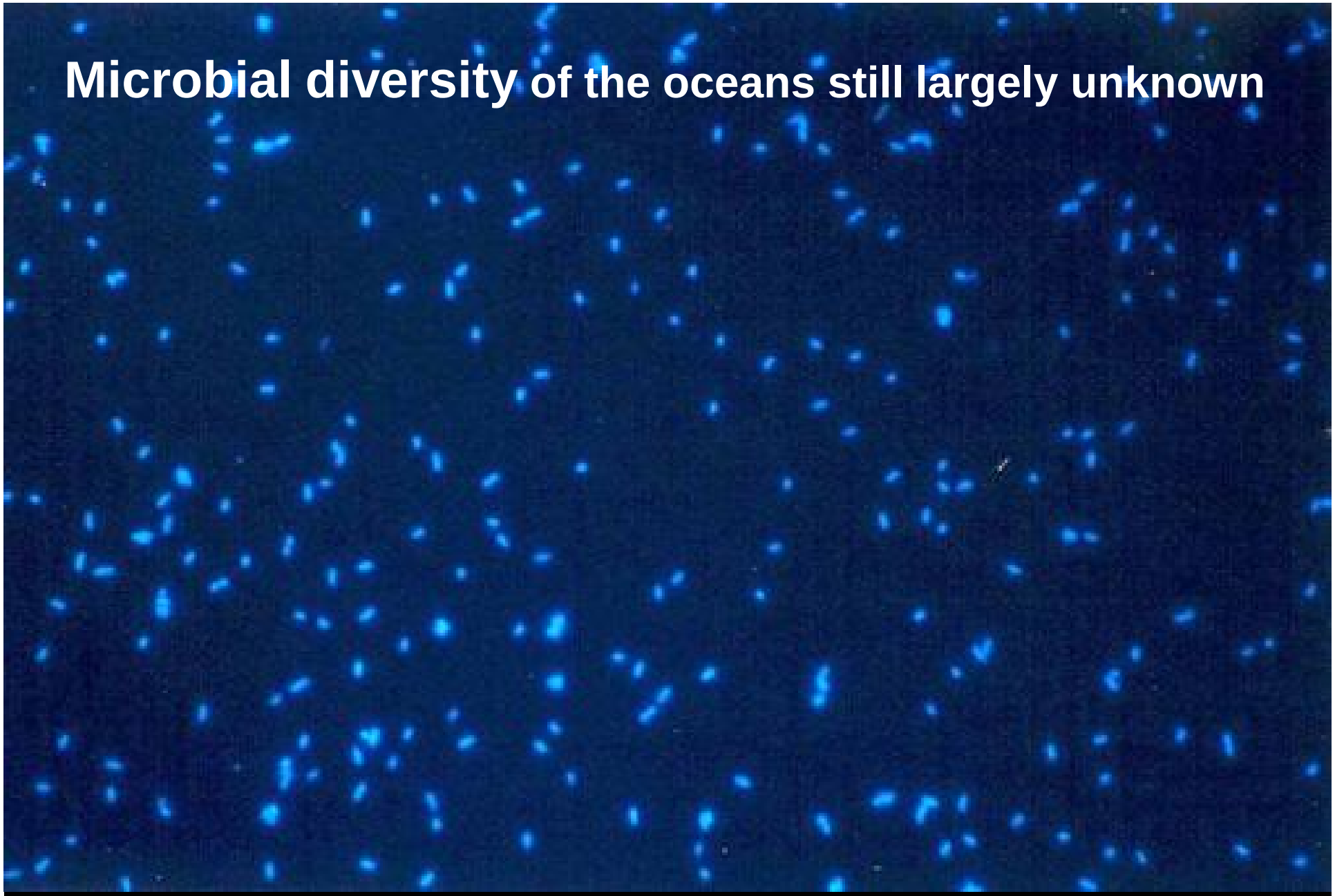
Life originated in the oceans and they are home to the greatest diversity of animal life.

Olympic Pool Programme

1. **Diversity Competition**
2. Predator versus Prey (head-to-head)
3. Finding a Mate
4. Long Distance Swimming

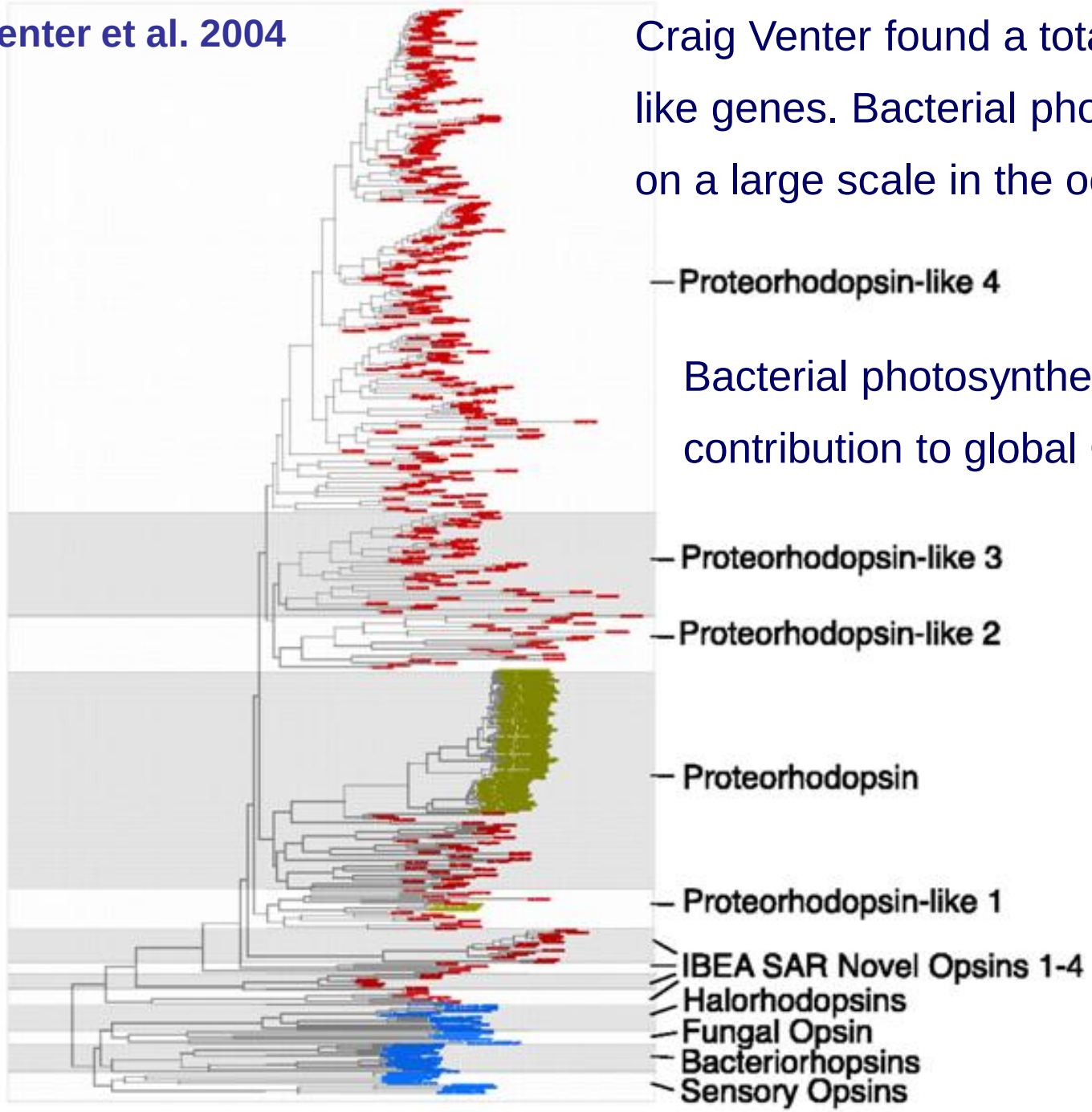
5. Future prospects

Microbial diversity of the oceans still largely unknown



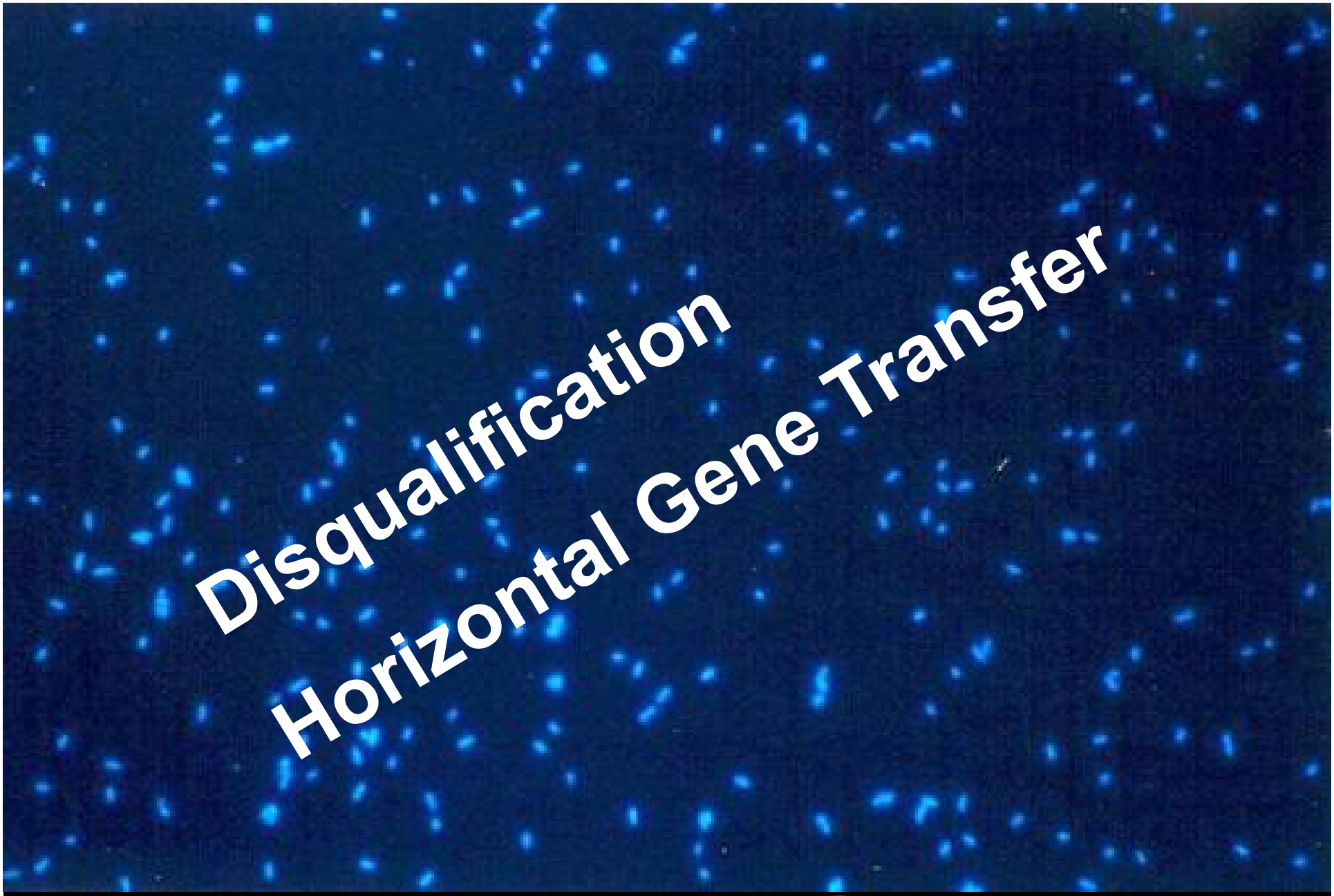
Census of Marine Life found 38,000 bacterial phylotypes in 1 litre of seawater

Venter et al. 2004



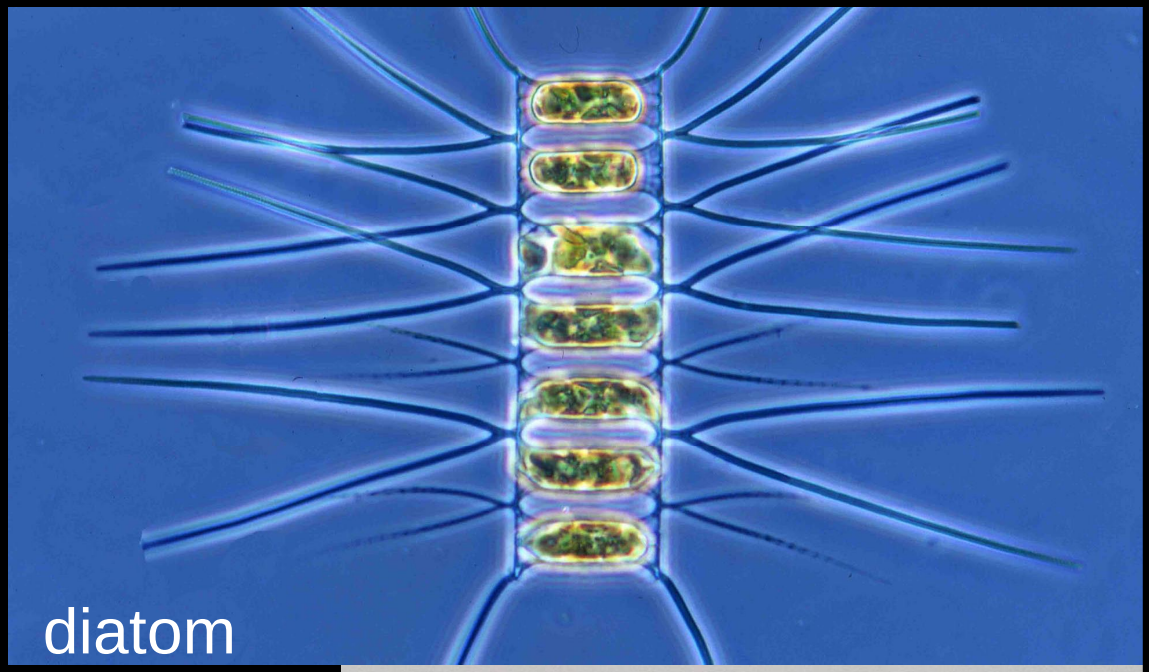
Craig Venter found a total of 782 Rhodopsin-like genes. Bacterial photosynthesis occurs on a large scale in the oceans.

Bacterial photosynthesis is a significant contribution to global Carbon fluxes

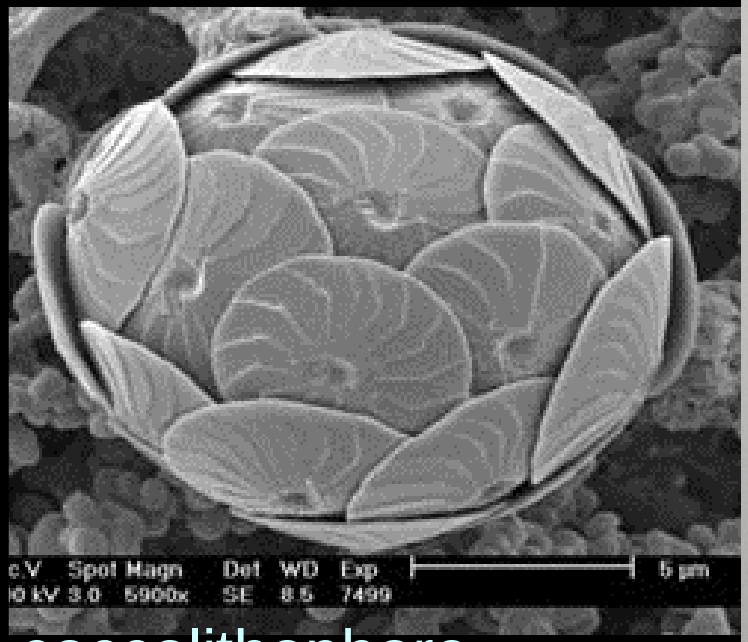


Census of Marine Life found 38,000 bacterial phylotypes in 1 litre of seawater

Planktonic algae

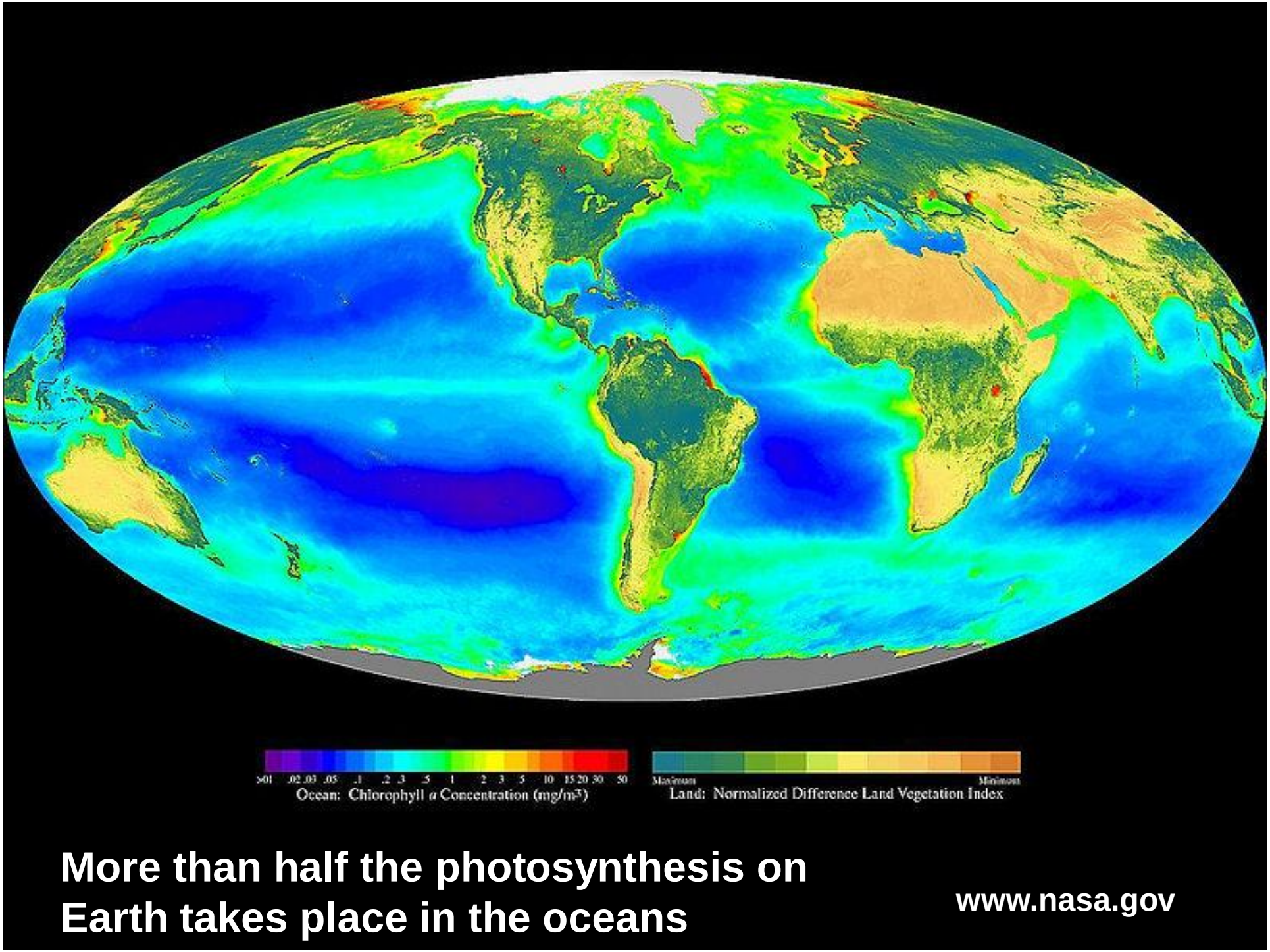


diatom



coccolithophore

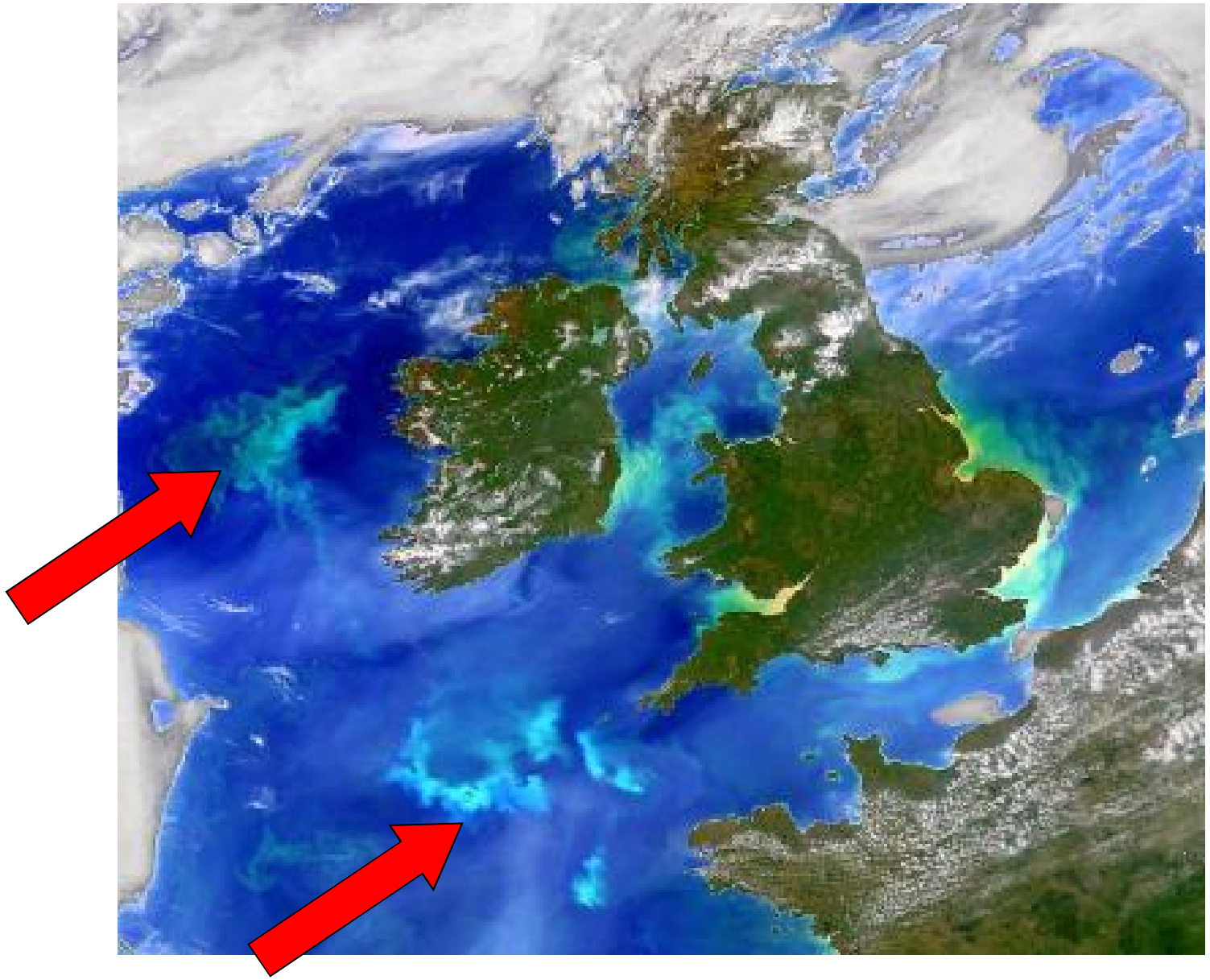
dinoflagellate



More than half the photosynthesis on Earth takes place in the oceans

www.nasa.gov

Satellite image of an algal bloom in the Celtic Sea



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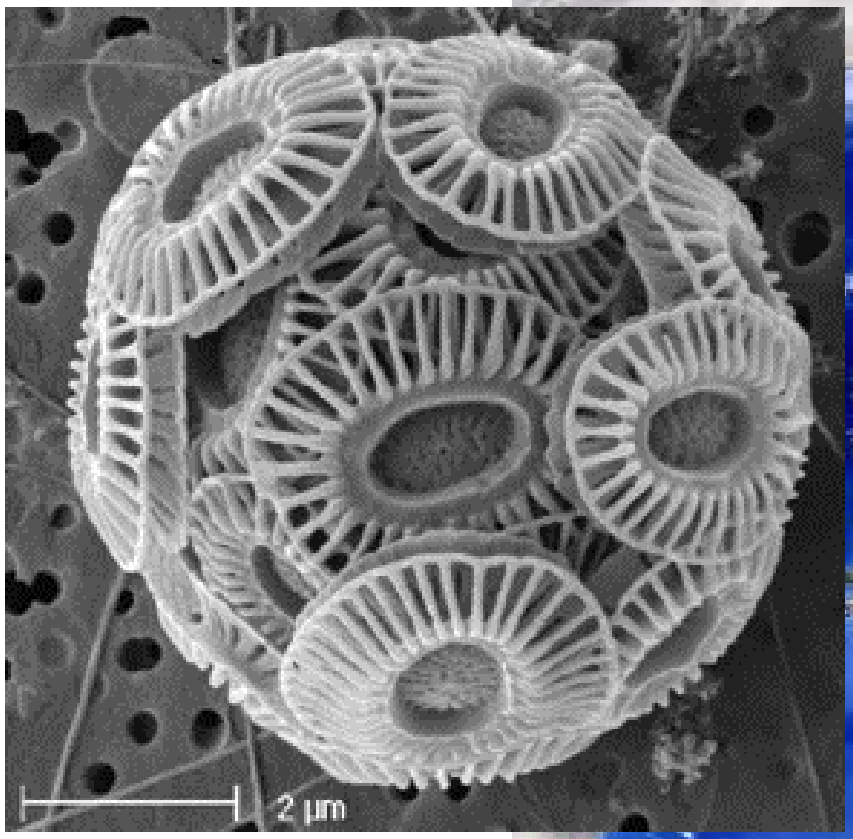
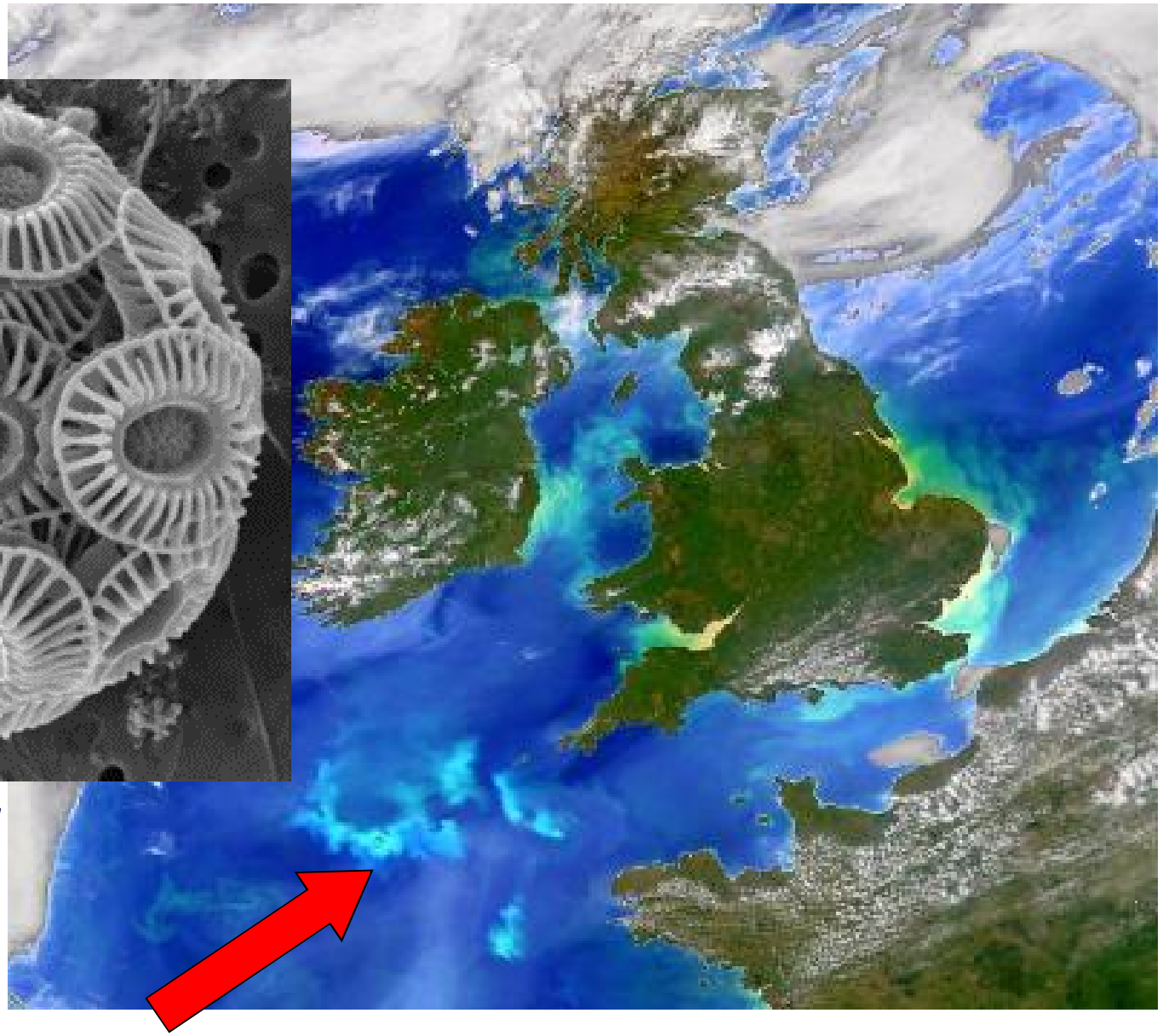
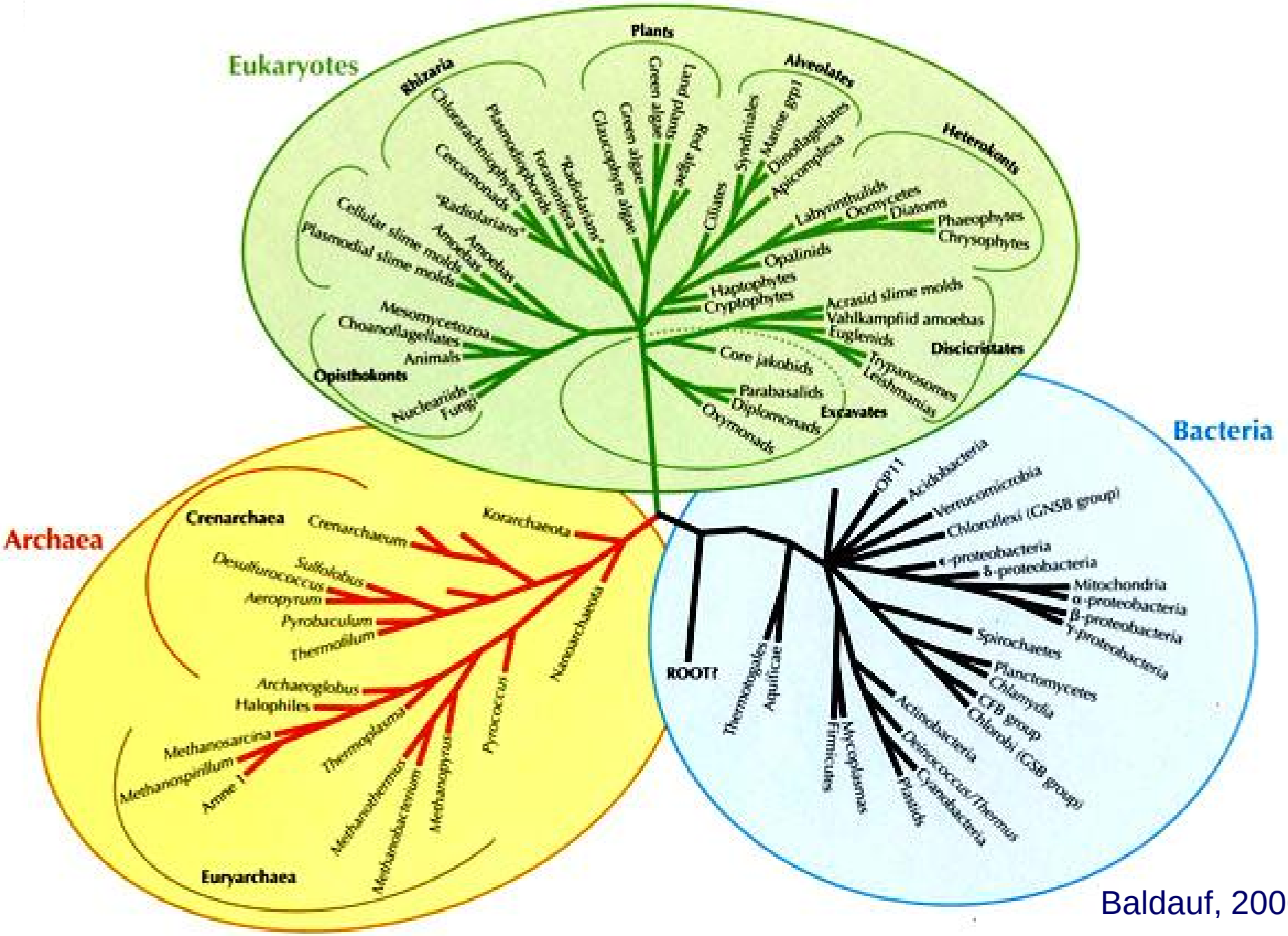


Emiliania huxleyi



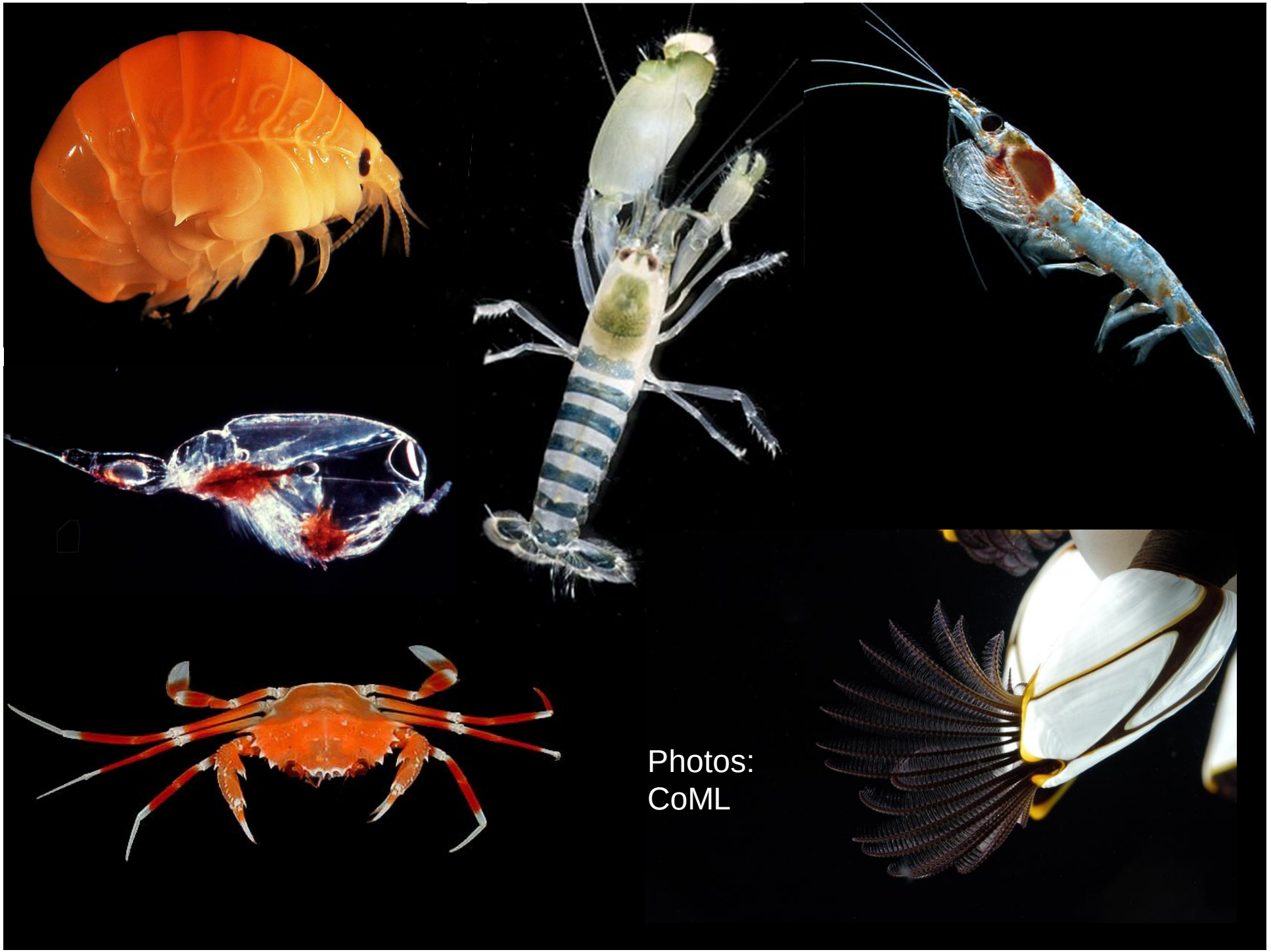


Baldauf, 2006


Metazoans

Photos:
CoML


Photos:
CoML

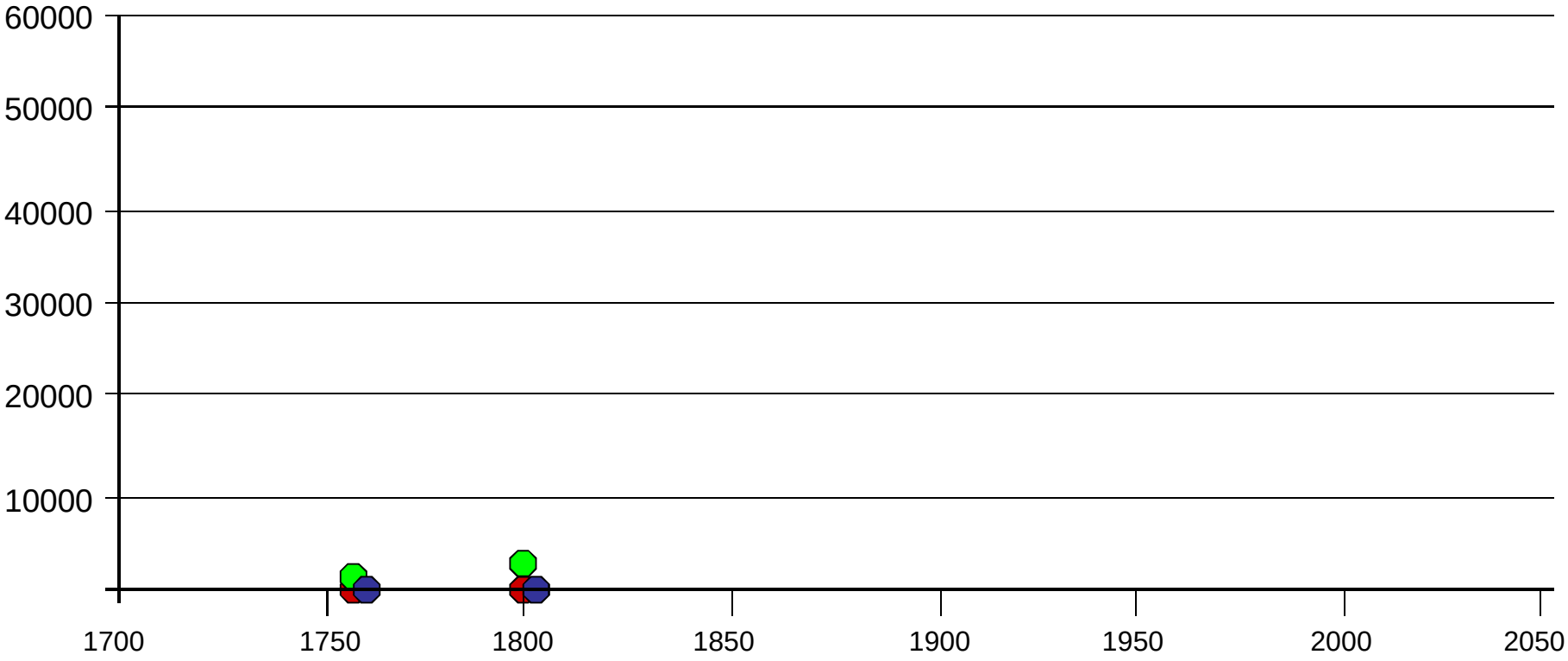

Photos:
CoML

Number of valid marine species described from Oceans

Linnaeus 1758

WoRMS
World Register of Marine Species

Number of valid marine species described from Oceans



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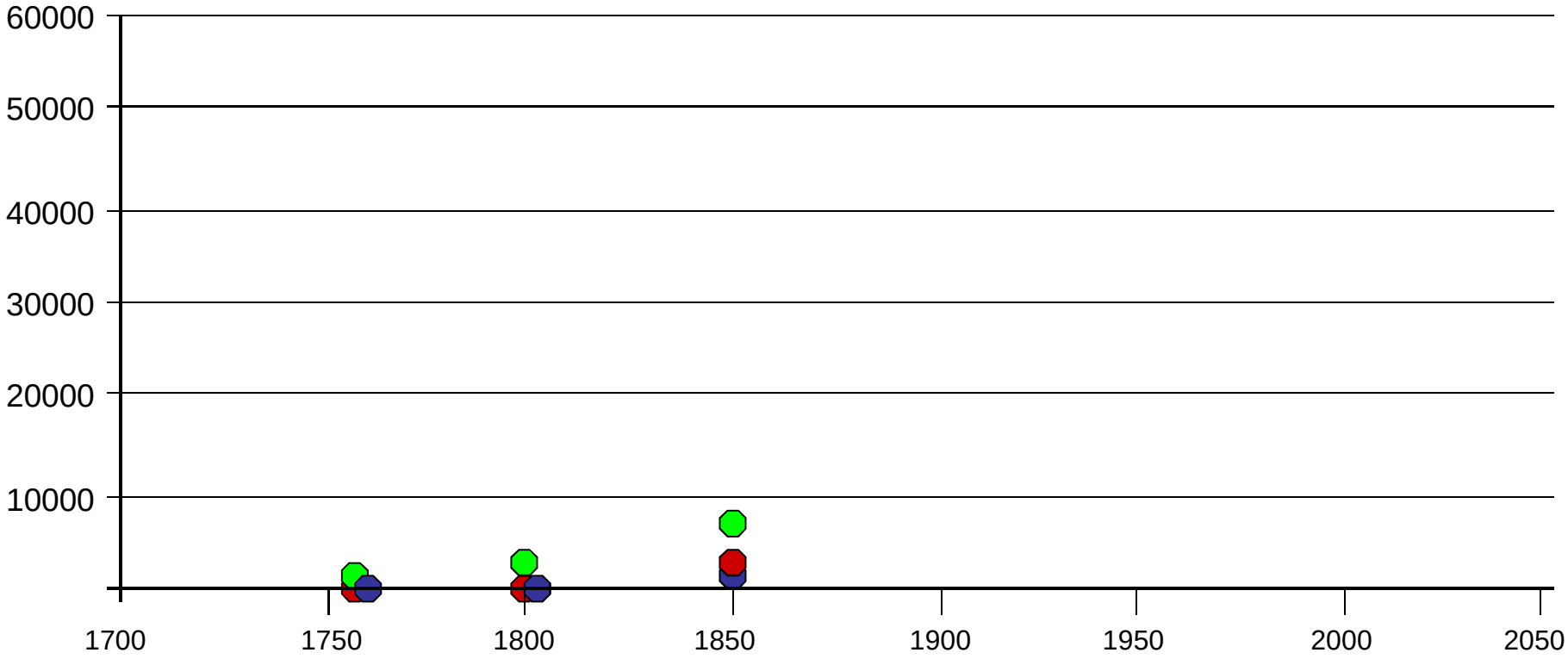

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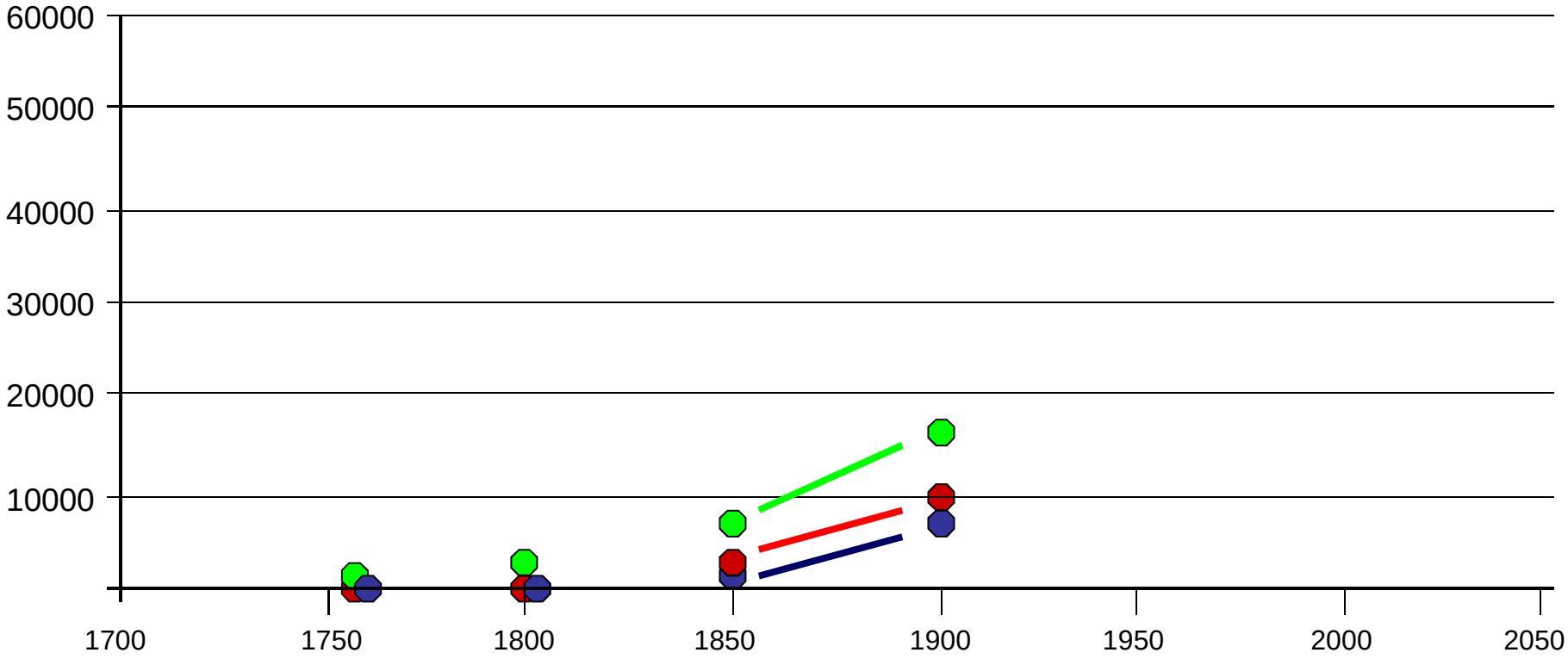

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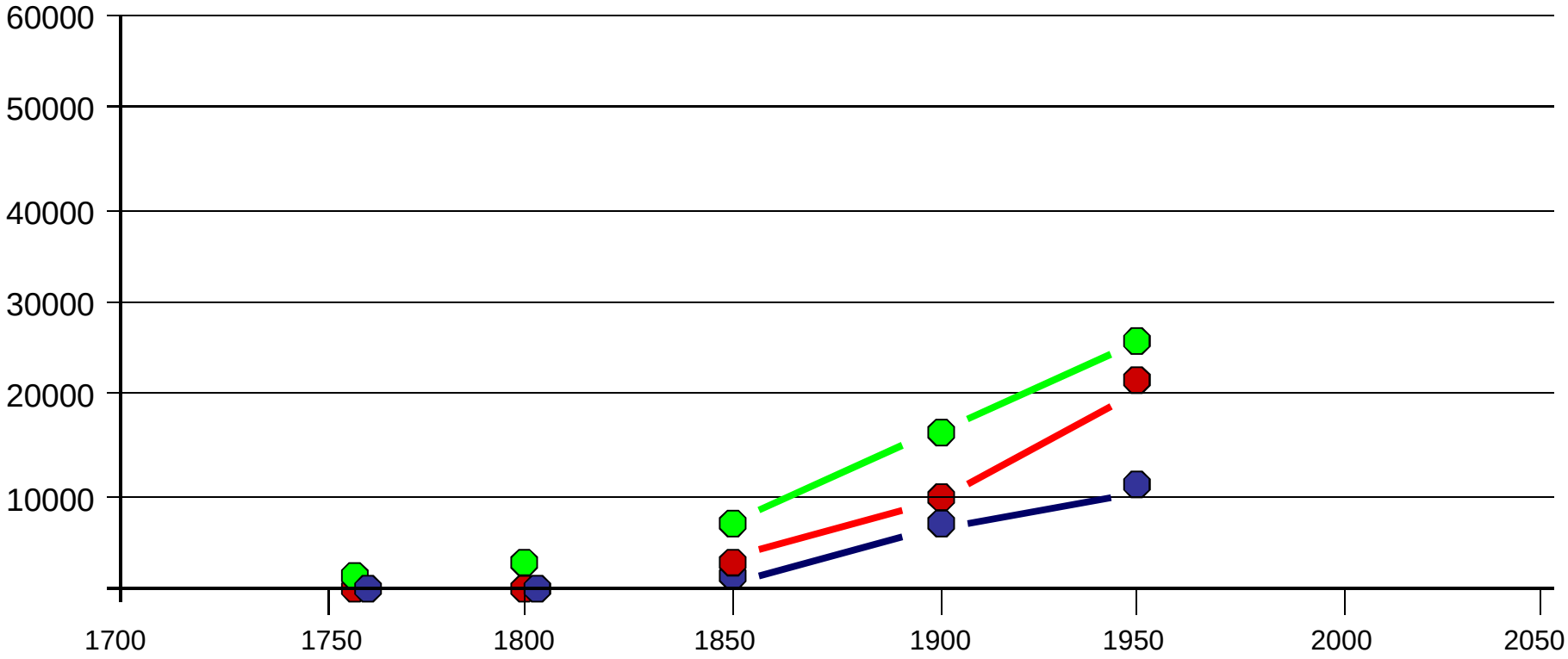

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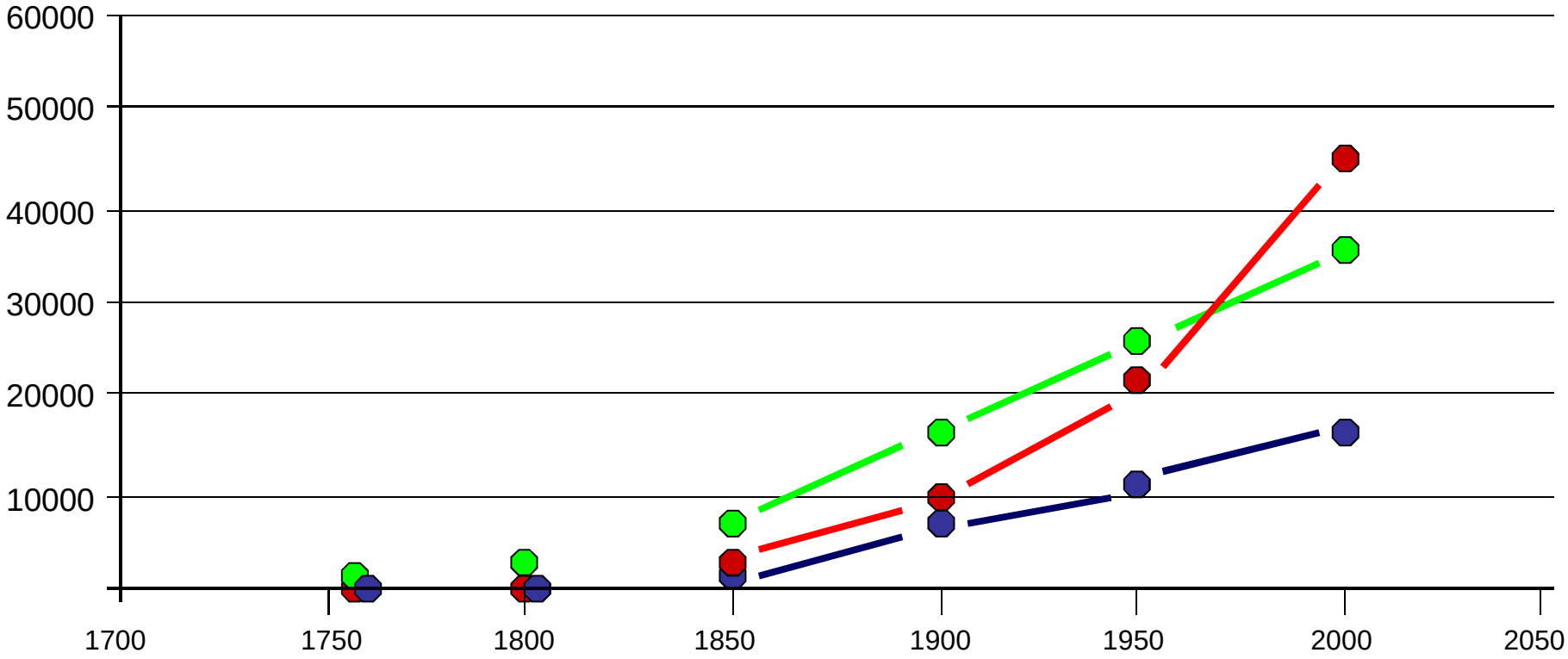

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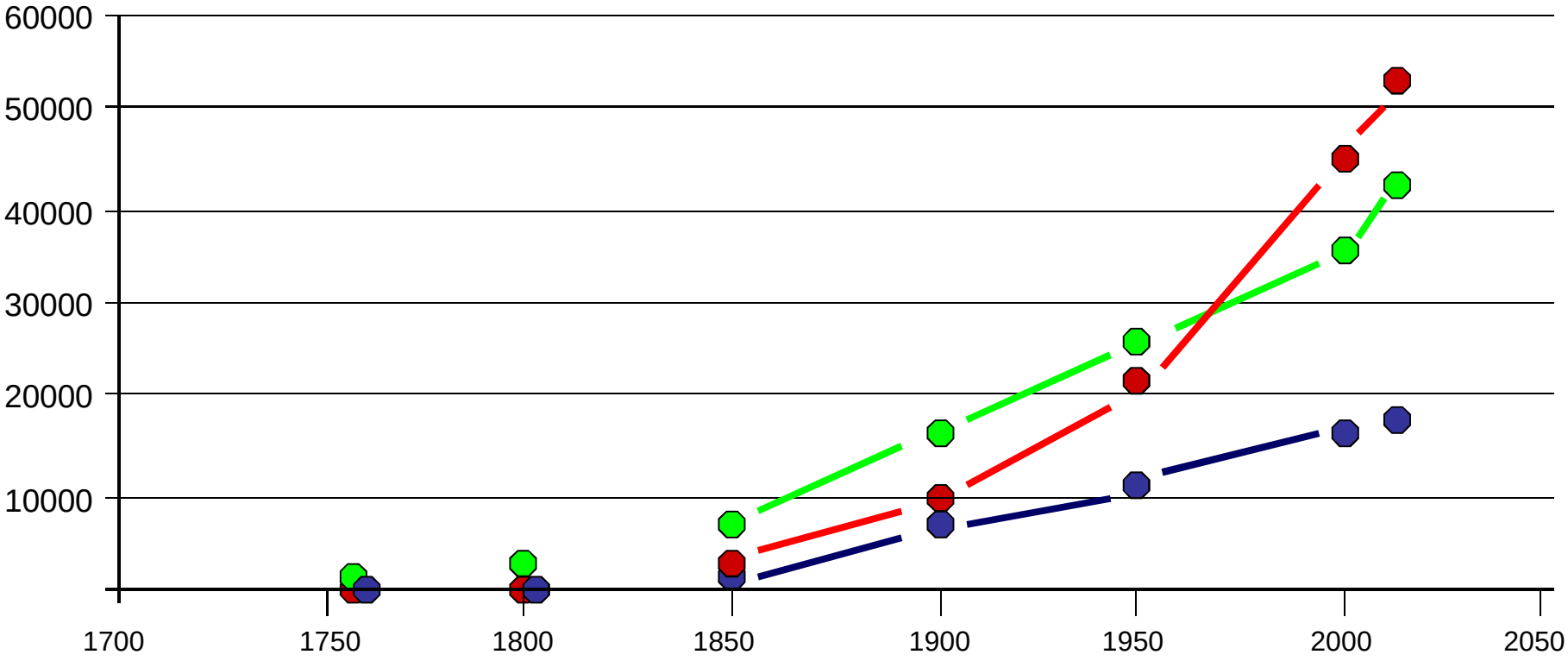

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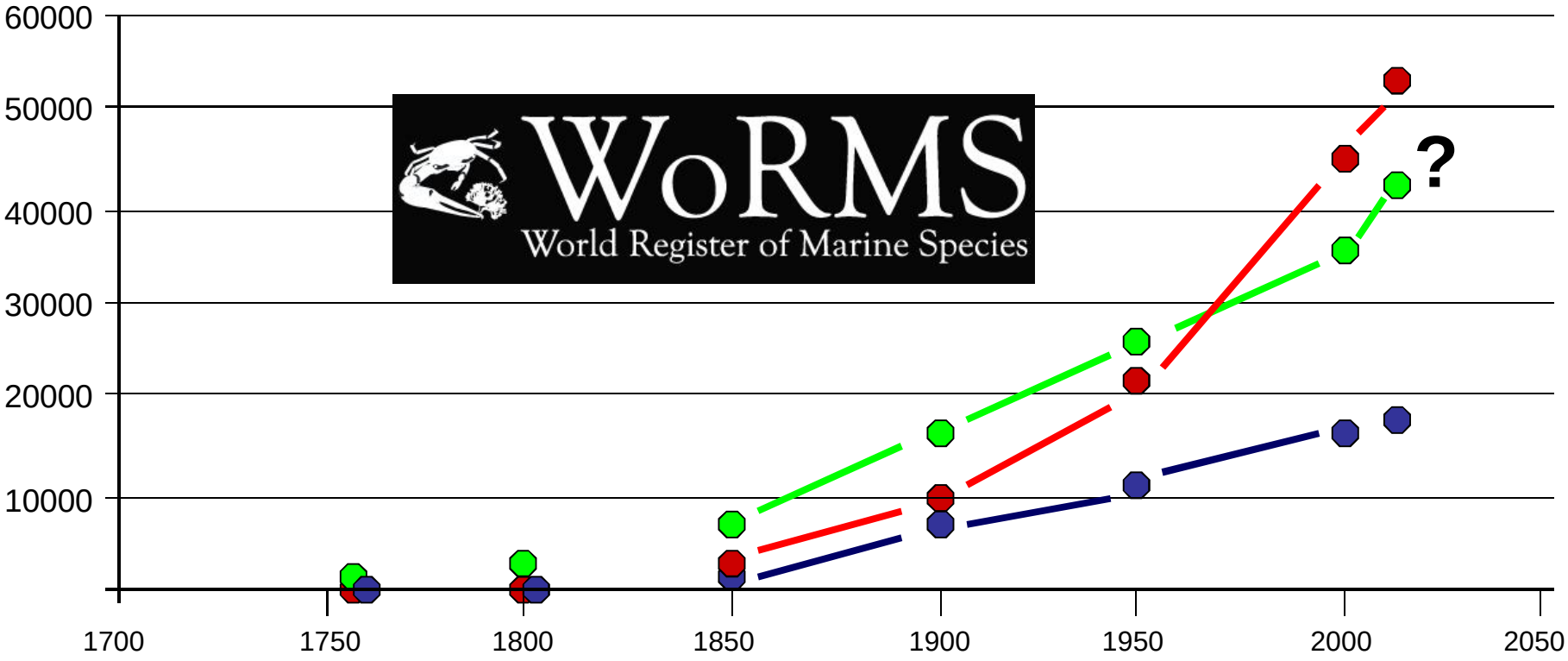
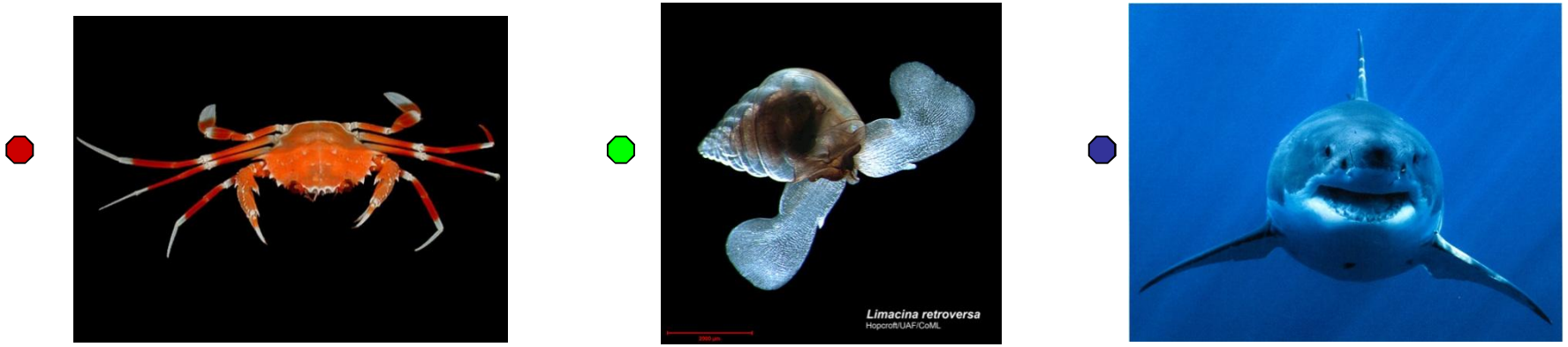
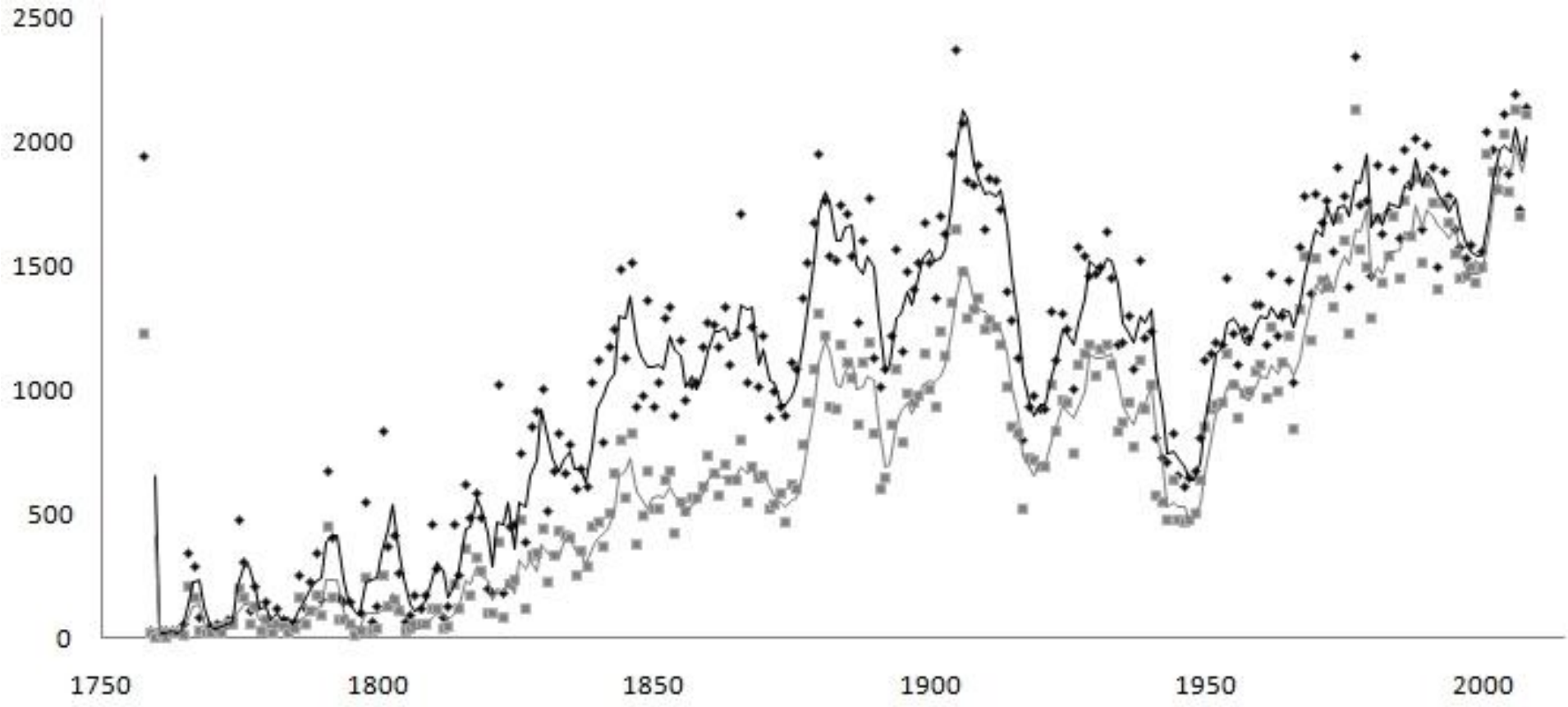




Numbers of new marine species described annually



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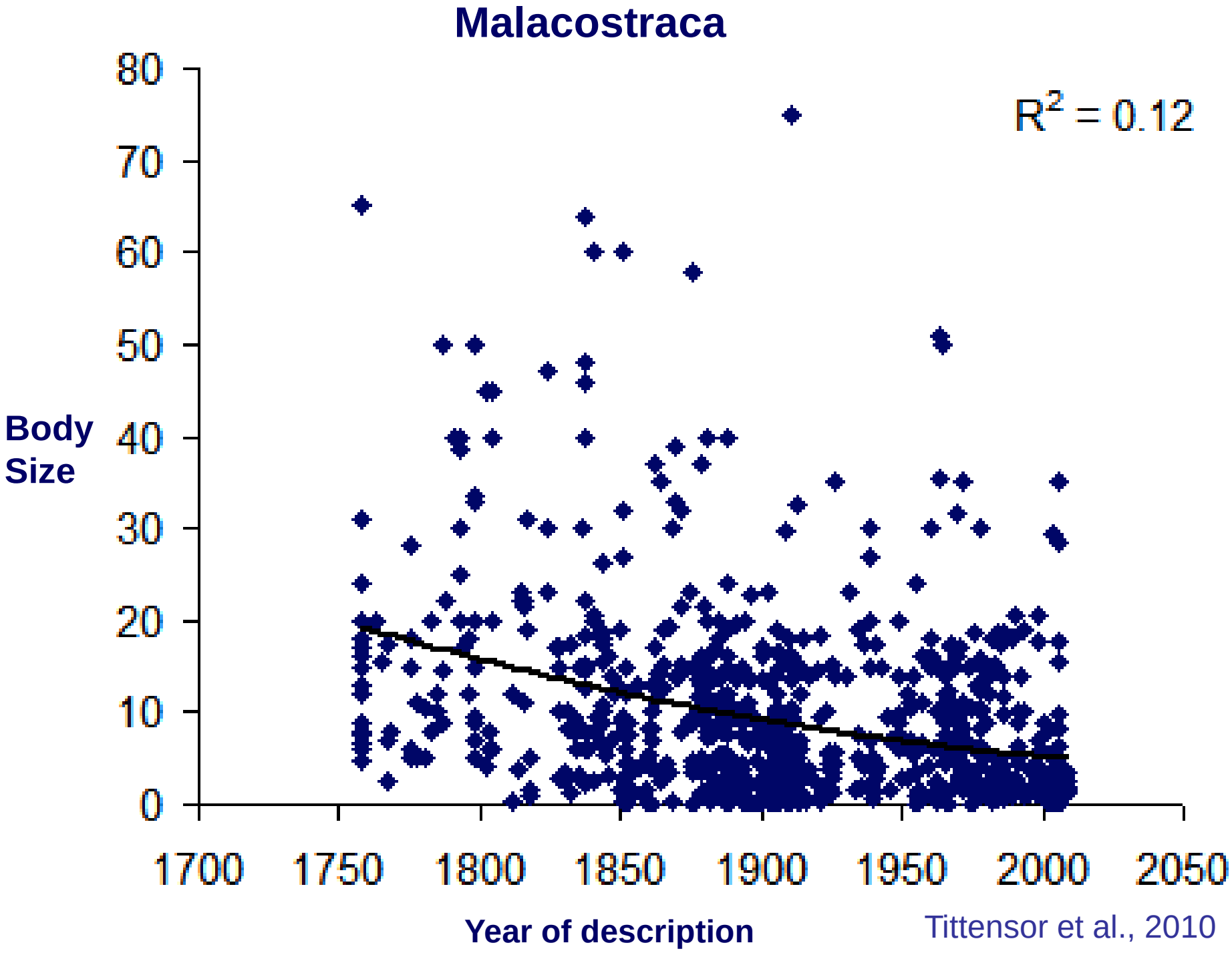
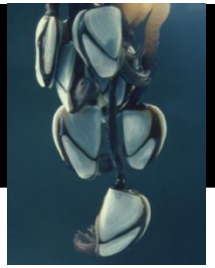


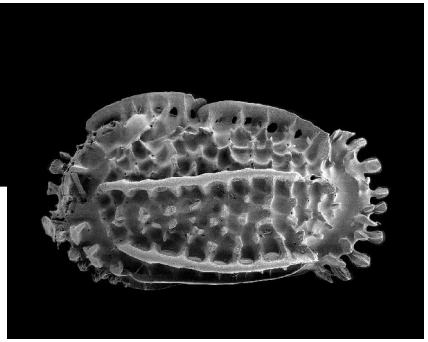
Tittensor et al., 2010

Peracarids

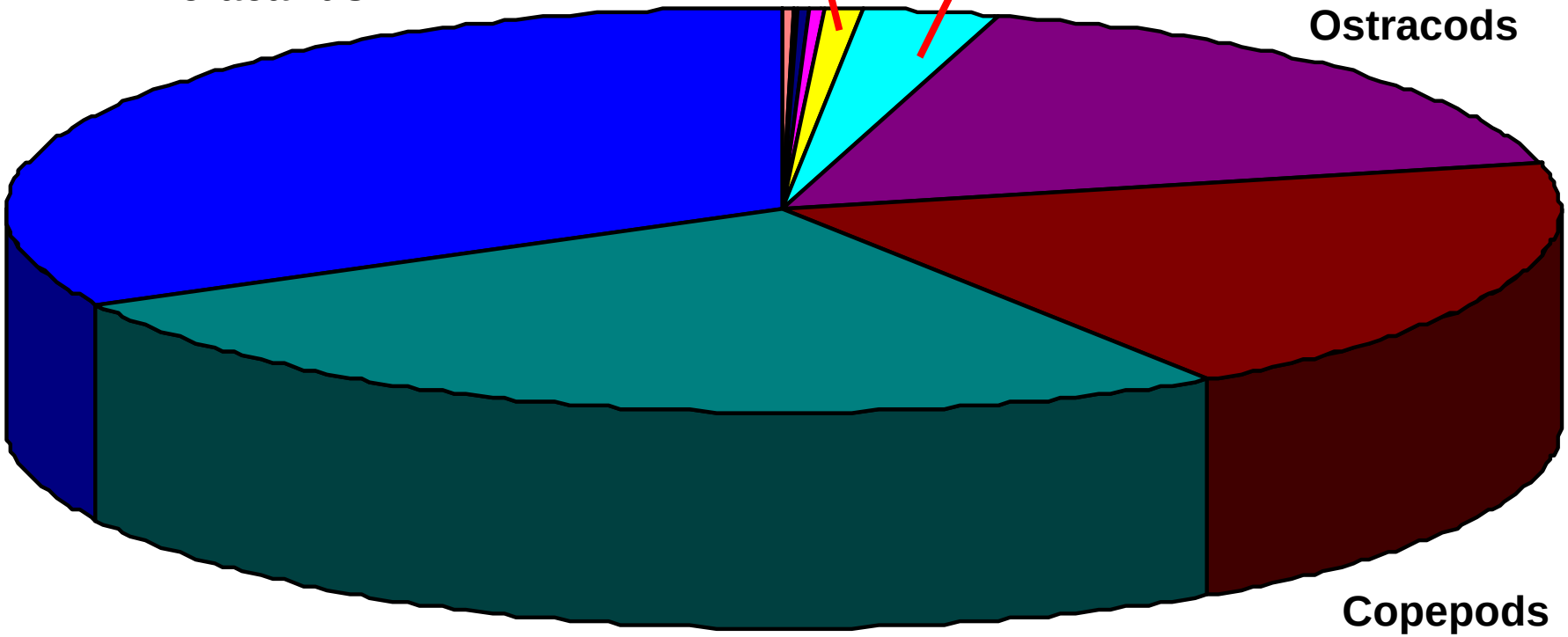
Stomatopods



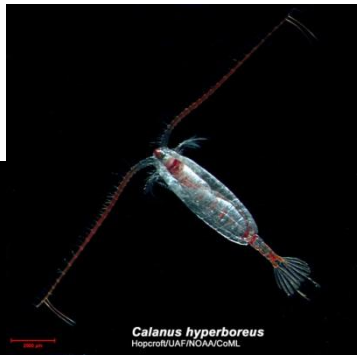
Barnacles



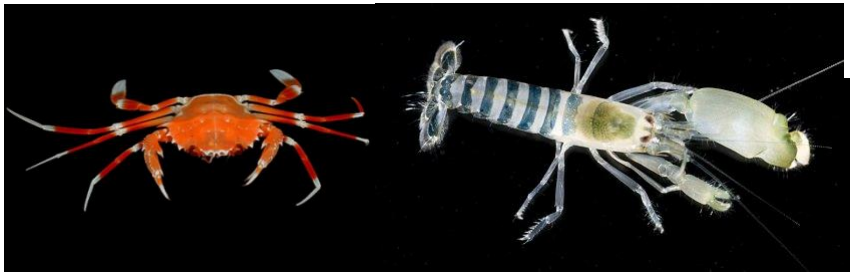
Ostracods



Copepods



Decapods



53,000 species

Olympic Pool Programme

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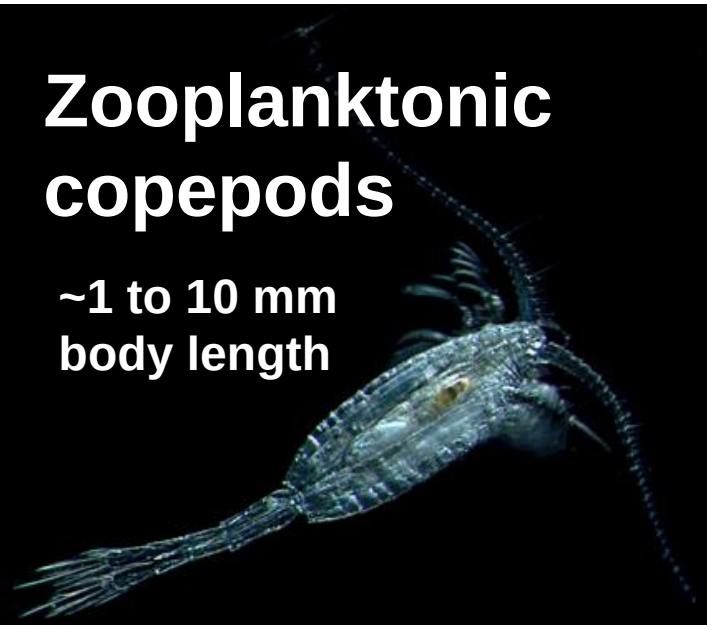
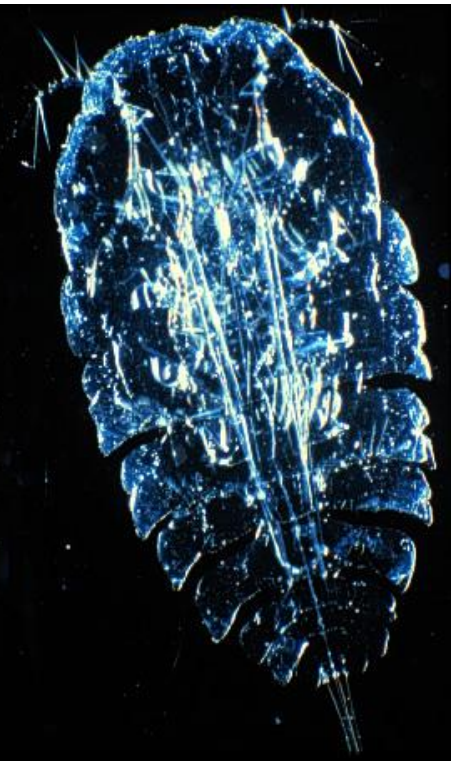
5. Future prospects

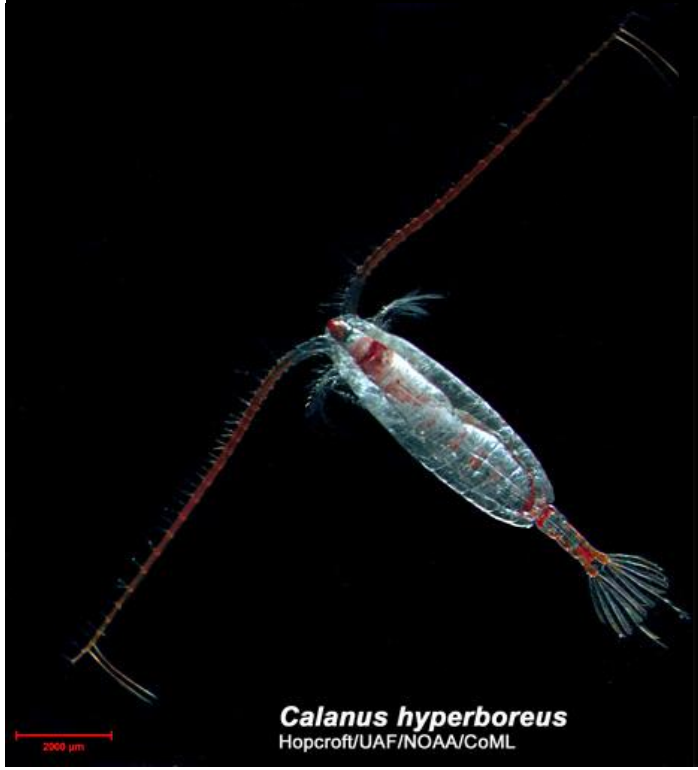
Zooplanktonic copepods

~1 to 10 mm body length





Metridia longa
Hopcroft/UAF/NOAA/CoML

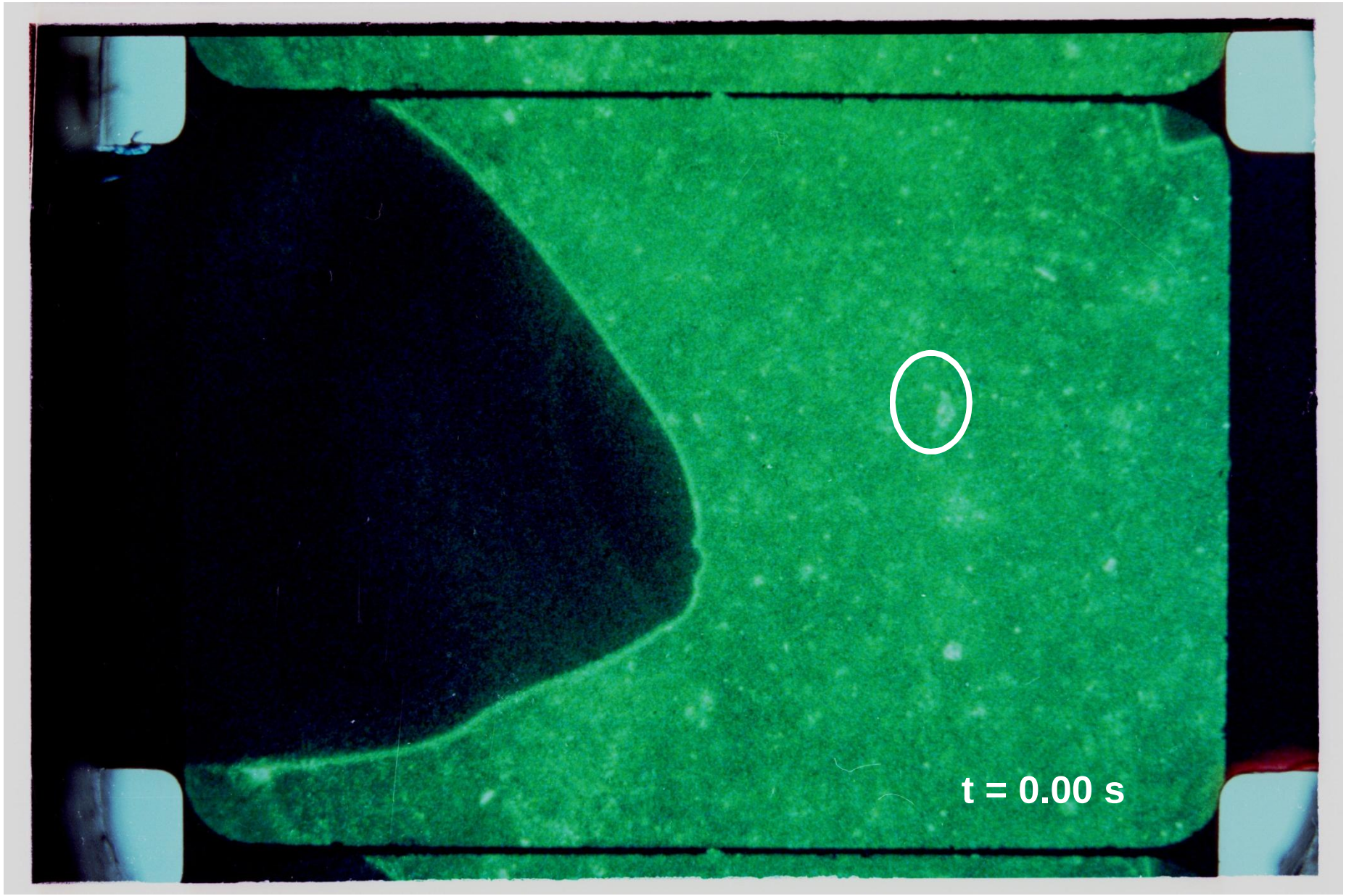


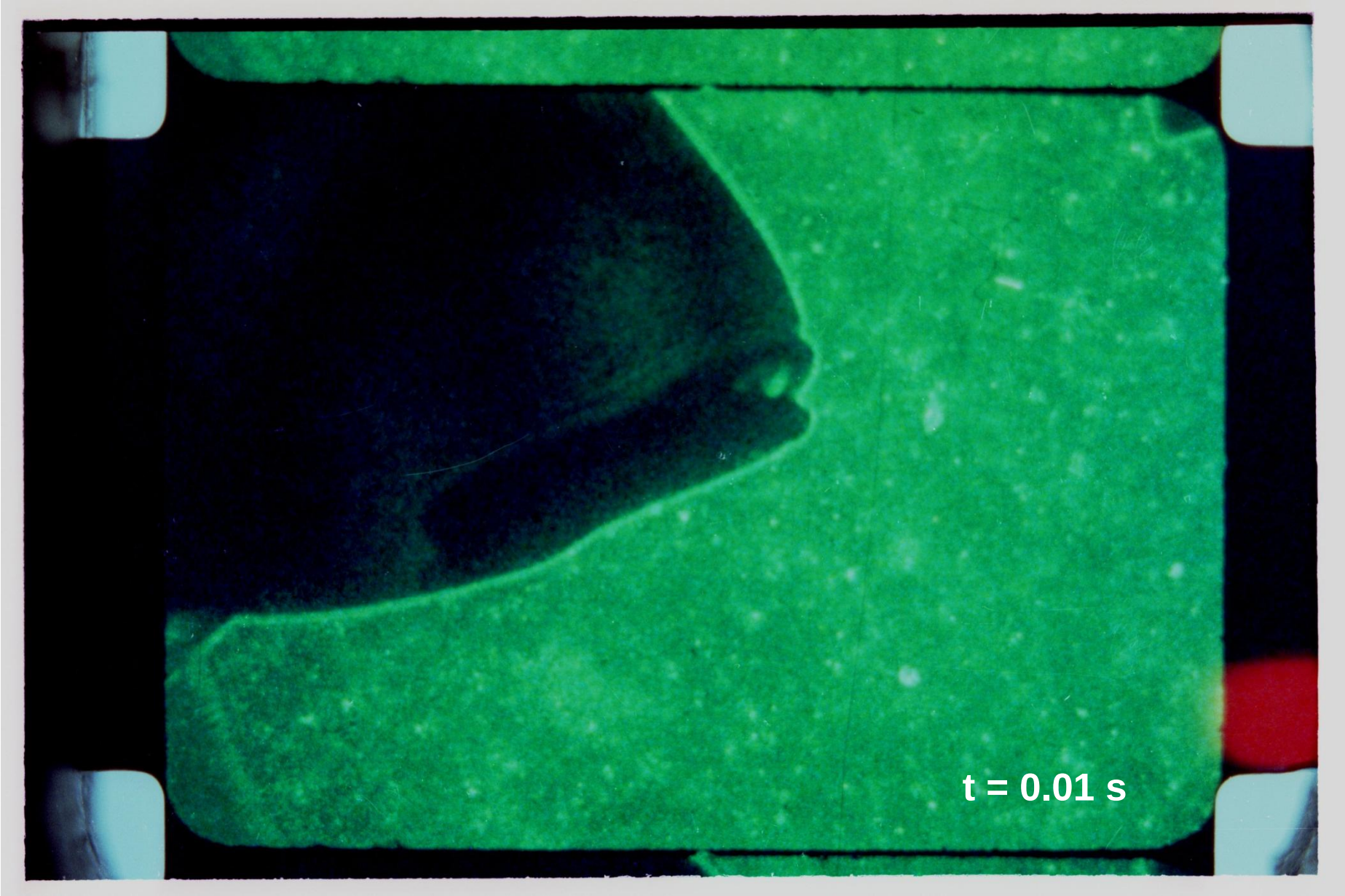
Calanus hyperboreus
Hopcroft/UAF/NOAA/CoML

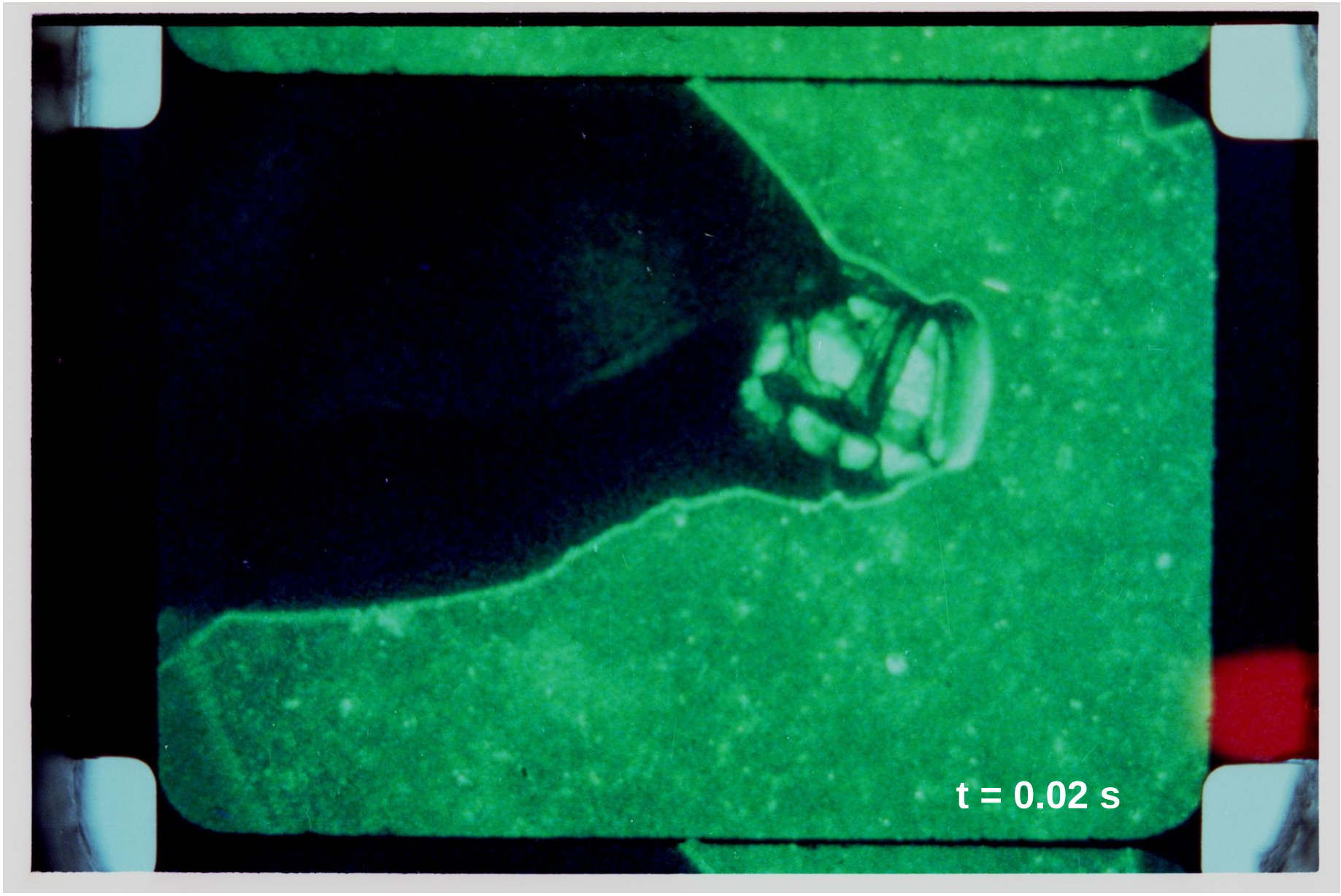
Gaetanus brevispinus
Hopcroft UAF/NOAA/CoML

Microsetella norvegica
Hopcroft/UAF/CoML

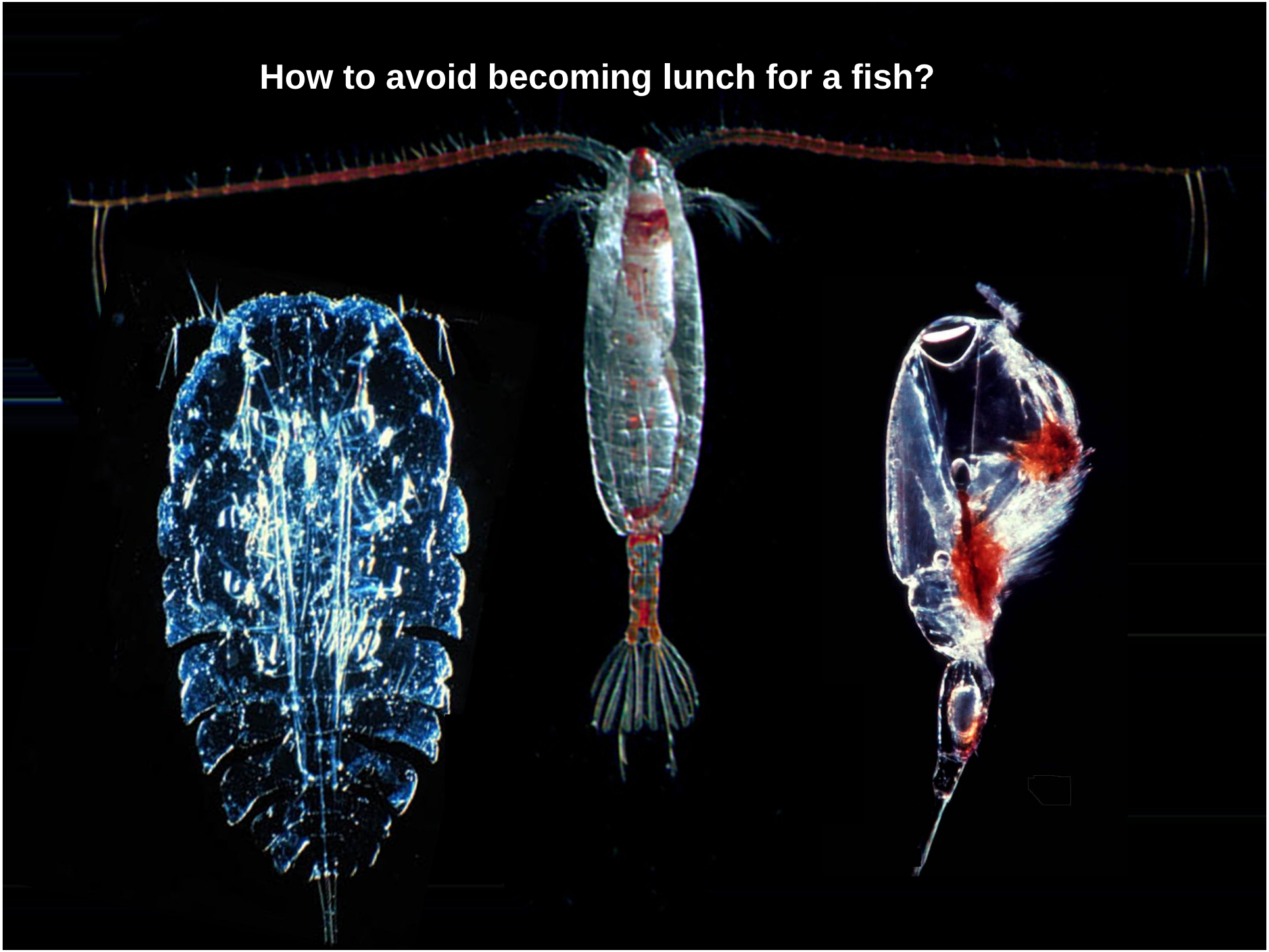

2000 µm
Calanus – the dominant copepod in North Atlantic
Hopcroft/NOAA

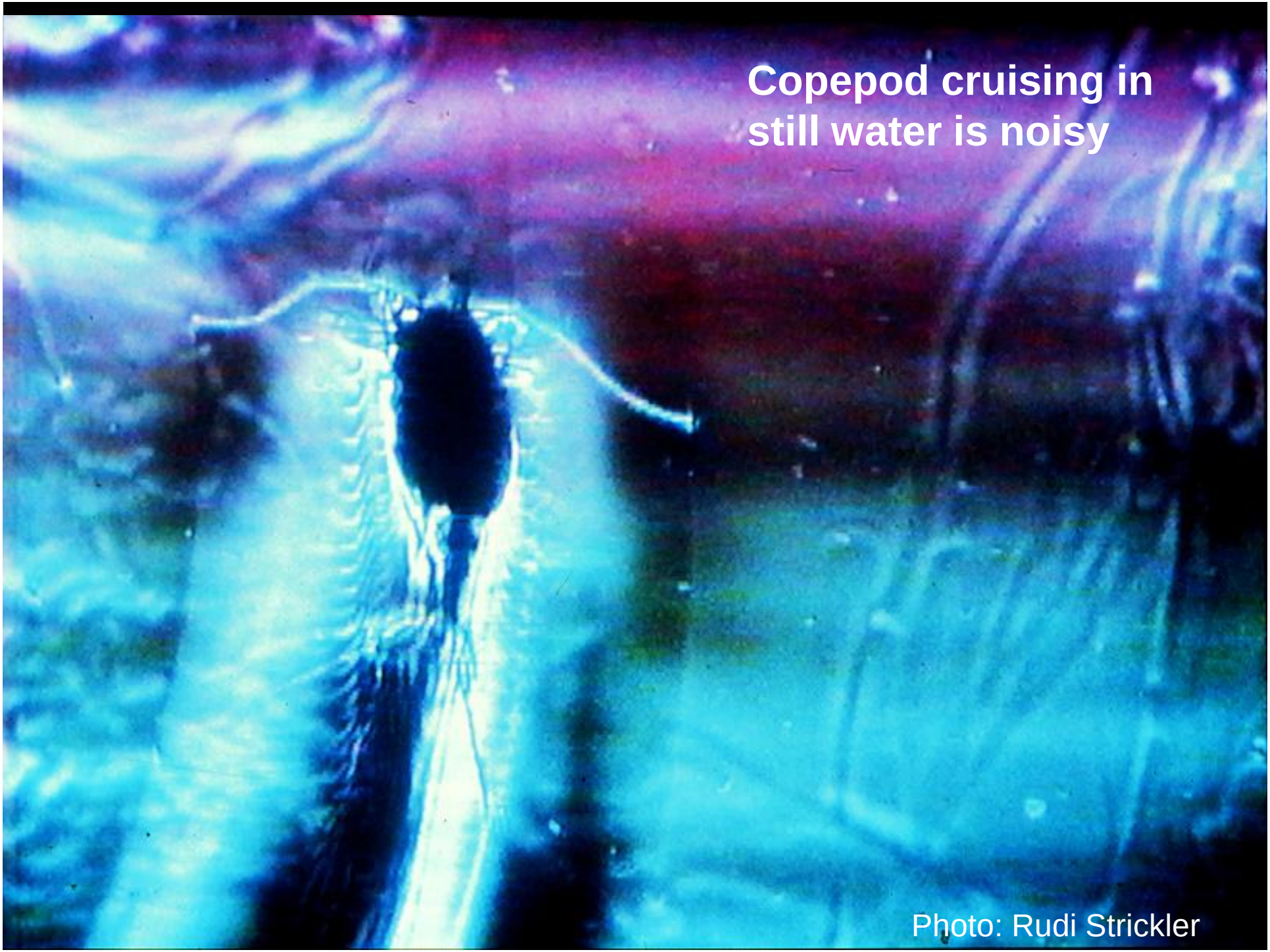


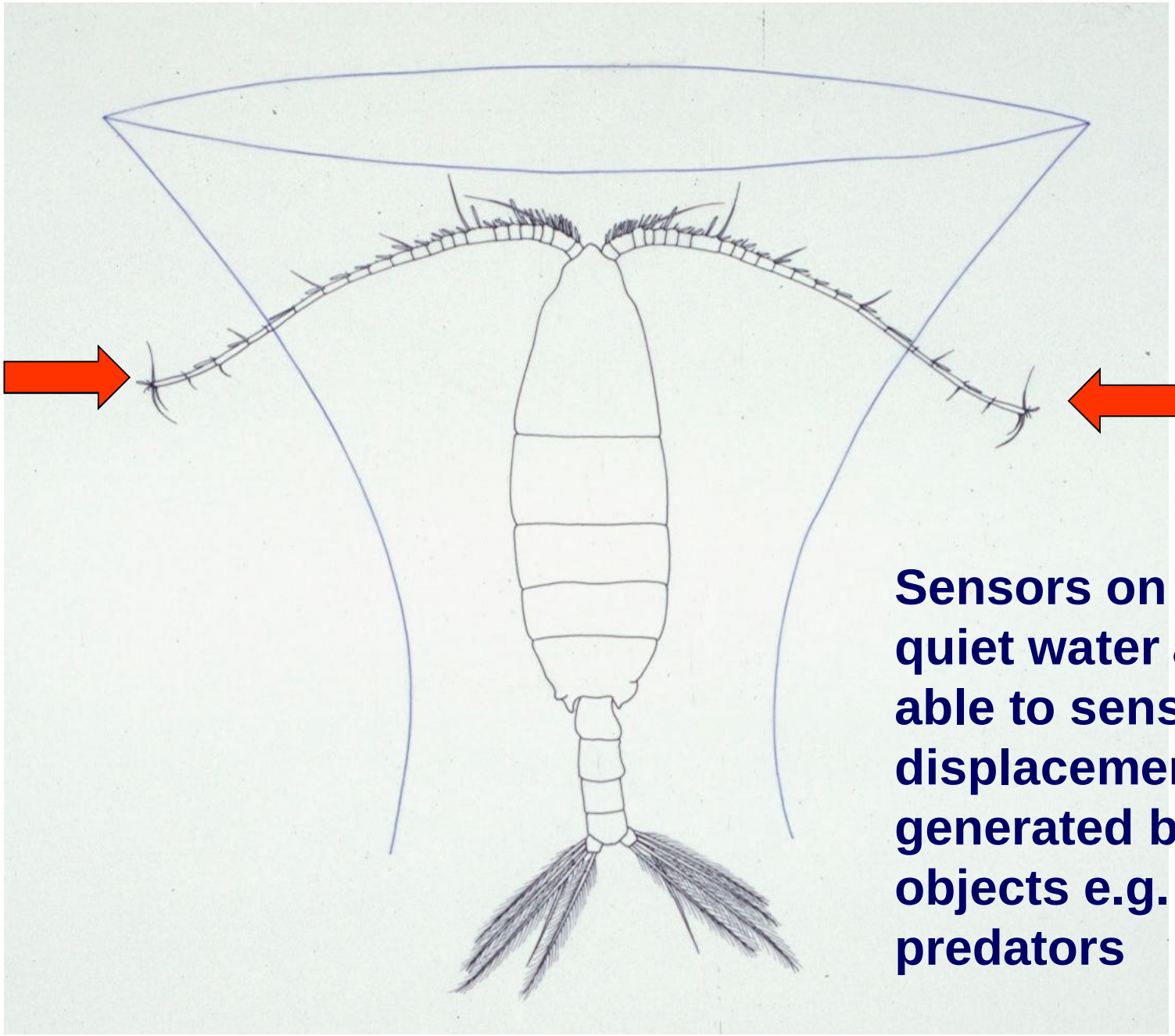




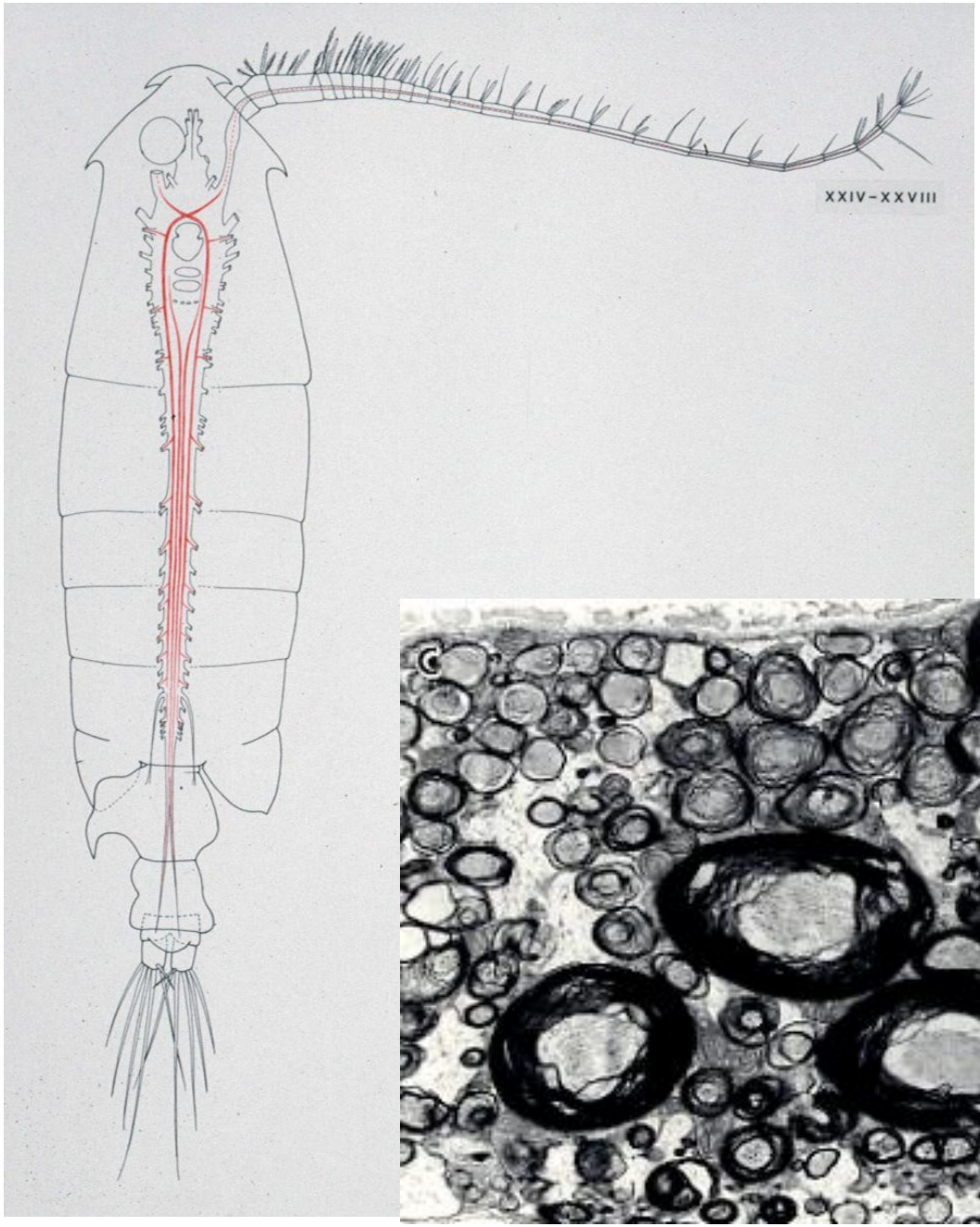
How to avoid becoming lunch for a fish?




Copepod cruising in
still water is noisy
Photo: Rudi Strickler

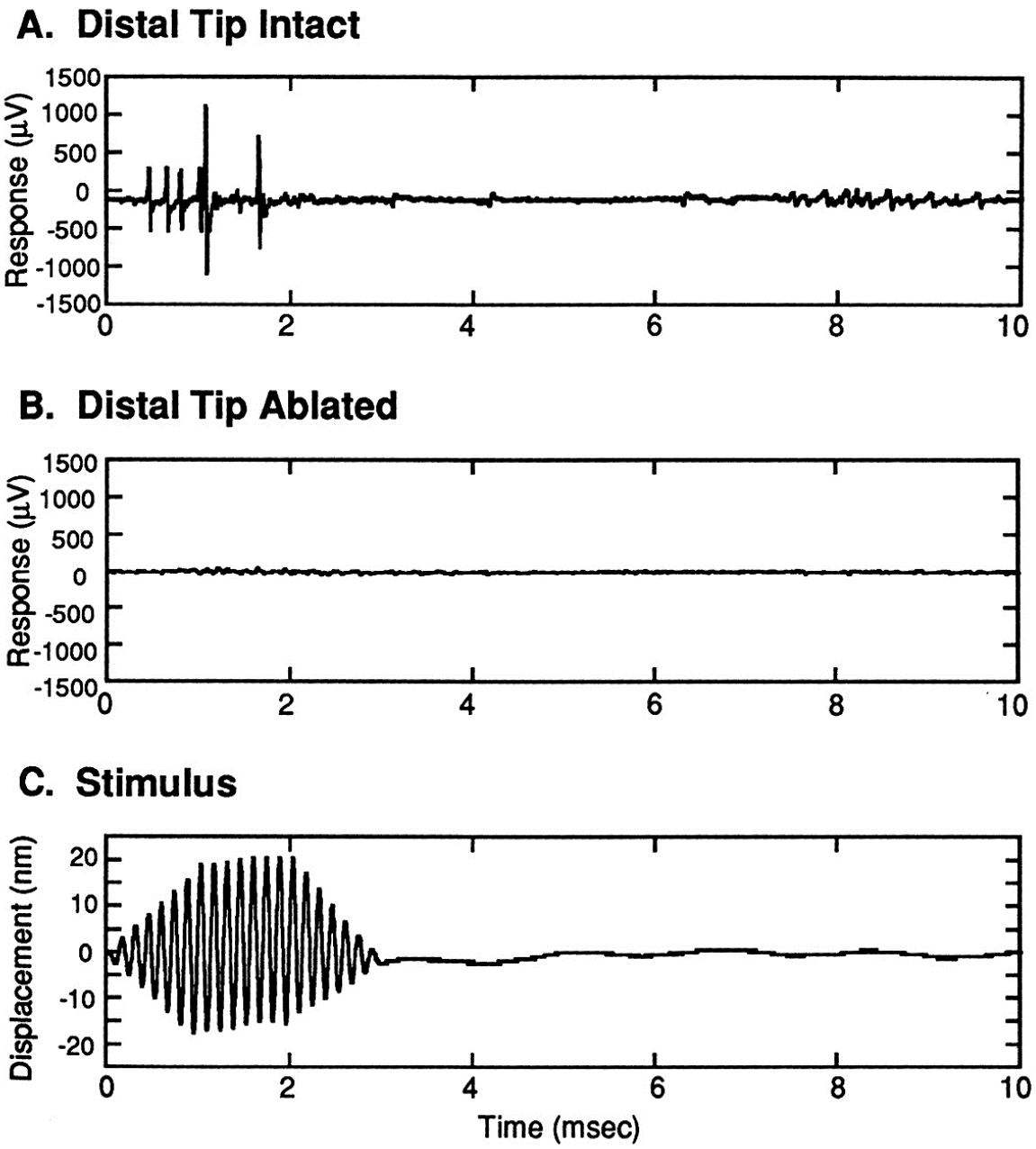


Sensors on tips are in quiet water and are able to sense water displacements generated by distant objects e.g. in-coming predators



Distal setae are the detectors & connect to giant fibres in nerve cord. Copepods have myelinised nerve axons - which facilitate rapid transmission of action potentials.

Davis et al. 1999



Lenz & Yen (1993) showed ablation of distal tip of antennules of *Pleuromamma* results in loss of ability to detect remote mechanical stimulus.

Photo: Rudi Strickler

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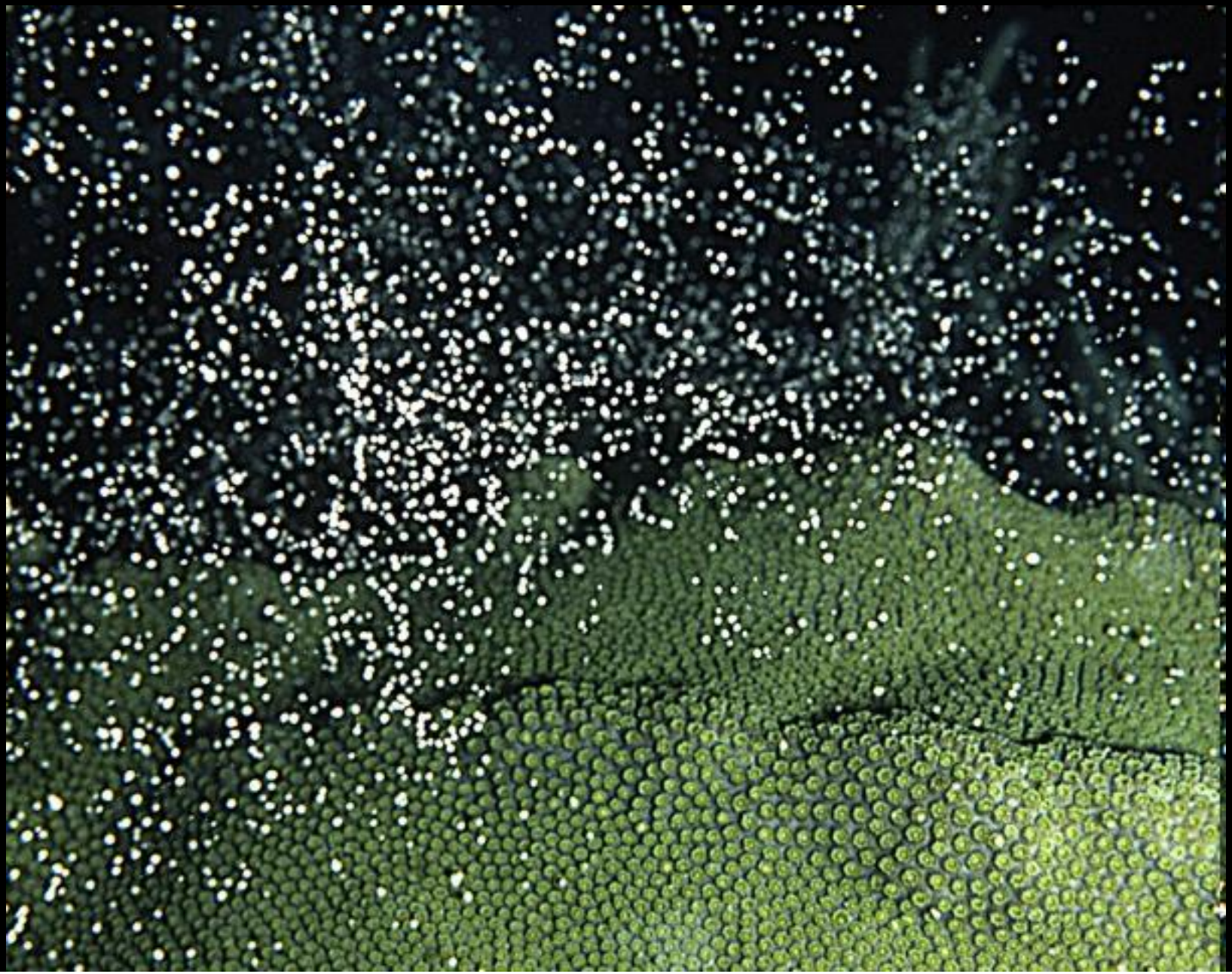
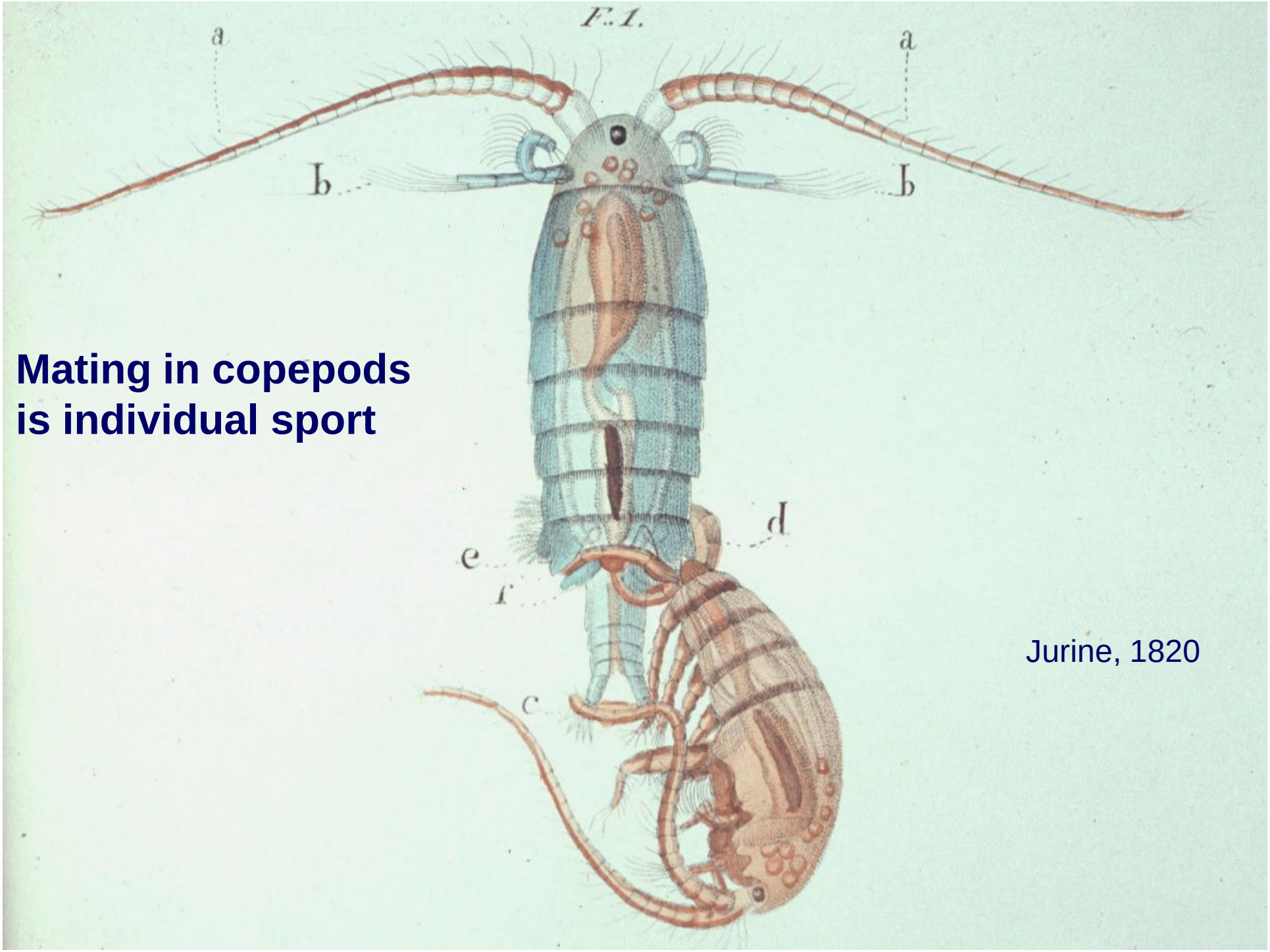
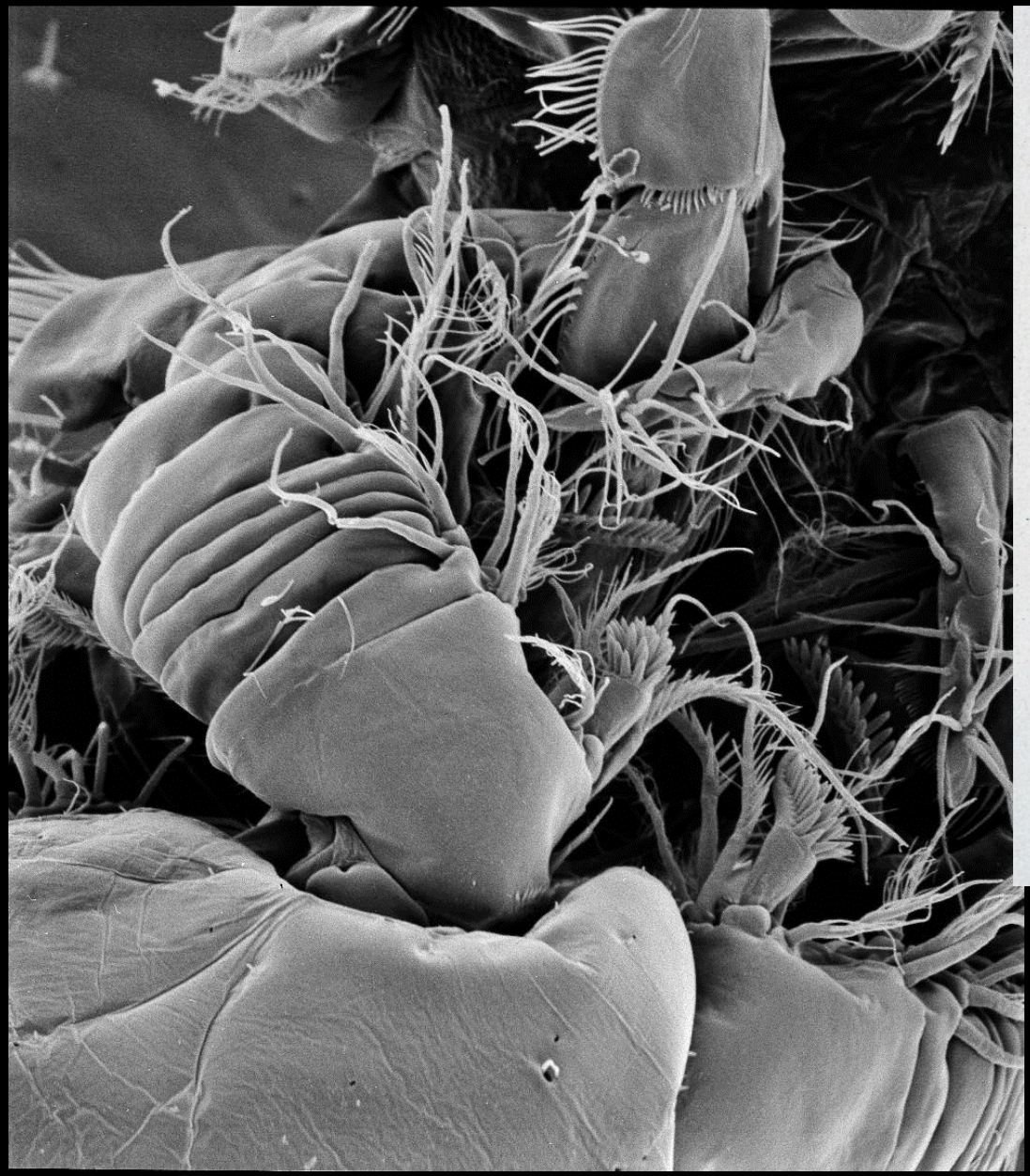
Mass spawning is still popular participation sport

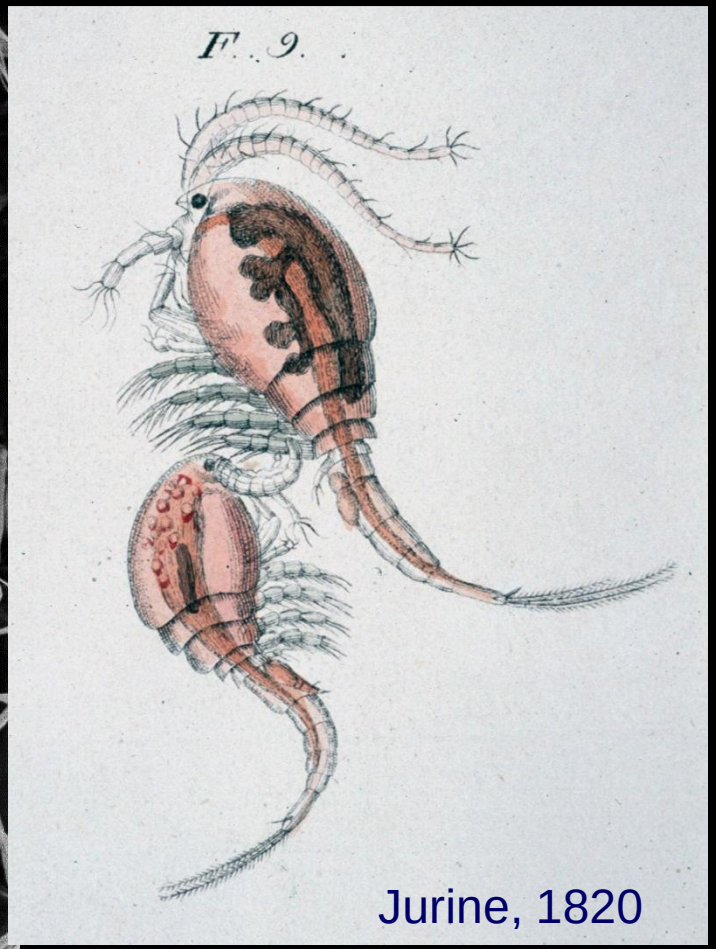




Mating in copepods is individual sport

Jurine, 1820




F. 9.
Jurine, 1820

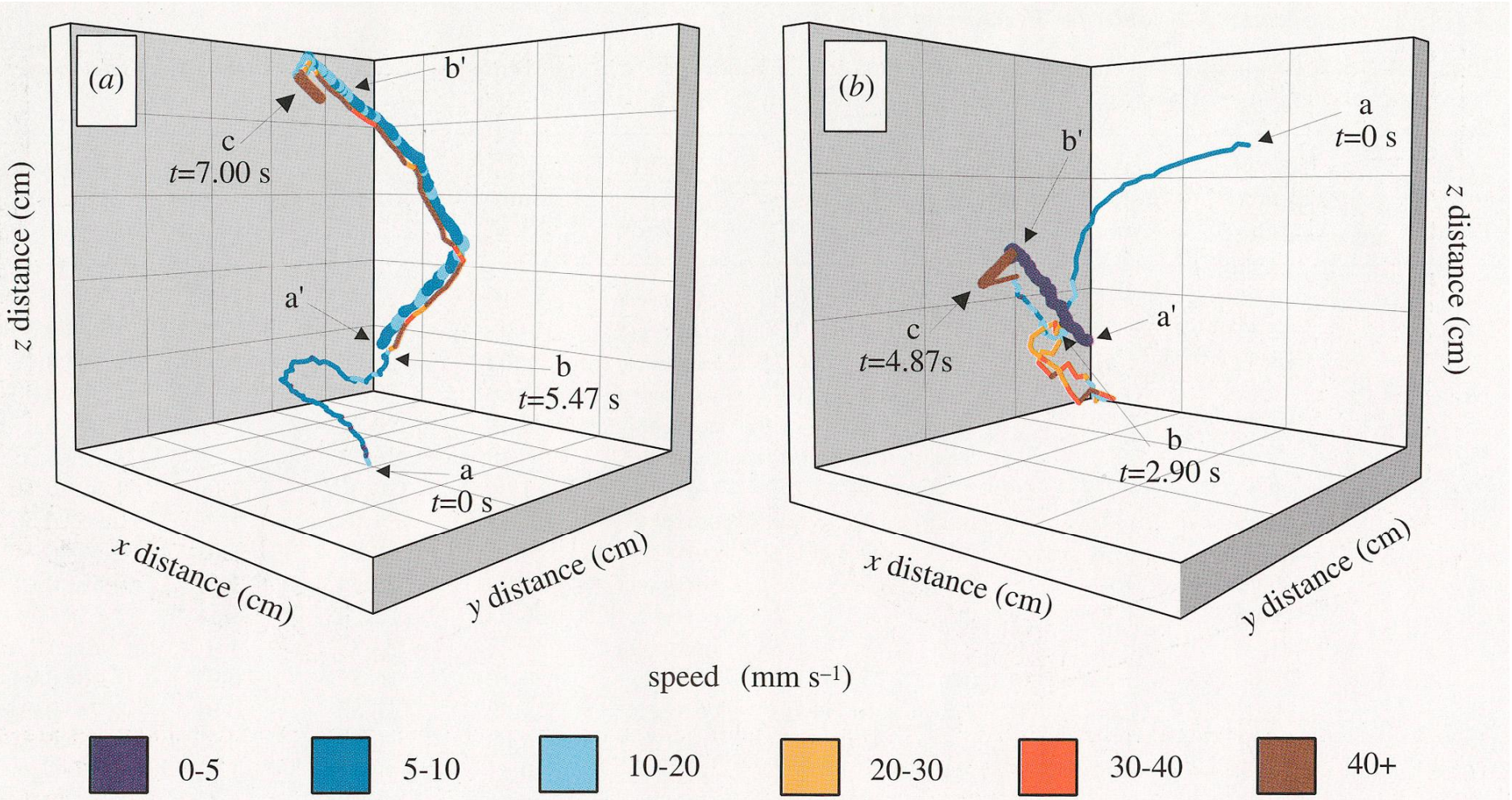
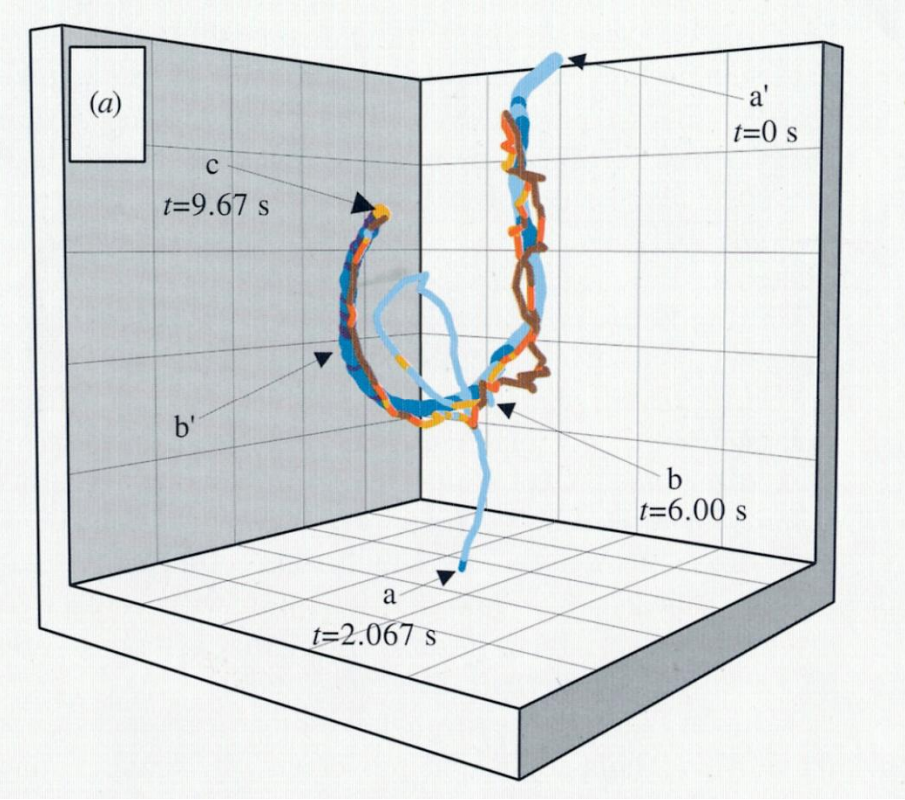


Figure 3. Mate-tracking by males of *Temora longicornis*. Male trajectories are represented by thinner lines than female trajectories. Time points are labelled with letters along male trajectories as follows: a, start of trajectory; b, male detects female's trail; c, male seizes female. The position of females at simultaneous time points are labelled with a′ and b′. (*a*) Tracking a cruising female (event 18 in table 1). The male copepod closely follows the sinuous trajectory of the cruising female, maintaining an average tracking distance of 1.02 mm. (*b*) Tracking a hovering female (event 4 in table 1). The male initiates casting behaviour on encountering the hovering female's trail.

Doall et al., 1998



Back-tracking:- male corrects his original incorrect pursuit by back-tracking, travelling a total distance of 137.8mm until capturing female (Doall et al., 1998)

Incorrect pursuit is common – in 40% of experiments – but backtracking successful in 41% of these cases.


Gold medal for mate location – to male copepods for tracking females over 60 body lengths away after encountering her trail (up to 10 seconds old)
Female lays trail of pheromones – male follows trail
Photo: Rudi Strickler

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Another Disqualification

Invasion via ship's ballast water

INDESCRIBABLE... INDESTRUCTIBLE! NOTHING CAN STOP IT!

THE BLOB

They look like a mass of rubbery goo. Their surface is acidic as stomach acid. They possess exponential reproductive powers and have no natural predators. They suffocate everything in their path. Damage them and they grow replacement parts, cut one in half and you create two living creatures. No one knows where they come from, but they are popping up all over the planet.

No, this isn't a creature invented by the mind of a 1950s B-movie director; it is real. Some marine scientists call the mysterious organism 'The Blob', but most know it as the sea squirt.

It may look harmless, but one particular species is invading shores all over the world and nothing can stand in its way.

The didemnum begins life as tadpole-like larvae with eyes, a heart and primitive, backbone-like tail. When it finds a suitable surface, it bonds to it and metamorphoses into a barrel-shaped animal. Once settled, the tiny creature starts to clone itself until, after a couple of years, it forms a blanket, several metres long, on the sea floor.

These colonies will cover anything in their path, creating dead zones on the ocean floor. If they cannot spread further in an area, parts of the colony simply break off and drift until they find a suitable home. Although they can reproduce in this asexual manner, they also breed sexually and release tadpoles to find new homes every summer.

Over the past few years, these suffocating mats have been threatening local sea life and the mussel, crab and lobster farming industries from the US to New Zealand.

Most recently, US scientists have been struggling to control the sea squirts on the bottom of Long Island Sound.

'This thing has the potential for causing significant economic impact when it attaches to the floor of the sound, where it blankets and suffocates shellfish and lobsters,' said Ivar Babb, of the University of Connecticut. 'They have no known predators. Nothing will grow on it.'

SEA SQUIRT FACTS

- They have no natural predators and are theoretically immortal – since they continue to clone themselves
- Sea squirts are the only animals to make cellulose, a primary structural component of plants
- Their primary food source is plankton which they trap in mucus and transport to the gut with tiny hairs
- They are distantly related to humans. Sea squirts are chordates which puts them in the same scientific group as vertebrates – sea squirts are literally our marine cousins

Didemnum smothering mussels

- Their blood contains the rare metal Vanadium at levels of up to one million times that of the surrounding sea water. It is not know how they achieve this, or why
- Some sea squirts have been found to contain a potent anti-cancer agent called ET-743. Because its early life cycle is so similar to our own, it is hoped that they could aid in human fertility research
- In some countries, such as Japan and Chile, they considered a delicacy
- It is thought they are spreading around the globe on the hulls or in the ballst tanks of cargo ships

A didemnum mat

There are some 3,000 species of sea squirt. Not all resemble cat's vomit

REPORTED DIDEMNUM INVASIONS SINCE 2001

Sea squirt tadpole

Some good science

www.metro.co.uk

METROCOSM

YOUR WEEKLY GUIDE TO THE WORLD OF SCIENCE AND DISCOVERY

Thur

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SEA SQUIRT FACTS

- They have no natural predators and are theoretically immortal – since they continue to clone themselves
- Sea squirts are the only animals to make cellulose, a primary structural component of plants
- Their primary food source is plankton which they trap in mucus and transport to the gut with tiny hairs
- They are distantly related to humans. Sea squirts are chordates which puts them in the same scientific group as vertebrates – sea squirts are literally our marine cousins

There are some 3,000 species of sea squirt. Not all resemble cat's vomit

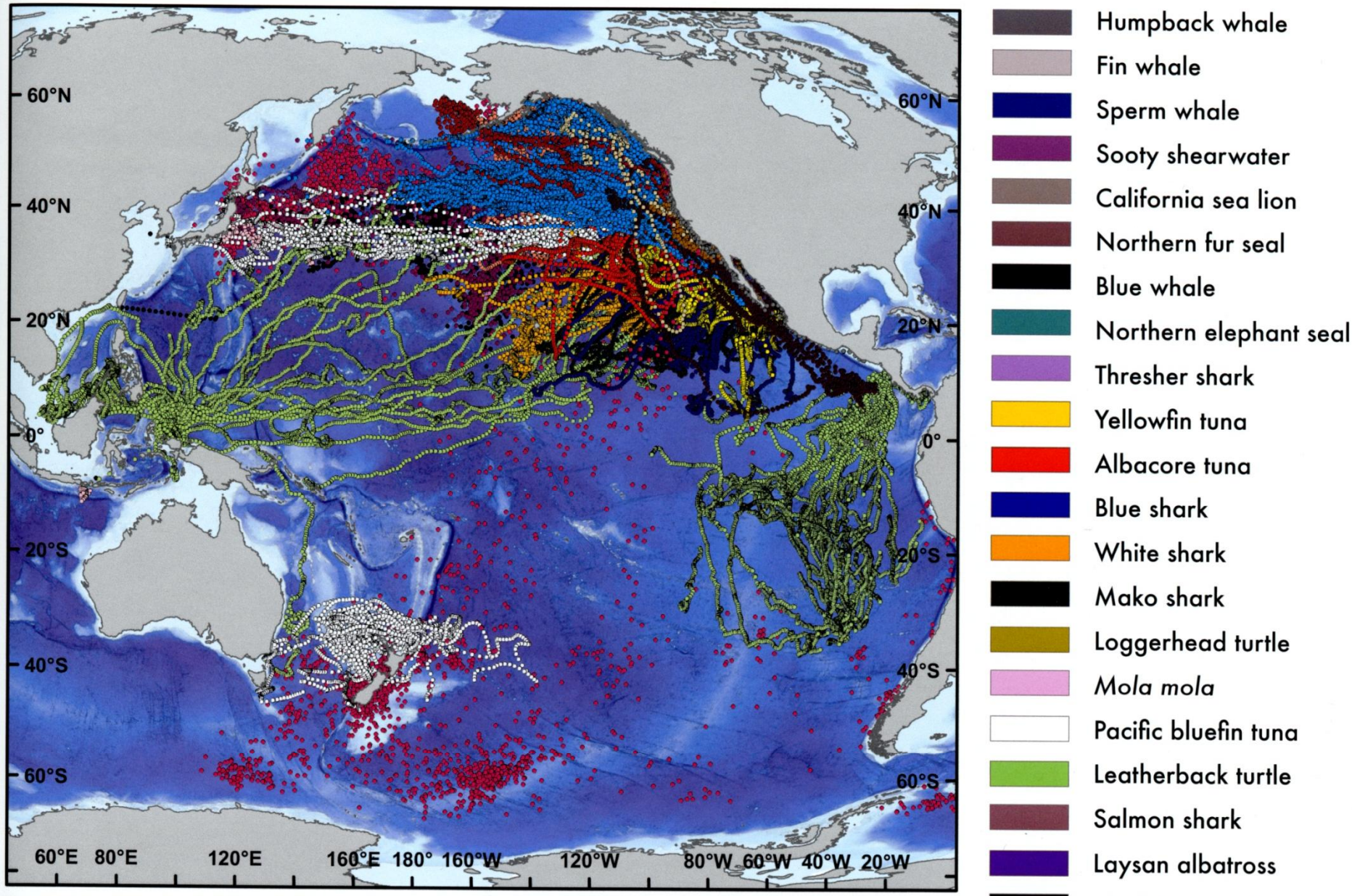
Didemnum smothering mussels

- Their blood contains the rare metal Vanadium at levels of up to one million times that of the surrounding sea water. It is not know how they achieve this, or why
- Some sea squirts have been found to contain a potent anti-cancer agent called ET-743. Because its early life cycle is so similar to our own, it is hoped that they could aid in human fertility research
- In some countries, such as Japan and Chile, they considered a delicacy
- It's thought they are spreading around the globe on the hulls or in the ballst tanks of cargo ships

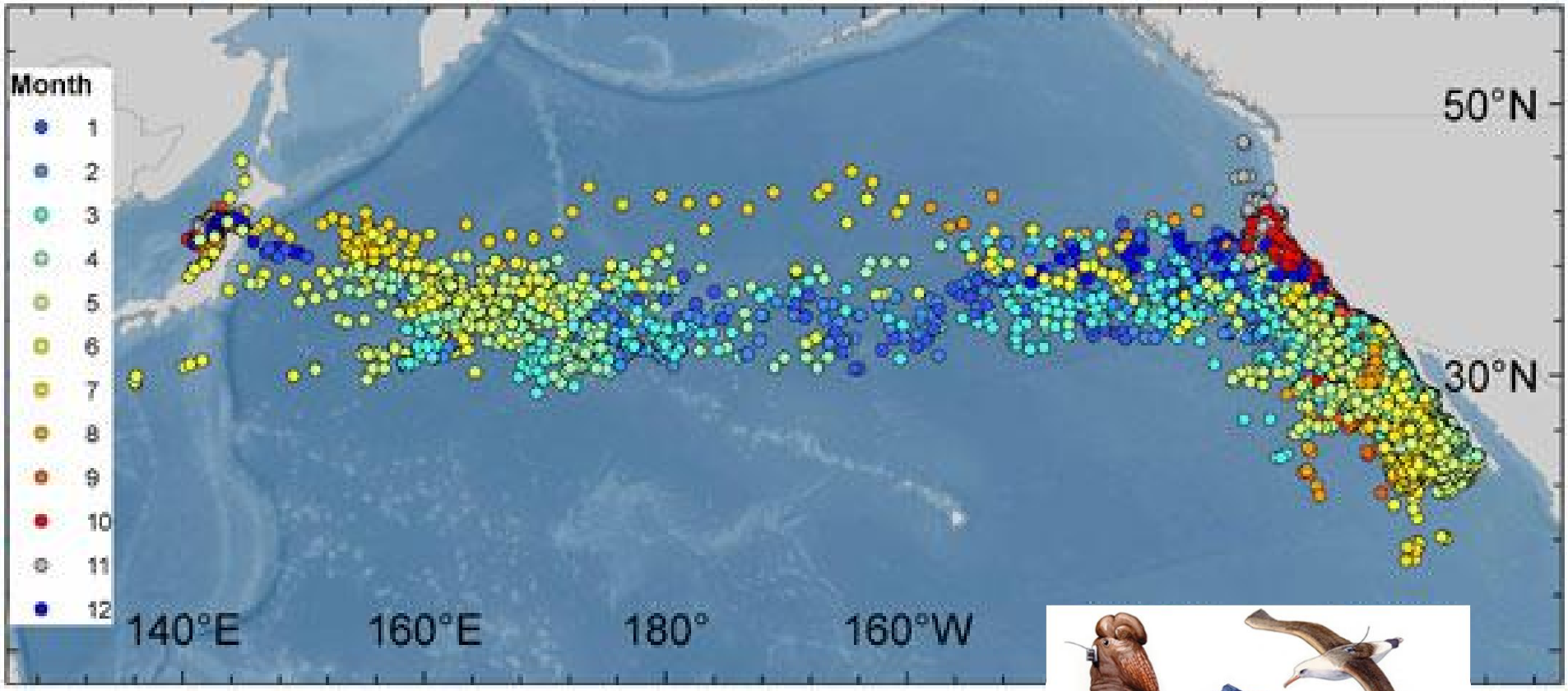
A didemnum mat

REPORTED DIDEMNUM INVASIONS SINCE 2001

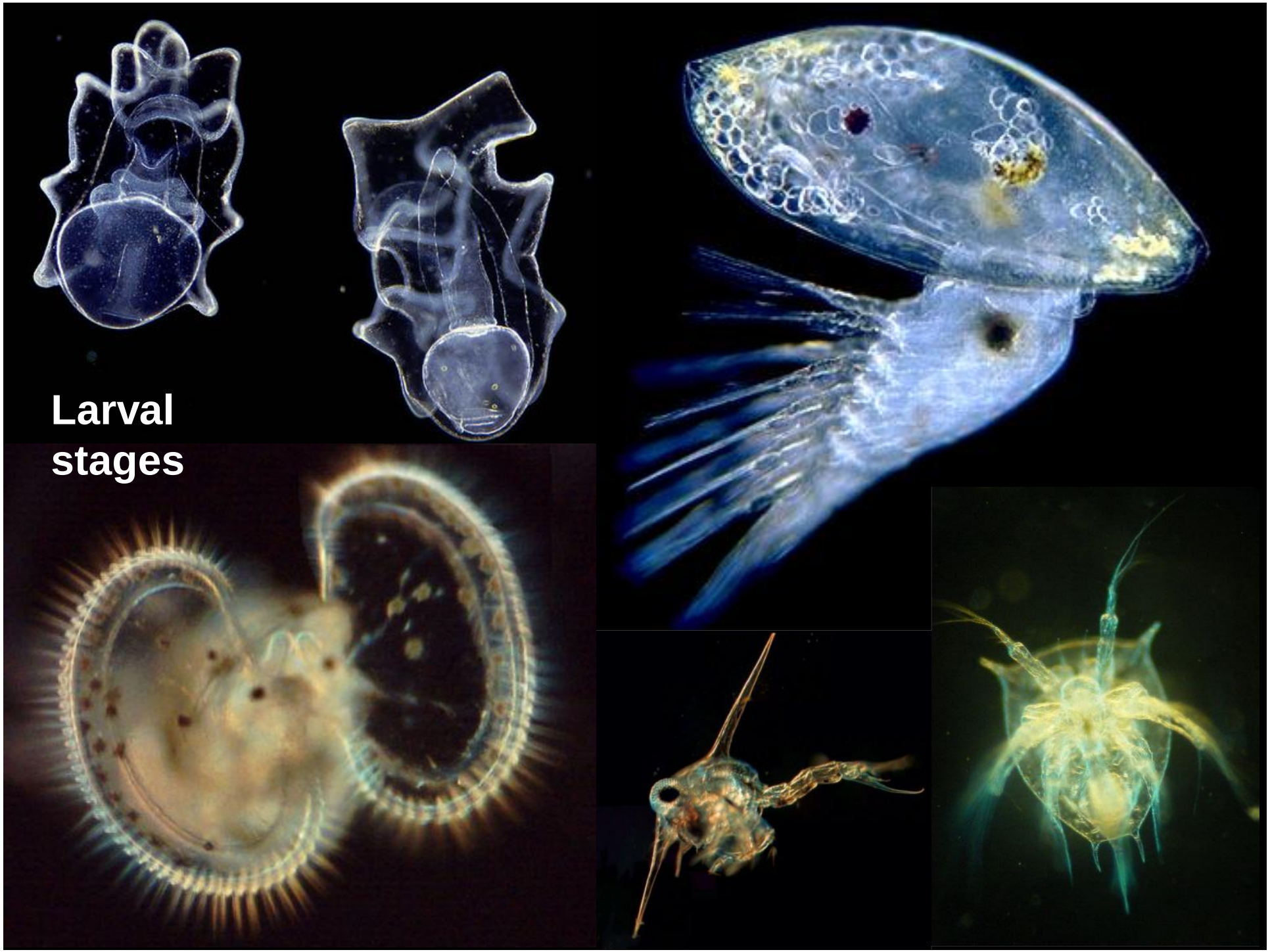
Sea squirt tadpole



34. Reports from birds, fish, whales, and other animals carrying small tags reveal highways and neighborhoods of the vast Pacific. Census biologgers followed bluefin tuna, *Thunnus orientalis,* commuting between Japan and California and leatherback turtles, *Dermochelys coriacea,* between Borneo and Mexico. Traveling animals connect all the oceans. *Source: Tagging of Pacific Predators. Image: Blackwell Publishing Ltd.*



TOPP programme tracked one Pacific Bluefin Tuna which crossed the Pacific three times in 600 days


Larval
stages

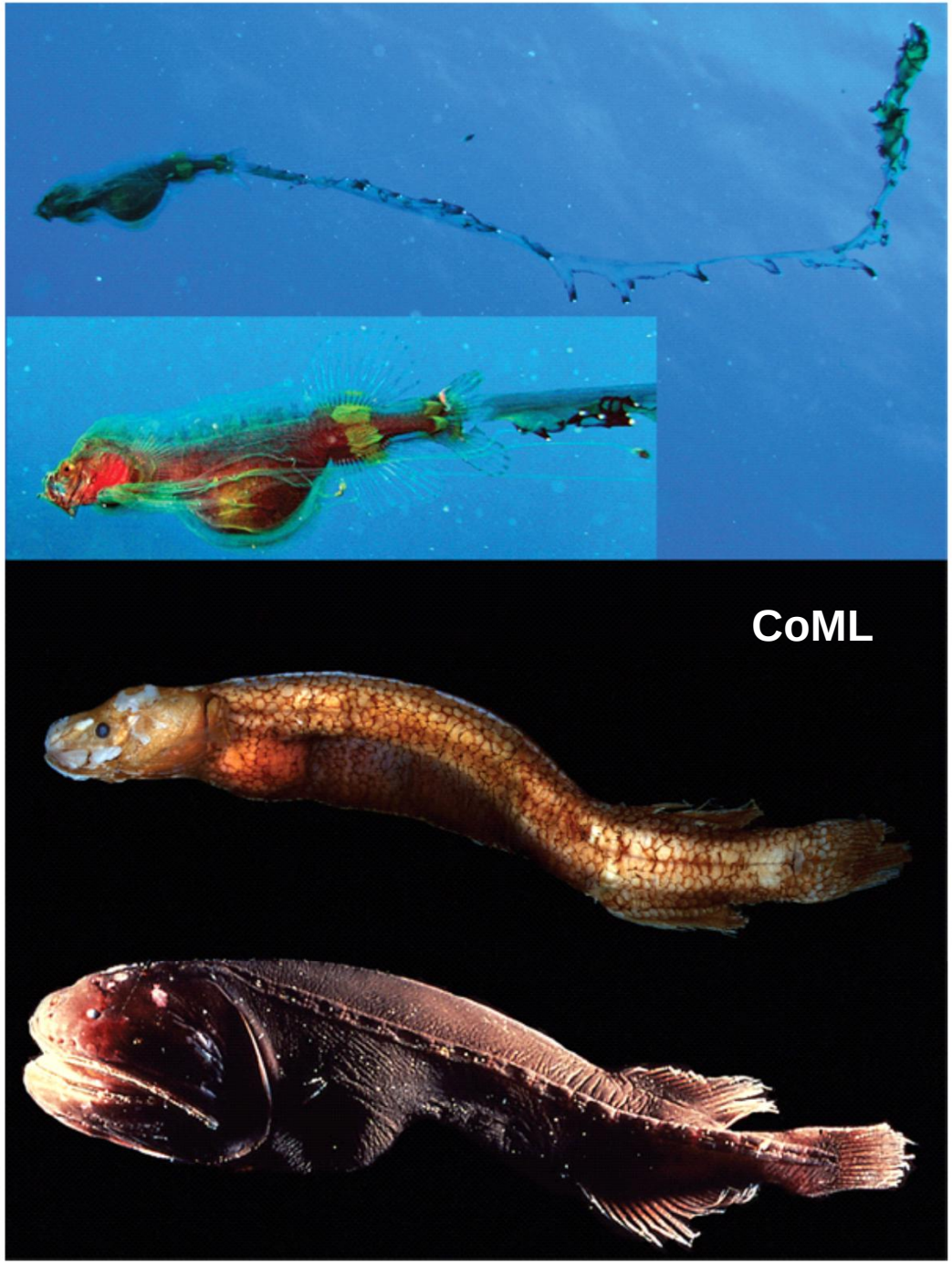
Some larvae so strange the adults remained unknown

Larval stages: classified as Tapetails – **Mirapinnidae**

DNA analysis revealed:

Adult Males: classified as bignose fishes - **Megalomycteridae**

Adult females: classified as whalefishes - **Cetomimidae**

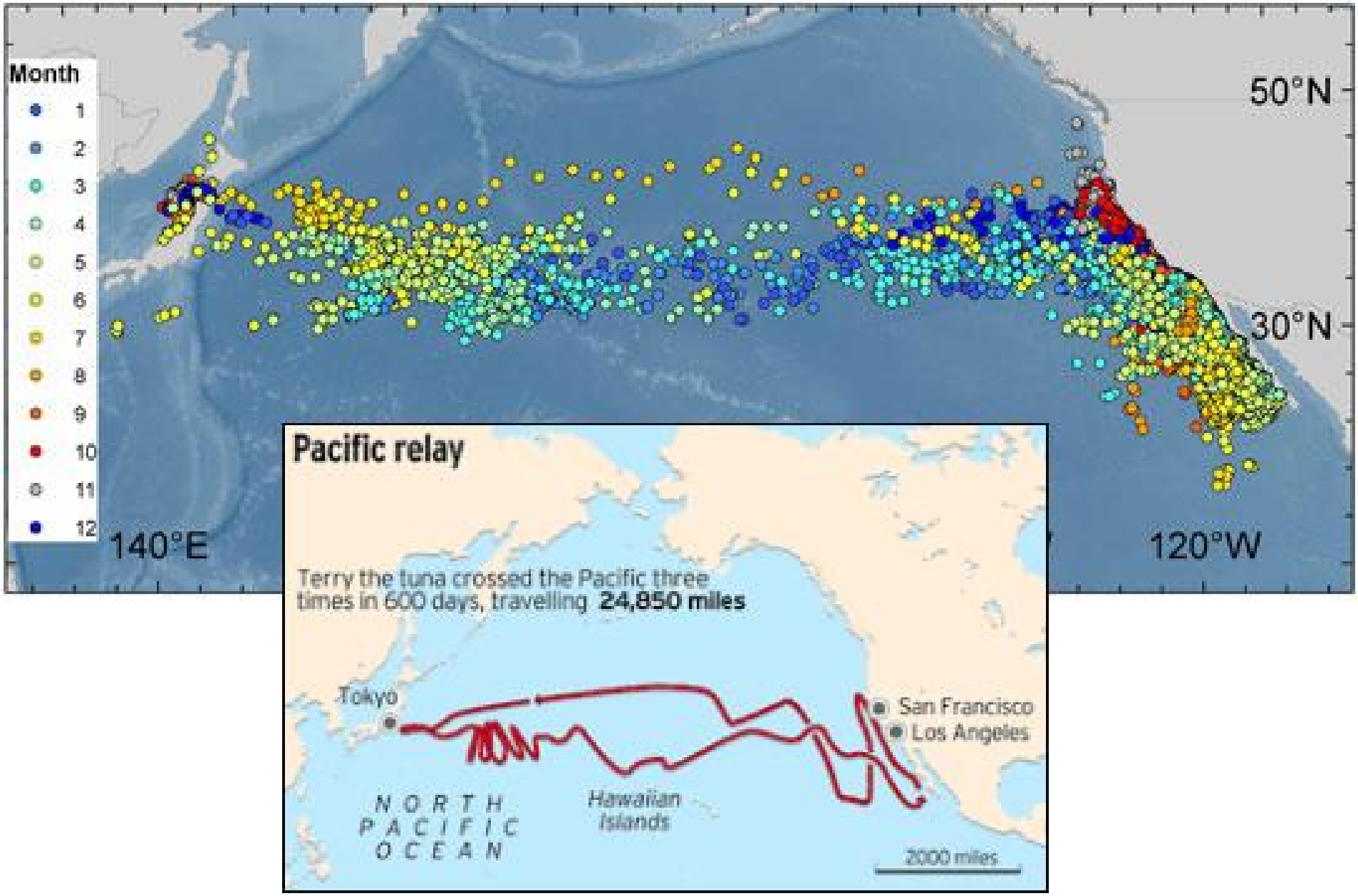


Silver medal goes to

Veliger of *Fusitriton oregonensis* – 4 years as larva and can drift across the Pacific

Strathman & Strathman (2007)

Gold medal goes to Terry the tuna



Olympic Pool Programme

1. Diversity Competition
2. Predator versus Prey (head-to-head)
3. Finding a Mate
4. Long Distance Swimming

5. **Future prospects**

Tuna on the quayside in the Azores in 1977 – now collapsed

Unsustainable exploitation of ocean resources adds to other stressors – temperature, ocean acidification, coastal eutrophication and invasive species...

80% of global fisheries are maximally or over-exploited (FAO)

Take Home Messages

- More than half of primary production takes place in the oceans
- There are nearly 250,000 described marine species and 2000 new species added p.a.
- Survival in the open water column depends on predator avoidance and mate location
- Many species are high mobile
- Mobility makes stock assessment difficult but we must manage the oceans better in future


Thank you