State of the Oceans: 2011

Jim Galasyn

University Congregational United Church of Christ

20 November 2011

Agenda

- Background
- Overfishing
- Biogeochemical cycles
- Prospects

Background

- Biography
- Exponential growth
- Predator-prey relationship
- Mass extinction events
- Permian-Triassic extinction

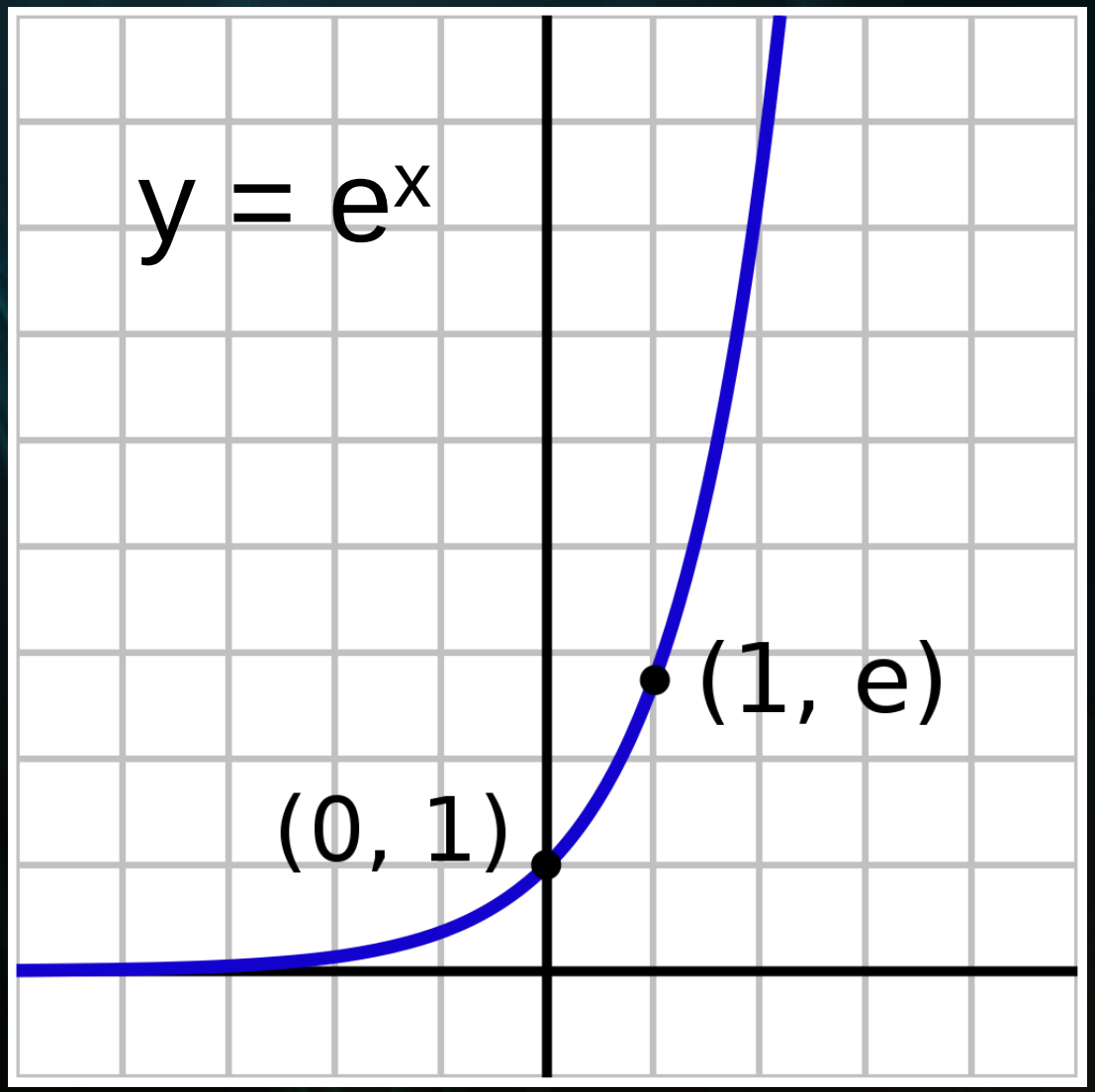
Soylent Green

Exponential function

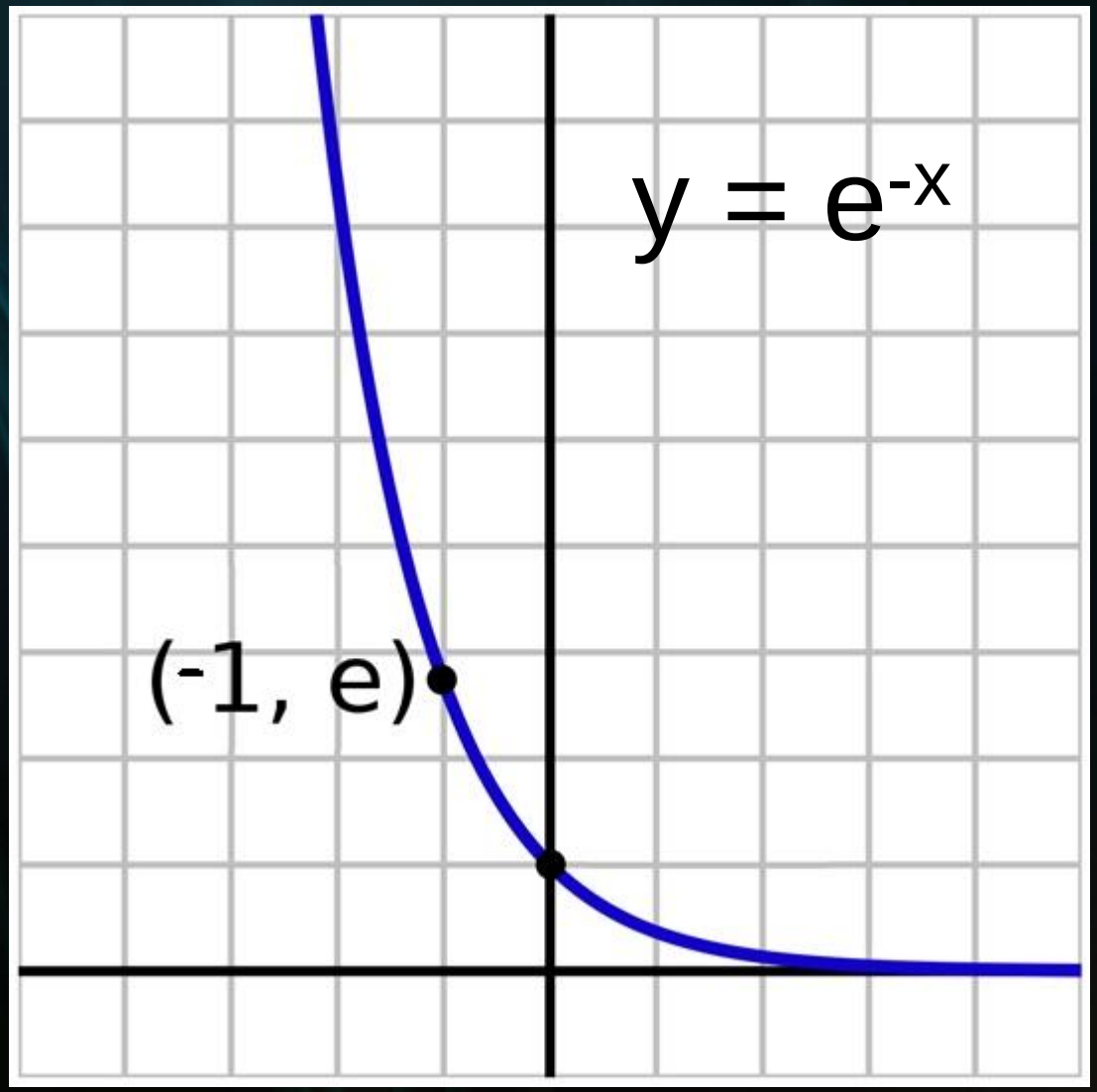
"The greatest shortcoming of the human race is our inability to understand the exponential function."

Albert Allen Bartlett

Exponential growth



Exponential decay



Predator-prey relationship

Predator-prey relationship

$$\frac{dN_h}{dt} = r_h N_h - p N_h N_p$$

Predator-prey relationship

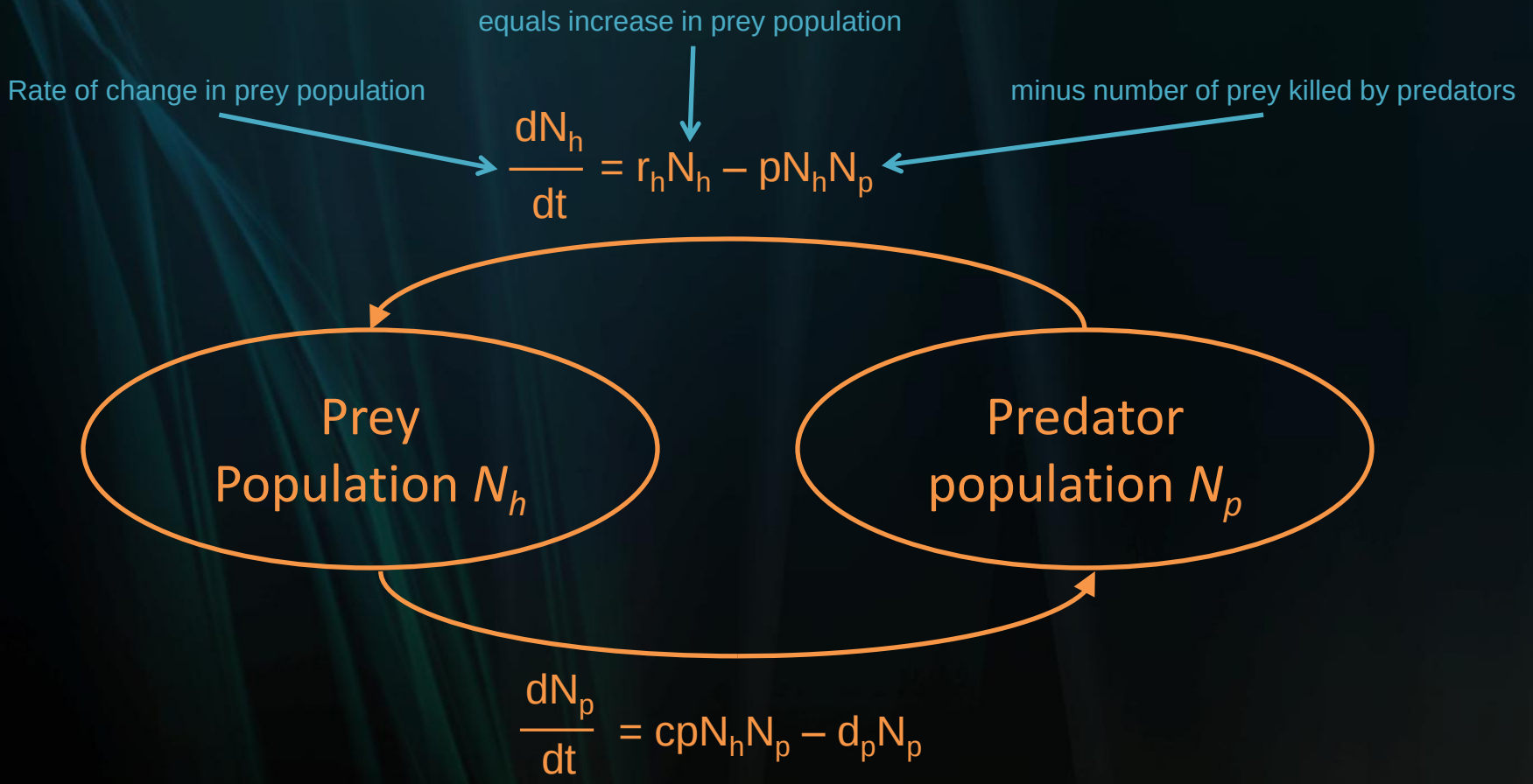
equals increase in prey population

Rate of change in prey population

minus number of prey killed by predators

$$\frac{dN_h}{dt} = r_h N_h - pN_h N_p$$

Predator-prey relationship



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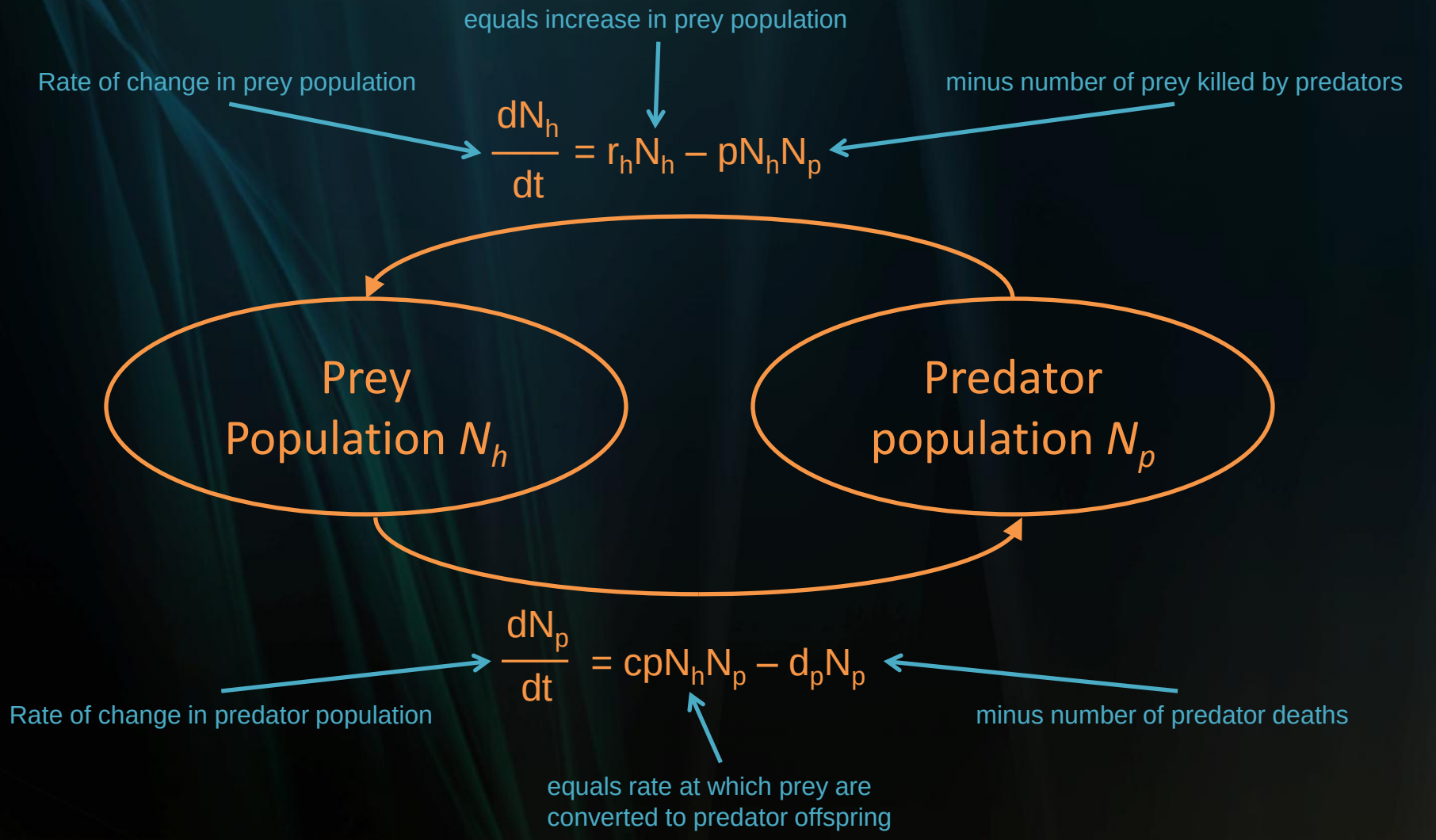

Predator-prey relationship

equals increase in prey population

Rate of change in prey population

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$$\frac{dN_h}{dt} = r_h N_h - pN_h N_p$$

$$N_h = \tfrac{1}{2}\tau \pm (\tau^2 - 4Ce^{\tau})^{\frac{1}{2}}$$

Prey population N_h

Predator population N_p

$$N_p = \tfrac{1}{2}\tau \mp (\tau^2 - 4Ce^{\tau})^{\frac{1}{2}}$$

$$\frac{dN_p}{dt} = cpN_h N_p - d_p N_p$$

Rate of change in predator population

minus number of predator deaths

equals rate at which prey are converted to predator offspring

Predator-prey relationship

equals increase in prey population

Rate of change in prey population

minus number of prey killed by predators

$$\frac{dN_h}{dt} = r_h N_h - pN_h N_p$$

$$N_h = \tfrac{1}{2}\tau \pm (\tau^2 - 4C)^{\tfrac{1}{2}} e^{\tau}$$

Prey population N_h

Predator population N_p

$$N_p = \tfrac{1}{2}\tau + (\tau^2 - 4C)^{\tfrac{1}{2}} e^{\tau}$$

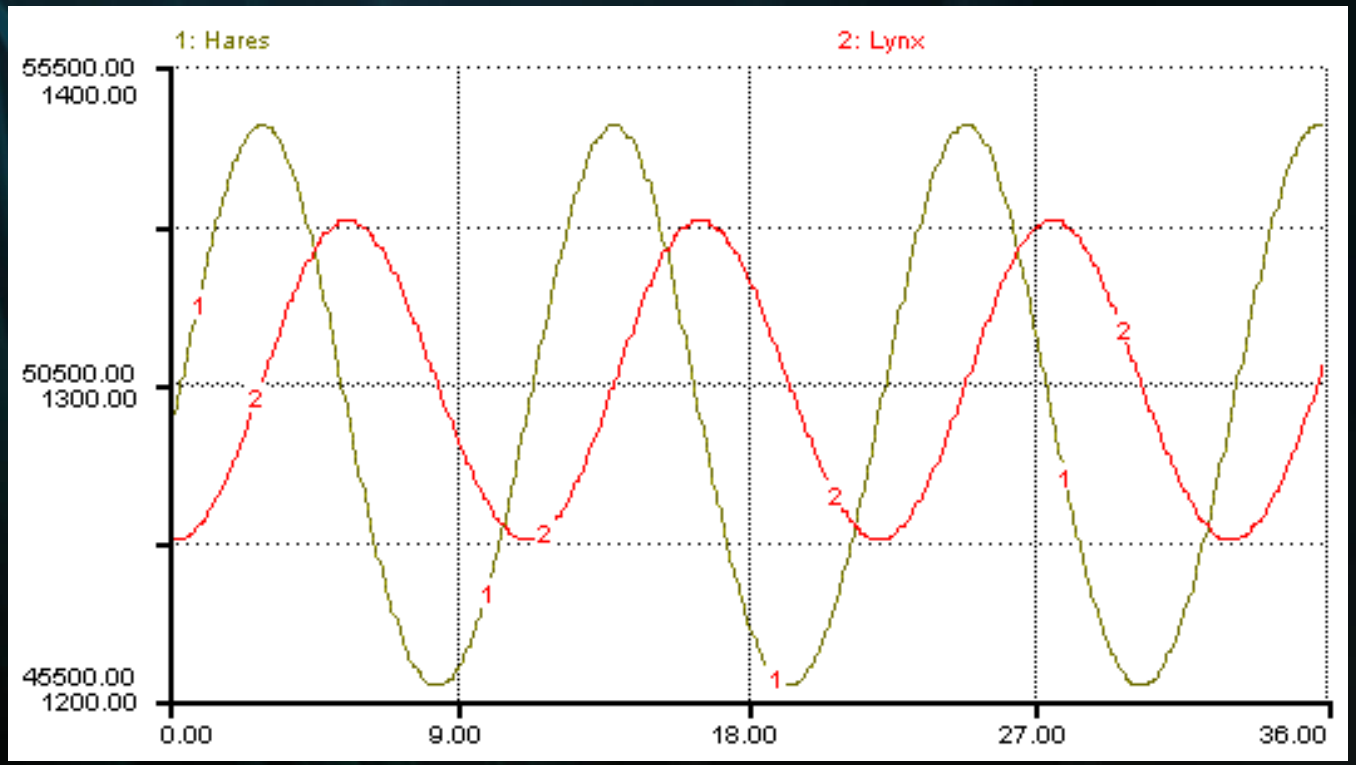
$$\frac{dN_p}{dt} = cpN_h N_p - d_p N_p$$

Rate of change in predator population

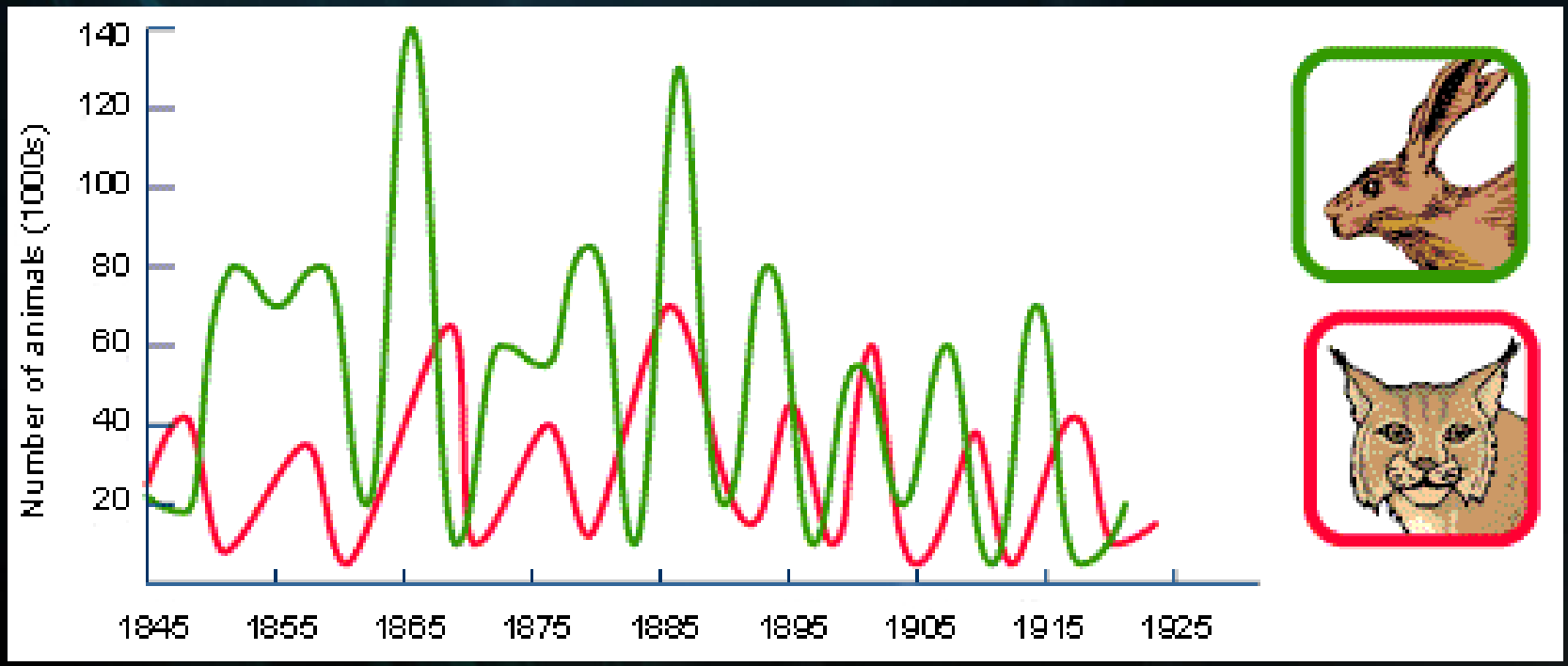
minus number of predator deaths

equals rate at which prey are converted to predator offspring

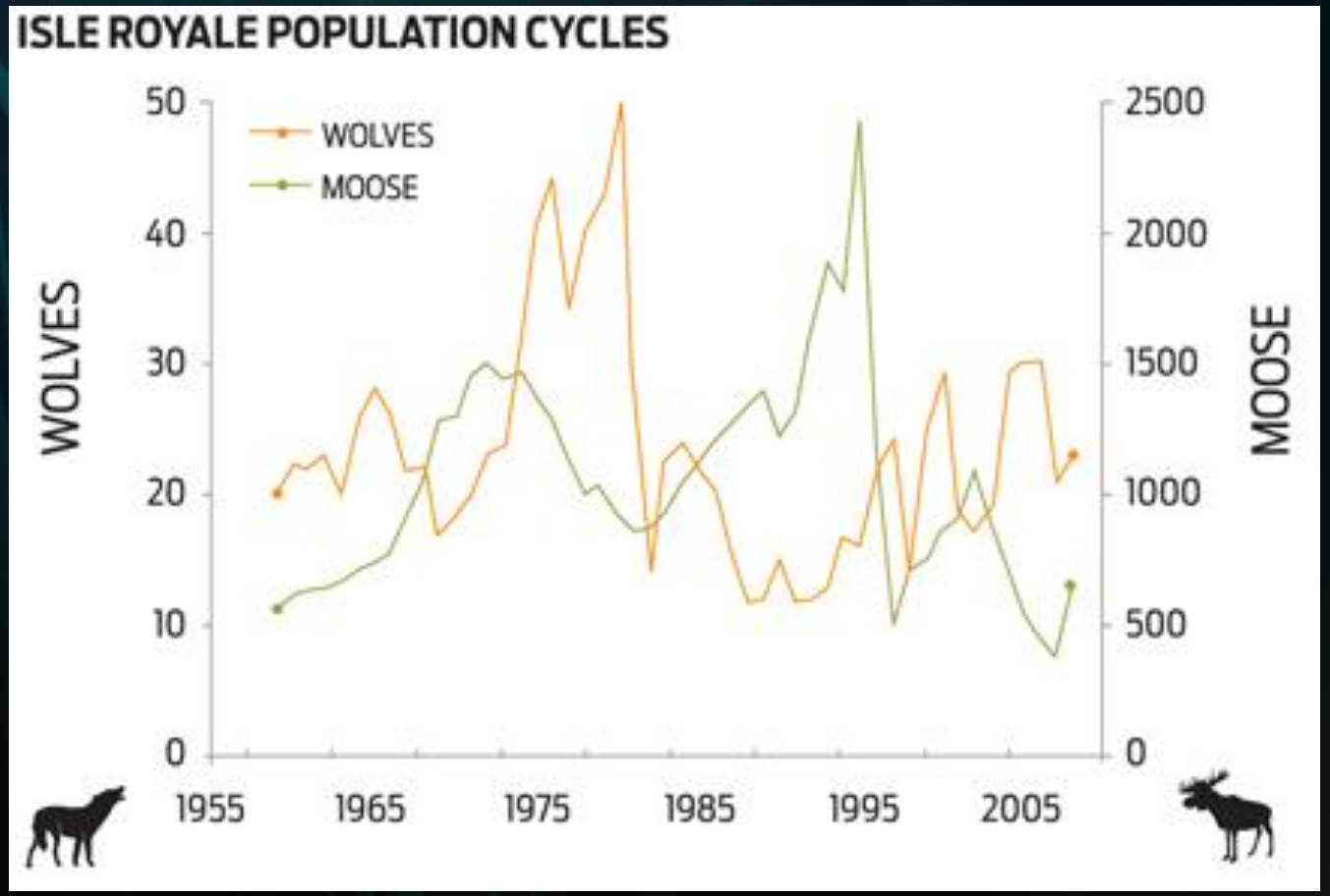
Predator-prey curves



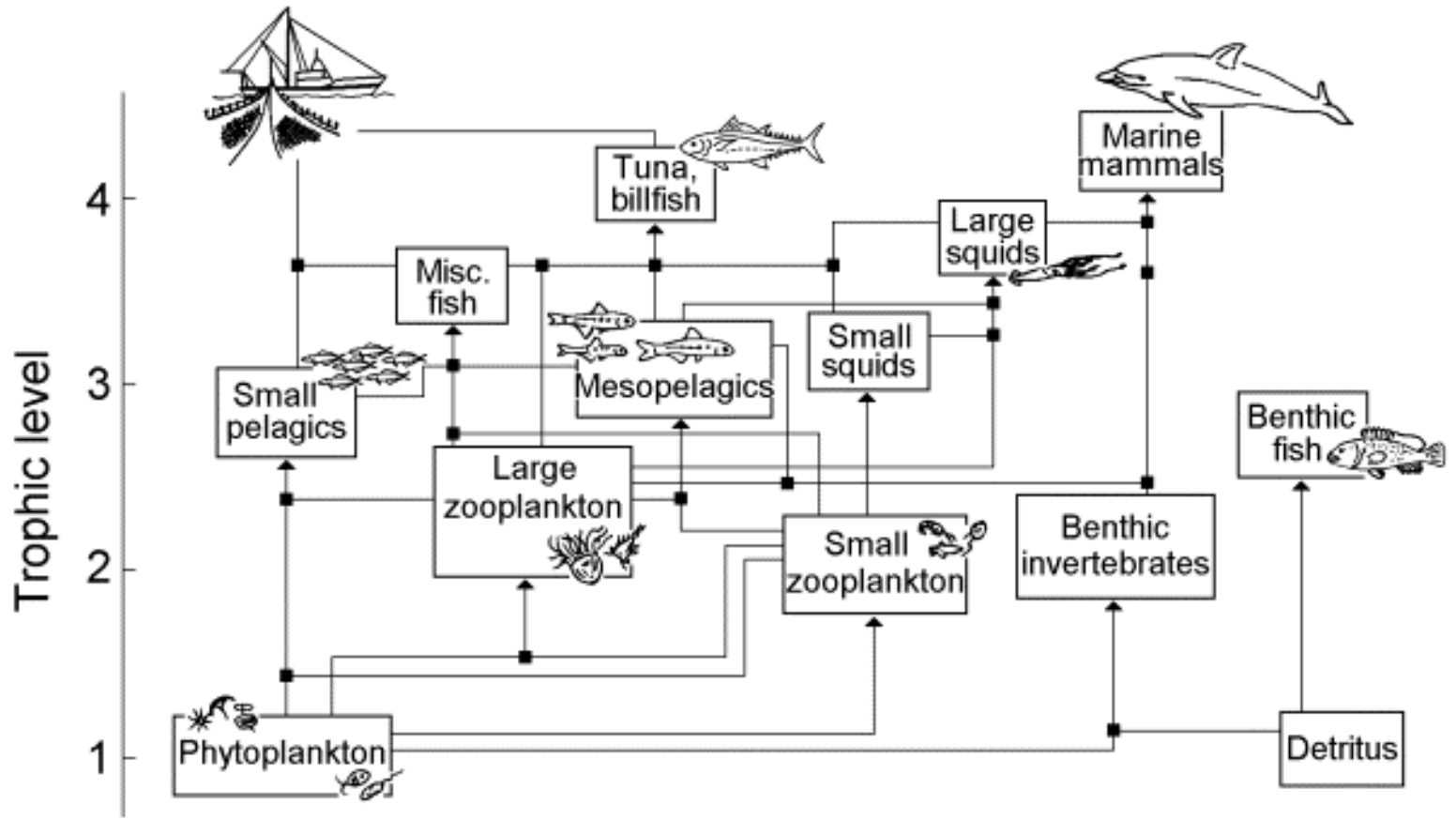
Predator-prey curves



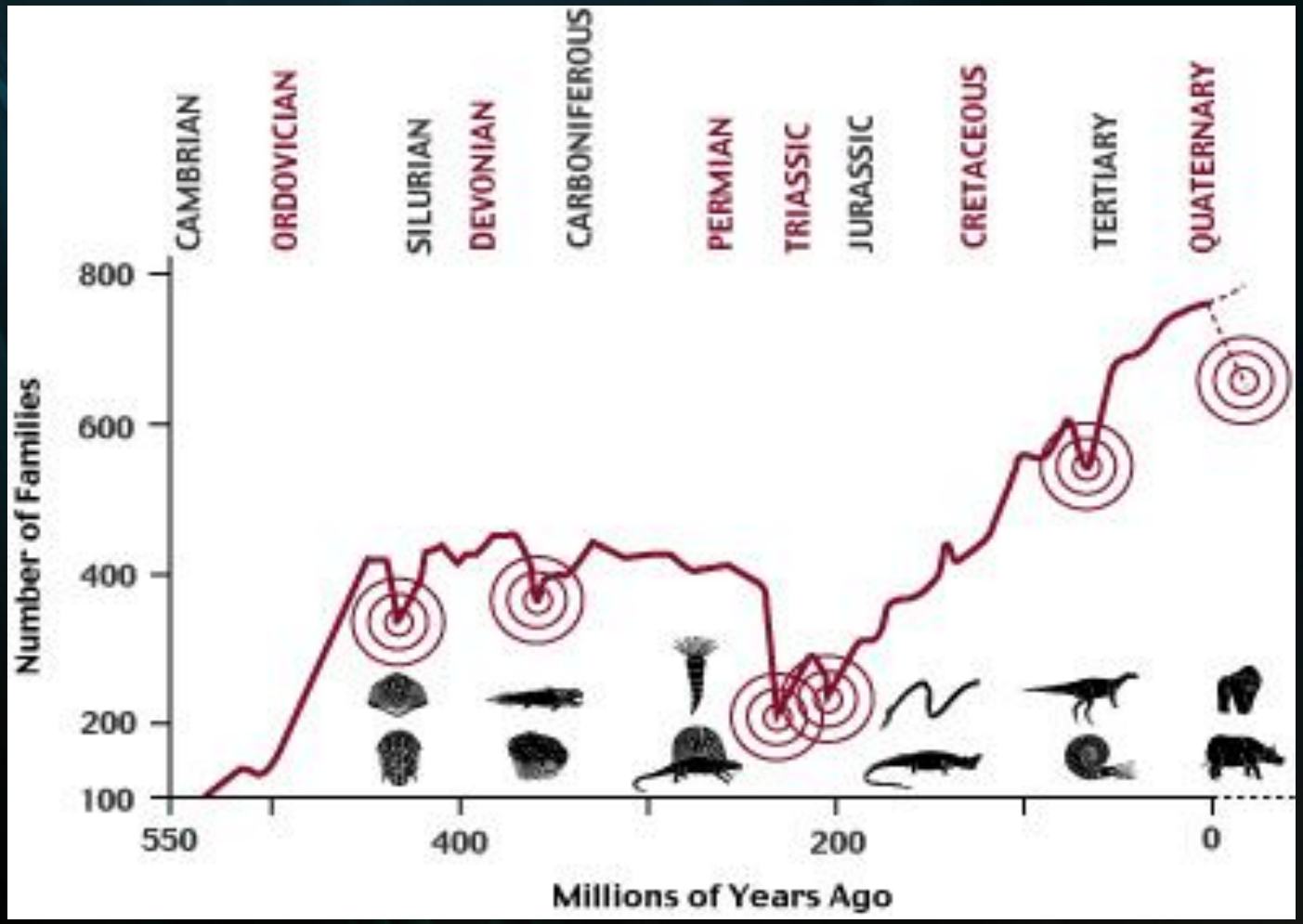
Predator-prey curves



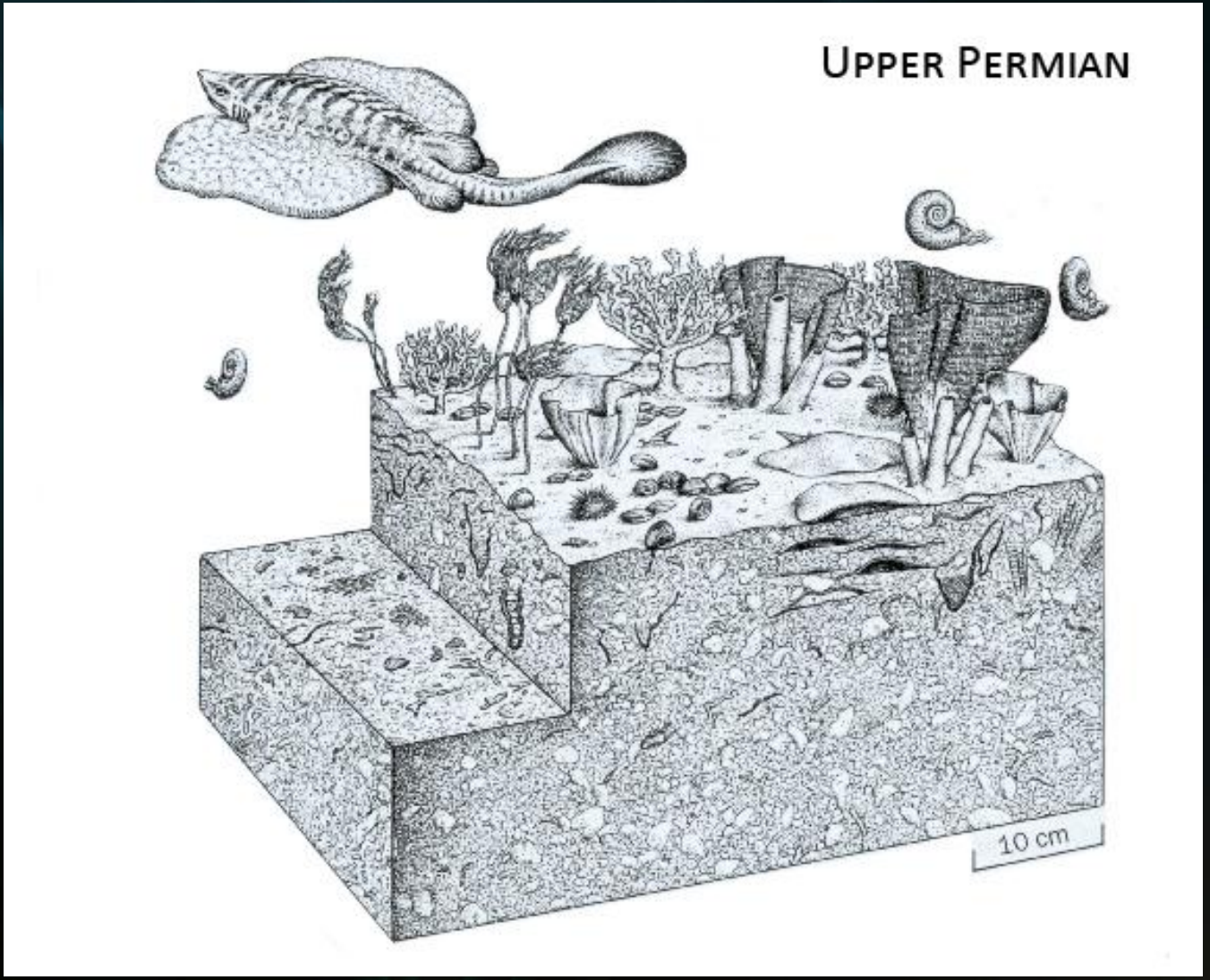
Marine food web



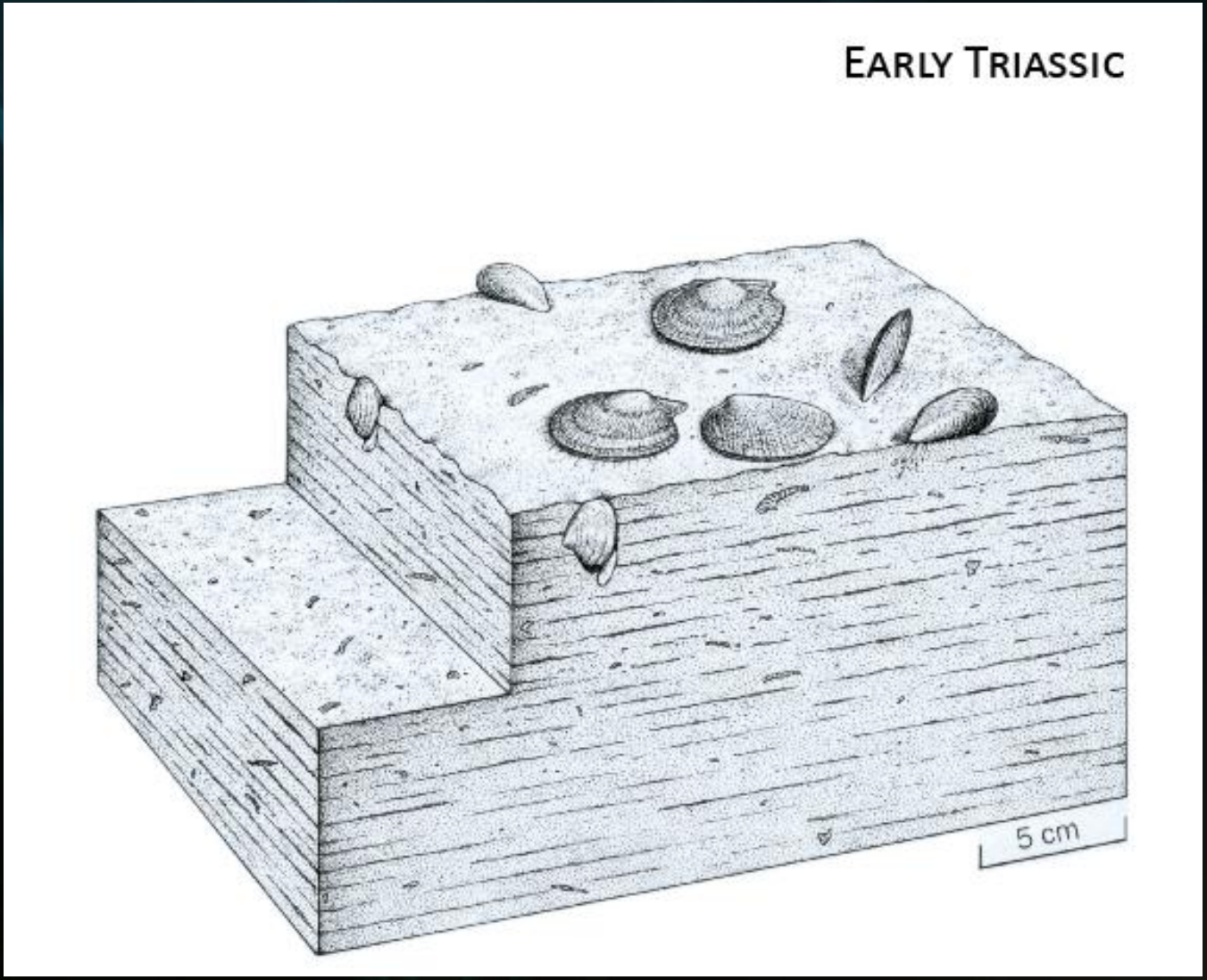
Mass extinction events



Permian-Triassic extinction



Permian-Triassic extinction



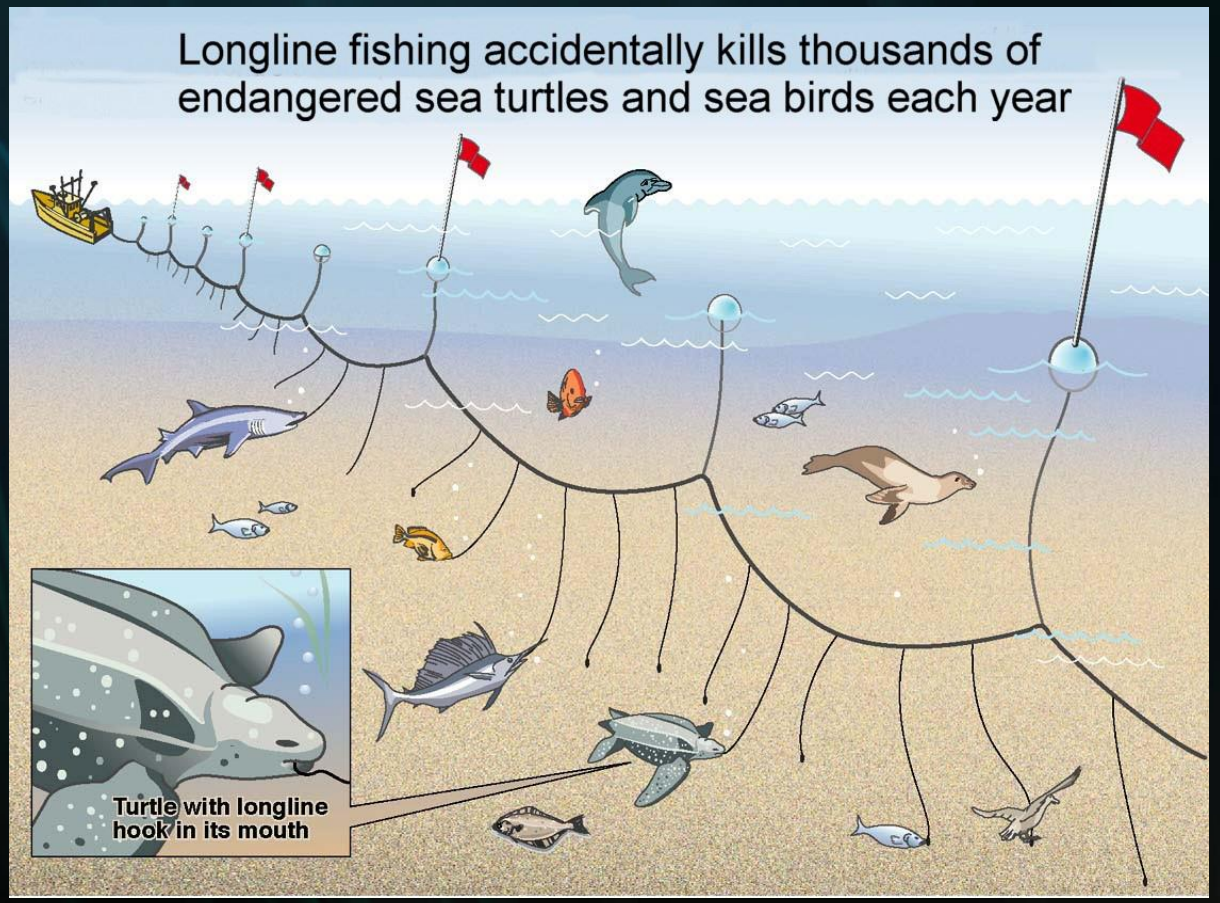
Permian-Triassic extinction

Permian-Triassic extinction

Overfishing

- Pelagic longlines
- Bottom trawling
- Trophic cascades: top-down
- Trophic cascades: bottom-up

Overfishing: pelagic longlines

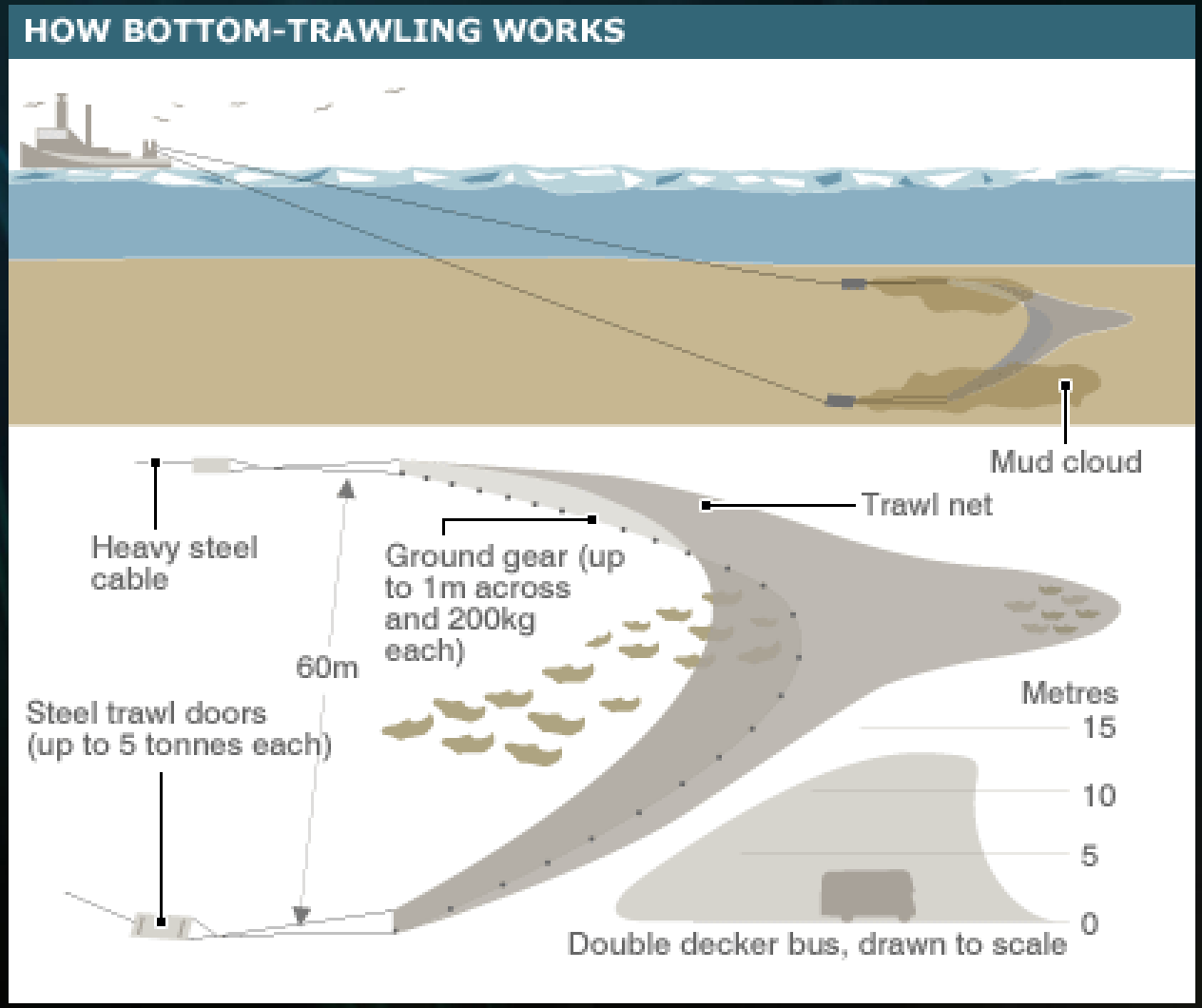


Pelagic longlines

Pelagic longlines

Pelagic longlines

Bottom trawling



Bottom trawling

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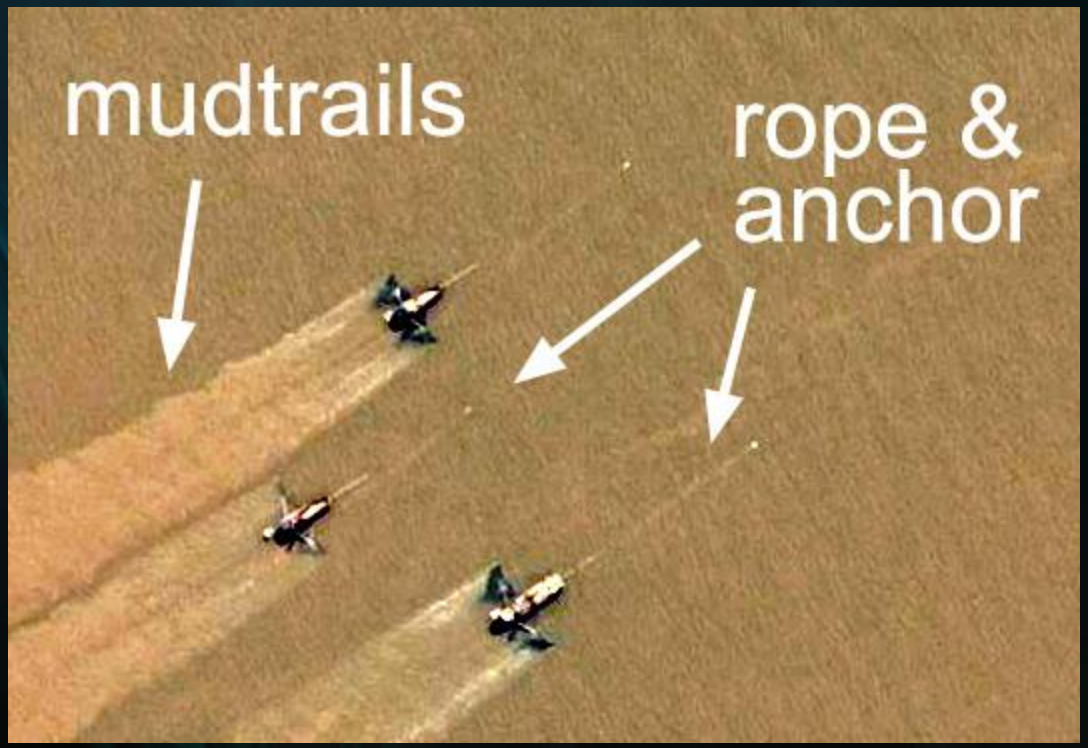
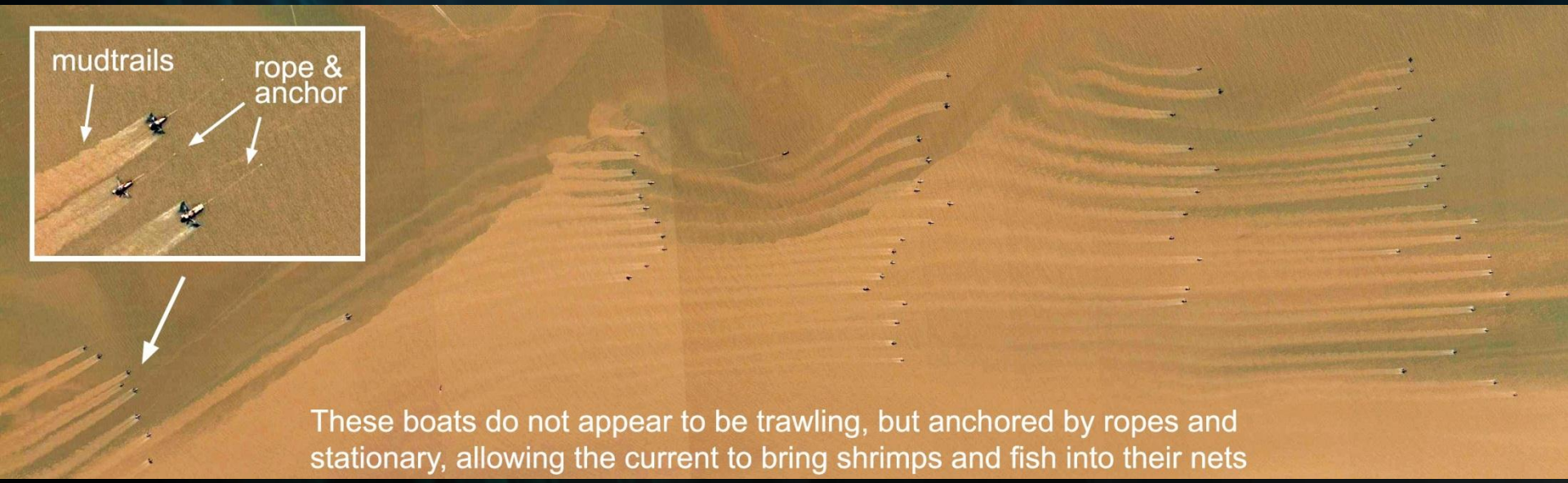


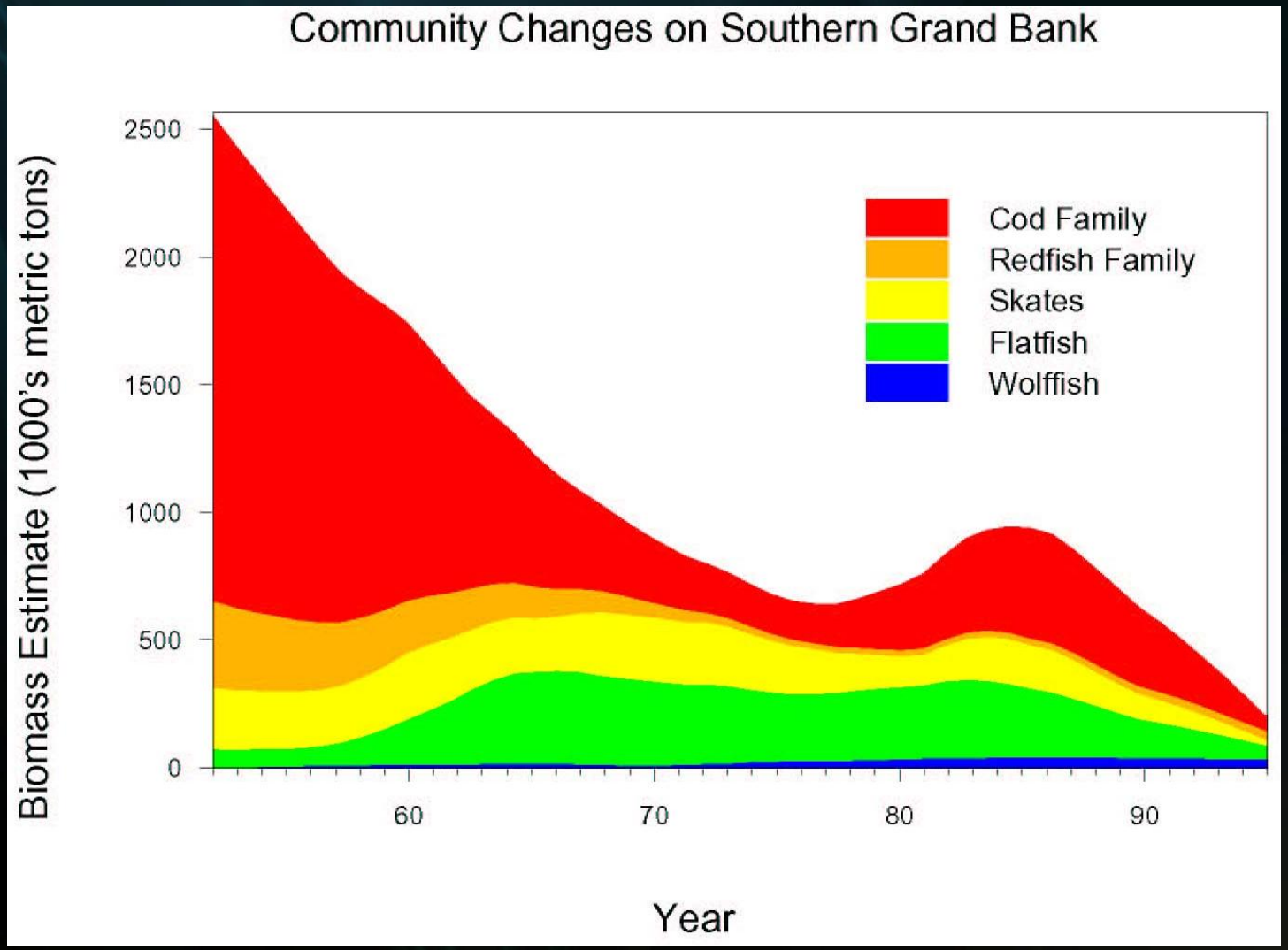
Bottom trawling



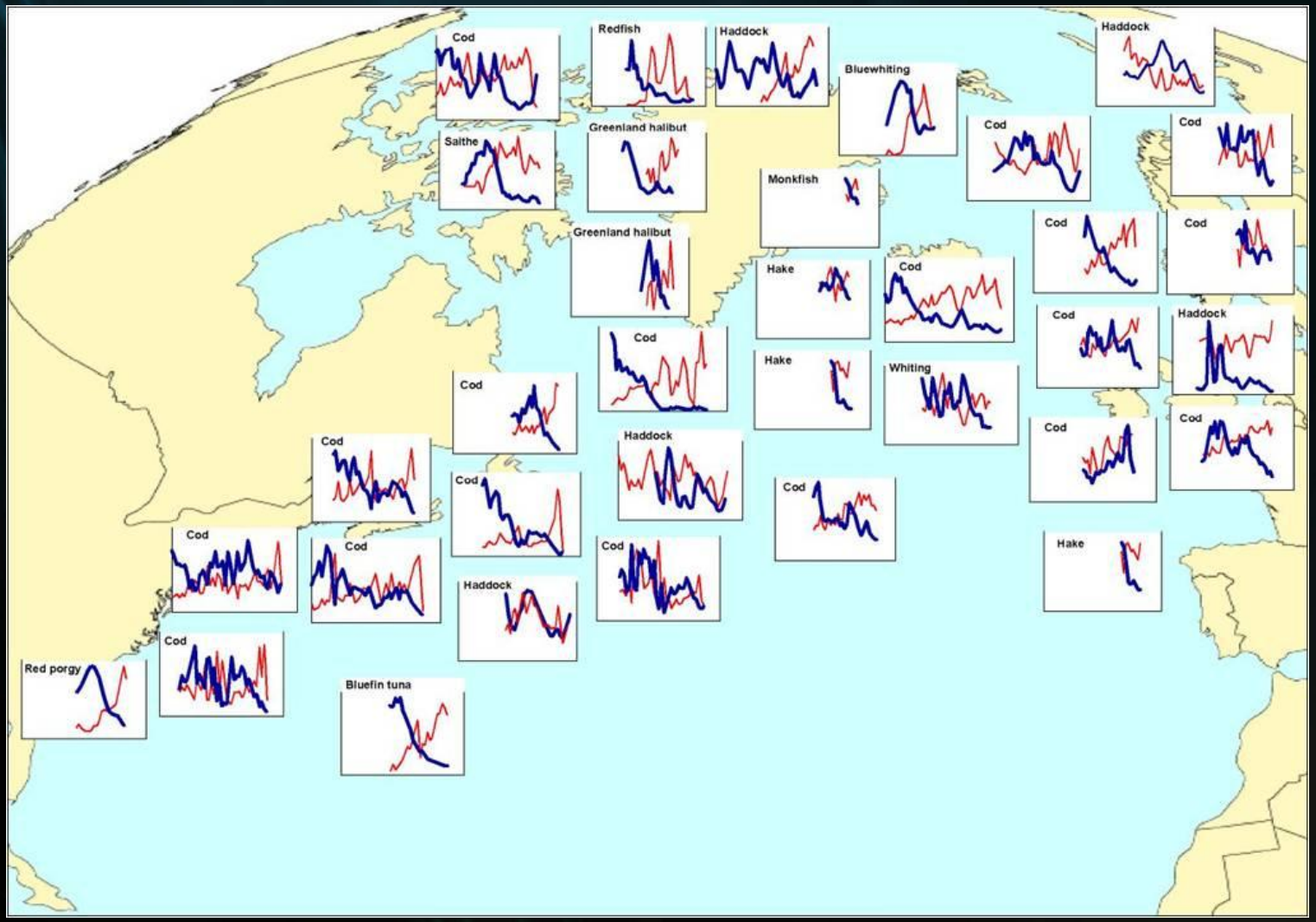
These boats do not appear to be trawling, but anchored by ropes and stationary, allowing the current to bring shrimps and fish into their nets

Bottom trawling

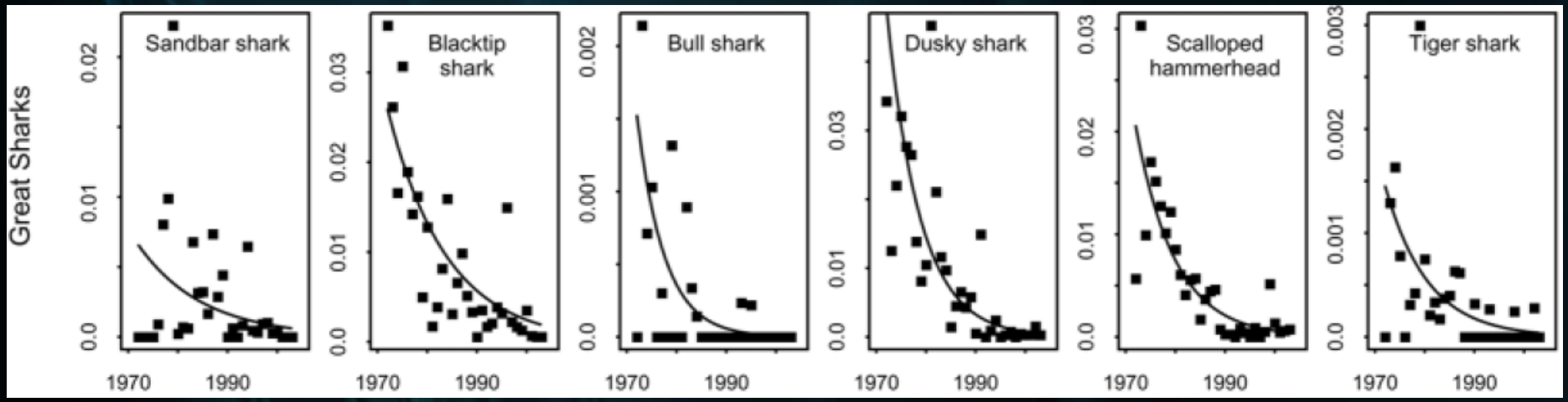
Overfishing



Overfishing



Trophic cascade



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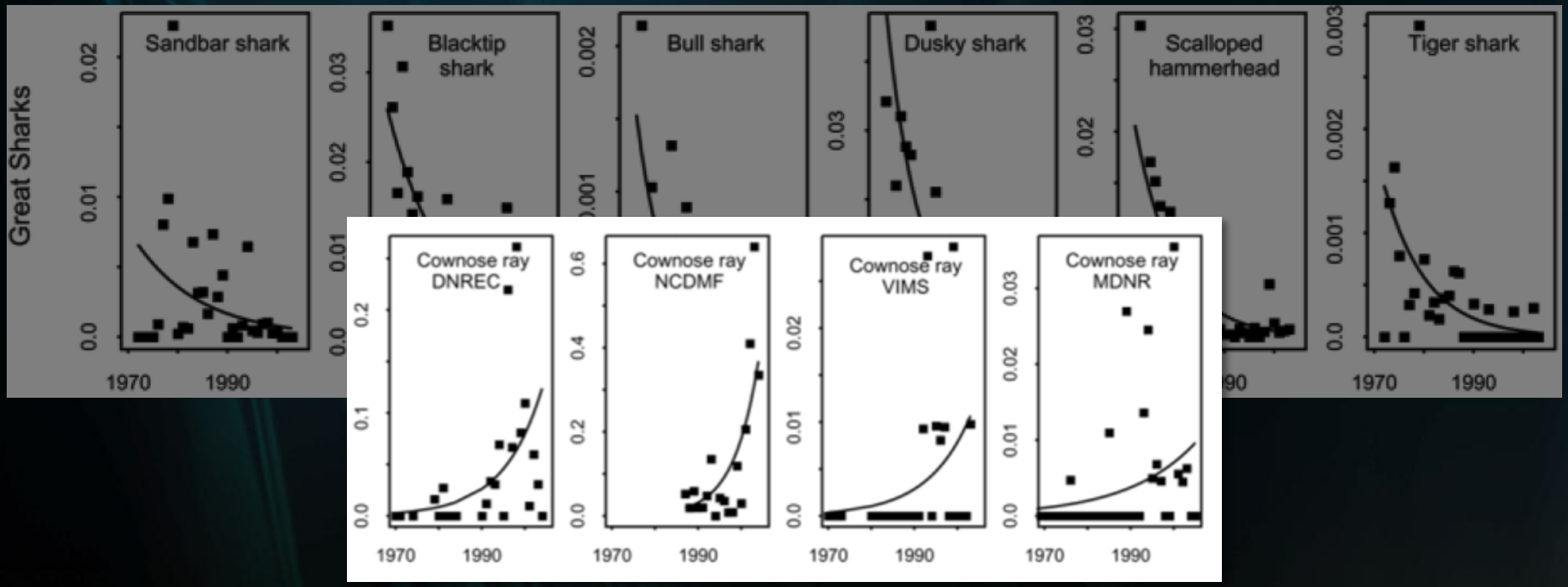

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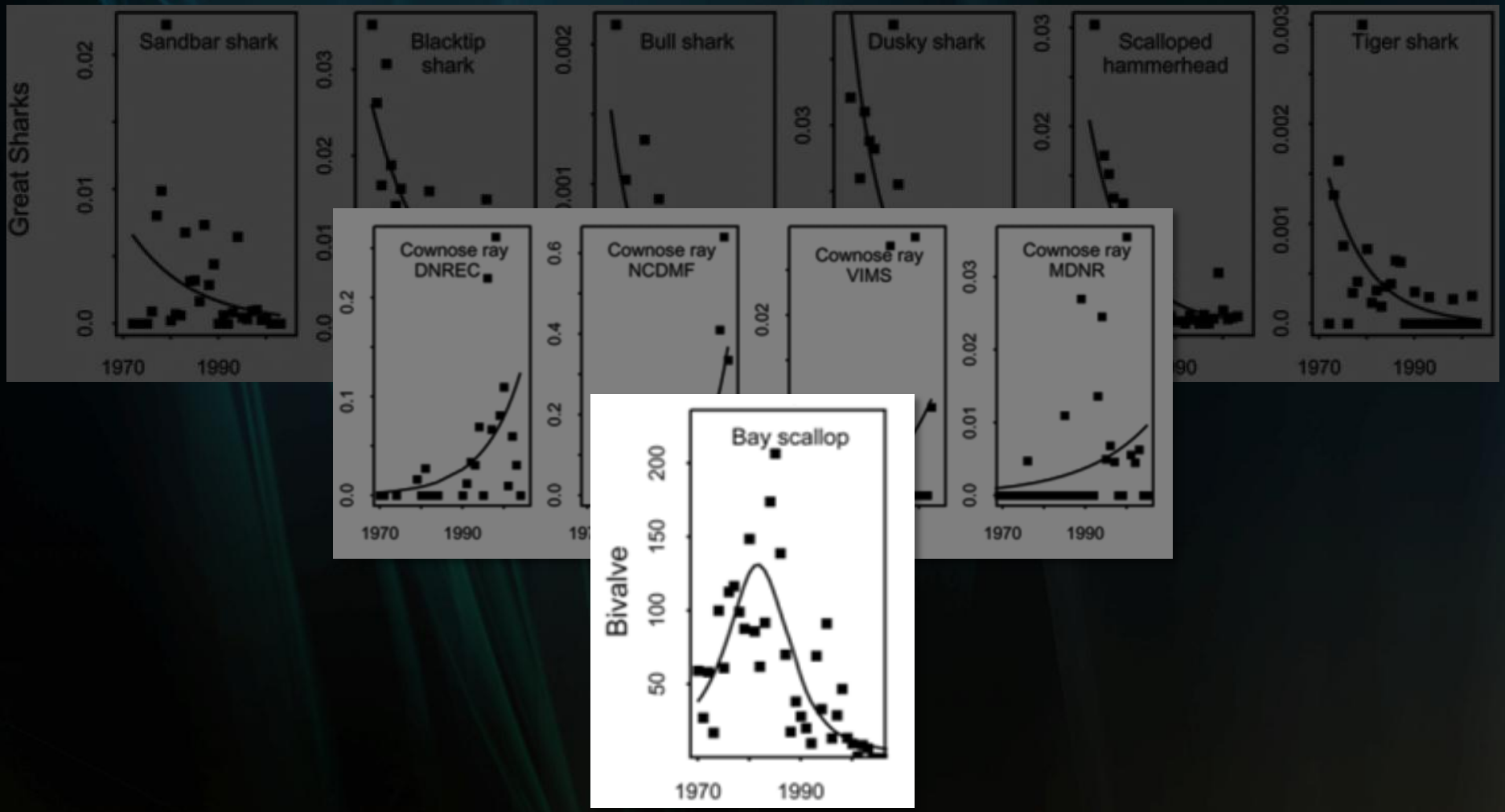
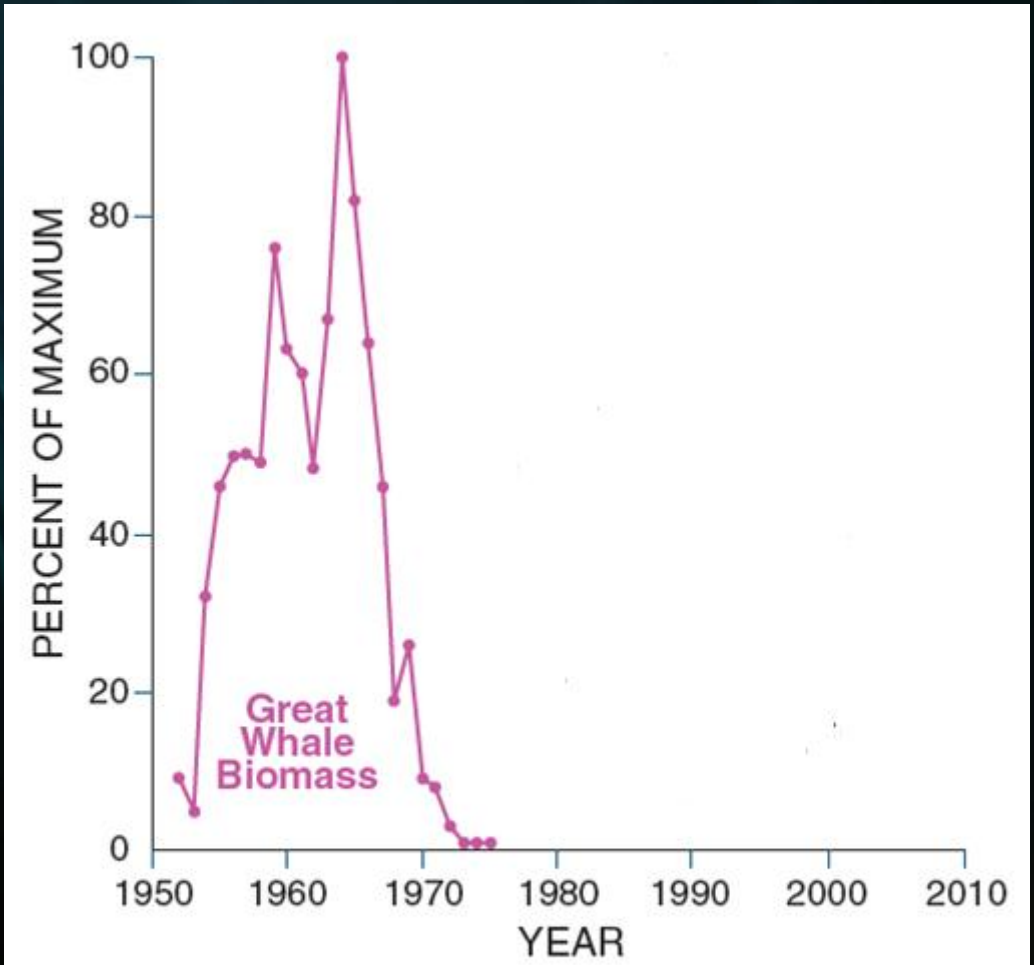
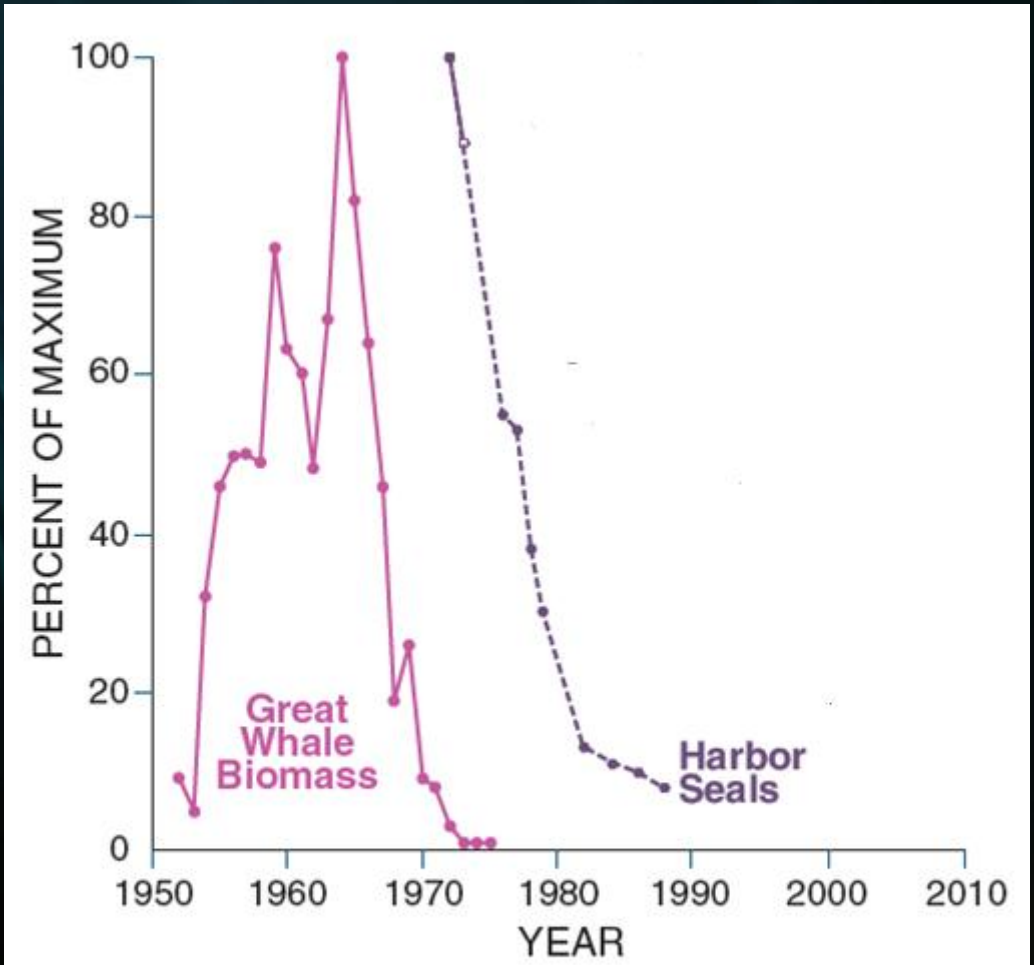


Marine mammal decline



Sequential collapse of marine mammals in the North Pacific Ocean and southern Bering Sea.

Marine mammal decline



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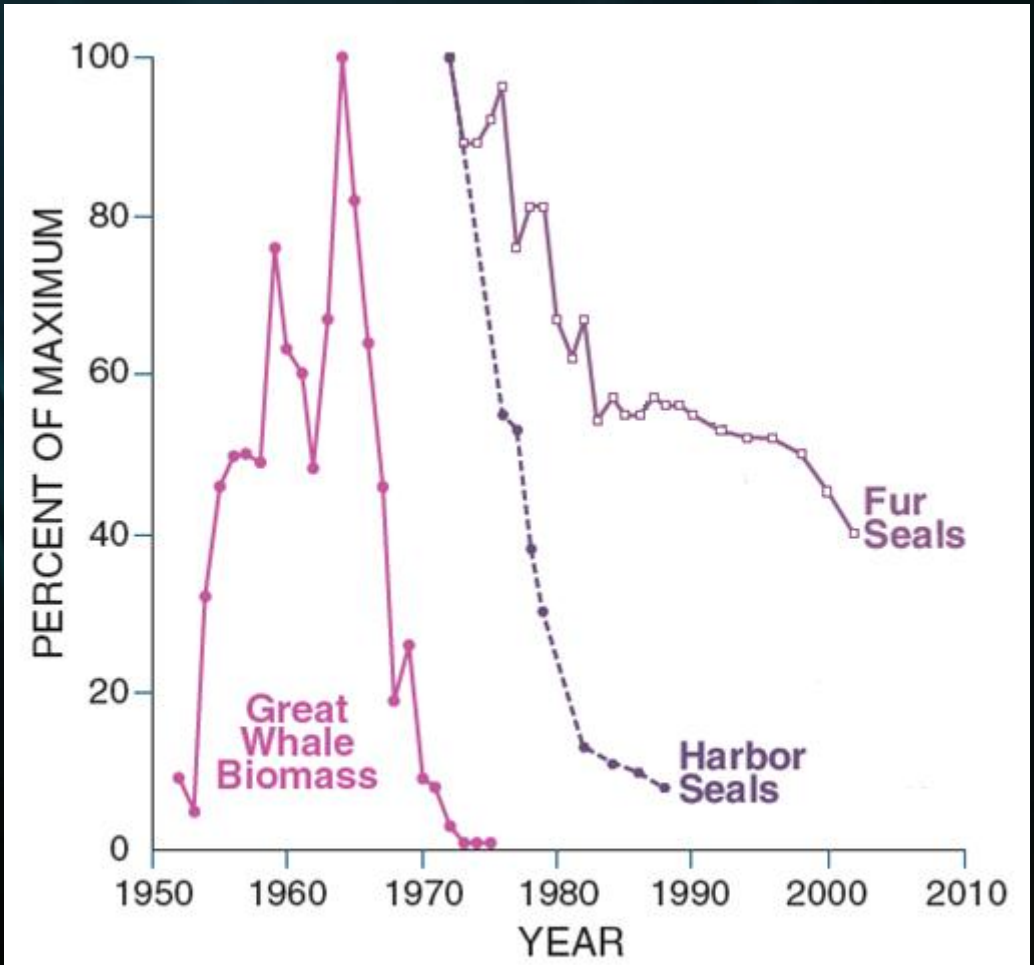

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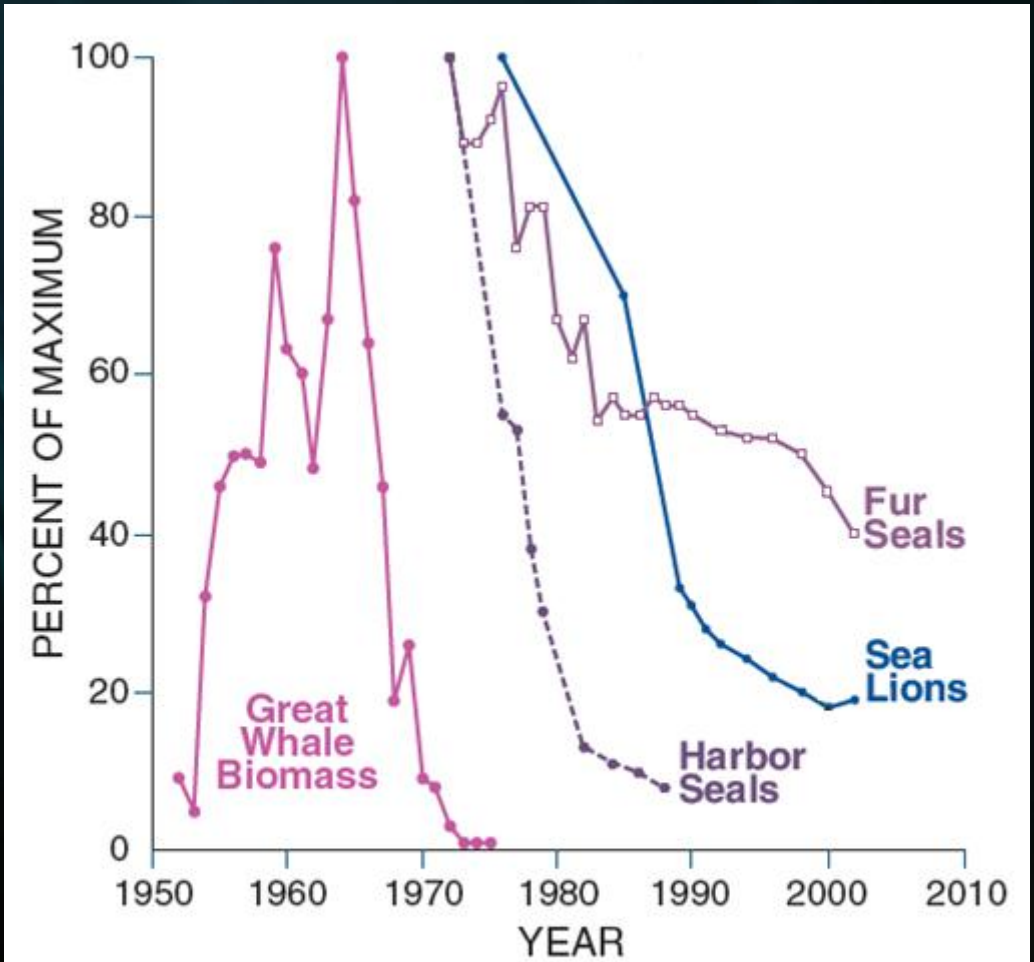

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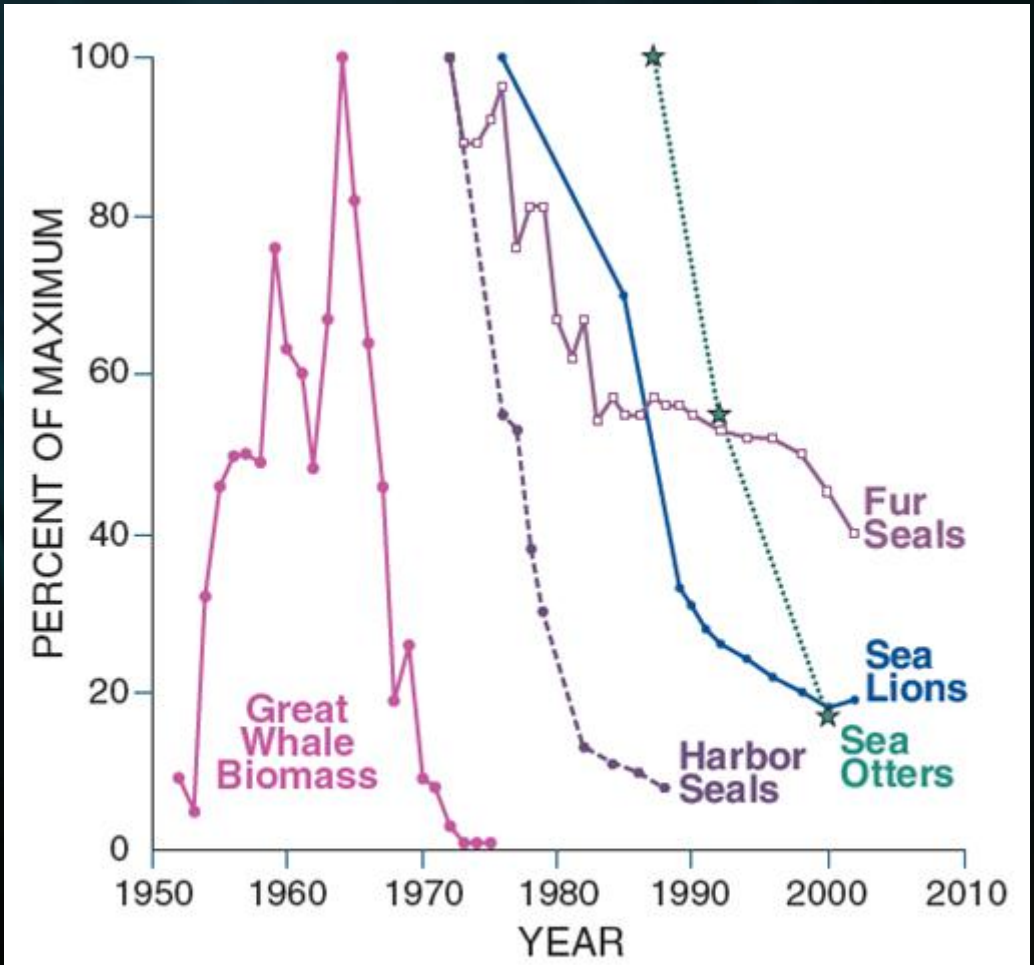
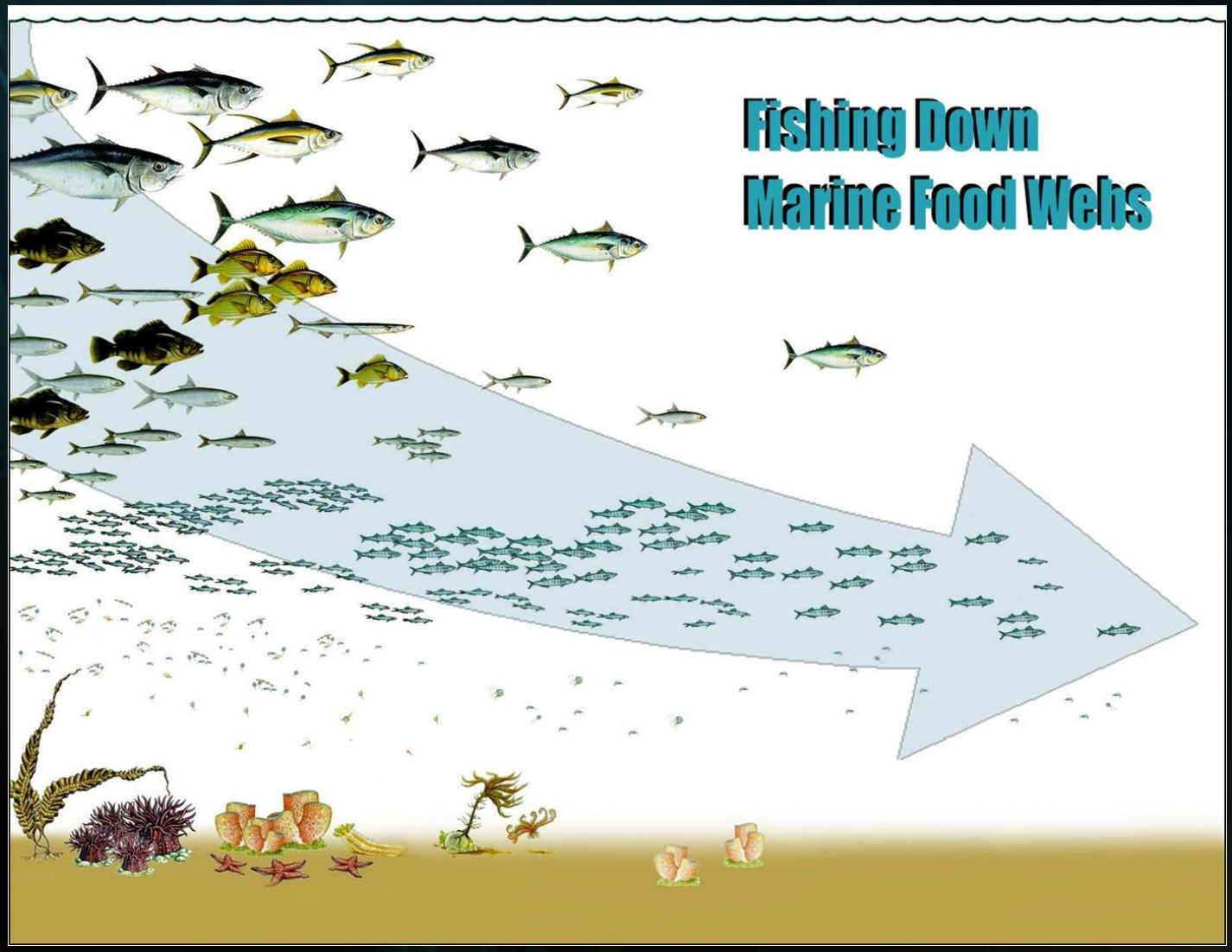
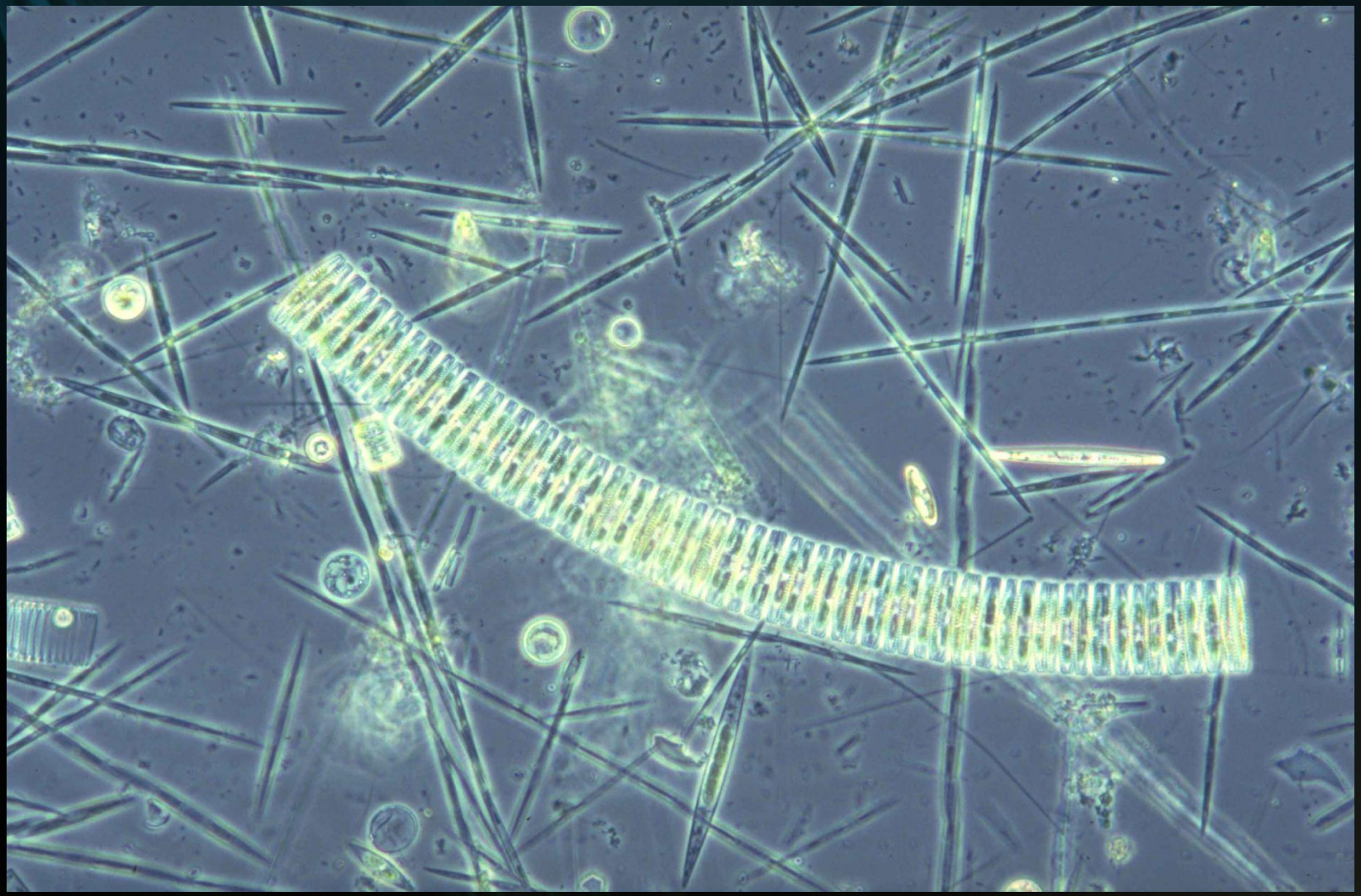


Sequential collapse of marine mammals in the North Pacific Ocean and southern Bering Sea.

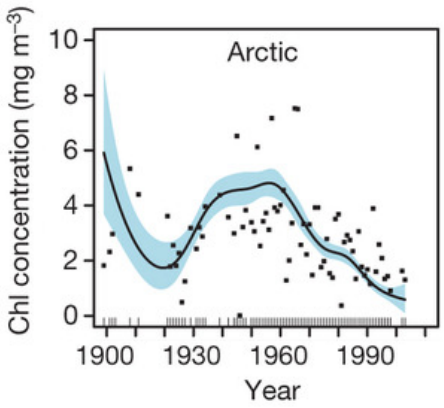
Fishing down the food web



Plankton



Global plankton decline



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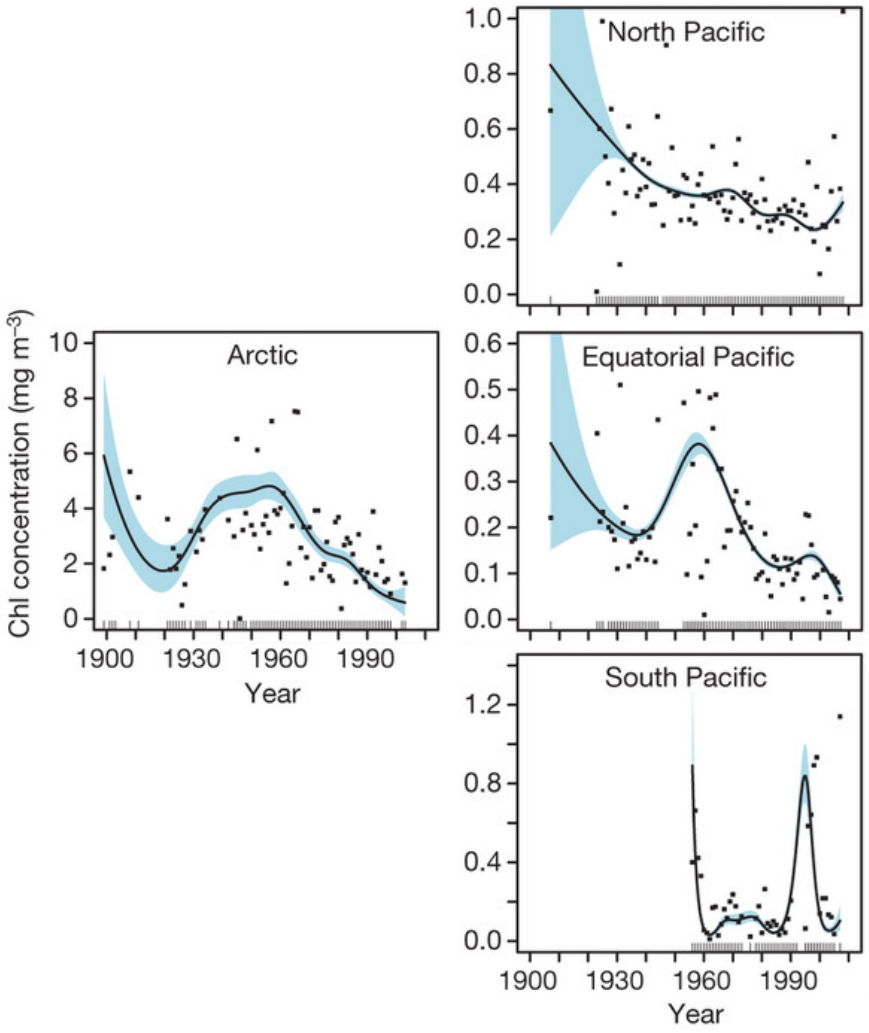

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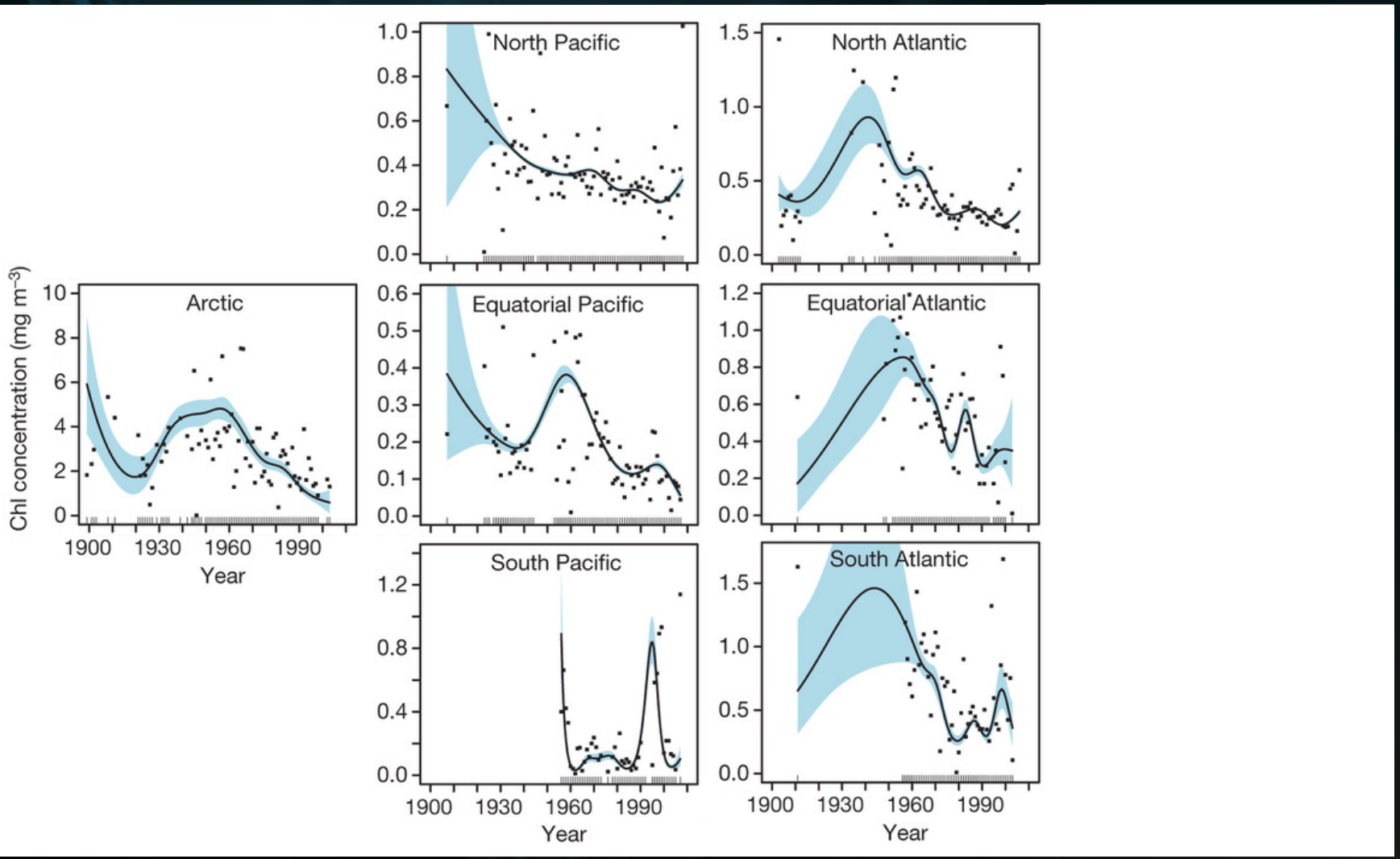
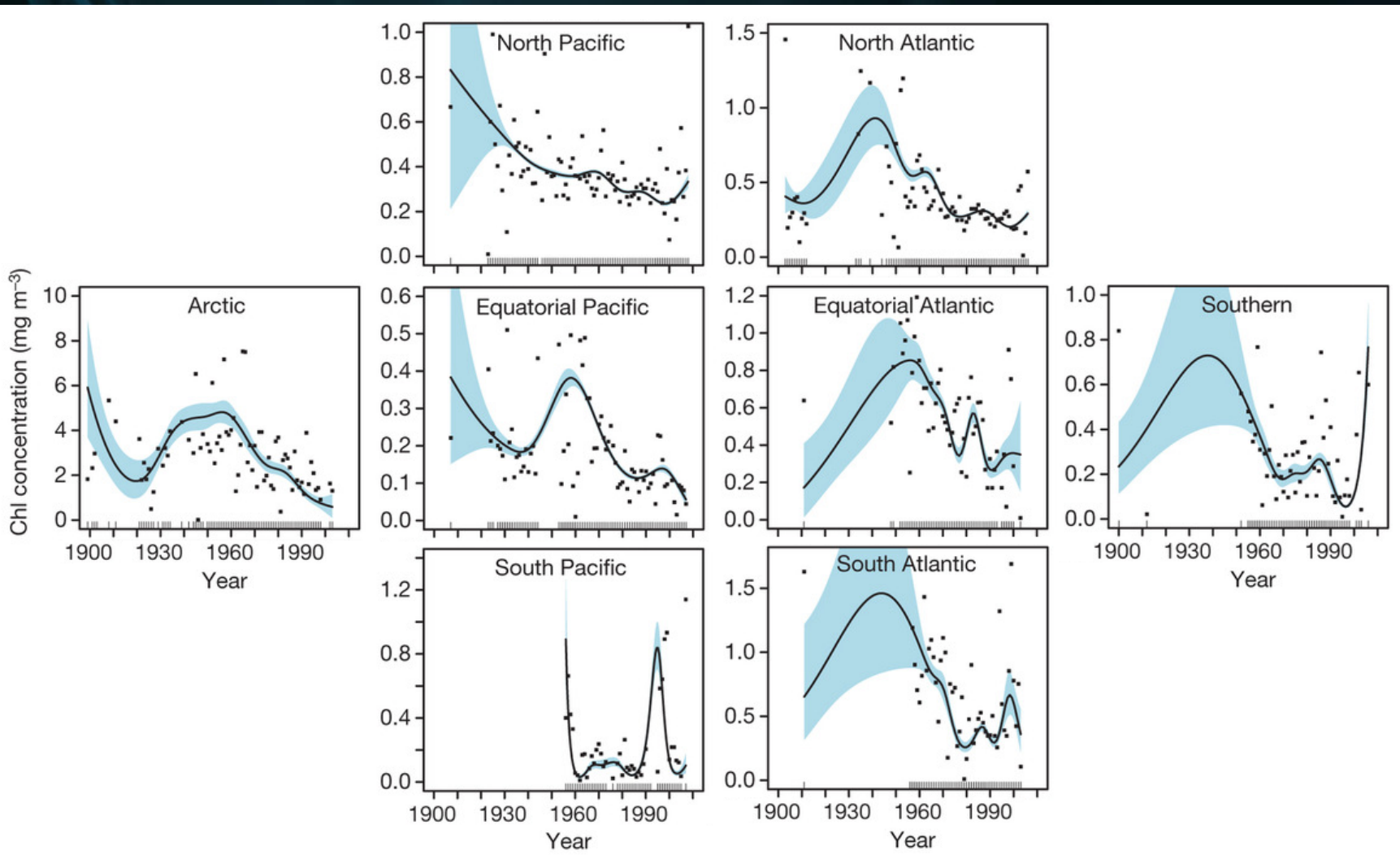


Global plankton decline



Krill decline

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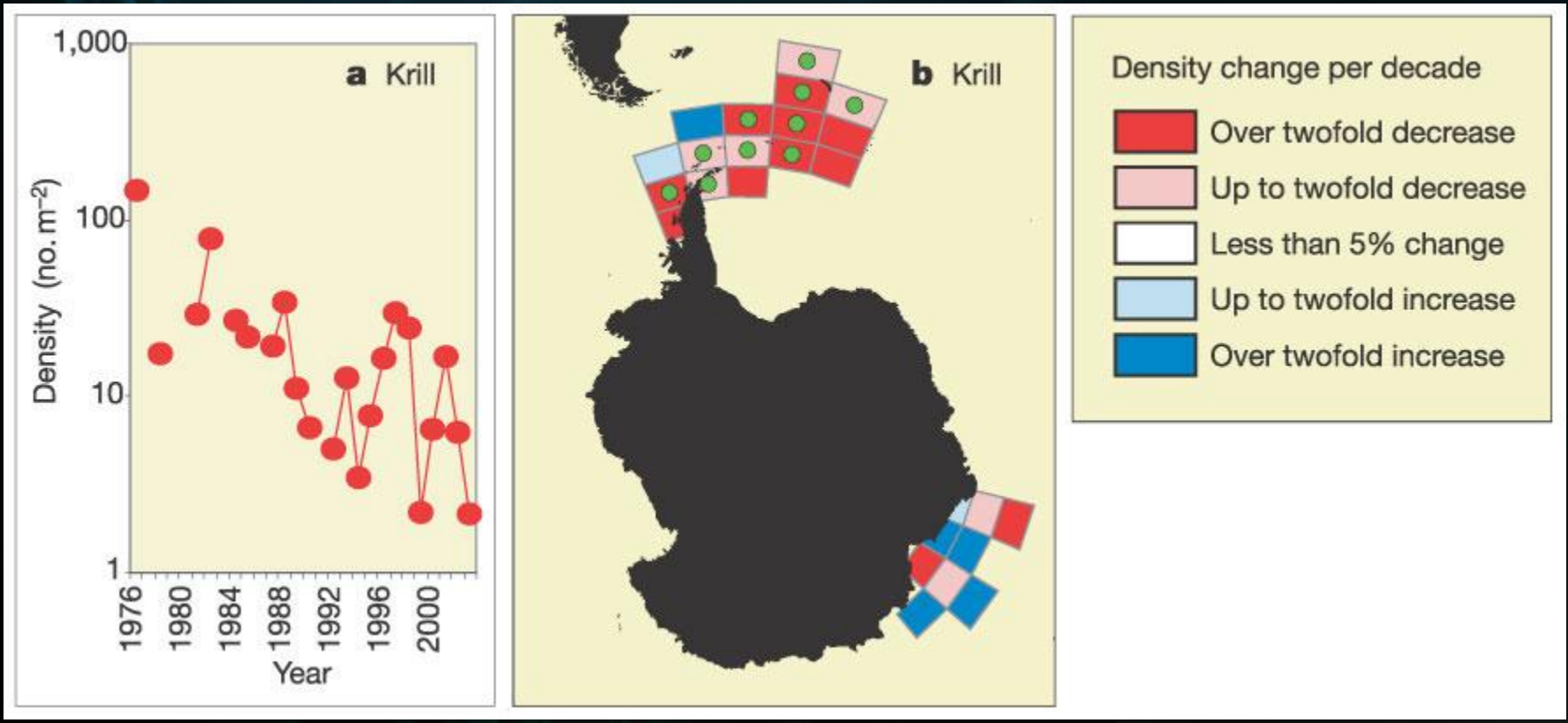
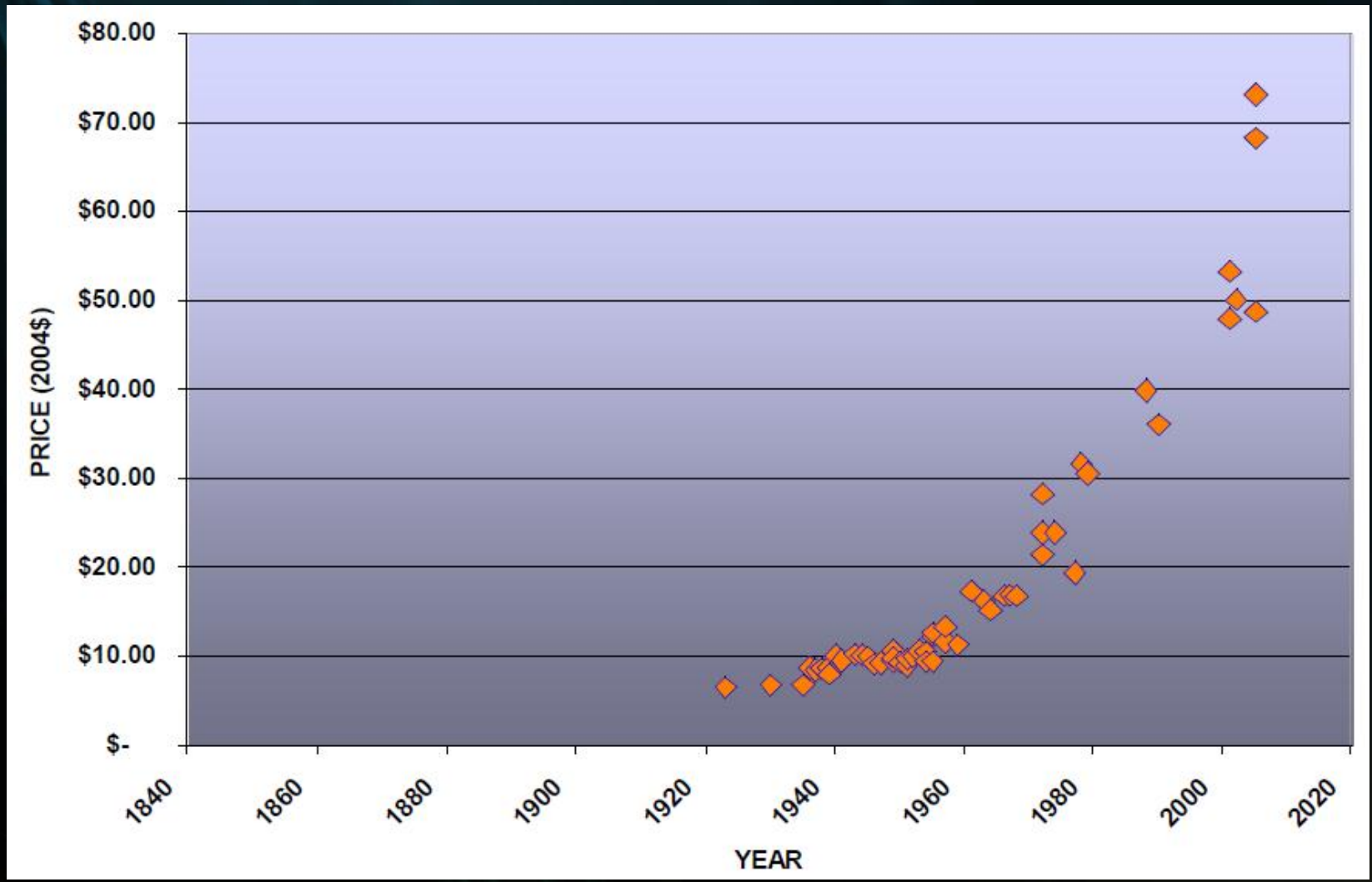
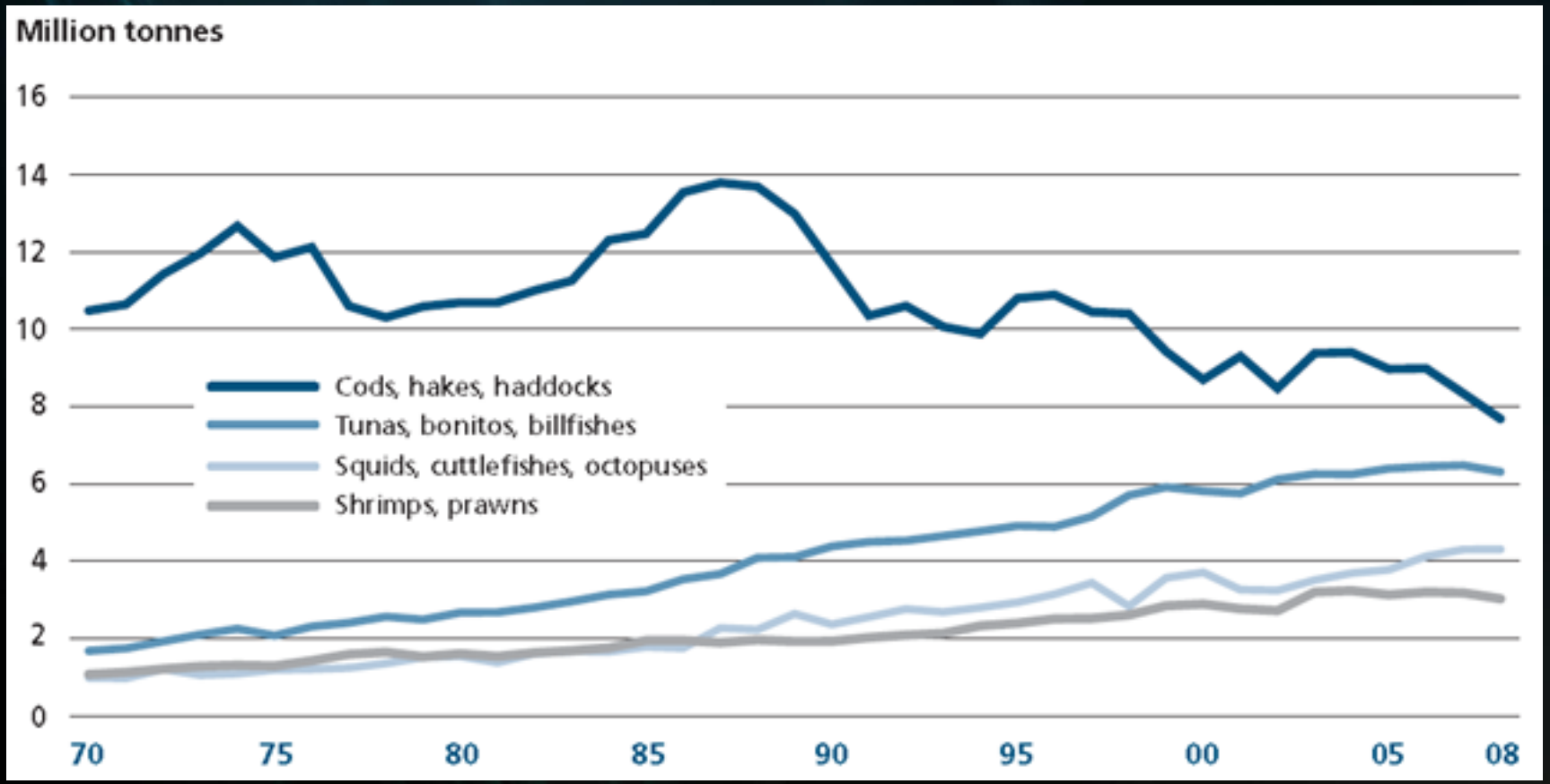


Shellfish decline



Ocean overexploitation



Element cycles

- Phosphorus – eutrophication
- Nitrogen – eutrophication, acid rain
- Sulfur – anoxia, acid rain
- Carbon – warming, euxinia, acidification

Element cycle perturbations

Element cycle	Anthropogenic perturbation	Perturbation source
Nitrogen	80 megatons/year	Fertilizer production transfers 80 Tg of N per year from atmosphere to soil.[1]
Sulfur	108 megatons/year	1 Tmol from transfer of oxidized and reduced sediments from mining to soil; 2 Tmol from transfer of reduced sediments to atmosphere from burning fossil fuels.[2]
Phosphorus	9-32 megatons/year	Fertilizer production transfers 9-32 Tg of P per year from mining to the oceans.[3]
Carbon	9000 megatons/year	33 Gt of CO_2 (9 Gt C) released from burning fossil fuels in 2010.[4]

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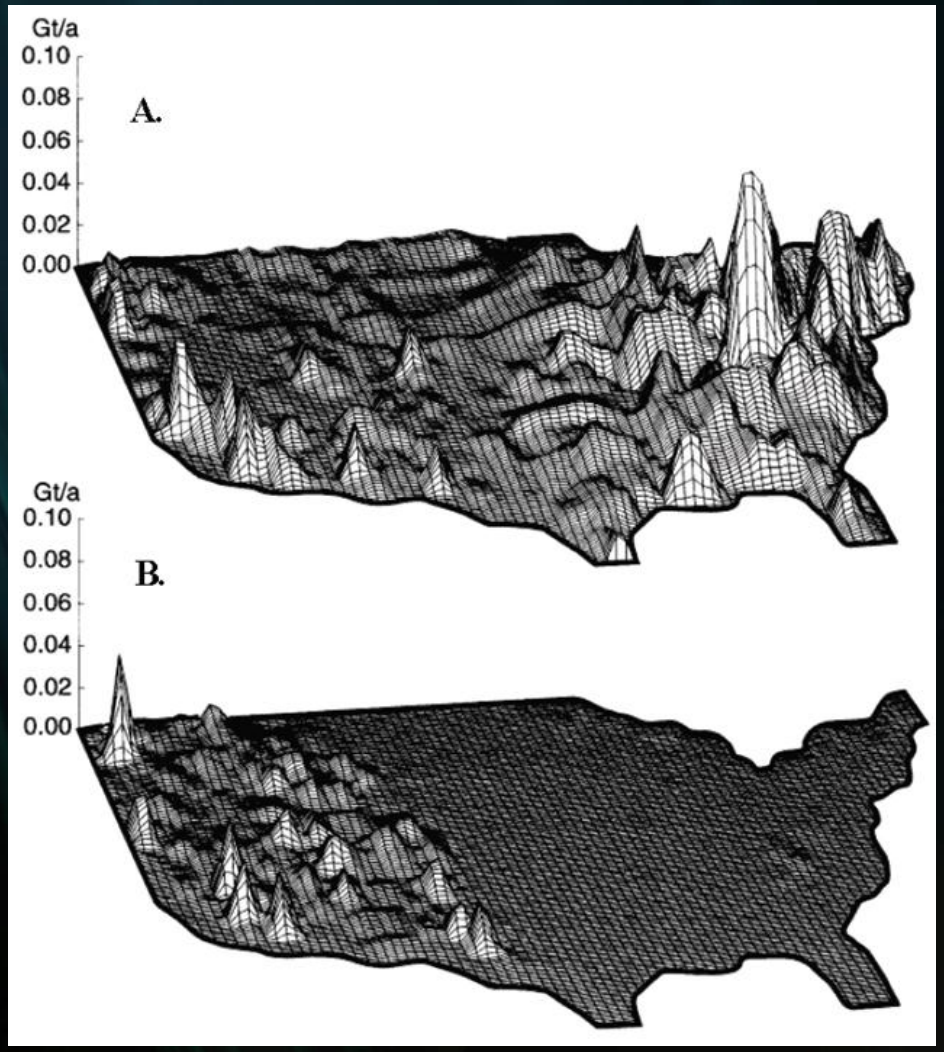
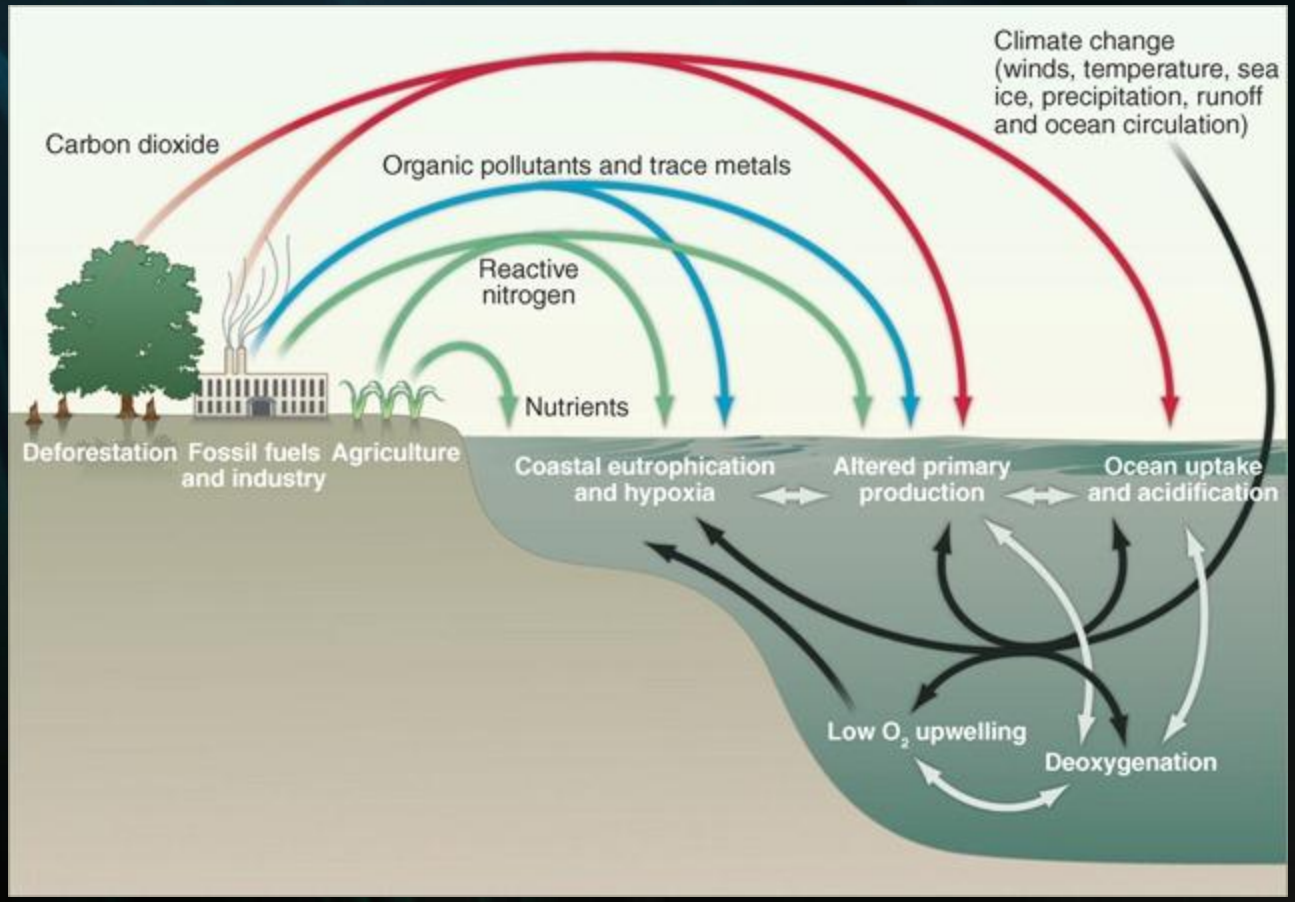
Earth movement by humans



Ocean stressors: element cycles



Phosphorus

Phosphorus

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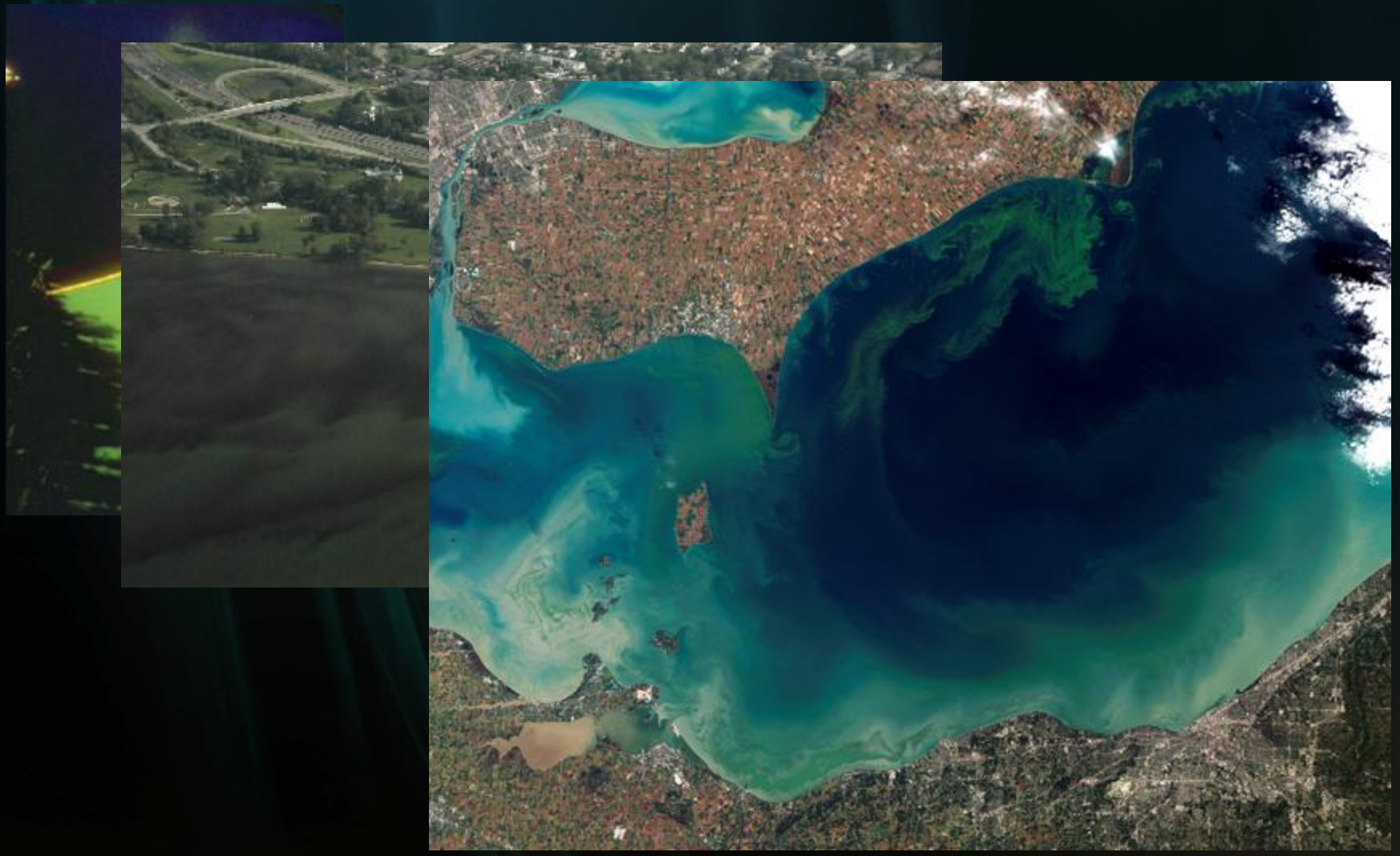
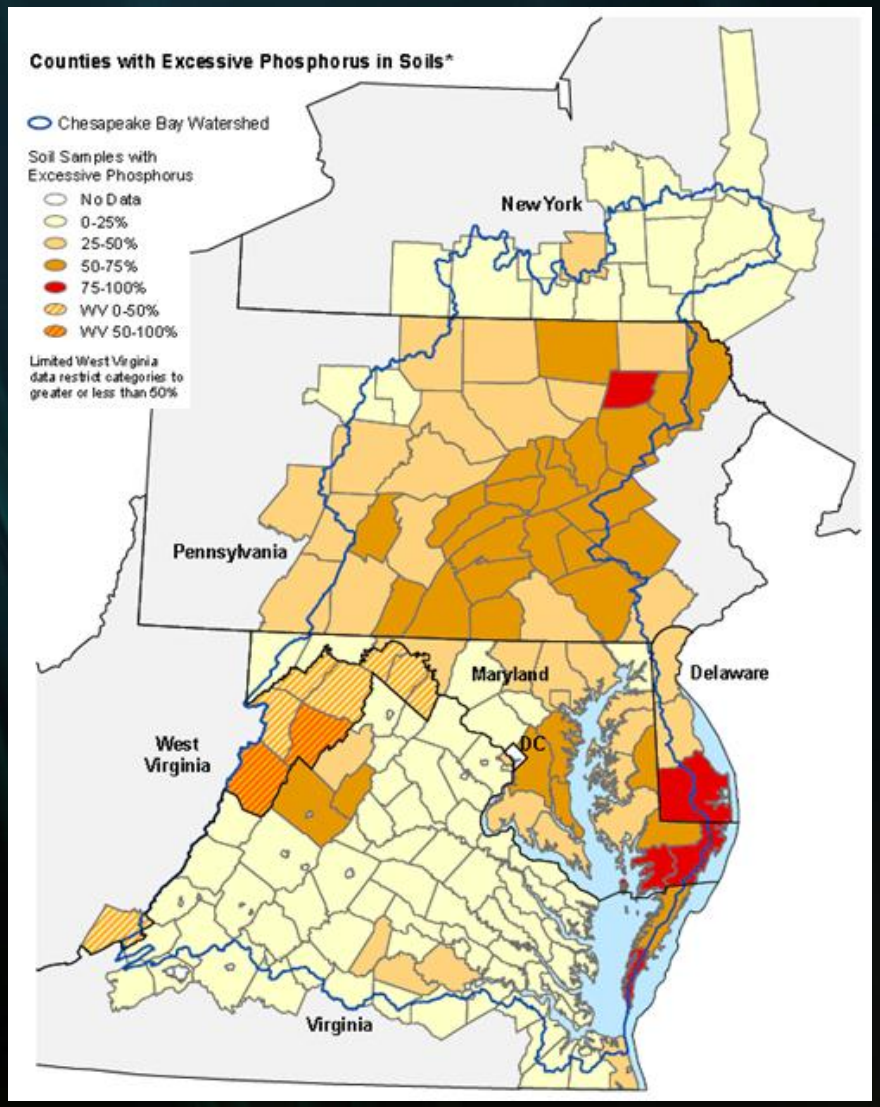


Phosphorus

Phosphorus in Chesapeake Bay



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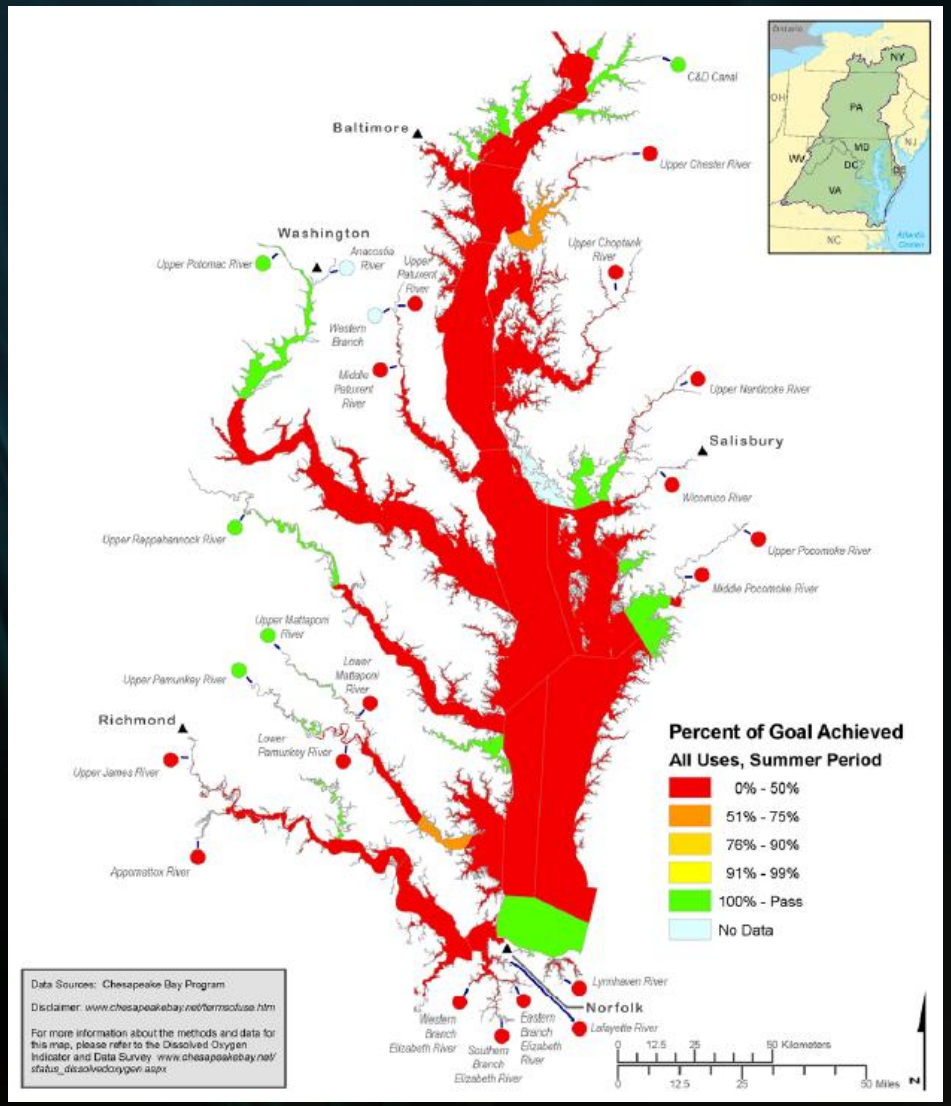
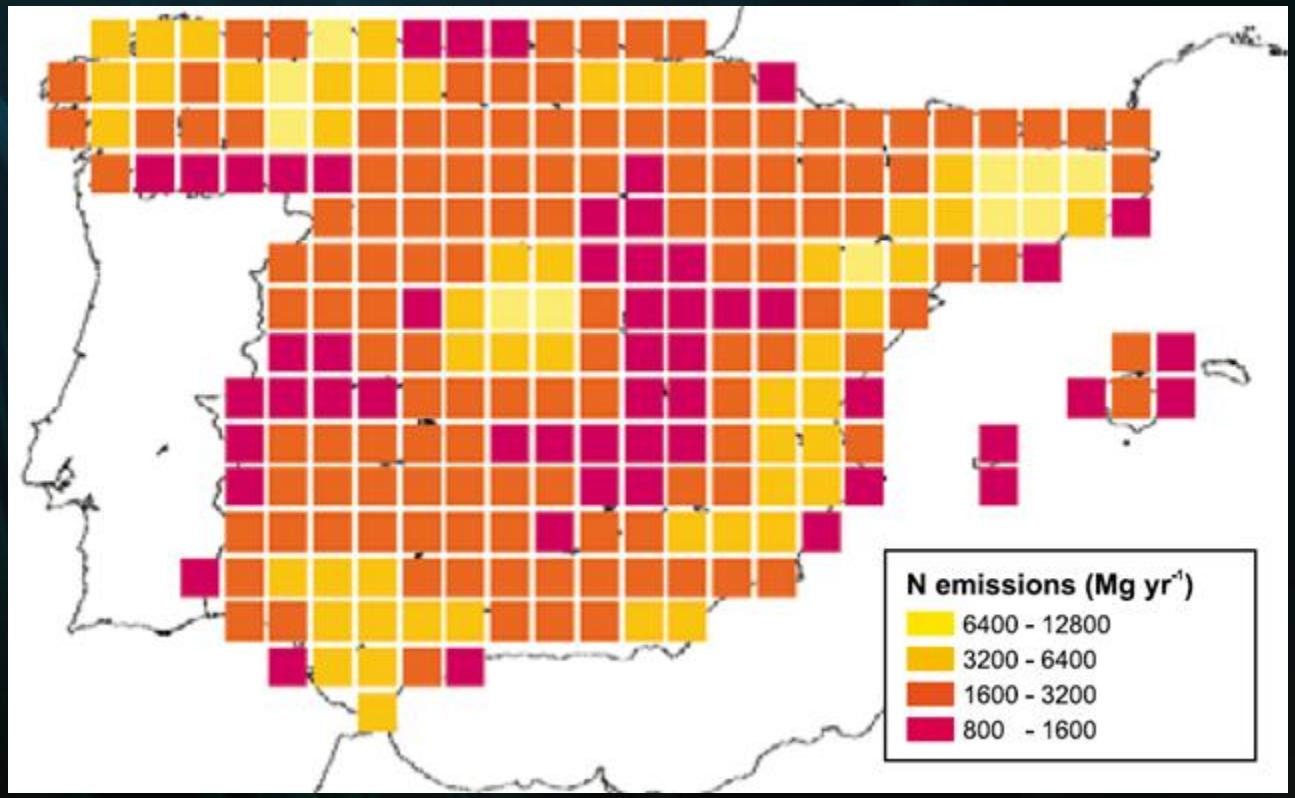


Nitrogen in Spain



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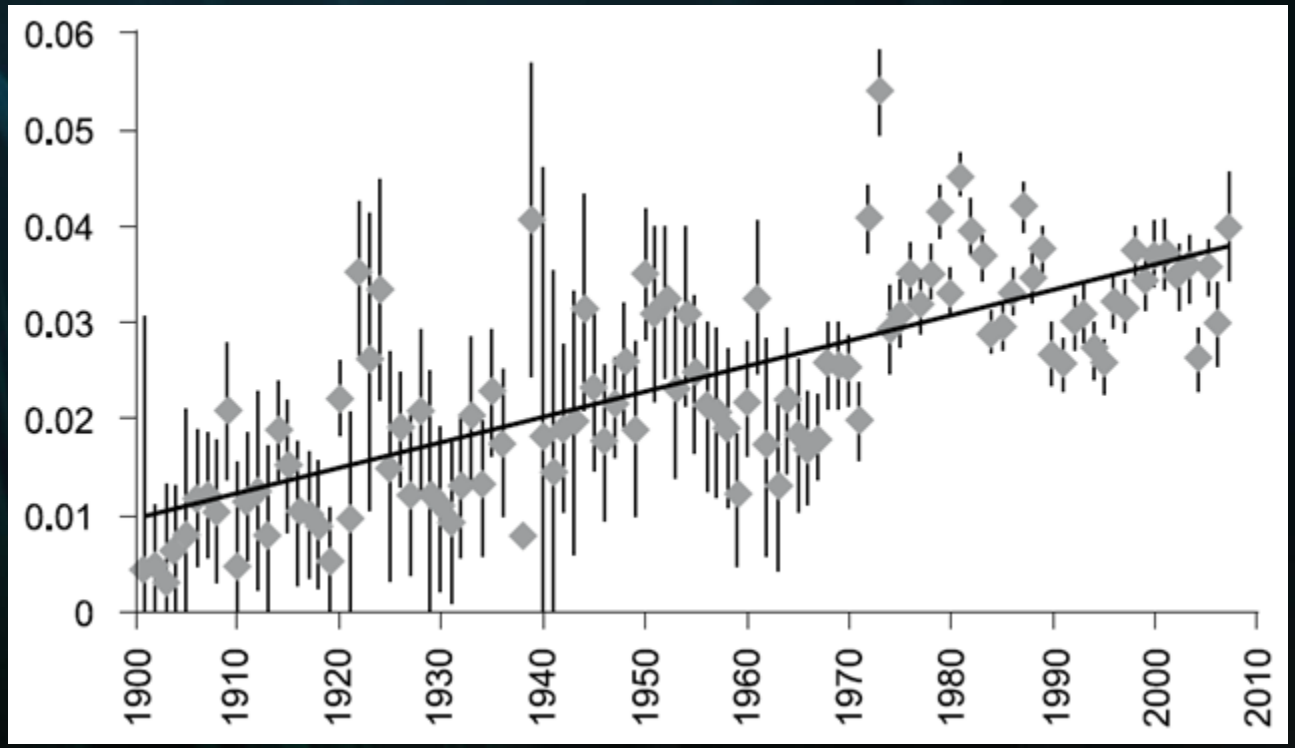
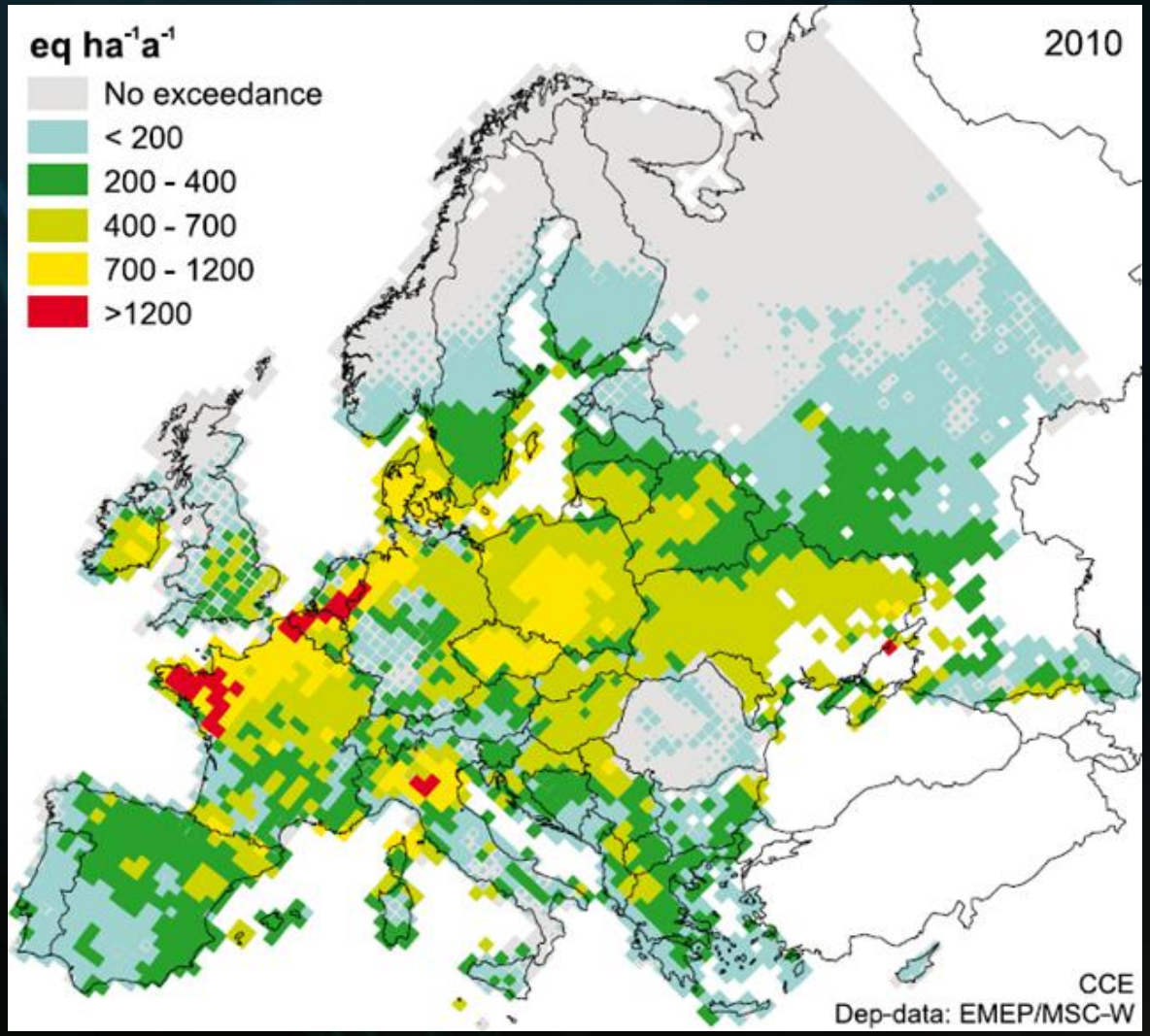
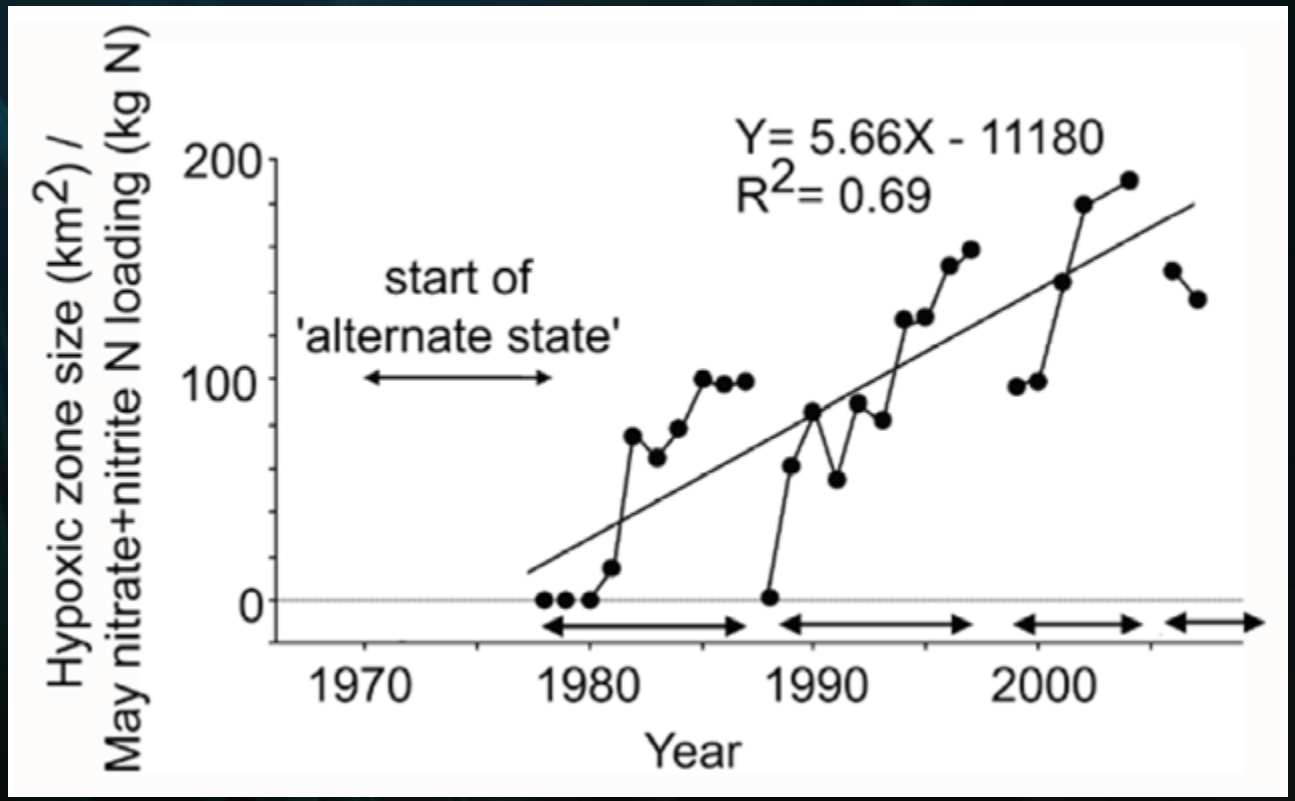


Nitrogen in Europe

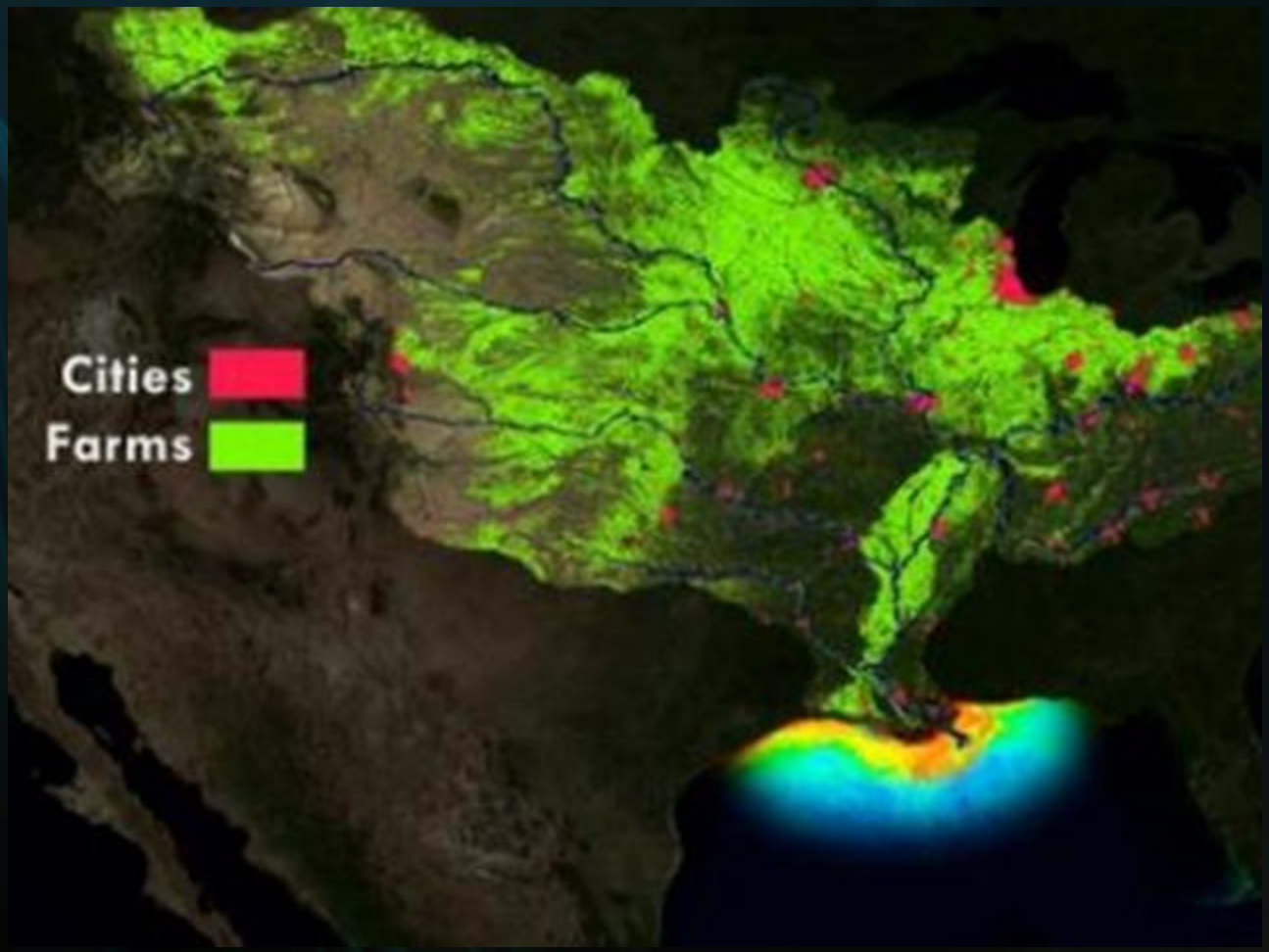


Nitrogen

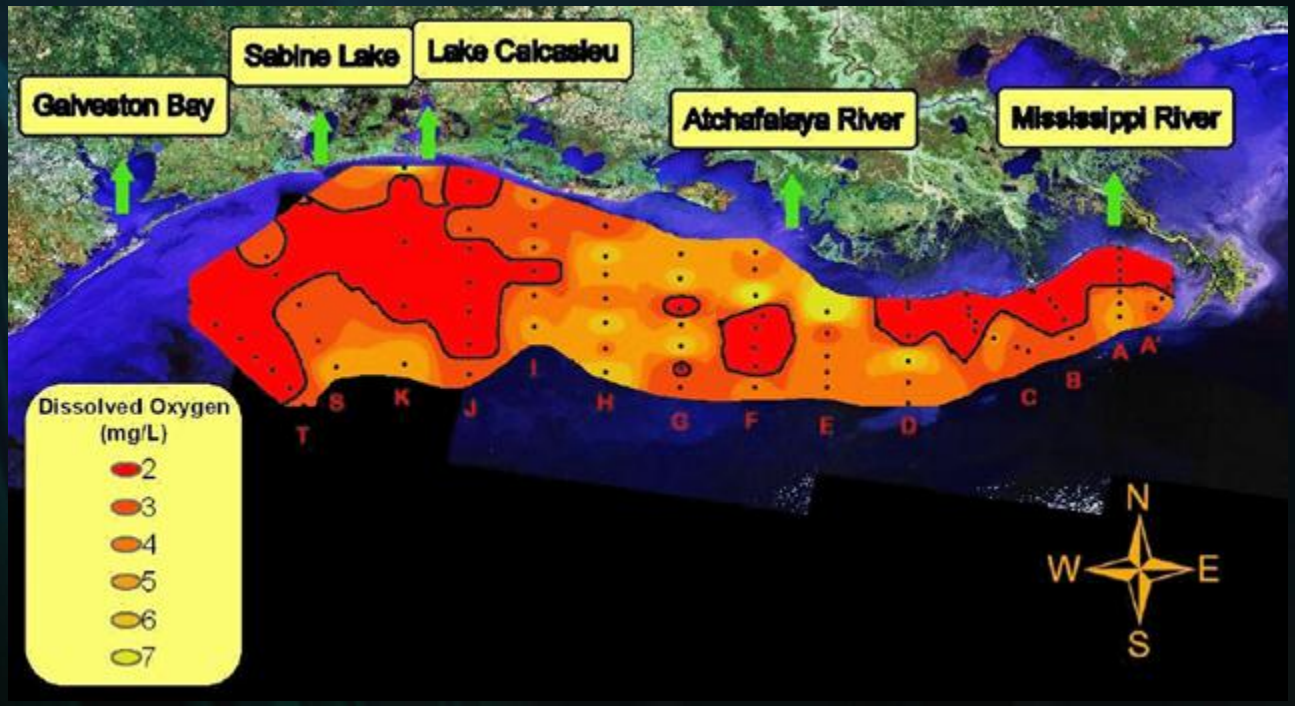
Nitrogen in the Gulf of Mexico



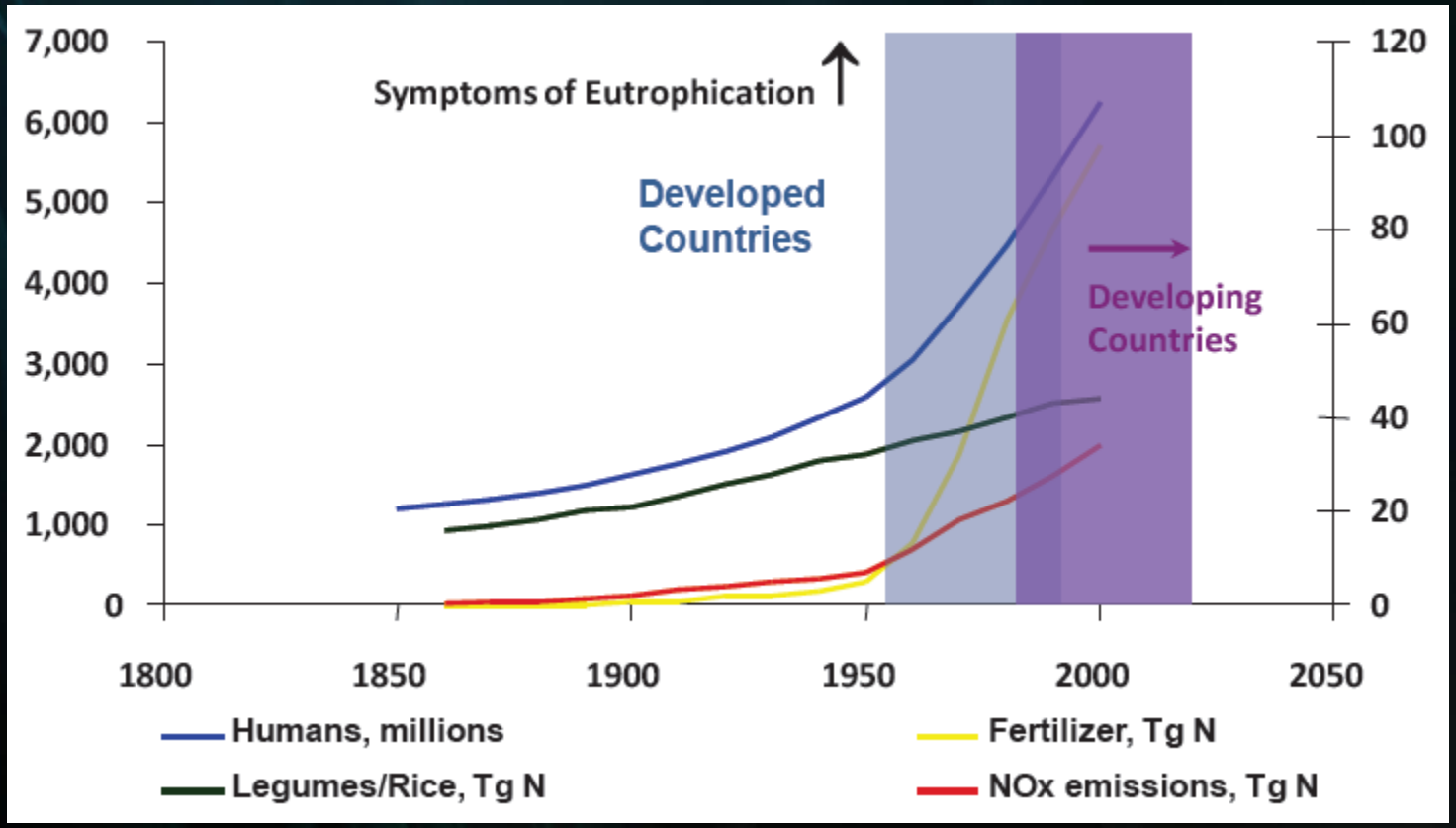
Nitrogen in the Gulf of Mexico



Gulf of Mexico dead zone



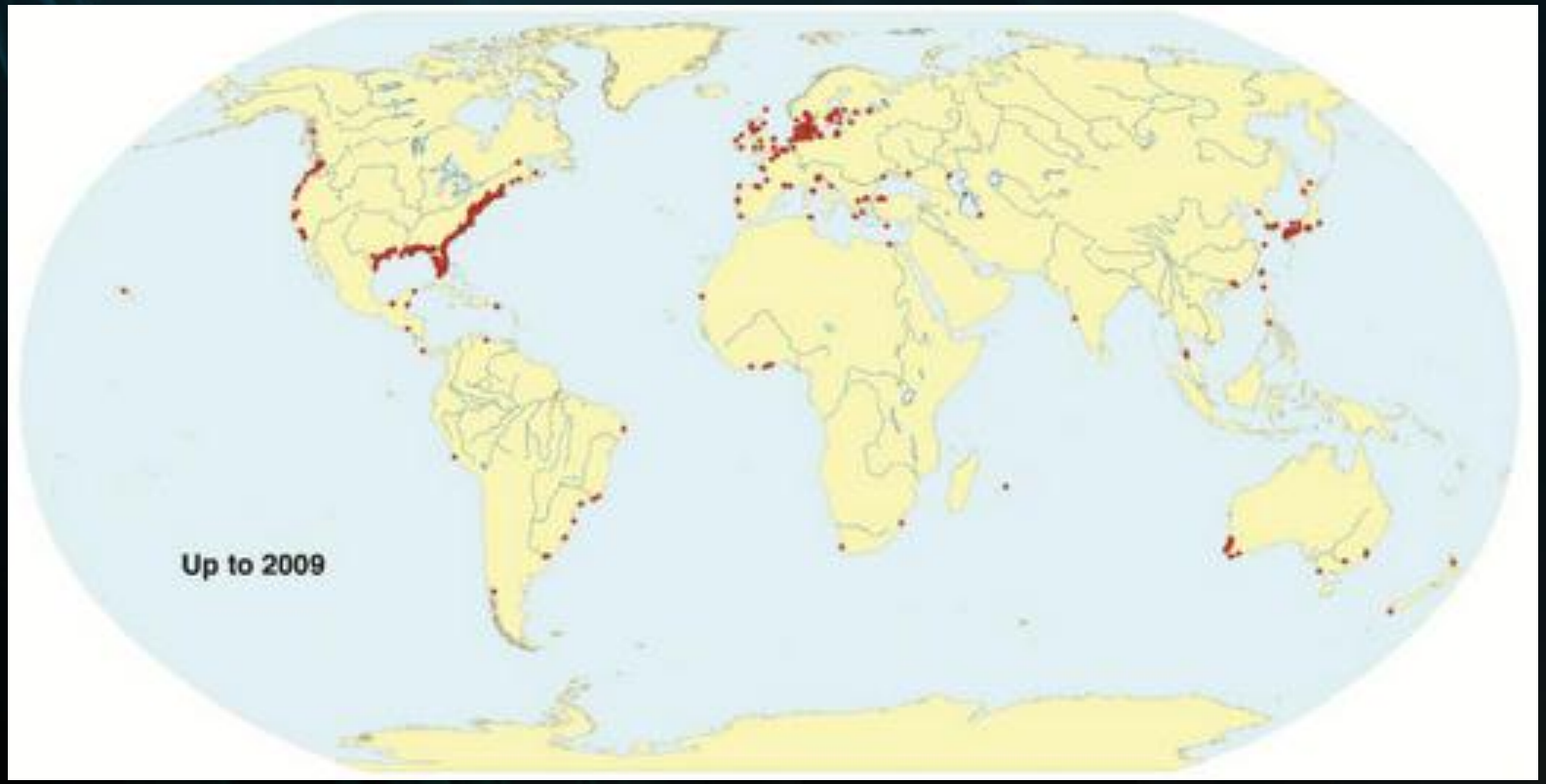
Global nitrogen perturbation



Global dead zones

1995: 195 hypoxia events

Global dead zones



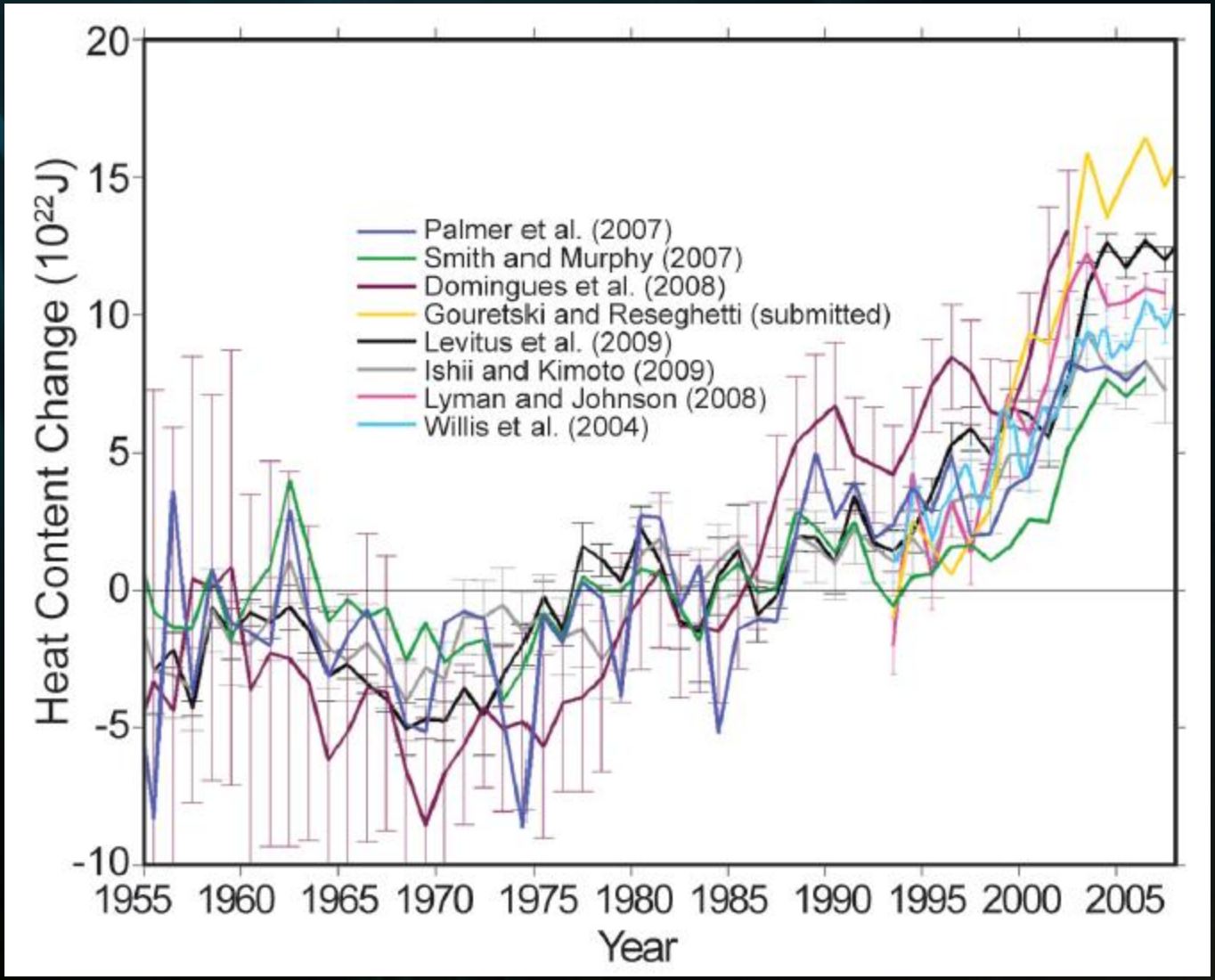
2008: 400 hypoxia events

Global dead zones

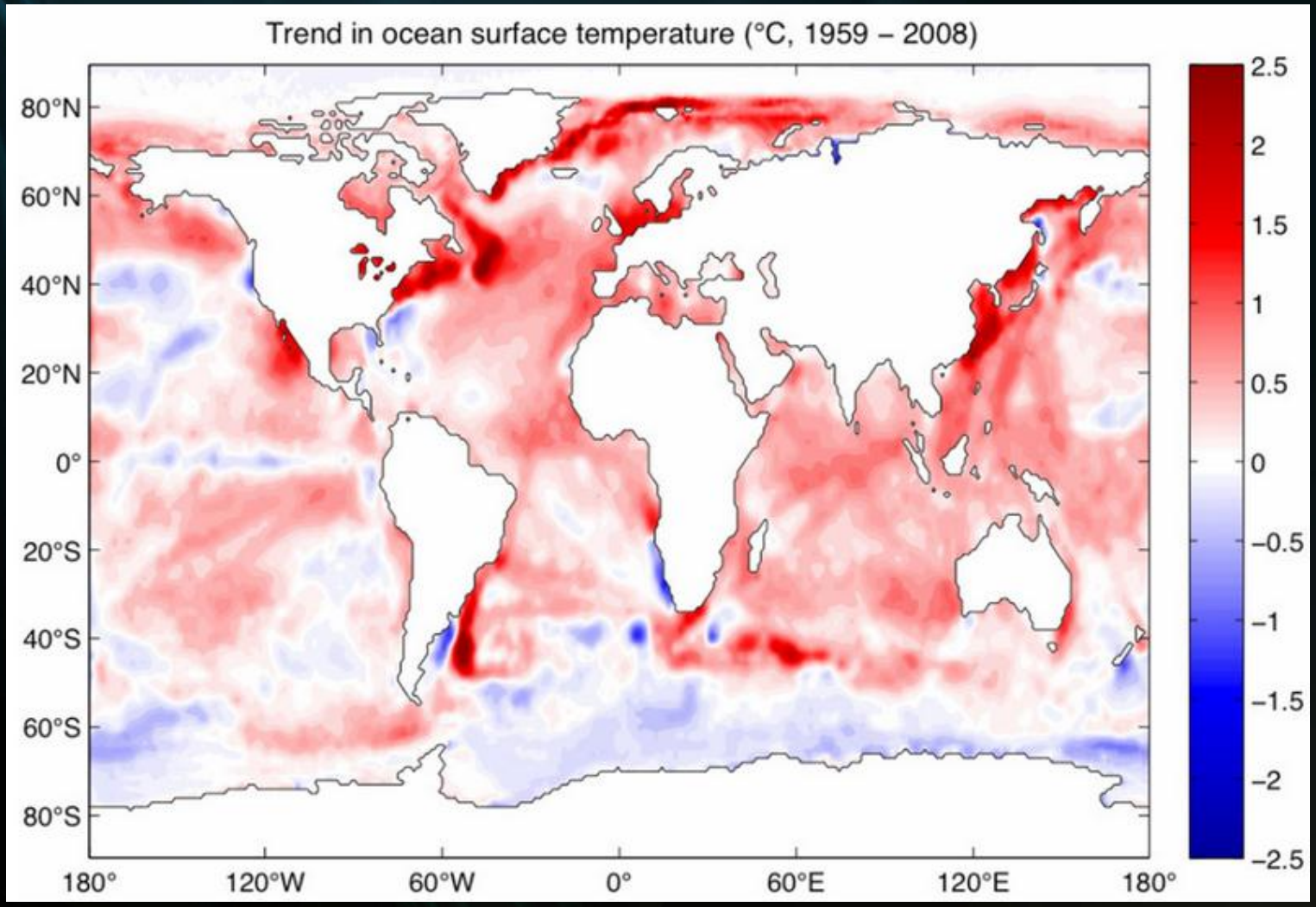
Number of dead zones doubles every 10 years

2008: 400 hypoxia events

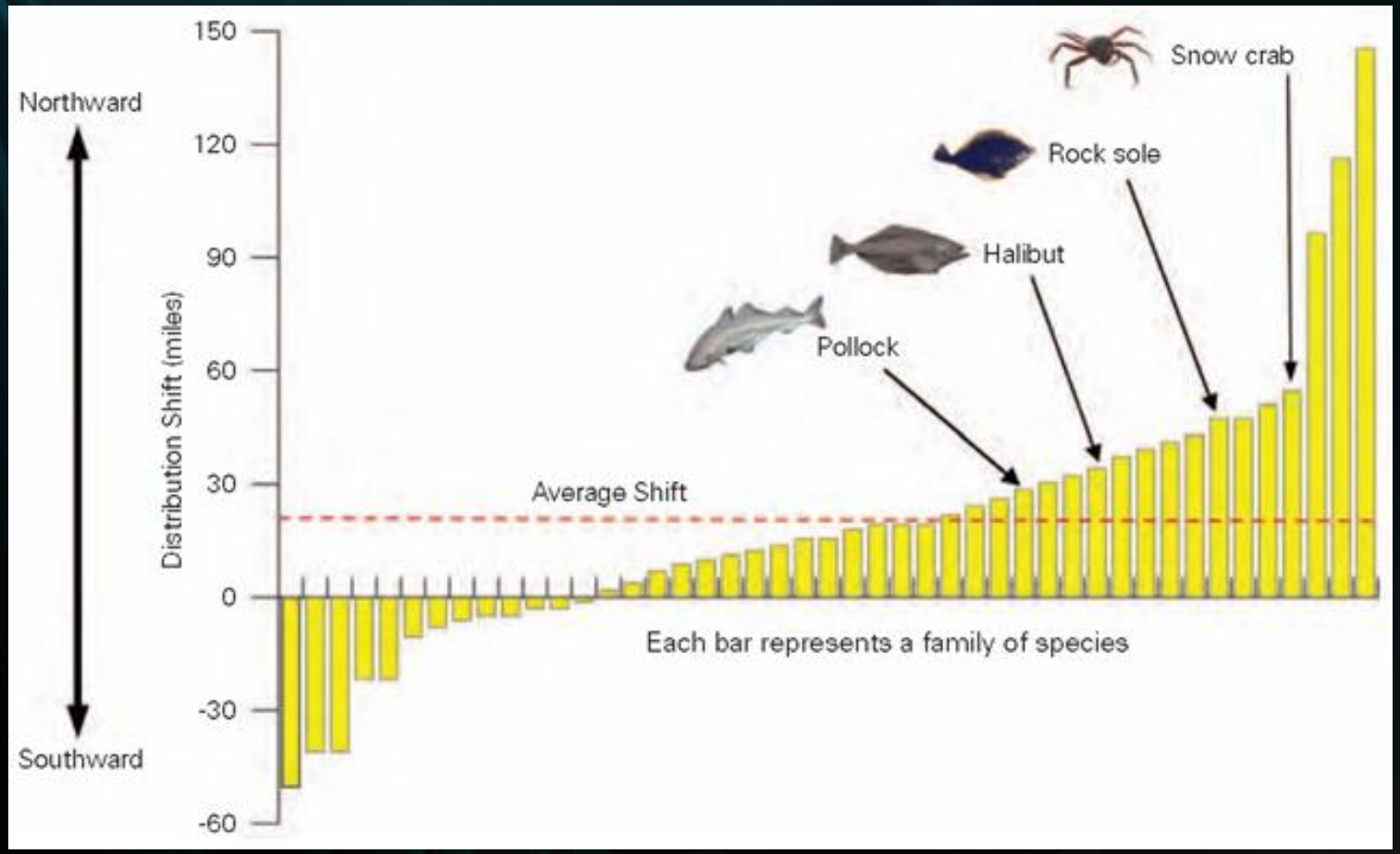
Carbon: ocean warming



Ocean warming



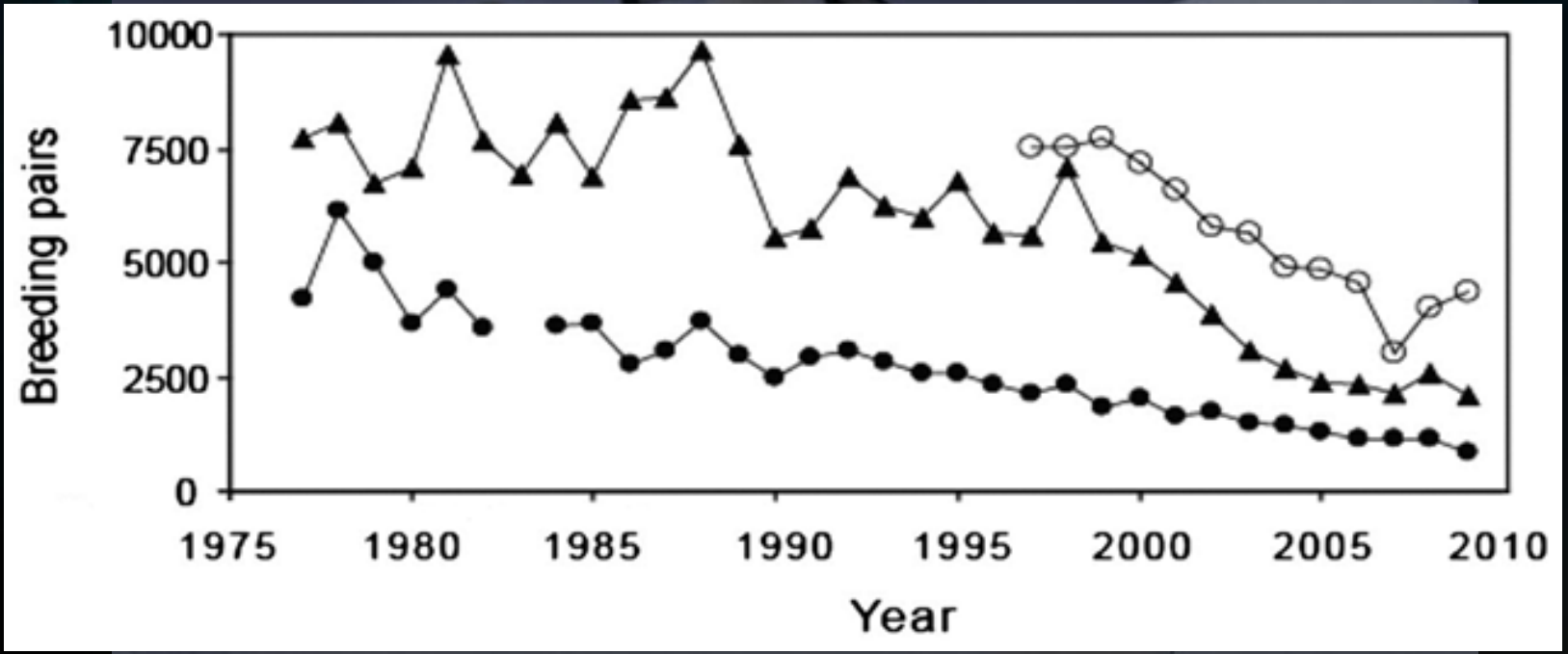
Ocean phenology changes



Ocean warming: invasive species

Chinstrap penguin decline

Chinstrap penguin decline



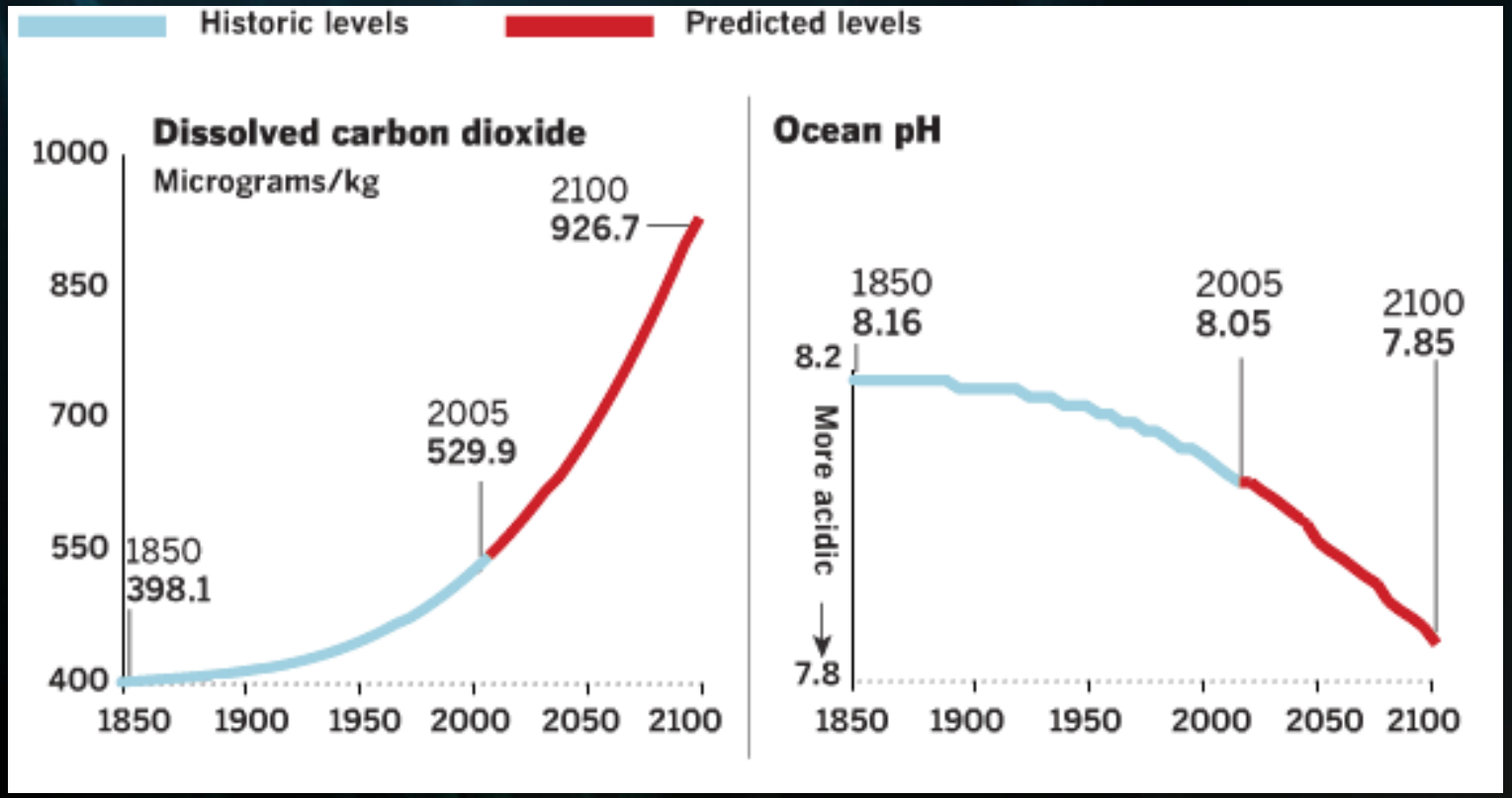
Chinstrap penguin decline

Hydrologic cycle

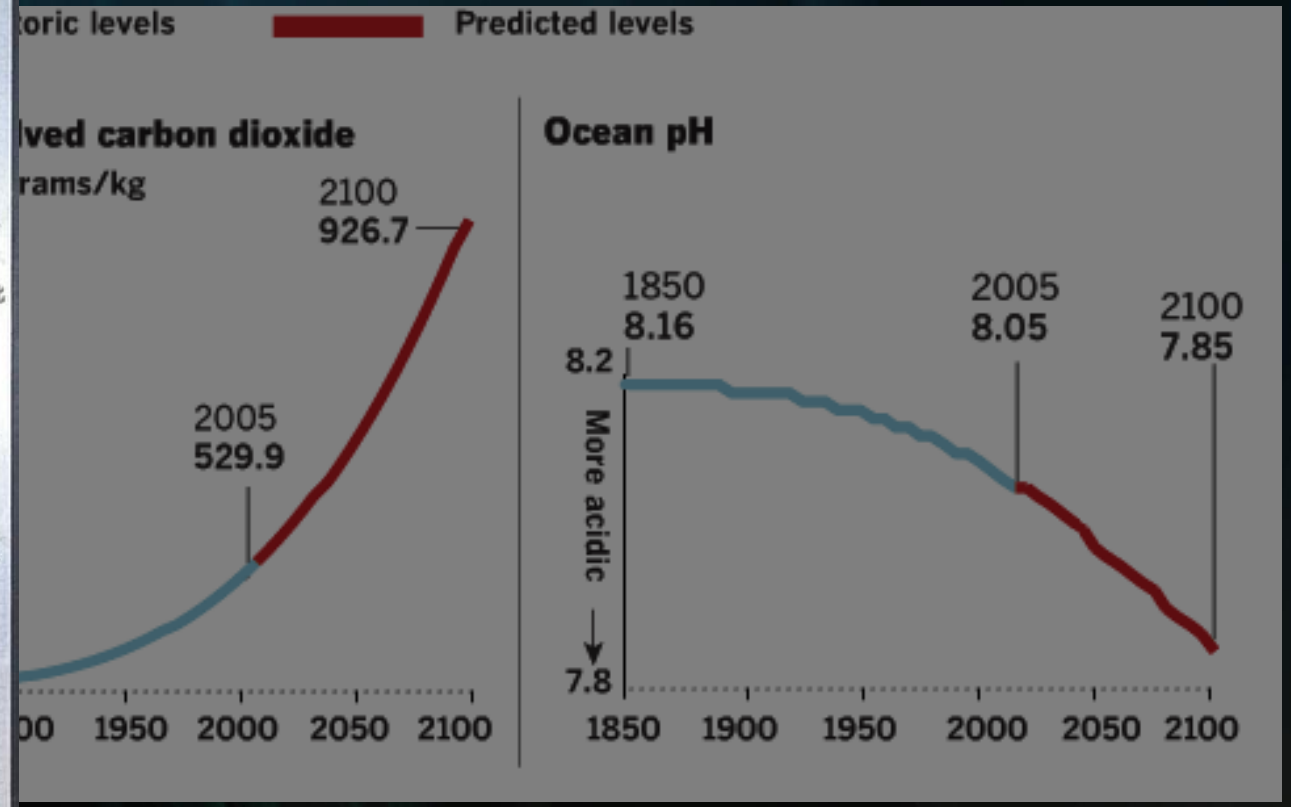
- “A warmer world is a wetter world.”
- Increased nutrient deposition into oceans
- Drives phenology

Hydrologic cycle

Ocean acidification



Ocean acidification



Ocean acidification

Before PETM: Sediment is 10% clay and rich in tiny calcareous shells.

Ocean acidification

55 million years ago: Large CO_2 release abruptly changes ocean pH.

Before PETM: Sediment is 10% clay and rich in tiny calcareous shells.

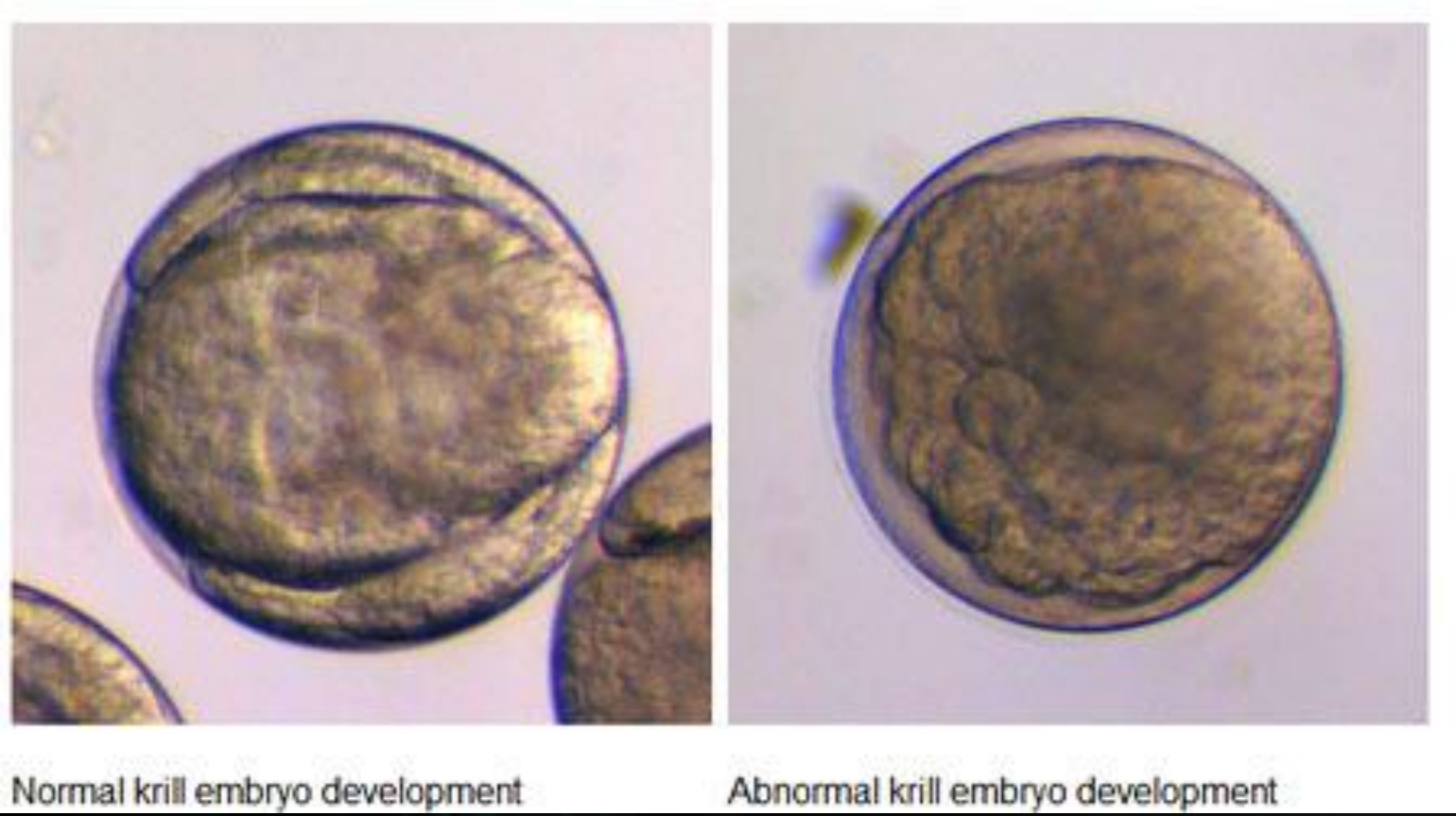
Ocean acidification

Sediments from this 50,000 year period are almost all red clay. Ocean acidity prevents formation of carbonate shells.

55 million years ago: Large CO_2 release abruptly changes ocean pH.

Before PETM: Sediment is 10% clay and rich in tiny calcareous shells.

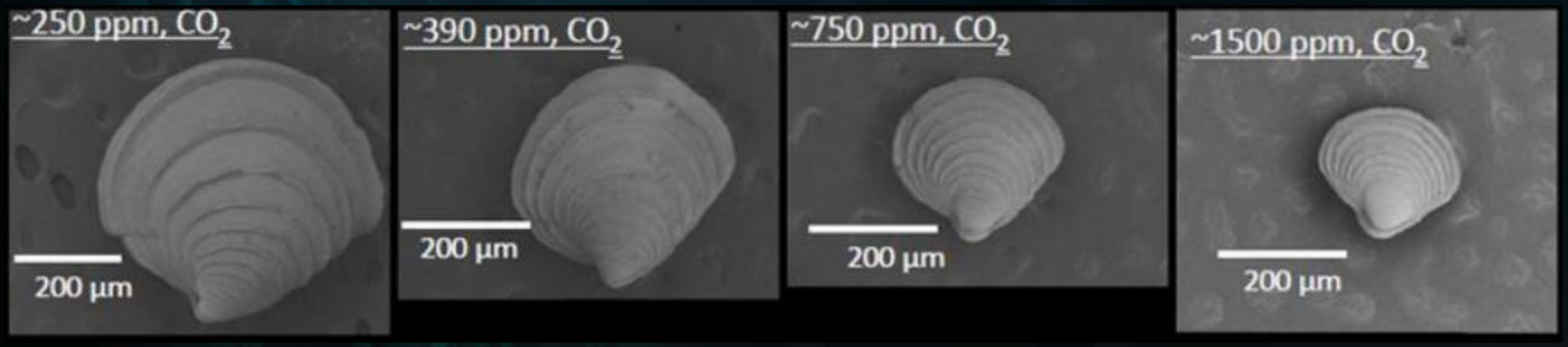
Ocean acidification and krill



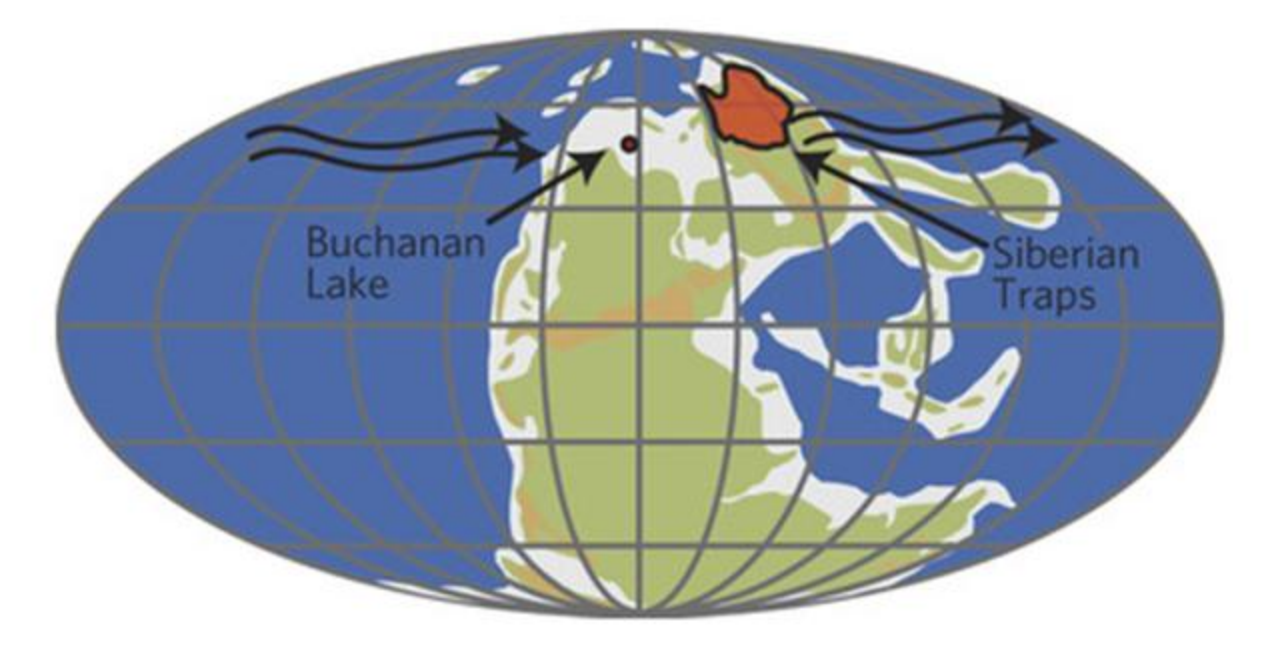
Normal krill embryo development

Abnormal krill embryo development

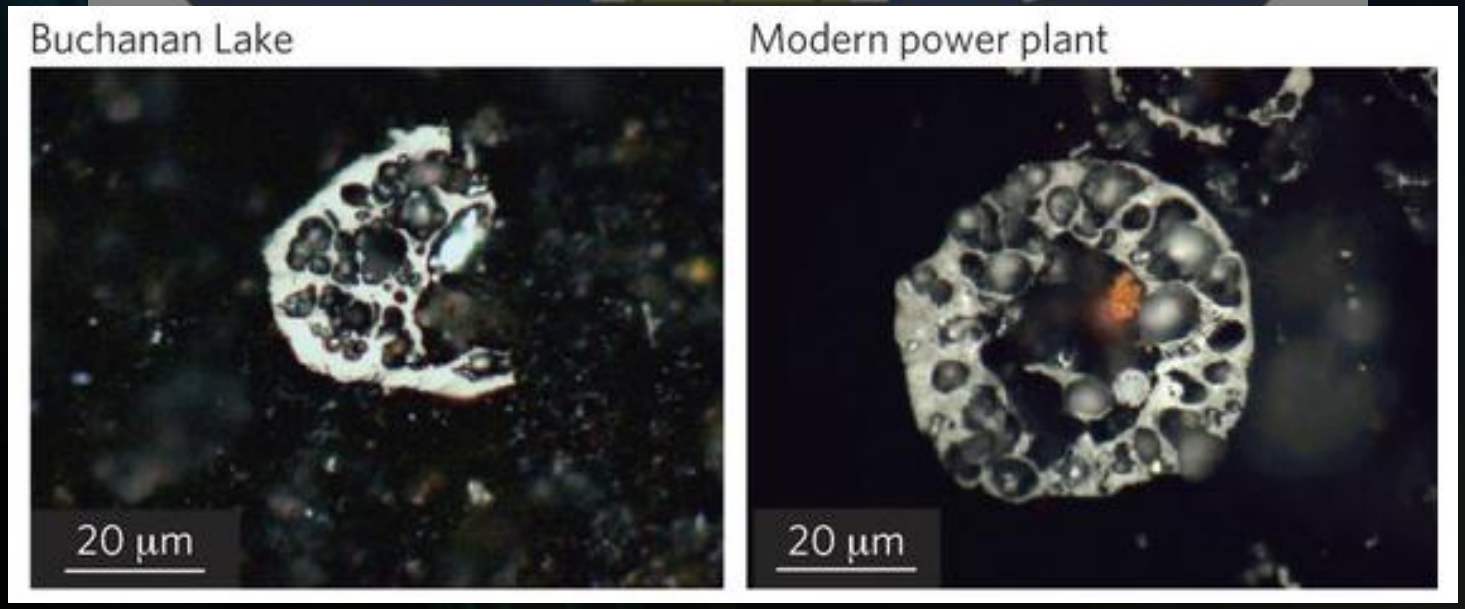
Ocean acidification and mollusks



Permian-Triassic extinction

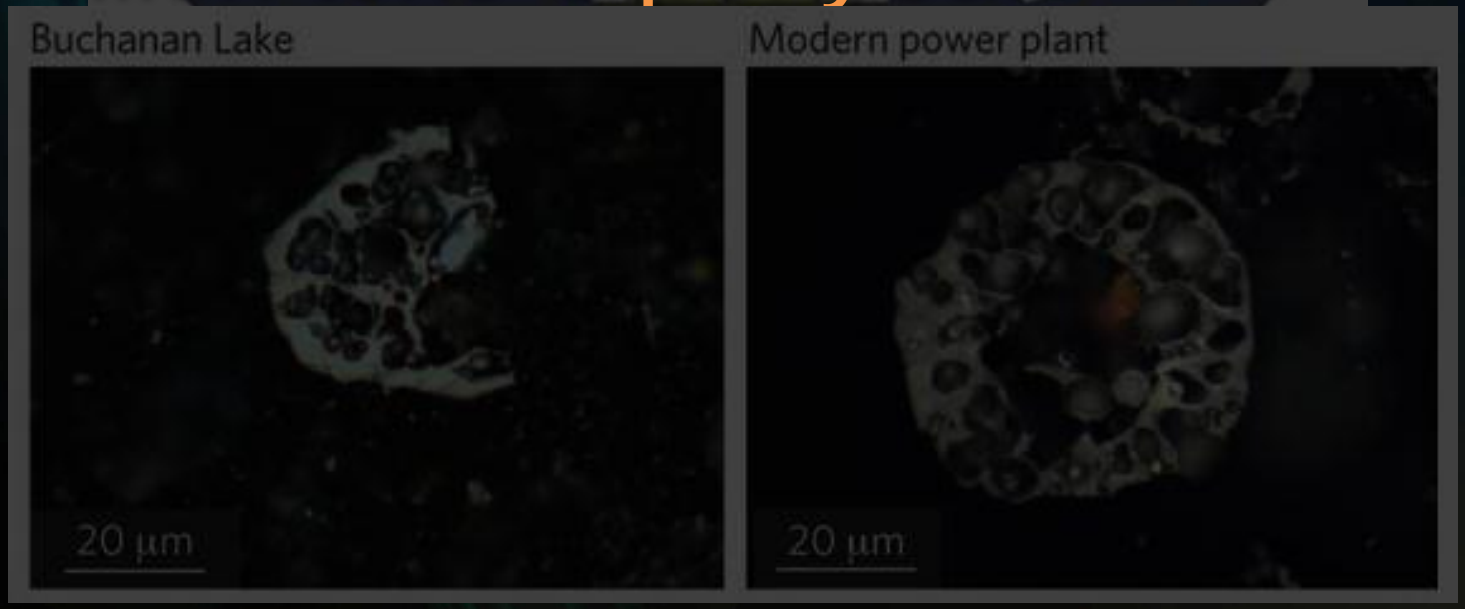


Permian-Triassic extinction



Permian-Triassic extinction

Siberian trap emissions:
3 trillion tons C over 1 million years
3 million tons C per year

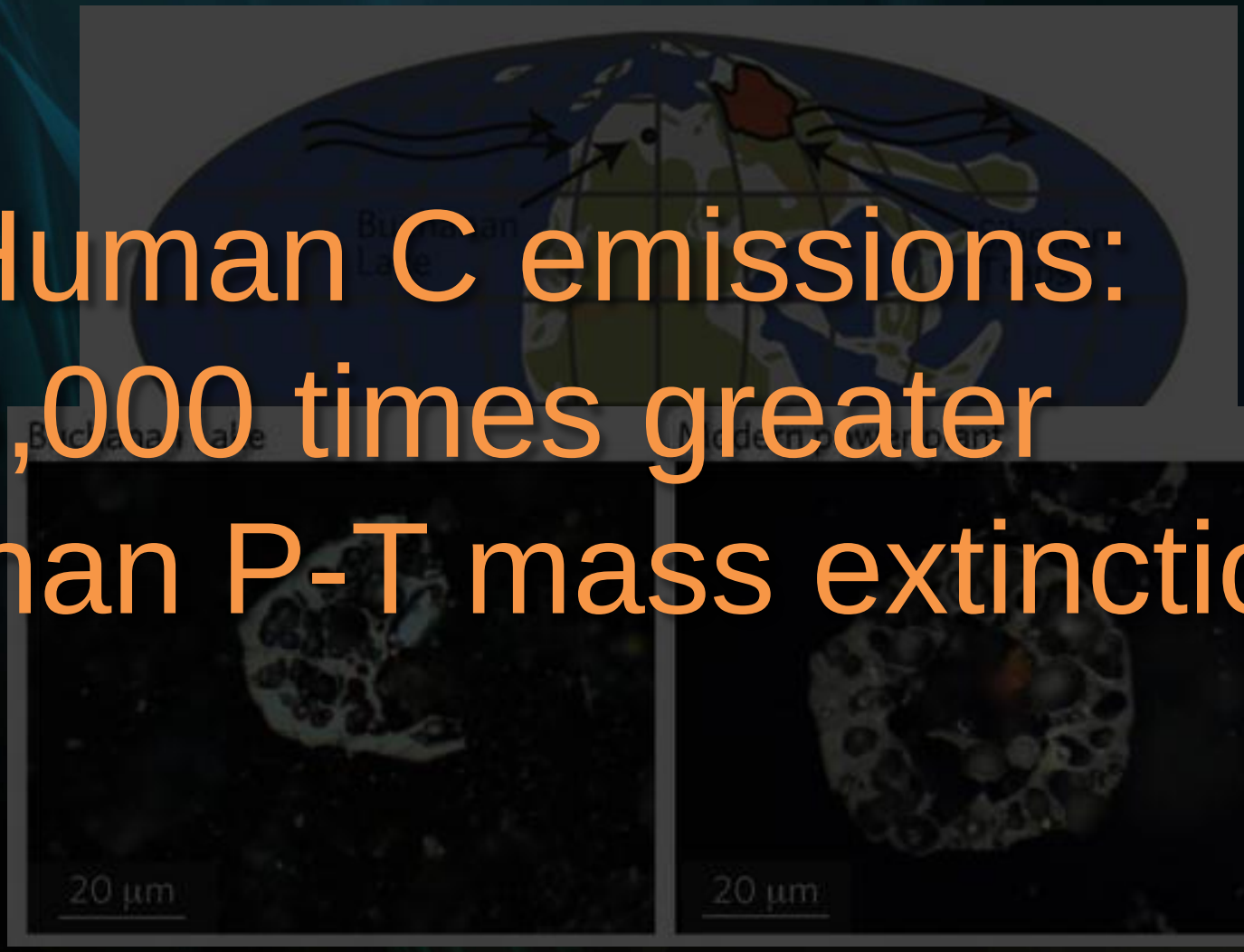


Permian-Triassic extinction

Siberian trap emissions:
3 trillion tons C over 1 million years
3 million tons C per year

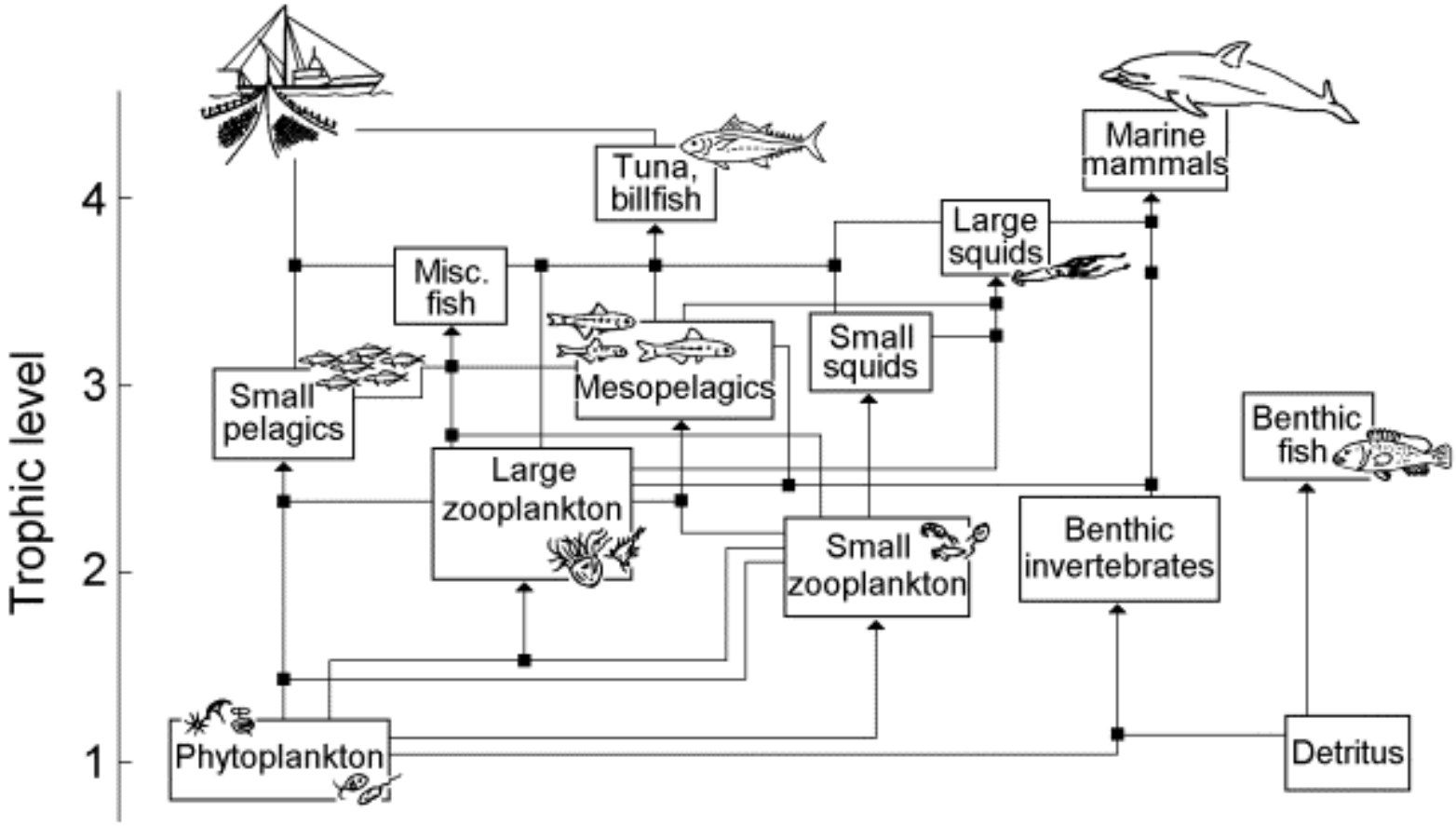
Human emissions:
1 trillion tons C over 100 years
9 **billion** tons C per year

Permian-Triassic extinction

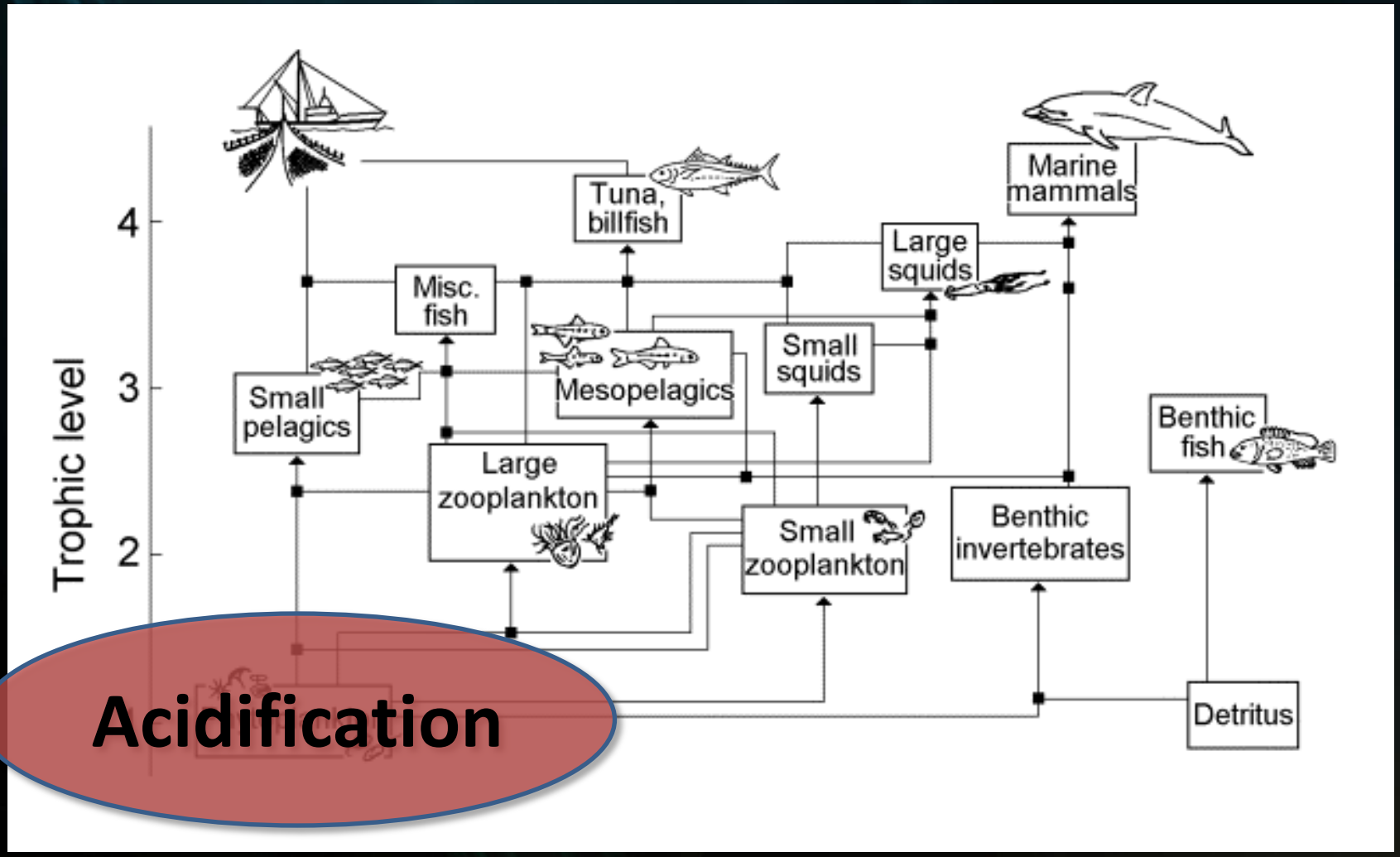


Human C emissions:
3,000 times greater
than P-T mass extinction

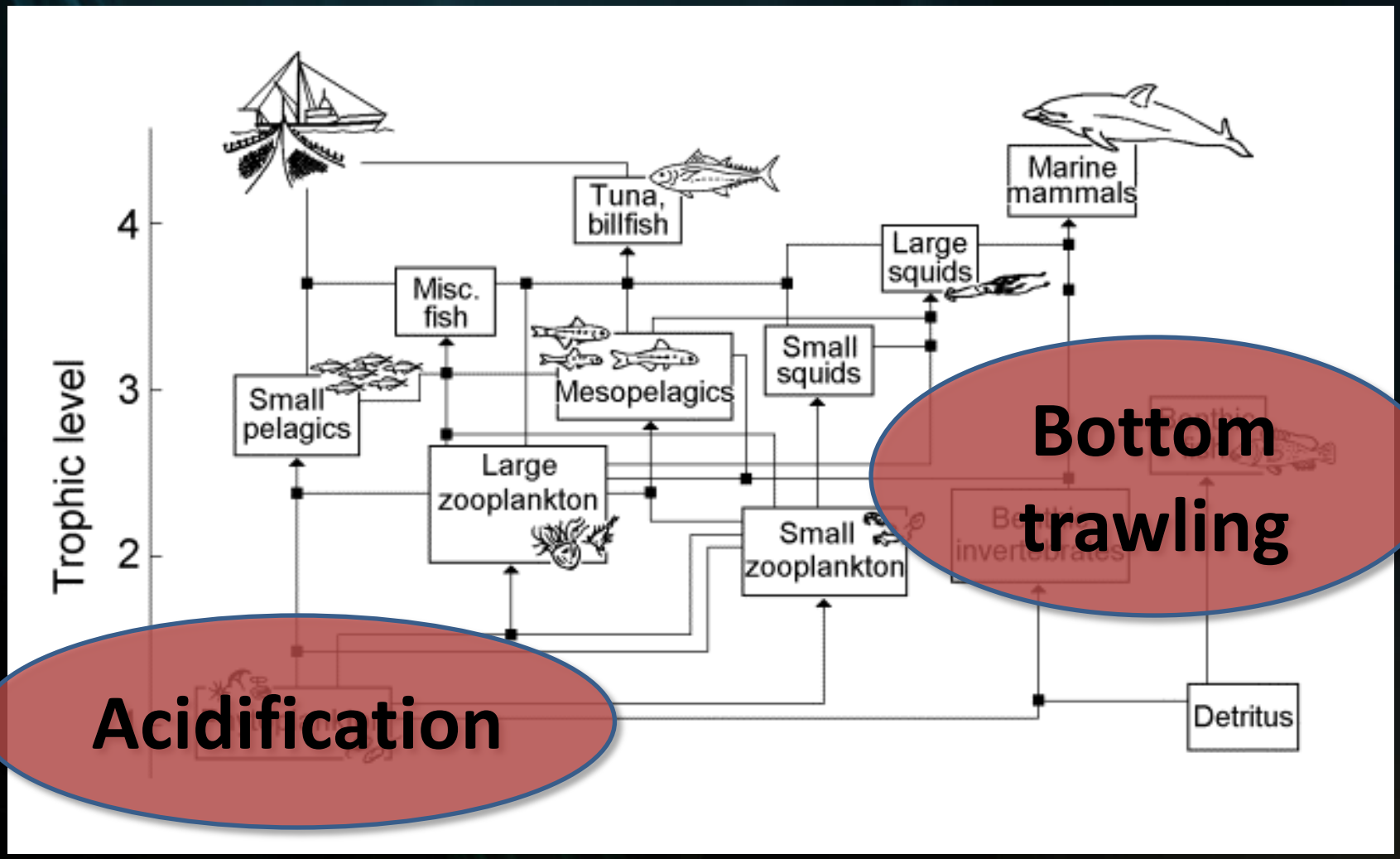
Marine food web



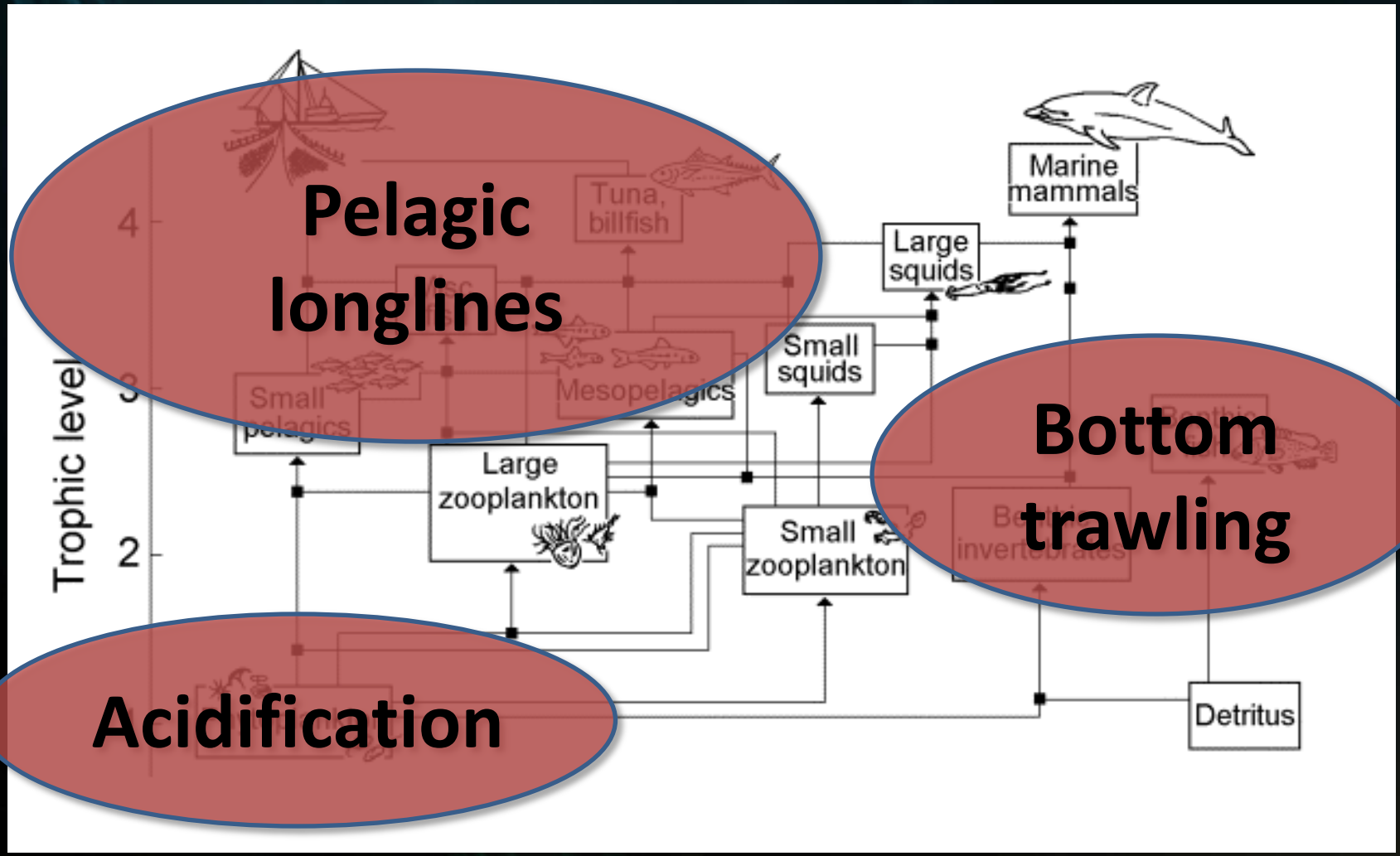
Marine food web



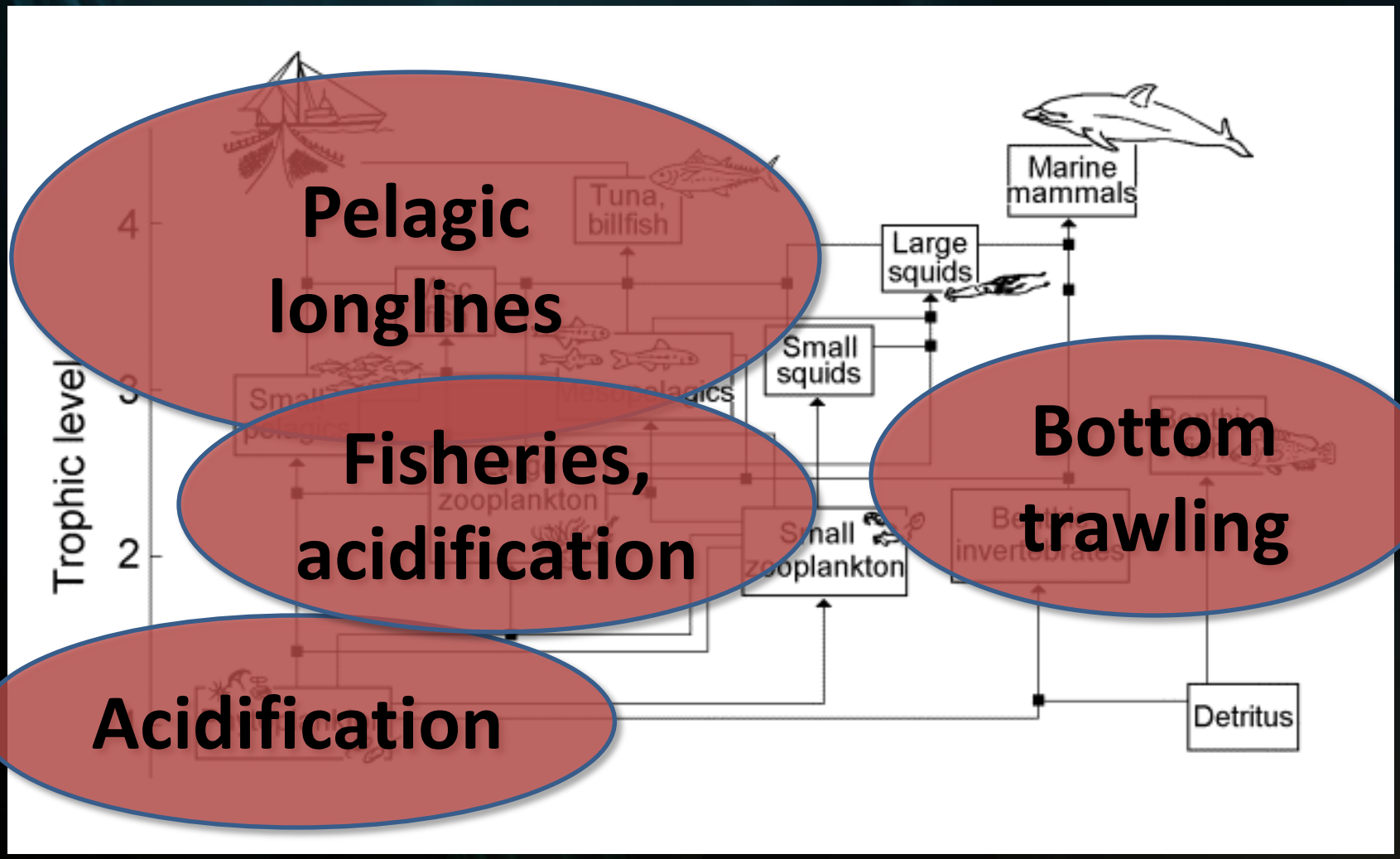
Marine food web



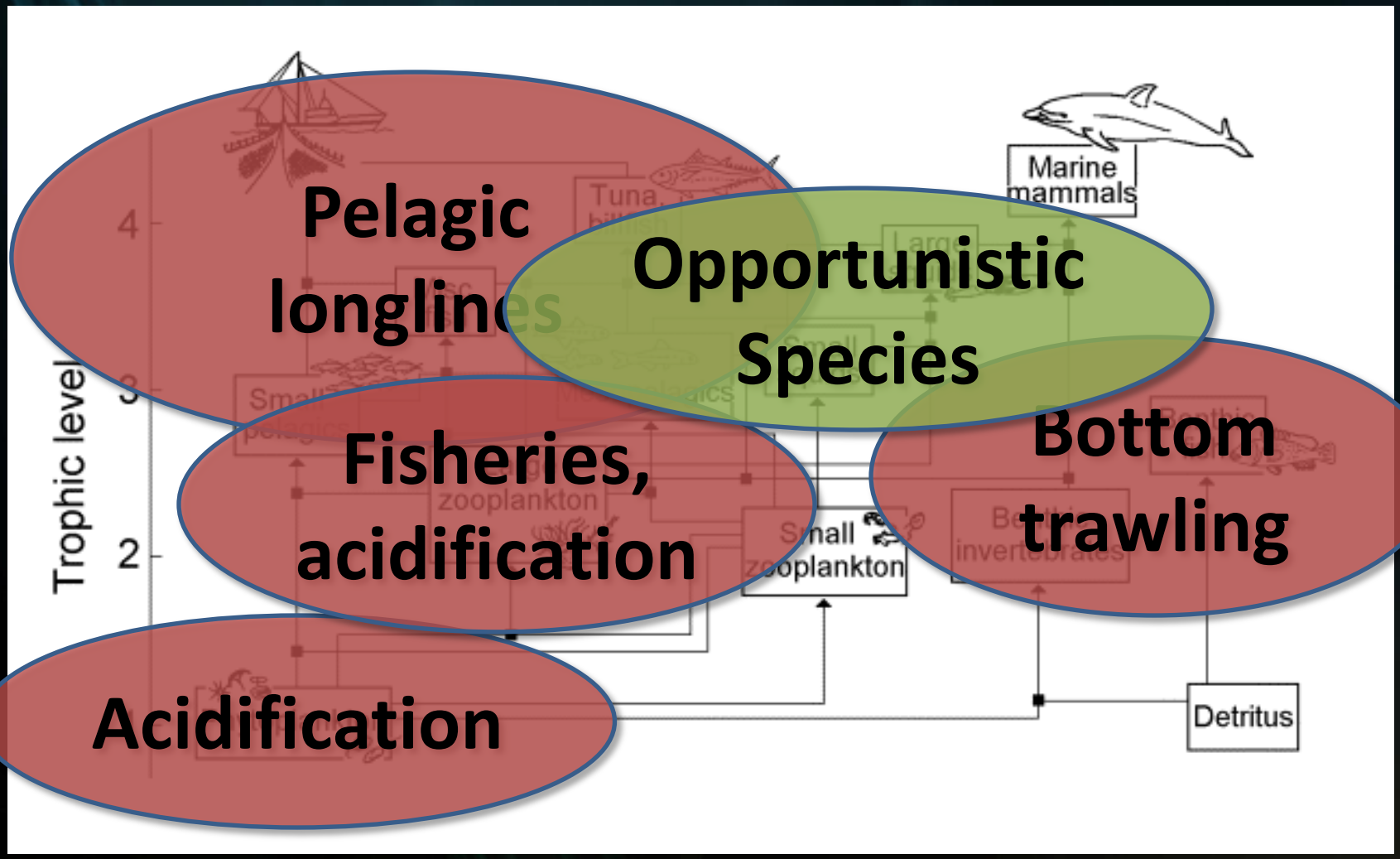
Marine food web



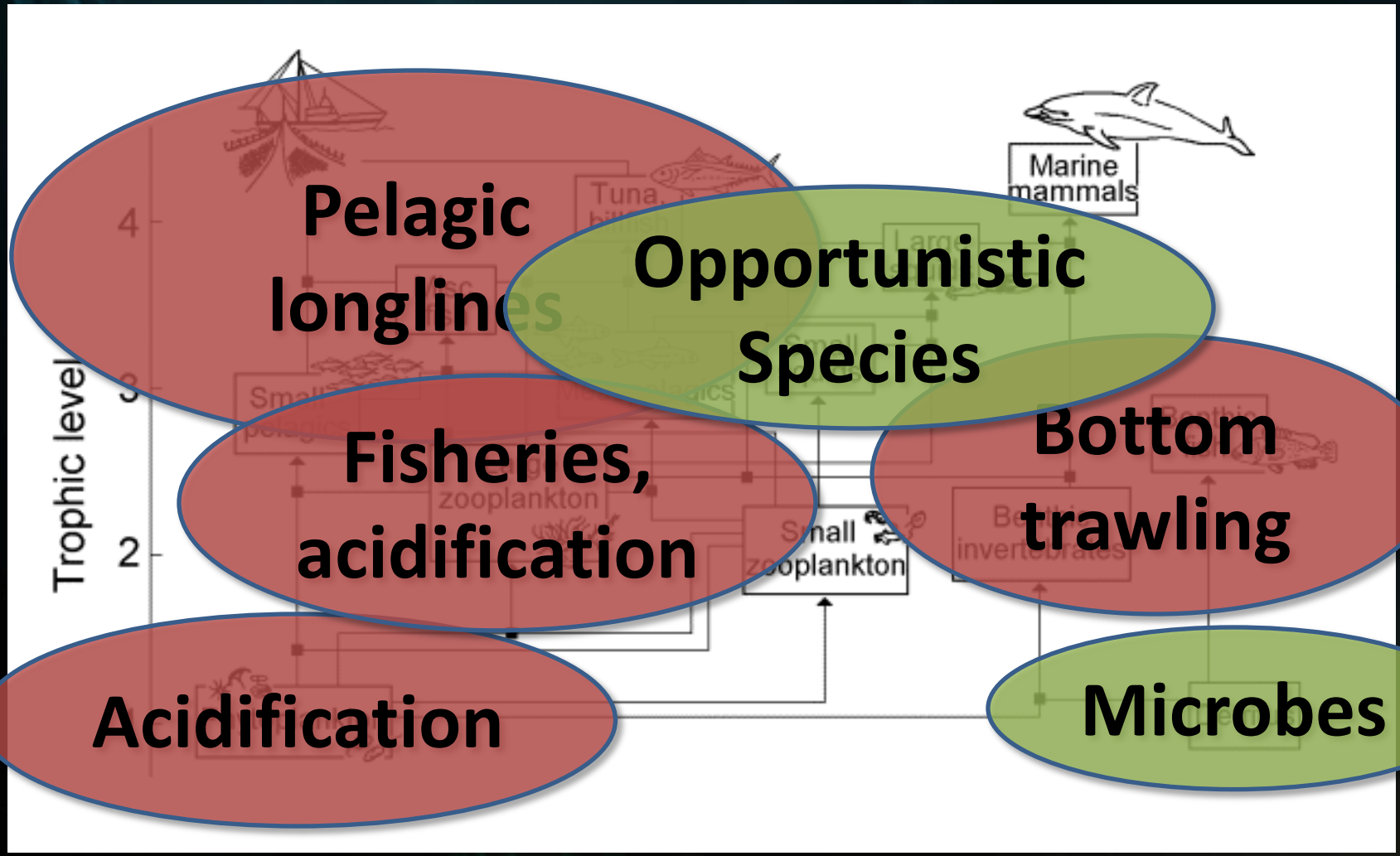
Marine food web



Marine food web

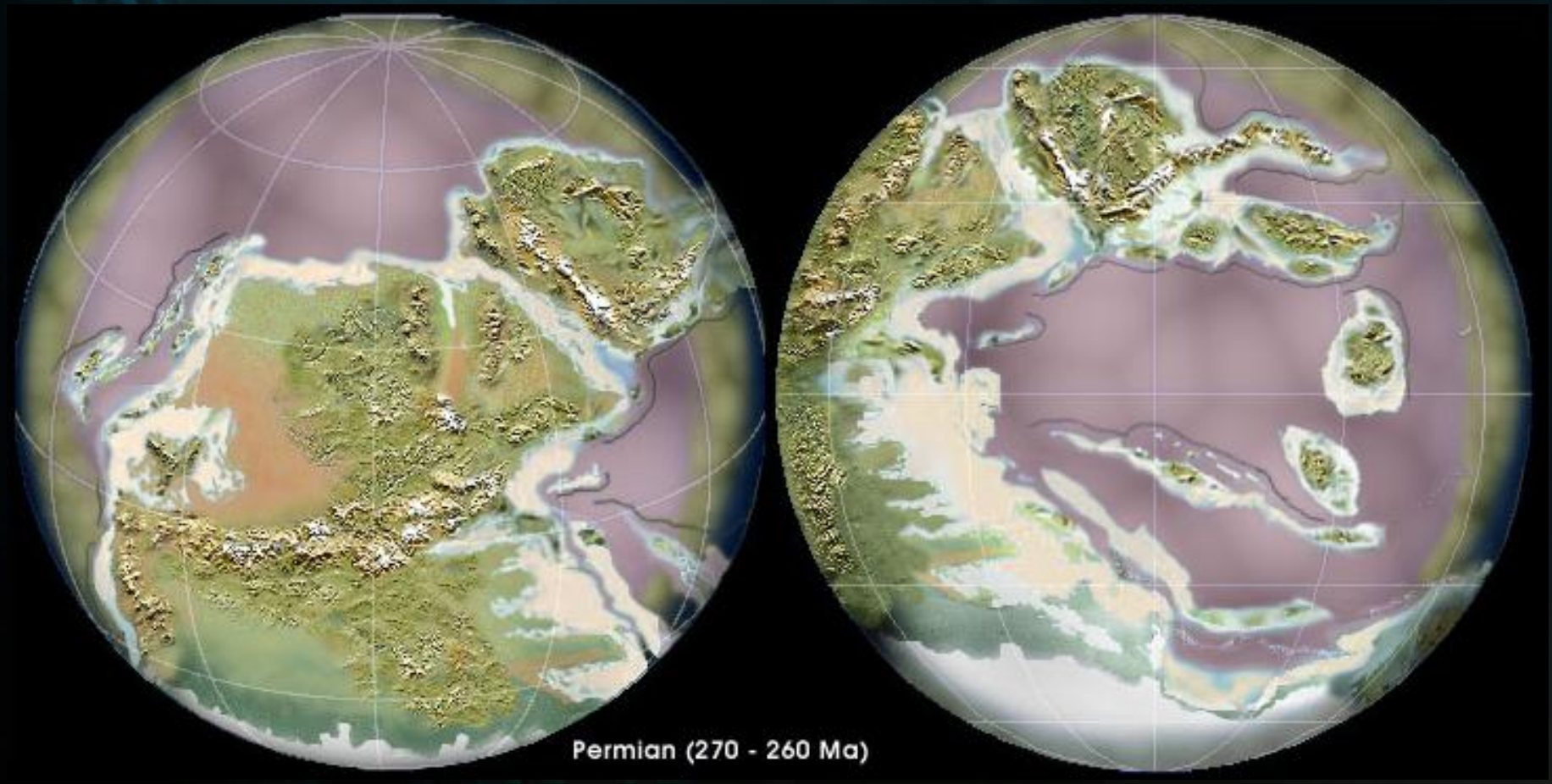


Marine food web



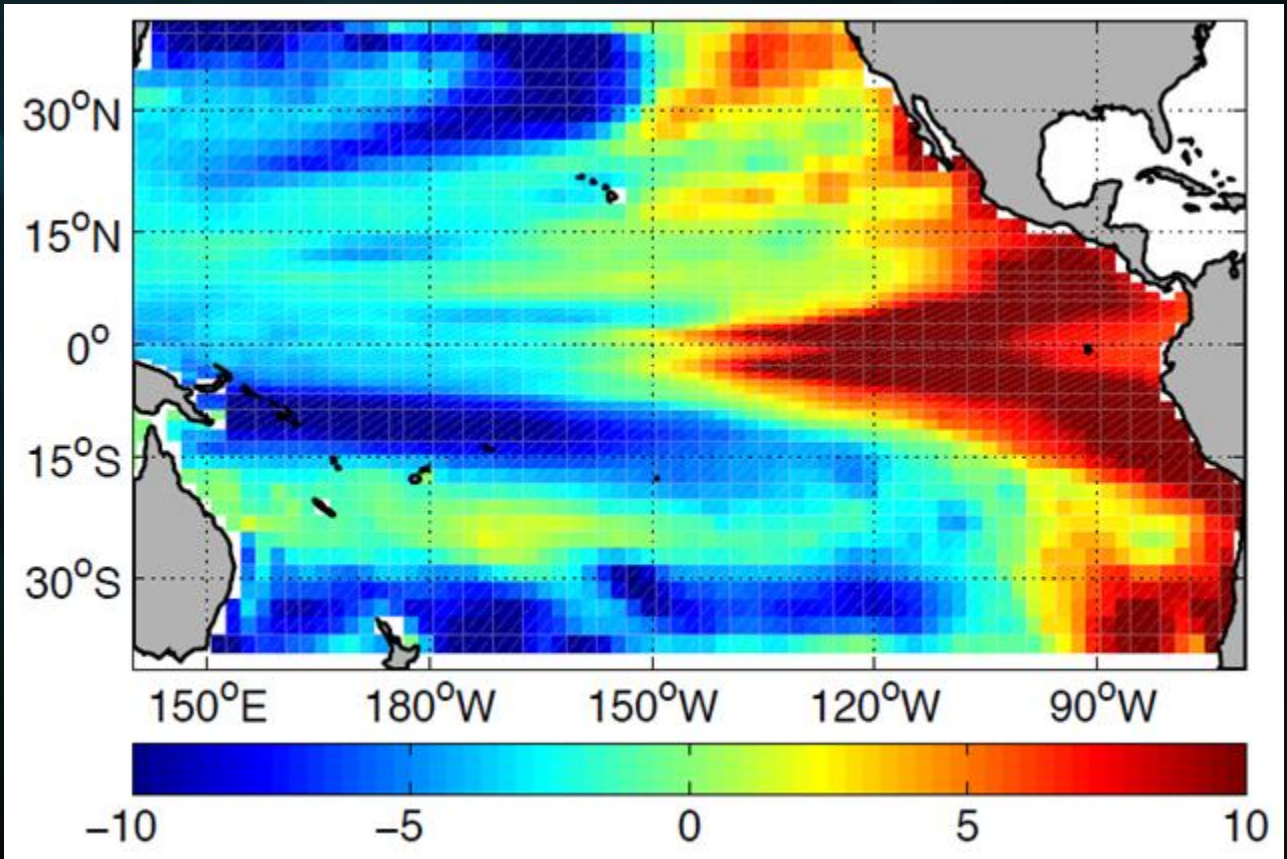
Anaerobic microbes

Ocean-wide anoxia



Ocean anoxia

Ocean anoxia



Microbe-dominated oceans

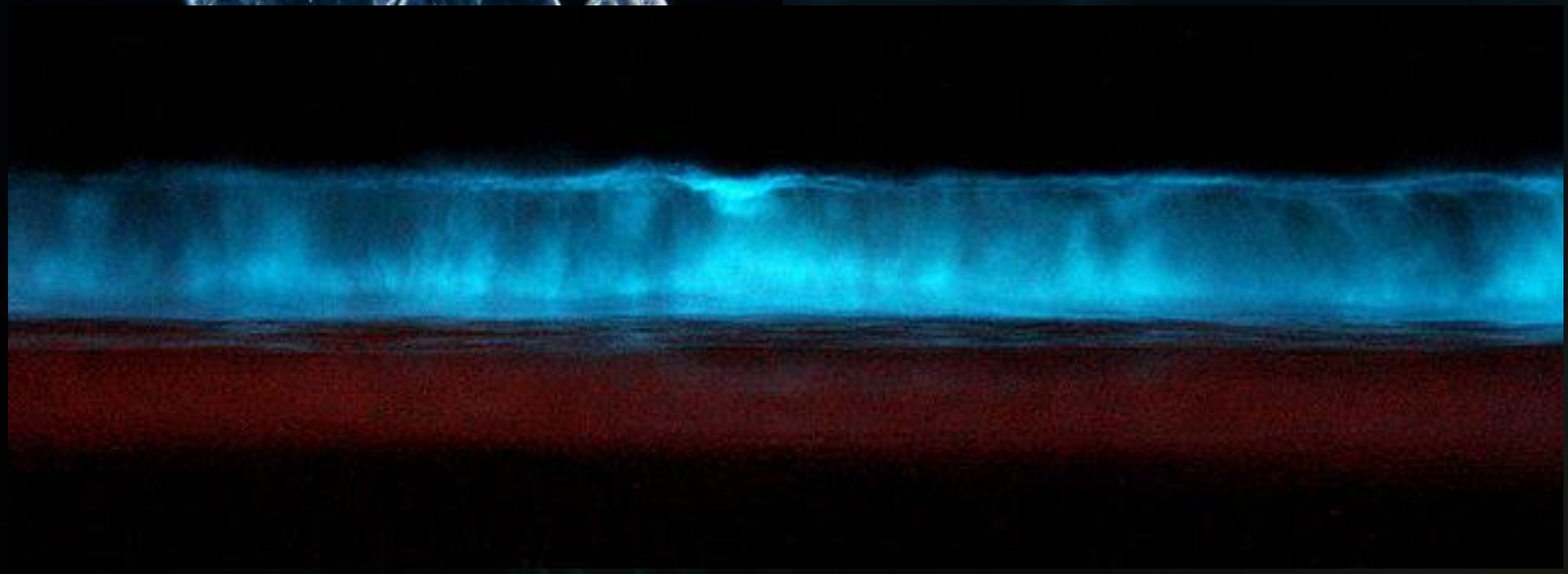
"The future is bright for dinoflagellates."

Jeremy Jackson

Microbe-dominated oceans

"The future is bright for dinoflagellates."

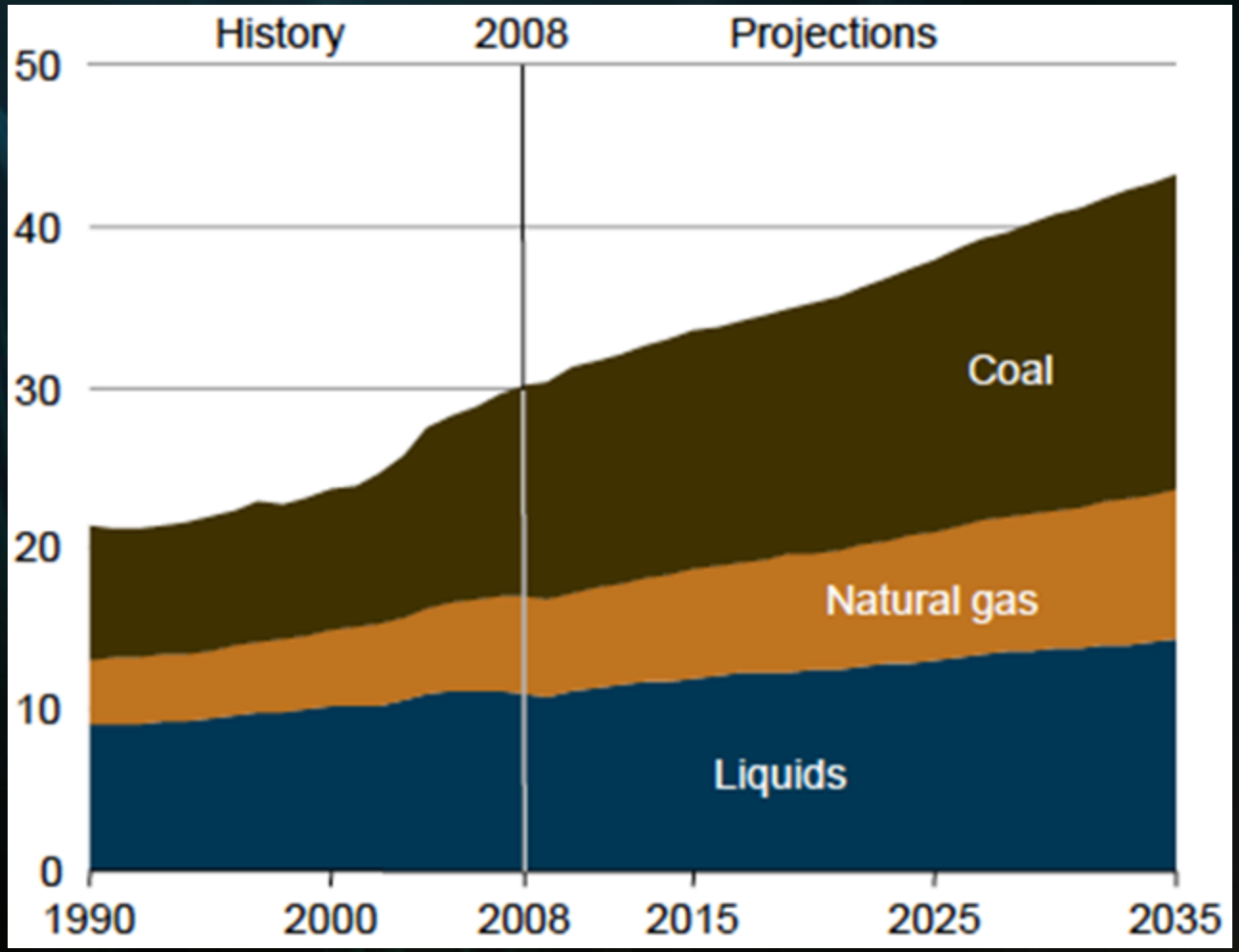
Jeremy Jackson



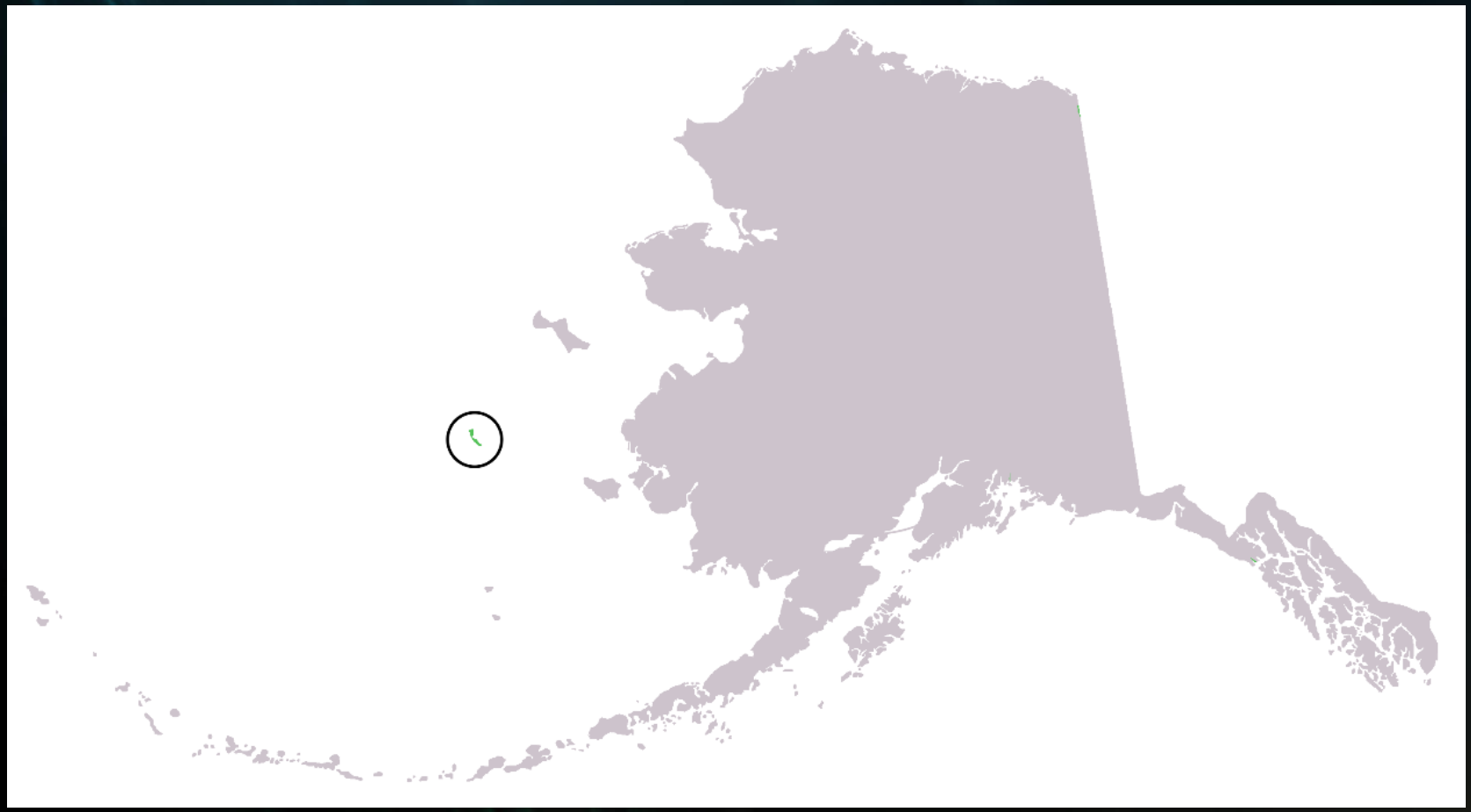
Prospects

- King Coal
- Human population
- Solutions: realistic, scalable
- Wastewater treatment
- Atmospheric vortex engines
- Sequestering ocean carbon
- What you can do

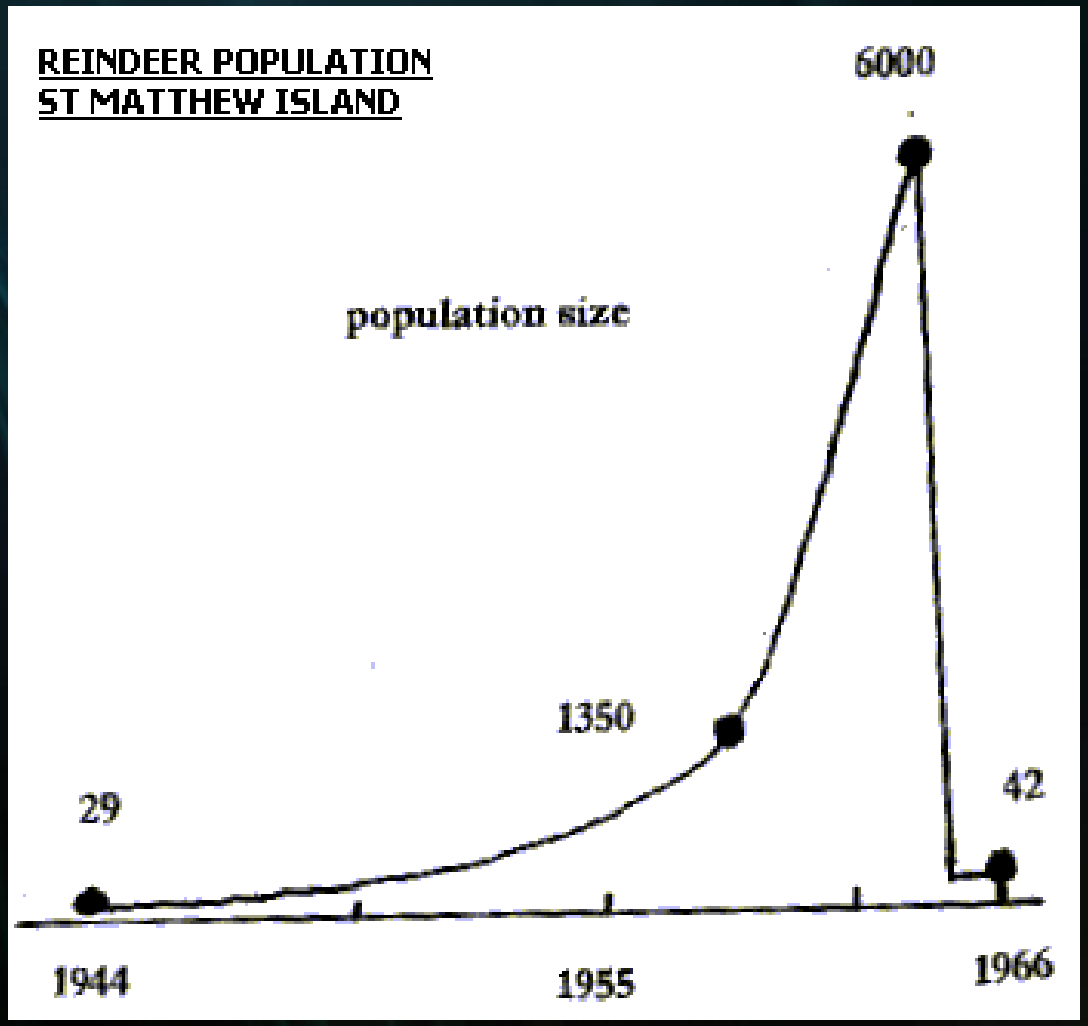
Prospects


History
2008
Projections
50
40
30
20
10
0
Coal
Natural gas
Liquids
1990
2000
2008
2015
2025
2035

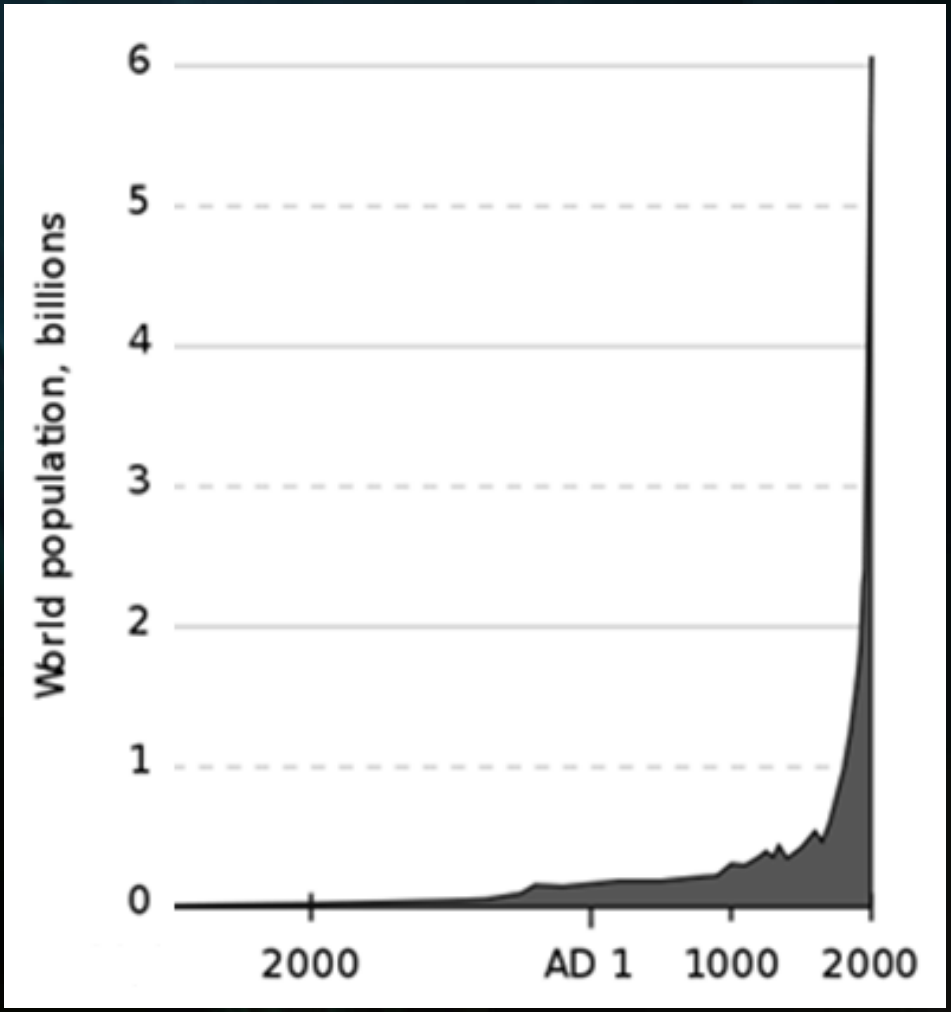
Isolated reindeer population



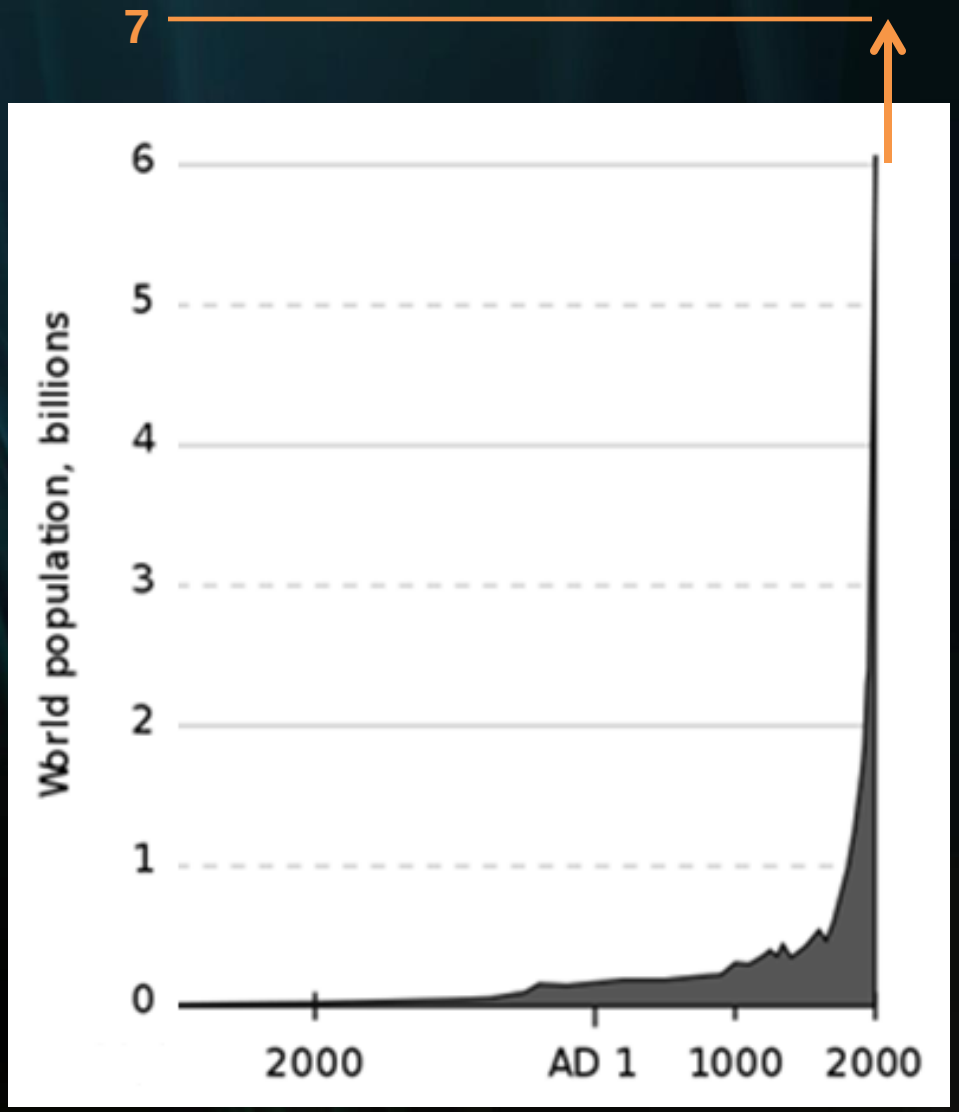
Population overshoot



Human population



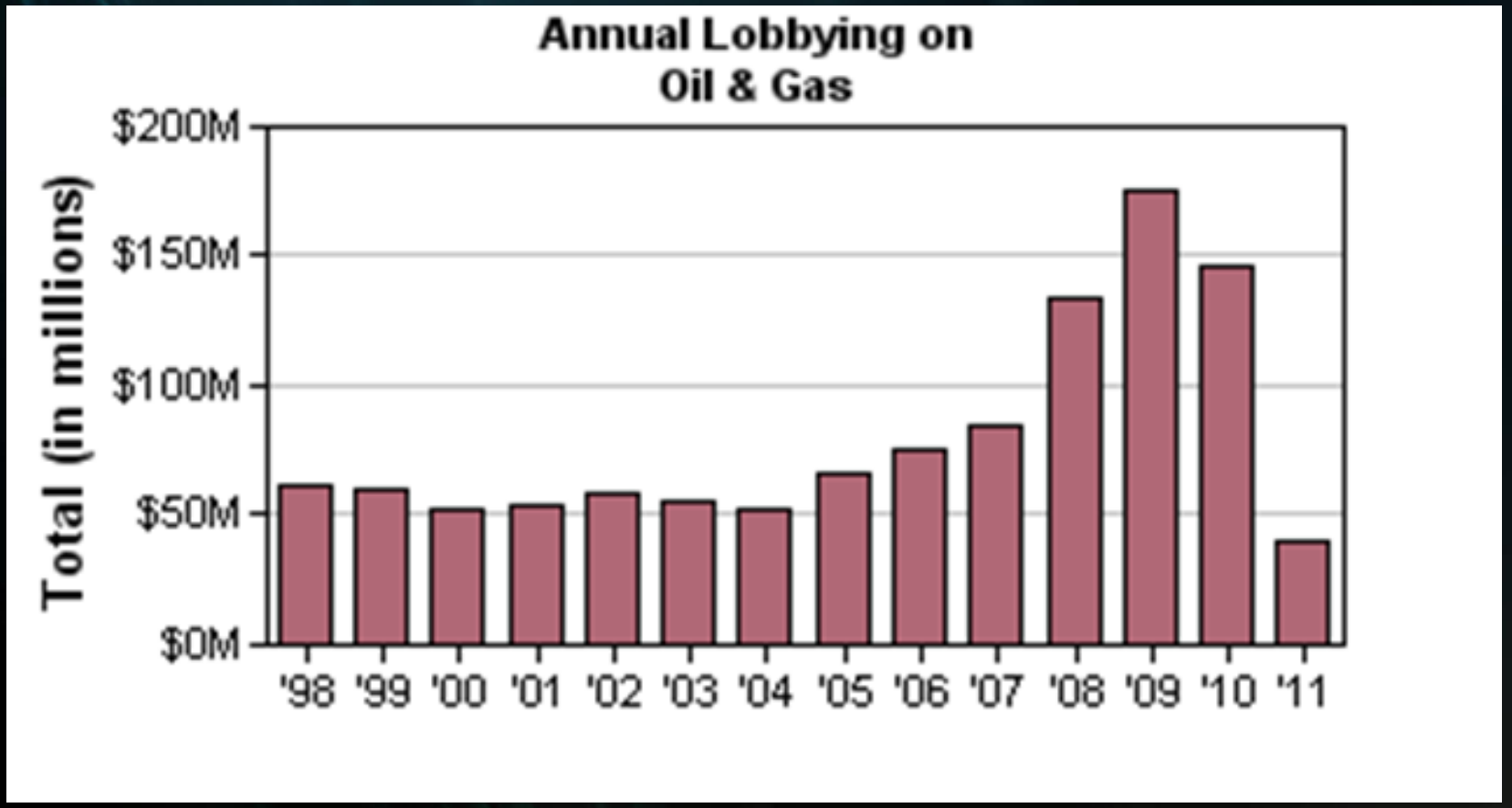
Human population



Fossil fuel industry

Fossil fuel industry

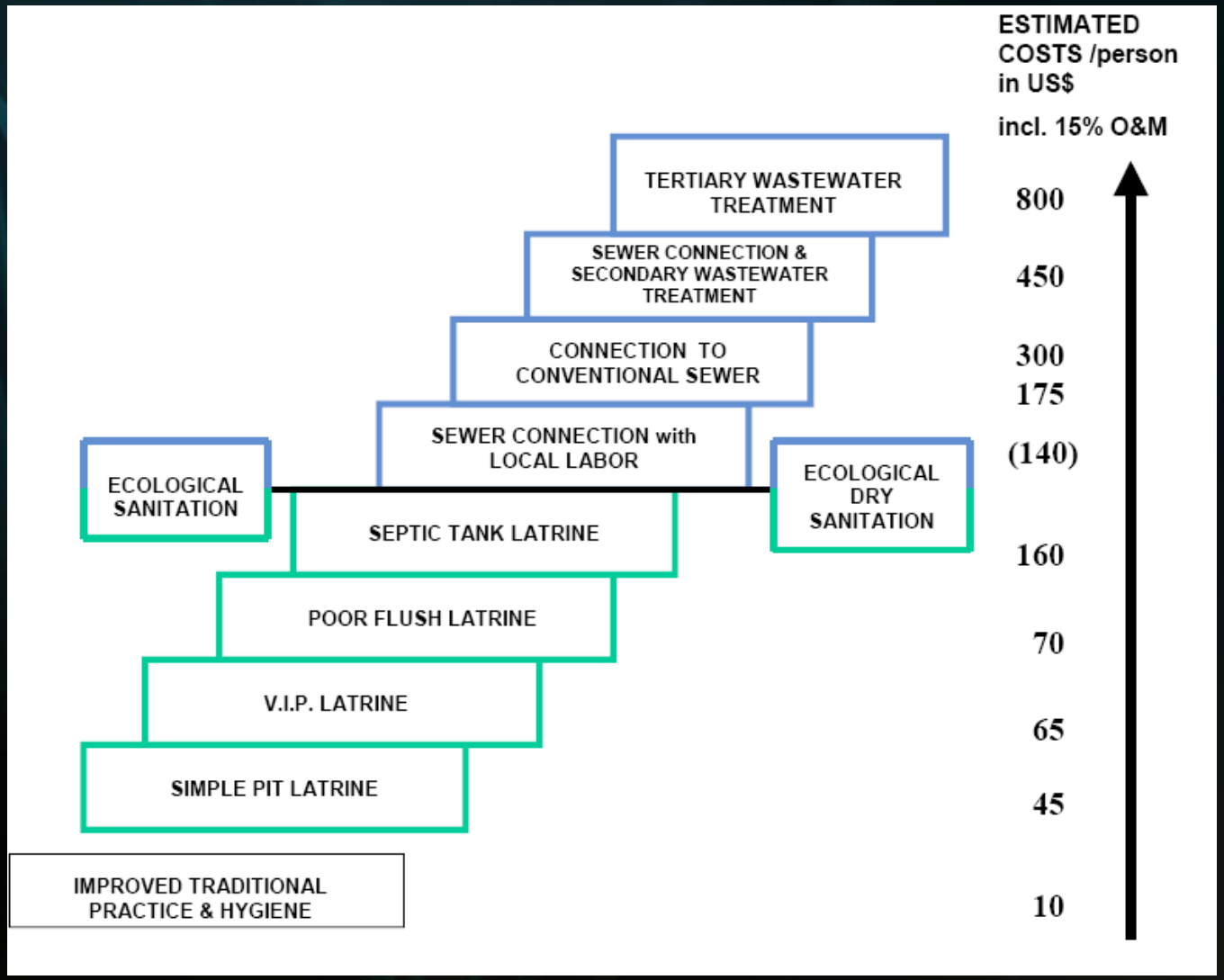
Fossil fuel industry



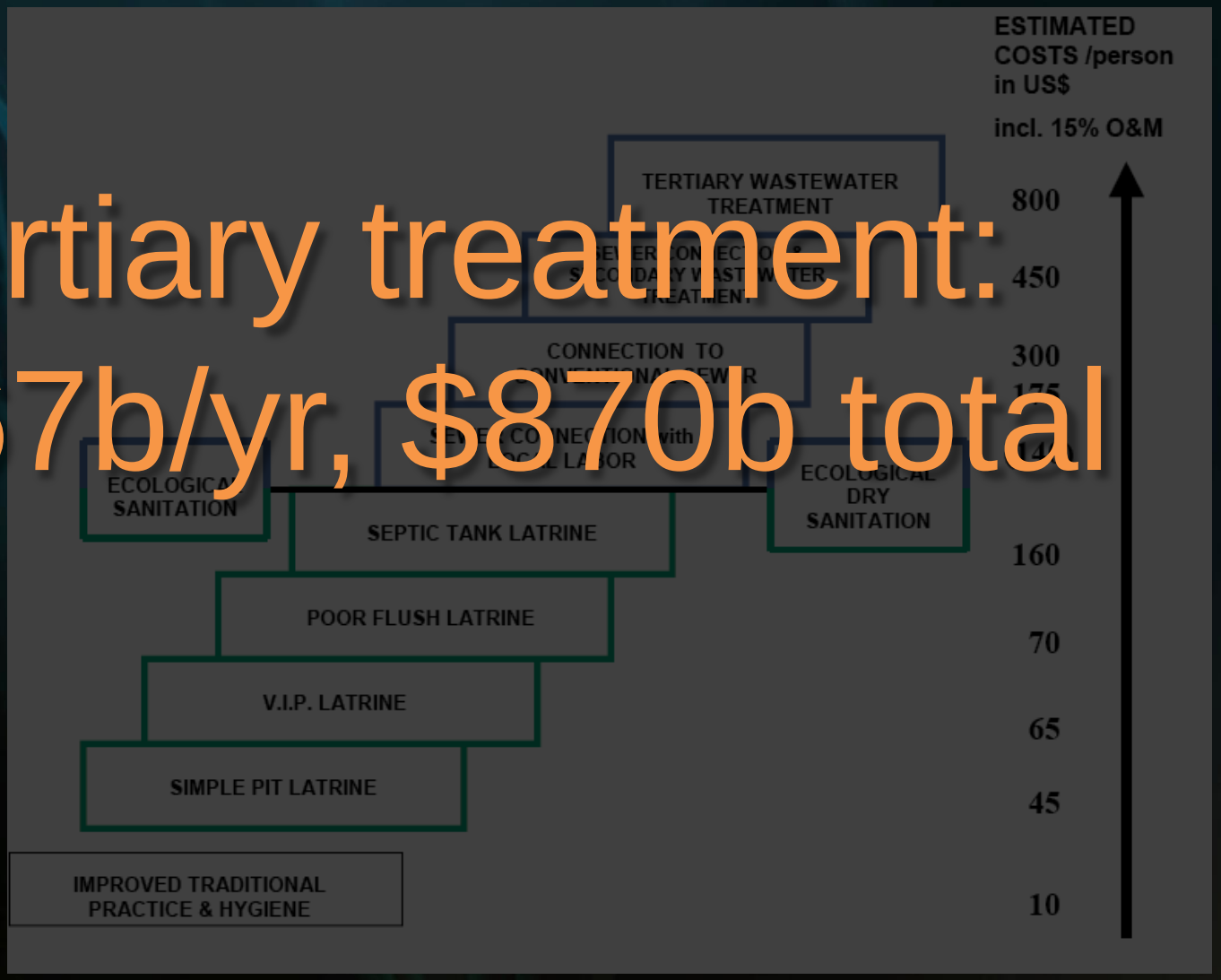
Wastewater treatment

- Globally, 2 million tons of sewage and industrial and agricultural waste are poured into the world's waters every day
- 730 million tons per year
- 90% of sewage in the developing world goes untreated

Wastewater treatment

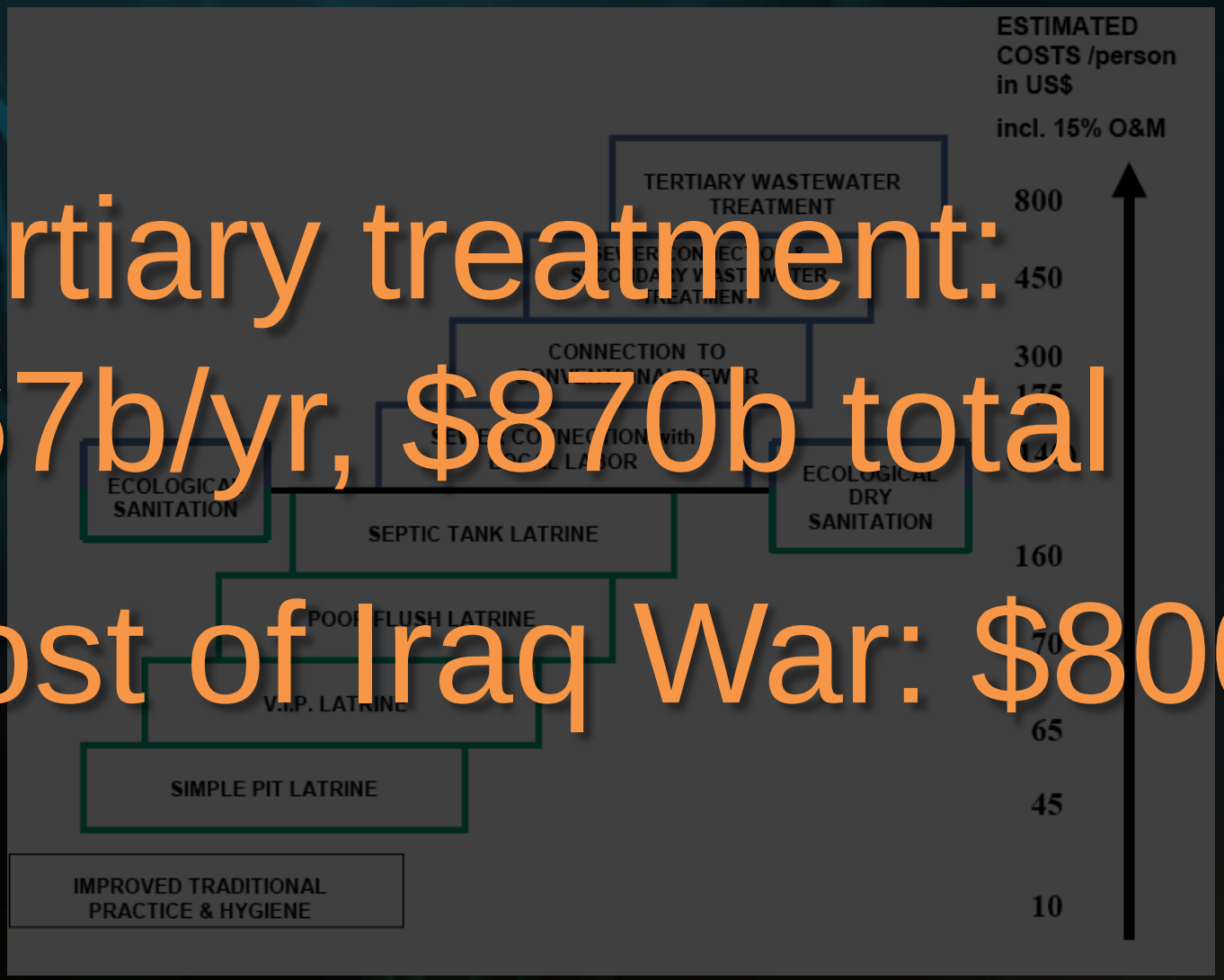


Wastewater treatment



Tertiary treatment: $67b/yr, $870b total

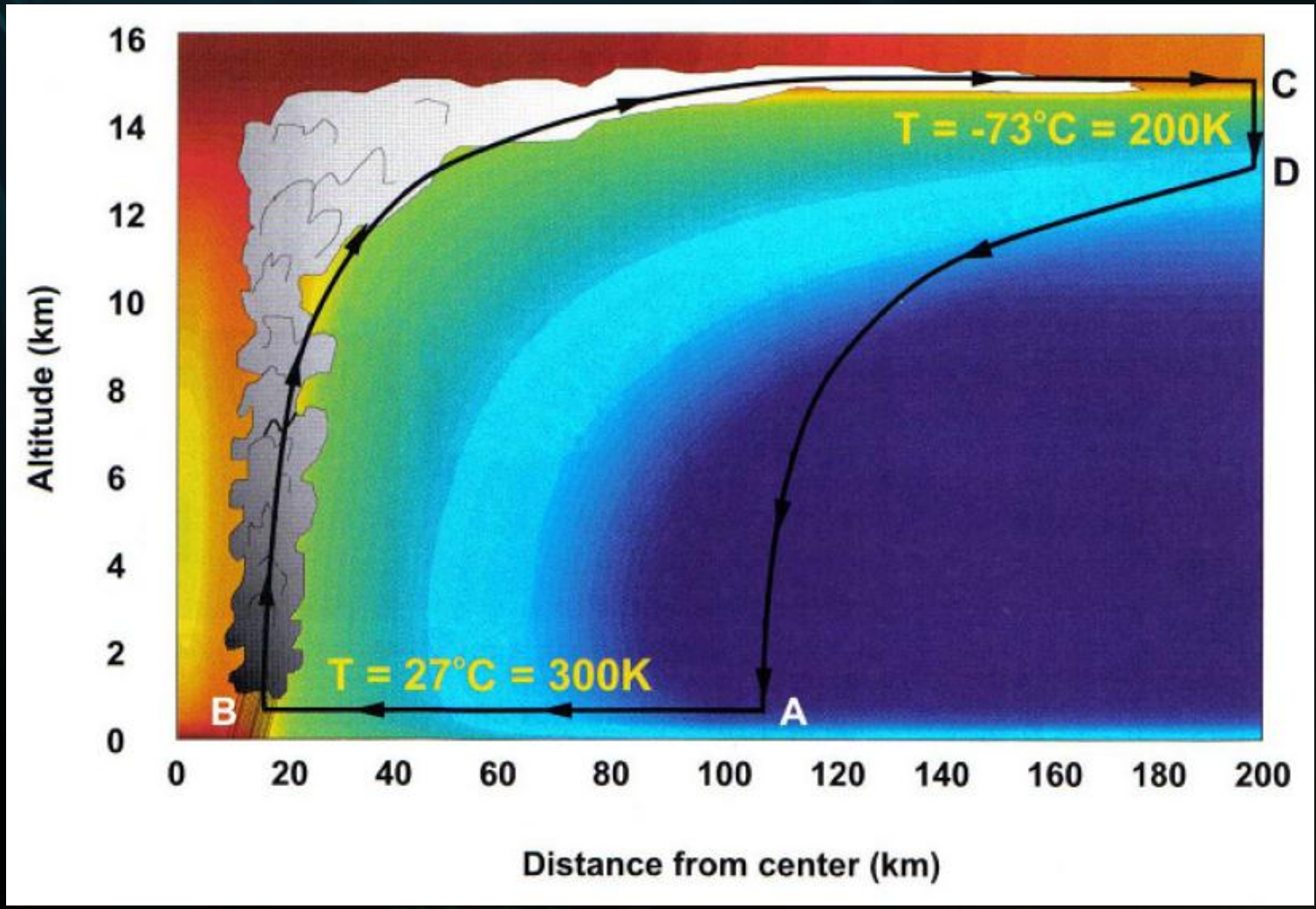
Wastewater treatment



Tertiary treatment: $67b/yr, $870b total

Cost of Iraq War: $800b

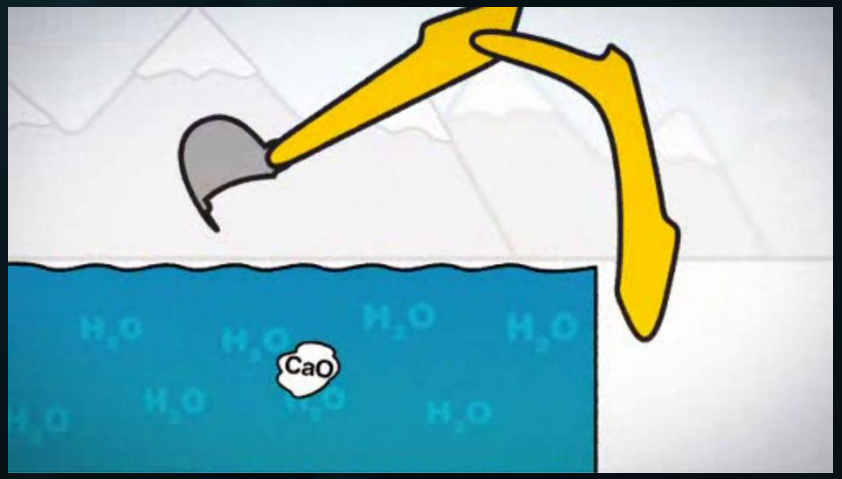
Hurricane Carnot cycle

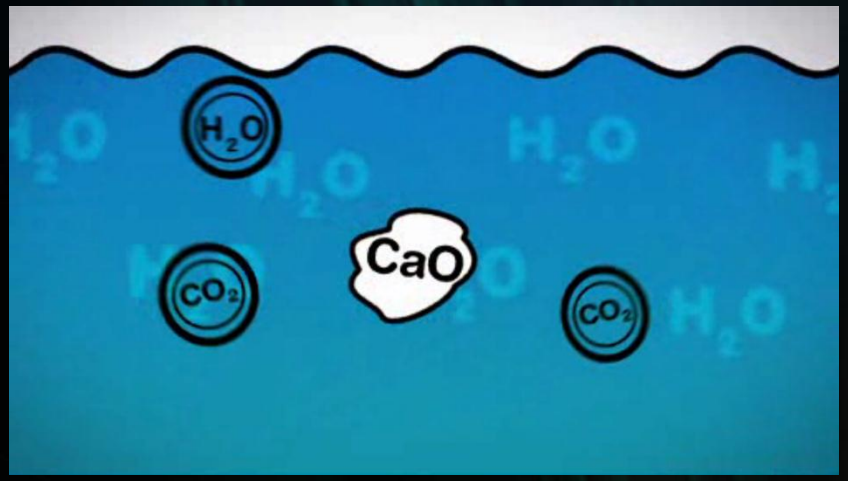


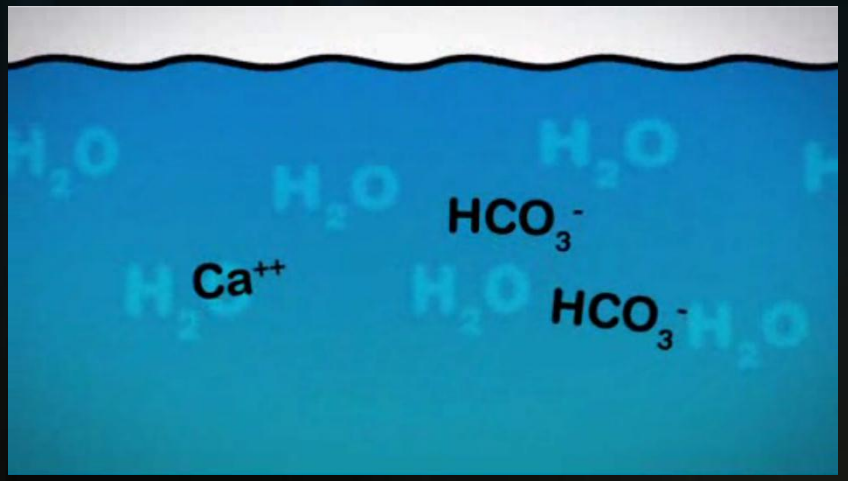
Supercell

Atmospheric Vortex Engine

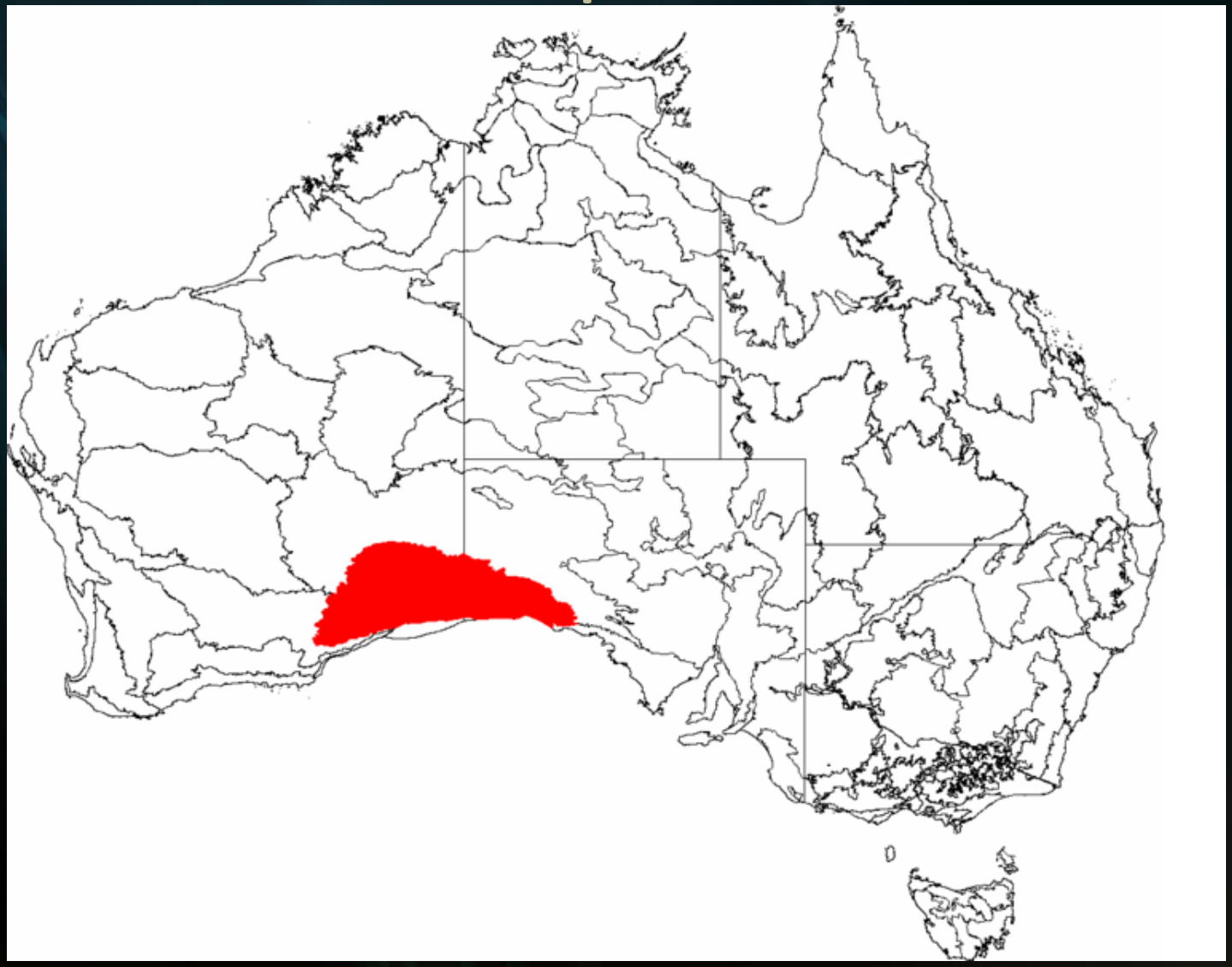
Ocean sequestration



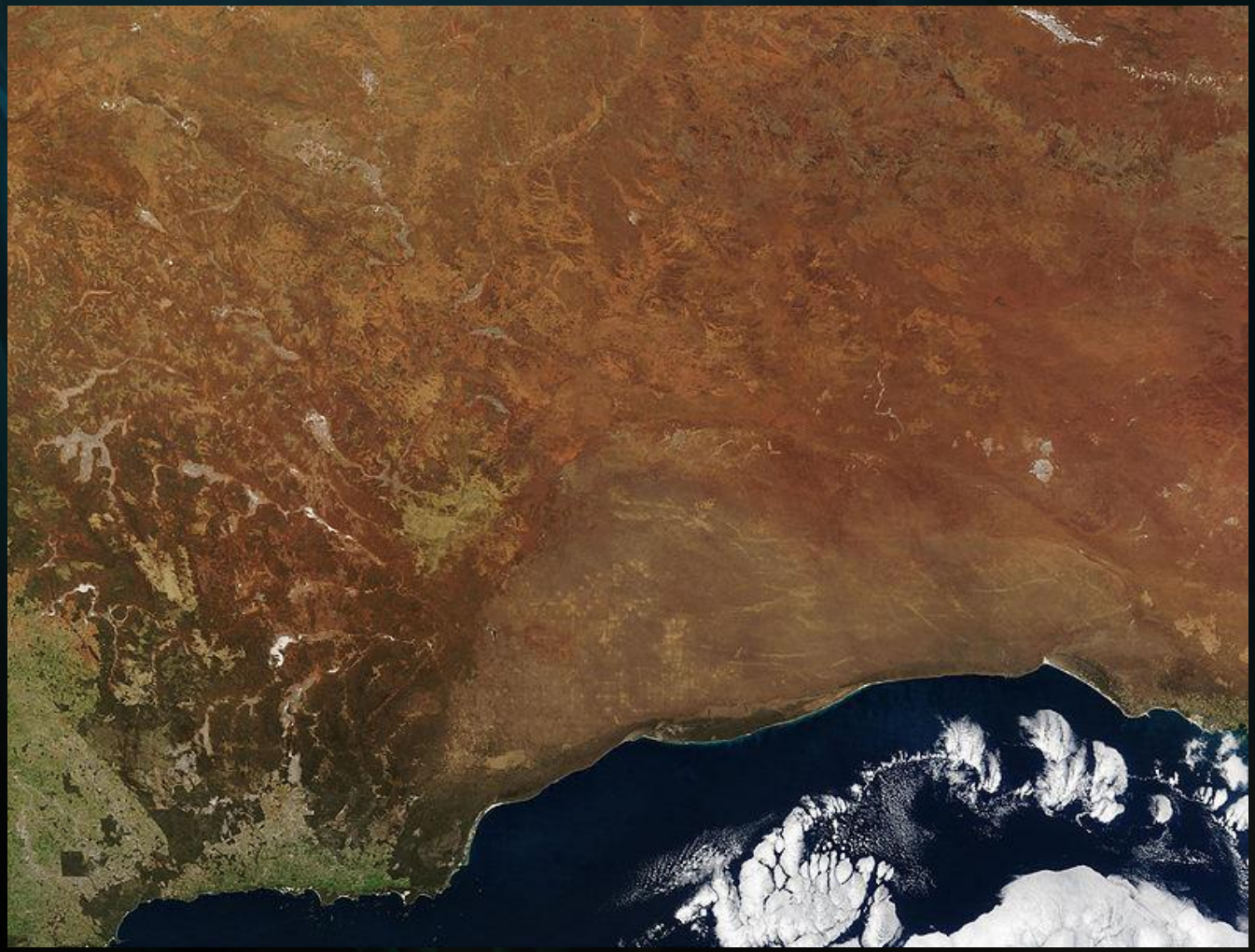




Prospects



Prospects



Carbon fast and carbon offsets

Carbon fast and carbon offsets

NativeEnergy

Bringing New Renewables To Market

What you can do right now

- Buy only sustainable seafood.
- Don’t use pesticides, herbicides, or fertilizers.
- Use phospate-free detergent.
- Buy organic and locally grown food.
- Recycle aggressively.
- Prefer public transportation to driving.
- Reduce or eliminate air travel.

Resources

- Desdemona Despair: Blogging the End of the World™
- Ecumenical Lenten Carbon Fast
- Creation Care
- *Native*Energy
- Atmospheric Vortex Engine
- Cquestrate
- Census of Marine Life
- Hypoxia in the Northern Gulf of Mexico
- Jeremy Jackson: Brave New Ocean