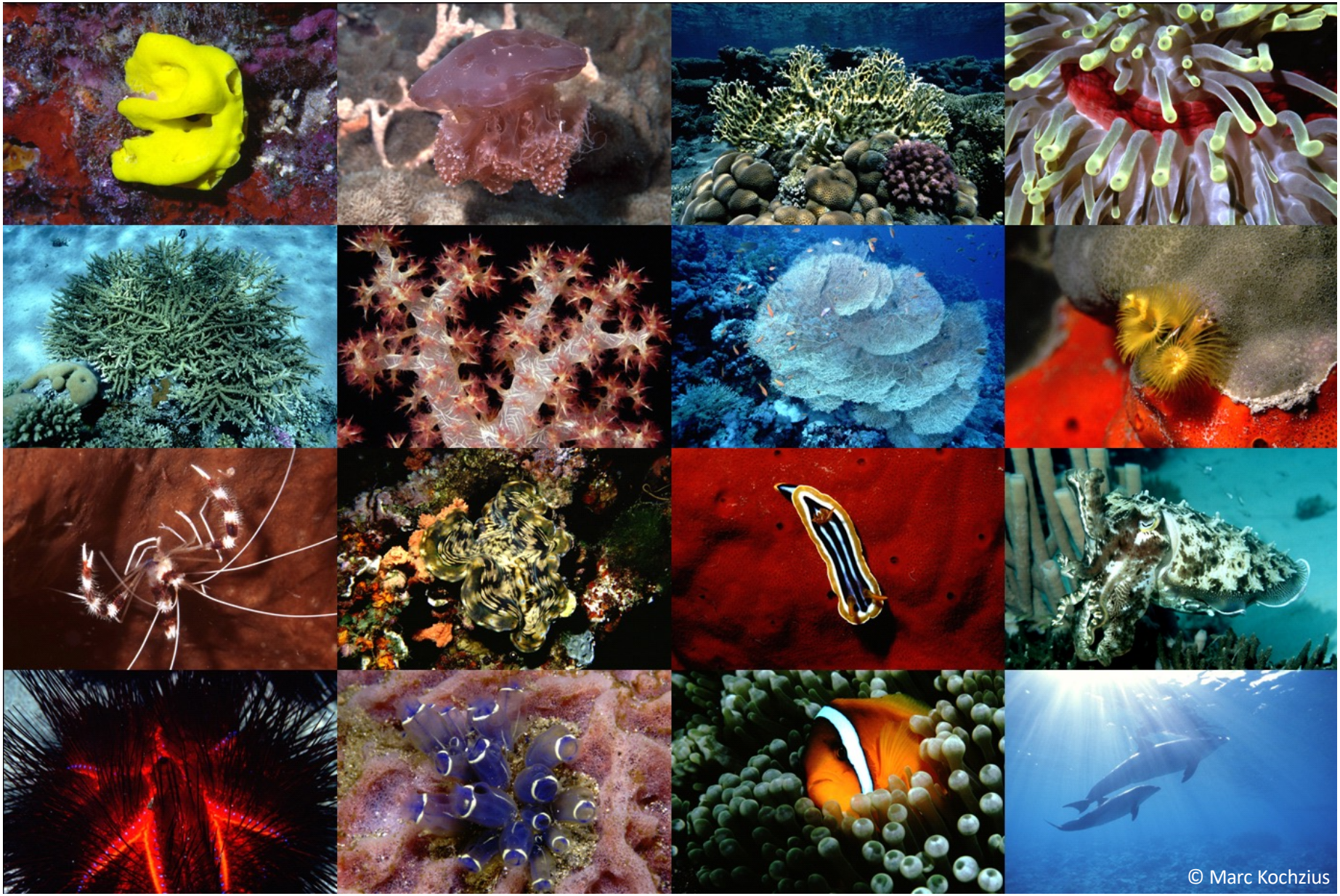
Marine Ecology/Fisheries



Mode Assessment

Theoretical part (70 %):

- Oral examination (presentation of a scientific publication and critical discussion)
- Language of the oral exam: English
- VUB students that are enrolled for the Dutch master programme can have the exam in Dutch
- ULB students can have their exam in French

Practical part (30 %):

- Reports of practicals

Communication

- Email: marc.kochzius@vub.be
- subject: Marine Biology or Fisheries, respectively
- text: first name and family name; university; master programme

Schedule of the course

Week ULB	Week VUB	Date	Time	Lecture	Lecturer	Location
4	3	05/10/2022	09:00-12:00	Oceanography, geology, history, and technology	MK	VUB, I.2.01
5	4	12/10/2022	09:00-12:00	Benthic biological processes	AVdP	ULB, UC2.236
6	5	18/10/2022	08:00-18:00	Excursion with Simon Stevin (ULB students)	MK + AVdP	Oostend
6	5	19/10/2022	08:00-18:00	Excursion with Simon Stevin (VUB students)	MK + AVdP	Oostend
7	6	26/10/2022	08:00-11:00	Analysis of data collected during the excursion	MK	VUB, E.1.4 + E.1.7.
8	7	02/11/2022		VUB is closed		
9	8	09/11/2022	09:00-12:00	Coral reef ecology	MK	VUB, I.2.01
10	9	16/11/2022	09:00-12:00	Pelagic biological processes	AVdP	ULB, UC2.236
11	10	23/11/2022	09:00-12:00	Practical	AVdP	ULB, UC2.236
12	11	30/11/2022	09:00-12:00	Connectivity of populations	MK	VUB, I.2.01
13	12	07/12/2022	09:00-12:00	Case study: Southern Ocean + global change in the ocean	AVdP	ULB, UC2.236
14	13	14/12/2022	09:00-12:00	Questions	AVdP+MK	ULB, UC2.236

- AVdP : Anton Van de Putte (ULB); anton.van.de.putte@ulb.be
- MK : Marc Kochzius (VUB); marc.kochzius@vub.be; ☎ 02 629 3406; office: F8.12
- Slides for AVdP lectures will be provided by AVdP
- Slides of MK lectures are available at Canvas and the following DropBox: https://www.dropbox.com/sh/f4w3szq565vjlex/AAAI5a3SLkR0JEnLCmxQ9LIAa?dl=0
- Students of the course “Fisheries” only attend lectures, excursion and practical will be in the 2nd semester
- Attendance to practicals and excursion is mandatory for the course “Marine Biology”

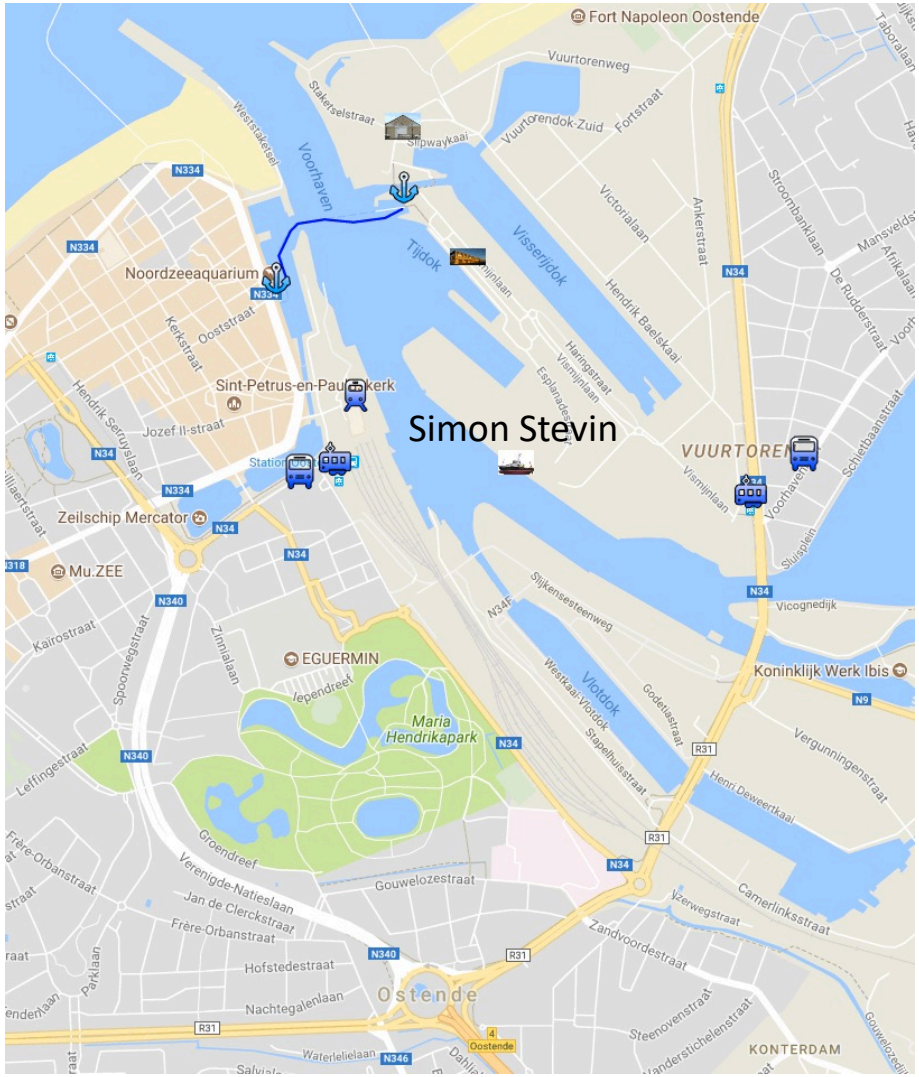
Simon Stevin excursion

Simon Stevin (2012)

Overall length: 36.0 m; overall width: 9.0 m; cruising speed: 12 knots (22 km/h)

Simon Stevin excursion

- ULB students: 18.10.2022
- VUB students: 19.10.2022
- Fisheries course: 11.-12. May 2023
- Departure of RV Simon Stevin: 9:00/13:00, port Oostende; for more information see www.vliz.be/en/how-reach-rv-simon-stevin
- Train from Brussels Midi to Oostende: IC 528/IC 532; departure: 07:08/11:04; arrival: 08:20/12:16
- Tram to stop “Weg naar Vismijn” or ferry boat
- Please bring rainwear (trousers, coat, and rubber boots) and something to eat and drink



Simon Stevin excursion

Van Ven grab for sediment samples

Simon Stevin excursion

Van Ven grab sample

Simon Stevin excursion

Corer sample: Sand mason worm (*Lanice conchilega*)

Simon Stevin excursion

Beam trawl

Simon Stevin excursion

Beam trawl catch

Simon Stevin excursion

Beam trawl catch: small-spotted catshark (*Scyliorhinus canicula*)

Simon Stevin excursion

Beam trawl catch

Simon Stevin excursion

Beam trawl catch

Simon Stevin excursion

Brittle star (Ophiuridae)

Simon Stevin excursion

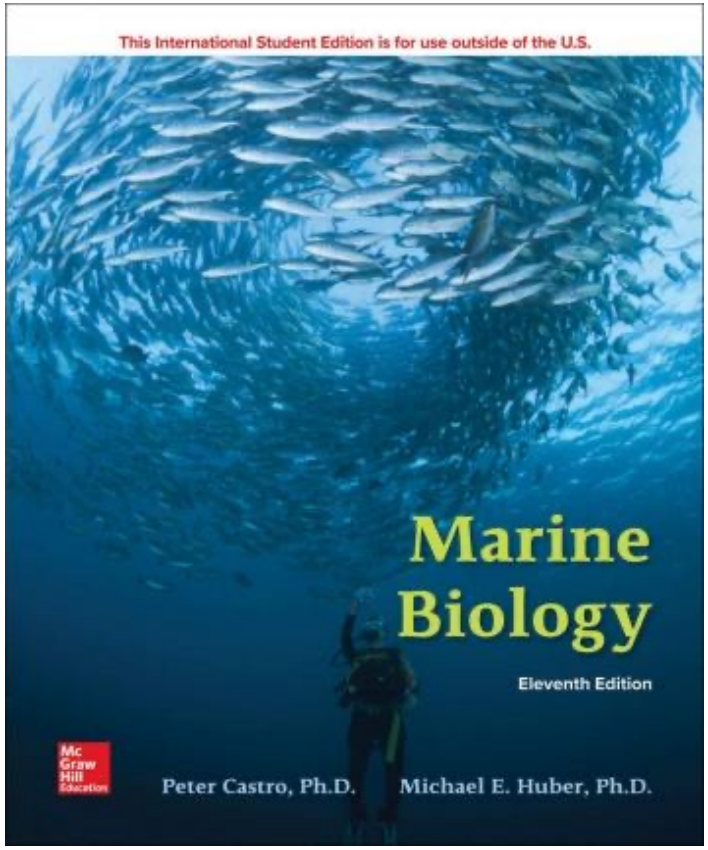
Crab

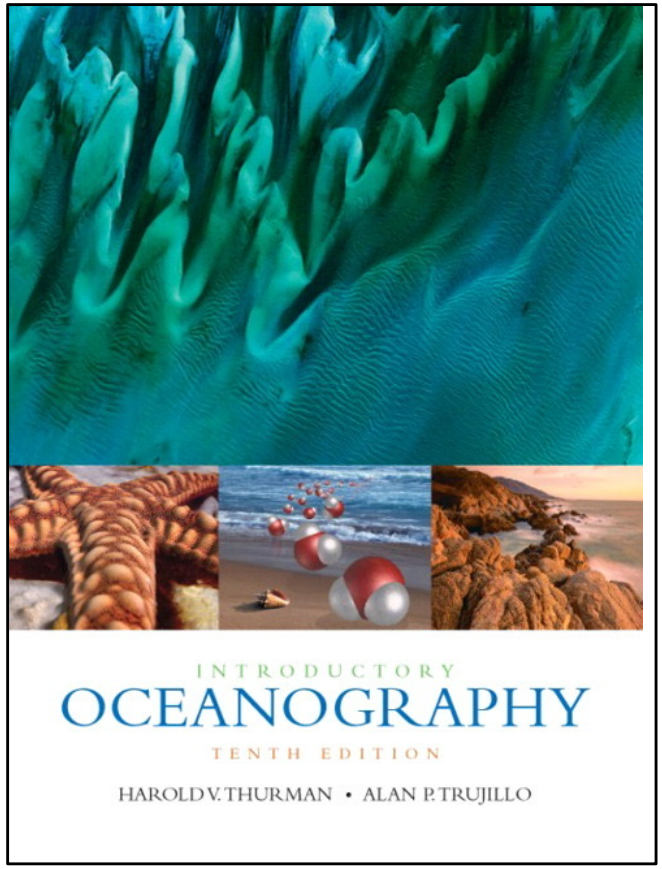
Simon Stevin excursion

Sea mouse (*Aphrodite aculeata*; Polychaeta)

Literature

- Castro & Huber (2019) Marine Biology
- Thurman & Trujillo (2004) Introductory Oceanography
- Copies in the VUB library



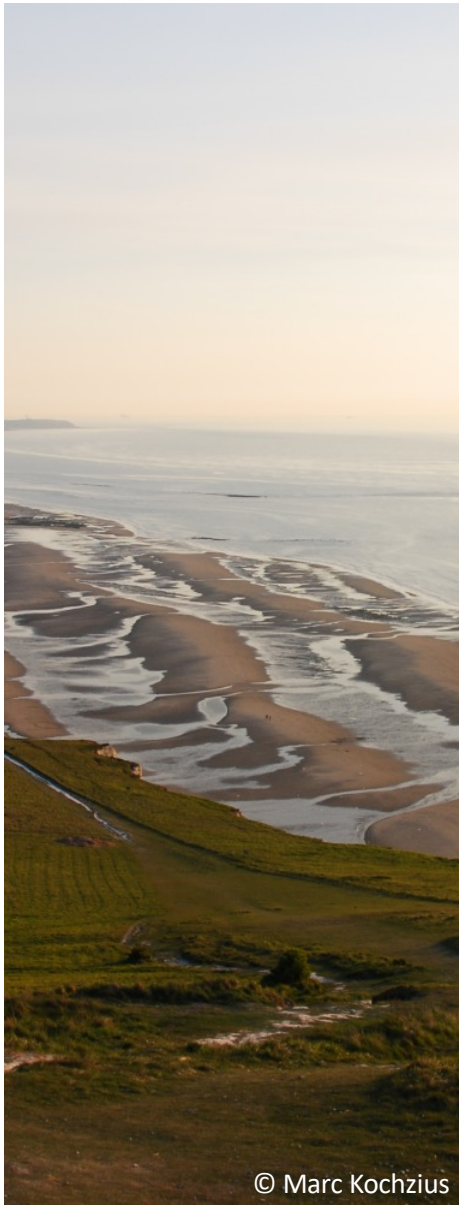


Marine research

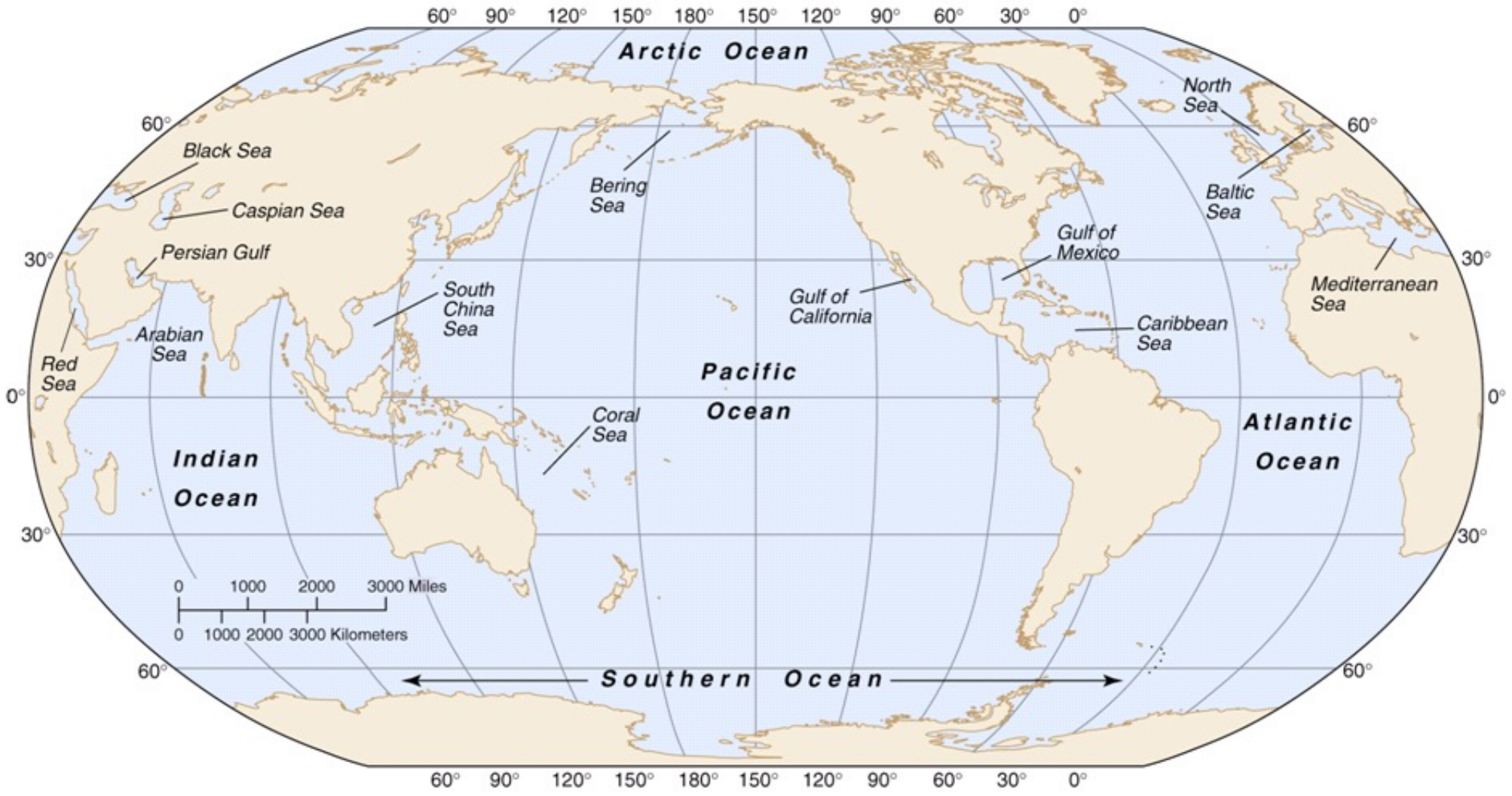
- **Marine biology = biological oceanography**:
  scientific study of organisms that live in the sea
  - Marine biology: organisms close to shore or perspective of the organisms
  - Biological oceanography: organisms of the open ocean or perspective of the ocean

- **Oceanography** (should be rather named *Oceanology*)
  - Biological oceanography (marine biology)
  - Geological oceanography
  - Physical oceanography
  - Chemical oceanography

- Marine research is **interdisciplinary**



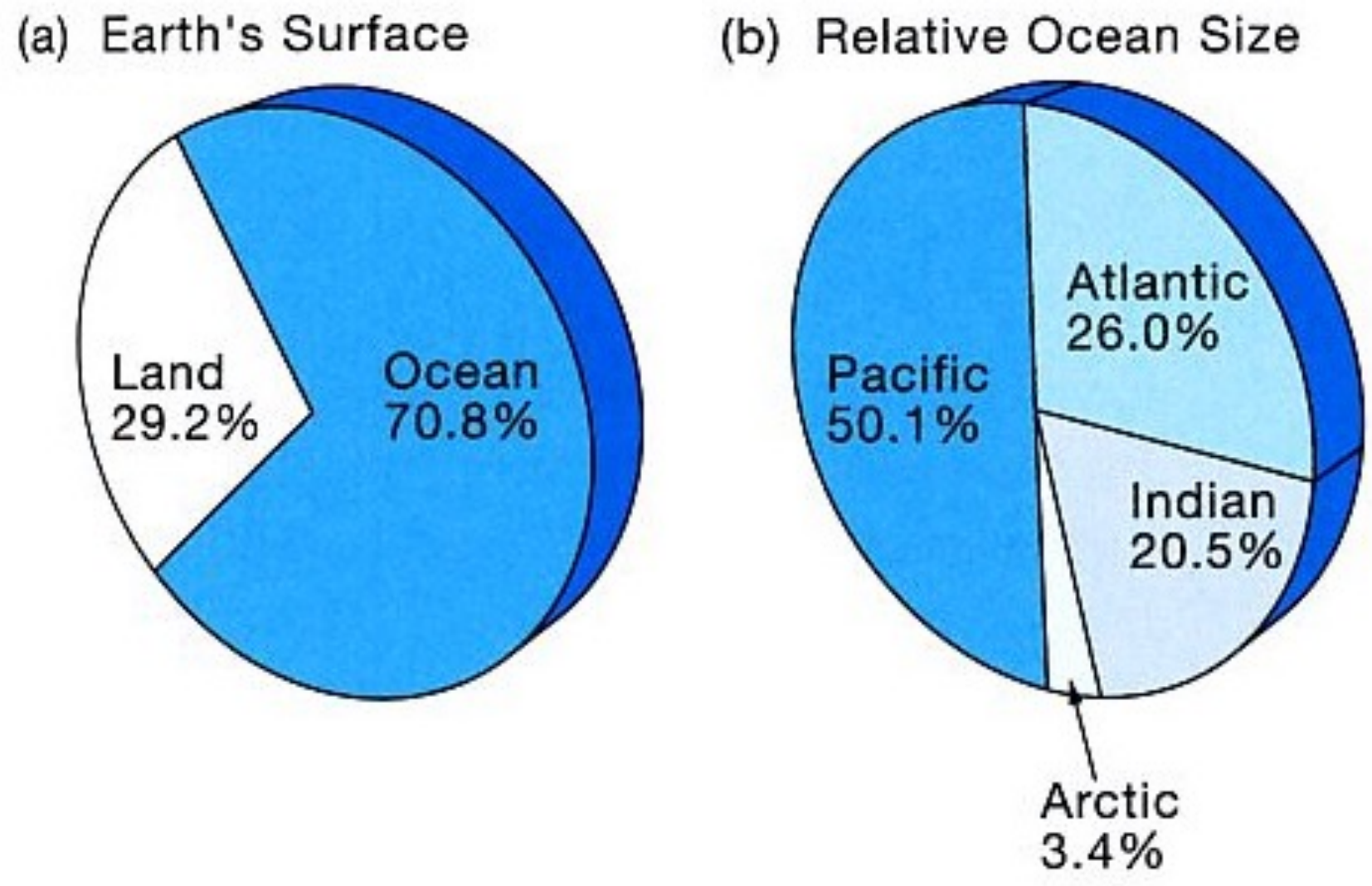
The World Ocean



(Castro & Huber 2010)

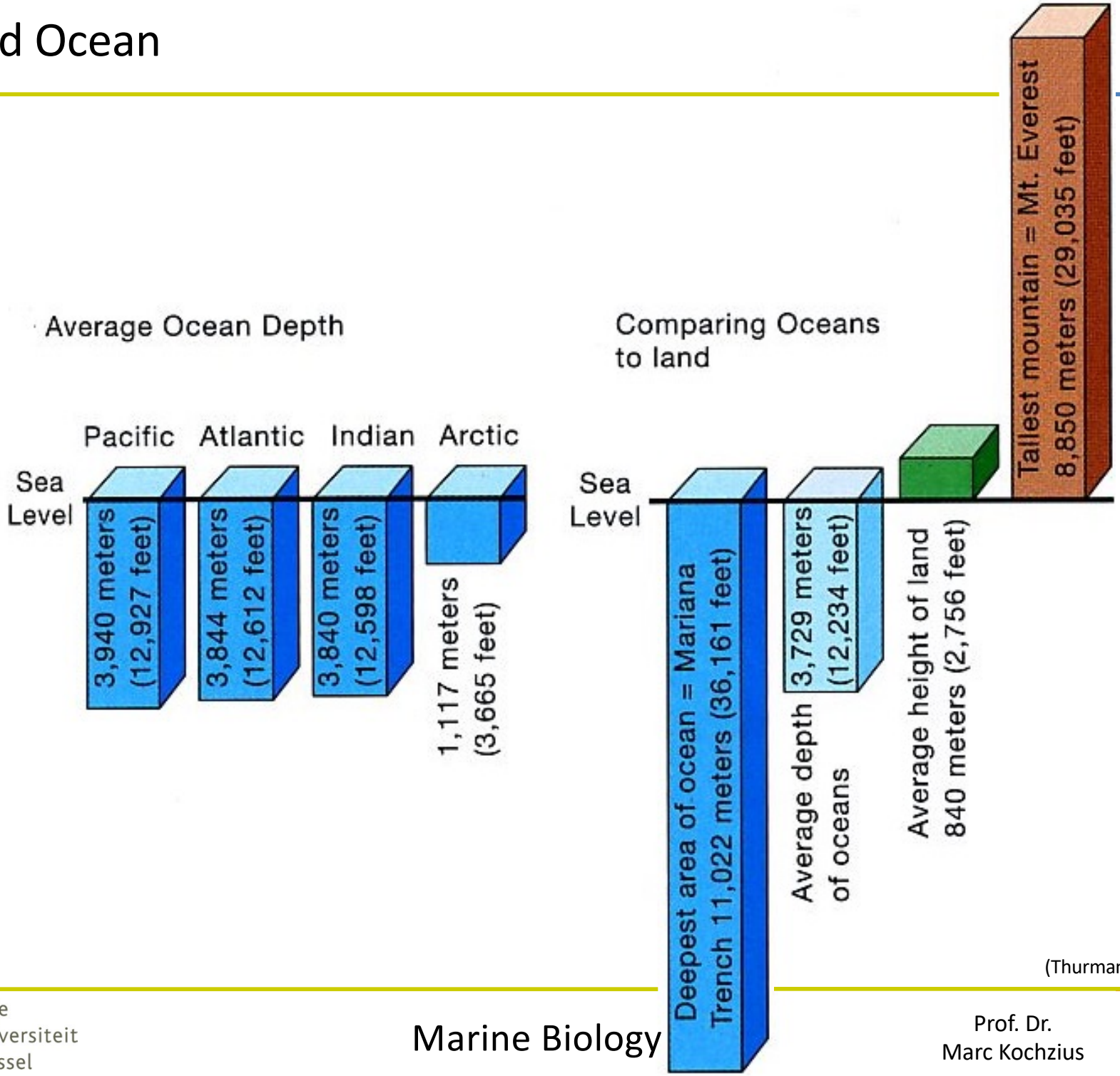
4 major ocean basins + Southern or Antarctic Ocean

The World Ocean



(Thurman &Trujillo 2004)

The World Ocean



(Thurman &Trujillo 2004)

The World Ocean

(Castro & Huber 2010)

Major ocean basins are extensions of the interconnected world ocean

Marine research: history

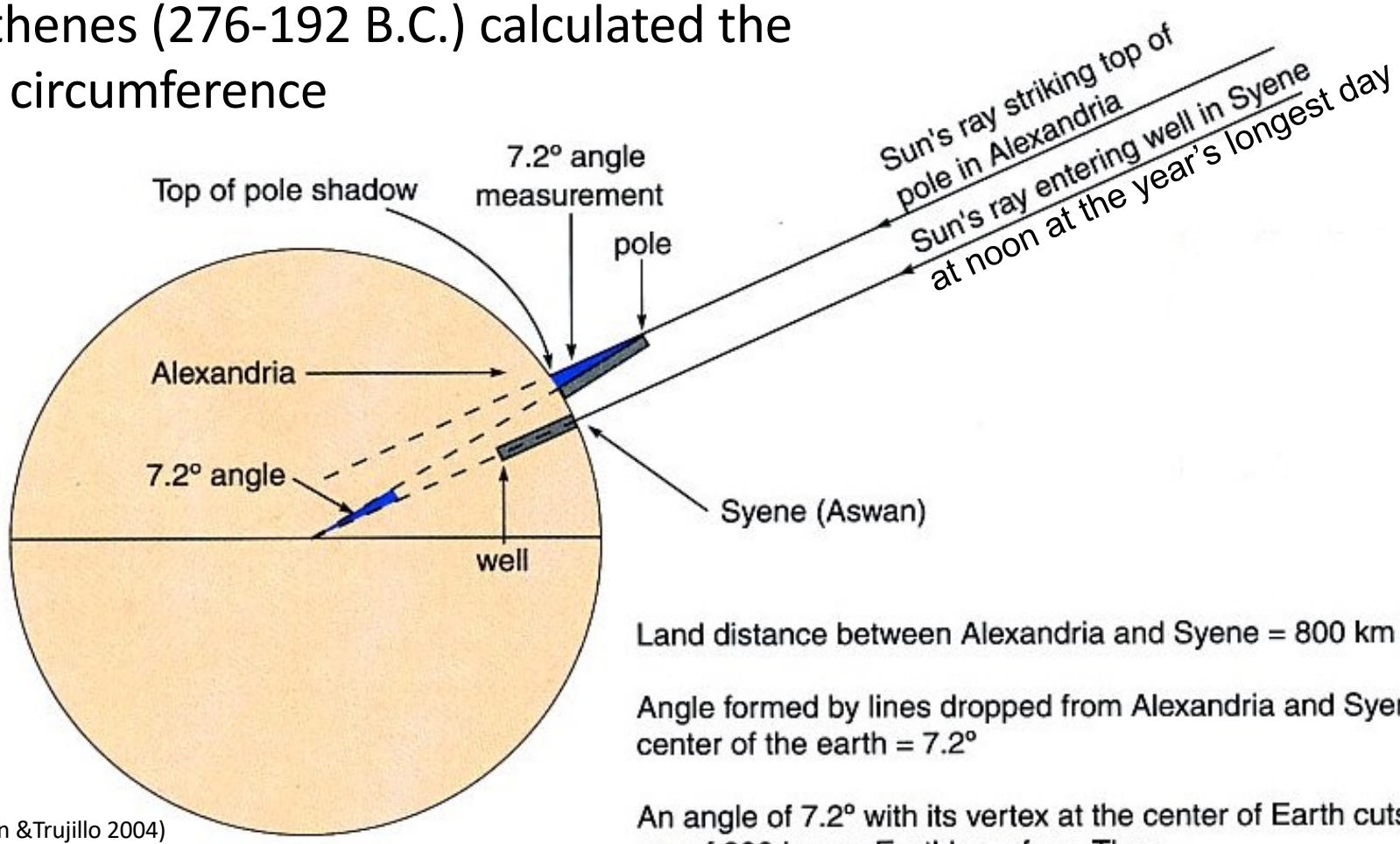
- **Phoenicians**:
  - Mediterranean Sea
  - Red Sea
  - Indian Ocean
  - British Isles

  } 2000 B.C.
  - Circumnavigation of Africa: 590 B.C.

- **Greeks**:
  - Herodotus: map of the known world in 450 B.C.
  - Aristotle (384-322 B.C.) 1st marine biologist: description of marine life; gills of fish are breathing apparatus
  - Pytheas (geographer) sailed to northern Atlantic around 325 B.C.
  - Eratosthenes (276-192 B.C.) calculated the Earth's circumference: 40,000 km
- **Romans**:
  - Claudius Ptolemy: map of the known world in 150 A.D.

Marine research: history

Eratosthenes (276-192 B.C.) calculated the Earth's circumference



(Thurman &Trujillo 2004)

Land distance between Alexandria and Syene = 800 km (500 mi)

Angle formed by lines dropped from Alexandria and Syene to center of the earth = 7.2°

An angle of 7.2° with its vertex at the center of Earth cuts an arc of 800 km on Earth's surface. Thus:

$$\frac{7.2^\circ}{800 \text{ km (500 mi)}} = \frac{360^\circ}{\text{Circumference of Earth}}$$

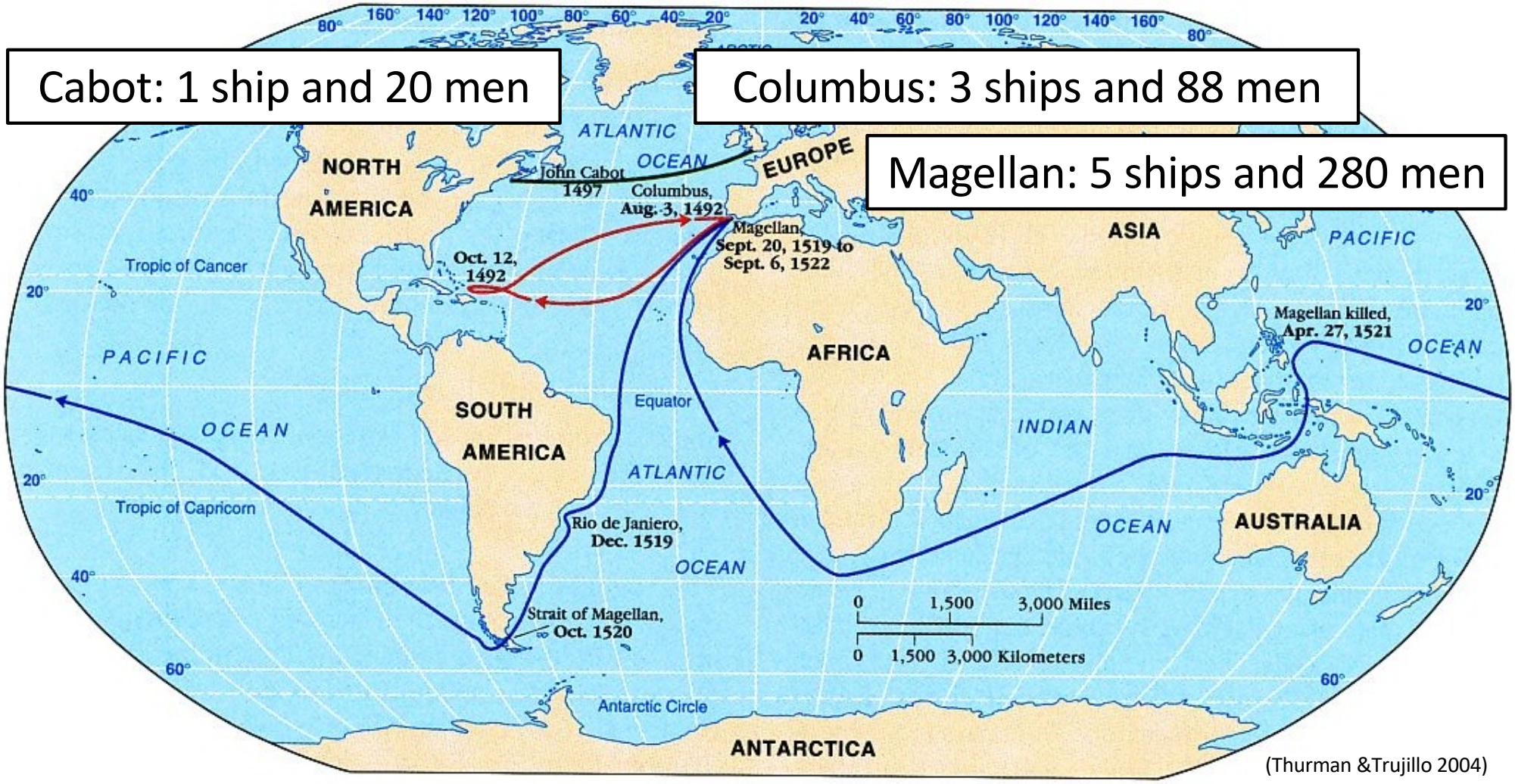
Circumference of Earth = 40,000 km (24,855 mi)
Value known today = 40,032 km (24,875 mi)

Marine research: history

(Thurman &Trujillo 2004)

Statue of Leif Eriksson in Reykjavik (Island)

Marine research: history



(Thurman &Trujillo 2004)

European age of discoveries (1492-1522)

Marine research: history

7 voyages from 1405-1433 with up to 317 ships and 37,000 men

Marine research: history

Cook killed in 1779 in Hawaii

(Thurman &Trujillo 2004)

One of the first scientific explorations:

- Cartography
- Natural history
- Measurements of water temperature, currents, wind, and depth

Marine research: history

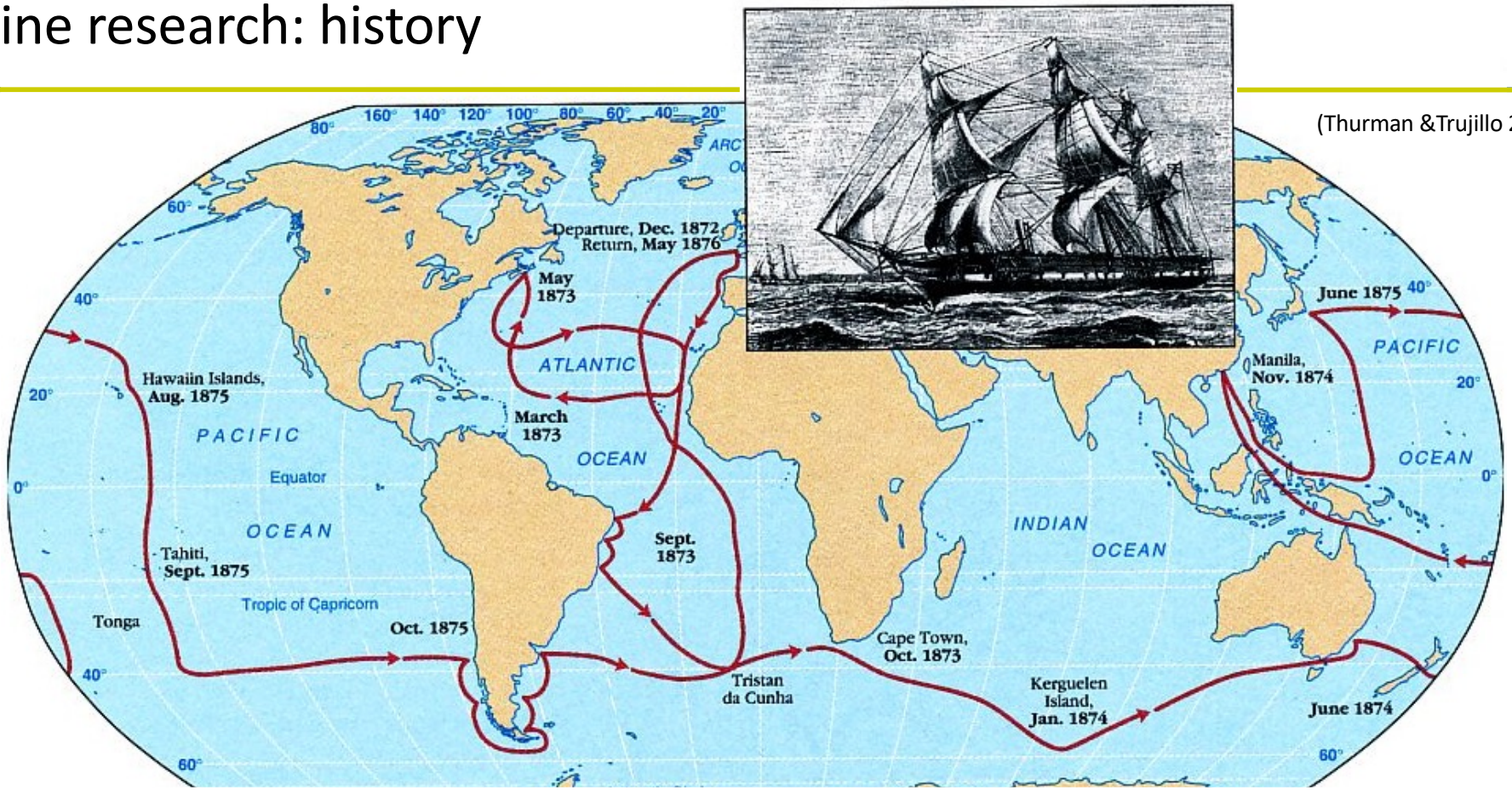
www.npg.si.edu/exh/brush/bigben.htm

Fig. 173.—FRANKLIN'S CHART OF THE GULF STREAM.

http://celebrating200years.noaa.gov/magazine/charleston_bump/franklin_mapgulfstream.html

Benjamin Franklin's chart of the Gulf Stream (1769)

Marine research: history



(Thurman &Trujillo 2004)

First oceanographic expedition (1872-1876): *HMS Challenger*

- 127,500-km voyage
- 492 deep-sea soundings
- Deepest sounding: 8183 m
- 133 bottom dredges
- 151 open water trawls
- 263 water temperature measurements
- Water samples from 1830 m depth
- 4717 new species

Marine research: history

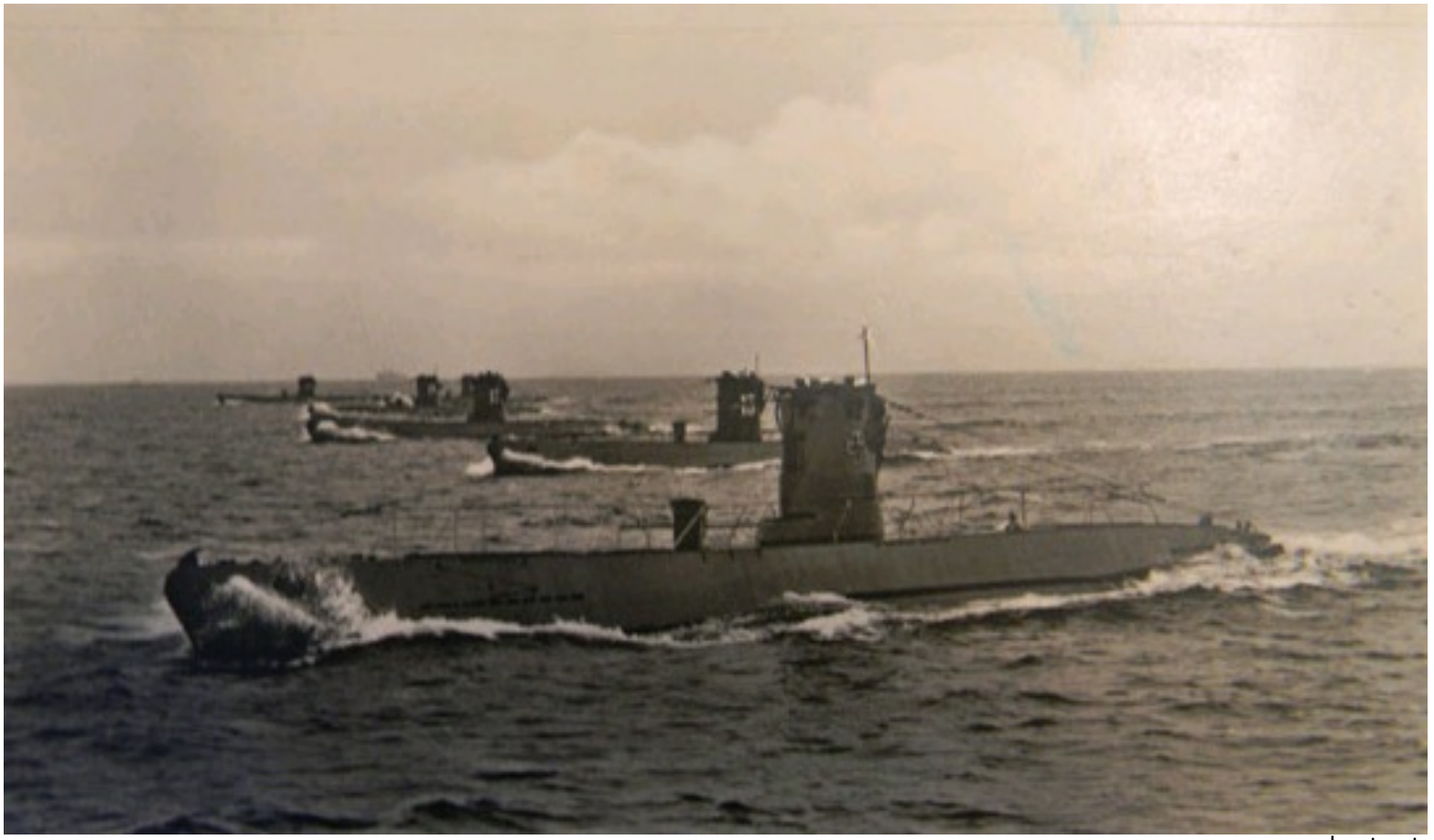
First scientific expedition to Antarctica (1897-1899): *Belgica*

- First overwintering in Antarctica
- Ice-drift for 12 month from March 1898 to March 1899: 3,600 km

Adrien de Gerlache (Belgium)

Roald Amundsen (Norway)

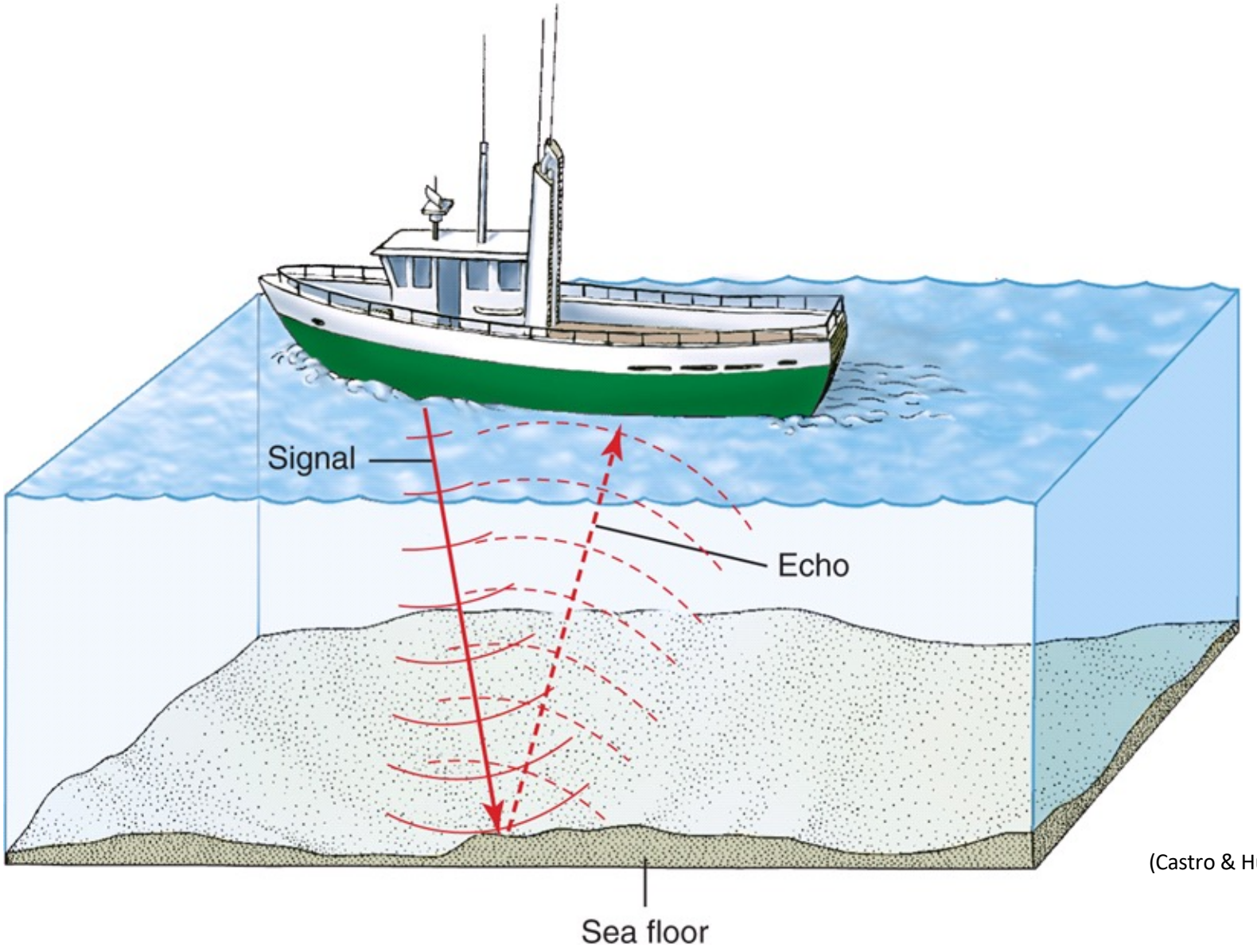
Marine research: history



www.uboat.net

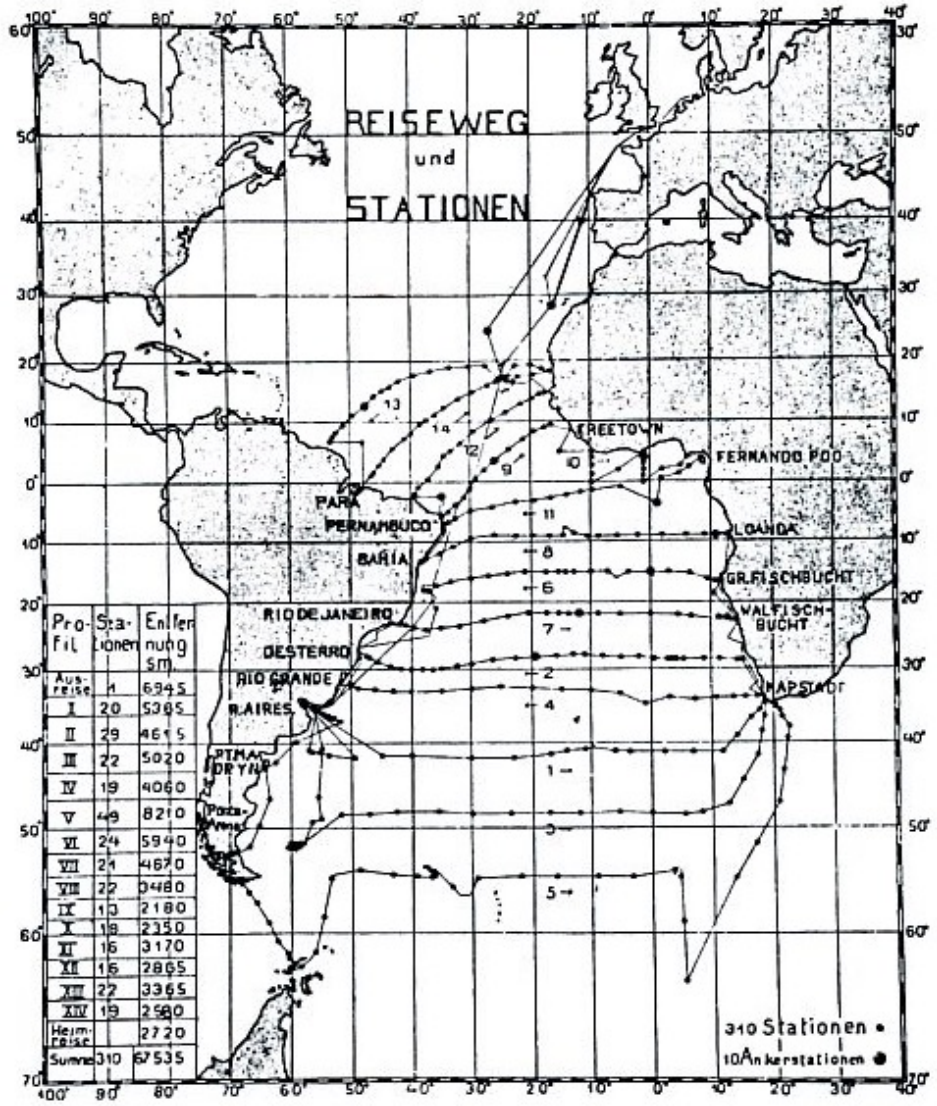
- German development of U-boat submarines in World War I
- Invention of echo sounder (**sonar**: **so**und **n**avigation **a**nd **r**anging)

Marine research: history



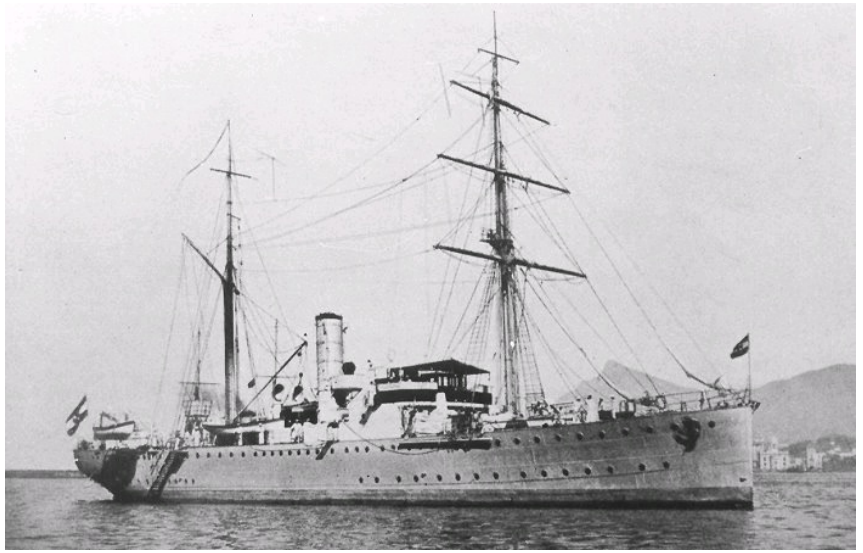
(Castro & Huber 2010)

Marine research: history



Pro-Fil	Sta-tionen	Entfernung sm
Ausreise	1	6945
I	20	5305
II	29	4615
III	22	5020
IV	19	4060
V	49	8210
VI	24	5940
VII	21	4670
VIII	22	5480
IX	10	2180
X	18	2350
XI	16	3170
XII	16	2805
XIII	22	3365
XIV	19	2580
Heim-reise		2720
Summe	310	67535

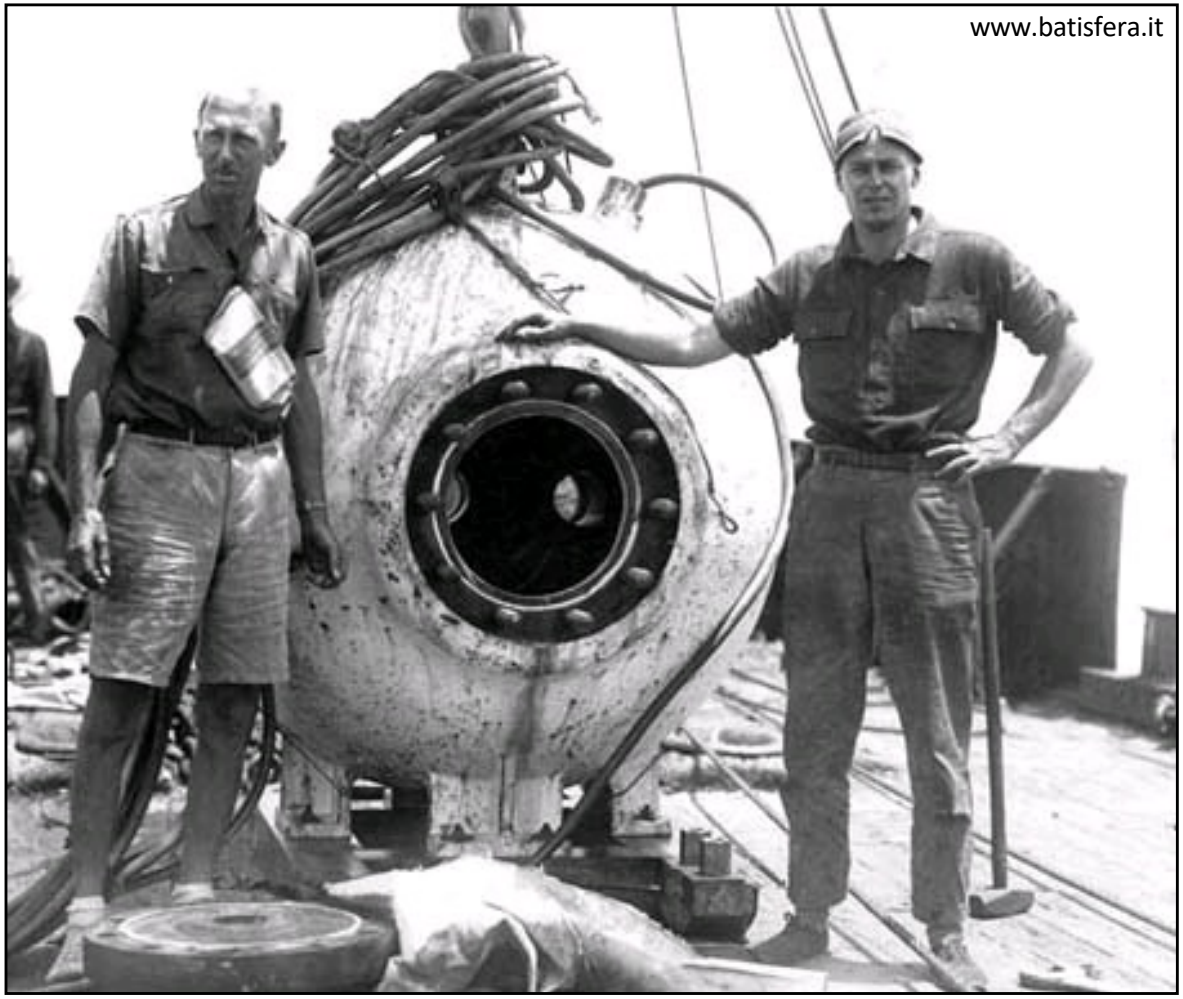
(Thurman &Trujillo 2004)



Meteor expedition (1925-1927):

- Multidisciplinary study on topography, currents, and chemistry of the South Atlantic
- 2 sonars for echo sounding
- 25 month voyage
- 310 sampling stations

Marine research: history

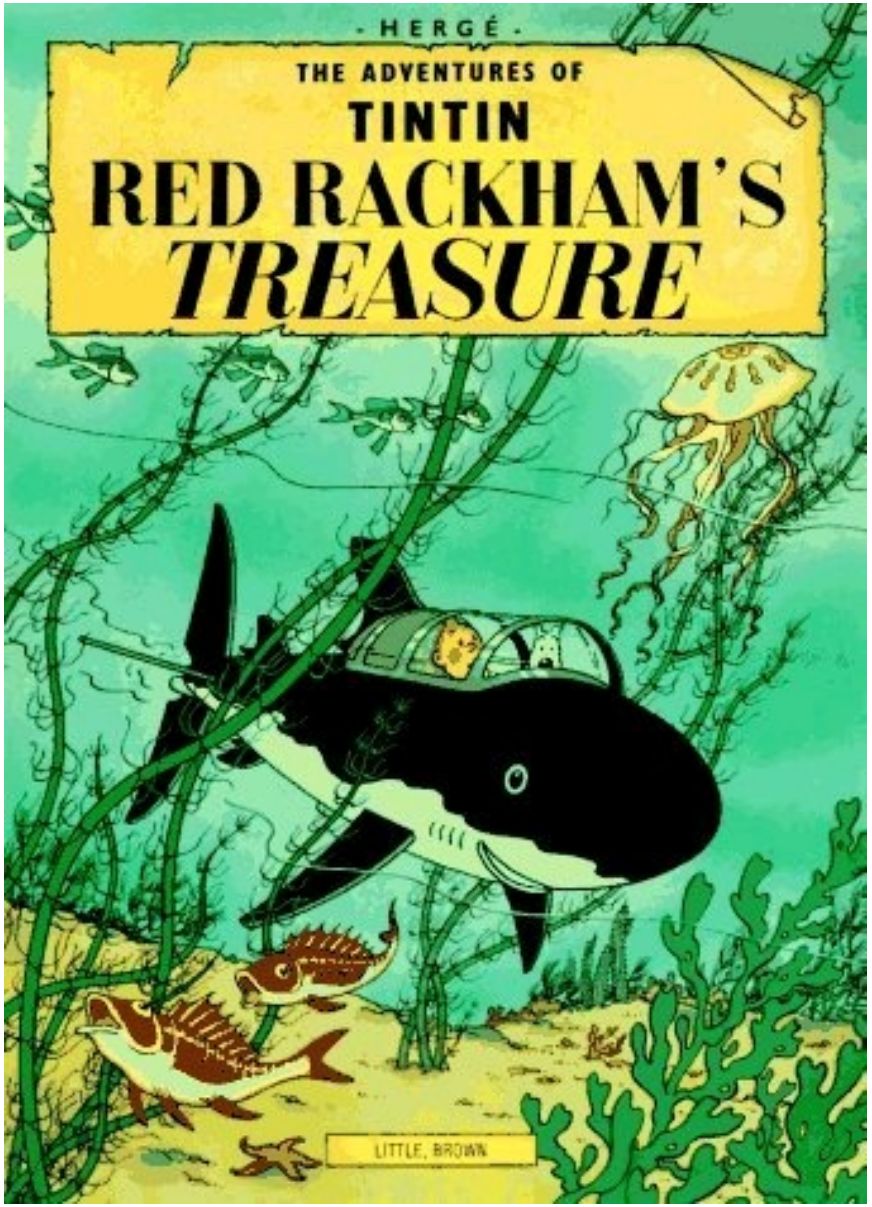


William Beebe (left) and Otis Barton dive to 923 m off Bermuda in 1934 with the submersible *Bathysphere*

Marine research: history

(Hergé 1944)

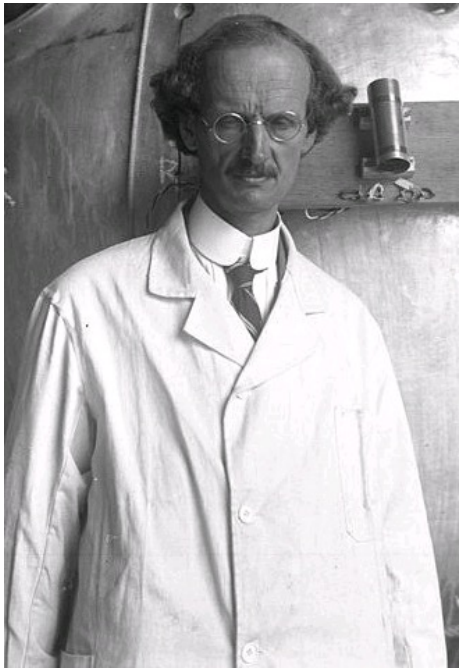
Prof. Tournesol (French)
Prof. Calculus (English)
Prof. Bienlein (German)



Marine research: history

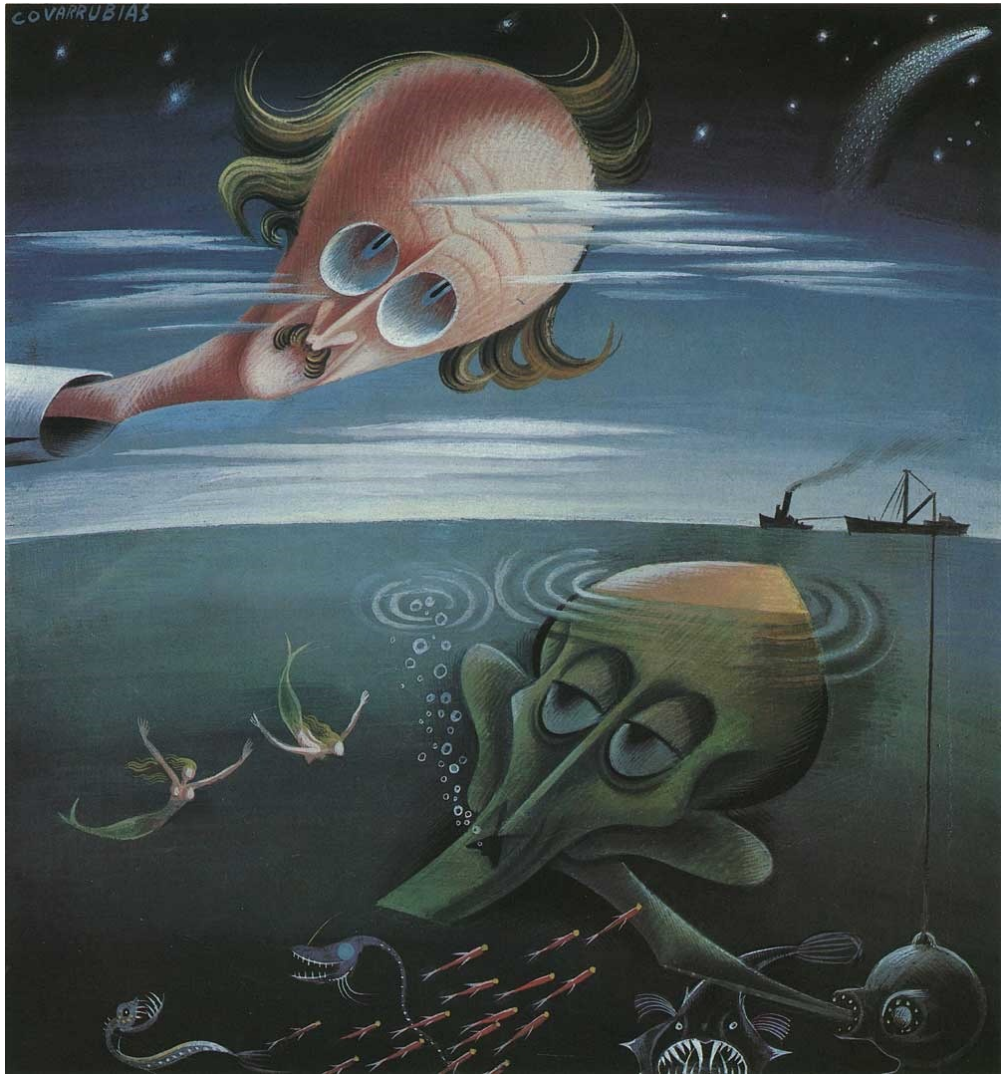
Auguste Piccard (1884-1962):

- Professor for physics at ULB in 1922
- 1930's: balloon-flights up to 23,000 m (world record)
- 1953: dive with submersible *Trieste* to 3,150m (world record)



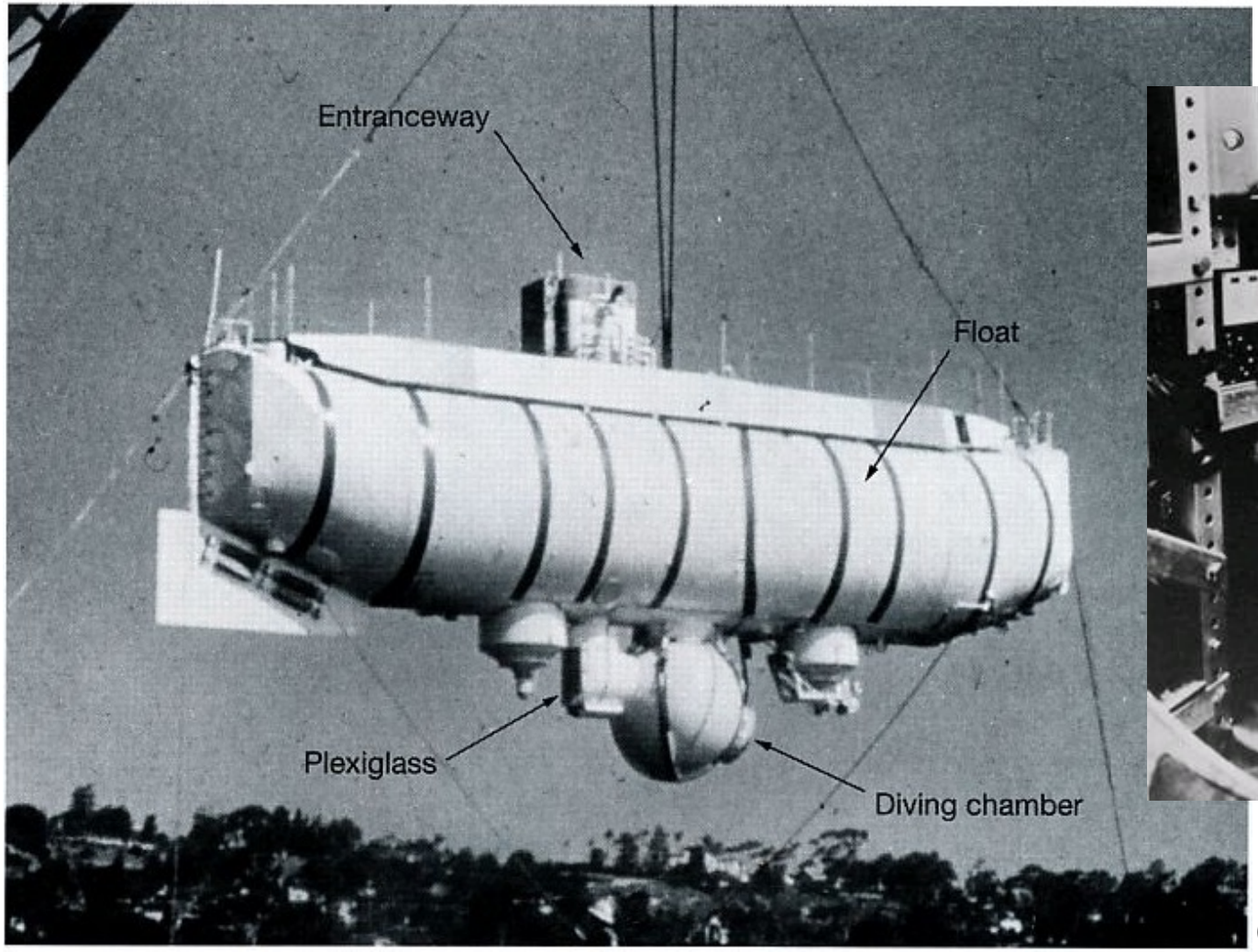
Auguste Piccard 1932

Prof. Calcullus (Hergé)



Caricature by Miguel Covarrubias, *Vanity Fair,* April 1935

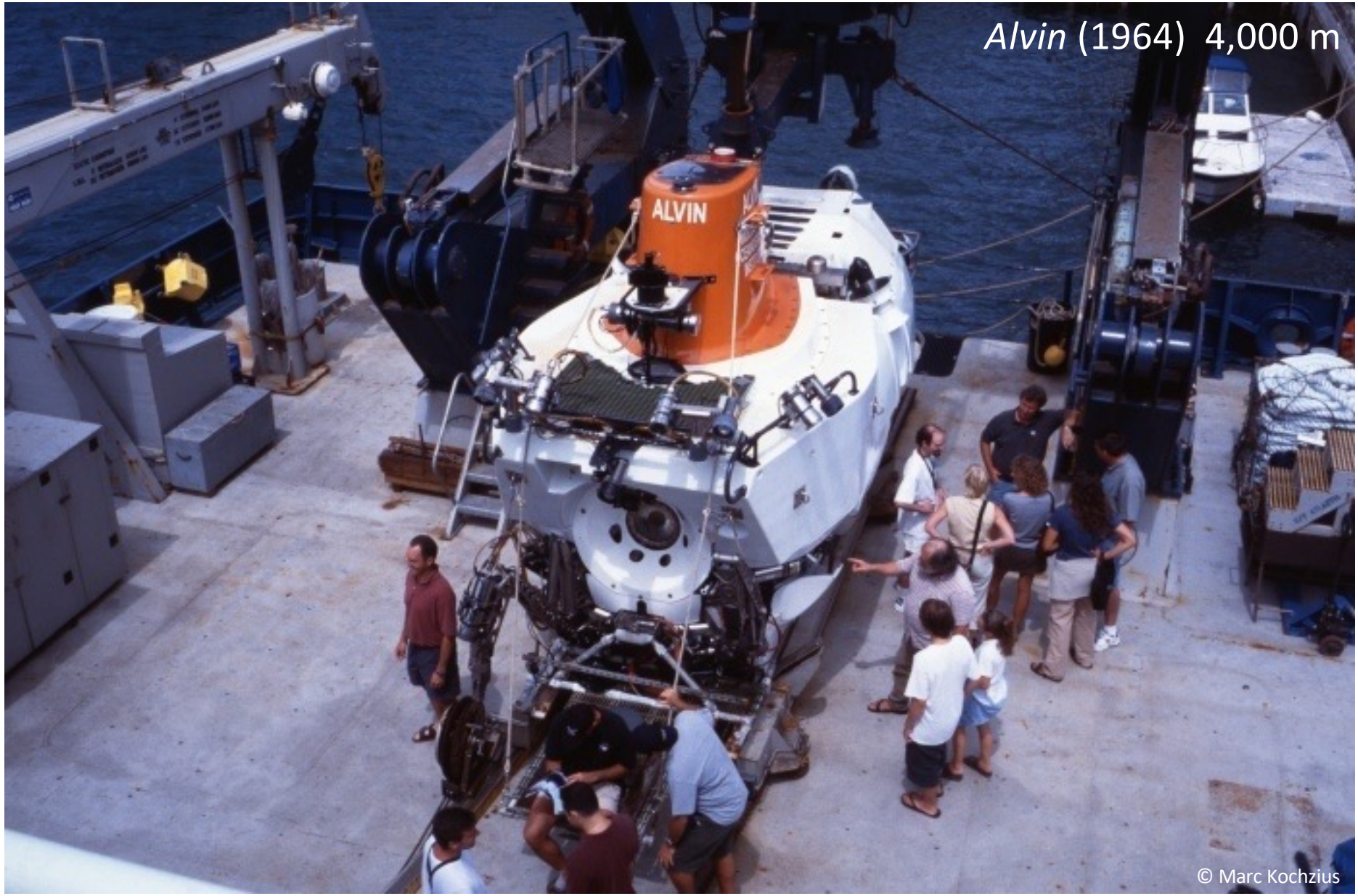
Marine research: history



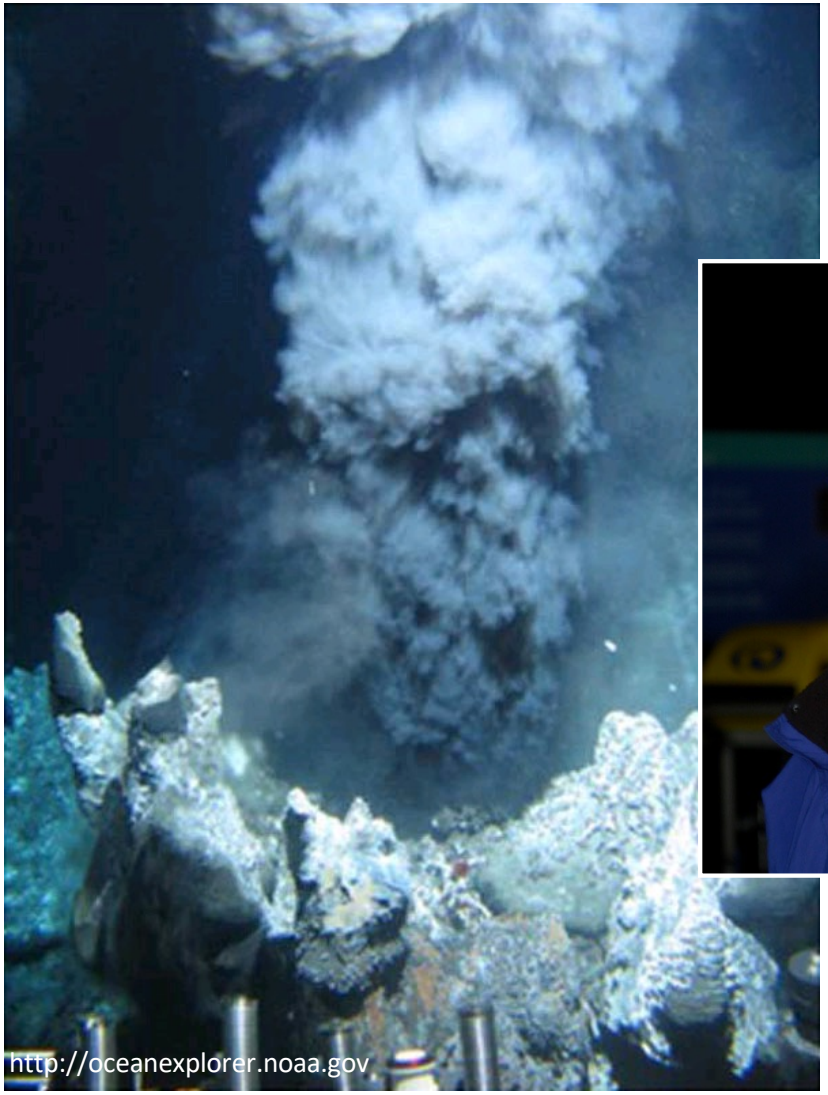
(Thurman &Trujillo 2004)

Jacques Piccard (right; son of Auguste Piccard) and Don Walsh (US Navy) dive to 10,912 m in the Challenger Deep, Mariana Trench in 1960

Marine research: modern technology



Marine research: modern technology



Discovery of black smokers (1977) and RMS *Titanic* (1985) by R. Ballard

Marine research: modern technology

Aqualung was developed by Emil Gagnan (right) and Jacques-Yves Cousteau in 1943

http://g-ecx.images-amazon.com

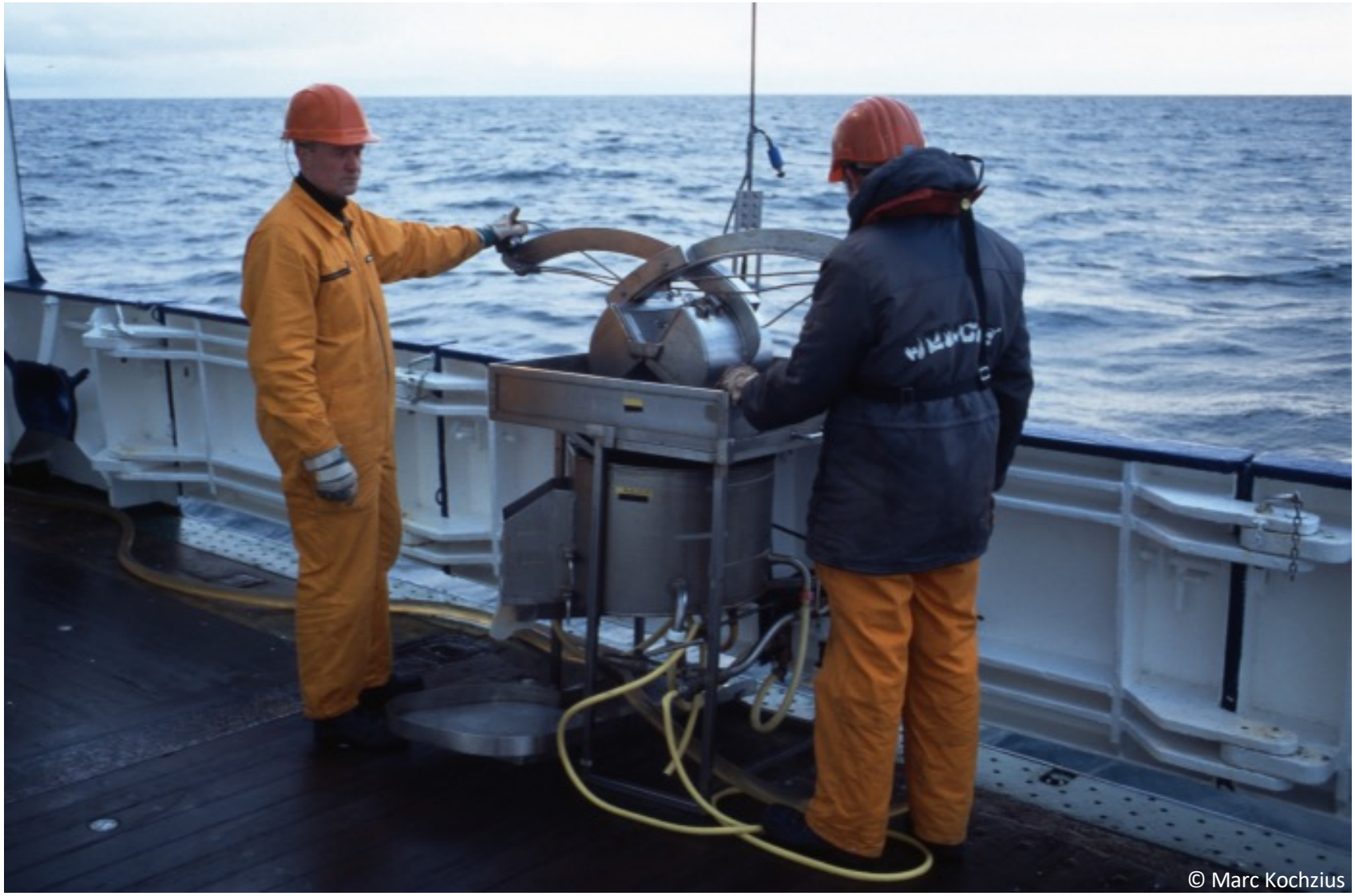
Marine research: modern technology

SCUBA (**S**elf **C**ontained **U**nderwater **B**reathing **A**pparatus)

Marine research: modern technology

Heincke (1990): Overall length: 54.5 m; overall width: 12.5 m
Cruising speed: 12.5 knots (23 km/h)

Marine research: modern technology

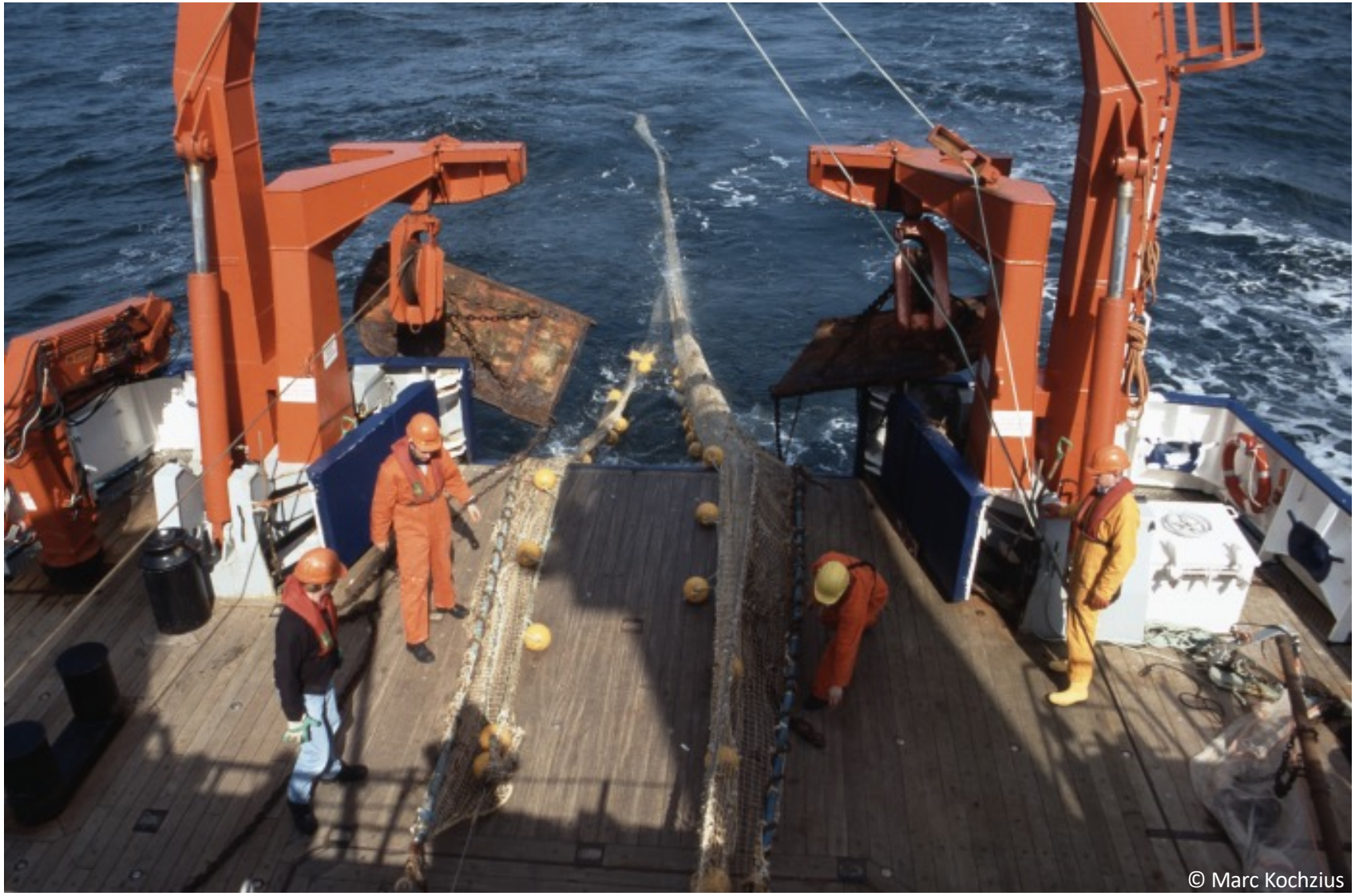


Van Veen grab

Marine research: modern technology

Trawl net

Marine research: modern technology



Trawl net

Marine research: modern technology

Trawl net

Marine research: modern technology

Trawl net catch: Pleuronectidae (flatfishes) and *Clupea harengus* (herring)

Marine research: modern technology

Trawl net catch: identification, sorting, and measurement (length and weight)

Marine research: modern technology

Trawl net catch

Marine research: modern technology

Trawl net catch: Pleuronectidae (flatfishes), *Clupea harengus* (herring), Triglidae (Gurnards), and *Asterias rubens* (starfish)

Marine research: modern technology

Trawl net catch: *Callionymus lyra* (Dragonnet lyre)

Marine research: modern technology

Trawl net catch: *Gadus morhua* (Atlantic cod)

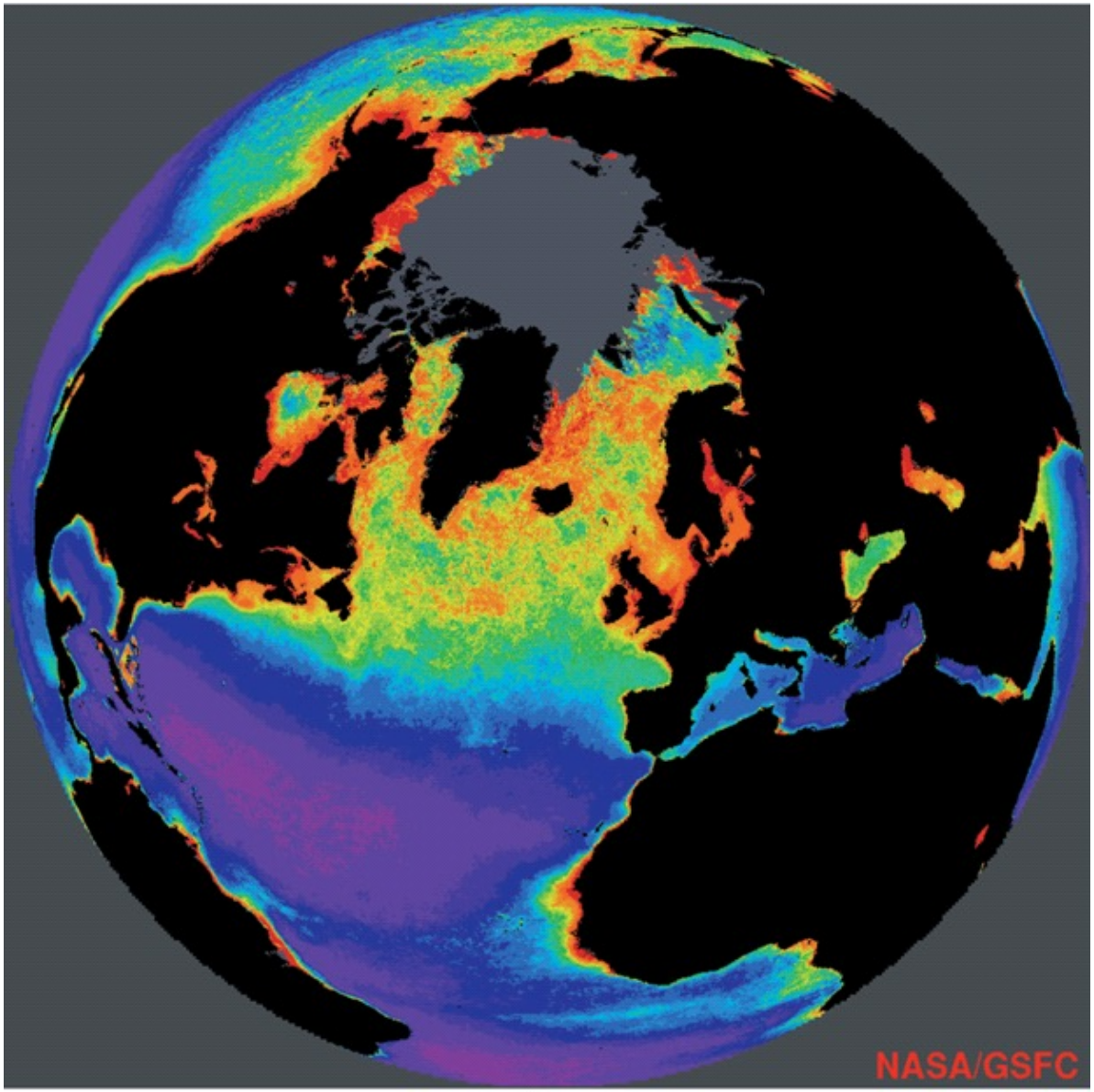
Marine research: modern technology

Beam trawl

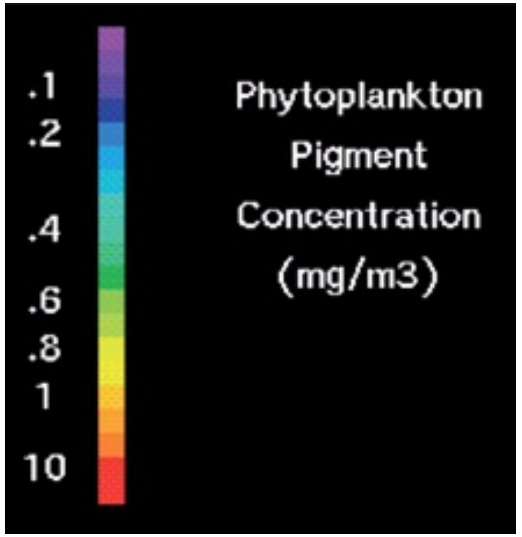
Marine research: modern technology

Bongo Net (Plankton)

Marine research: modern technology

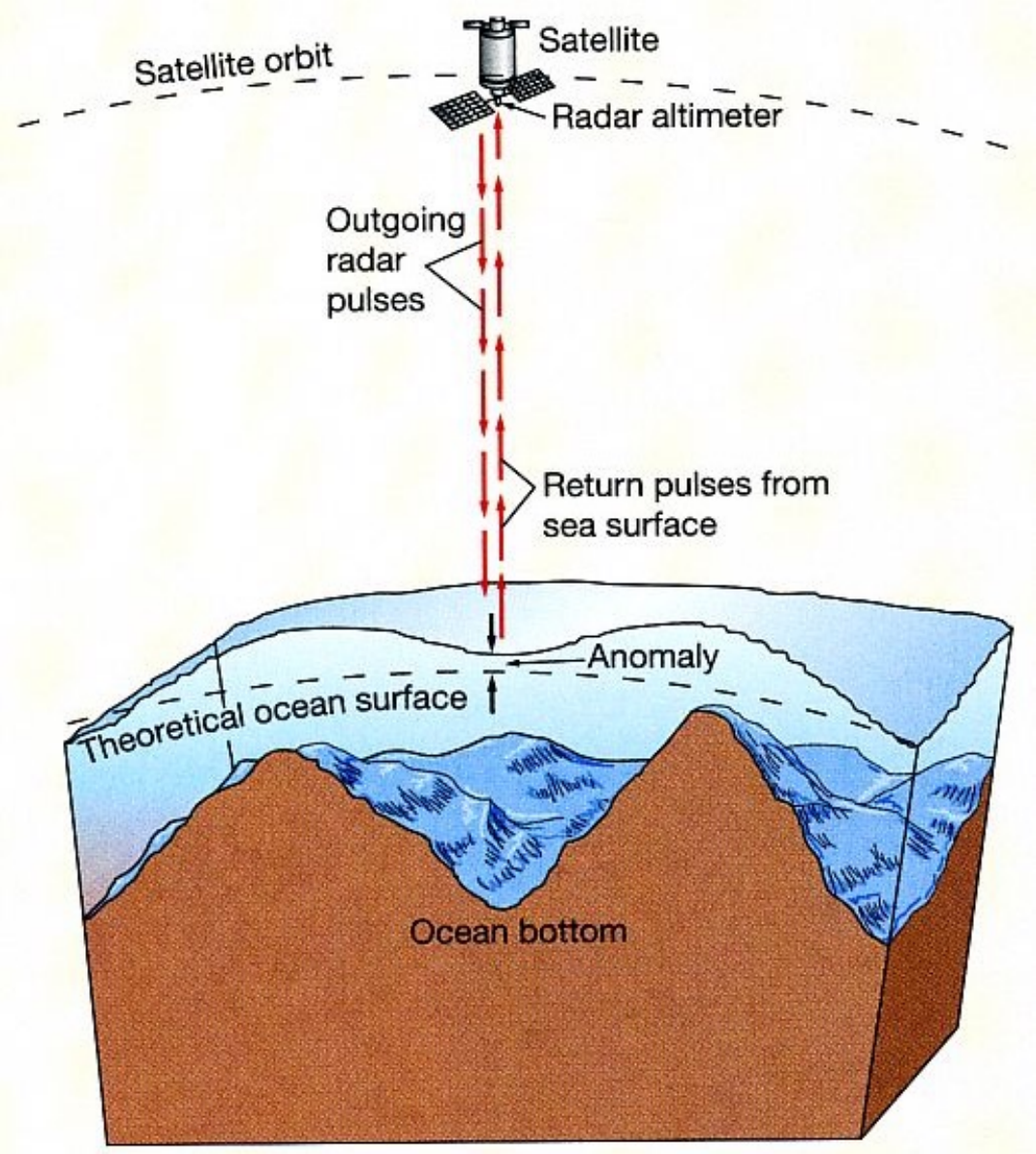


Coastal Zone Colour Scanner (CZCS) on the *Nimbus-7* satellite



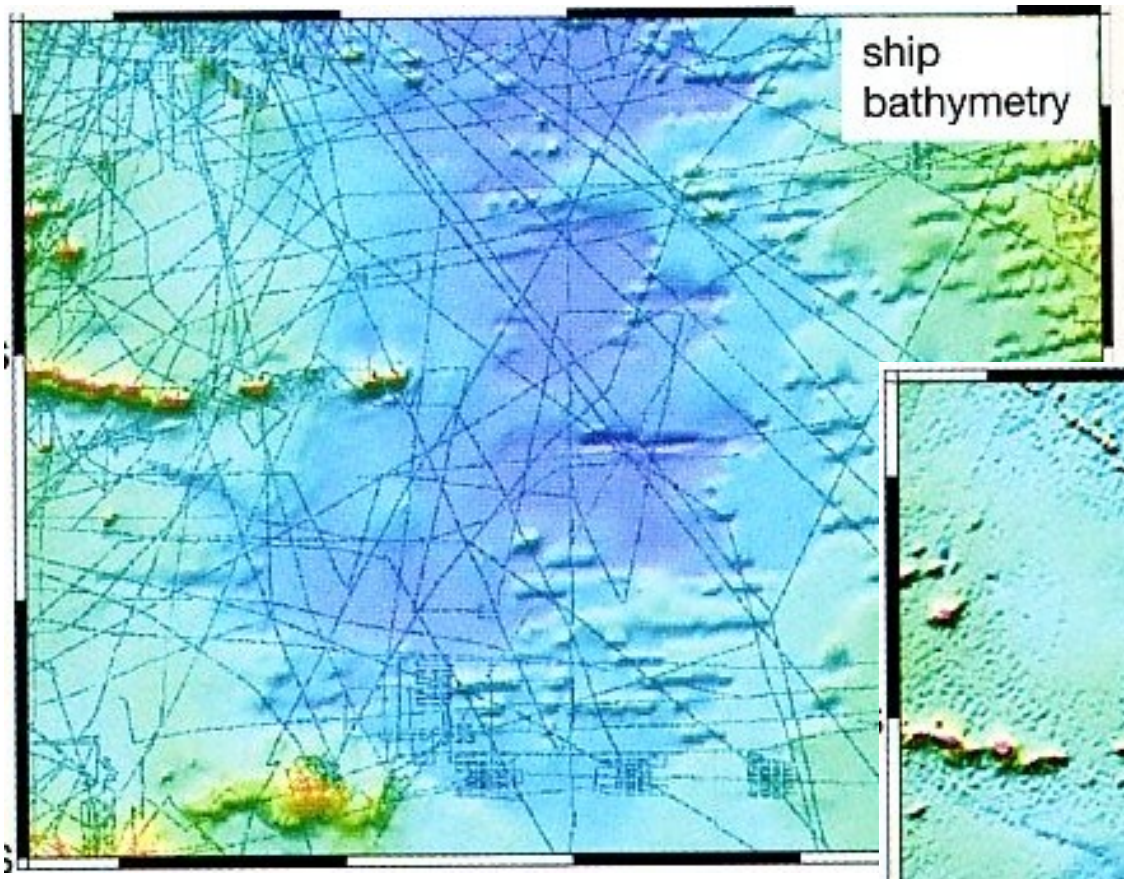
(Castro & Huber 2010)

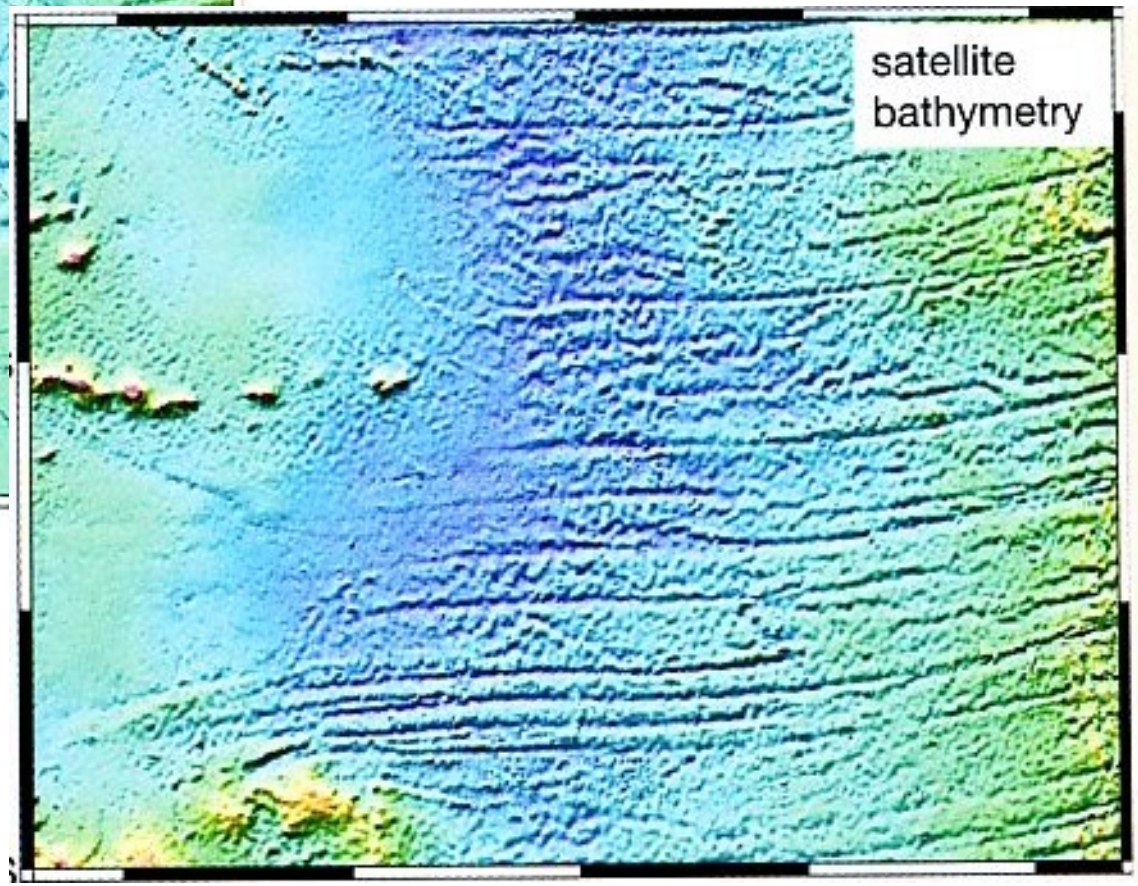
Marine research: modern technology



(Thurman &Trujillo 2004)

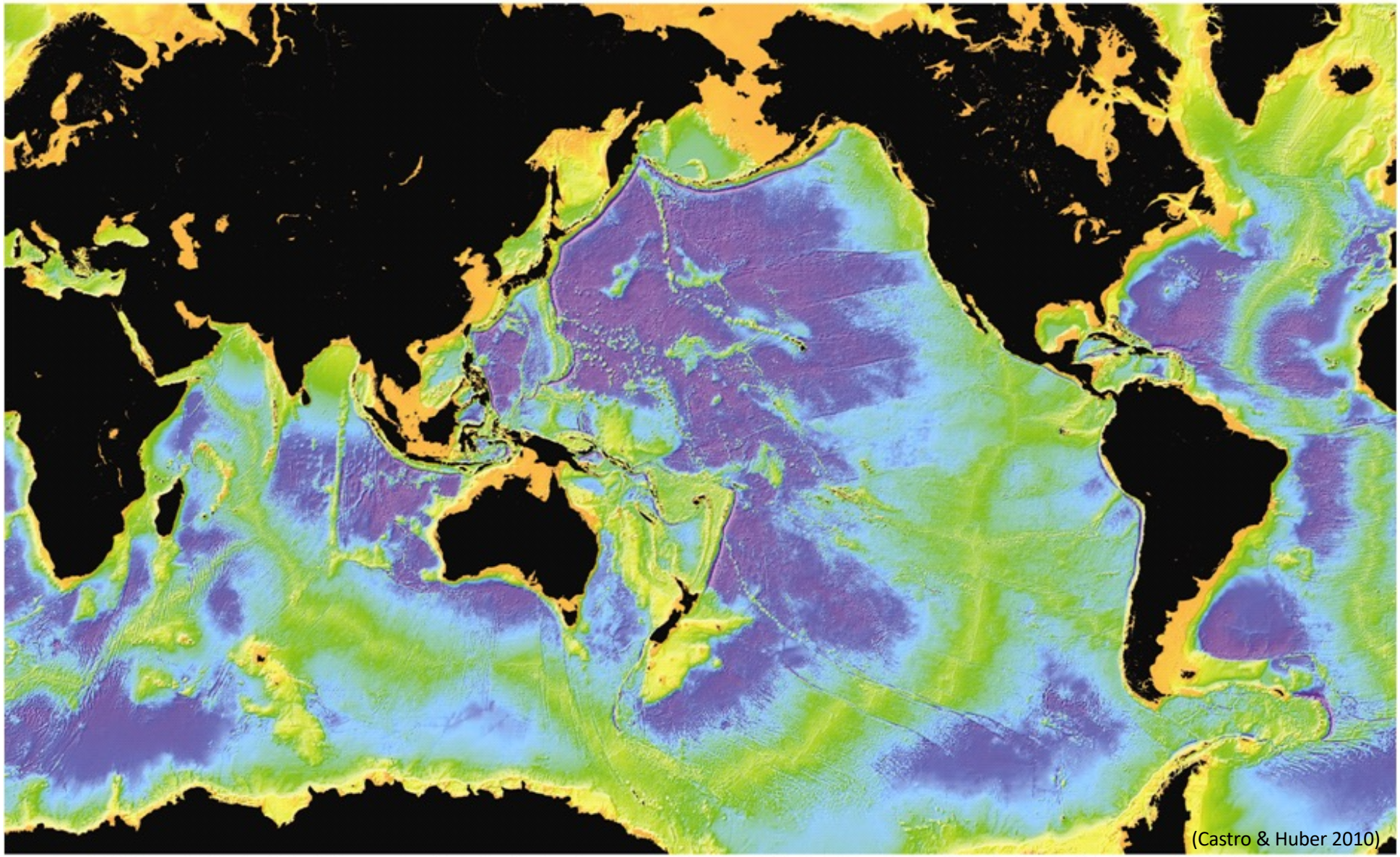
Marine research: modern technology





(Thurman &Trujillo 2004)

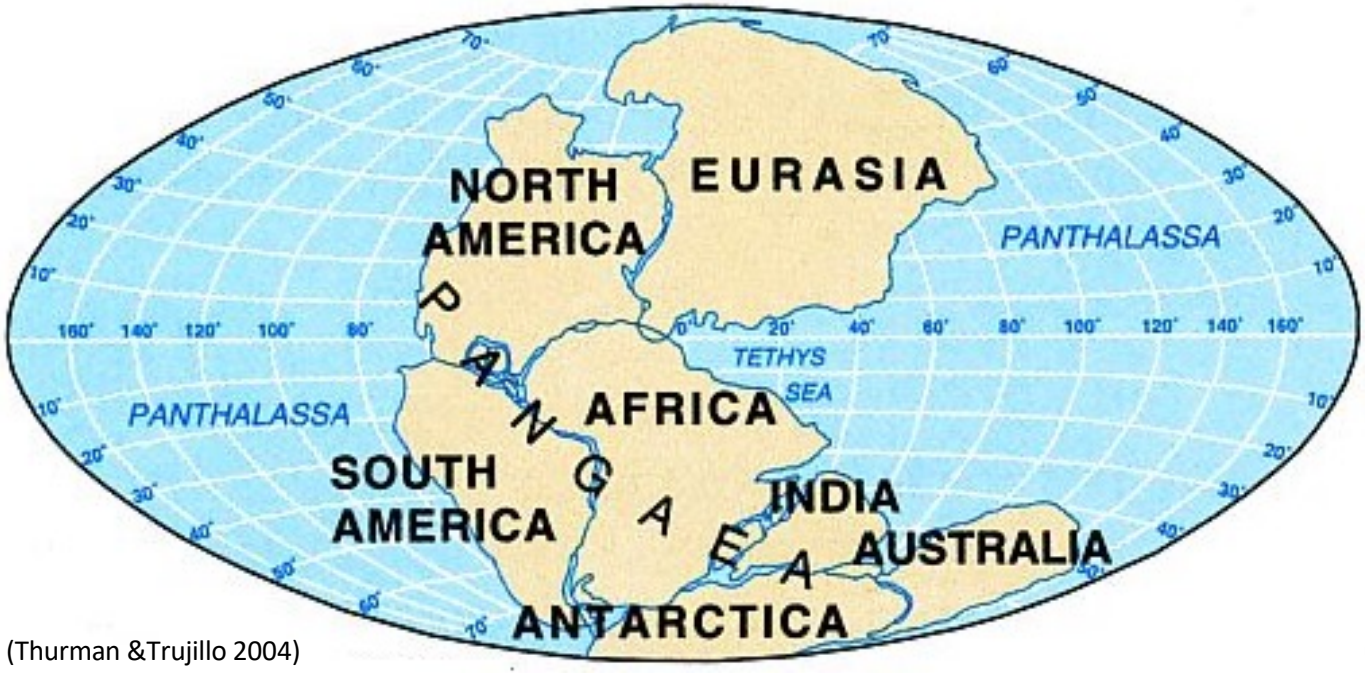
Oceanography: the sea floor



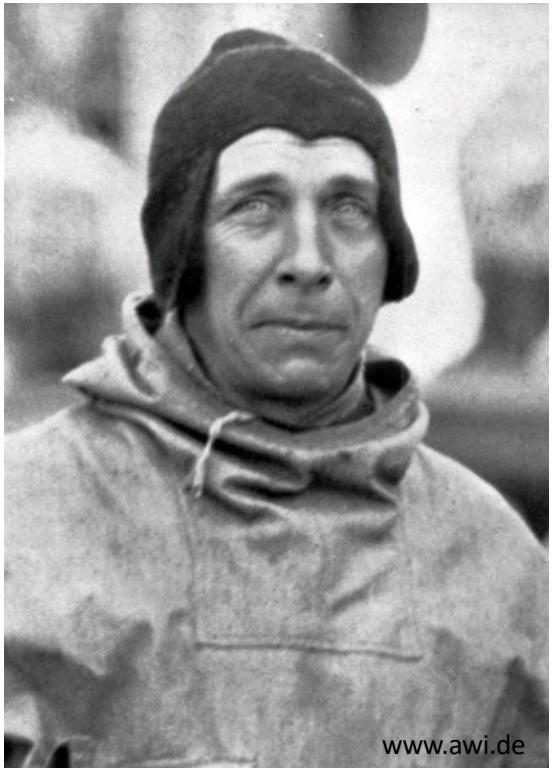
From W. Smith and D. Sandwell, 1997, "Measured and Estimated Seafloor Topography," World Data Center for Marine Geology & Geophysics, Boulder Research Publication RP-1, NOAA

Continental drift theory by Alfred Wegener (German geophysicist) in 1912:

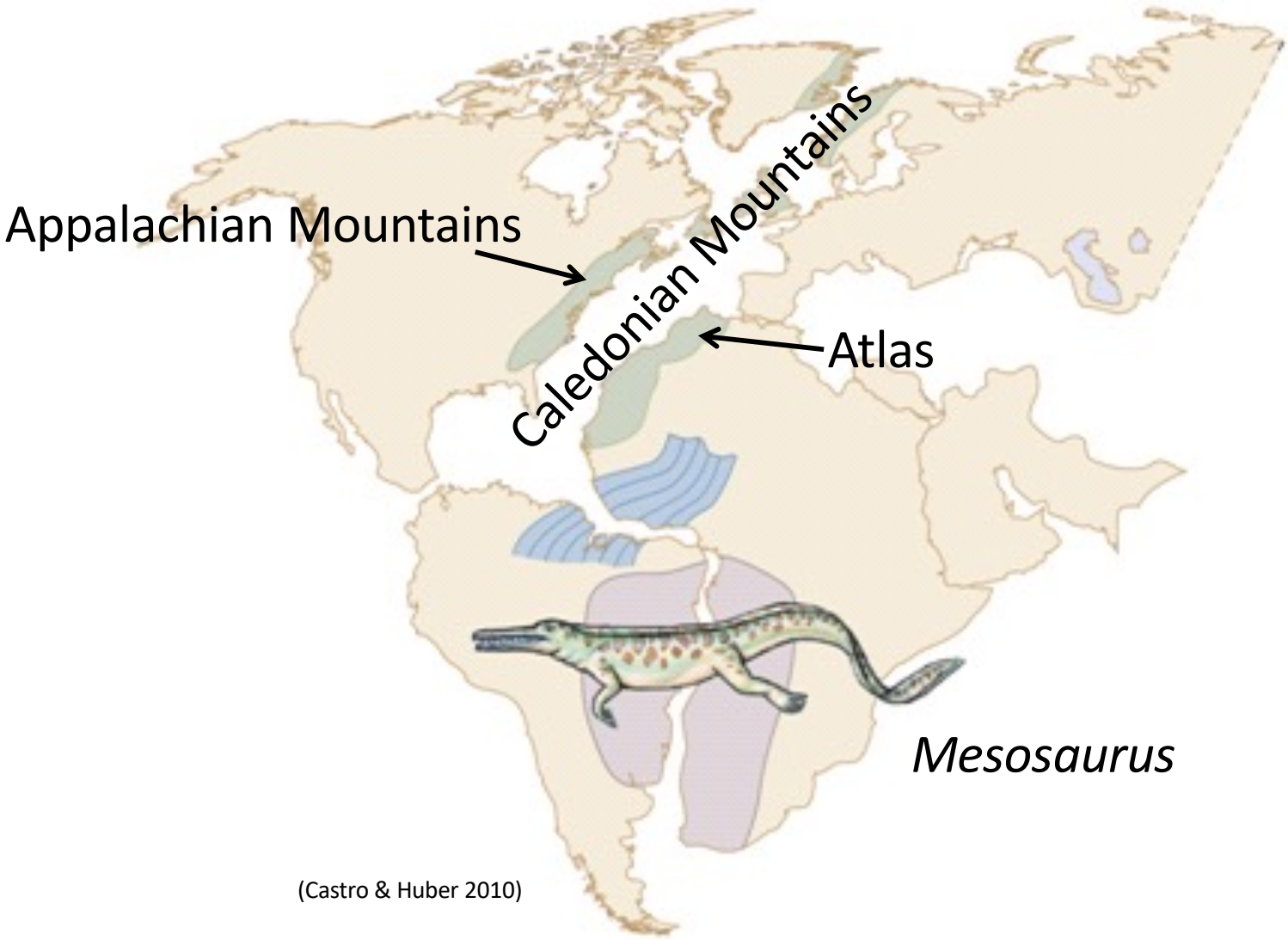
- All continents were joint to the "supercontinent" **Pangea** 180-200 million years ago
- One large Ocean called *Panthalassa* and smaller *Tethys Sea*



(Thurman &Trujillo 2004)



Oceanography: the sea floor



Geological evidence for continental drift

Oceanography: the sea floor

Mid-ocean ridge in Iceland

Björk: mutual core (http://vimeo.com/68675931)

I shuffle around the tectonic plates in my chest.

You know I gave it all,
Try to match our continents
To change seasonal shift,
To form a mutual core.

As fast as your fingernail grows,
The Atlantic ridge drifts
To counteract distance.

You know I gave it all,
Can you hear the effort of the magnetic strife?
Shuffling of columns
To form a mutual core.

This eruption undoes stagnation.
You didn't know I had it in me,
Withheld your love, an unspent capsule.
I didn't know you had it in you,
You hid the key to our continuity.
I didn't know you had it in you.
This eruption undoes stagnation.
You didn't know, you didn't know.

What you resist persists, nuance makes heat
To counteract distance
I know you gave it all,
Offered me harmony if things were done your way.
My Eurasian plate subsumed,
Forming a mutual core

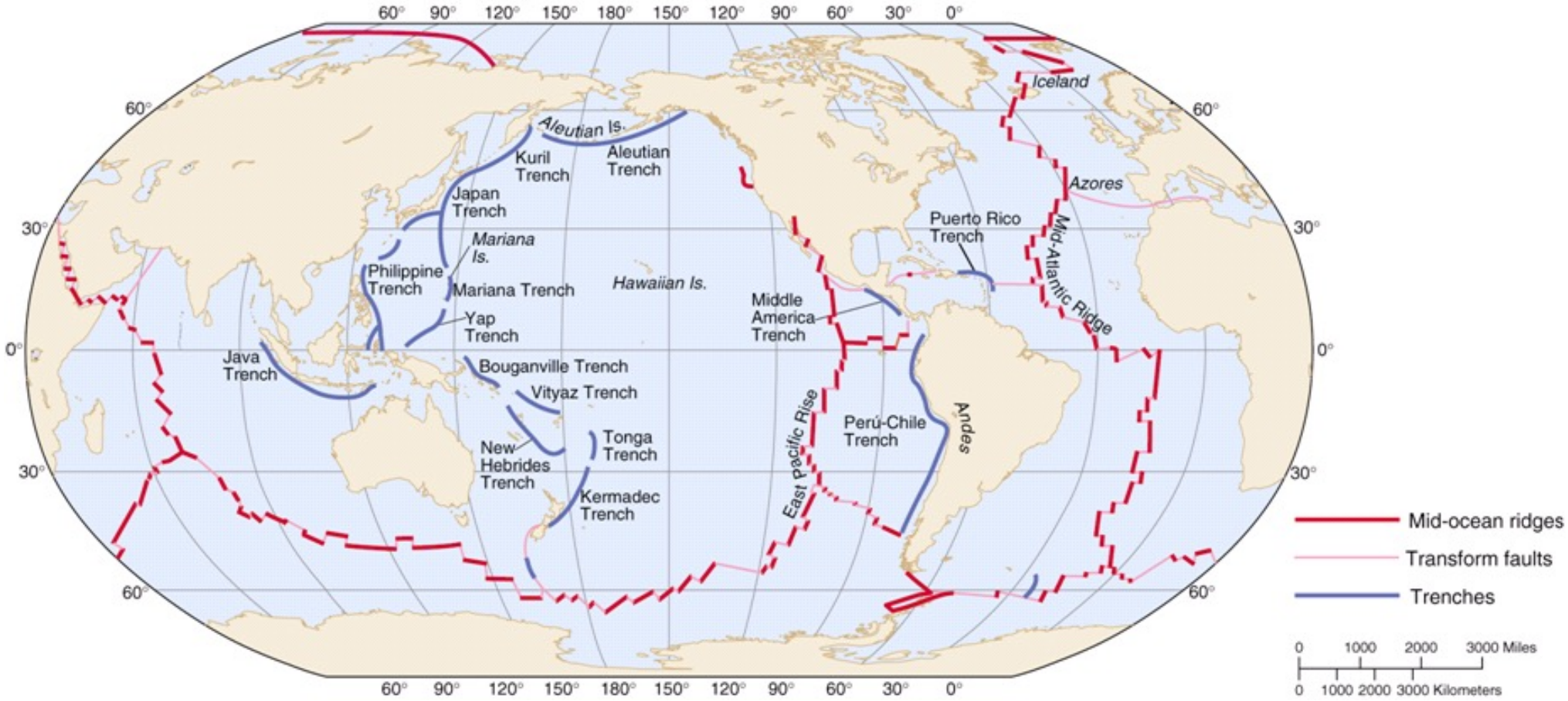
This eruption undoes stagnation.
You didn't know I had it in me,
Withheld your love, an unspent capsule.
I didn't know you had it in you.
This eruption undoes stagnation
You didn't know I had it in me
This eruption undoes stagnation
You didn't know, you didn't know.

http://heybehappy.com/music-2.html/

http://blogs.scientificamerican.com/brainwaves/2012/11/15/geology-porn-the-science-and-art-of-bjorks-mutual-core-music-video/

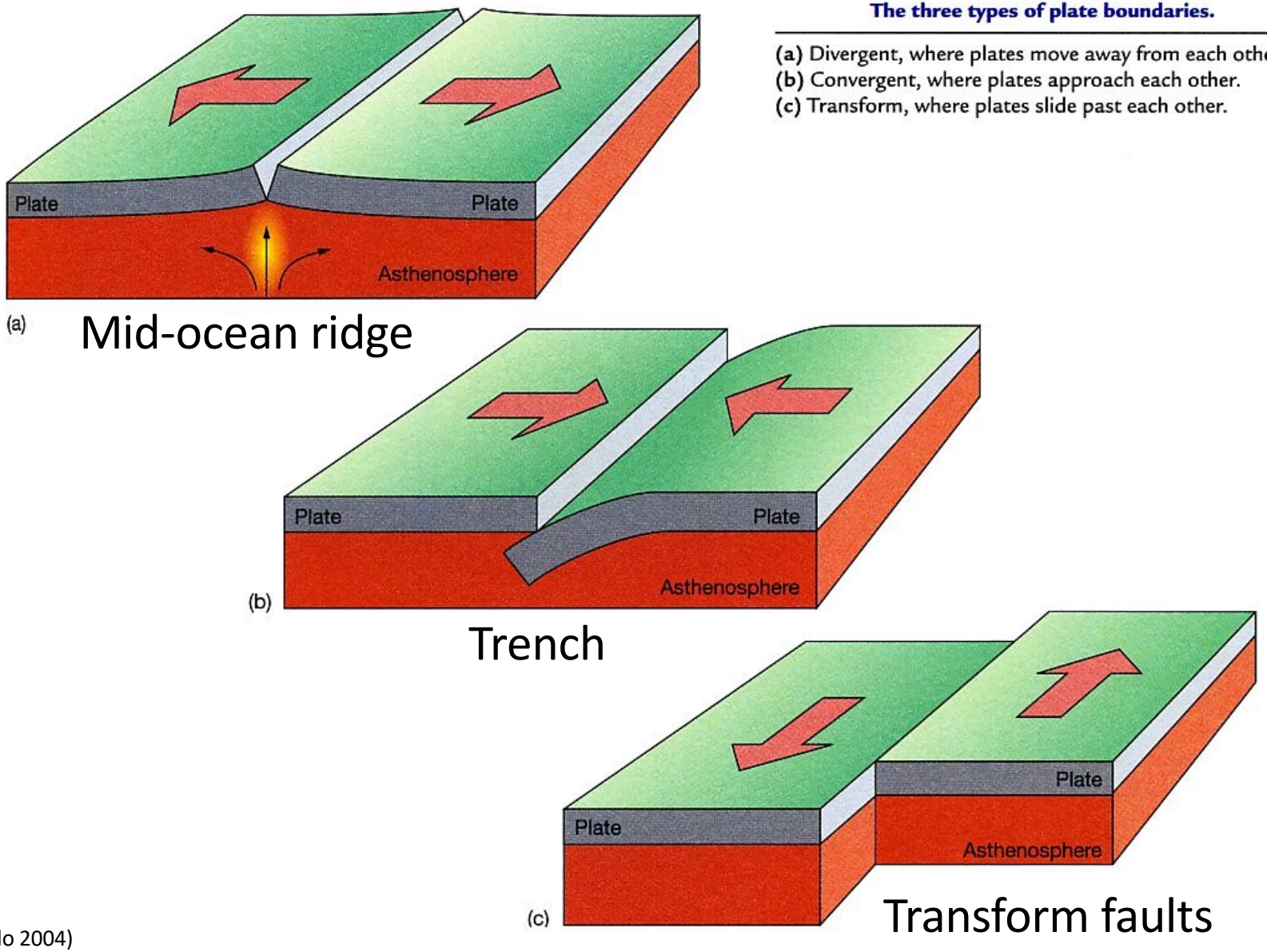
Theory of plate tectonics, developed in the 1950s and 1960s:

- Detailed bathymetry of the ocean floor ⇨ discovery of mid-ocean ridges



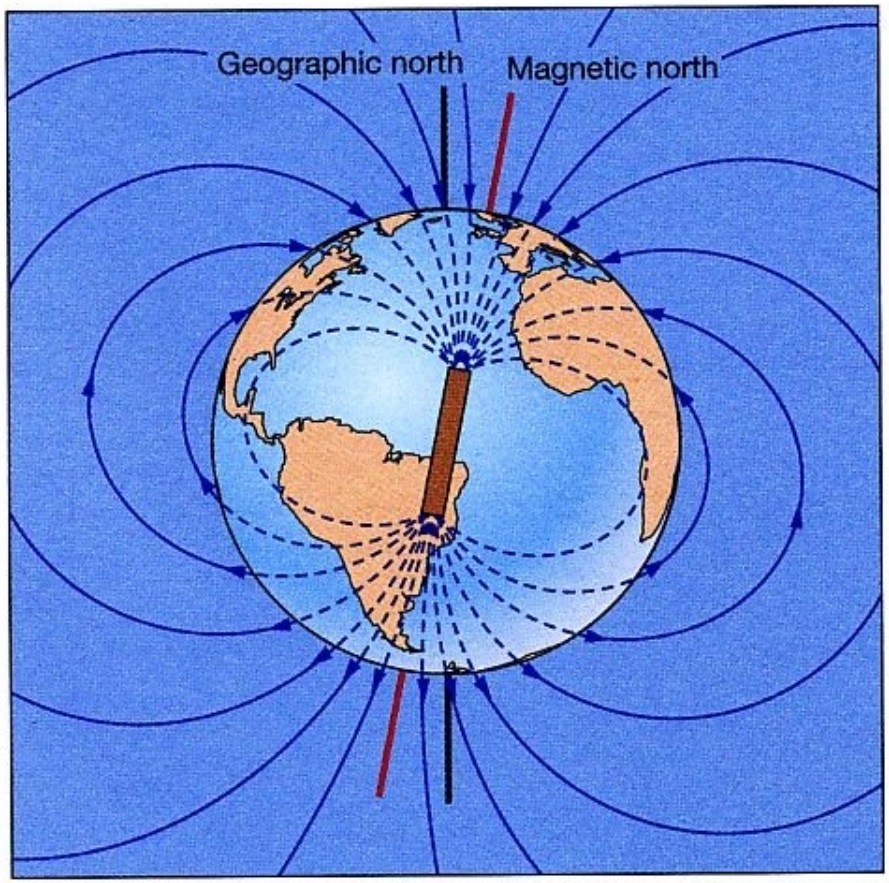
(Castro & Huber 2010)

Oceanography: the sea floor

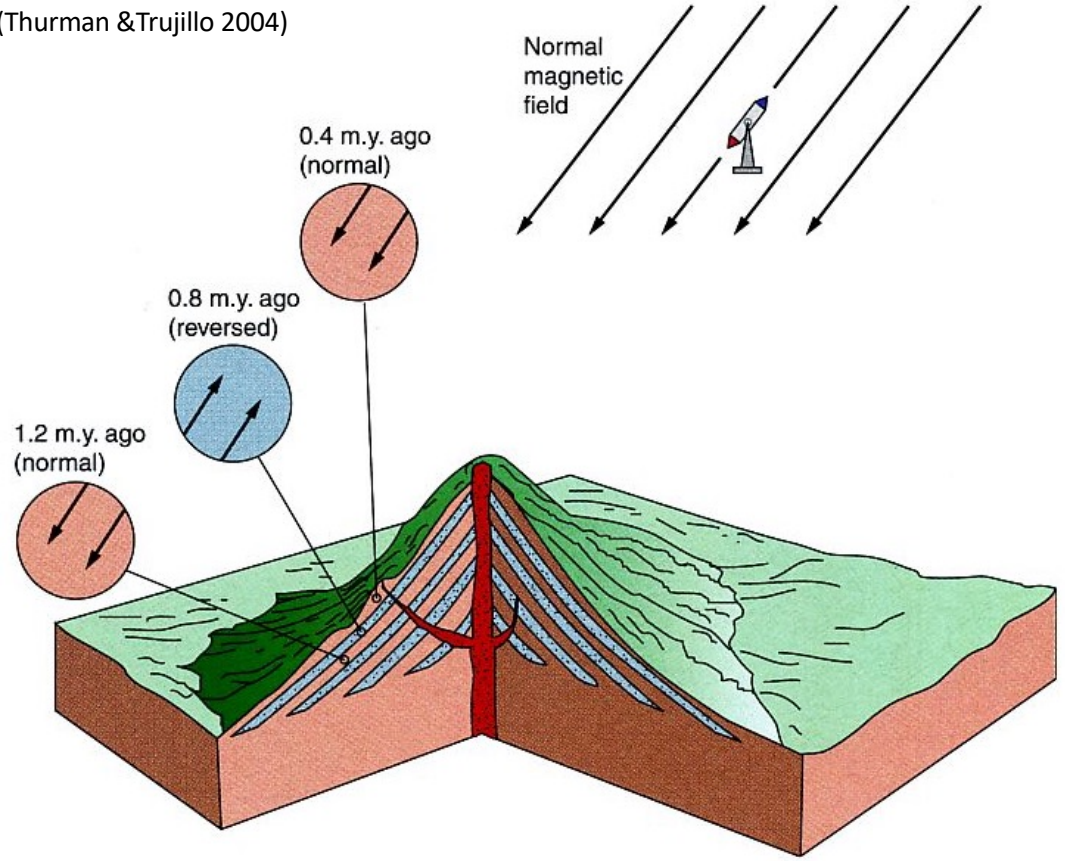


(Thurman &Trujillo 2004)

Oceanography: the sea floor



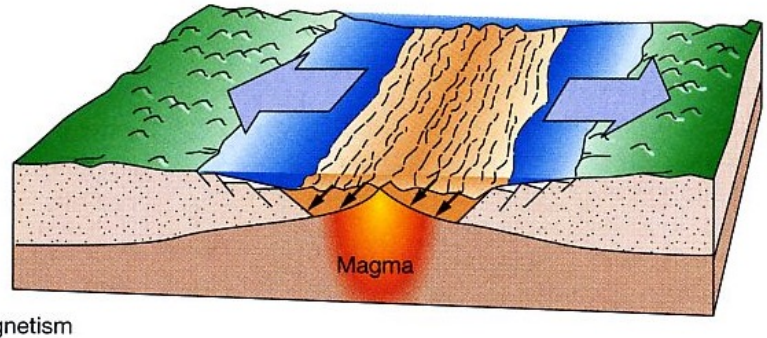
(Thurman &Trujillo 2004)



Palaeomagnetism:

- Magnetic polarity reversals at an rate of 1-2 times/million years
- **Magnetite** (magnetic iron mineral) aligns itself to the Earth's magnetic field in volcanic lava; signature "frozen" at 600 ° C (Curie point)

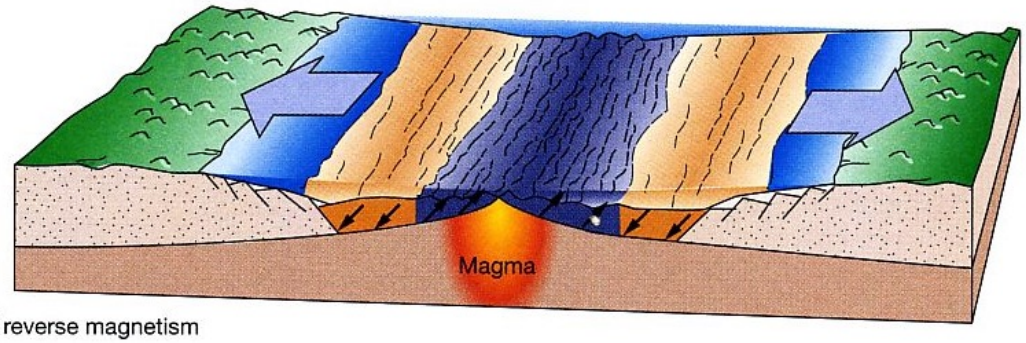
Oceanography: the sea floor



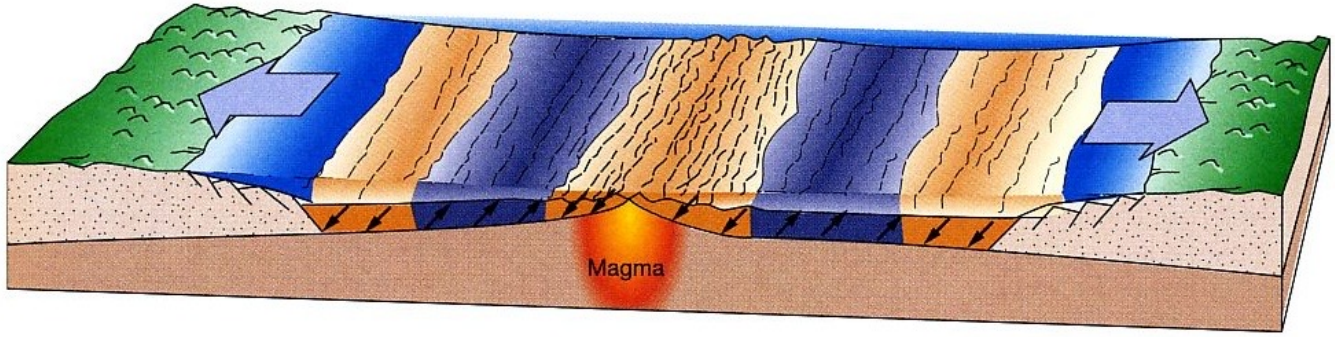
Magnetic evidence of sea floor spreading.

As new basalt is added to the ocean floor at mid-ocean ridges, it is magnetized according to Earth's existing magnetic field.

(a) Period of normal magnetism



(b) Period of reverse magnetism

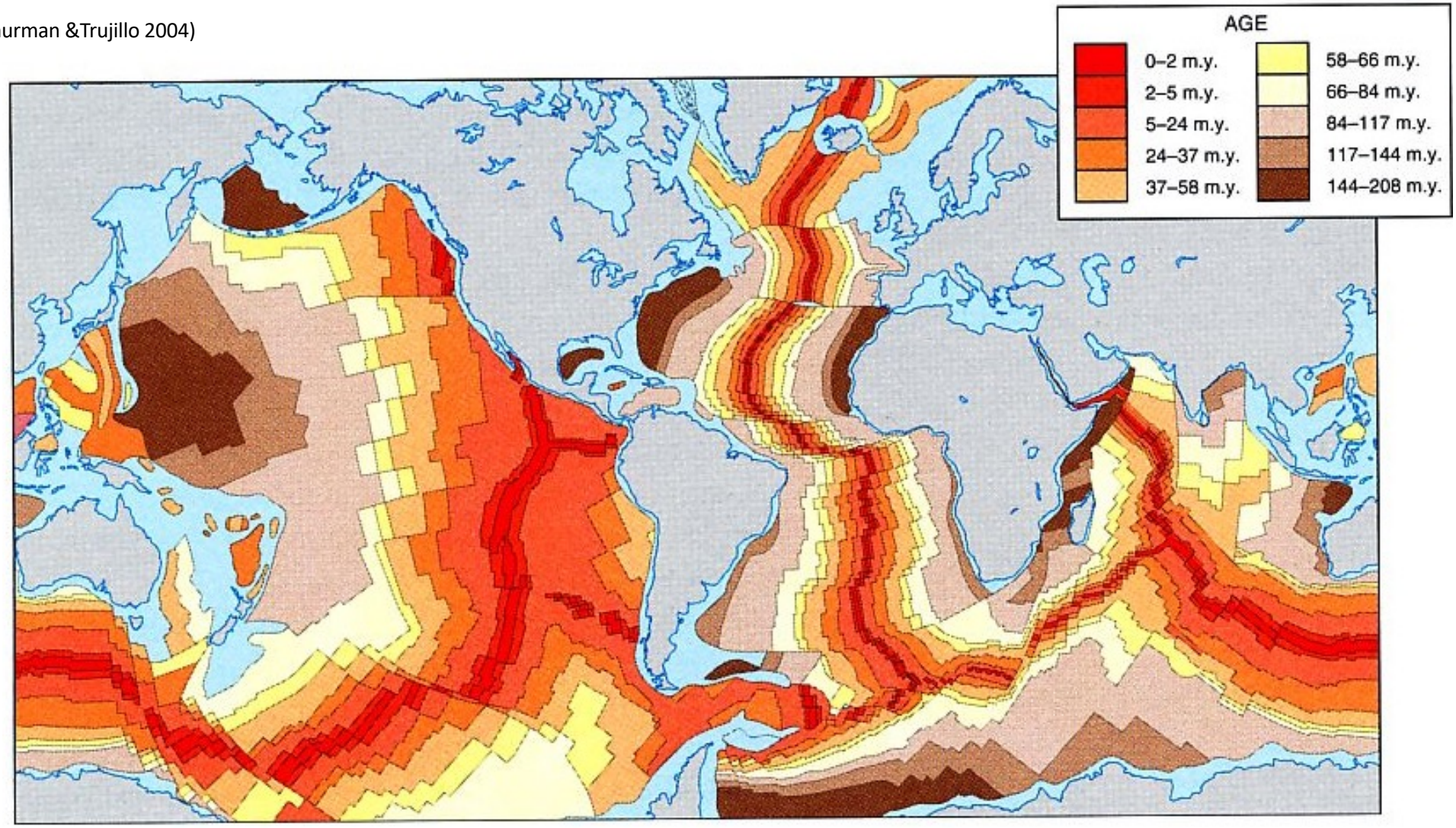


(c) Period of normal magnetism

(Thurman &Trujillo 2004)

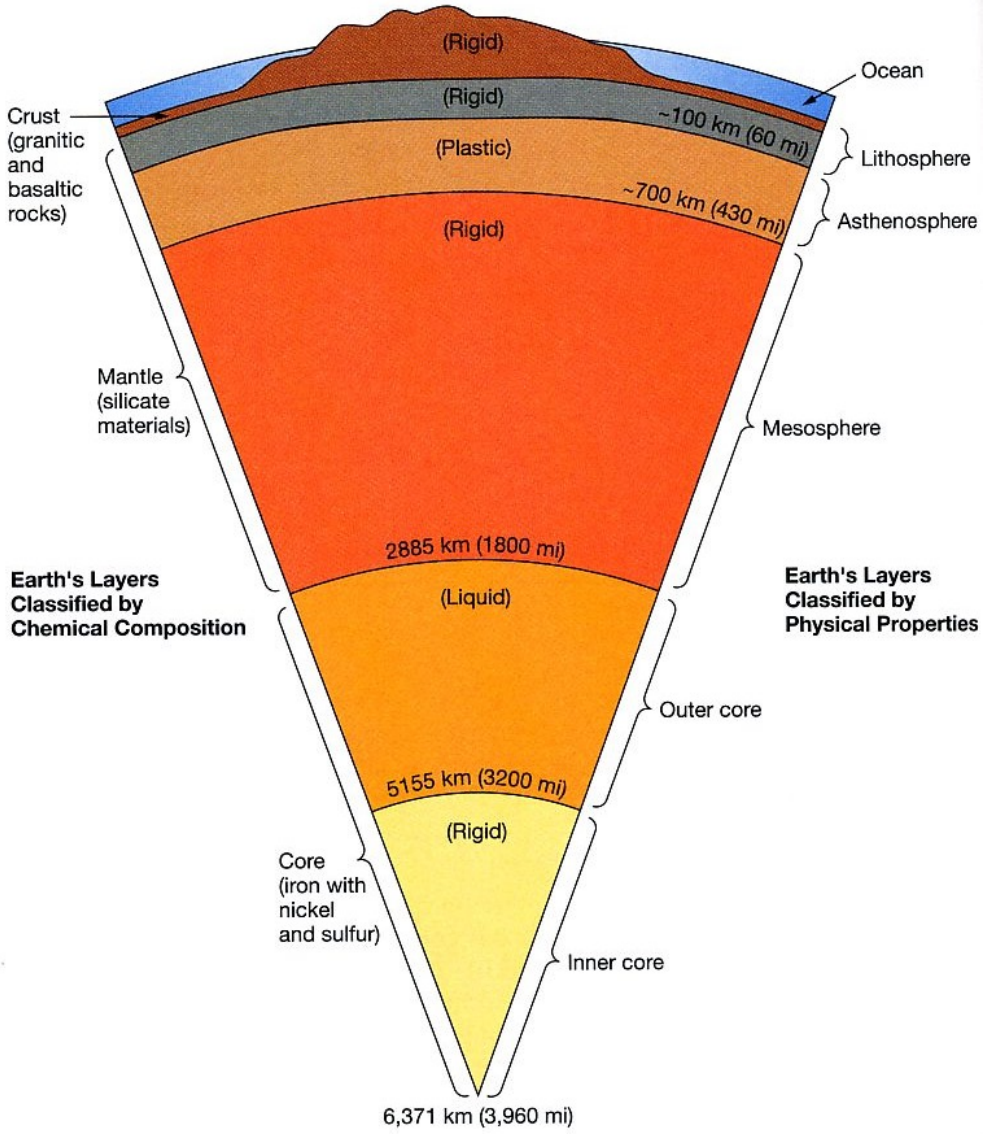
Oceanography: the sea floor

(Thurman &Trujillo 2004)

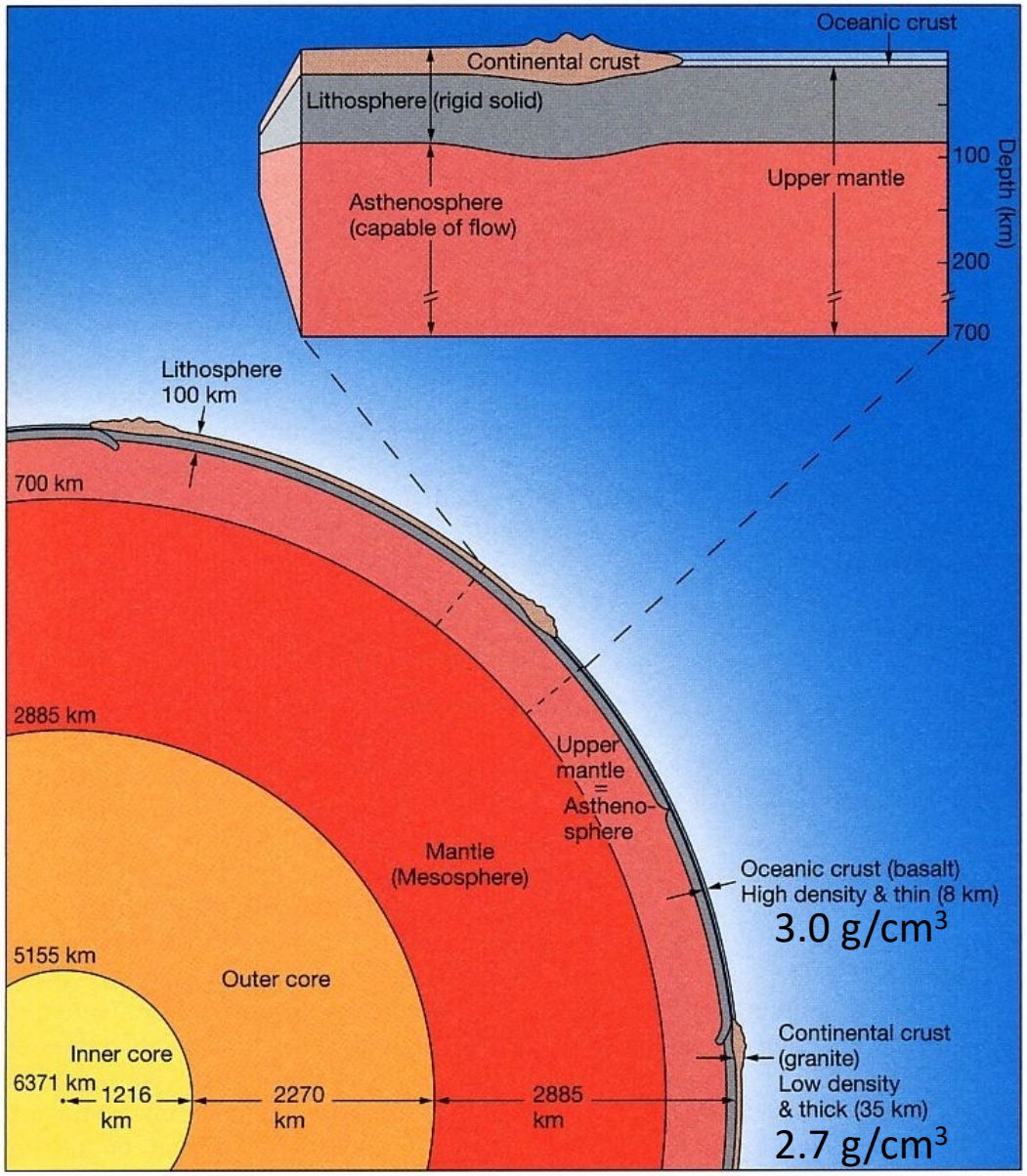


Age of ocean crust, also correlates with thickness of sediments

Oceanography: the sea floor



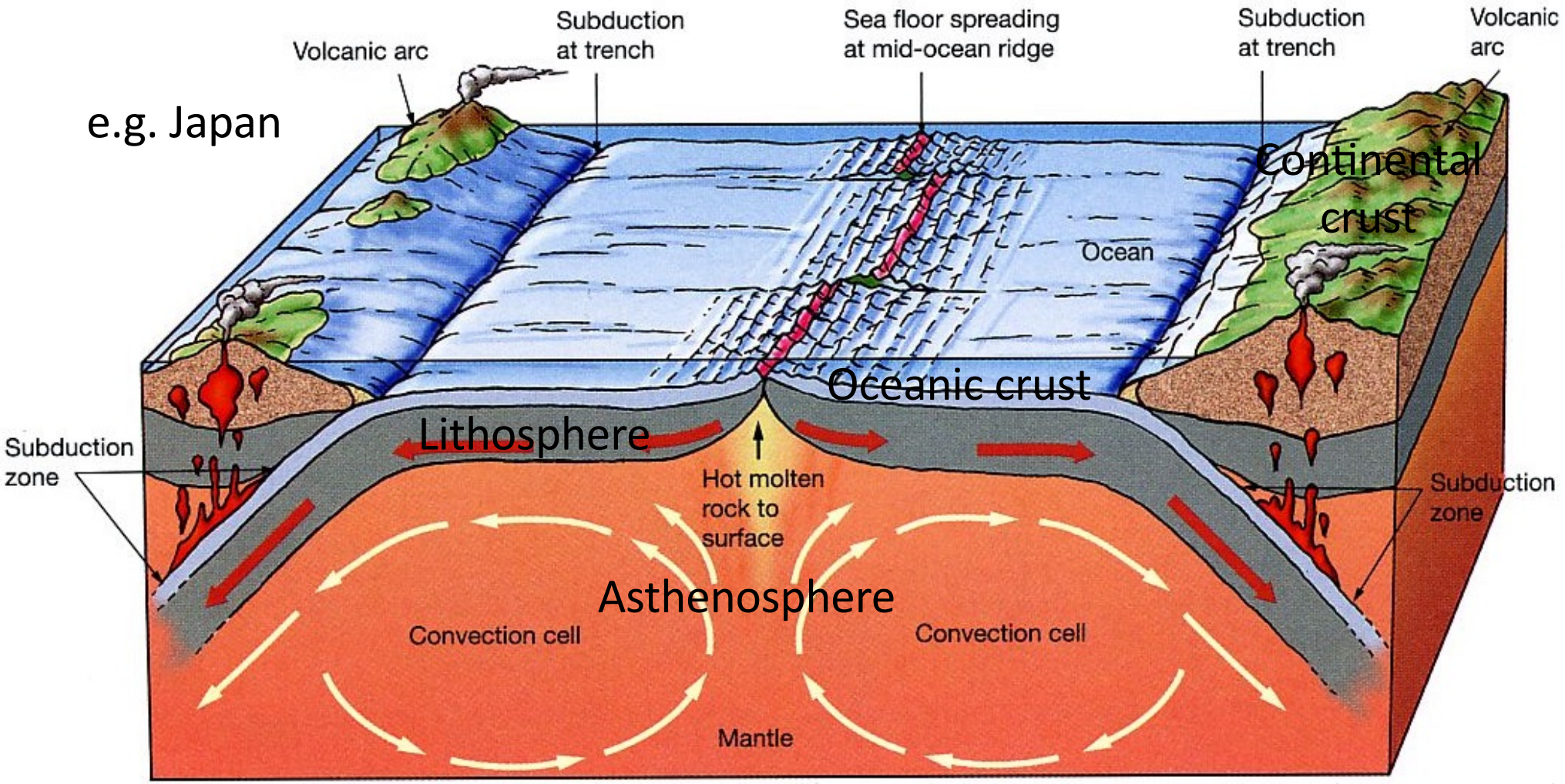
(Thurman &Trujillo 2004)



Oceanography: the sea floor

e.g. Andes

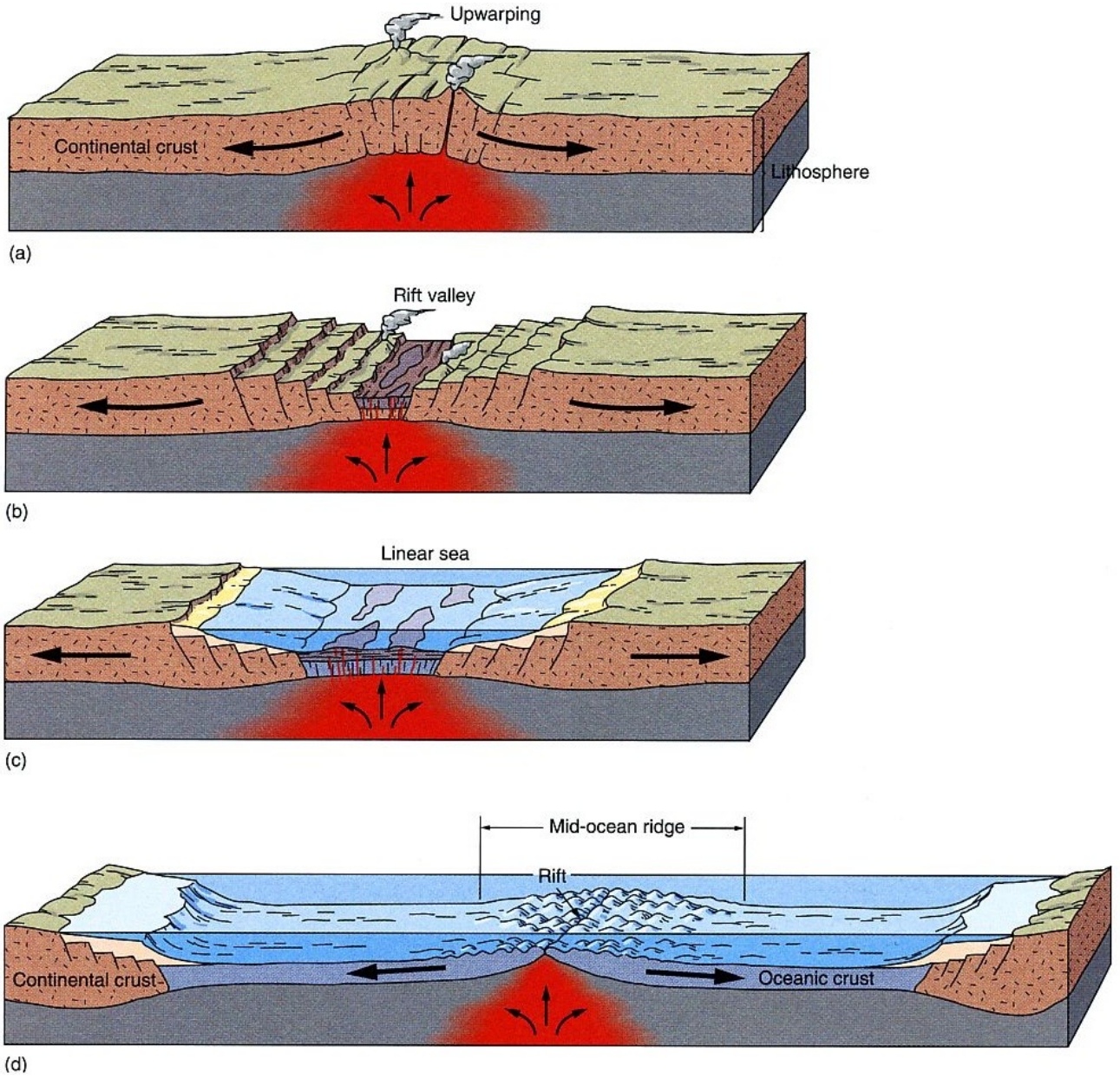
e.g. Japan



(Thurman &Trujillo 2004)

Sea floor spreading at mid-ocean ridges and **subduction** at trenches

Oceanography: the sea floor



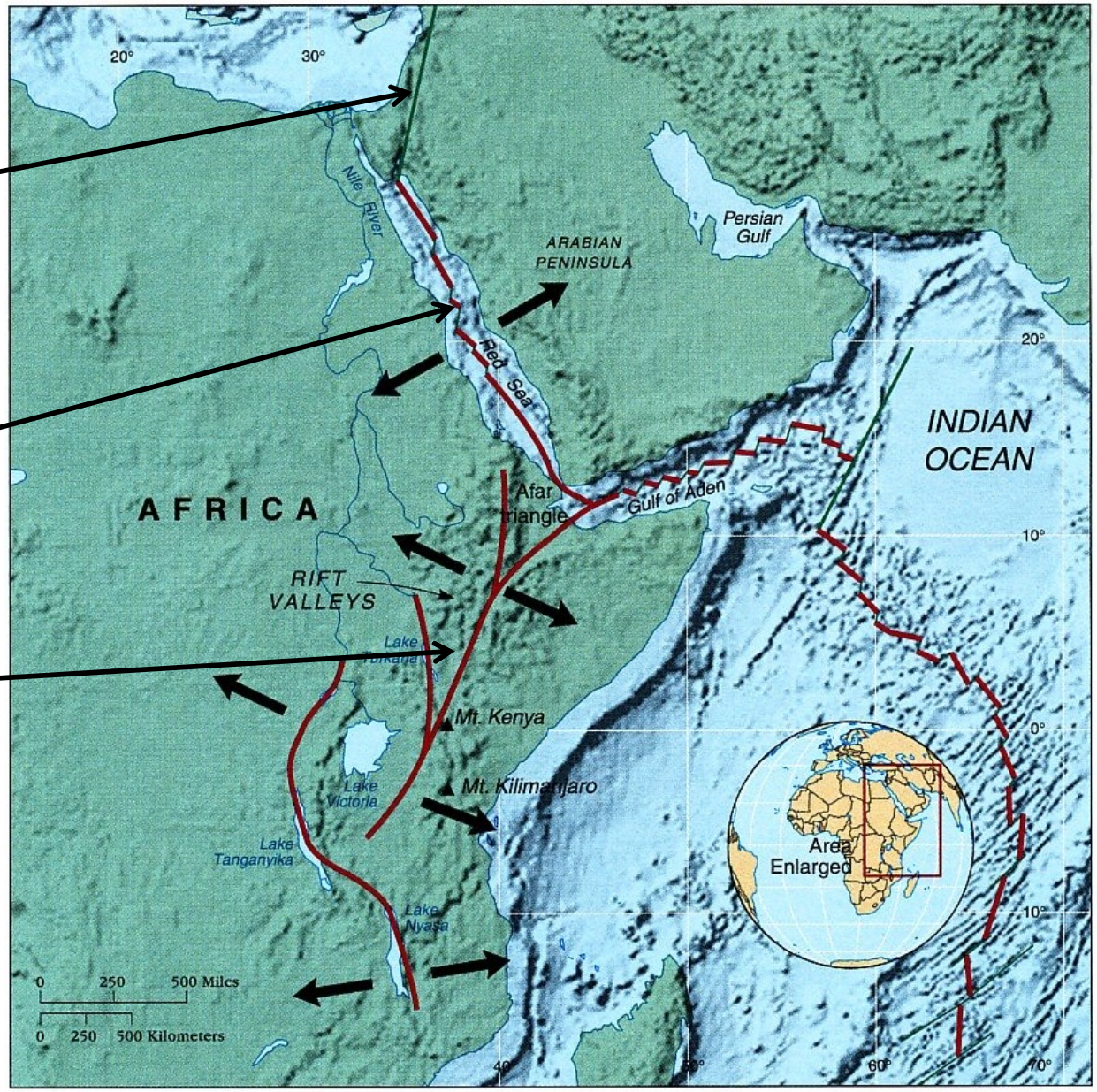
(Thurman &Trujillo 2004)

Oceanography: the sea floor

Dead Sea (-422 m),
Jordan River,
Sea of Galilee (-209 m)

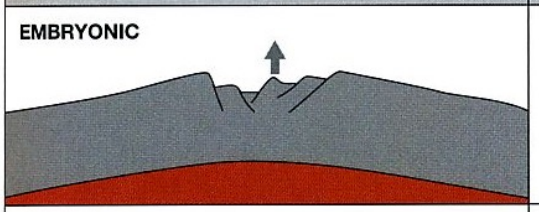
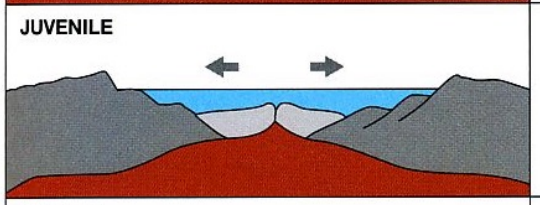
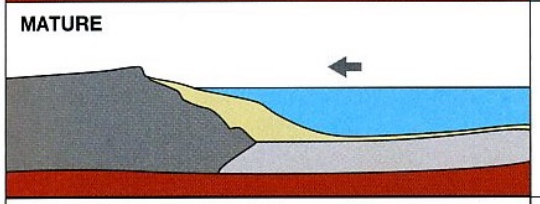
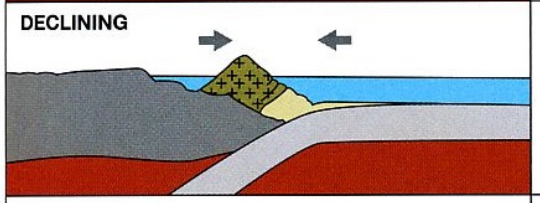
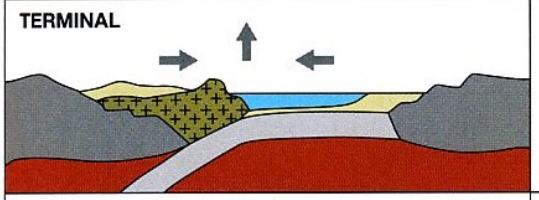
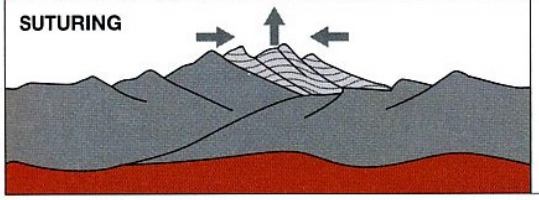
Red Sea

East African Rift Valley



(Thurman &Trujillo 2004)

Oceanography: the sea floor

STAGE	MOTION	PHYSIOGRAPHY	EXAMPLE
EMBRYONIC 	Uplift	Complex system of linear rift valleys on continent	East African rift valleys
JUVENILE 	Divergence (spreading)	Narrow seas with matching coasts	Red Sea
MATURE 	Divergence (spreading)	Ocean basin with continental margins	Atlantic and Arctic Oceans
DECLINING 	Convergence (subduction)	Island arcs and trenches around basin edge	Pacific Ocean
TERMINAL 	Convergence (collision) and uplift	Narrow, irregular seas with young mountains	Mediterranean Sea
SUTURING 	Convergence and uplift	Young to mature mountain belts	Himalaya Mountains

Wilson cycle of ocean basin evolution

(Thurman &Trujillo 2004)

Oceanography: the sea floor

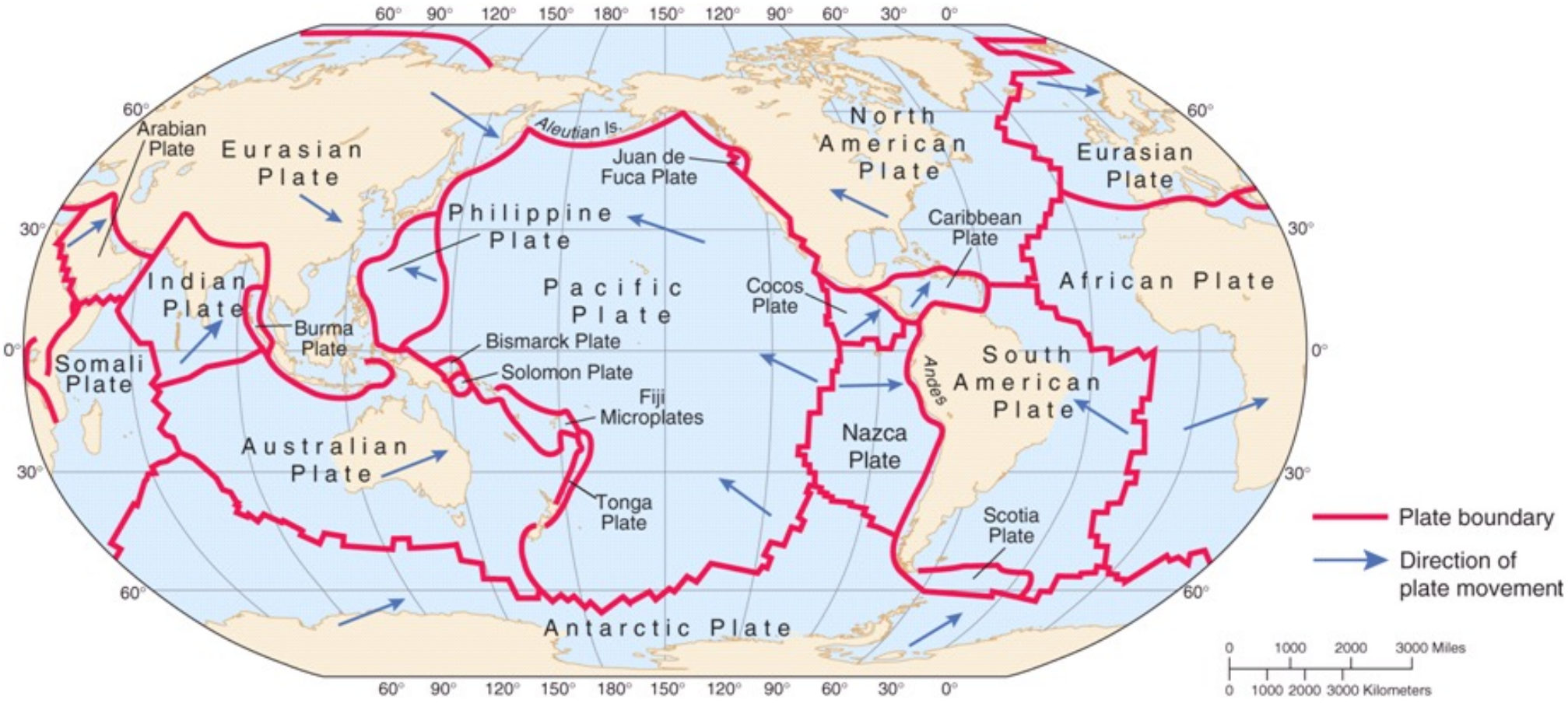
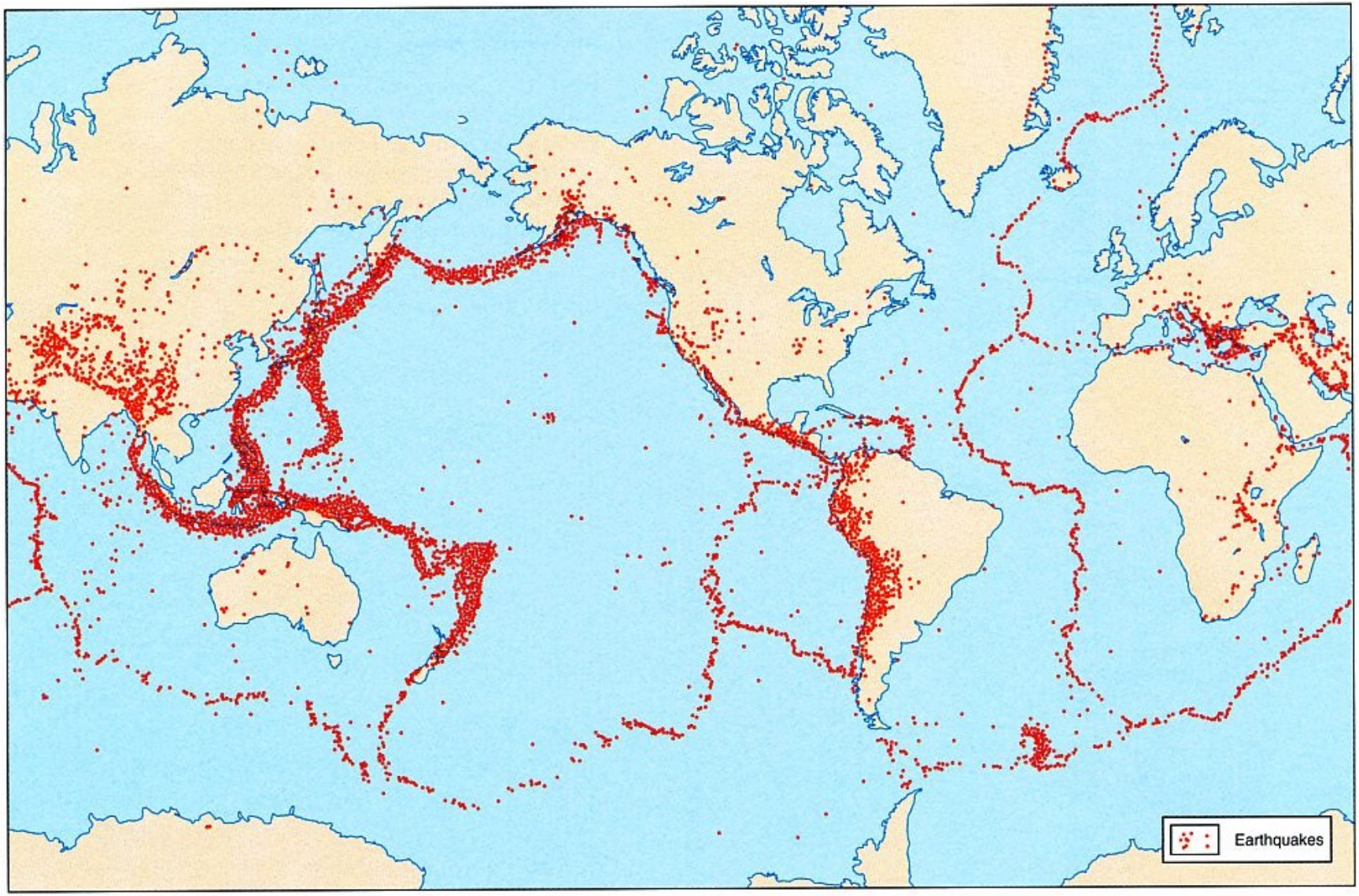


Plate boundaries

(Castro & Huber 2010)

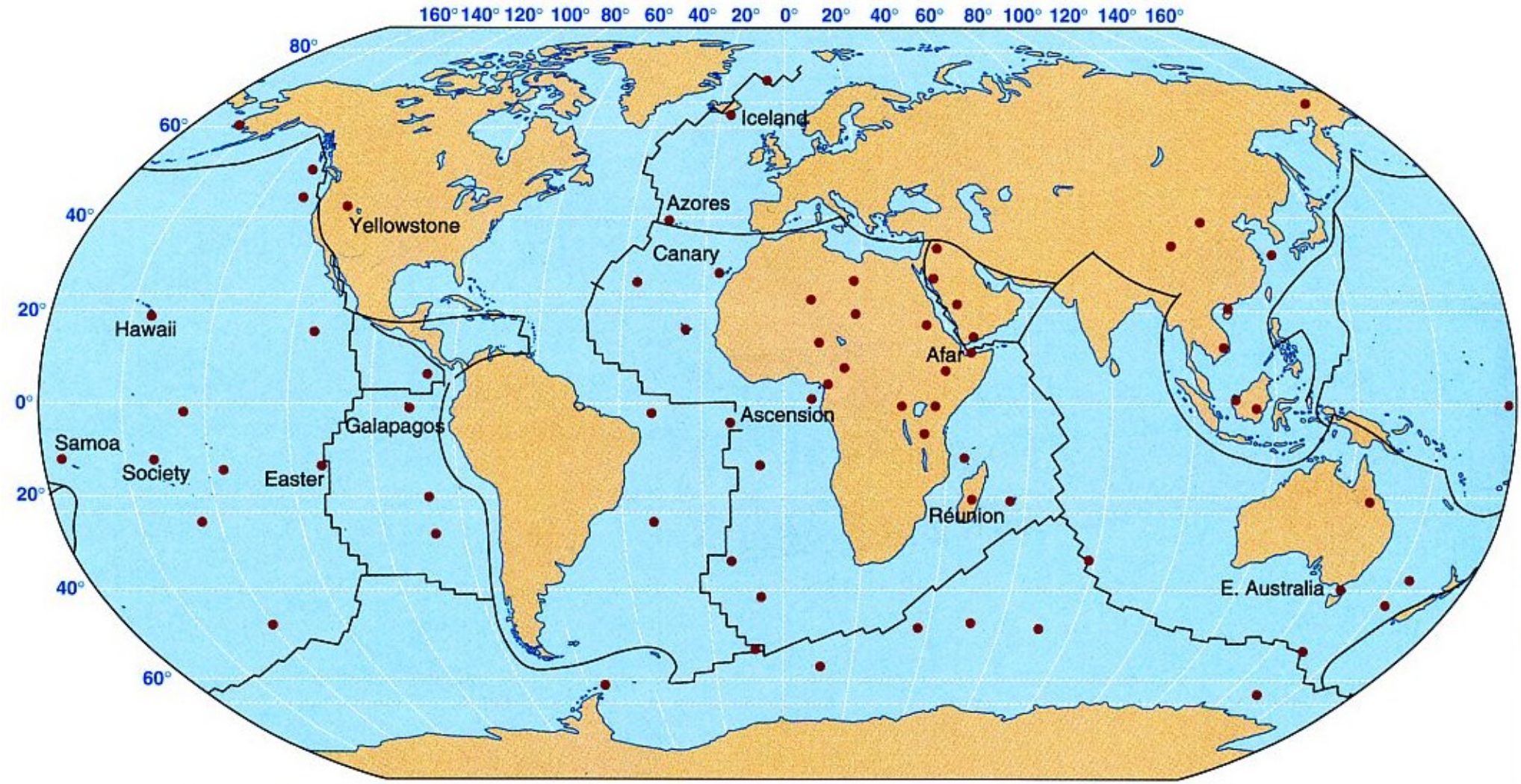
Oceanography: the sea floor



Global distribution of earthquakes

(Thurman &Trujillo 2004)

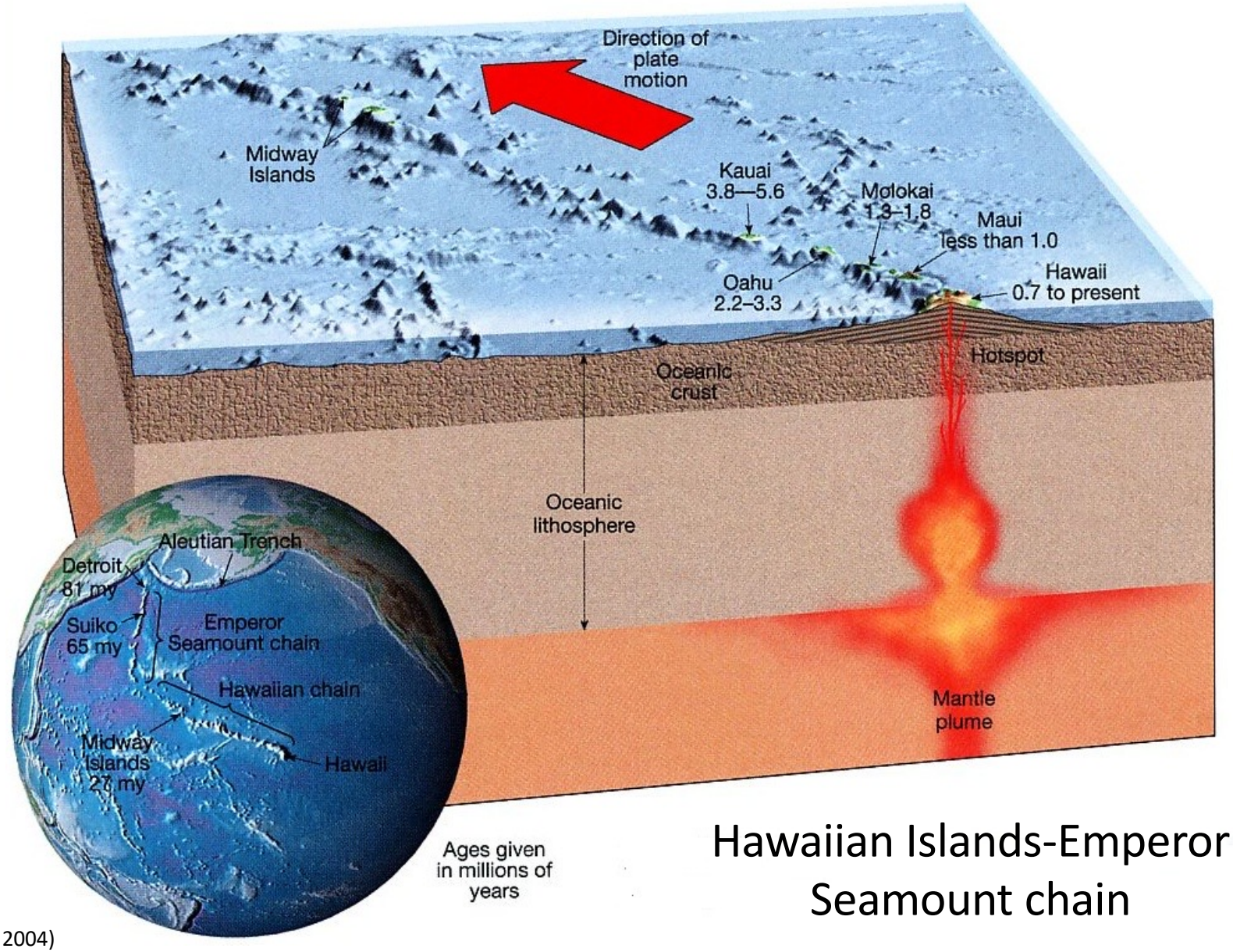
Oceanography: the sea floor



Global distribution of prominent hot spots

(Thurman &Trujillo 2004)

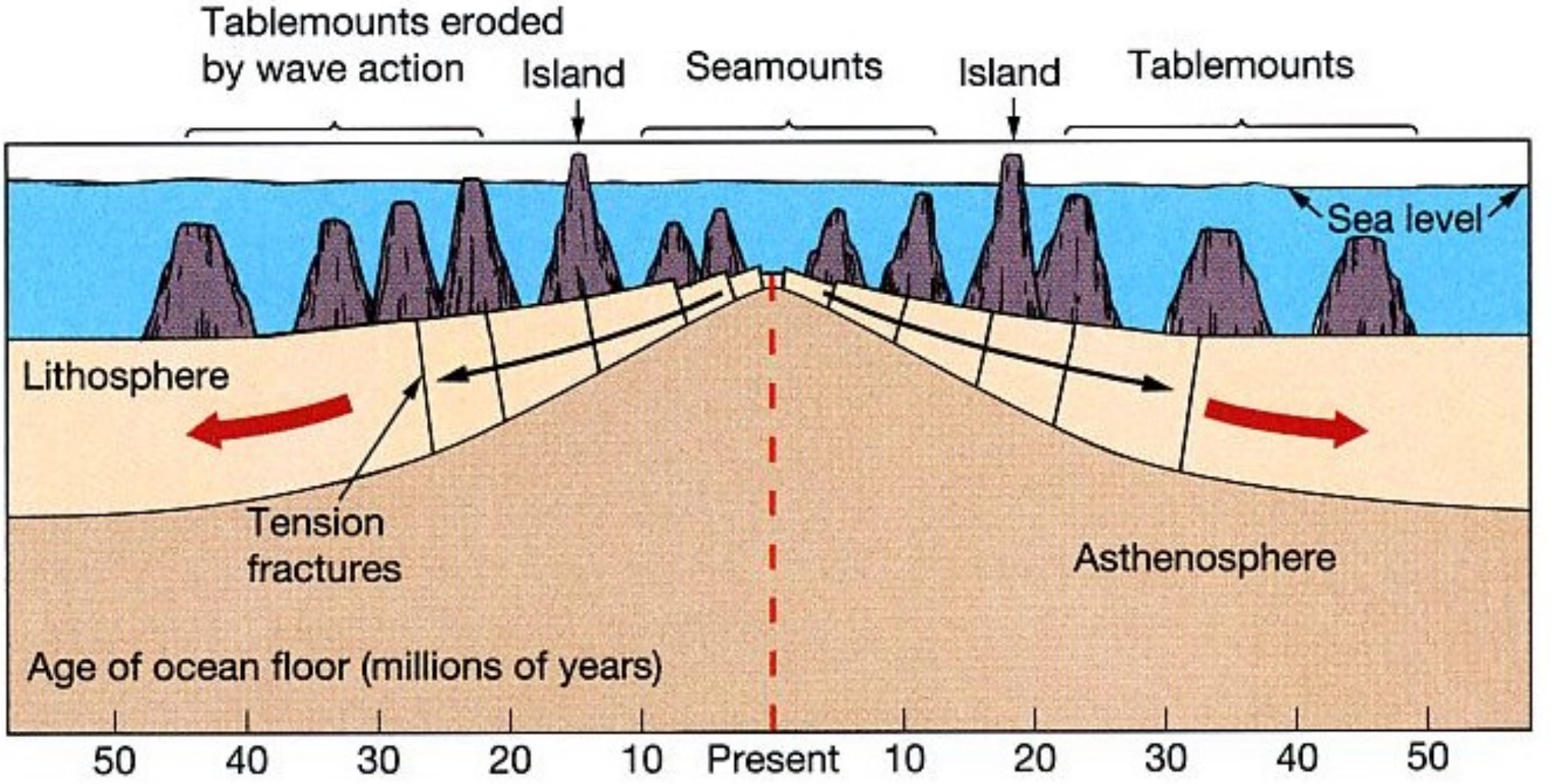
Oceanography: the sea floor



Hawaiian Islands-Emperor Seamount chain

(Thurman &Trujillo 2004)

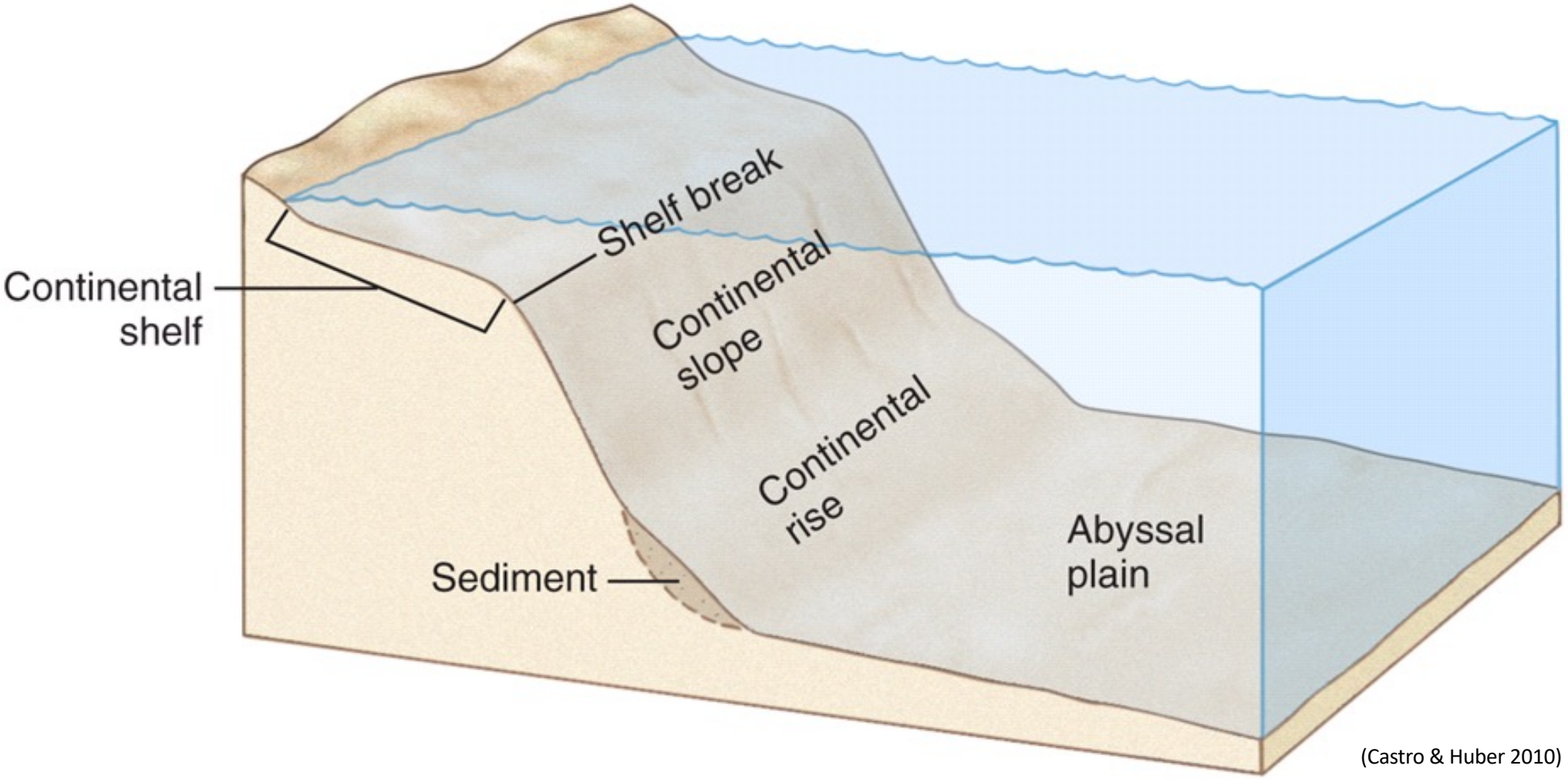
Oceanography: the sea floor



(Thurman &Trujillo 2004)

Formation of seamounts and tablemounts at a mid-ocean ridge

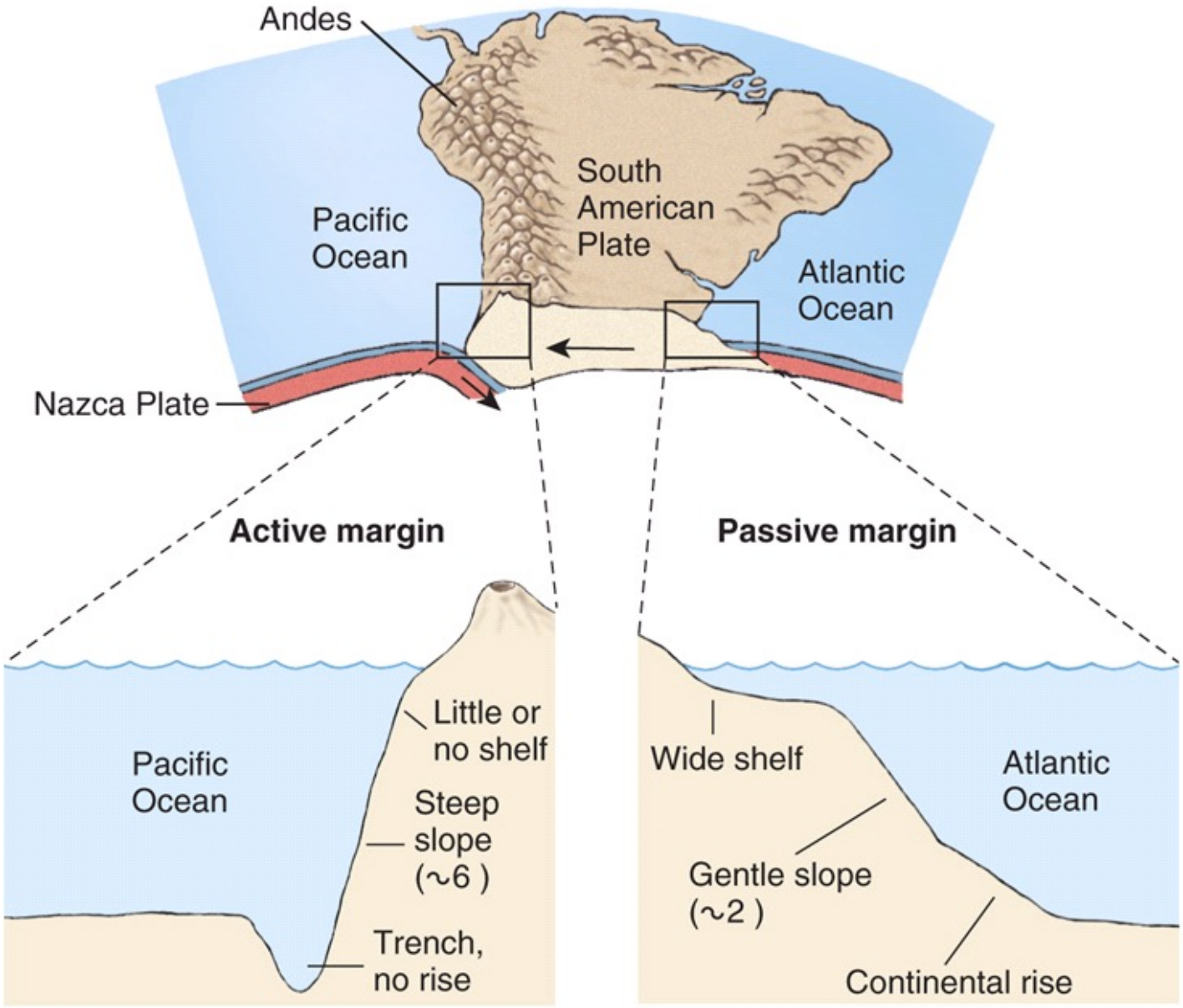
Oceanography: the sea floor



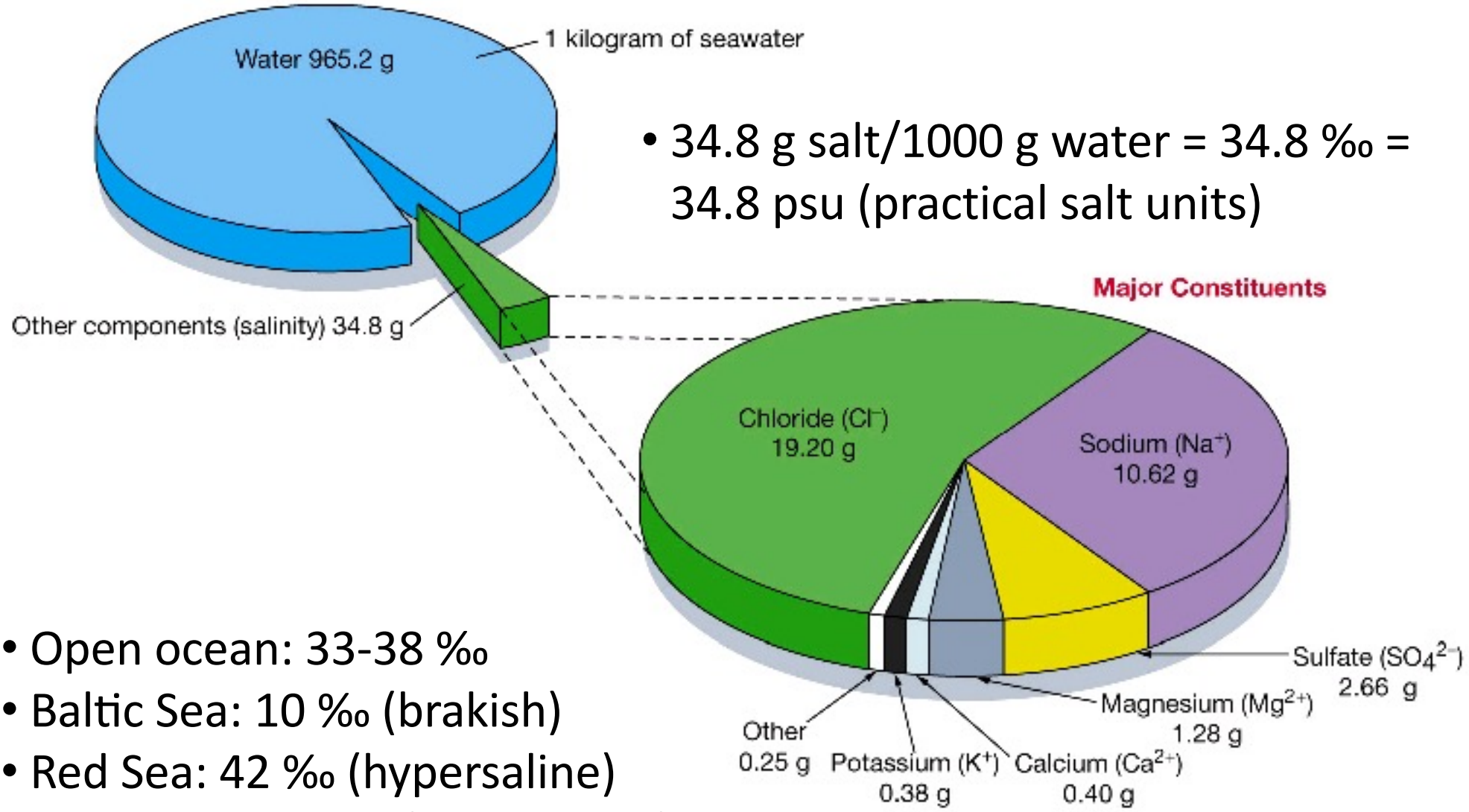
(Castro & Huber 2010)

Idealised **continental margin** with continental shelf, slope and rise

Oceanography: the sea floor



(Castro & Huber 2010)



- 34.8 g salt/1000 g water = 34.8 ‰ = 34.8 psu (practical salt units)

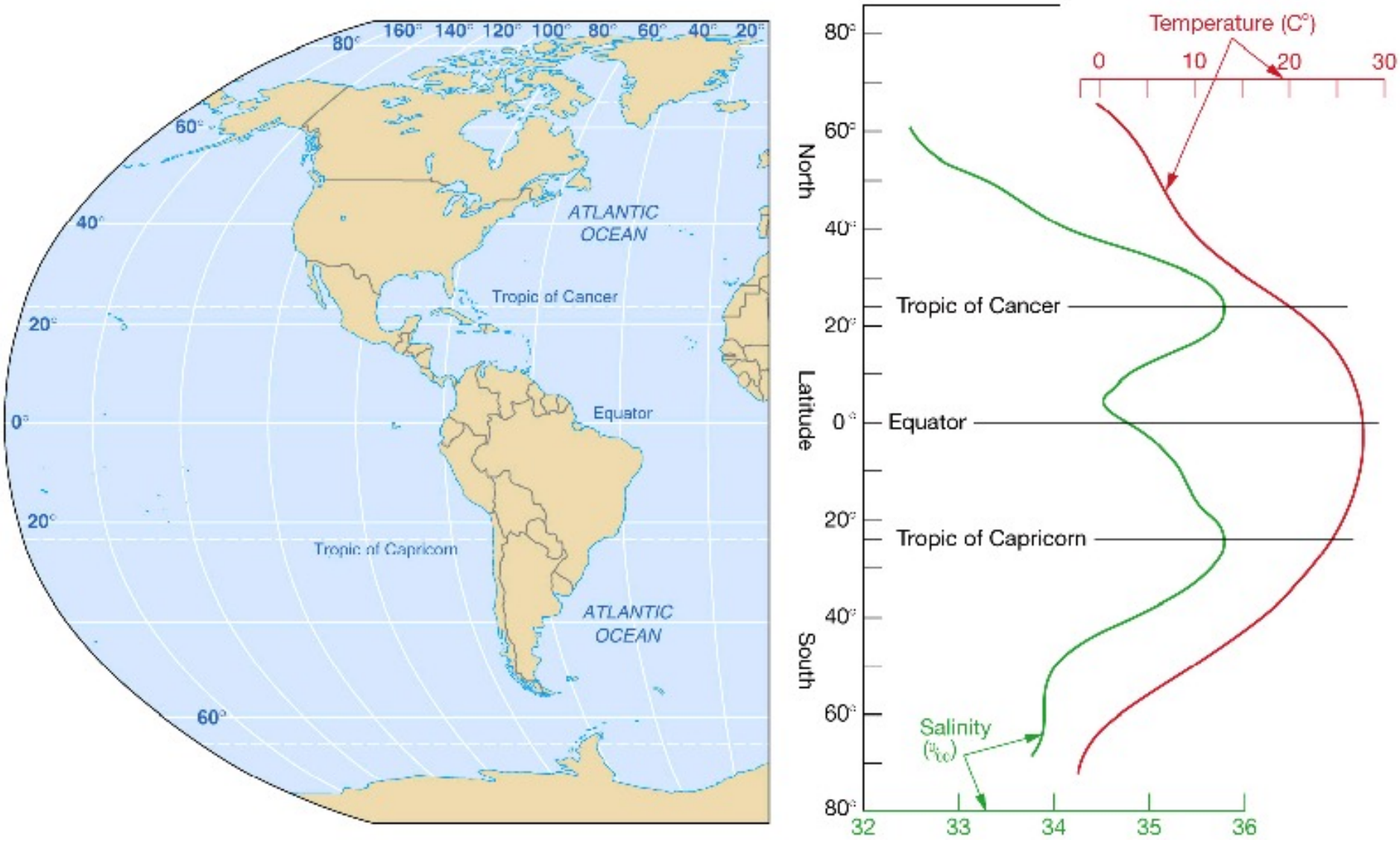
- Open ocean: 33-38 ‰
- Baltic Sea: 10 ‰ (brakish)
- Red Sea: 42 ‰ (hypersaline)
- Dead Sea: 330 ‰ (hypersaline)

(Thurman &Trujillo 2004)

Oceanography: salinity, temperature, and density

Hypersalinity in the Dead Sea (330 ‰)

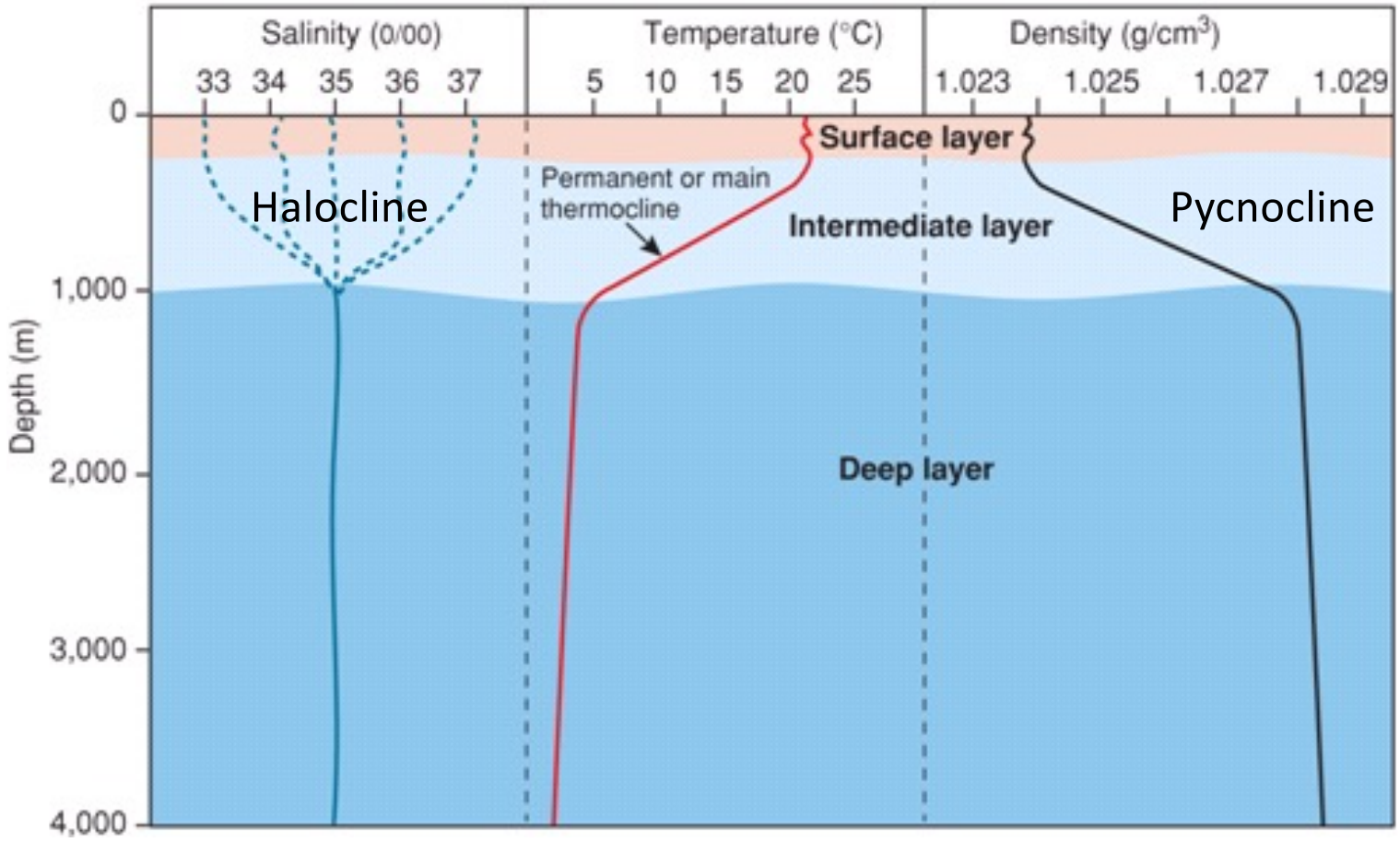
Oceanography: salinity, temperature, and density



Global seawater salinity and temperature

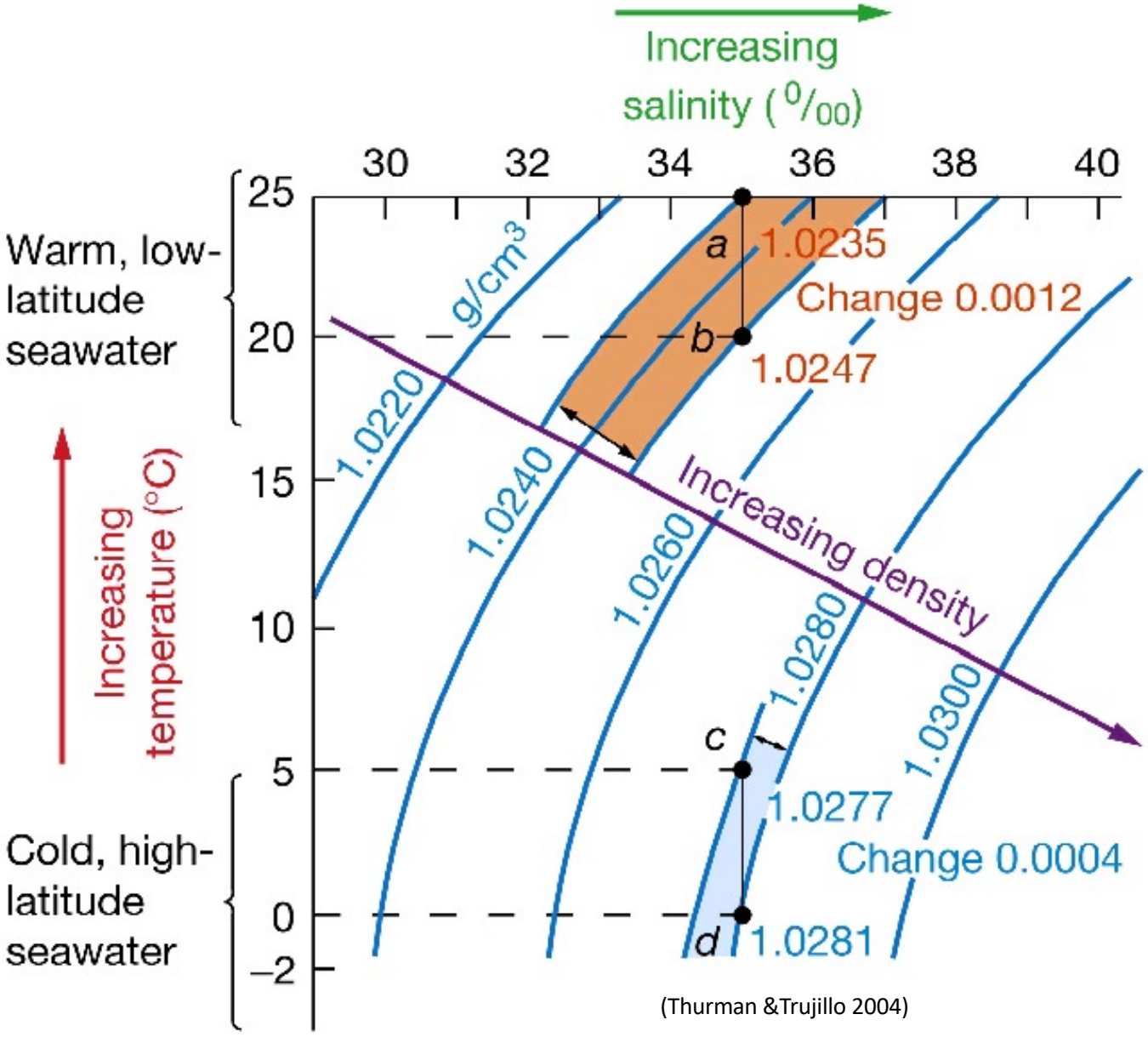
(Thurman &Trujillo 2004)

Oceanography: salinity, temperature, and density



- Salinity varies widely at the surface, but not in the deep ocean
- processes that affect seawater salinity occur at the surface:
  - precipitation
  - melting sea ice
  - evaporation
  - runoff
  - sea ice forming

Oceanography: salinity, temperature, and density



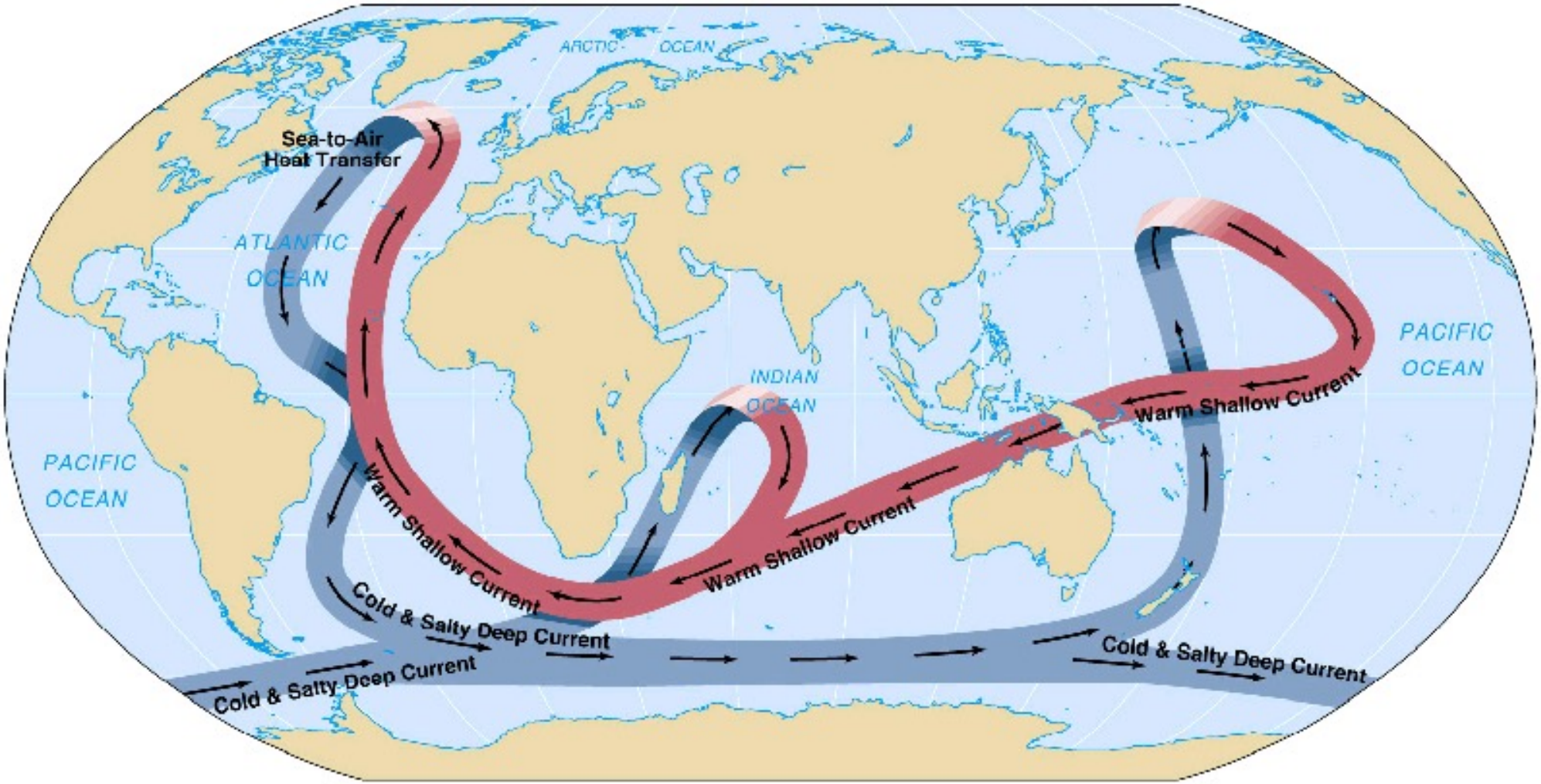
(Thurman &Trujillo 2004)

- ↑ temperature
  ↓ density
  ⇨ thermal expansion

- ↑ salinity
  ↑ density
  ⇨ more dissolved material

- ↑ pressure
  ↑ density
  ⇨ compression

Oceanography: salinity, temperature, and density



Thermo-haline circulation: global conveyer-belt

(Thurman &Trujillo 2004)

Oceanography: salinity, temperature, and density

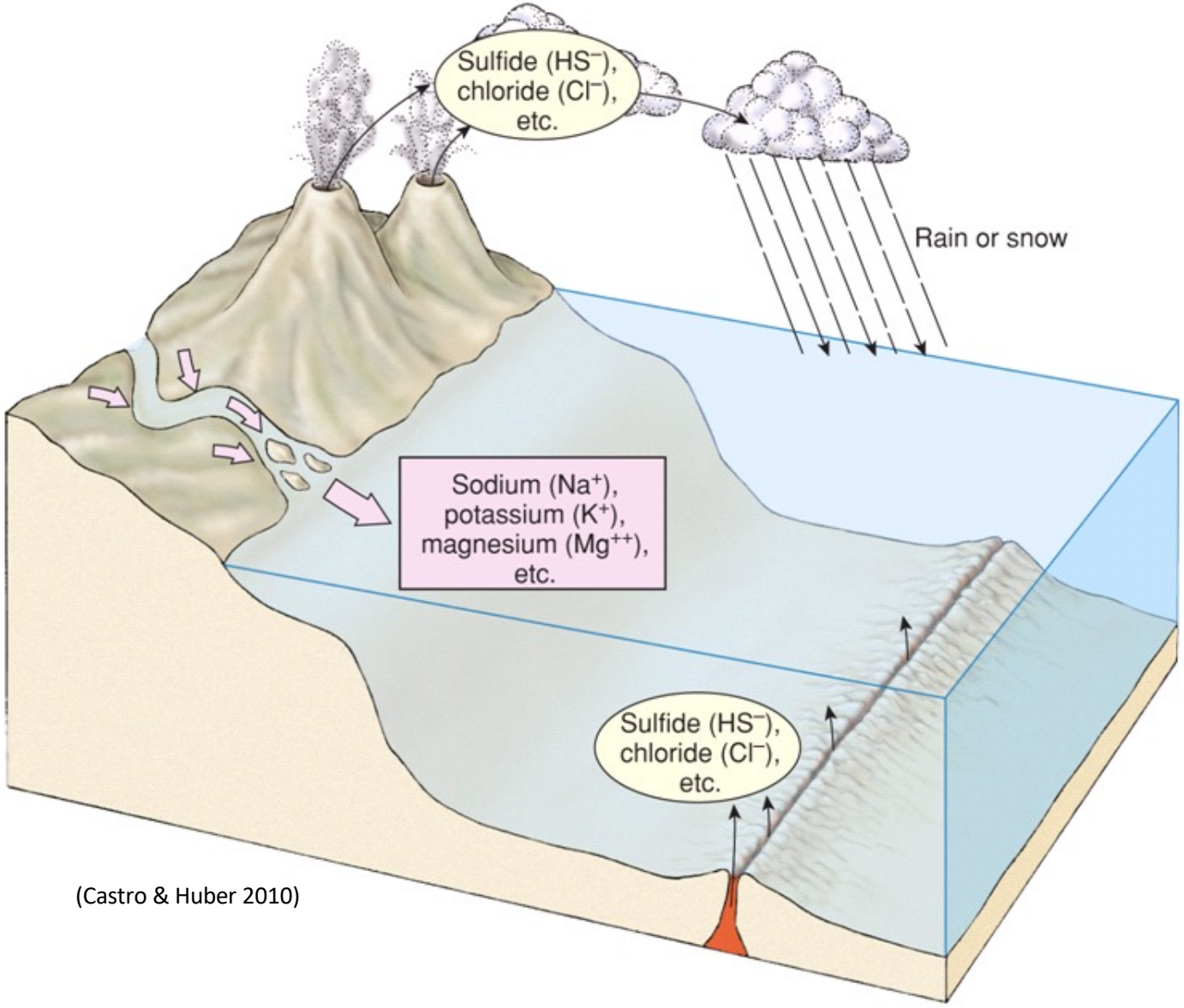
How to make a perfect Latte Macchiato?

- ↓ temperature of milk
- Fill milk and milk foam into the glass
- ↑ temperature of espresso
- Carefully pour espresso into the glass

A matter of densities:

- Milk foam has the lowest density
- The hot espresso has a higher density than the milk foam, but a lower density than the milk
- the milk has the highest density (more dissolved substances and cooler)

Oceanography: salinity, temperature, and density



(Castro & Huber 2010)

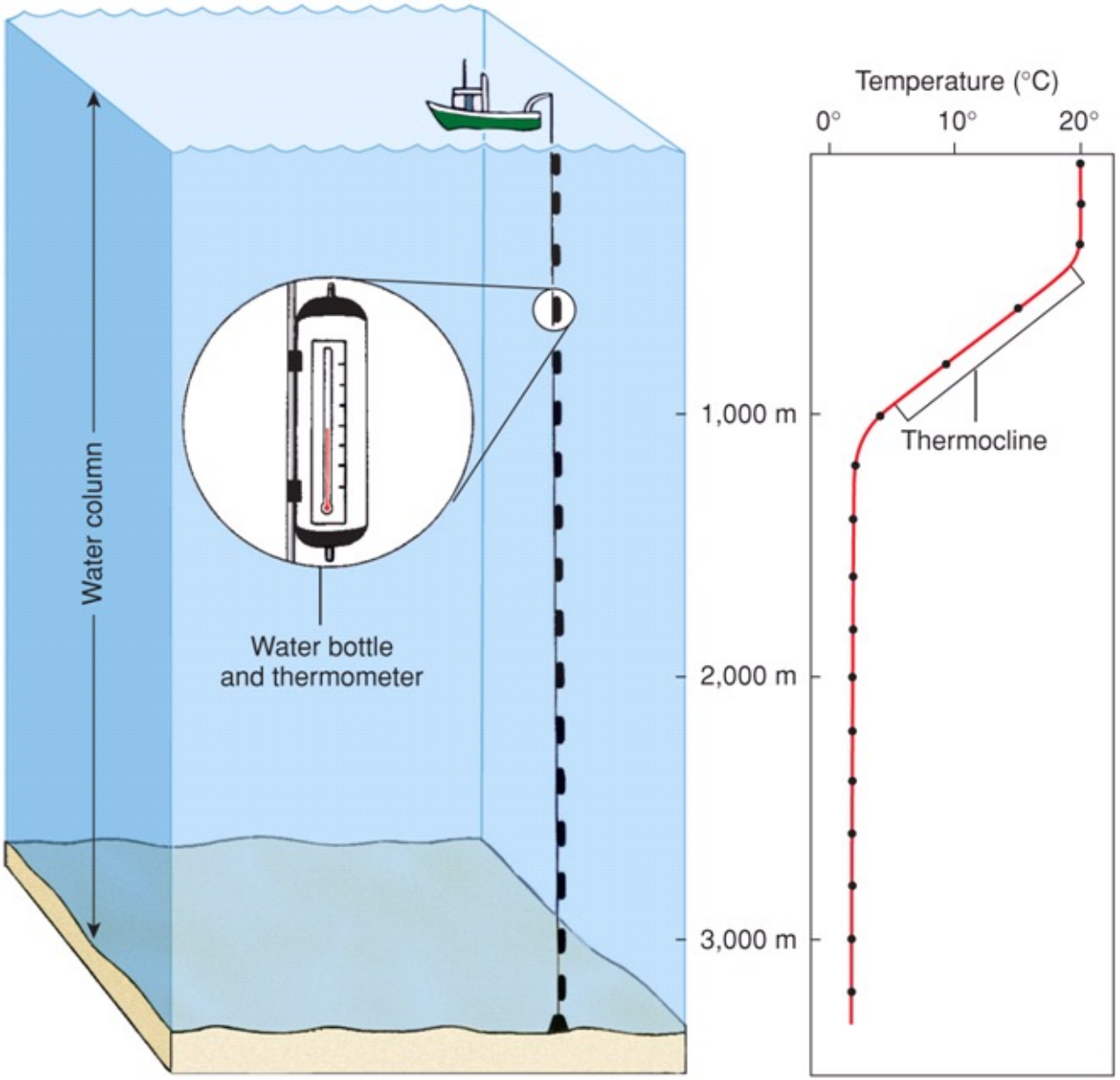
- Rule of constant proportions of ions in seawater of the open ocean
- Discovered by William Dittmar, analysing water samples from the *Challenger* expedition (1872-1876)

Oceanography: salinity, temperature, and density

Niskin bottle with thermometer

Sampling with a Niskin bottle

Oceanography: salinity, temperature, and density



- Temperature profile
- Temperature range in the open ocean: -2 to +30 ° C
- Seawater does not freeze at 0 ° C due to the salt

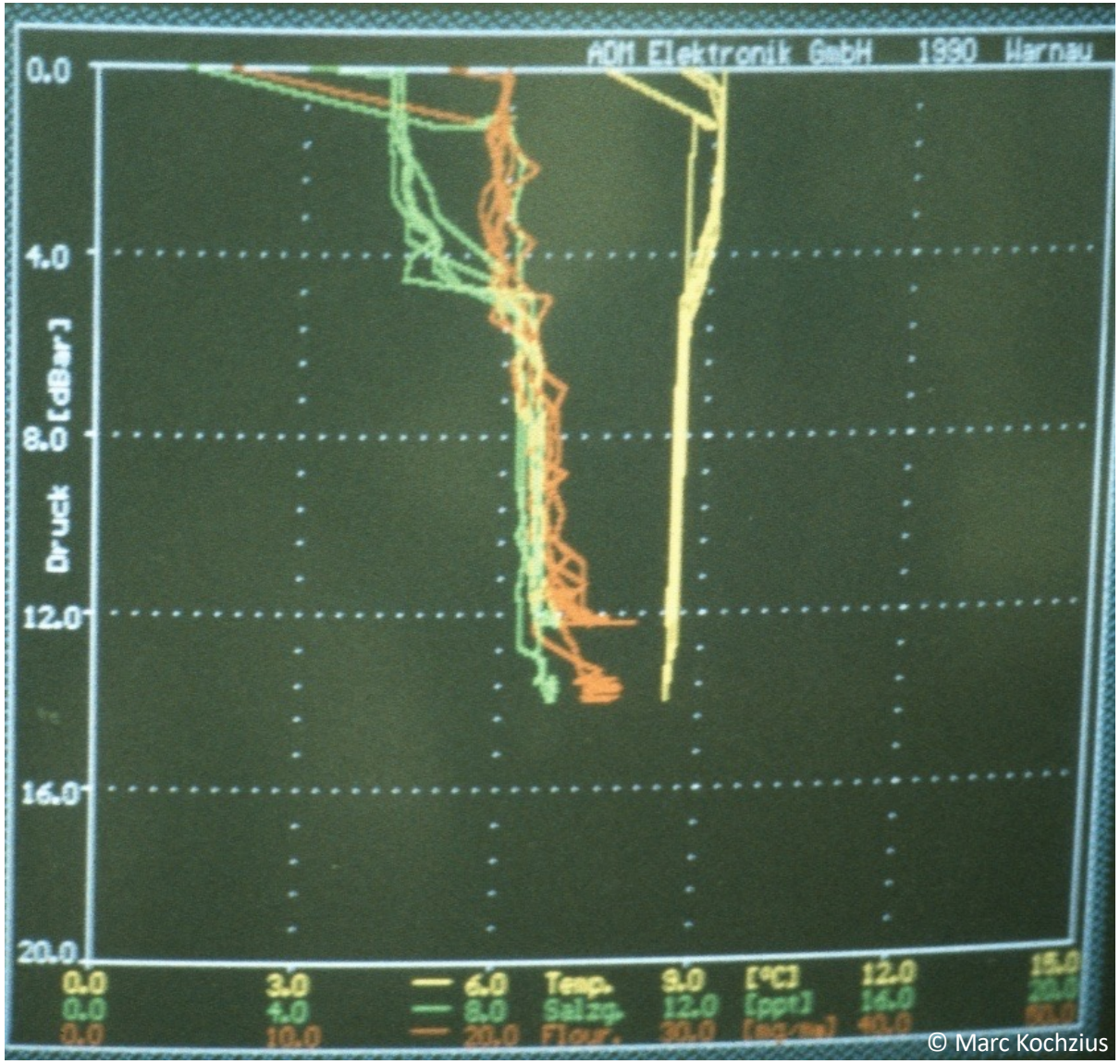
(Castro & Huber 2010)

Oceanography: salinity, temperature, and density

CTD (**C**onductivity-**T**emperature-**D**epth meter)

Oceanography: salinity, temperature, and density

Rosette with CTD and Niskin bottles



Temperature, salinity, and turbidity

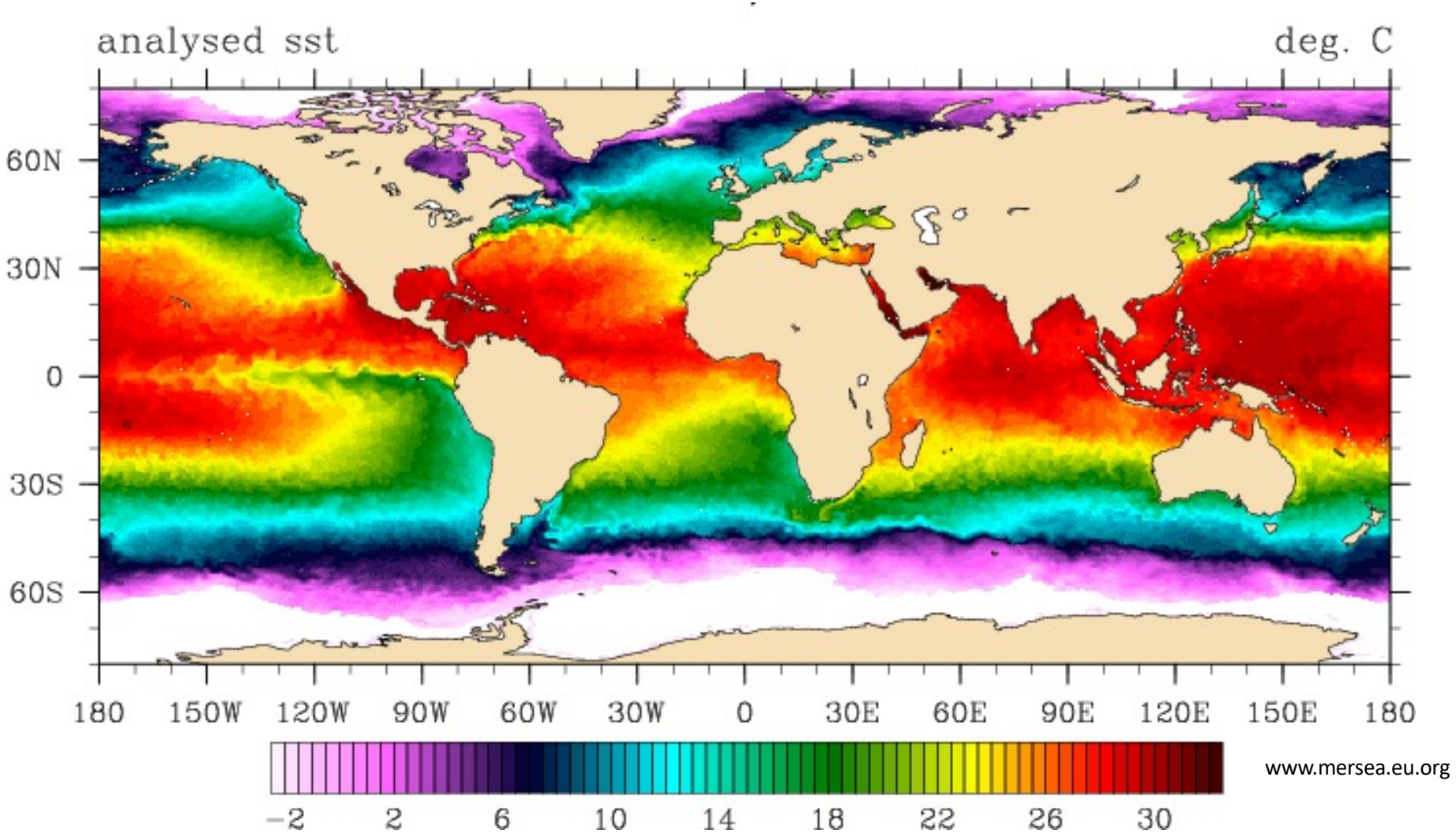
Oceanography: salinity, temperature, and density

Rosette with CTD and Niskin bottles on RV *Polarstern*

Oceanography: salinity, temperature, and density

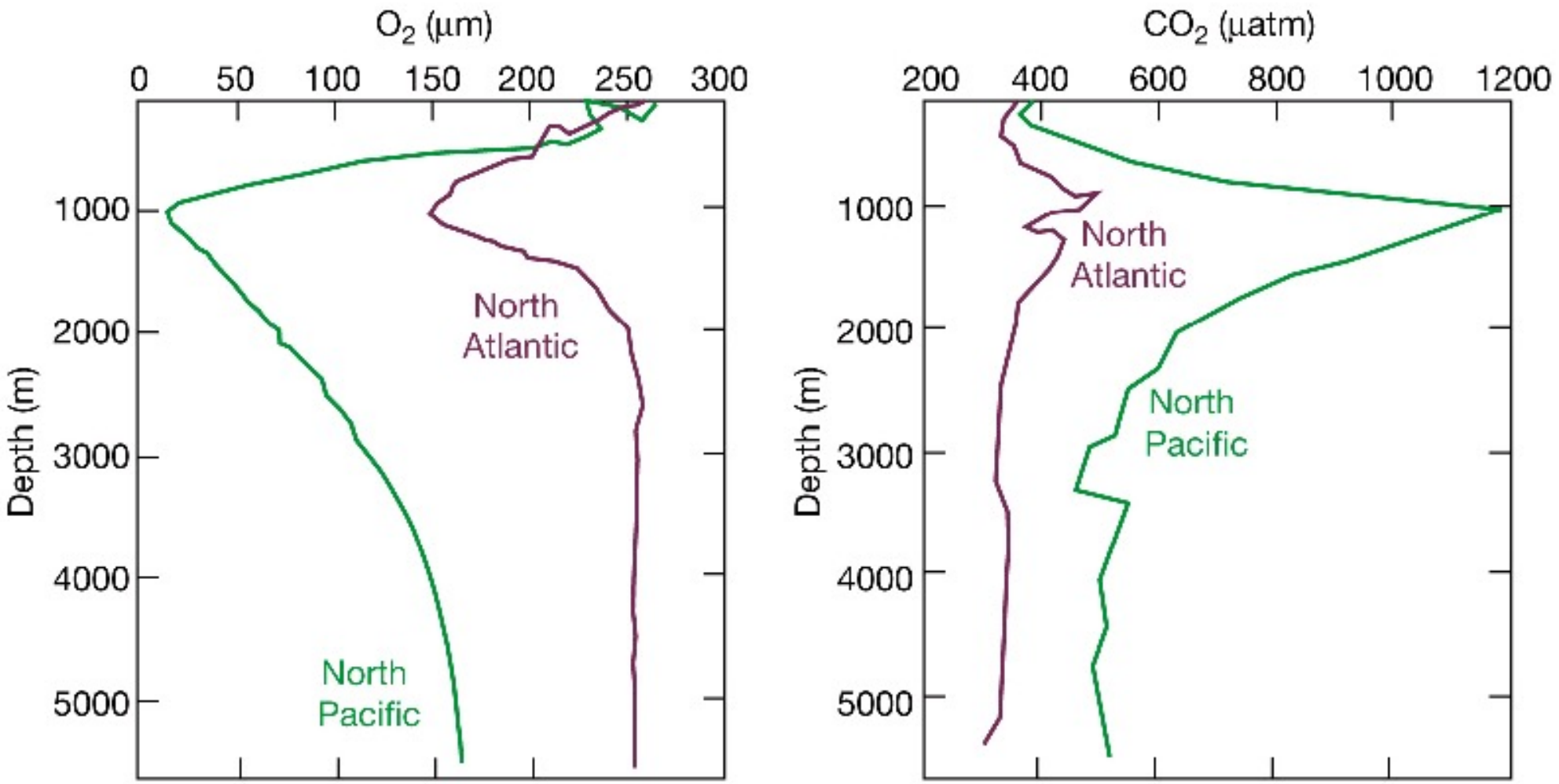
Rosette with CTD and Niskin bottles on RV *Polarstern*

Oceanography: salinity, temperature, and density



Daily gap-free map of sea surface temperature at 10 km resolution, using infra-red and microwave satellite sensors

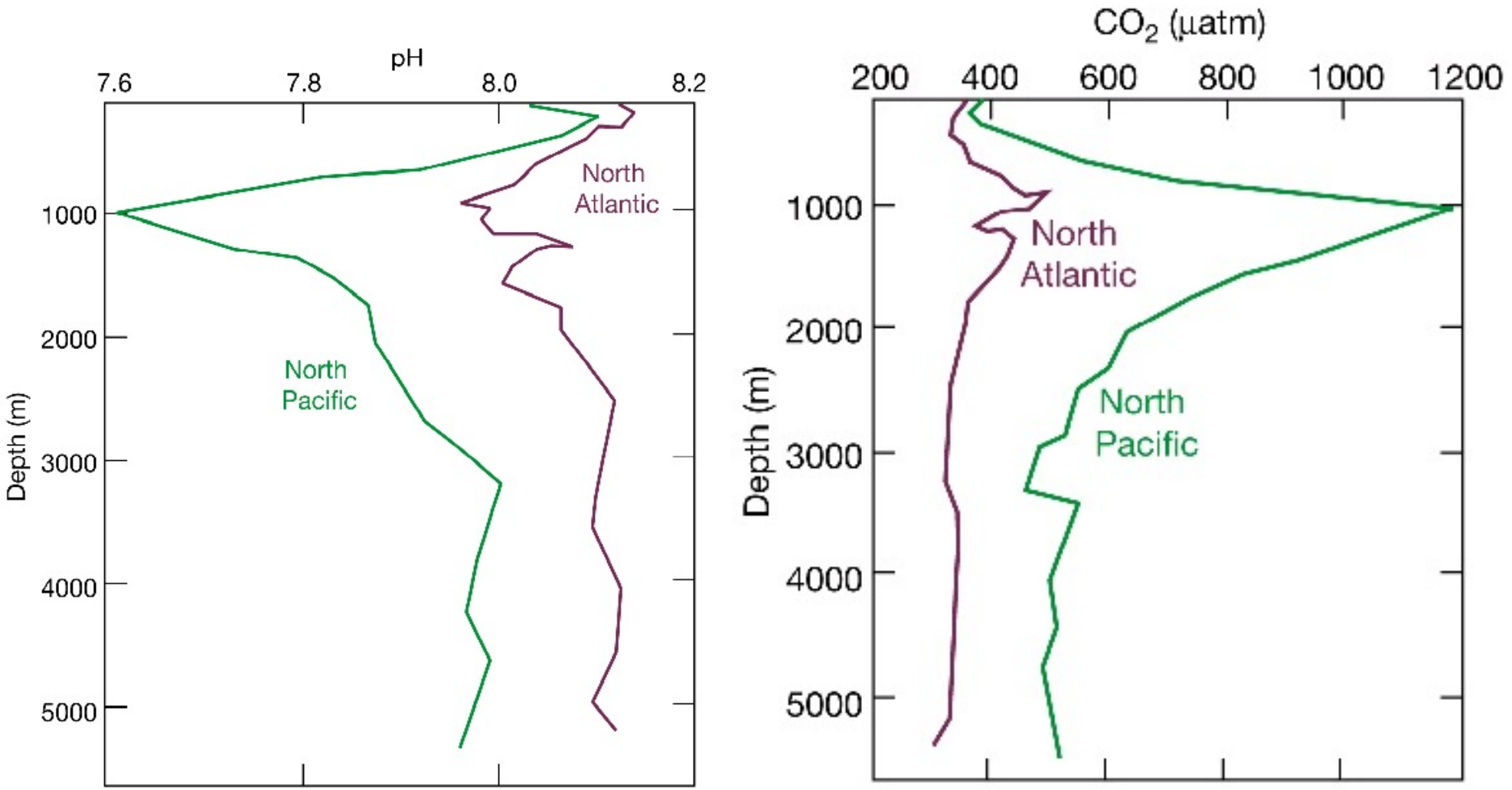
Oceanography: dissolved gases



Seawater dissolved oxygen and carbon dioxide variation with depth

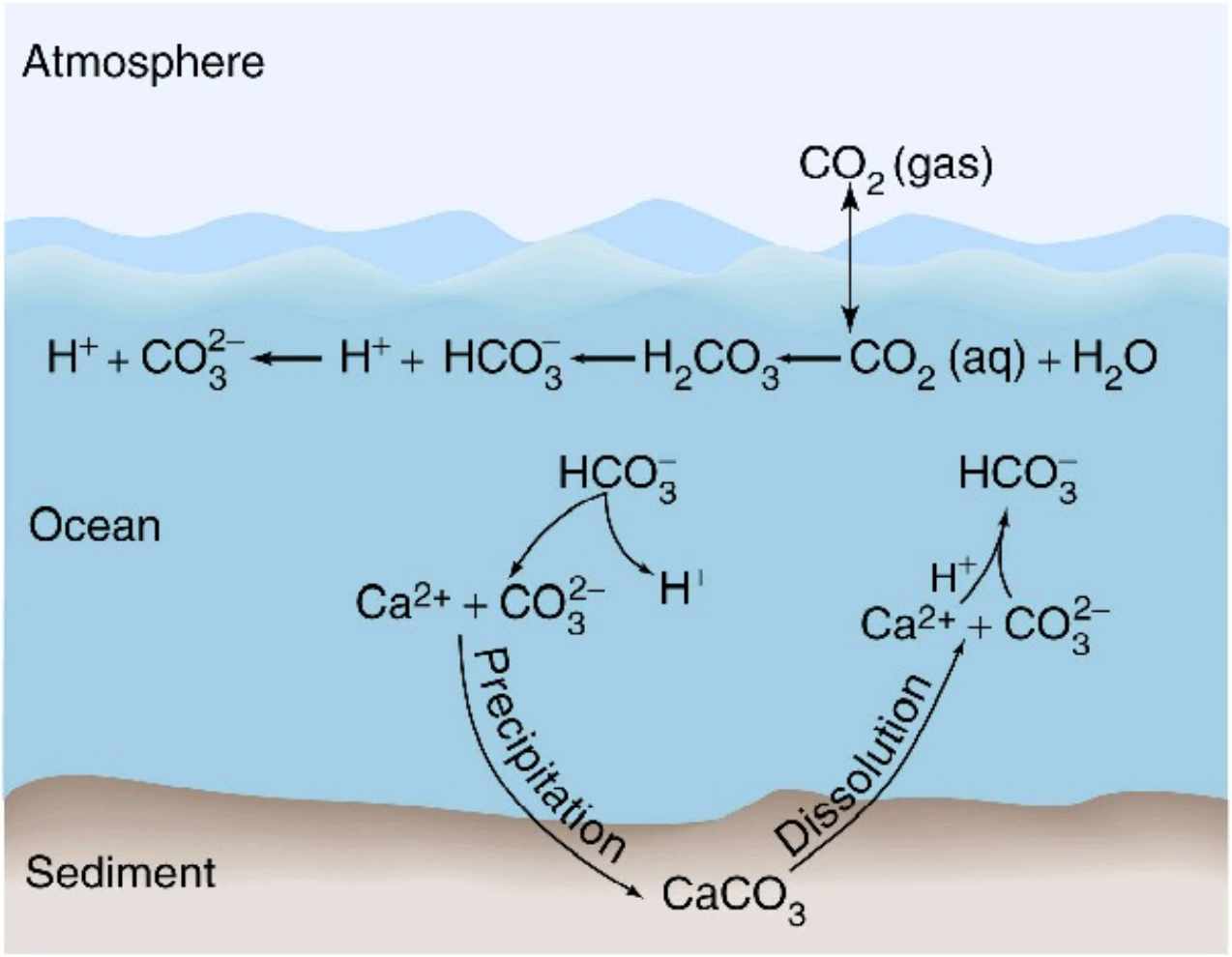
(Thurman &Trujillo 2004)

Oceanography: acidity and alkalinity



Seawater pH and dissolved carbon dioxide variation with depth

Oceanography: acidity and alkalinity



Carbonate buffering system

- H_2CO_3: carbonic acid
- HCO_3^-: bicorbonate
- CO_3^{2-}: carbonate
- $CaCO_3$: calcium carbonate

Ocean acidification

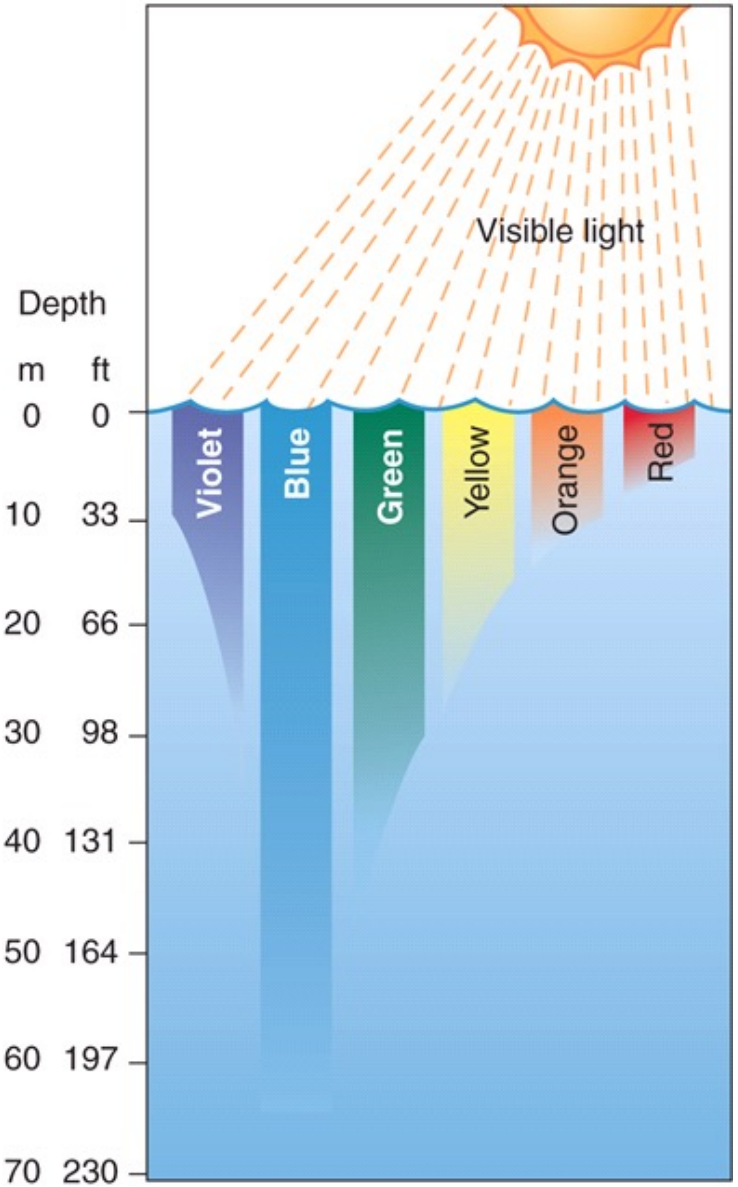
- Dissolution of calcium carbonate (aragonite) skeletons (e.g. corals) and shells (e.g. bivalves and snails)
- Reduced precipitation

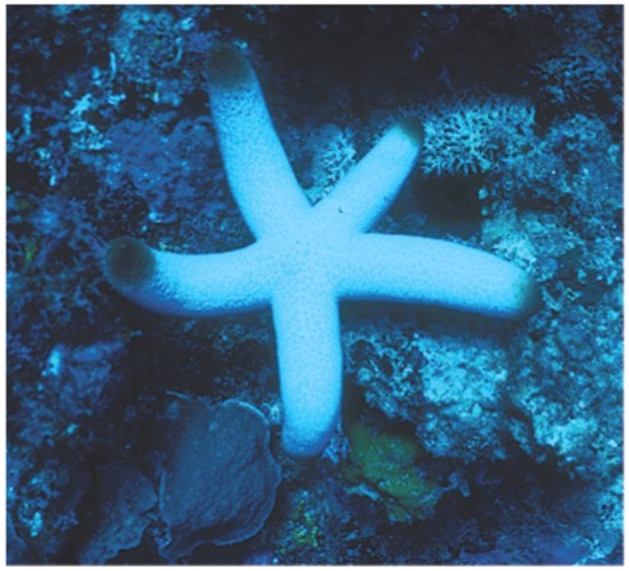
Seawater too basic: $H_2CO_3 \longrightarrow HCO_3^- + H^+$ pH drops

Seawater too acidic: $HCO_3^- + H^+ \longrightarrow H_2CO_3$ pH rises

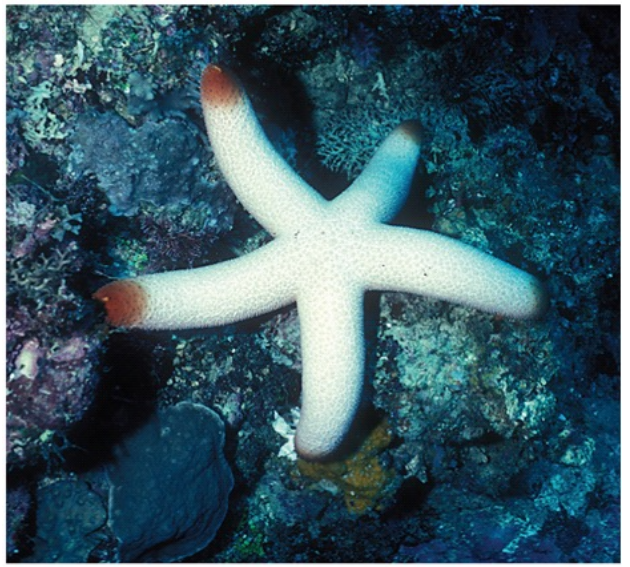
(Thurman &Trujillo 2004)

Oceanography: light





30 m depth without flash



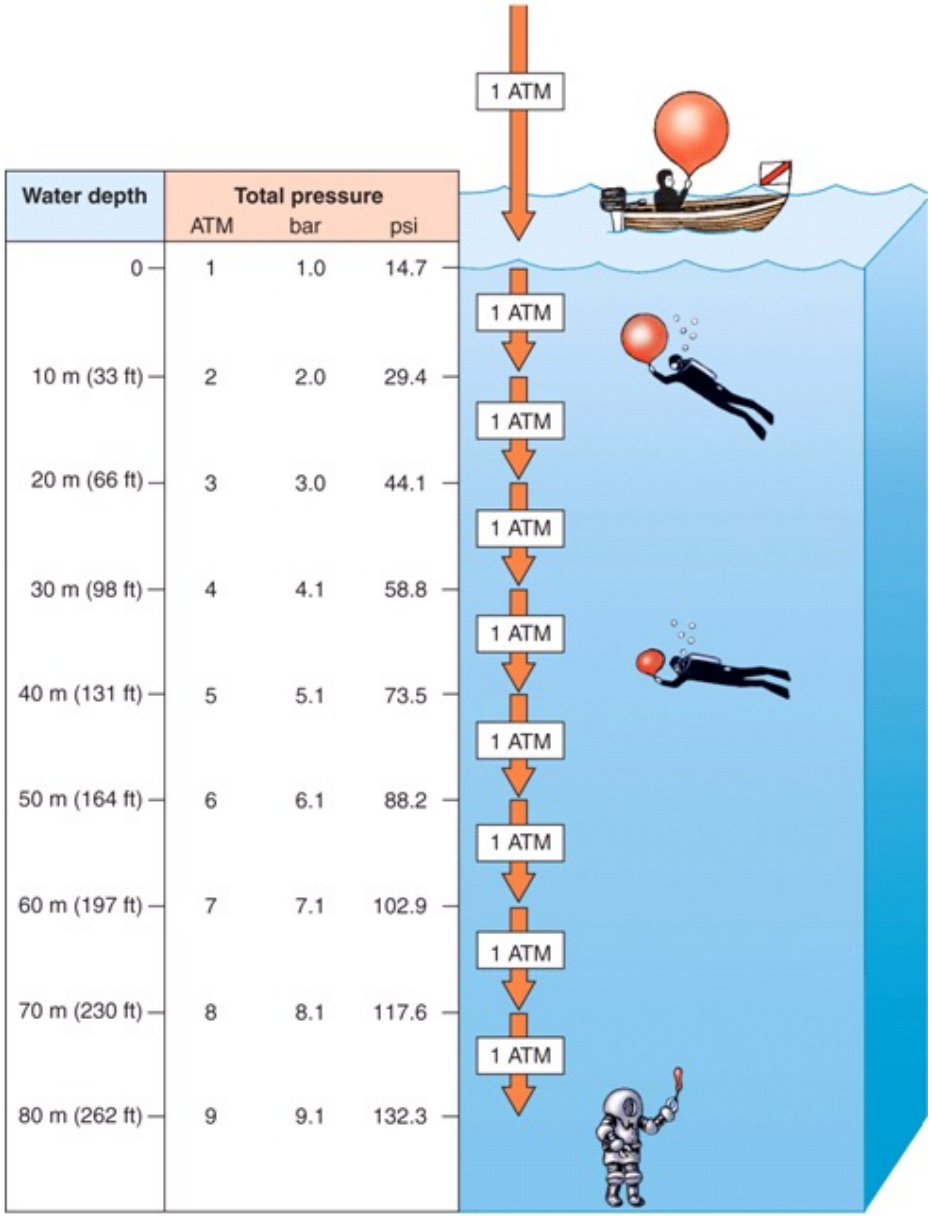
30 m depth with flash

(Castro & Huber 2010)

Oceanography: light

Secchi disc

Oceanography: pressure

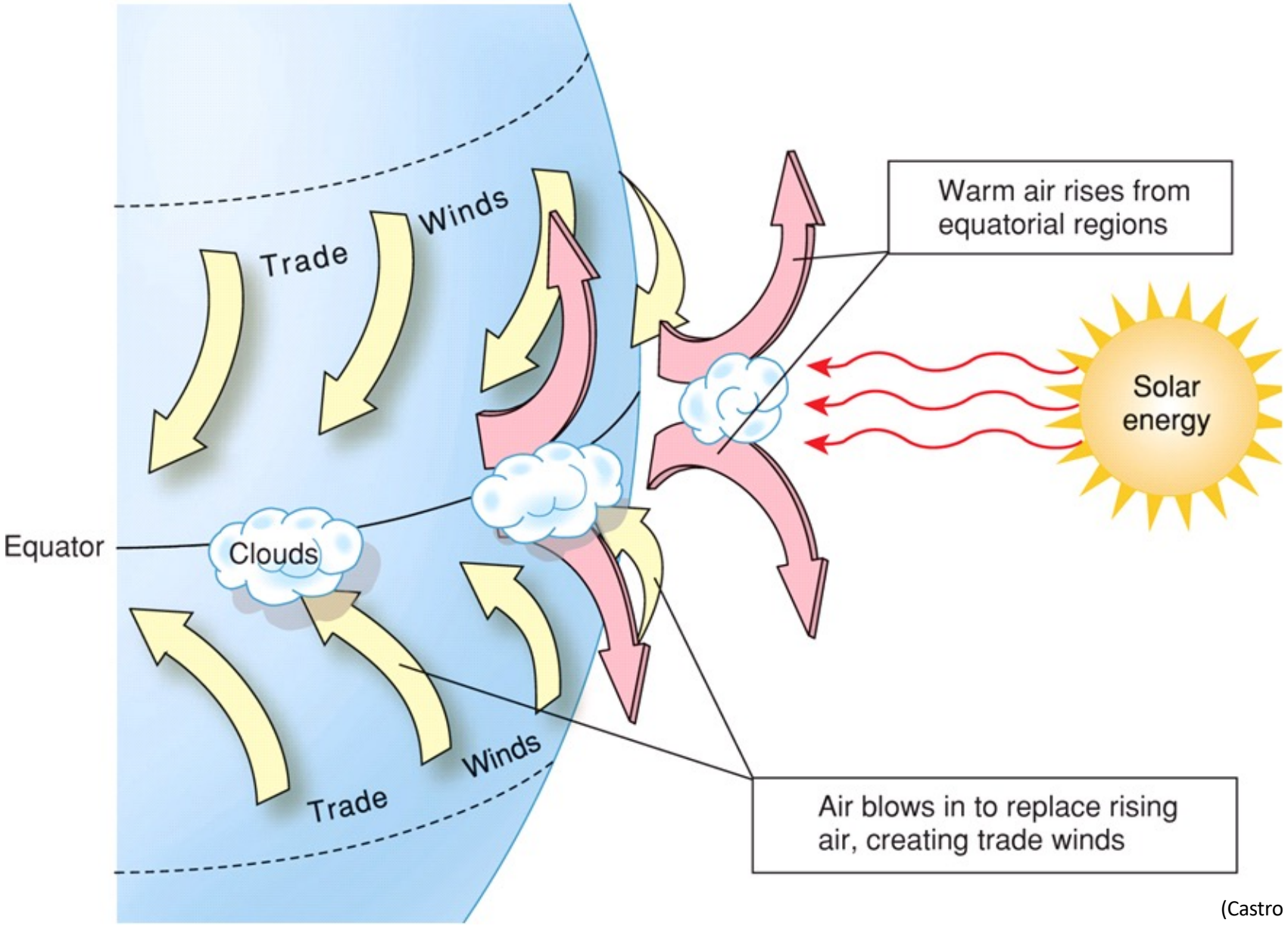


Water depth	Total pressure ATM	bar	psi
0	1	1.0	14.7
10 m (33 ft)	2	2.0	29.4
20 m (66 ft)	3	3.0	44.1
30 m (98 ft)	4	4.1	58.8
40 m (131 ft)	5	5.1	73.5
50 m (164 ft)	6	6.1	88.2
60 m (197 ft)	7	7.1	102.9
70 m (230 ft)	8	8.1	117.6
80 m (262 ft)	9	9.1	132.3

Pushed out stomach by the expanding swim bladder

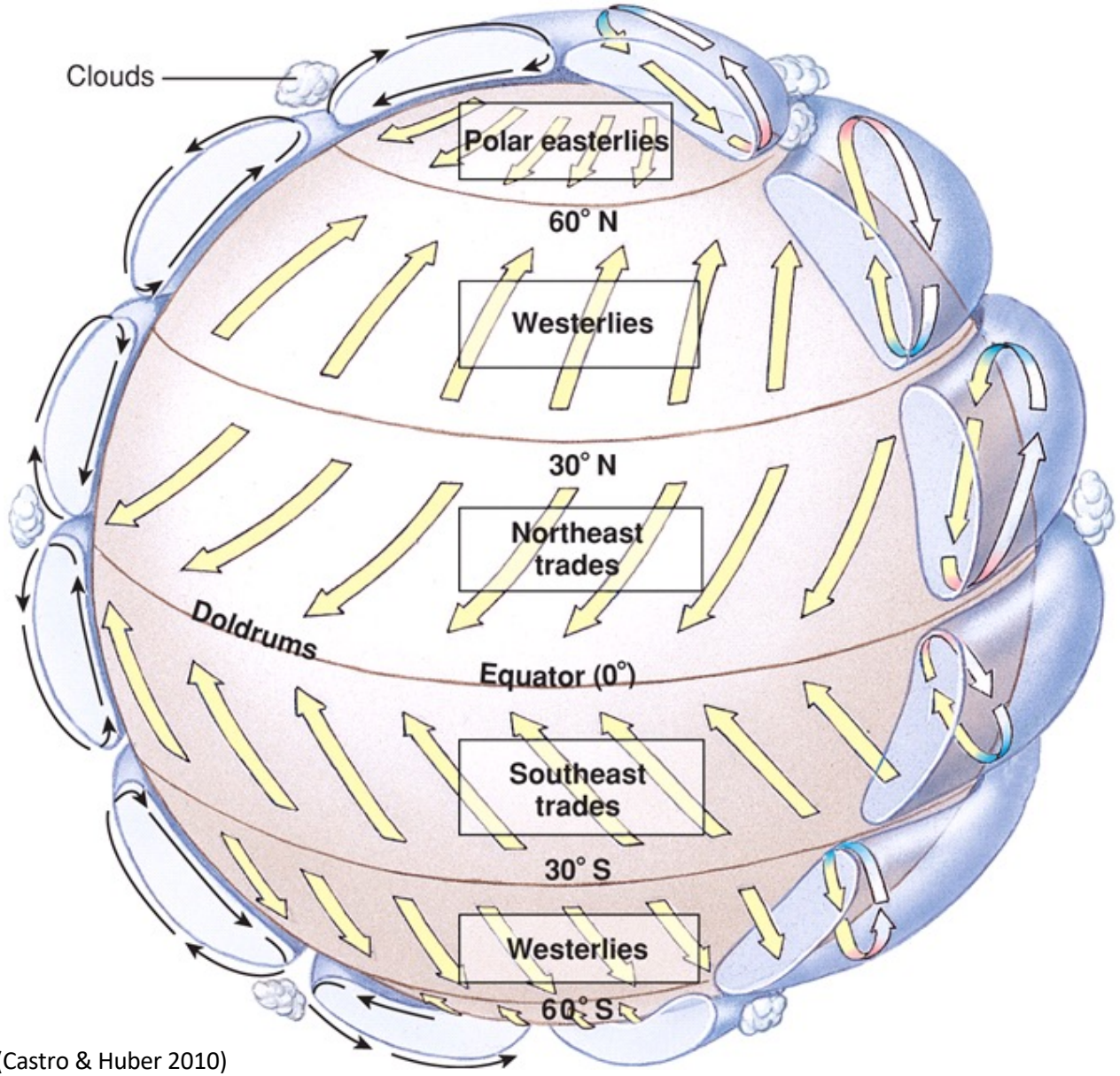
(Castro & Huber 2010)

Oceanography: wind patterns



(Castro & Huber 2010)

Oceanography: wind patterns

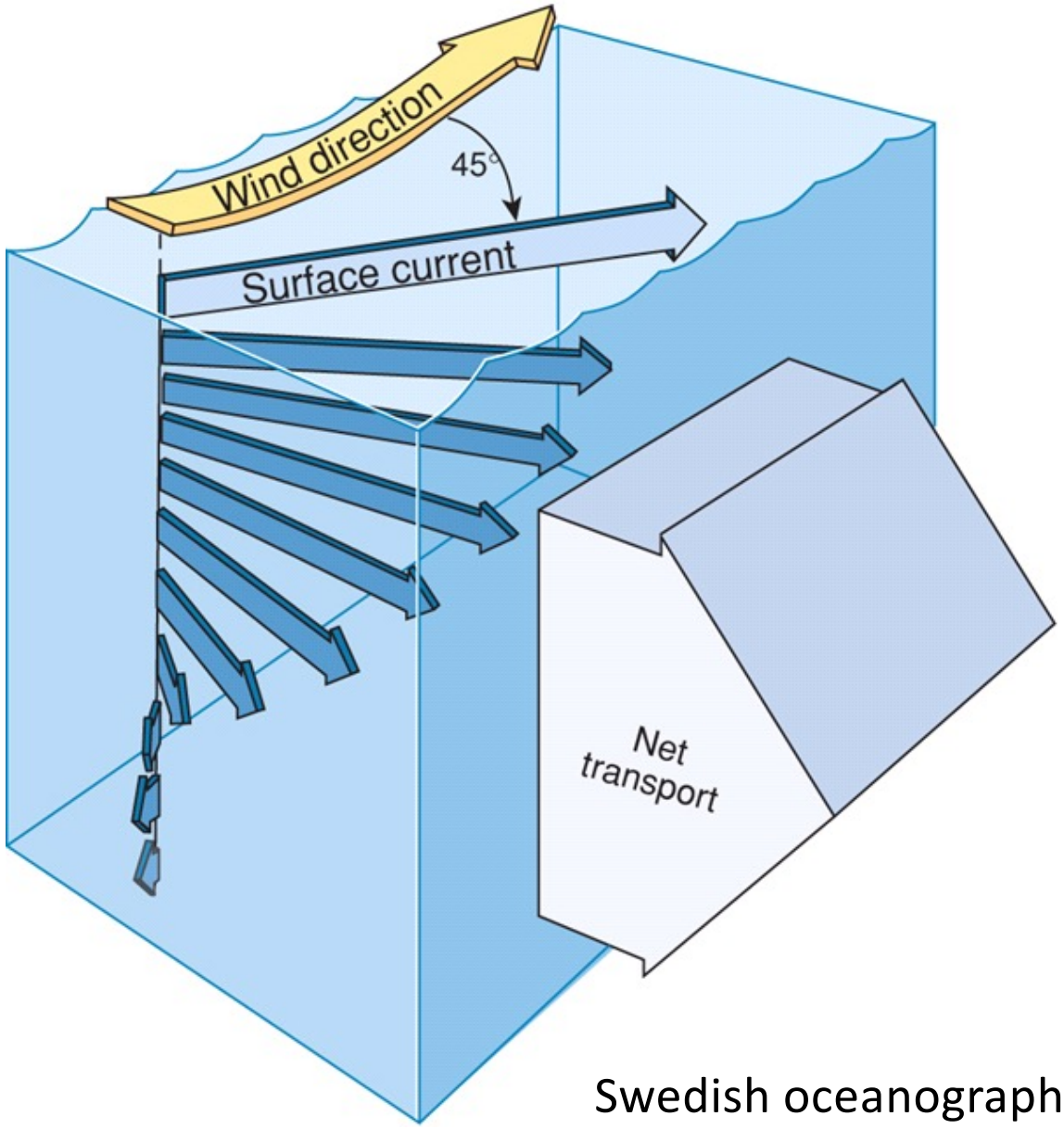


(Castro & Huber 2010)

Coriolis effect

- Deflection of moving objects due to spinning of Earth
- Winds and currents are deflected by 45° to the right on the northern and to the left on the southern hemisphere

Oceanography: currents



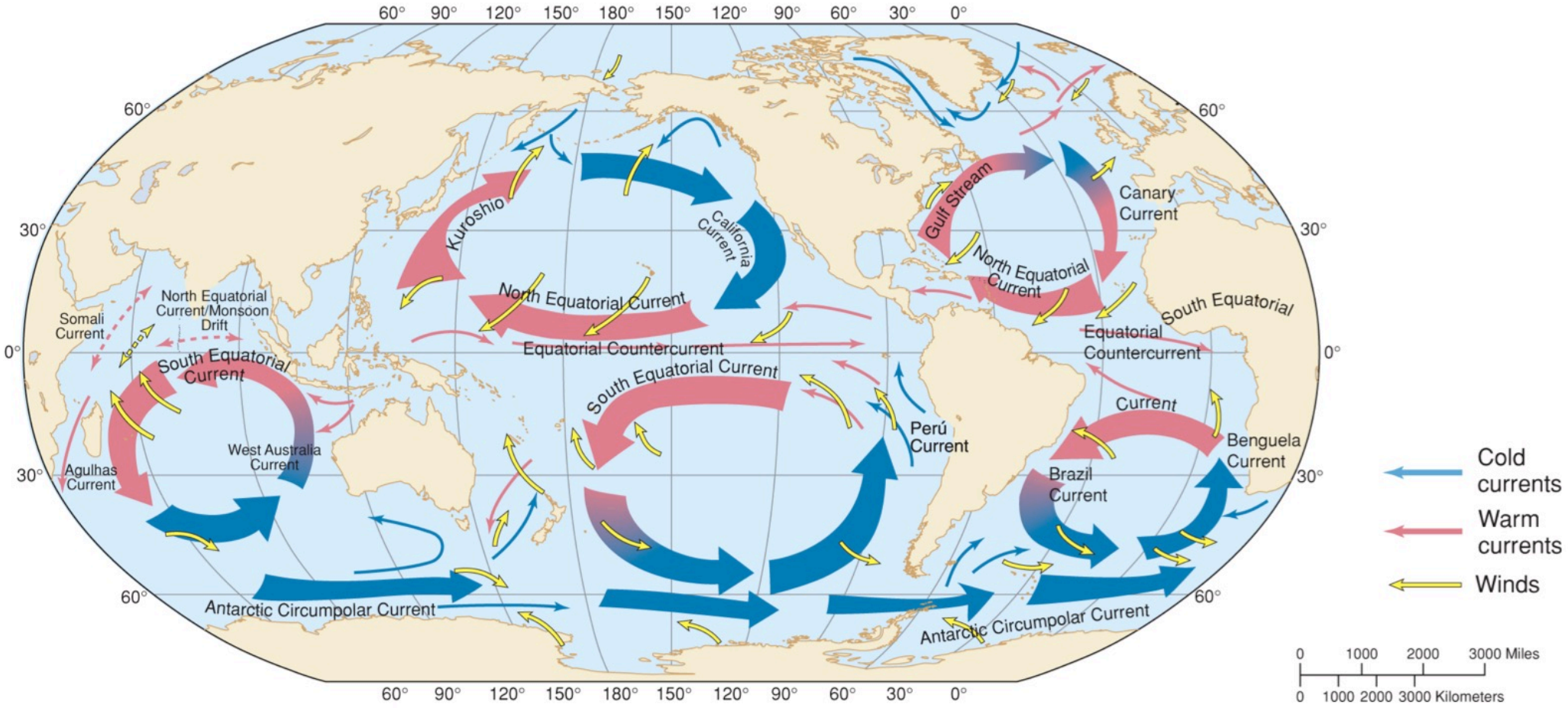
(Castro & Huber 2010)

Ekman spiral

- Deflection due to Coriolis effect
- **Ekman layer**: water body affected by wind
- **Ekman transport**: 90° to wind direction

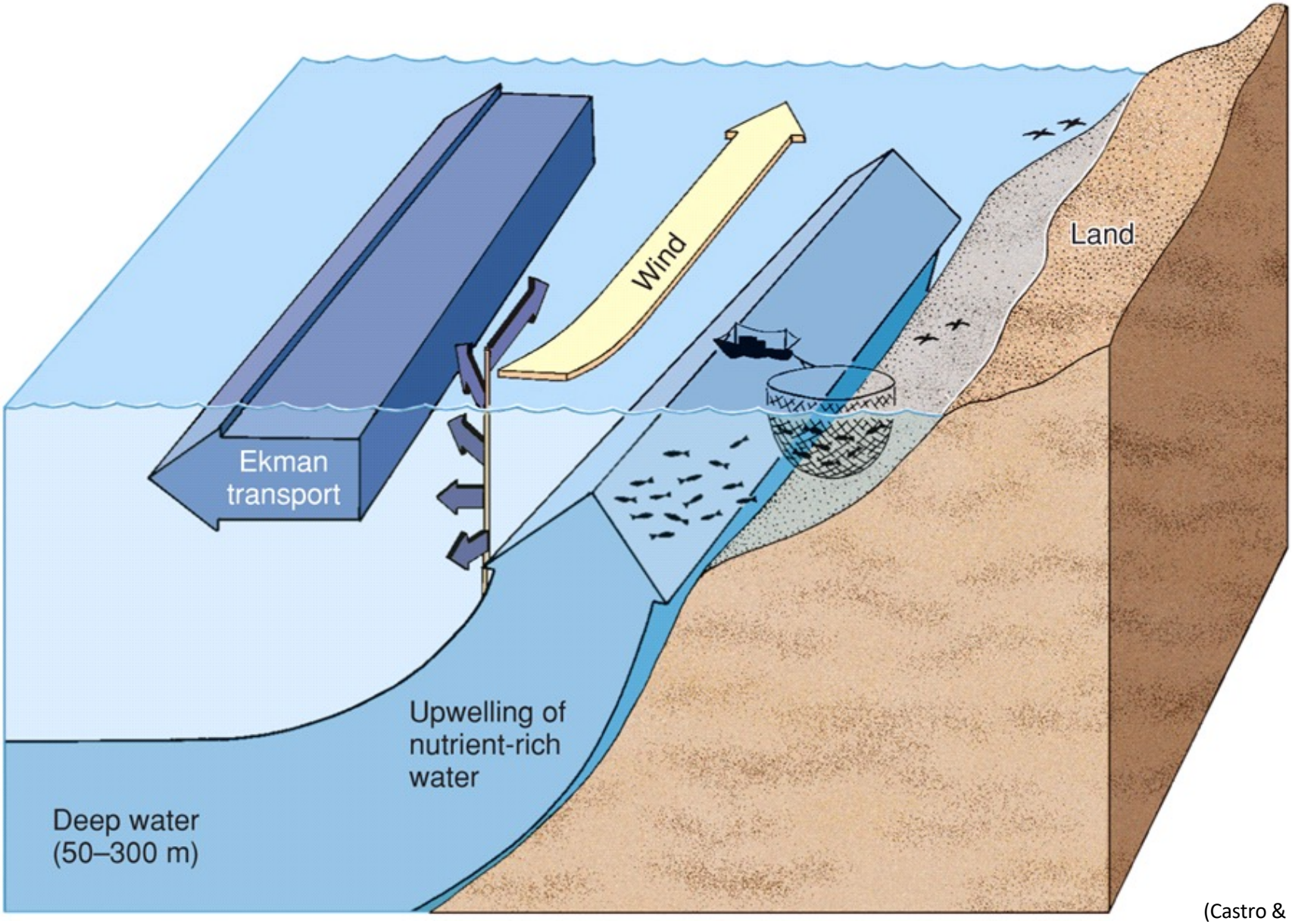
Swedish oceanographer Vagn Walfrid Ekman (1874-1954)

Oceanography: currents



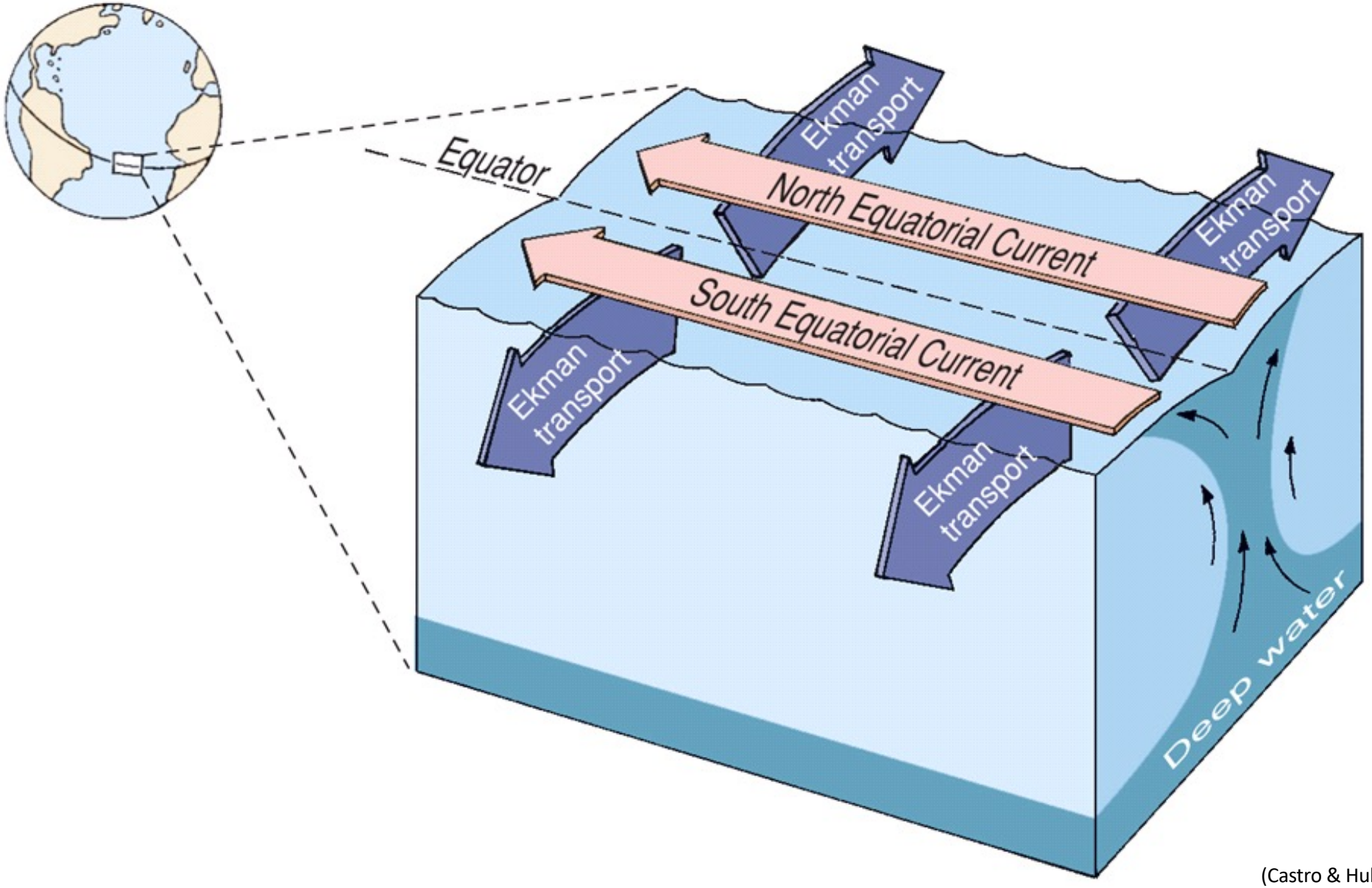
(Castro & Huber 2010)

Oceanography: currents



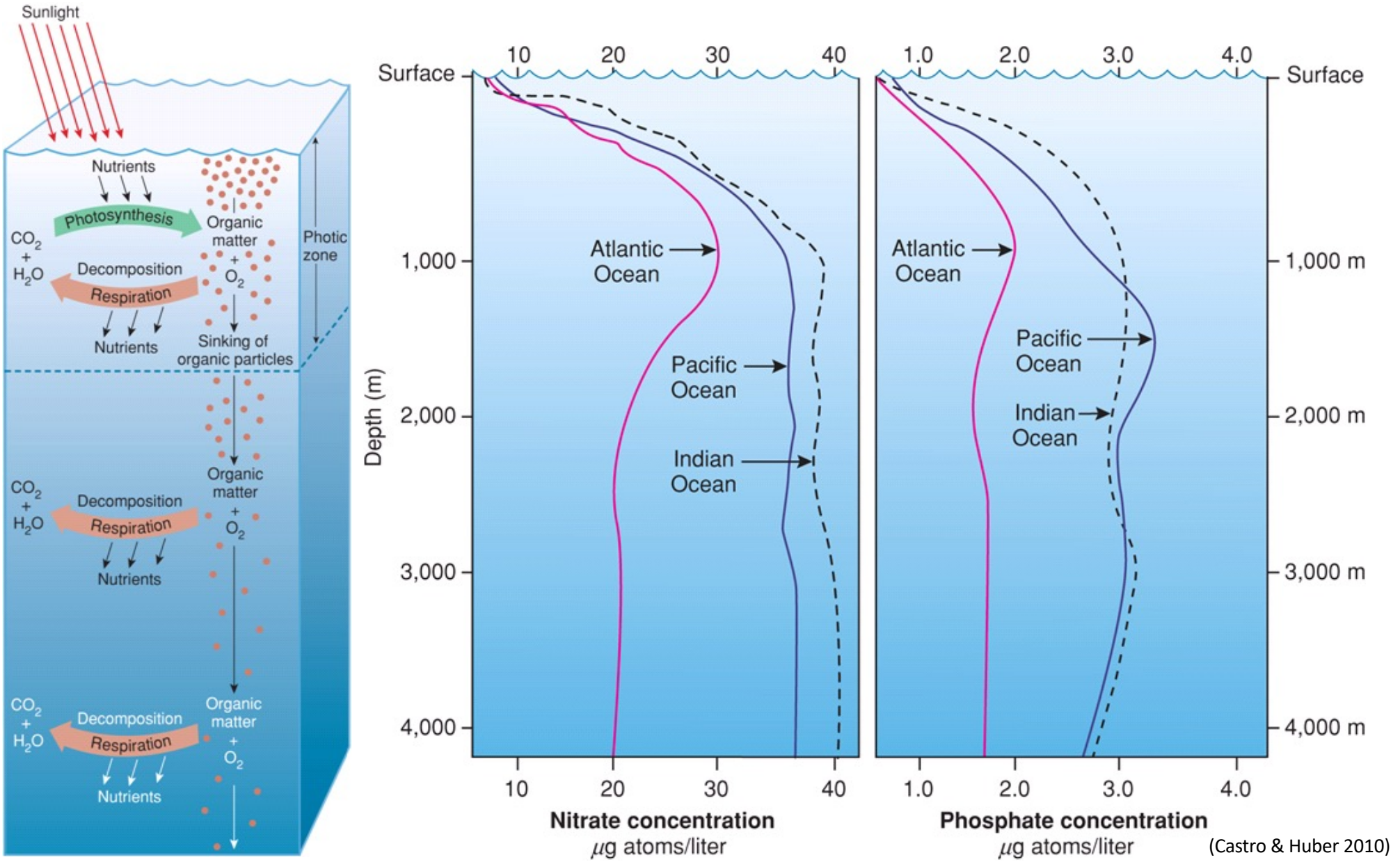
(Castro & Huber 2010)

Oceanography: currents



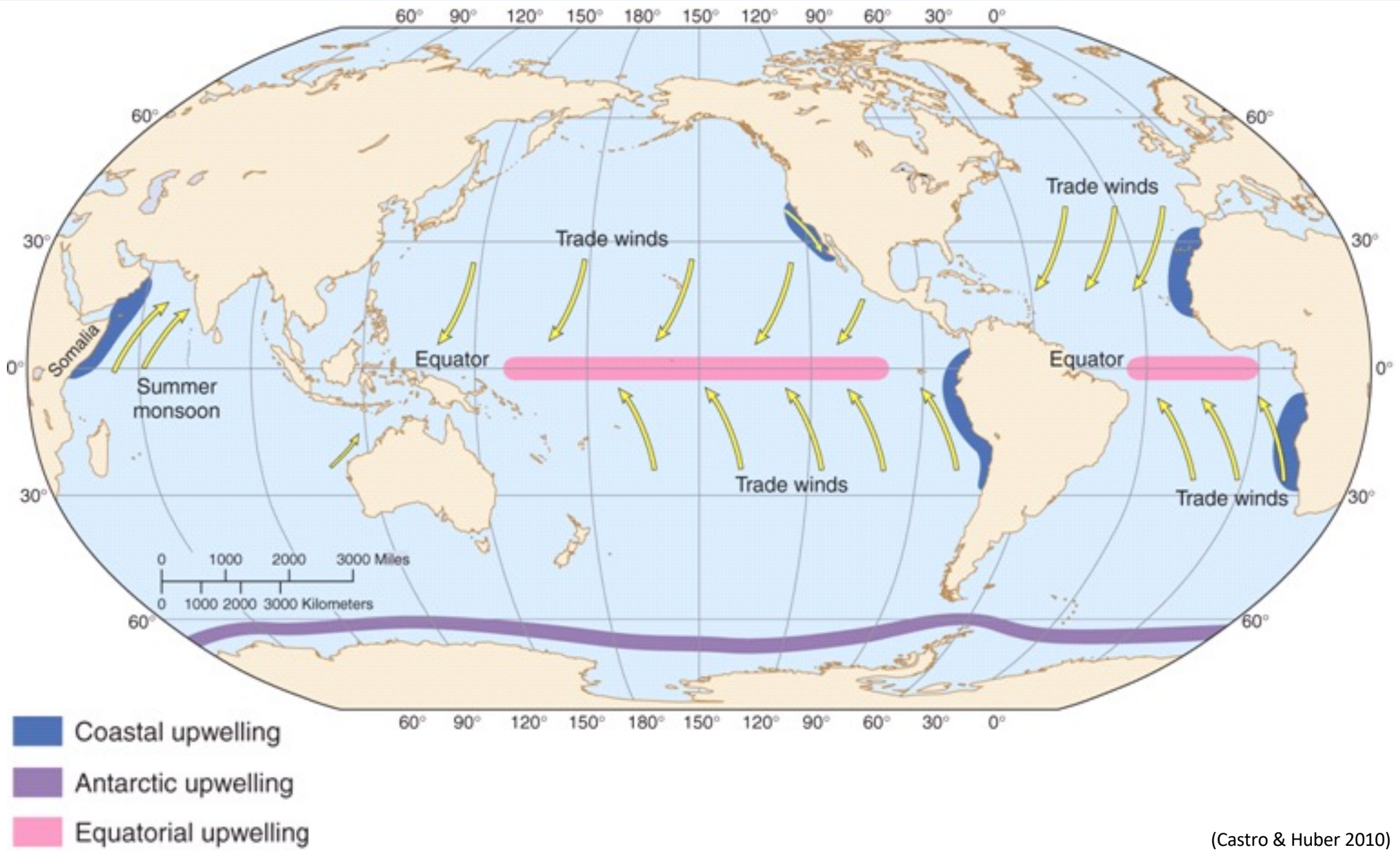
(Castro & Huber 2010)

Oceanography: nutrients



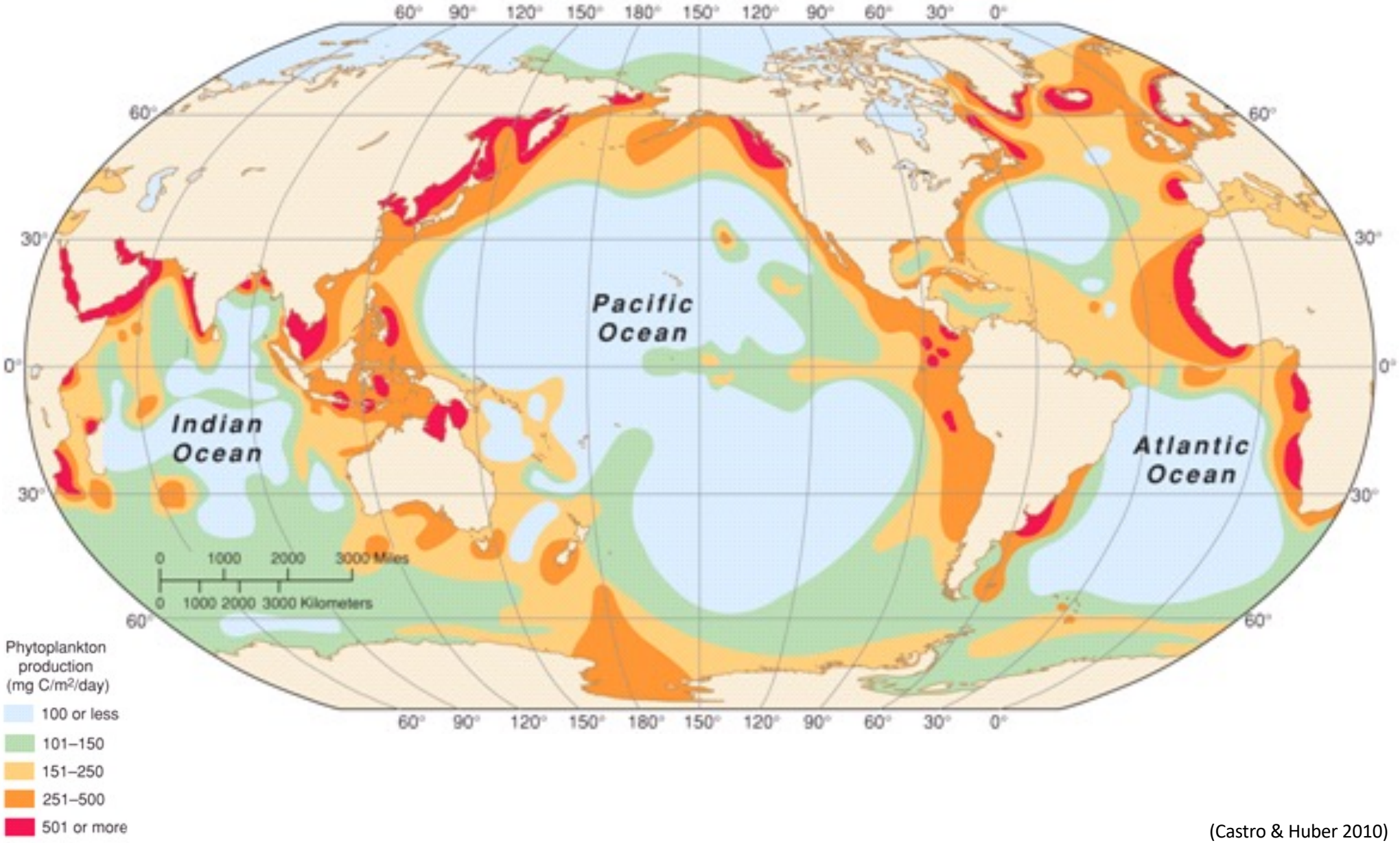
(Castro & Huber 2010)

Oceanography: upwelling



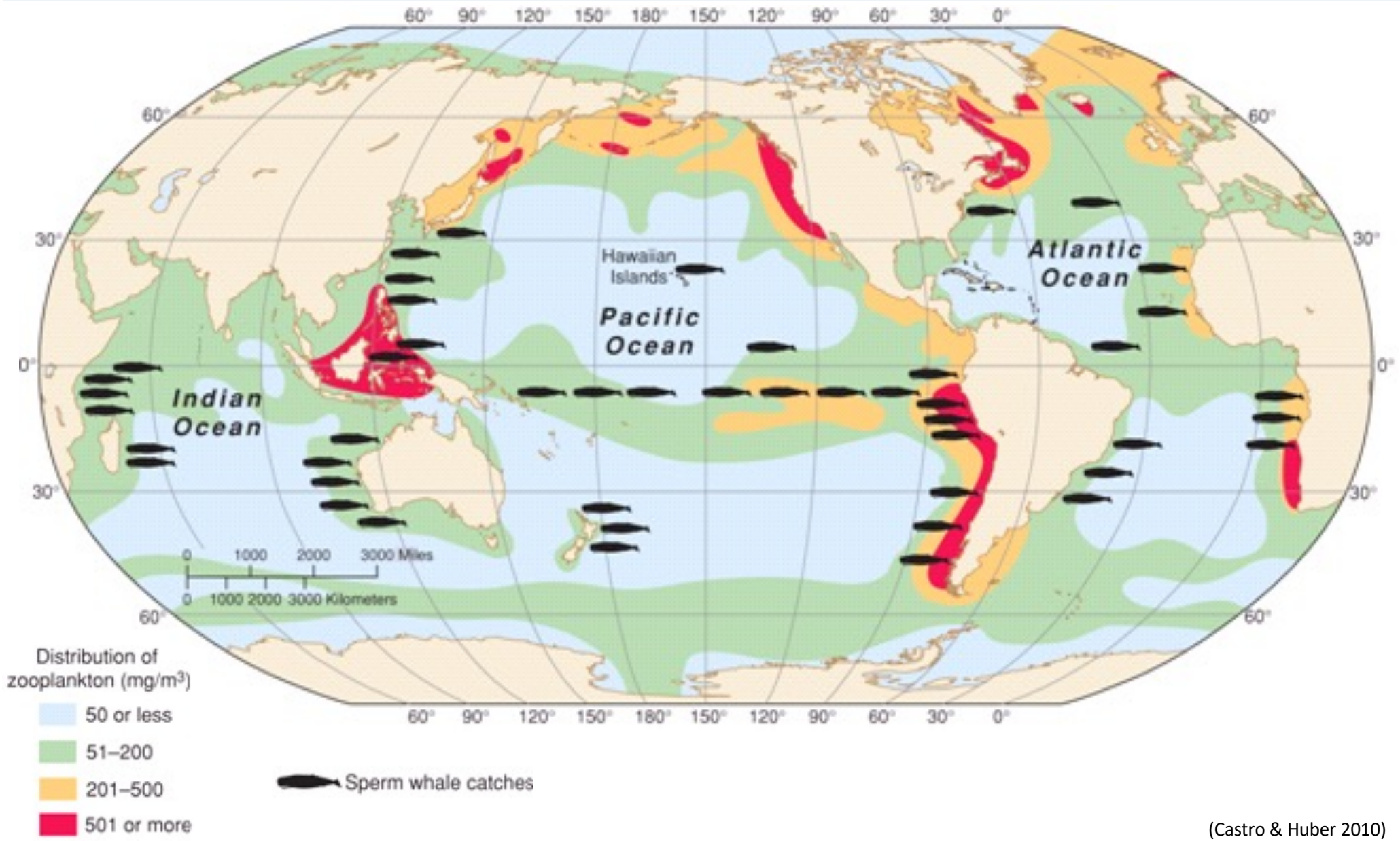
(Castro & Huber 2010)

Oceanography: primary production



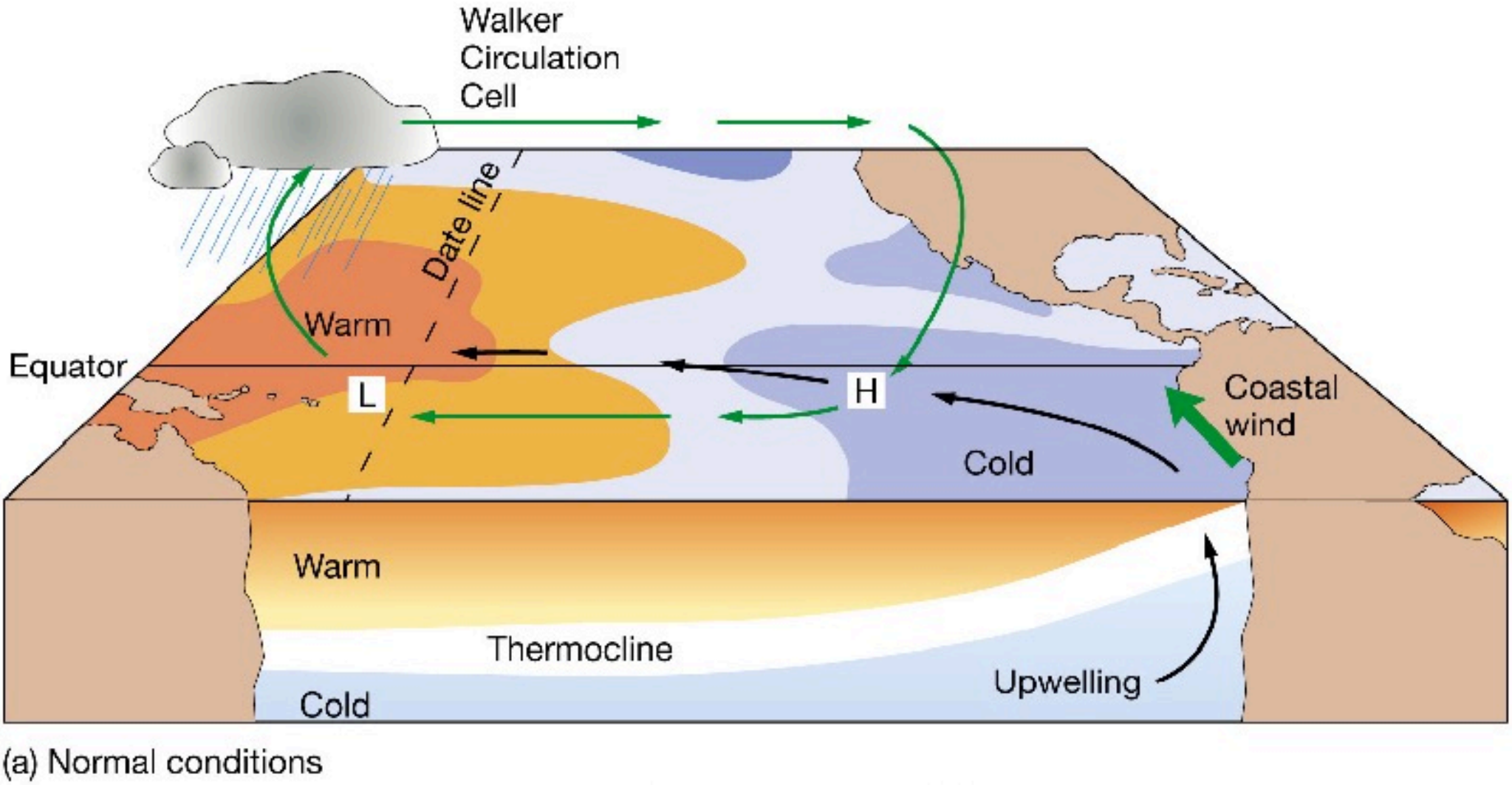
(Castro & Huber 2010)

Oceanography: secondary production



(Castro & Huber 2010)

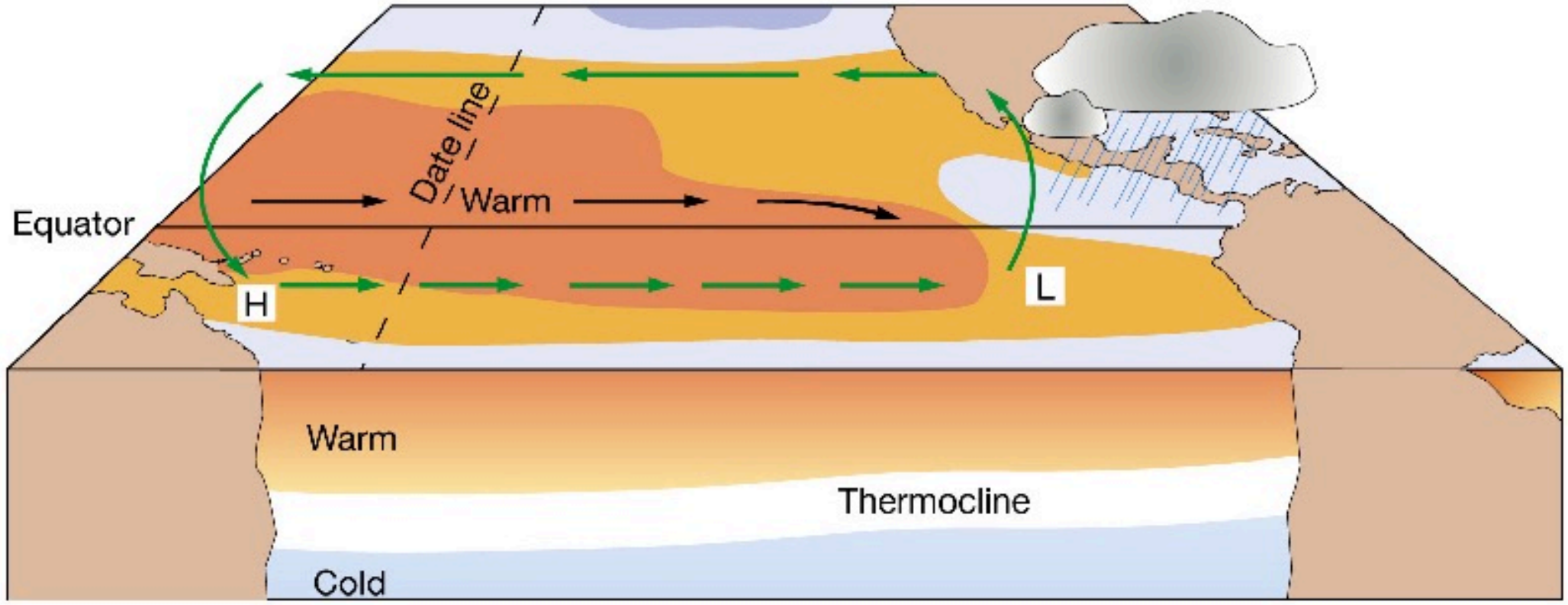
Oceanography: El Niño



(a) Normal conditions

(Thurman &Trujillo 2004)

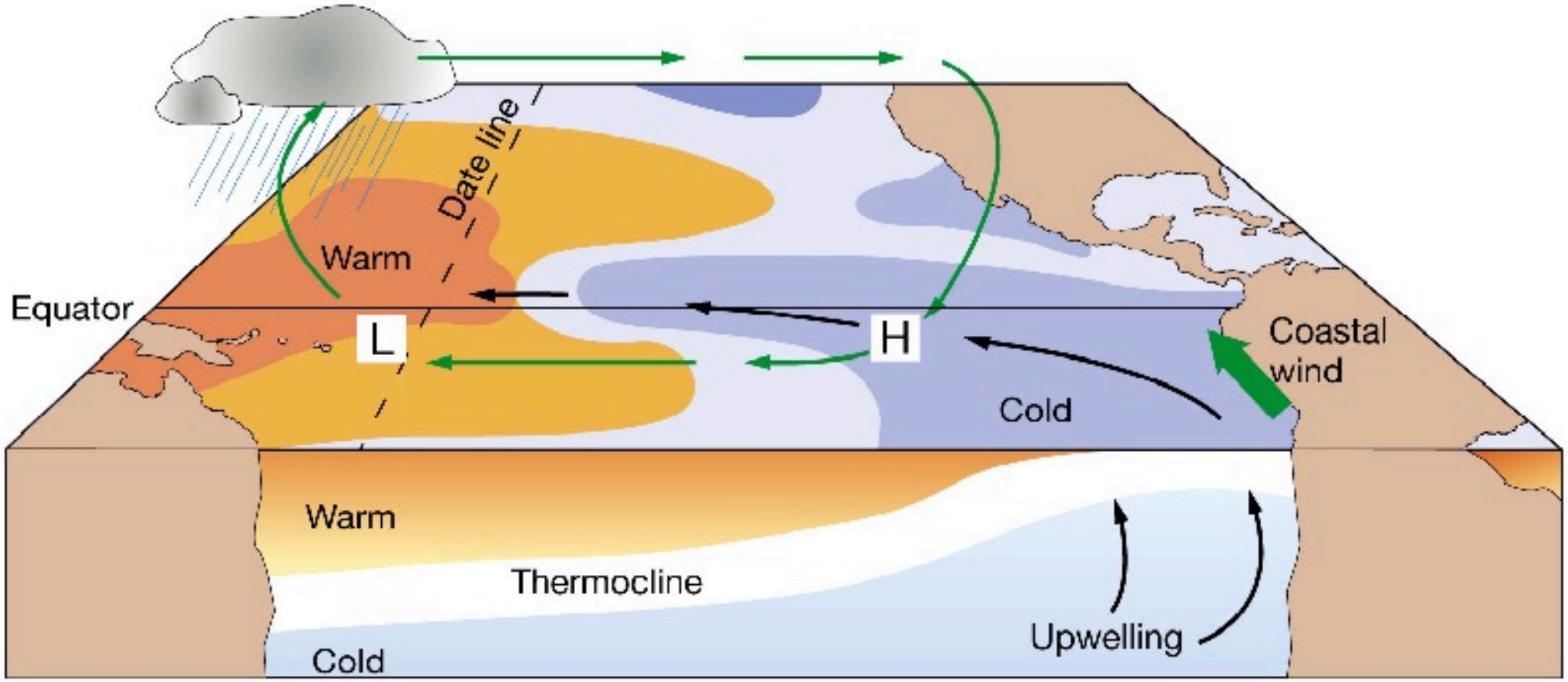
Oceanography: El Niño



(b) El Niño conditions

(Thurman &Trujillo 2004)

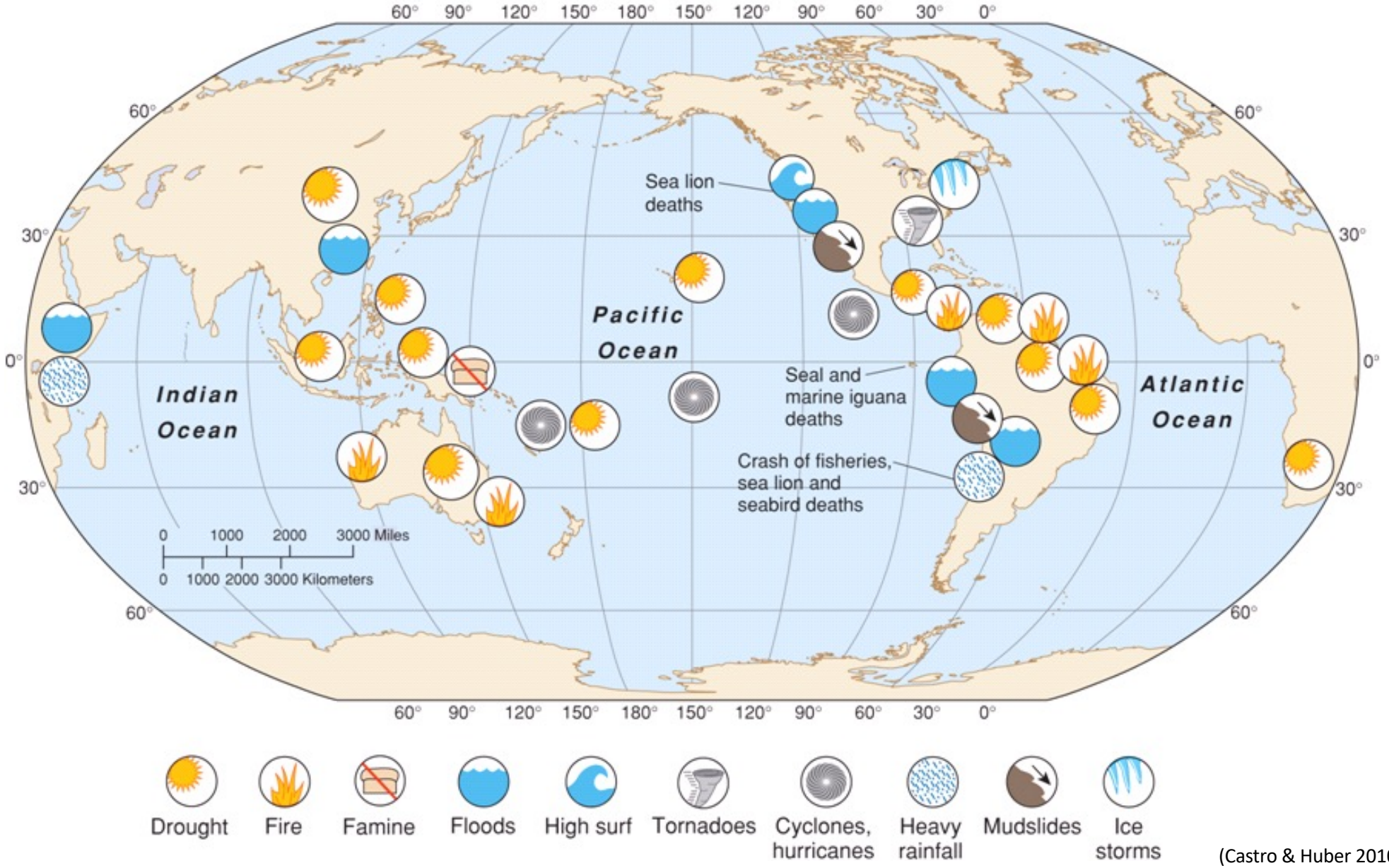
Oceanography: El Niño



(c) La Niña conditions

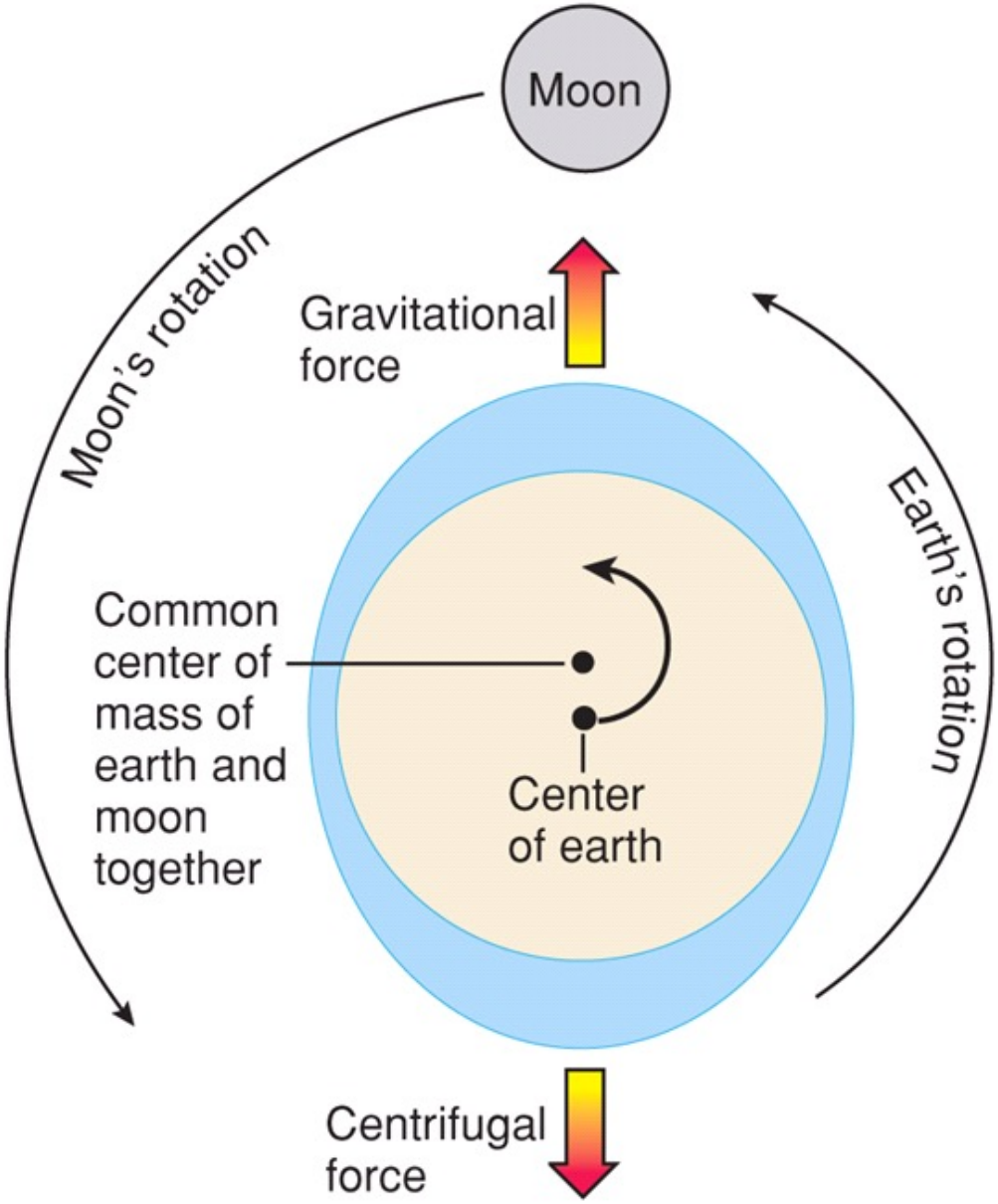
(Thurman &Trujillo 2004)

Oceanography: El Niño



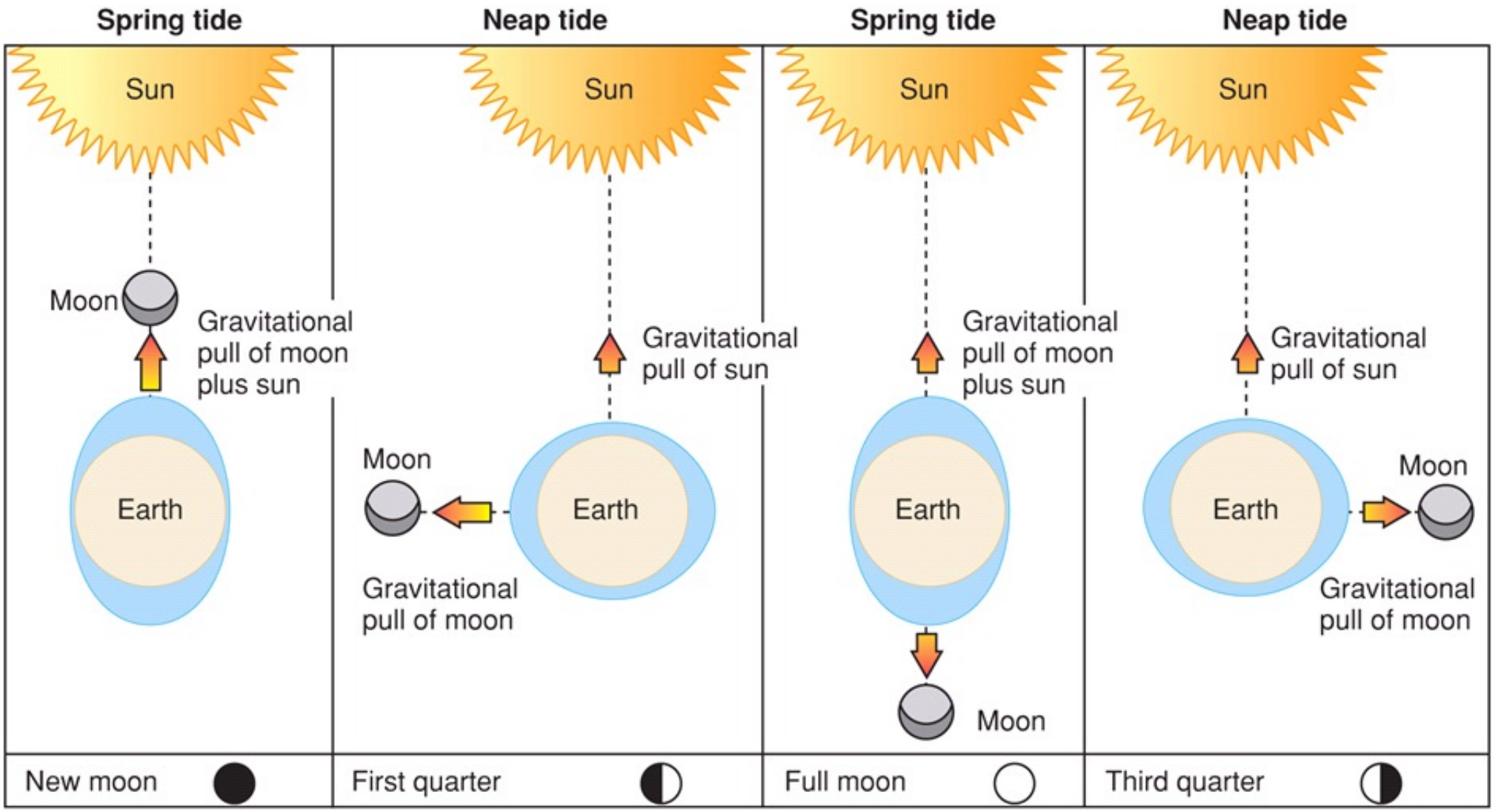
(Castro & Huber 2010)

Tides



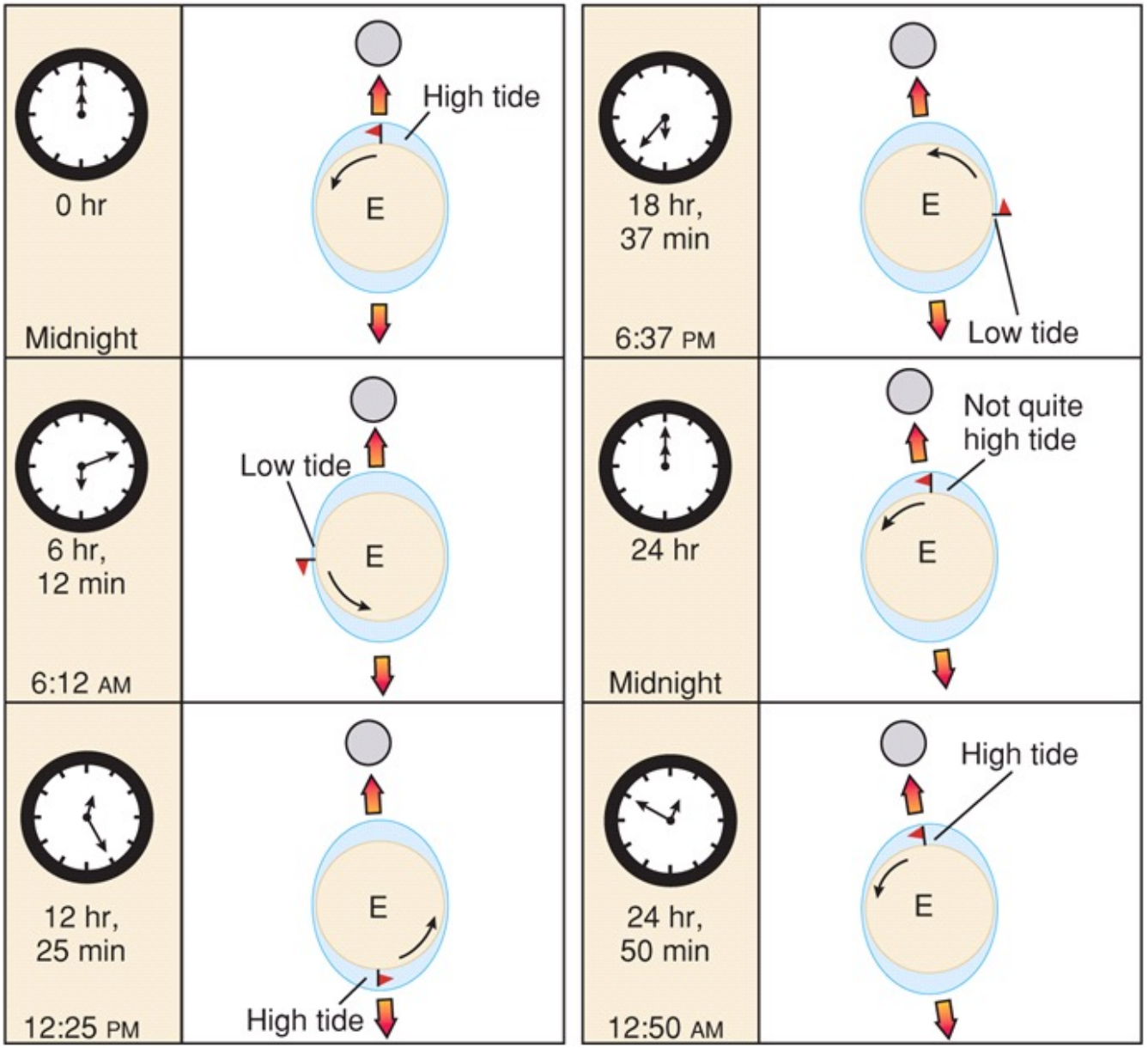
(Castro & Huber 2010)

Coastal marine habitats: tides



(Castro & Huber 2010)

Coastal marine habitats: tides



(Castro & Huber 2010)