

ZOOGEOGRAPHY OF FISHES



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Planet Earth(?)

- 70% of its surface covered by the Ocean
- 300x greater space than that of land
- Great zoning of organism occurrence
- Out of total 33 animal phyla, 32 present
- 15 phyla exclusively in the ocean



Zoogeography

- Study of geographical distribution of animals on the Earth
- From traveler's legends to the science in the 18th century due to Alfred Russel Wallace (1823-1913)



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Wallace's findings

- in general, the different parts of the world supported greatly different assemblages of organisms
- these geographical disparities in life are not random but:
 - continental regions have more or less uniform biotas, but there are great discontinuities
 - the biotas of some parts of the globe are much more unusual than others
 - elements of the biotas of given continents were related to each other more closely than they were to elements from the biotas of other continents.

= continental regions are occupied by typical arrays of related organisms, different from other such regions

Regions = Zoogeographic Realms

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Why is it so?

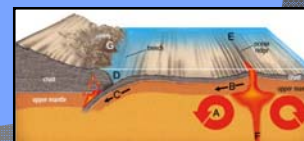
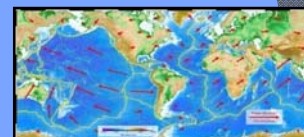
- The Earth and all of its content has very long history (4.5 billion years)
- Plate tectonic
- From the very beginning, geography developed, continents are constantly moving – at times widely separate and other times agglomerated into large lumps
= CONTINENTAL DRIFT

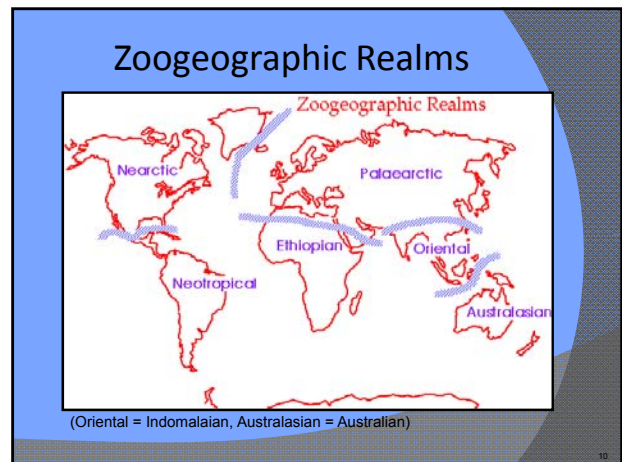
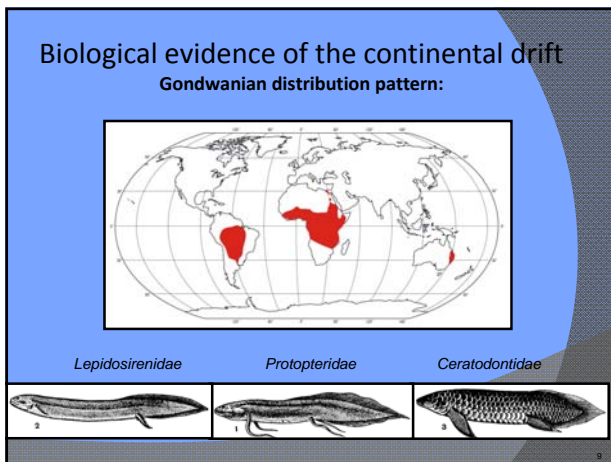
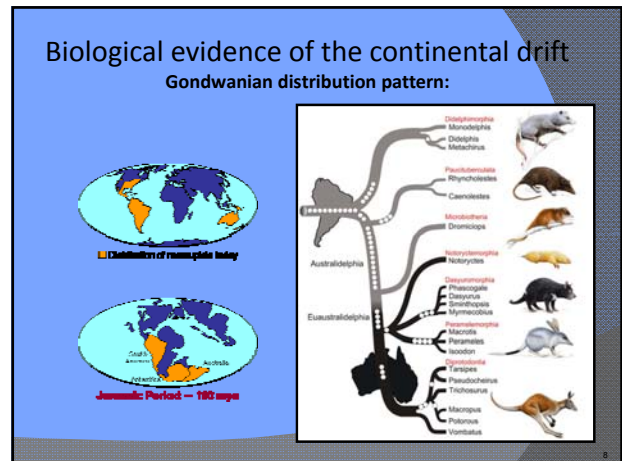
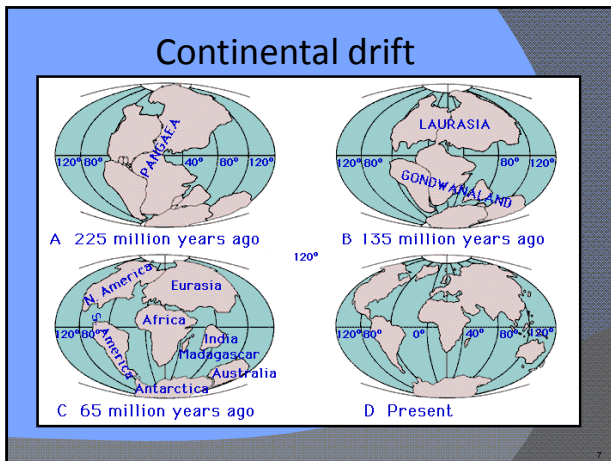
All the life bounded to the land is following

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Continental drift

- Alfred Wegener (1880- 1930)
 - Presented data supporting theory of continental drift which became a part of the larger theory of plate tectonics





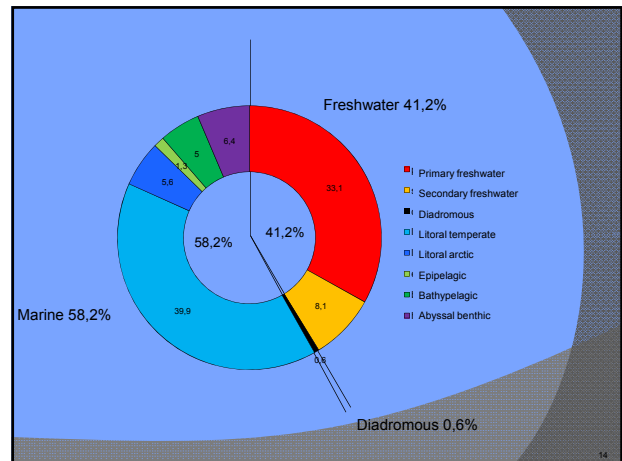
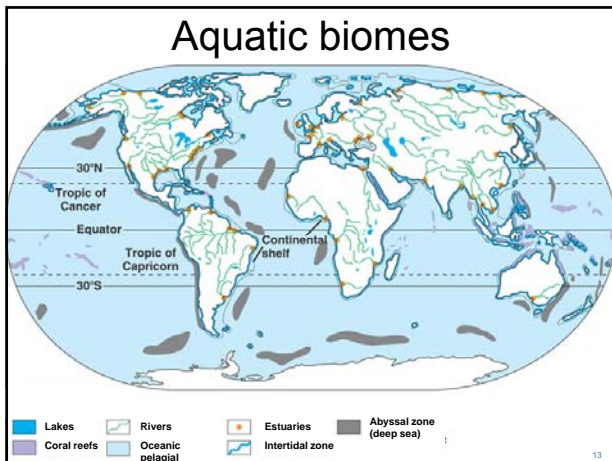
Zoogeographic Realms

- Defined by A.R. Wallace (1876)
 - Mainly based on distribution of mammals
 - Do not always correspond to continents
- According to A. Wegener (1915)
 - continental drift and plate tectonic are important factors of animal distribution

Zoogeography of fishes:

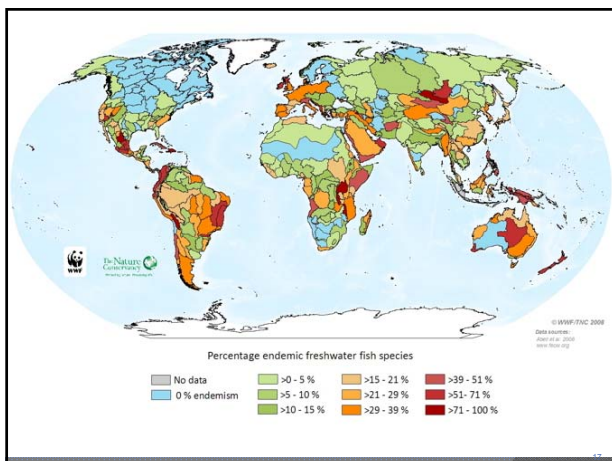
Aquatic biocycle

- Limnic = freshwater**
 - 0,3% of the Earth's surface
 - 2,5% of water (much of that found in polar caps)
 - Young ecosystem (since the last ice age period)
 - Rapid environmental changes
 - Organisms must be adaptable to a wide range of conditions
- Marine = oceanic**
 - Large continuous area, 70% of the Earth's surface
 - Seasonal changes rather slow
 - Stable conditions through the time
 - Supports existence of less flexible and archaic organisms



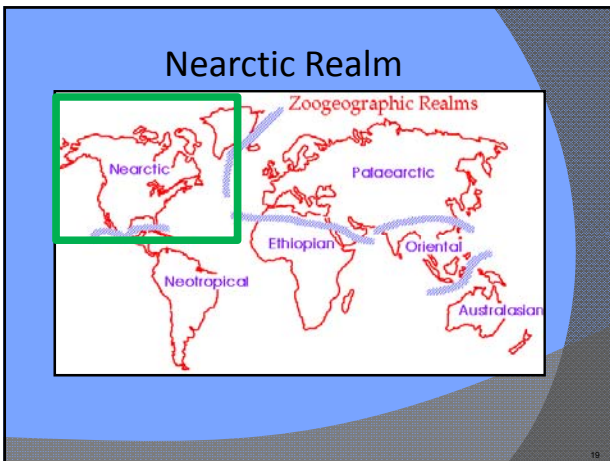
- ### Freshwater fish distribution
- ◉ Fragmental distribution
 - ◉ Numerous isolated water bodies
 - ◉ Land as spreading barrier
 - ◉ High species diversity
 - ◉ Rapid speciation
 - ◉ Realms according to Wallace

- ### Freshwater fishes
- ◉ Primary freshwater fishes
 - little salt tolerance, saltwater acts as barrier to distribution, about 13,000 species
 - ◉ Secondary freshwater fishes
 - some salt tolerance, may disperse through short distances of coastal waters, derived from marine ancestors, about 700 species
 - ◉ Peripheral freshwater fishes
 - Marine species that enter freshwaters, about 700 species, including diadromous species
- Berra 2001, Freshwater Fish Distribution



Freshwater Fishes by Realm

Zoogeographic realm	Species records	Percent
Nearctic	1,052	7.9
Palaearctic	1,397	10.5
Neotropical	4,385	32.8
Ethiopian	3,072	23.0
Oriental	2,821	21.1
Australian	627	4.7



Nearctic Realm

- ⊙ Influenced by the last glacial period
- ⊙ approximately 950 fish species
- ⊙ Few of them primary freshwater (14 families out of 55)
 - Mississippi River basin only
 - north-southern orientation
 - other rivers west-eastern orientation

The last glacial period

- ⊙ Mississippi River basin:
 - thermophilic fauna was able to retreat through the basin to the south when glacier expanded
- ⊙ Other rivers
 - primary freshwater species extincted
 - only species which tolerate higher salinity could survive

NORTH AMERICA

The most common Nearctic Families

Family	Common Name	Species
Cyprinidae	Minnnows or carps	293
Percidae	Perches	169
Catostomidae	Suckers	72
Poeciliidae	Poeciliids	71
Goodeidae	Splitfins	52
Ictaluridae	North American freshwater catfishes	47
Salmonidae	Salmonids	46
Cyprinodontidae	Pupfishes	39
Atherinopsidae	Neotropical silversides	38
Fundulidae	Topminnows and killifishes	32

Endemites of Nearctic Realm

American paddlefish *Polyodon spathula*

Bowfin *Amia calva*

Family Centrarchidae – Sunfishes

- ⊙ 32 species in common
- ⊙ Endemic family for Nearctic Realm, some species introduced out of the realm (Sunfish, *Lepomis gibosus*)

Distribution of *Centrarchidae*


Redbreast sunfish *Lepomis auritus*

Spotted bass *Micropterus punctulatus*

Orangespotted sunfish *Lepomis humilis*

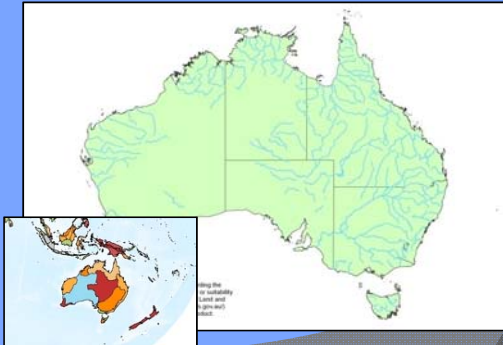
Pikes *Esocidae*

- 1 family, 6 species
- Holarctic distribution (Nearctic and Palearctic realms)
- 4 species endemic for Nearctic realm
- Northern pike (*Esox lucius*) – circumpolar distribution
- Amur pike (*Esox reichertii*) – Amur River basin, Sakhalin Island and Mongolia



The muskellunge *Esox masquinongy*

Australian Realm



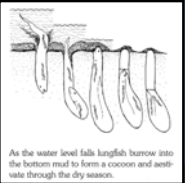
The most common Australian Families

Family	Common Name	Species
Gobiidae	Gobies	108
Eleotridae	Sleepers	70
Melanotaeniidae	Rainbowfishes, blue eyes	67
Galaxiidae	Galaxiids	41
Terapontidae	Grunters or tigerperches	39
Ariidae	Sea catfishes	25
Atherinidae	Silversides	23
Plotosidae	Eeltail catfishes	23
Hemiramphidae	Halfbeaks	20
Ambassidae	Asiatic glassfishes	20


Australian Realm

- Few primary freshwater fishes in limnic biocycle (2 species, relicts)
 - Lungfish (*Sarcopterygii*)
 - Barramundi (*Osteoglossiformes*)
- Secondary freshwater fishes: 2 families
- Peripheral freshwater fishes: 16 families
 - mostly anadromous
- Artificially introduced species (*Siluriformes, Cyprinidae*)


- 6 species, 3 families, 3 continents
- 1 or 2 lungs
- aestivation in cocoon
- Fossil records in Devon
- Gondwanian distribution pattern



As the water level falls lungfish burrow into the bottom mud to form a cocoon and aestivate through the dry season.

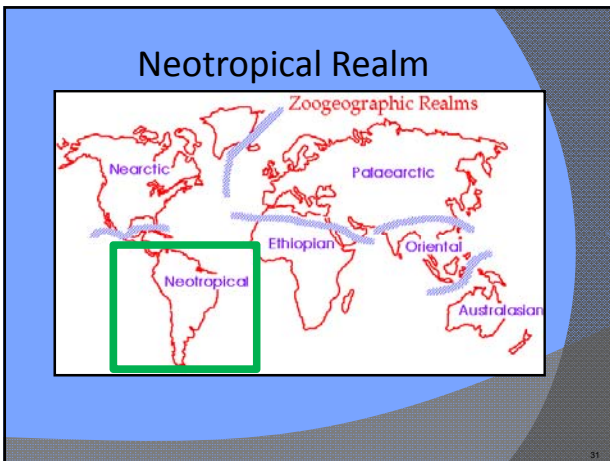


Lungfish (*Neoceratodus forsteri*) (AUS)



Spotted arowana (barramundi) (*Scleropages leichardti*)

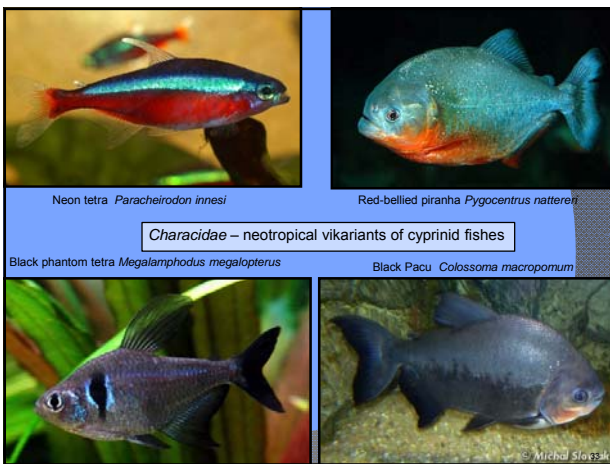
- Belong to family *Osteoglossiformes*, which split into two families (*Arapaimidae* and *Osteoglossidae*)
- Distribution of this family reflects former Gondwanian distribution pattern



The most common Neotropical Families

Family	Common Name	Species
Characidae	Characins	>1200
Loricariidae	Armored catfishes	682
Cichlidae	Cichlids	401
Rivulidae	Rivulines	231
Heptapteridae	Pimelodella catfishes	186
Callichthyidae	Callichthyid armored catfishes	176
Trichomycteridae	Pencil or parasitic catfishes	172
Poeciliidae	Poeciliids	154
Anostomidae	Headstanders	133
Curimatidae	Curimata characins	98

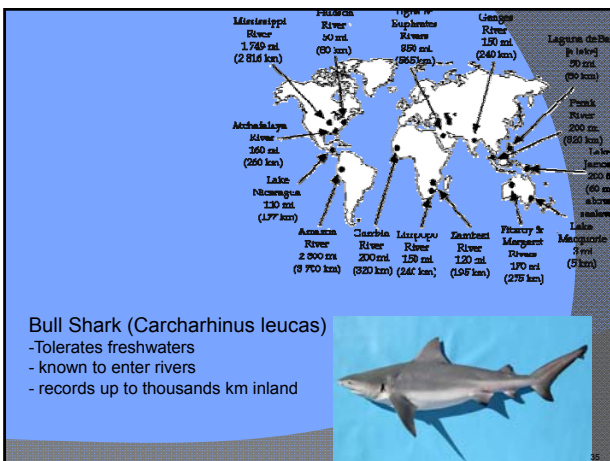
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© Candirú (*Vandellia cirrhosa*)

- Parasitic fish, feeding on blood of other fishes
- Accidentally can get into human urethra
- Surgery necessary

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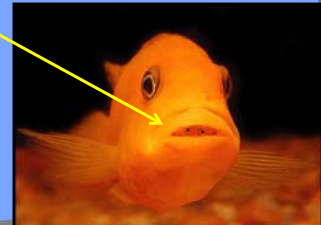
The most common Ethiopian Families

Family	Common Name	Species
Cichlidae	Cichlids	>1100
Cyprinidae	Minnnows or carps	523
Aplocheilidae	Killifishes	221
Mormyridae	Elephantfishes	203
Mochokidae	Squeakers or upside-down catfishes	189
Alestiidae	African tetras	110
Citharinidae	Citharinid tetras	102
Bagridae	Bagrid catfishes	96
Poeciliidae	Poeciliids	82
Clariidae	Airbreathing catfishes	76

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Cichlids (*Cichlidae*)

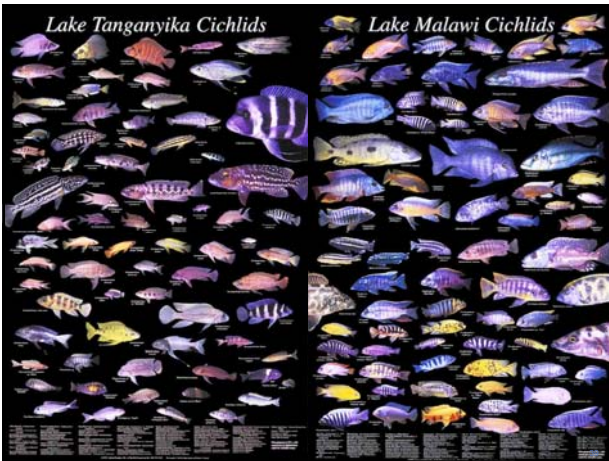
- Gondwanian pattern of distribution (SA, AF, Southeast Asia)
- African Great Lakes – huge diversity
- Annually described new species, many stay undescribed
- Mouth-breeders



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Lake Tanganyika Cichlids

Lake Malawi Cichlids



bichirs *Polypteridae*

- archaic (primitive) family
- Ganoid scales
- Endemic for Ethiopian realm
- 10 species, 9 in Zaire River basin



Marbled bichir *Polypterus palmas*



Ornate bichir *Polypterus ornatipinnis*

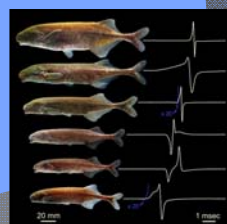
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Elephantfishes *Mormyridae*

- Belong to archaic order *Osteoglossiformes*
- endemic, 215 species recently described
- Nile River basin and tropical Africa
- Abnormally developed cerebellum, high intelligence
- Ability to generate electric field



Peter's elephantnose *Gnathonemus petersii*



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Oriental (Indomalayan) Realm



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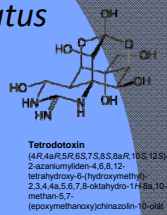
The most common Oriental Families

Family	Common Name	Species
Cyprinidae	Minnnows or carps	1058
Balitoridae	River loaches	458
Gobiidae	Gobies	185
Bagridae	Bagrid catfishes	133
Cobitidae	Loaches	105
Sisoridae	Sisorid catfishes	101
Osphronemidae	Gouramies	91
Siluridae	Sheatfishes	75
Akysidae	Stream catfishes	36
Hemiramphidae	Halfbeaks	32



pufferfish *Takifugu ocellatus*

- Endemic for Southeast Asia
- Juveniles in freshwaters, adults require salinity
- Highly toxic poison – Tetrodotoxin
- Adrenaline delicacy – the cook must have special certificate confirming ability to prepare this fish, otherwise he can become a mass murderer (the fish poison can kill up to 30 person)



„Eat Fugu or die trying“

Palaearctic Realm

- Low level of endemism
- Highly influenced by glacial periods
- ichthyofauna similar to Nearctic Realm
 - similar climatic conditions
 - tectonic origin (Laurasia)

The most common Palaearctic Families

Family	Common Name	Species
Cyprinidae	Minnnows or carps	576
Salmonidae	Salmonids	154
Balitoridae	River loaches	148
Cobitidae	Loaches	95
Gobiidae	Gobies	94
Bagridae	Bagrid catfishes	35
Sisoridae	Sisorid catfishes	25
Abyssocottidae	Deep-water sculpins	22
Cichlidae	Cichlids	22
Cyprinodontidae	Pupfishes	22

Deep-water sculpins *Abyssocottidae*

- 24 recently described species
- Entire family endemic for Baikal Lake
- In the depths below 50 meters



Cyprinid fishes

- Carps and Minnows
- Origin in Southeast Asia
- Not native to Neotropical and Australian realms but artificially introduced there



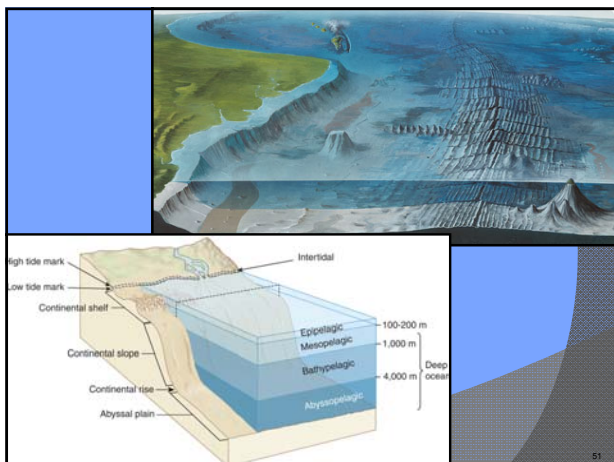
Natural distribution of Cyprinid fishes

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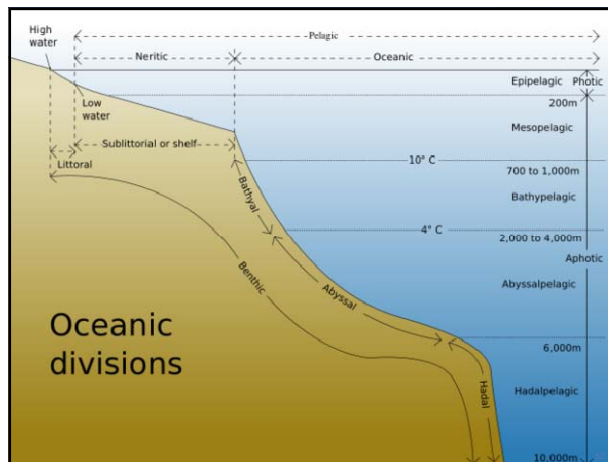
Marine fishes distribution

- Salinity approx. 35‰
- Almost constant conditions (in the matter of time and space)
- depth↑ - light ↓- pressure↑ - temperature↓
- Light: till 200 m = euphotic zone
- Below 1000-1500m absolut darkness

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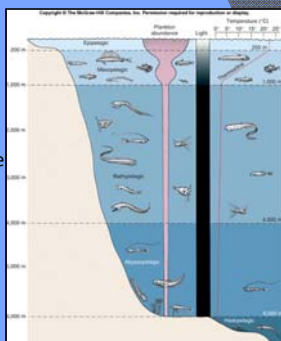


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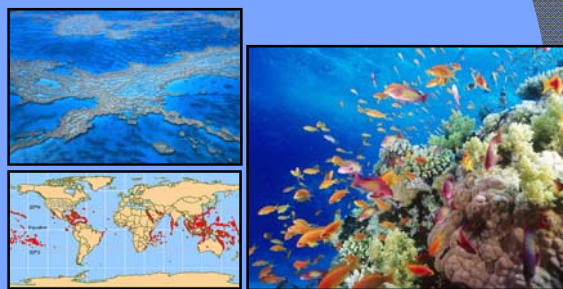
Abundance of marine fauna

- From the surface to the bottom
- from 50 m down rapid decline of abundance
- Only areas incompatible with any life support are not settled by organisms (e.g. depths of the Black Sea)
- In the direction from the equator towards poles species biodiversity as well as abundance of organisms decline



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- The highest diversity is in the areas of coral reefs
- limits: annual isotherm 20°C, optimum 23-25°C; 50m
- Annual primary production of organic matter reach higher values than on the majority of continents



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Zoogeographical divisions of marine biocycle


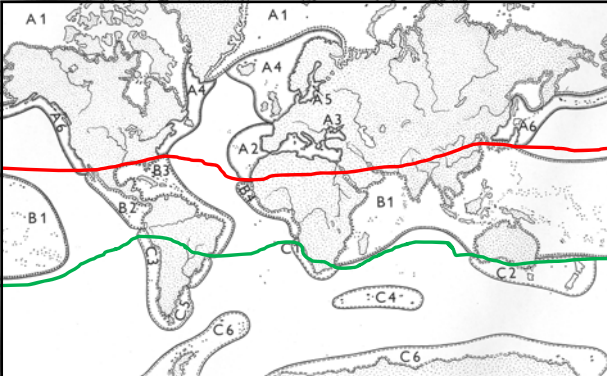
Divisions according to ecologic conditions

- Litoral (1)
- Pelagic (2)
- Abyssal(3)

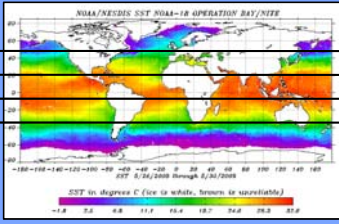
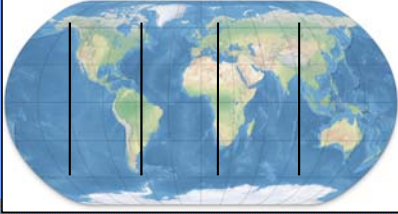
(1) + (3) fauna related to the substrate
 (2) – necton, plancton

Litoral

- Continental shelf seas
- Euphotic zone – high primar production
- 7% of the world seas, but 11250 fish species (45%)
 = very rich in fish species





Zoogeographic zonation of the sea litoral:
 A) Boreal zone
 B) Tropical zone
 C) Antiboreal zone

Strong division of litoral:

- zonal character of main zoogeogr. areas:
 - boreal
 - tropical
 - antiboreal
- zoogeographic barriers:
 - boundaries of continents
 - temperature
 - open sea between continents




Ichthyofauna of litoral zone

- *Muraenidae, Holocentridae, Serranidae, Chaetodontidae, Pomacentridae, Acanthuridae, Scaridae, Balistidae...*



Pelagic zone

- ⊙ Epipelagic – euphotic zone, photosynthesis possible
- ⊙ Mesopelagic – twilight zone
- ⊙ Bathypelagic – aphotic zone, pitch dark, animals dependent on deposition of organic matter from higher zones = „the rain of falling corpses“



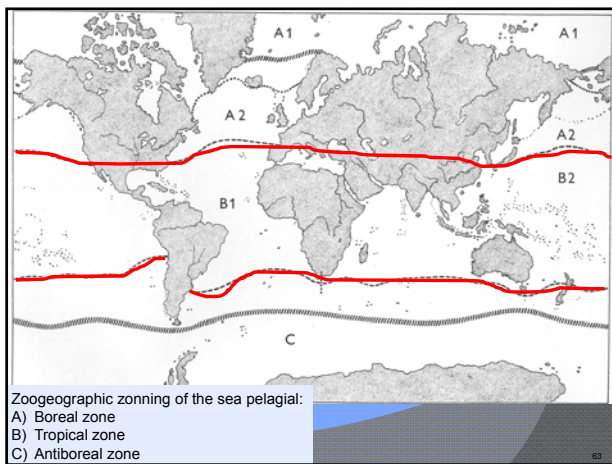
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Pelagic zone




- ⊙ Limited isolation = zoogeographically little structured
 - epipelagic zone – division similar to littoral zone
 - few of sub-regions
 - bathypelagic regions not defined
- ⊙ Organisms fully independent on solid substrate
 - active swimming = necton
 - passively floating = plancton (fish eggs, fry...)
- ⊙ Early ontogenic stages of bathypelagic species in epipelagic zone

Sea pelagial: **LOW species diversity** („desert of the sea“)

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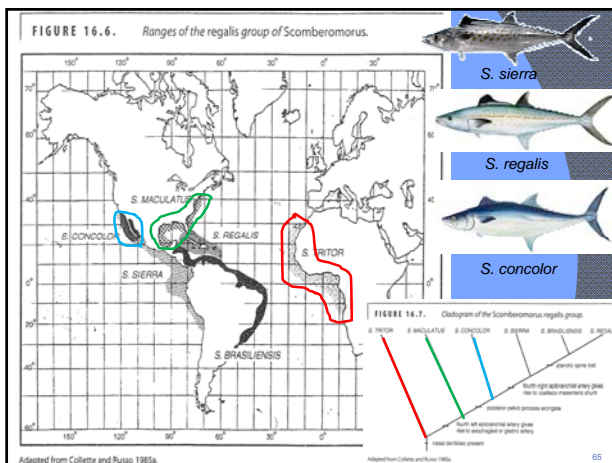


- ⊙ Many species cosmopolitan distribution
- ⊙ Often alopatric areals (*Scomberomorus*)
- ⊙ Species occurring closer to the coast – limited by water temperature (*Strongylura*)
- ⊙ Bathypelagic species – hudge areals, as barriers are submarine ridges and trenches (temperature, e.g. Gibraltar)






Distribution of Great White shark *Carcharodon carcharias*

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Bathypelagic (= deep sea) fishes



66

Extreme conditions = extreme organism

ilicium

Ability of bioluminescence

Hudge mouth, teeth, eyes, colour – black, red or white

male parasitism

Viper fish, *Chauliodus* spp.

Abyssal

- Organisms living on the bottom
- The second most inhabited marine zone
- Extreme but stabile conditions (absolute darkness, low temperature, extreme pressure)
- Hadal = bottom zone below the limit of 6 km
- Highly specialized species, often exposed to temperature below 0°C
- No plant matter = prayers and scavengers only

Abyssal

- Division based on geomorphologic and thermal diversification
- Claims of the cosmopolitan character of abyssal fauna disproved:

2000 m	40%	species in common
3000 m	7,2%	
4000 m	0%	
- Hadal zone – high degree of endemism within single region

Abyssal (hadal) fishes

Hadal snailfish, *Pseudoliparis amblystomopsis*
Caught on tape 8 km under the surface

Tripod fish, *Bathypterois* spp.