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)

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

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

Continental drift

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

Biological evidence of the continental drift

Gondwanian distribution pattern:

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
Aquatic biomes

- Lakes
- Rivers
- Lakes in seas
- Intertidal zones
- Coral reefs
- Marine
- Pelagial
- Estuaries
- Abyssal zone (deep sea)
- Rivers
- Arctic
- Litoral
- Temperate
- Tropical
- Freshwater
- Primary freshwater
- Secondary freshwater
- Freshwater fishes
- Diadromous
- Litoral
- Epipelagic
- Bathypelagic
- Abyssal benthic
- abyssal

Freshwater fish distribution

- Fragmental distribution
- Numerous isolated water bodies
- Land as spreading barriere
- 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

Freshwater Fishes by Realm

<table>
<thead>
<tr>
<th>Zoogeographic realm</th>
<th>Species records</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearctic</td>
<td>1,052</td>
<td>7.9</td>
</tr>
<tr>
<td>Palaearctic</td>
<td>1,397</td>
<td>10.5</td>
</tr>
<tr>
<td>Neotropical</td>
<td>4,365</td>
<td>32.6</td>
</tr>
<tr>
<td>Ethiopian</td>
<td>3,072</td>
<td>23.0</td>
</tr>
<tr>
<td>Oriental</td>
<td>2,821</td>
<td>21.1</td>
</tr>
<tr>
<td>Australian</td>
<td>627</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Berco 2004, Freshwater Fish Distribution
Influenced by the last glacial period
- approximately 950 fish species
- Few of them primary freshwater (14 families out of 55)
  - Mississippi River basin only
  - northsouthern 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

The most common Nearctic Families

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprinidae</td>
<td>Minnows or carps</td>
<td>293</td>
</tr>
<tr>
<td>Percidae</td>
<td>Perches</td>
<td>169</td>
</tr>
<tr>
<td>Catostomidae</td>
<td>Suckers</td>
<td>72</td>
</tr>
<tr>
<td>Poeciliidae</td>
<td>Poeciliids</td>
<td>71</td>
</tr>
<tr>
<td>Goodeidae</td>
<td>Splittins</td>
<td>52</td>
</tr>
<tr>
<td>Ictaluridae</td>
<td>North American freshwater catfishes</td>
<td>47</td>
</tr>
<tr>
<td>Salmonidae</td>
<td>Salmonids</td>
<td>46</td>
</tr>
<tr>
<td>Cyprinodontidae</td>
<td>Pupfishes</td>
<td>39</td>
</tr>
<tr>
<td>Atherinopsidae</td>
<td>Neotropical silversides</td>
<td>38</td>
</tr>
<tr>
<td>Fundulidae</td>
<td>Topminnows and killifishes</td>
<td>32</td>
</tr>
</tbody>
</table>

Endemites of Nearctic Realm
- American paddlefish Polystoe 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 gibbosus)
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

**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*)

**The most common Australian Families**

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gobiidae</td>
<td>Gobies</td>
<td>108</td>
</tr>
<tr>
<td>Eleotridae</td>
<td>Sleepers</td>
<td>70</td>
</tr>
<tr>
<td>Melanotaeniidae</td>
<td>Rainbowfishes, blue eyes</td>
<td>67</td>
</tr>
<tr>
<td>Galaxiidae</td>
<td>Galaxids</td>
<td>41</td>
</tr>
<tr>
<td>Tarponidae</td>
<td>Grunters or tigerperches</td>
<td>39</td>
</tr>
<tr>
<td>Anidae</td>
<td>Sea catfishes</td>
<td>25</td>
</tr>
<tr>
<td>Atherinidae</td>
<td>Silversides</td>
<td>23</td>
</tr>
<tr>
<td>Plotosidae</td>
<td>Eeltail catfishes</td>
<td>23</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Halfbeaks</td>
<td>20</td>
</tr>
<tr>
<td>Ambassidae</td>
<td>Asiatic glassfishes</td>
<td>20</td>
</tr>
</tbody>
</table>

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

**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 Neotropical Realm

### The most common Neotropical Families

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characidae</td>
<td>Characins</td>
<td>&gt;1200</td>
</tr>
<tr>
<td>Loricariidae</td>
<td>Armored catfishes</td>
<td>682</td>
</tr>
<tr>
<td>Cichlidae</td>
<td>Cichlids</td>
<td>401</td>
</tr>
<tr>
<td>Rivulidae</td>
<td>Rivulines</td>
<td>231</td>
</tr>
<tr>
<td>Haplopteridae</td>
<td>Haplopterylid catfishes</td>
<td>115</td>
</tr>
<tr>
<td>Callorhynidae</td>
<td>Callorhynid armored catfishes</td>
<td>176</td>
</tr>
<tr>
<td>Trichomycteridae</td>
<td>Pencil or parasitic catfishes</td>
<td>172</td>
</tr>
<tr>
<td>Poeciliidae</td>
<td>Poeciliids</td>
<td>154</td>
</tr>
<tr>
<td>Anostomidae</td>
<td>Headstanders</td>
<td>133</td>
</tr>
<tr>
<td>Curimatidae</td>
<td>Curimata characins</td>
<td>98</td>
</tr>
</tbody>
</table>

### Neotropical Families

- **Characidae**: Characins - neotropical relatives of cyprinid fishes
  - Neon tetra: *Paracheirodon innesi*
  - Red-bellied piranha: *Pygocentrus nattereri*
  - Black phantom tetra: *Megalamphodus megalopterus*
  - Black Peacock Cichlid: *Colossoma macropomum*

- **Candiru** (*Vandellia cirrhosa*):
  - Parasitic fish, feeding on blood of other fishes
  - Accidentally can get into human urethra
  - Surgery necessary

- **Bull Shark** (*Carcharhinus leucas*):
  - Tolerates freshwaters
  - Known to enter rivers
  - Records up to thousands km inland

### Ethiopian Realm

- **Bull Shark** (*Carcharhinus leucas*): Tolerates freshwaters, known to enter rivers, records up to thousands km inland.

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23.4.2012
The most common Ethiopian Families

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cichlidae</td>
<td>Cichlids</td>
<td>&gt;1100</td>
</tr>
<tr>
<td>Cyprinidae</td>
<td>Minnows or carps</td>
<td>523</td>
</tr>
<tr>
<td>Aplocheilidae</td>
<td>Killfishes</td>
<td>221</td>
</tr>
<tr>
<td>Mormyridae</td>
<td>Elephantfishes</td>
<td>203</td>
</tr>
<tr>
<td>Mochokidae</td>
<td>Squeakers or upside-down catfishes</td>
<td>189</td>
</tr>
<tr>
<td>Alestidae</td>
<td>African tetras</td>
<td>110</td>
</tr>
<tr>
<td>Citharinidae</td>
<td>Citharinid tetras</td>
<td>102</td>
</tr>
<tr>
<td>Bagridae</td>
<td>Bagrid catfishes</td>
<td>96</td>
</tr>
<tr>
<td>Poeciliidae</td>
<td>Poeciliids</td>
<td>82</td>
</tr>
<tr>
<td>Claridae</td>
<td>Airtreating catfishes</td>
<td>76</td>
</tr>
</tbody>
</table>

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

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

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

Oriental (Indomalaian) Realm
The most common Oriental Families

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprinidae</td>
<td>Minnows or carps</td>
<td>1058</td>
</tr>
<tr>
<td>Balitoridae</td>
<td>River loaches</td>
<td>458</td>
</tr>
<tr>
<td>Gobiidae</td>
<td>Gobies</td>
<td>185</td>
</tr>
<tr>
<td>Bagridae</td>
<td>Bagrid catfishes</td>
<td>133</td>
</tr>
<tr>
<td>Cobitidae</td>
<td>Loaches</td>
<td>105</td>
</tr>
<tr>
<td>Sisoridae</td>
<td>Sisorid catfishes</td>
<td>101</td>
</tr>
<tr>
<td>Osphronemida</td>
<td>Gouramies</td>
<td>91</td>
</tr>
<tr>
<td>Siluridae</td>
<td>Sheatfishes</td>
<td>75</td>
</tr>
<tr>
<td>Akytsidae</td>
<td>Stream catfishes</td>
<td>36</td>
</tr>
<tr>
<td>Hemiramphida</td>
<td>Halfbeaks</td>
<td>32</td>
</tr>
</tbody>
</table>

The most common Palearctic Families

<table>
<thead>
<tr>
<th>Family</th>
<th>Common Name</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprinidae</td>
<td>Minnows or carps</td>
<td>576</td>
</tr>
<tr>
<td>Salmonidae</td>
<td>Salmonids</td>
<td>154</td>
</tr>
<tr>
<td>Balitoridae</td>
<td>River loaches</td>
<td>148</td>
</tr>
<tr>
<td>Gobiidae</td>
<td>Gobies</td>
<td>95</td>
</tr>
<tr>
<td>Bagridae</td>
<td>Bagrid catfishes</td>
<td>35</td>
</tr>
<tr>
<td>Sisoridae</td>
<td>Sisorid catfishes</td>
<td>26</td>
</tr>
<tr>
<td>Abyssocottida</td>
<td>Deep-water sculpins</td>
<td>22</td>
</tr>
<tr>
<td>Cichlidae</td>
<td>Cichlids</td>
<td>22</td>
</tr>
<tr>
<td>Cyprinodontida</td>
<td>Pupfishes</td>
<td>22</td>
</tr>
</tbody>
</table>

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)

Palearctic Realm

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

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

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

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

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

Ichthyofauna of litoral zone
- Muraenidae, Holocentridae, Serranidae, Chaetodontidae, Pomacentridae, Acanthuridae, Scaridae, Balistidae...

Zoogeographic zonning 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
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"

Limited isolation = zoogeographically little structured
- epipelagic zone – division similar to litoral 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"]

Zoogeographic zonning of the sea pelagial:

A) Boreal zone
B) Tropical zone
C) Antebraoreal zone

Many species cosmopolitan distribution
- Often allopatric 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)

Needlefish, Strongylura spp.

Distribution of Great White shark (Carcharodon carcharias)

Bathypelagic (= deep sea) fishes
Extreme conditions = extreme organism

Viper fish, Chauliodus spp.

Ability of bioluminescence

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

Male parasitism

Organisms living on the bottom
The second most inhabited marine zone
Extreme but stable 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 = parasites and scavengers only

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.