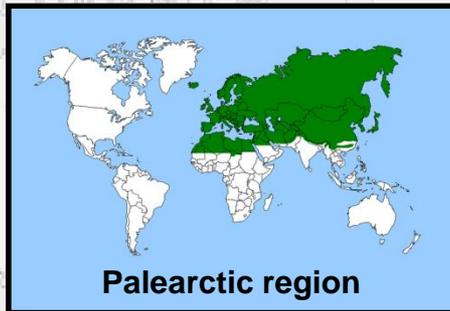


Zoogeography – part 2

Zoogeographic realms



Palearctic region



Ethiopian region



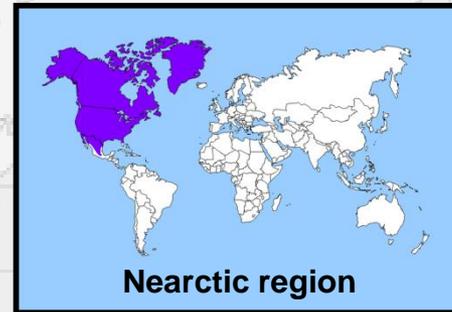
Oriental region



Australian region



Neotropical region

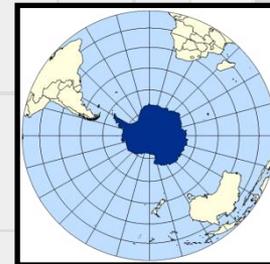


Nearctic region

7. Oceania ecozone



8. Antarctic ecozone

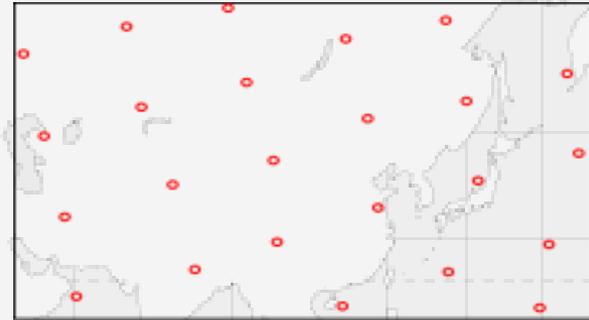


Fish distribution - definitions

Distribution patterns

1. Continuous distribution.

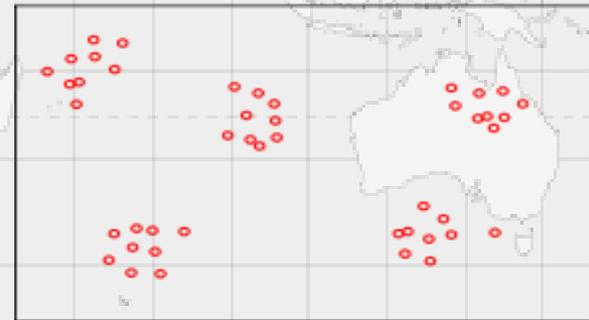
Within the range of its distribution, no significant suitable habitats are unoccupied.



2. Discontinuous distribution.

The distribution pattern is characterised by gaps which are greater than transversed by normal dispersal in one generation.

- A. Disperse distribution: There are many small, well-separated populations.
- B. Disjunct distribution: There are only few, widely separated populations.

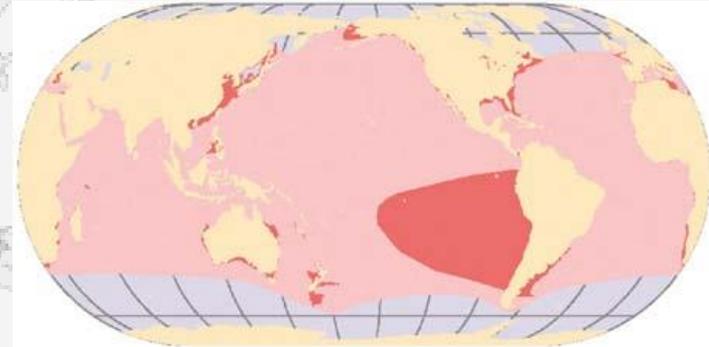


Fish distribution - definitions

Distribution patterns

1. Cosmopolitan distribution.

The population is widely distributed, and its range extends across all or most of the world in appropriate habitats.

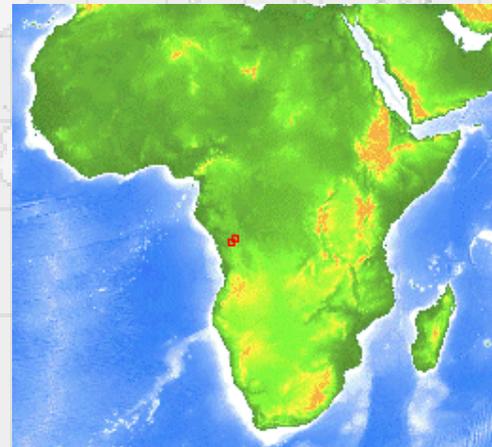


Carcharodon carcharias (Linnaeus, 1758).

2. Endemic distribution.

The population is limited, and it is unique to a defined geographic location, such as an island, nation or other defined zone, or habitat type.

Organisms that are indigenous to a place are not endemic to it if they are also found elsewhere.



Caecobarbus geertsii Boulenger, 1921.

Fish distribution - definitions

Aquatic biomes

The aquatic biomes can be broken down into two basic regions:

1. The freshwater region is defined as having a low salt concentration. It includes ponds and lakes, streams and rivers, and wetlands.



© Isabel Ahlgren

2. The marine region is characterized by its salt concentration and covers about $\frac{3}{4}$ of the earth's surface. It includes oceans and coral reefs.



© Carol Van Houten



© Lyn Topinka

The area where freshwater meets saltwater is usually called an estuary. This mixture is also called brackish water.

Fish distribution - definitions

Migration

1. Diadromous.

The fishes are regularly migrating between freshwater and seawater. The migrations should be cyclidal and predictable, and cover more than 100 km.

- a. **Anadromous:** There is a migration from the sea to freshwater to spawn. Species are ascending rivers.
e.g. *Oncorhynchus mykiss* (Walbaum, 1792).



- b. **Catadromous:** There is a migration from freshwater to the sea to spawn. Species are entering oceans.
e.g. *Anguilla anguilla* (Linnaeus, 1758).



- c. **Amphidromous:** Species are regularly migrating between freshwater and the sea (in both directions), but not for the purpose of breeding.
e.g. *Plecoglossus altivelis* (Temminck & Schlegel, 1846).



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Fish distribution - definitions

Migration

2. Potamodromous.

The fishes are migrating within streams. The migrations should be cyclidal and predictable, and cover more than 100 km.

e.g. *Oxyeleotris marmorata* (Bleeker, 1852).



3. Limnodromous.

The fishes are migrating within large lakes. The migrations should be cyclidal and predictable, and cover more than 100 km.

e.g. *Perca flavescens* (Mitchill, 1814).



4. Oceanodromous.

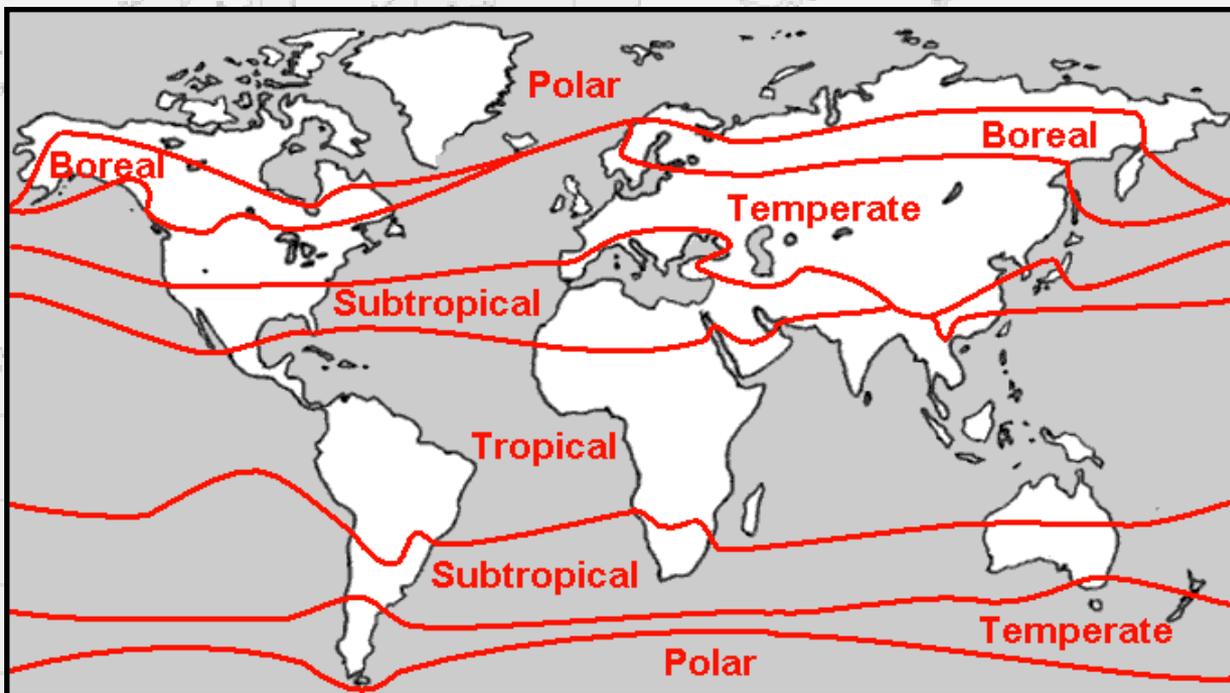
The fishes are migrating within oceans, typically between spawning and different feeding areas. The migrations should be cyclidal and predictable, and cover more than 100 km.

e.g. *Thunnus albacares* (Bonnaterra, 1788).



Fish distribution - definitions

Climate zones



These are the climate zones of the world as used in FishBase.

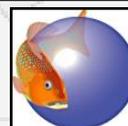
Thunnus alalunga
Albacore
Thunnus alalunga (Bonaparte, 1785)
Family: Scombridae (Mackerels, tunas, bonitos), subfamily: Scombrinae

Order: Perciformes (perch-like)
Class: Actinopterygii (ray-finned fishes)
FishBase name: Albacore

Max. size: 140 cm FL (male unsexed; (Ref. 1662)); max. published weight 60.3 kg (Ref. 1662); max. reported age: 9 years (Ref. 2282)

Environment: pelagic, pelagic, pelagic, pelagic (Ref. 1122); marine; depth range 0 - 600 m (Ref. 165)
Climate: subtropical; 10 - 20°C (Ref. 168); 30°C - 40°C, 18°C - 19°C
Importance: commercial; gamefish; yes; price category: high; price reliability: reliable based on ex-vessel price for this species
Resilience: 10 years minimum population doubling time 1.1 - 4.4 years (C0-1.0-1.0; mean=1.0; mean=1.0; Eco2=medium)

The complex block contains taxonomic information for the Albacore, including its scientific name, family, order, class, and various biological and environmental data points. It also includes a small image of the fish and a distribution map showing its range in the North Pacific and North Atlantic.



Fish distribution

FAO Areas

The FAO Areas are defined by the FAO to record fisheries catches.

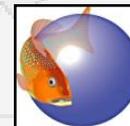
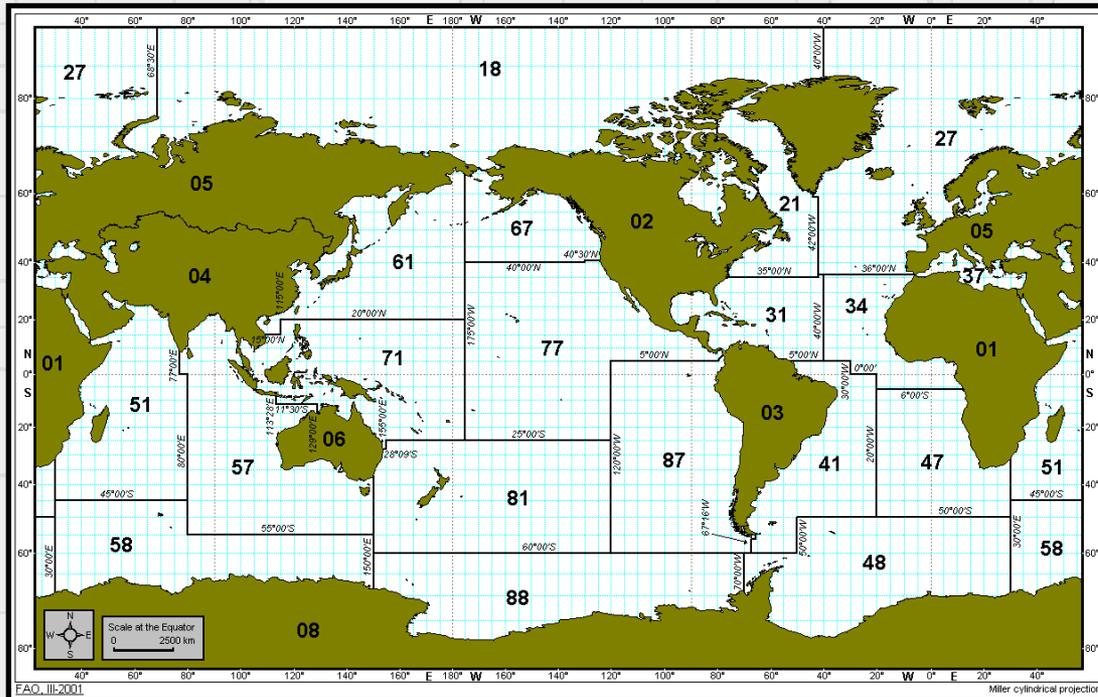
- 01. Africa
- 02. North America
- 03. South America
- 04. Asia
- 05. Europe / Russia (07)
- 06. Australia
- 08. Antarctica

18. Arctic Sea

- 21. Atlantic Ocean, northwest
- 27. Atlantic Ocean, northeast
- 31. Atlantic Ocean, western central
- 34. Atlantic Ocean, eastern central
- 37. Mediterranean and Black Sea
- 41. Atlantic Ocean, southwest
- 47. Atlantic Ocean, southeast
- 48. Atlantic Ocean, Antarctic

- 51. Indian Ocean, western
- 57. Indian Ocean, eastern
- 58. Indian Ocean, Antarctic

- 61. Pacific Ocean, northwest
- 67. Pacific Ocean, northeast
- 71. Pacific Ocean, western central
- 77. Pacific Ocean, eastern central
- 81. Pacific Ocean, southwest
- 87. Pacific Ocean, southeast
- 88. Pacific Ocean, Antarctic



Distribution of marine fishes

Marine Ecoregions

Spalding *et al.* (2007) made a new global system to classify the coastal and shelf areas.

Spalding, M.D., H.E. Fox, G.R. Allen, N. Davidson, Z.A. Ferdaña, M. Finlayson, B.S. Halpern, M.A. Jorge, A. Lombana, S.A. Lourie, K.D. Martin, E. McManus, J.Molnar, C.A. Recchia and J. Robertson (2007), *Marine Ecoregions of the world: a bioregionalization of coastal and shelf areas. BioScience* 57(7): 573-583.

REALM =

- (1) **terrestrial:** continent or subcontinent-sized areas with unifying features of geography and fauna/flora/vegetation.
- (2) **marine:** very large regions of coastal, benthic, or pelagic ocean across which biotas are internally coherent at higher taxonomic levels, as a result of a shared and unique evolutionary history.

PROVINCES = large areas defined by the presence of distinct biotas that have at least some cohesion over evolutionary time frames.

ECOREGIONS = areas of relatively homogeneous species composition, clearly distinct from adjacent systems.



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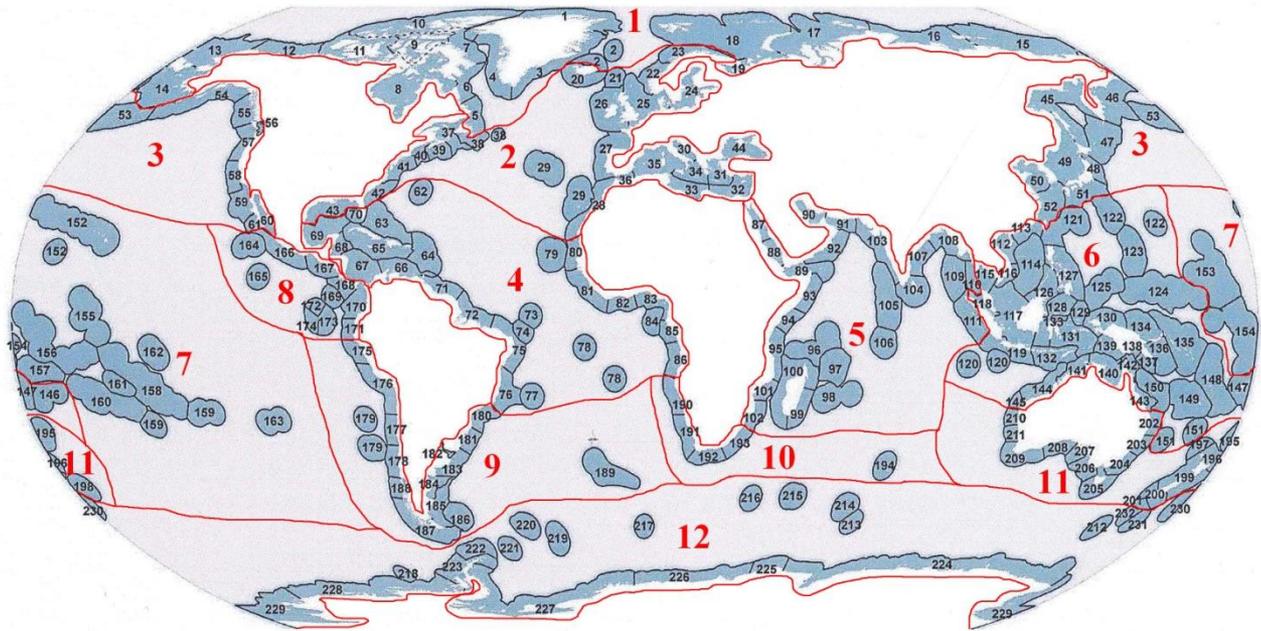
© www.greenglobaltravel.com

Distribution of marine fishes

Marine Ecoregions

MARINE REALMS:

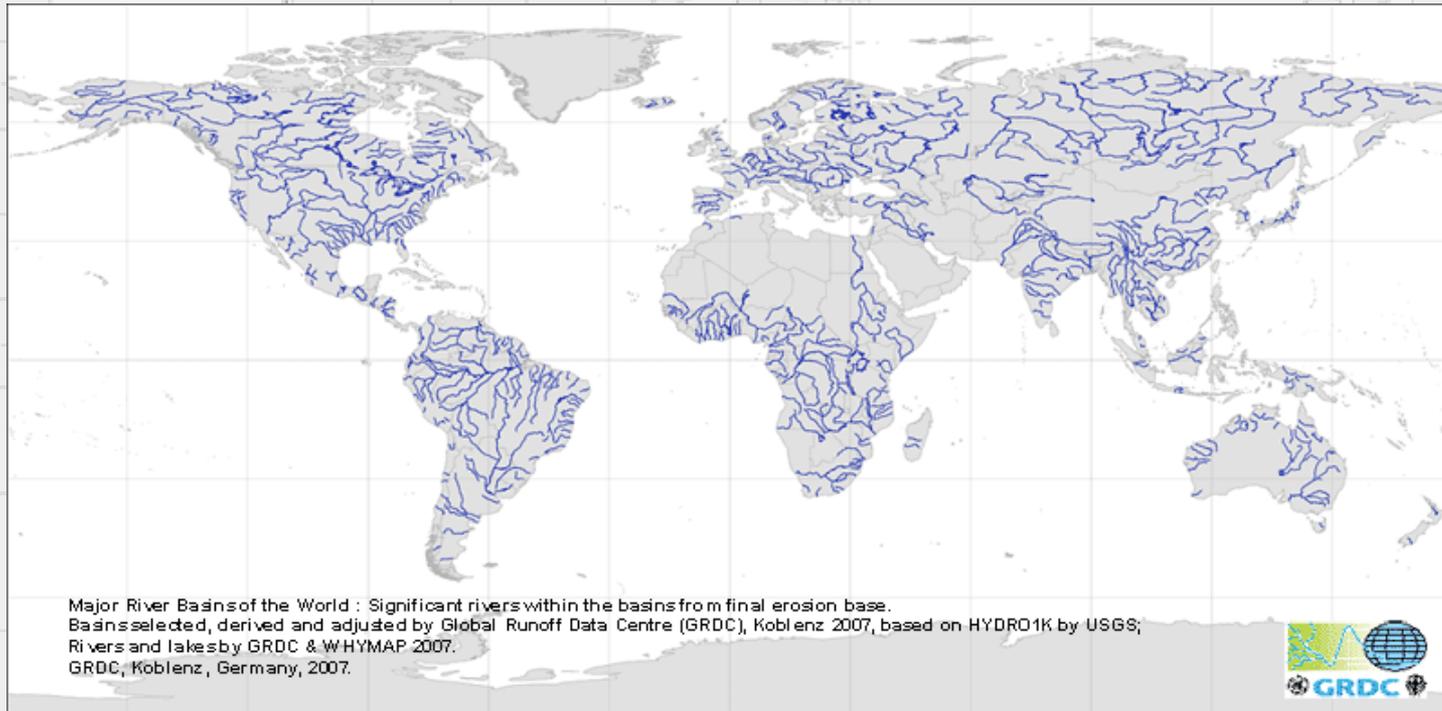
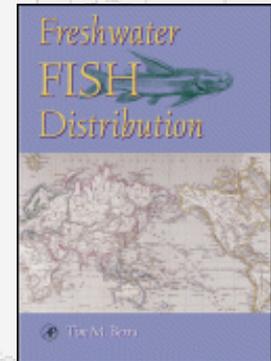
1. Arctic
2. Temperate Northern Atlantic
3. Temperate Northern Pacific
4. Tropical Atlantic
5. Western Indo-Pacific
6. Central Indo-Pacific
7. Eastern Indo-Pacific
8. Tropical Eastern Pacific
9. Temperate South America
10. Temperate Southern Africa
11. Temperate Australasia
12. Southern Ocean



Distribution of freshwater fishes

Berra, T.M. (1981), An atlas of distribution of the freshwater fish families of the world. University of Nebraska Press, Lincoln and London. 197 pp.

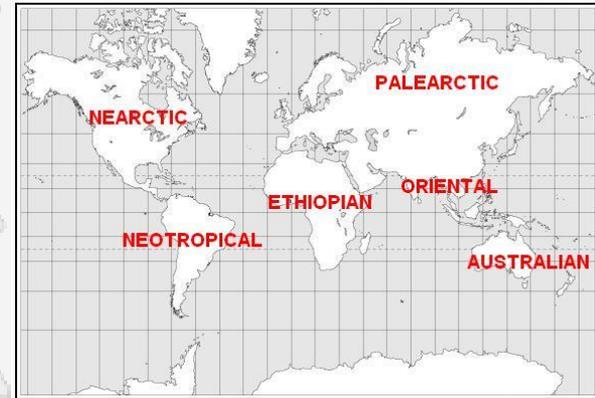
Berra, T.M. (2001), Freshwater fish distribution. Academic Press, San Diego. 604 pp.



Distribution of freshwater fishes

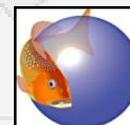
Distribution in the zoogeographic regions

Boden, G., T. Musschoot & J. Snoeks (2004), African fish biodiversity, FishBase and fishculture. *Tropicultura* SPE: 37-43.



Region	number of species
Ethiopian region	3100
Paleartic region	1477
Oriental region	2924
Australian region	676
Nearctic region	1103
Neotropic region	4456

FishBase (2016)
3360
1427
2821
669
1064
4398



Distribution of freshwater fishes

Classification of freshwater fishes

1. Primary Division freshwater fish families.

All members have a little salt tolerance and are confined to freshwaters. Their distribution has not depended on passage through the sea.

2. Secondary Division freshwater fish families.

The members are usually confined to freshwater, but they have some salt tolerance. Their distribution may reflect dispersal through coastal waters or across short distances of salt water.

3. Peripheral Division fish families.

Some families have members which are confined to freshwater, others may spend a considerable portion of their life cycle in freshwater. Both are derived from marine ancestors who used the oceans as dispersal routes. Other families are basically marine groups, some of which enter freshwater.

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Distribution of freshwater fishes

Example 1: Polypteridae

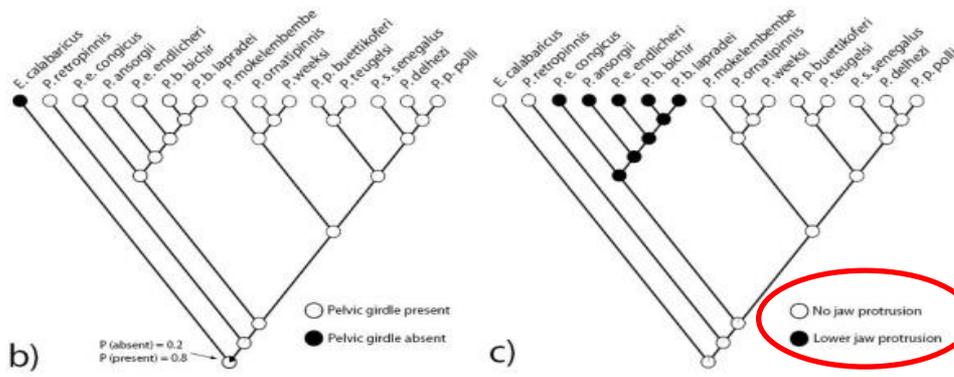
The Polypteridae (bichirs) is a primary freshwater fish family with an endemic distribution in Africa.

- rivers in Central and West Africa
- Nile River
- absent in Indian Ocean drainages



© Yu-Chia Chang

Erpetoichthys calabaricus



Polypterus endlicheri



Polypterus ornatipinnis

from Suzuki et al. (2010)

Distribution of freshwater fishes

Example 2: Polyodontidae

The Polyodontidae (paddlefishes) has a disjunct distribution. This primitive family contains two extant species.

- *Polyodon spathula*: Mississippi drainage.
- *Psephurus gladius*: Yangtze River.

The most distinctive feature of the Polyodontidae is the very long rostrum, also called 'paddle'. Its function is not well understood, but it is covered with many sensory and electroreceptors that aid in detecting zooplankton.



The biogeographic connection between China and North America is also apparent in some other taxa, e.g. Cryptobranchidae (giant salamanders).



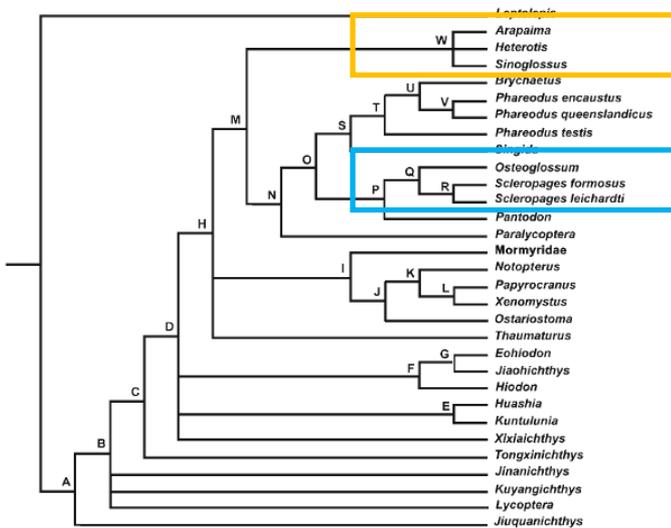
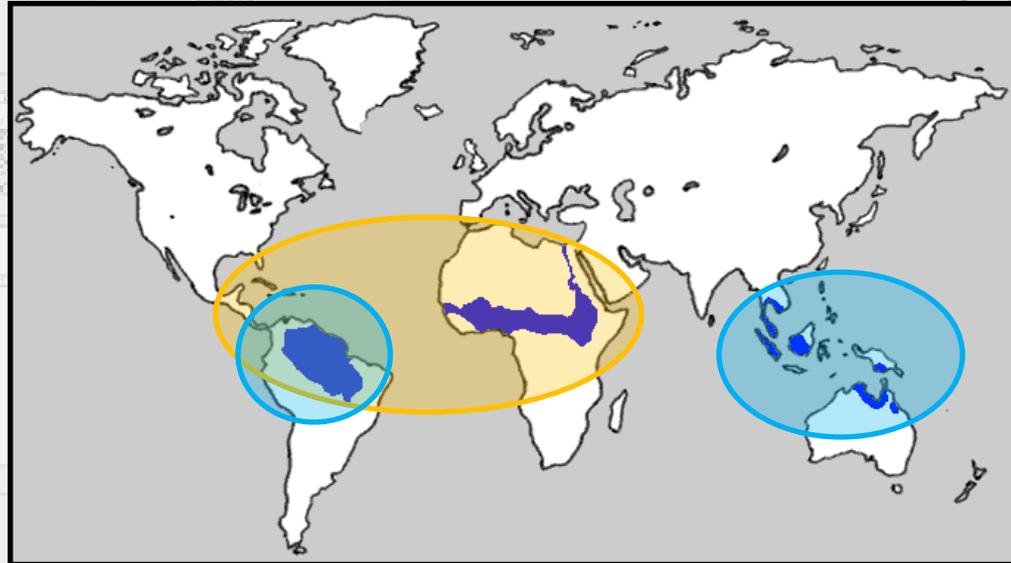
© Ken Lucas

Distribution of freshwater fishes

Example 3: Osteoglossidae

The Osteoglossidae (bonytongues) is a primary freshwater fish family with a circumtropical distribution in South America, Africa, Southeast Asia and Australia. Its distribution pattern reflects a previous Gondwanian pattern.

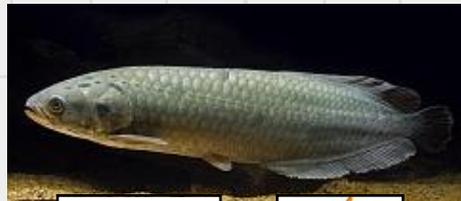
The Osteoglossidae is splitted into two separate families by Ferraris (2003).



from Zhang (2006)

A. Arapaimidae

It includes the genera *Arapaima* (South America) and *Heterotis* (Africa).



B. Osteoglossidae

It includes the genera *Osteoglossum* (South America) and *Scleropages* (Southeast Asia and Australia).



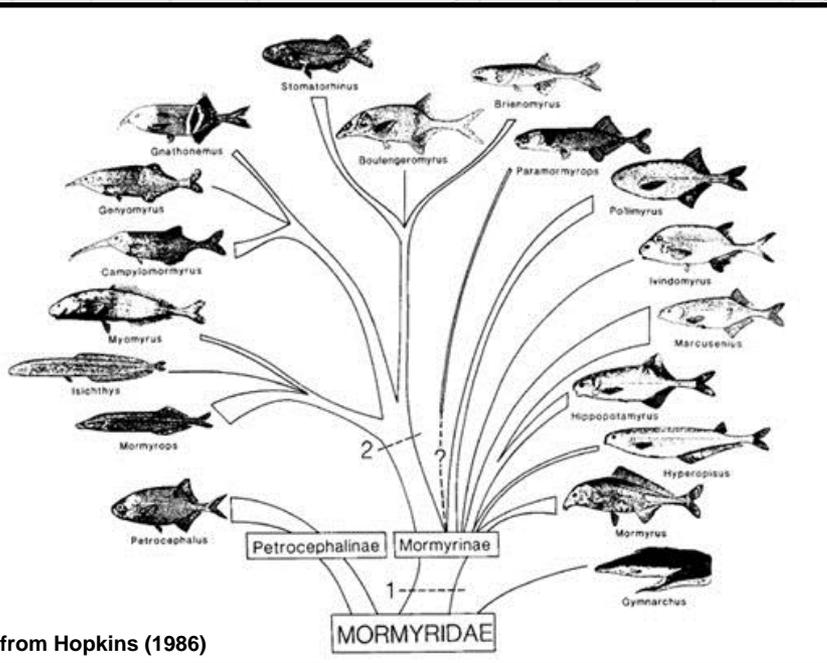
© Benny Ng



Distribution of freshwater fishes

Example 4: Mormyridae

The Mormyridae (elephantfishes) is a primary freshwater fish family which is endemic to Africa. The family is best known for the diversity of peculiar snouts among its species and the electric signals they can produce.

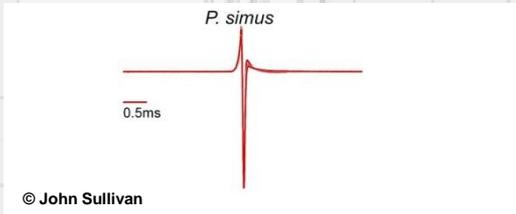
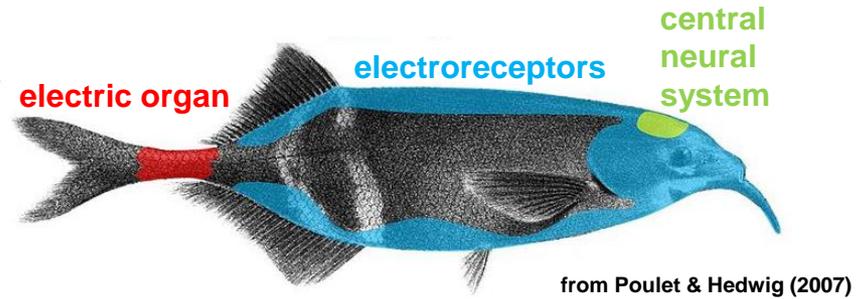


The mormyridae feed mainly on (benthic) invertebrates. There are a few piscivorous species.

Distribution of freshwater fishes

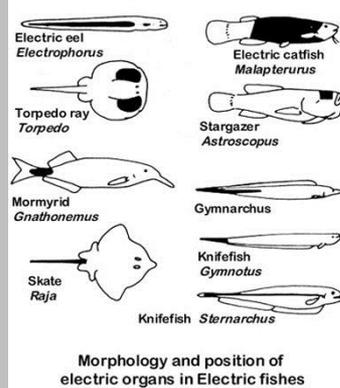
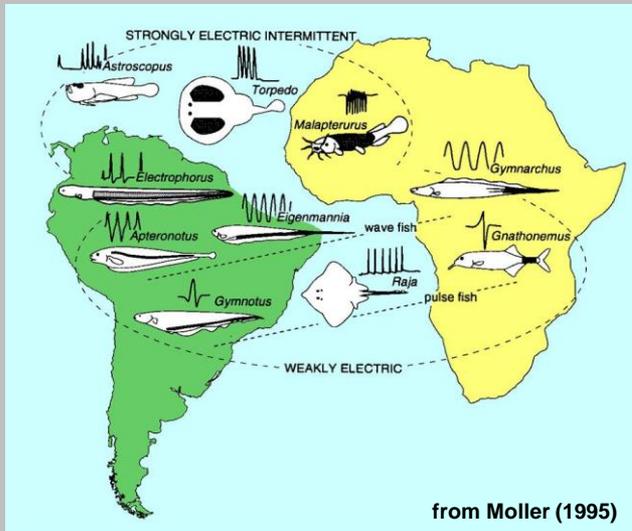
Example 4: Mormyridae

The Mormyridae are also known for their ability to produce an electric signal. An electric fish can generate an electric field produced by a specialised structure called an electric organ. The output of the organ is called the 'electric organ discharge' (EOD).



Electric fishes, belonging to different groups, live in the oceans, but also in the freshwaters of Africa and South America.

➔ Convergent evolution



Phylogenetic convergences in the evolution of electric organ function	Ela-mo-bran-chii	Teleost						
		Rajids	Torpedinids	Mormyrids	Gymnarchus	Ostariophysii		Acan-tho-por-tygii
						Cypriniformes (Gymnotids)		
				Electric eel	Gymnotus	Sternarchids	Electric catfish	Stargazers
Freshwater fish								
Strongly electric		+	+	+	+	+	+	+
Weakly electric		+	+	+	+	+		
Intermittently active		+	+		+		+	+
Continously active			+			+		
Constant frequency				+				
Variable frequency				+				
Can cease firing			+	+		+		

from Madl & Yip (2000)

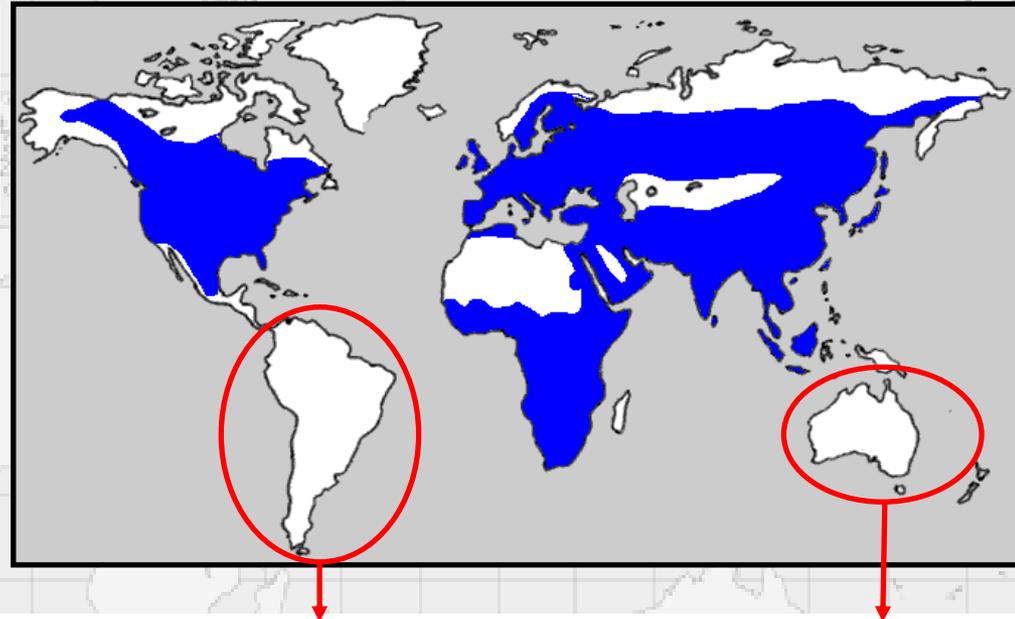
Distribution of freshwater fishes

Example 5: Cyprinidae

The Cyprinidae (minnows & carps) is the most dominant fish family in the world's freshwaters, only absent in South America and Australia. The center of origin of this primary freshwater fish family is Orientalis.

1. Cyprinidae	3114 species
2. Gobiidae	1843 species
3. Cichlidae	1703 species
4. Characidae	1123 species
5. Loricariidae	938 species

Data from CofF 04/2017



The ecological role is fulfilled by characiforms (South America) and melanotaeniids (Australia). However, some species of Cyprinidae are introduced and now considered as pest species.



© Germano Schüür

Some species, like *Cyprinus carpio* Linnaeus, 1758 and *Carassius auratus* (Linnaeus, 1758) are introduced in the whole world and exist as wild populations in non-native regions.



© Robert M. McDowall

Distribution of freshwater fishes

Example 6: Alestidae / Characidae

Alestiidae and Characidae are both primary freshwater fish families, which are closely related to each other. Currently, there is much debate on the classification within the Characiformes.

Nelson (1976, 1984, 1994):

There is only 1 family, Characidae, with a discontinuous distribution.

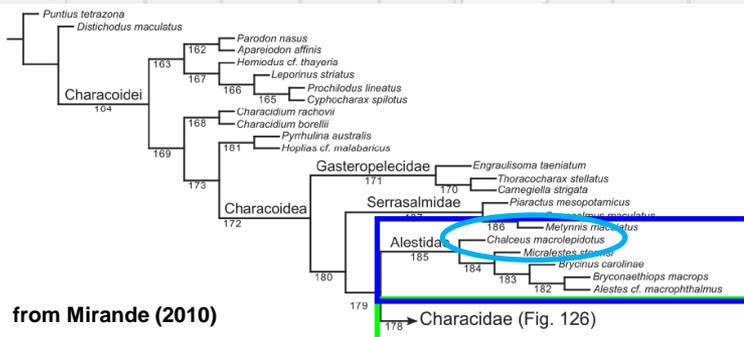
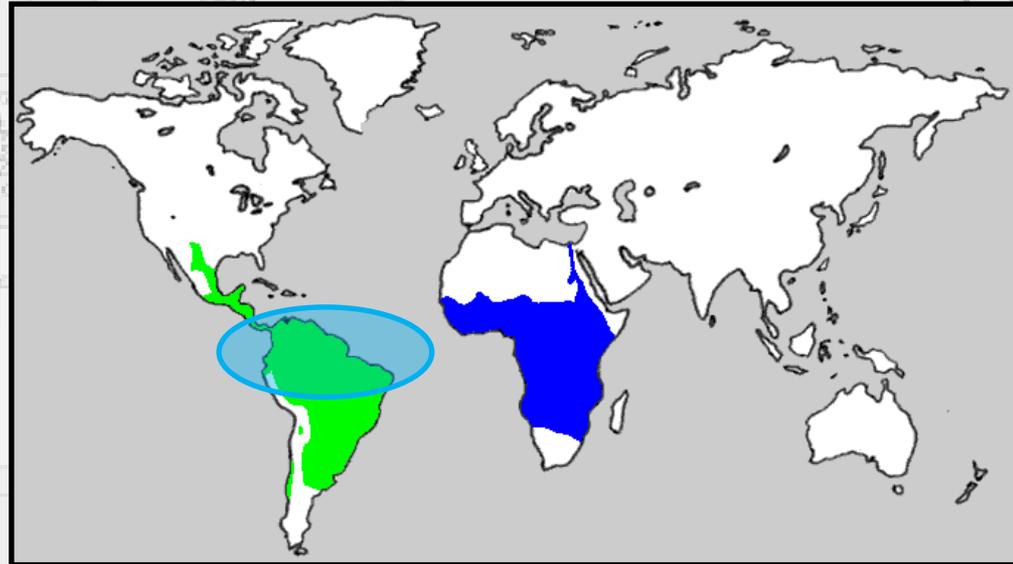
Buckup (1998) / Géry (1977):

This freshwater fish family is splitted into 2 different families:

- Characidae (endemic in South America).
- Alestidae (endemic in Africa).

Zanata & Vari (2005):

The South American genus *Chalceus* is included in the African Alestidae.



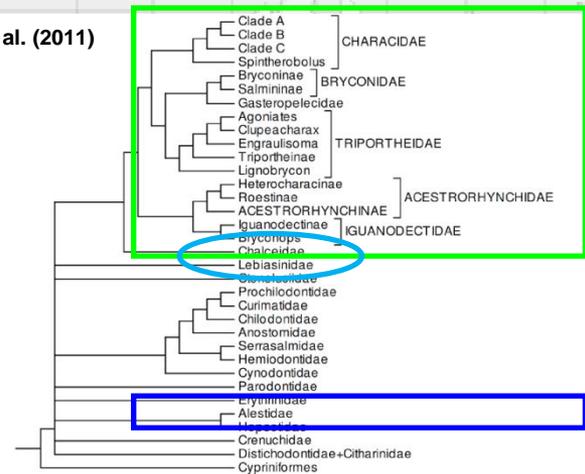
from Mirande (2010)

Royal Museum for Central Africa (RMCA Tervuren)

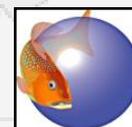


© Miguel Landines

from Oliveira et al. (2011)



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Distribution of freshwater fishes

Example 7: Clariidae

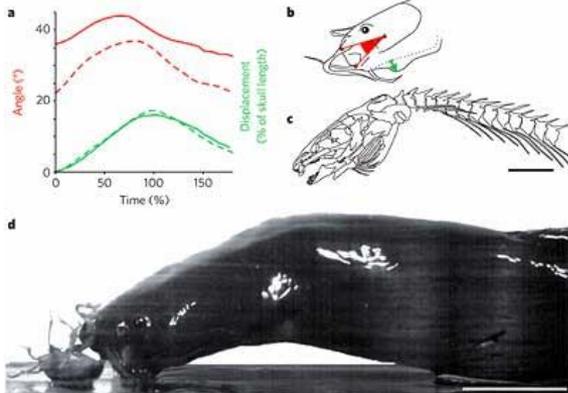
The Clariidae (air-breathing catfishes) are widely distributed in Africa to Asia Minor and from southern and southeastern Asia to the Philippines and Java. The range of the genus *Clarias* more or less approximates the range of the family.



Suprabranchial organ



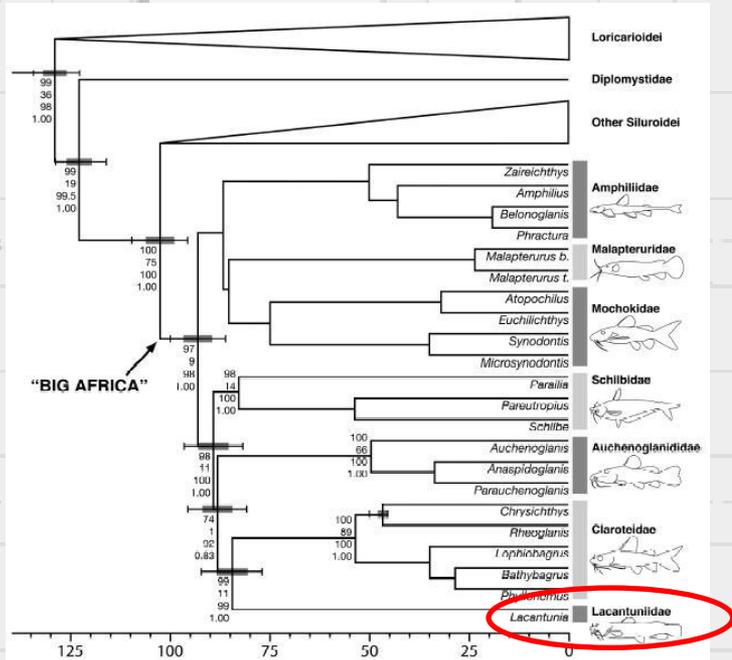
Some species are able to survive in drying mud pools. It is also shown for some species that they can catch their prey on land (Van Wassenberghe et al., 2006).



Distribution of freshwater fishes

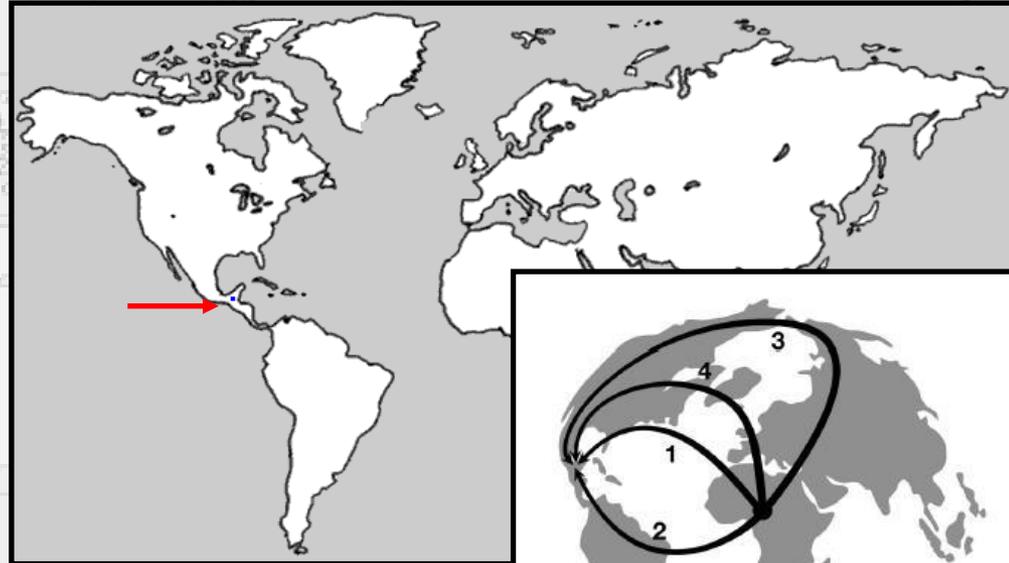
Example 8: Lacantuniidae

The Lacantuniidae are a freshwater fish family recently discovered in Mexico.



Based on phylogeny, this American fish family has African roots (Lundberg *et al.*, 2007). Since there are no living or fossil intermediates, this is an extraordinary case of biogeographic disjunction. There are different hypotheses to explain this disjunct distribution.

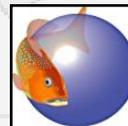
Royal Museum for Central Africa (RMCA Tervuren)



© John P. Sullivan

from Lundberg *et al.* (2007)

Fig. 4. Schematic alternative hypotheses for freshwater dispersion from Africa to Mesoamerica. 1) Pangean: Africa to North America before opening of the Central Atlantic and then to Mesoamerica, 2) Gondwana: Africa to South America before opening of the South Atlantic and then to Mesoamerica, 3) Bering land bridge: Africa to Asia to North America during Late Cretaceous to Late Miocene warm climate and then to Mesoamerica, 4) North Atlantic land bridge: Africa to Europe to North America during Late Cretaceous to Late Paleogene warm climate and then to Mesoamerica. Freshened surface waters of the Arctic and adjacent northern oceans during the middle Eocene raises a possibility of direct open-water dispersion from Europe or Asia to North America.



FishBase and Fish Taxonomy Training
Session 2017

Distribution of freshwater fishes

Example 9: Galaxiidae

The Galaxiidae are a peripheral family containing some diadromous species. The family occurs in cool temperate waters of the southern hemisphere in South America, South Africa and Australia.

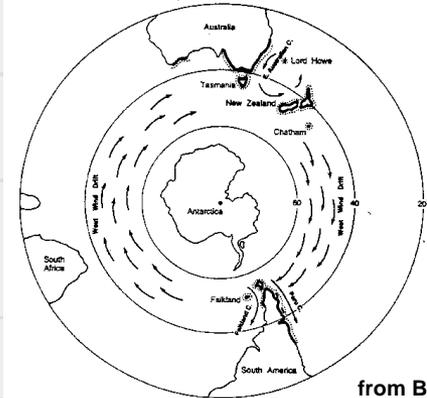
© Robert M. McDowall



Galaxias maculatus (Jenyns, 1842) has a widely disjunct distribution for a freshwater fish. Two hypotheses have been used to explain it.

- A. Dispersal: movement of the marine juvenile stage through the sea (McDowall, 1970).
- B. Vicariance: the present distribution reflects an ancient Pangaean pattern followed by continental drift (Rosen, 1974).

Berra *et al.* (1996) proved the two populations did not differ genetically, indicating that gene flow via dispersal through the sea occurs today.

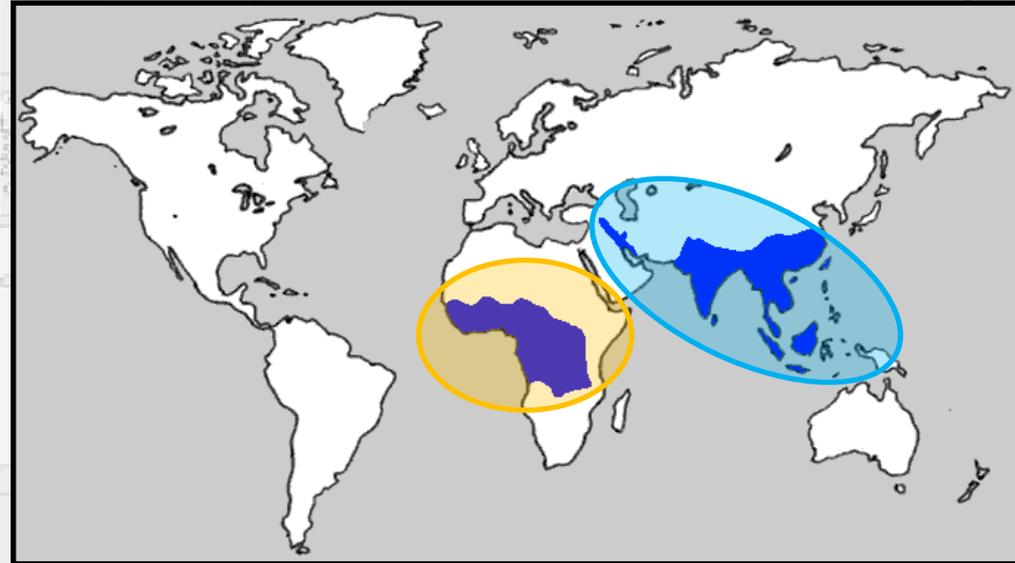
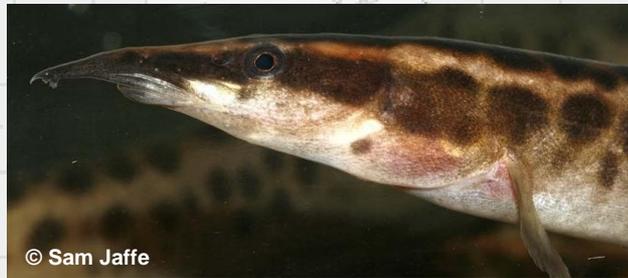


from Berra *et al.* (1996)

Distribution of freshwater fishes

Example 10: Mastacembelidae

The Mastacembelidae (spiny eels) are a primary freshwater fish family found in tropical and subtropical Africa, the Euphrates River, the Indian region, southeastern Asia and China. Some Asian species are found in brackish water.



Travers (1984) separated the Mastacembelidae into two subfamilies:

A. Mastacembelinae: distributed in southeast Asia.

B. Afromastacembelidae: distributed in Africa.



According to Vreven (2006), the use of subfamilies is rejected. The proposed characters supporting their monophyly are refutable. Moreover, all African species are now placed in the genus *Mastacembelus*.

Distribution of freshwater fishes

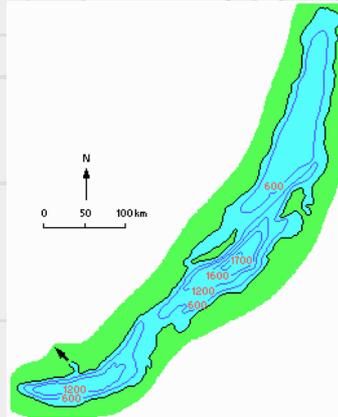
Example 11: Comephoridae

The Comephoridae (baikal oilfishes) are a small family consisting of two species. They are endemic in Lake Baikal. They are called oilfishes, because of their very high fat content (as much as 25% of its body weight).



The Comephoridae are considered as the world's most abyssal freshwater fish. They live at depths between 200m and 1000m, and are so numerous and spawn so rapidly that they represent the largest biomass of fish in the lake. In order not to unbalance the ecosystem, it is constantly fed upon by predators.

Royal Museum for Central Africa (RMCA Tervuren)



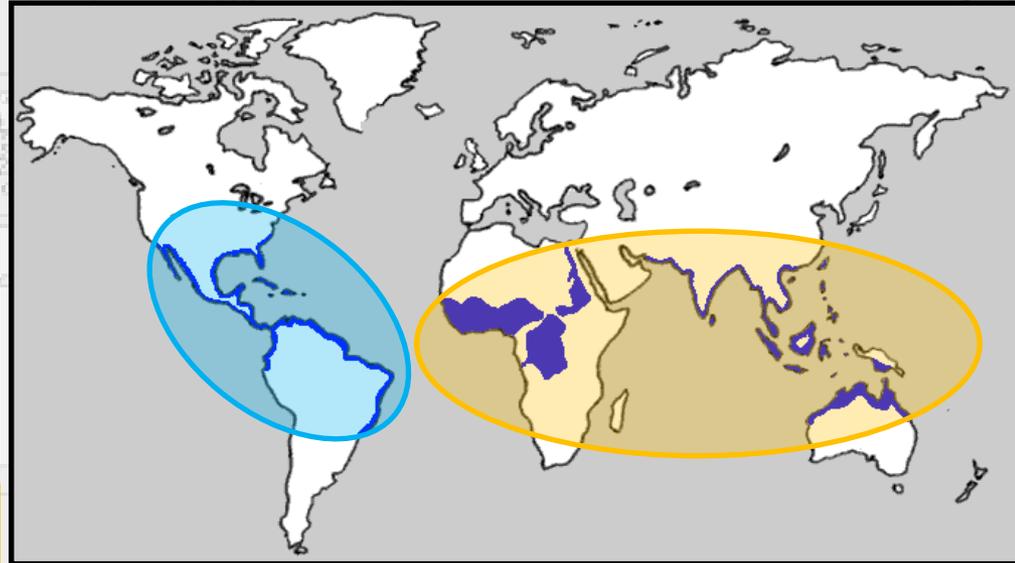
Distribution of freshwater fishes

Example 12: Centropomidae

The Centropomidae (snooks) are a widespread family, containing some freshwater species, especially in Africa.

Recently, this family is divided into 2 families by Mooi & Gill (1995):

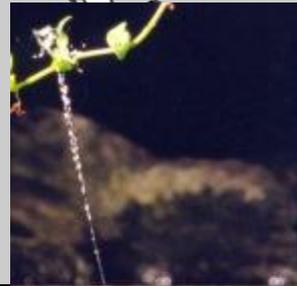
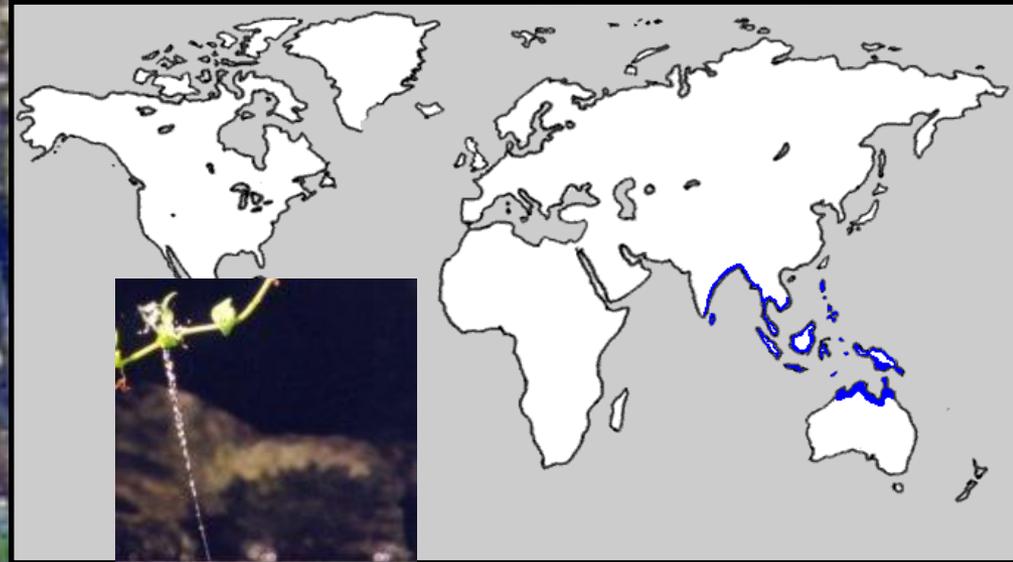
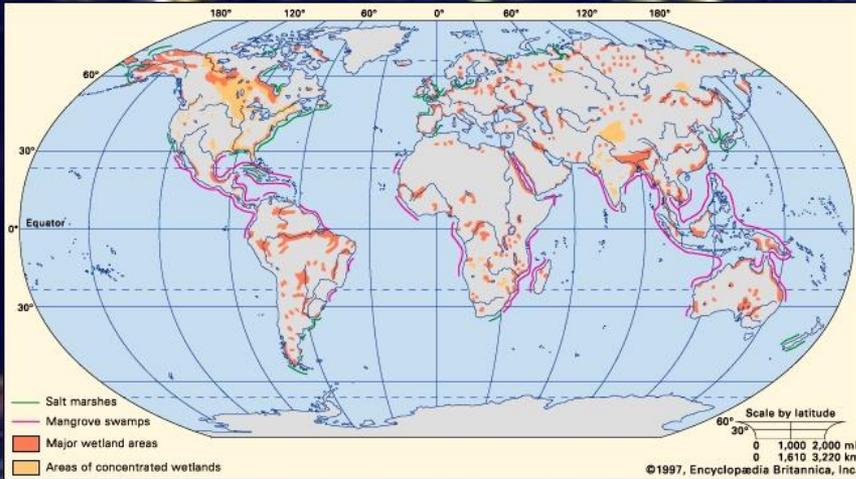
- A. Centropomidae: It includes 6 species distributed in the Pacific Ocean and 6 species distributed in the Atlantic Ocean. They all belong to the genus *Centropomus*.
- B. Latidae: It includes 9 species of the genus *Lates*, distributed in Africa, Asia and Australia, and 1 species of the genus *Psammoperca*, distributed in the Pacific Ocean and Indian Ocean.



Distribution of freshwater fishes

Example 13: Toxotidae

The Toxotidae (archerfishes) are a peripheral fish family, distributed in southeastern Asia and Australia. The archerfishes occur in coastal mangrove swamps, brackish estuaries and freshwater streams.



© David Stone

Archerfishes are known for their remarkable ability to 'shoot down' insects from the vegetation overhanging the water surface. They can actually hit an insect 1,6 m above the water's surface.

Distribution of freshwater fishes

Example 14: Cichlidae

The Cichlidae (cichlids) are a secondary freshwater family, belonging to an otherwise marine suborder, the Labroidei (Perciformes). The distribution includes Central America, the West Indies, South America, Africa, Madagascar, Middle East, coastal India and Sri Lanka. The exact number of species is not known, many are still undescribed.



Many cichlid fishes have a fair degree of salt water tolerance (*Oreochromis*, *Tilapia* and *Sarotherodon*).



The African lakes are characterized by the presence of species flocks of Cichlidae, with a high degree of endemism.



Ichthyofaunal provinces in Africa

Africa has a well-diversified fish fauna. It shares affinities with both South America and Asia.

- The levels of endemism are high for many parts of Africa.
- Several archaic taxa are present in Africa (e.g. Protopteridae).
- There is recent adaptive radiation in some regions (e.g. Cichlidae of Lake Victoria).

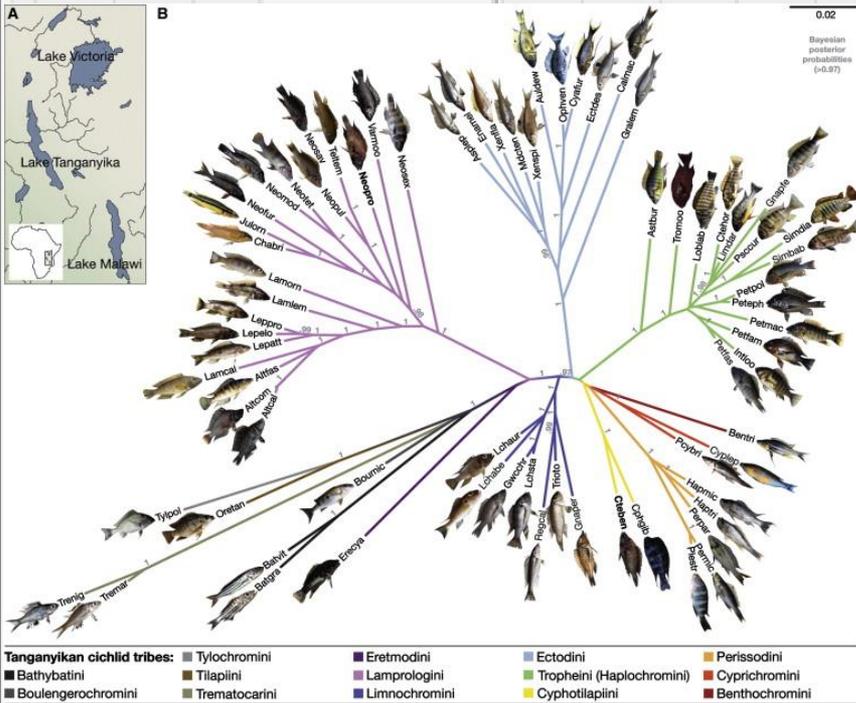
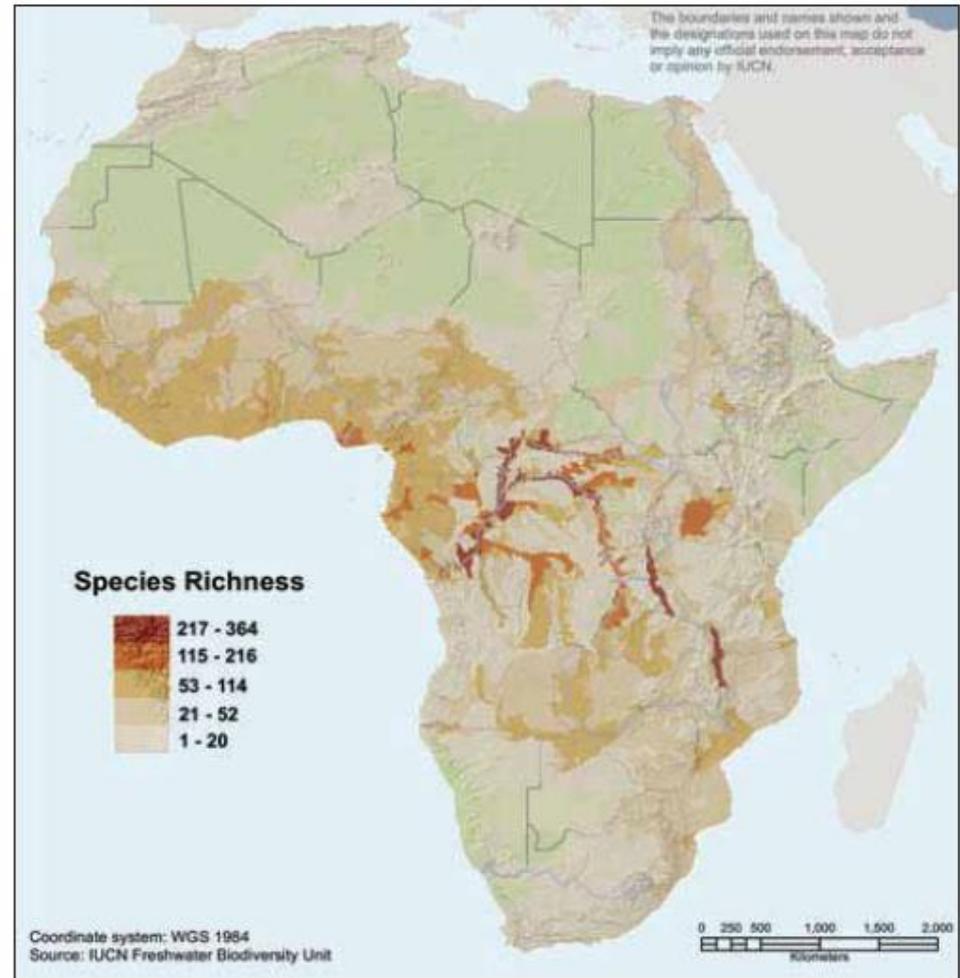


Figure 3.4. The distribution of freshwater fish species across mainland continental Africa. Species richness = number of species per river/lake sub-catchment.

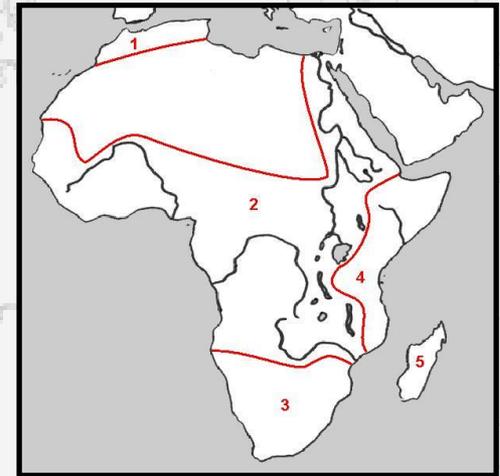


Ichthyofaunal provinces in Africa

Attempts to subdivide Africa into ichthyofaunal provinces dates back to Boulenger (1905).

Boulenger, G.A. (1905), The distribution of African freshwater fishes. *Nature* 72(1905): 413-421.

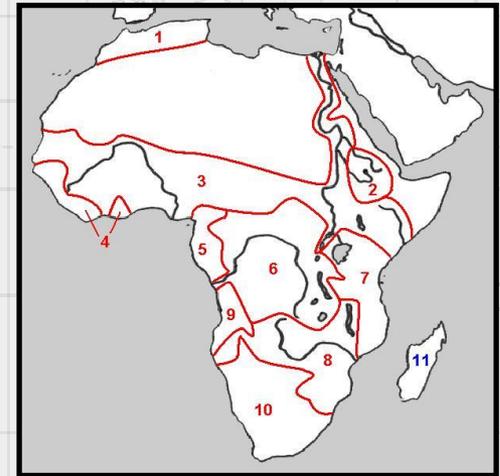
1. North-western subregion.
2. Western-central subregion.
3. Southern subregion.
4. Eastern subregion.
5. Madagascar.



The basis for a modern synthesis was formulated by Roberts (1975).

Roberts, T.R. (1976), Geographical distribution of African freshwater fishes. *Zoological Journal of the Linnean Society* 57: 249-319.

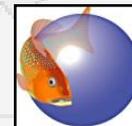
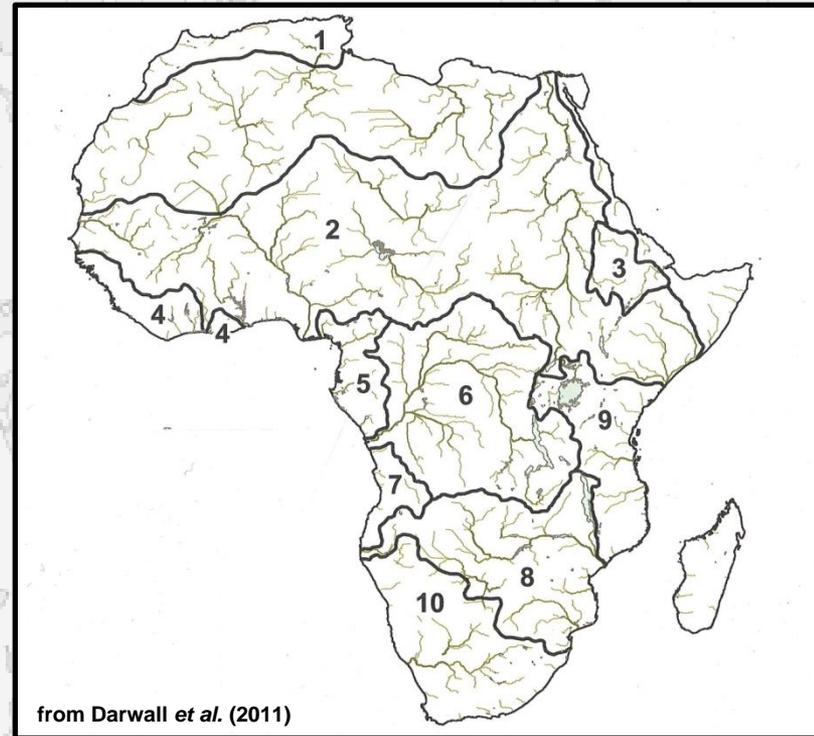
1. Maghreb.
2. Abyssinian Highlands.
3. Nilo-Sudan.
4. Upper-Guinea.
5. Lower-Guinea.
6. Zaire (Congo).
7. East Coast.
8. Zambezi.
9. Quanza.
10. Cape of Good Hope.
11. Madagascar.



Ichthyofaunal provinces in Africa

The modern ichthyofaunal provinces

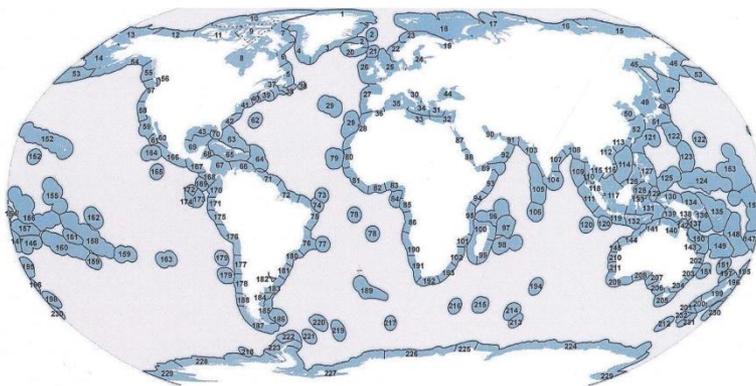
- 1. Maghreb.**
 - Atlas mountains and coastal rivers to Atlantic Ocean and Mediterranean Sea.
- 2. Nilo-Sudan.**
 - Senegal River, Volta River, Niger River, Chad basin, Nile River (excluding Lake Victoria and Lake Edward) and Lake Turkana.
- 3. Abyssinian Highlands.**
 - Upper Blue Nile, Lake Tana and Awash River.
- 4. Upper Guinea.**
 - Coastal rivers from Senegal to Ghana.
- 5. Lower Guinea.**
 - Coastal rivers from Nigeria to Congo DR.
- 6. Zaire (Congo).**
 - Congo River basin, including Lake Tanganyika.
- 7. Quanza.**
 - Coastal rivers between Congo River and Cunene River.
- 8. Zambezi.**
 - Cunene River, Okavango basin, Zambezi River basin (with Lake Malawi) and Limpopo River.
- 9. East Coast.**
 - Coastal rivers between Juba River system and the Zambezi River, including Lake Victoria, Lake Edward and Lake Kivu.
- 10. Southern.**
 - Orange-Vaal River, and all rivers south of it, and west of the Pongolo River.



Ecoregions of the world

Marine Ecoregions

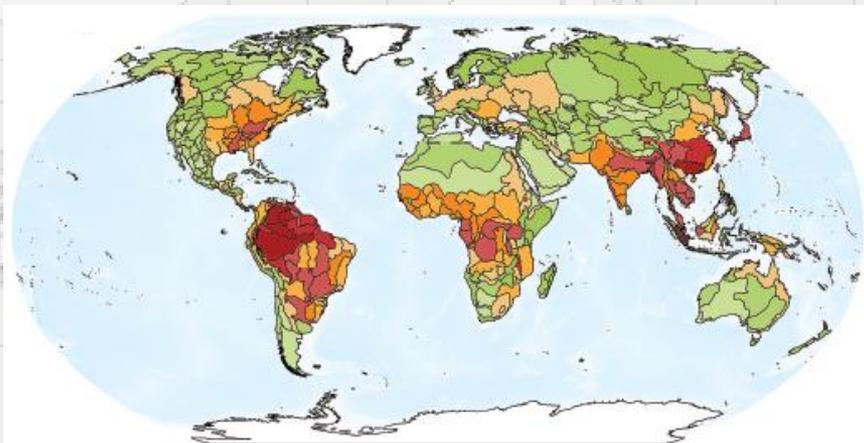
Spalding *et al.* (2007):



232 ecoregions

Freshwater Ecoregions

Abell *et al.* (2008):



426 ecoregions