

The background of the slide is a light gray gradient with several realistic water droplets of various sizes scattered across it. The droplets have highlights and shadows, giving them a three-dimensional appearance.

INTRODUCTION TO AQUATIC SCIENCES

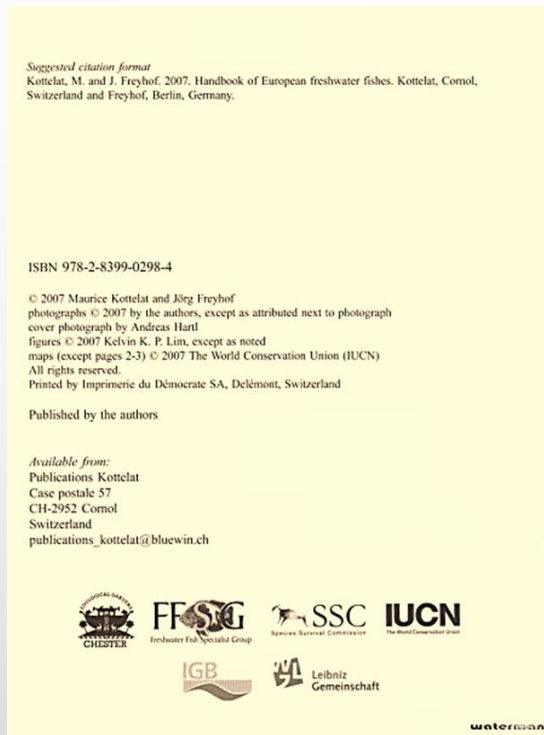
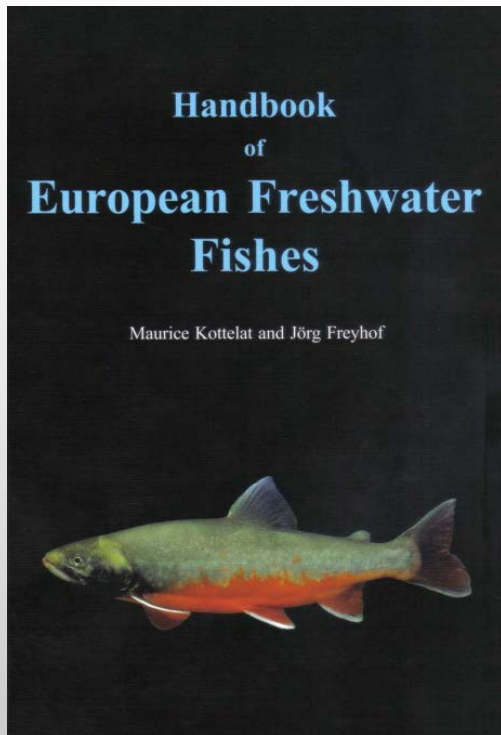
7. Week

Introduction to Freshwater Fish

Introduction to Aquatic Sciences

WEEKLY TOPICS (CONTENT)

Week	Topics
1. Week	Aquaculture in Turkey and world
2. Week	The role of fish in human consumption
3. Week	What is fish? Taxonomy of fish
4. Week	Aquatic Crustacean
5. Week	Water quality for aquaculture
6. Week	Introduction to marine fish
7. Week	Introduction to freshwater fish
8. Week	Live foods (microalgae, zooplankton and <i>Artemia</i>)
9. Week	Introduction to fishing techniques
10. Week	Fish transport
11. Week	Introduction to fish disease
12. Week	Introduction to fisheries economy
13. Week	Processing and marketing of fish
14. Week	Introduction to fisheries and aquaculture management



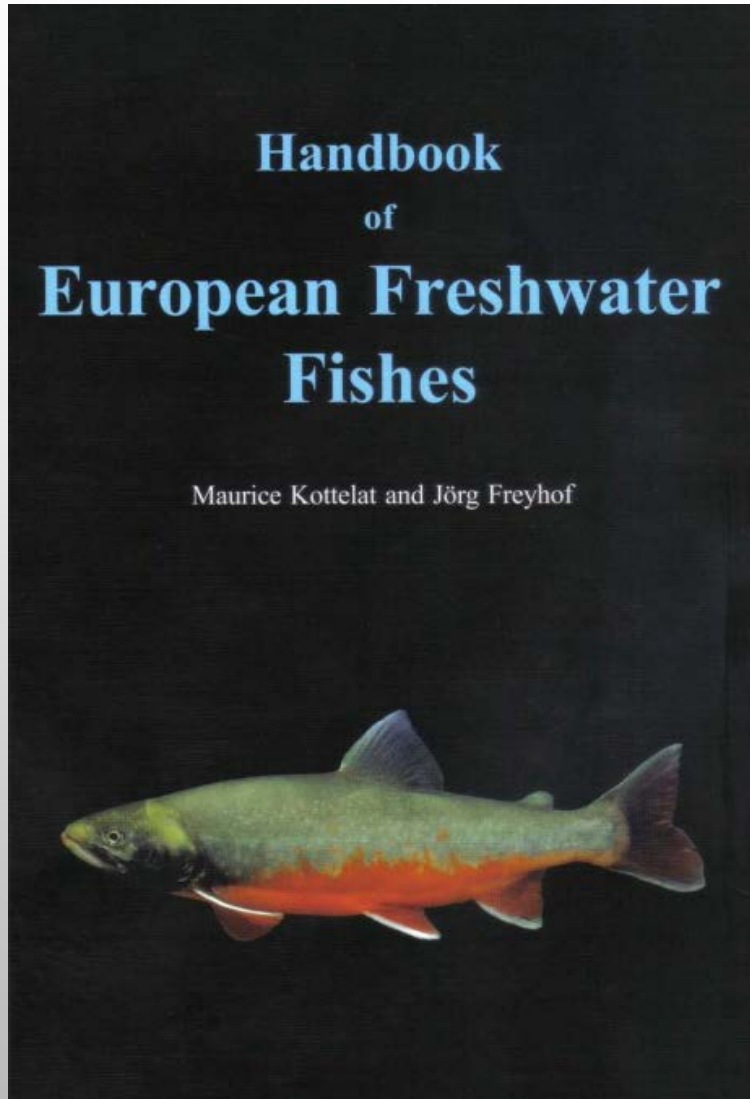
Morphological features
 Measurements
 Fins and fin rays
 Scales
 Colour marks
 Others
 Taxonomy and nomenclature
 Preserving fishes
 Conservation status

Petromyzontidae ..
 Acipenseridae
 Polyodontidae
 Anguillidae

Clupeidae
 Cyprinidae
 Acheilognathinae ...
 Gobioninae
 Cyprininae
 Leuciscinae
 Squaliobarbinae
 Tincinae

Kottelat, M. (2007). Handbook of European freshwater fishes-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.

Kottelat, M. (2007). Handbook of European freshwater fishes-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.



Catostomidae
Cobitidae
Nemacheilidae ..
Ictaluridae
Siluridae
Esocidae
Umbridae
Osmeridae

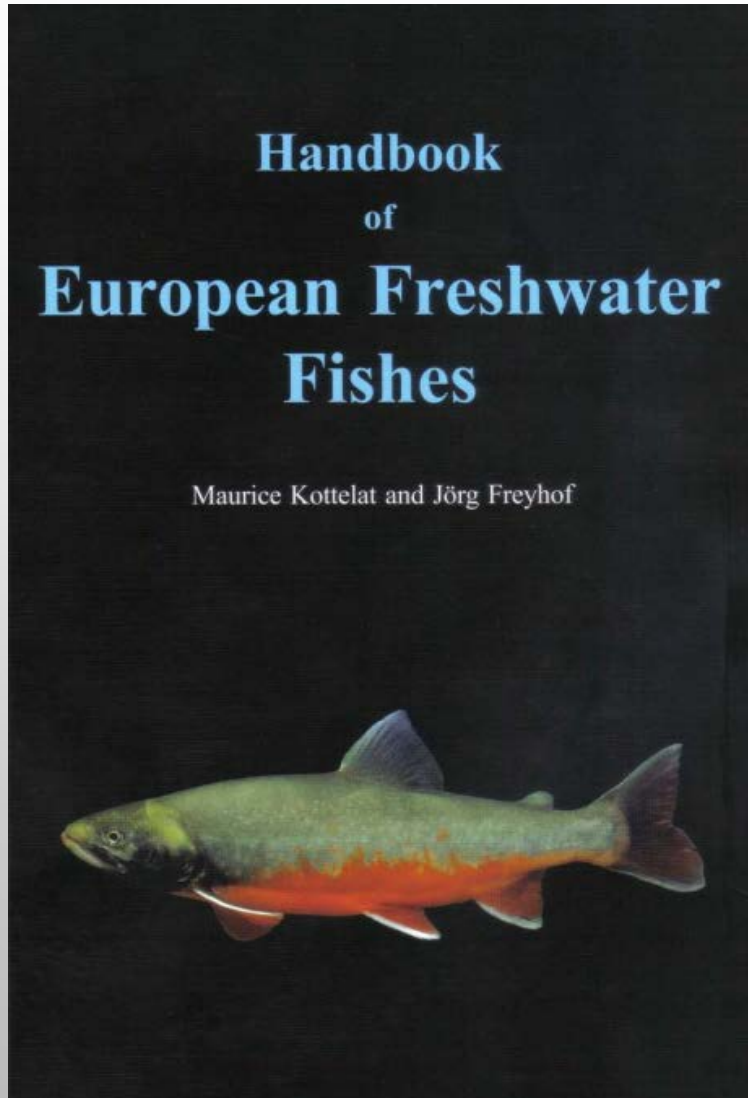
Coregonidae
Salmonidae
Thymallidae
Lotidae
Mugilidae
Atherinidae
Atherinopsidae
Adrianichthyidae ..
Fundulidae

Valenciidae
Poeciliidae
Cyprinodontidae ..
Gasterosteidae
Syngnathidae
Cottidae
Moronidae

Centrarchidae ..
Percidae
Cichlidae
Blenniidae
Odontobutidae ..
Gobiidae
Pleuronectidae ..



Kottelat, M. (2007). Handbook of European freshwater fishes-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.



On current assessments and projections, there may be anything between 25,000 and 40,000 species of fish in the world. This high global diversity of fishes, including at least 14,000 species in freshwaters, remains the least well known among the vertebrates. As many as three hundred new species of fish are scientifically described and named every year, even in geographical areas where knowledge has been assembled over centuries.

Handbook
of
European Freshwater
Fishes

Maurice Kottelat and Jörg Freyhof



Kottelat, M. (2007). Handbook of European freshwater fishes-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.

Kevin Smith, IUCN Species Programme, generated and edited the maps from the data entered in the IUCN Red List database and wrote the backbone of the Conservation status chapter.

Freshwater fishes

Biogeographers usually classify freshwater fish according to their tolerance to salt water. **Primary division families** are those *families* whose members are strictly intolerant of salt water, both currently and historically; examples include Cyprinidae, Cobitidae and most siluriform families. **Secondary division families** are those *families* whose members now live in freshwater but are able, or supposedly were once able, to tolerate seawater for a short period; they are supposed to be of marine origin; examples include Cottidae, Lotidae and Valenciidae.

In addition to these categories that apply to *whole families*, many species occur in freshwaters that belong to mainly marine families; they are termed as follows:

- **diadromous species** are those *species* that migrate between fresh and seawater at different periods of their life, either to spawn in the sea (catadromous, like the eel *Anguilla anguilla*) or in freshwater (anadromous, like the salmon *Salmo salar*);
- **vicarious species** are non-diadromous, strictly freshwater *species* of primarily marine families; examples are freshwater shad *Alosa agone*, the blenny *Salaria fluviatilis* and many Gobiidae;
- **sporadic species** are those *species* that seem to be indifferent to salinity (i.e. euryhaline) and usually occur in estuaries; examples are many species of Mugilidae and the pipefish *Syngnathus abaster*;
- **accidental species** are those normally marine *species* that are very occasionally caught in inland waters; their occurrence is not predictable and there are usually only a few records of the species in freshwaters; an example is the record of the flatfish *Citharinus linguatulus* from Skadar Lake.

Further reading. Myers, 1938, 1951.

Handbook
of
European Freshwater
Fishes

Maurice Kottelat and Jörg Freyhof



Kottelat, M. (2007). Handbook of European freshwater fishes-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.

Family Petromyzontidae

Lampreys

'Parasitic' and 'non-parasitic' lampreys

Lampreys are usually qualified as parasitic or non-parasitic depending on their mode of life. Parasites are defined as species or life stages obligatorily depending on the metabolism on the host. Among the characteristics of parasitism is that the host does not die because of the presence of the parasite, at least not immediately.

Figure 1. Mediterranean river basins as defined for this project



Source: Hydro1k Elevation Derivative Database (USGS EROS)

IUCN
The World Conservation Union

IUCN – The Species Survival Commission

The Species Survival Commission (SSC) is the largest of IUCN's six specialist commissions with a global membership of 8,000 experts. SSC's members work on a number of an ever-widening range of technical and scientific aspects of species conservation and is involved in working to fulfil the biodiversity goals that governments have agreed in international agreements dealing with conservation concerns.

www.iucn.org/species

IUCN – Freshwater Biodiversity Programme

The IUCN Freshwater Biodiversity Programme was set up in 2001 in response to the rapidly increasing rates of freshwater habitat and fish species loss. Its mission is to provide information for the conservation and sustainable management of freshwater biodiversity.

www.iucn.org/freshwater/biodiversity

IUCN – Centre for Mediterranean Cooperation

The Centre was opened in October 2001 and is located in the offices of the Program "Mediterranean Biodiversity Assessment" (MBA) that covers 127 freshwater fish in the Mediterranean region, including 18 governments. Its mission is to enhance, strengthen and promote the capacity of the concerned and to coordinate the regional assessment of the region and work with IUCN experts and associated staff and other agencies that share the objectives of the SSC.

www.iucn.org/mediterranean

Rue des Saussaies 28
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France
Tel: +33 (0) 1 47 32 6000
Fax: +33 (0) 1 47 32 6002
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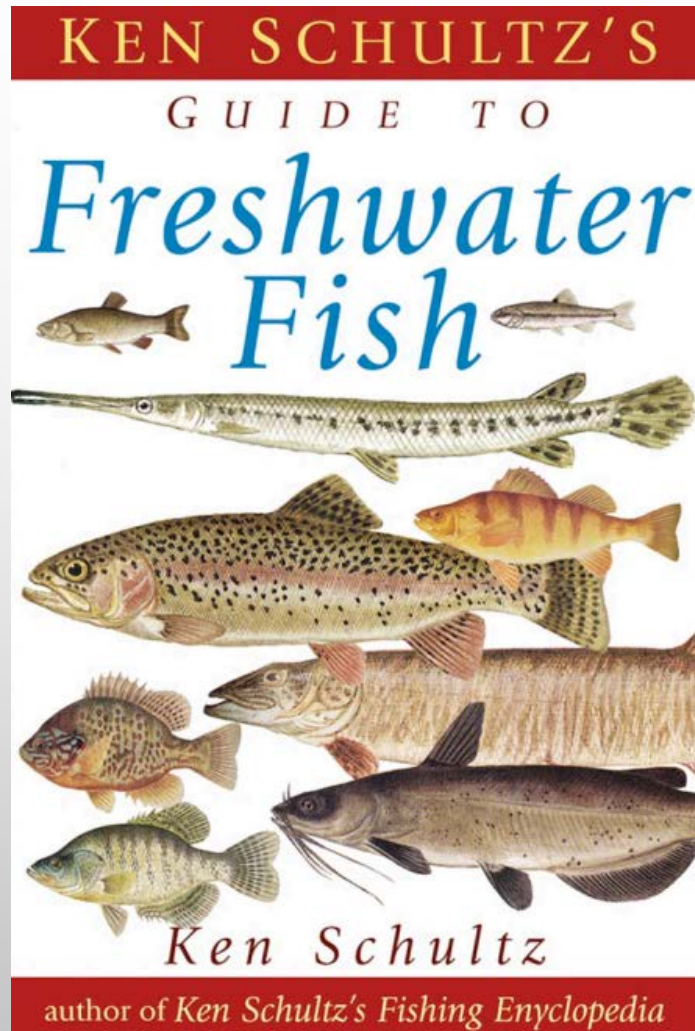
Core support in the IUCN Centre for Mediterranean cooperation is granted by the Spanish Ministry of Environment and the Junta de Andalucía.

IUCN
The World Conservation Union

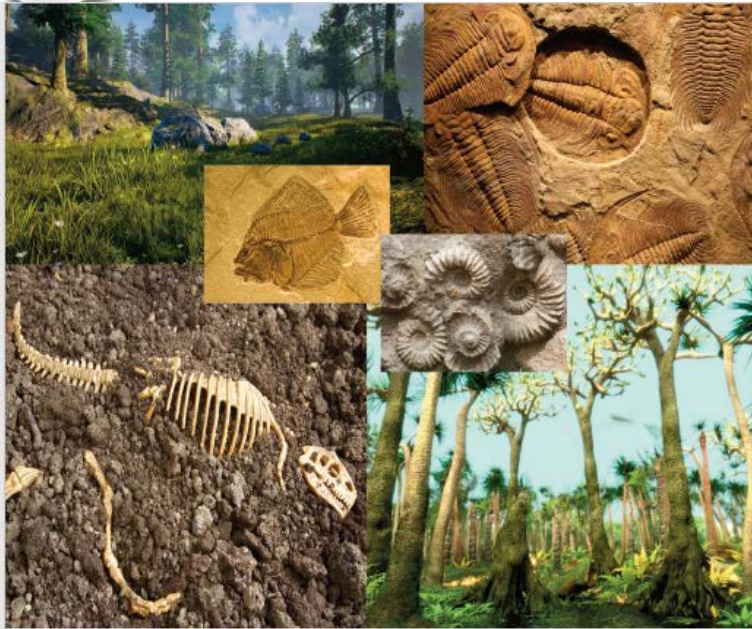
The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin

Compiled and edited by Fern G. Stott and Robert H.T. Davies

IUCN Red List of Threatened Species™ – Mediterranean Regional Assessment No. 1



Schultz, K. (2010). *Ken Schultz's field guide to freshwater fish*. John Wiley & Sons.



Freshwater Fishes

Lionel Cavin

250 Million Years of Evolutionary History

ISTE
PRESS



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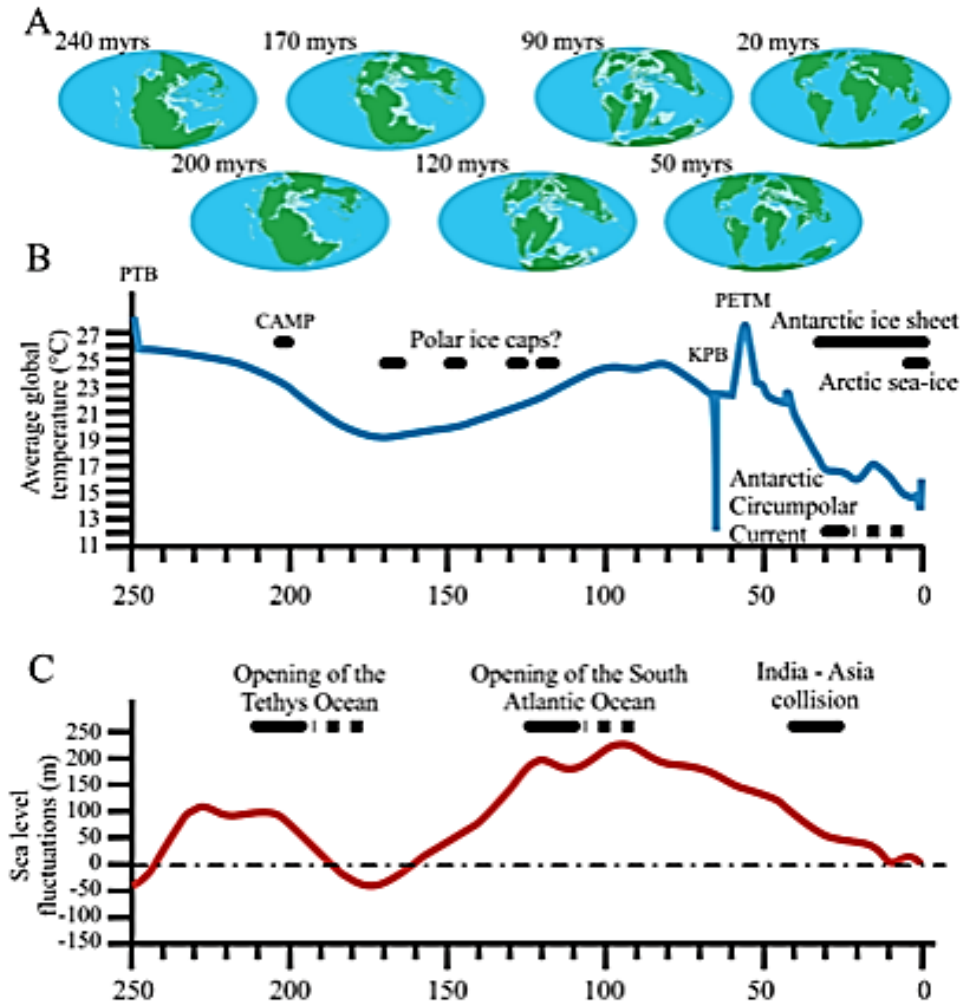


Figure. 1.2. a) Paleogeographic outline in the Mesozoic and Cenozoic. Ages in millions of years; b) Average temperature in the Mesozoic and Cenozoic (according to [SCO 15]) associated with various global events. CAMP, Central Atlantic magmatic province; KPB, Cretaceous–Paleogene boundary; PETM, Paleocene–Eocene thermal maximum; PTB, Permian–Triassic boundary; c) Sea level associated with a few major tectonic events (according to [VER 15]). For a color version of the figure, see www.iste.co.uk/cavin/fishes.zip

Fossil records and estimations of the origins of freshwater fishes.

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Late Triassic (230 myrs)



Figure 2.1. Main sites and formations from the Triassic that yielded faunas of freshwater fishes positioned on a paleogeographic map of the Late Triassic. For a color version of the figure, see www.iste.co.uk/cavin/fishes.zip

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Middle Jurassic (170 myrs)



Figure 2.2. Main sites and formations from the Jurassic that yielded faunas of freshwater fishes positioned on a paleogeographic map of the Middle Jurassic. For a color version of the figure, see www.iste.co.uk/cavin/fishes.zip

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Early Cretaceous (120 myrs)



Figure 2.3. Main sites and formations from the Early Cretaceous that yielded faunas of freshwater fishes positioned on a paleogeographic map of the Aptian. For a color version of the figure, see www.iste.co.uk/cavin/fishes.zip

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Late Cretaceous (66 myrs)

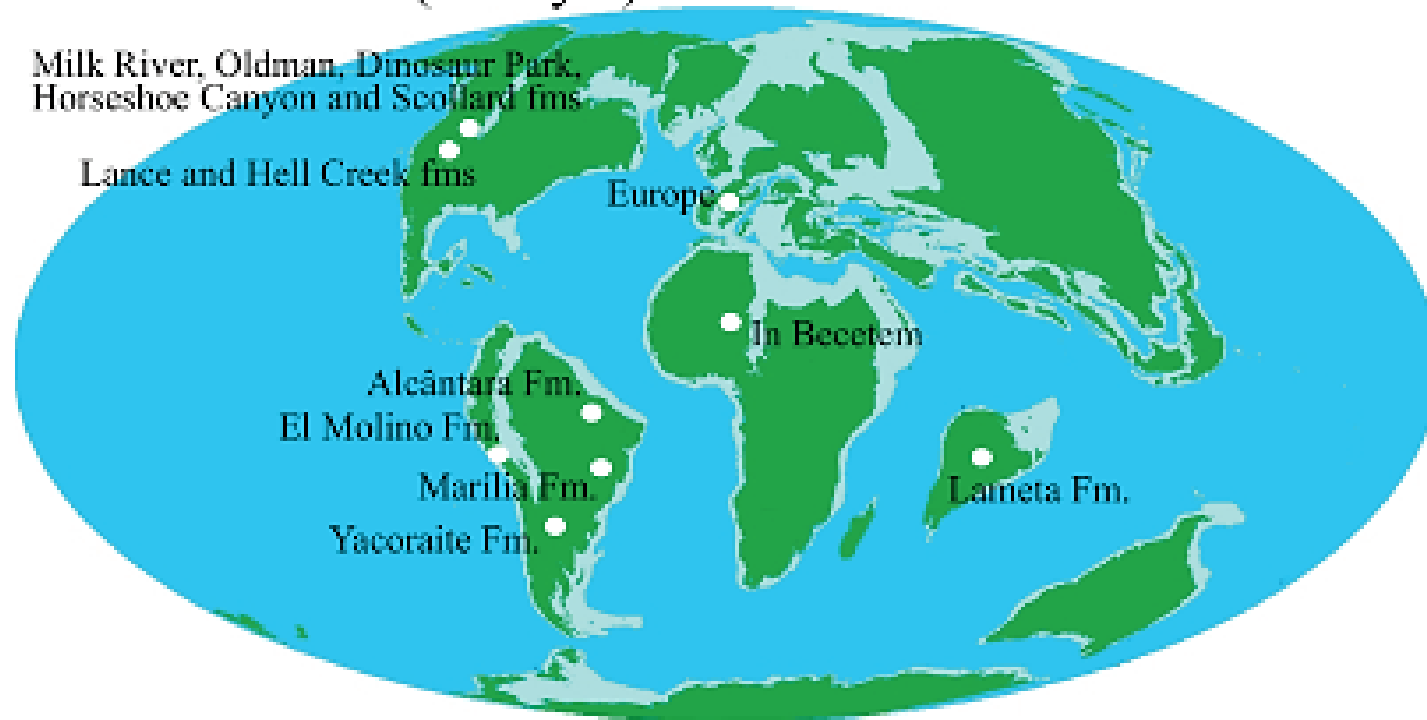


Figure 2.4. Main sites and formations from the Late Cretaceous that yielded faunas of freshwater fishes positioned on a paleogeographic map of the Maastrichtian. For a color version of the figure, see www.iste.co.uk/cavin/fishes.zip

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Common Name

(e.g. rainbow trout)
[A](#) [B](#) [C](#) [D](#) [E](#) [F](#) [G](#) [H](#) [I](#) [J](#) [K](#) [L](#) [M](#) [N](#) [O](#) [P](#) [Q](#) [R](#) [S](#) [T](#) [U](#) [V](#) [W](#) [X](#) [Y](#) [Z](#)
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Scientific Name

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[Why name assignments may be different](#) between FishBase and the independent [Catalog of Fishes \(Eschmeyer, 2014\)](#)

Glossary

(e.g. *page*)

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References

Boyd, C.E. (2015) *Water Quality*, Springer International Publishing Switzerland DOI 10.1007/978-3-319-17446-4_1

Cavin, L. (2017). *Freshwater Fishes: 250 Million Years of Evolutionary History*. Elsevier.

Copp, G.H., Bianco, P.G., Bogutskaya, N.G., Erős, T., Falka, I., Ferreira, M.T., Fox, M.G., Freyhof, J., Gozlan, R.E., Grabowska, J., Kováč, V. (2005). To be, or not to be, a non-native freshwater fish?. *Journal of Applied Ichthyology*, 21(4): 242-262.

Kottelat, M. (2007). *Handbook of European freshwater fishes*-Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany, 646 p.

Roberts, R. J. (2012). *Fish pathology*. John Wiley & Sons.