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## Esociformes: Esocidae, Pikes, and Umbridae (Mudminnows)

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## Chapter 19 Esociformes: Esocidae, Pikes, and Umbridae (Mudminnows)

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By blue lake marge, upon whose breast  
The water-lilies love to rest,  
Lurking beneath those leaves of green  
The fierce pike seeks his covert screen,  
And thence with sudden plunge and leap,  
Swift as a shaft through the air may sweep,  
He seizes, rends, and bears away  
To hidden lair his struggling prey.

—*Fishing in American Waters* by Genio C. Scott

I saw, dimly,  
Once a big pike rush  
And small fish fly like splinters . . .

—*Fish* by D. H. Lawrence

The order Esociformes (Pikes and Mudminnows) comprises two families, Esocidae (Pikes) and Umbridae (Mudminnows). The Pikes are a small Holarctic (Northern Hemisphere) family, that includes large, elongate predators with duckbill-like snouts full of sharp teeth. Popular with sport fishers, the largest Pikes fight fiercely on hook and line. As piscivorous, voracious, ambush predators, the Pikes play an important functional role in the trophic ecology and fish assemblage structure of many aquatic systems, especially in northern lakes. Other esocids, such as the Olympic Mudminnow, *Novumbra hubbsi*, and Blackfishes, genus *Dallia*, are interesting because of their tolerance of low dissolved oxygen and pH. The Alaska Blackfish, *Dallia pectoralis*, and the Northern Pike, *Esox lucius*, can also withstand the extremely cold conditions of the Arctic and subarctic waters of Canada, Alaska, and Siberia. The name Esocidae is derived from Linnaeus's (1758) generic name for Pike, *Esox*,

from the Latin word *esox* meaning Pike, which came originally from the Greek *isox* or possibly the Gaelic *eog*, *ehawe* (= salmon) (Boschung & Mayden 2004).

The three members of the Umbridae (genus *Umbra*) are small, secretive species living primarily in vegetated wetlands, sloughs, and ditches; slow-moving creeks and river margins; and off-channel habitats such as oxbows. Occasionally used as baitfish or sporadically popular in the aquarium trade, they are rarely seen except by fishery biologists and ichthyologists sampling such habitats. They can breathe atmospheric oxygen using a modified swim bladder, which allows them to survive in hypoxic (low dissolved oxygen) conditions in the lowland habitats they usually occupy. They also feed and digest food under relatively cold winter temperatures in their northern haunts. The family name is derived from the Latin word for shade or shadow, *umbra*, apparently in reference to the propensity of the group to inhabit darkly stained waters with abundant cover (Scott & Crossman 1973; Etnier & Starnes 1993).

### DIVERSITY AND DISTRIBUTION

The number of living species of Esociformes is relatively small (Table 19.1). Worldwide, 14 species are recognized; eight of these are native to North America. All fossil and extant species assigned to this order are restricted to continents in the Northern Hemisphere. Extant esociform species are assigned to four genera: *Esox*, *Novumbra*, *Dallia*, and *Umbra*. All are represented in North America. These four genera are recognized either as one family, the Esocidae (Page & Burr 2011; Campbell et al. 2013; Page et al. 2013) or as two families, Esocidae (including

Table 19.1. Classification of the Mudminnows (Umbridae) and Pikes (Esocidae) based primarily on genetic evidence (López et al. 2000; Grande et al. 2004; Near et al. 2012b, 2013; Betancur-R. et al. 2013ab; Grande et al. 2013). After each genus name the number of extant, recognized species is given in parentheses.

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Classification

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Order Esociformes

Family Umbridae (Mudminnows)

Genus *Umbra* (3)

Family Esocidae (Pikes)

Subfamily Dallinae (Blackfishes)

Genus *Dallia* (3)

Subfamily Esocinae (Pikes)

Genus *Novumbra* (1)

Genus *Esox* (7)

Subgenus *Esox* (5)

Subgenus *Kenoza* (2)

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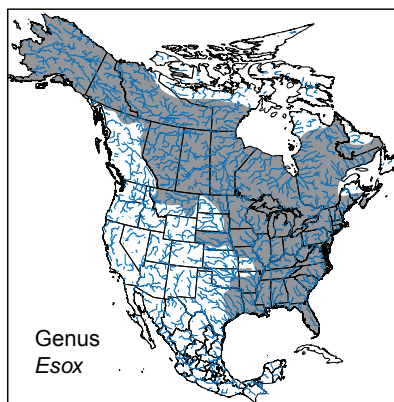


Figure 19.1. Geographic range of *Esox* in North America.



Figure 19.2. Northern Pike, *Esox lucius*, this group in the Yellowknife River, Northwest Territories, has the largest geographic range of any esociform in North America (photograph in May 2012 by and used with permission of © Paul Vecsei / Engbretson Underwater Photography).



Figure 19.3. The Chain Pickerel, *Esox niger*, one of two species in the subgenus *Kenoza*, the other being the Grass Pickerel, *Esox americanus*. *Kenoza* contains the smallest North American Pikes (photographs taken in Nov 2013 by and used with permission of Lance Merry).

*Esox*, *Novumbra*, and *Dallia*) and Umbridae (including *Umbra*). We adopt the latter approach herein (see phylogenetic relationships section) (López et al. 2000; Grande et al. 2004, 2013; Betancur-R. et al. 2013ab, 2017; Nelson et al. 2016).

### Genus *Esox*

The genus *Esox*, the Pikes (and pickerels), is the most diverse and has the widest geographic distribution among esociform genera. Seven living species are currently rec-

ognized in *Esox*; three are endemic to North America, one has a Holarctic distribution (Table 19.1; Fig. 19.1), one is native to Asia, and two are endemic to southern Europe.

The species of *Esox* are divided between the subgenera *Esox* and *Kenoza*. The subgenus *Esox* comprises of the Northern Pike (*Esox lucius*), Holarctic distribution (Fig. 19.2); Muskellunge (or musky), *Esox masquinongy*, endemic to North America; Amur Pike, *Esox reichertii*, of Asia; and Southern Pike, *Esox cisaplinus* = *E. flaviae* and Aquitanian Pike, *Esox aquitanicus*, of southern Europe (Launey et al. 2006; Berra 2007; Bianco & Delmastro 2011; Lucentini et al. 2011; Bianco 2014; Denys et al. 2014; Gandolfi et al. 2015; Nelson et al. 2016). The subgenus *Kenoza* comprises the Chain Pickerel, *Esox niger* (Fig. 19.3), and Grass Pickerel, *Esox americanus* (Fig. 19.4), both of which are endemic to North America. The Grass Pickerel has two subspecies, the Redfin Pickerel, *E. a. americanus*, and the Grass Pickerel, *E. a. vermiculatus* (Page & Burr 2011; Fig. 19.4). The eastern Asian endemic, Amur Pike, and the European endemics, Southern Pike (native to Padano-Veneto, Tuscany and Lazio, Italy, and apparently historically to Lake Geneva, Switzerland, and

France), and Aquitanian Pike (endemic to southwestern France) are the only extant species in the genus that are not native to North America (Bianco & Delmastro 2011; Lucentini et al. 2011; Denys et al. 2014).

The Northern Pike exhibits the widest distribution of any esociform species, occurring at temperate latitudes in Asia, Europe, and North America (Crossman 1996; Berra 2007; see Bianco & Delmastro 2011; Denys et al. 2014). In North America, the native range of the species includes most of Canada except the Maritime Provinces, most of western and southern British Columbia, and the Arctic Archipelago. In the United States, the native range of the Northern Pike includes the northern half of the country (as far south as Missouri) between the Rocky and Appalachian Mountains, a range covering 23 states (Page & Burr 2011). Generally, the Northern Pike is restricted to fresh water, but some European populations regularly enter brackish water and spawn in coastal areas of the Baltic Sea (Scott & Crossman 1973). The present distribution of the species and apparent genetic homogeneity throughout its range probably resulted from a rapid range expansion of some small number of populations, which took place after receding glaciers made habitat available; however,



Plate 19.1. Muskellunge, *Esox masquinongy*.



Figure 19.4. Grass Pickerel, *Esox americanus vermiculatus* (adult, upper, and juvenile, lower), another member of the subgenus *Kenoza* (photographs taken in Kankakee County, Illinois, upper, and Newton County, Indiana, lower, in April 2008 by and used with permission of Uland Thomas).

debate is ongoing over the number and location of the populations of the Northern Pike that survived the glacial maxima and gave rise to living populations (see genetics section).

The other three North American species of *Esox* are more limited in native distribution than the Northern Pike. They are restricted to the Great Lakes, Mississippi River, and Atlantic Coast drainages of central and eastern North America. The Muskellunge (from the Ojibwa word *maash-kinoozhe*) is native to the Great Lakes and the upper Mississippi River system from southern Canada to Tennessee. The native range of the Muskellunge is sometimes divided into three geographic regions reflecting variation in color pattern among populations, which may be indicative of incipient taxonomic differentiation. The three regions are Wisconsin, Minnesota, southwestern Ontario, and southeastern Manitoba; Great Lakes and St. Lawrence River; and the Ohio River system (Scott & Crossman 1973) with possibly a fourth variant in the Tennessee and Cumberland Rivers (Etnier & Starnes 1993). The taxonomic status of the color variants prevalent in these regions is the subject of debate (e.g., Hourston 1955; Crossman 1978; Trautman 1981; Etnier & Starnes 1993). Dramatic population declines in much of the Ohio River system (e.g., Cumberland and Tennessee River populations) and introductions and artificial hybridization confound understanding of these variants (Casselman et al. 1986; Etnier & Starnes 1993; Jenkins & Burkhead 1994).

The native range of the two species in the subgenus *Kenoza* (Chain Pickerel and Grass Pickerel) extends south into central Florida and includes the southernmost latitudes naturally inhabited by any esociform. The Chain Pickerel (Fig. 19.3) inhabits Atlantic Coastal Plain drainages from southern Canada to Florida, in the lower reaches of the Mississippi River basin, and Gulf Coast drainages (Page & Burr 2011). The native range of the Grass Pickerel

(Fig. 19.4) includes Atlantic and Gulf Coast drainages as far north as the U.S.–Canadian border (Page & Burr 2011). The two species are morphologically distinct (e.g., *E. americanus*, unlike *E. niger*, exhibits an elongation of the maxillae beyond the midpoint of the eye, and reduction in the number of branchiostegal rays, pelvic-fin rays, and lateral-line scales) (Grande et al. 2004).

Populations of the Grass Pickerel in the Atlantic Coast drainages correspond to the subspecies *E. a. americanus*, Redfin Pickerel, which gradually intergrades with populations of *E. a. vermiculatus*, Grass Pickerel, in the southern part of its range between western Florida and western Mississippi (Crossman 1978). The Mississippi drainage populations consist mostly of Redfin Pickerel. Individuals of both subspecies occur in Coastal Plain drainages of Alabama and Georgia. Morphological analyses (i.e., morphometrics, cardioid scale frequencies) confirm distinctiveness of the two subspecies. In the intergrade zone fish show intermediacy in some characters and tendency to overlap with one subspecies or the other in other characters (Crossman 1966; Reist & Crossman 1987).

Mitochondrial DNA barcoding, using partial sequences of cytochrome *c* oxidase subunit I among geographically dispersed individuals of *E. americanus* revealed two unconfirmed candidate species with genetic divergences of >2% (April et al. 2011). A similar analysis of Canadian populations detected genetic differentiation between *E. a. americanus* from the St. Lawrence River to the east and *E. a. vermiculatus* from the Laurentian Great Lakes farther west (Hubert et al. 2008). DNA barcoding did not detect any unconfirmed candidate species in the Chain Pickerel, but the species did share DNA barcodes with the Grass Pickerel (April et al. 2011; see genetics section); other genetic analyses of these taxa produced similar results (Grande et al. 2004; Hubert et al. 2008).



Figure 19.5. The Olympic Mudminnow, *Novumbra hubbsi*, is the smallest and most range restricted esocid, reaching only about 80 cm TL, and being restricted to the Olympic Peninsula, Washington (photograph taken by and used with permission of Tom Baugh).

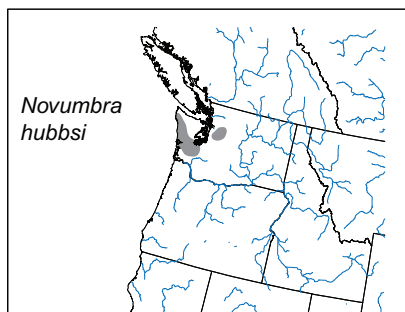


Figure 19.6. Geographic range of the Olympic Mudminnow, *Novumbra hubbsi*.

### Genus *Novumbra*

The monotypic genus *Novumbra* includes the Olympic Mudminnow, *Novumbra hubbsi*, (Fig. 19.5), but one fossil species, †*Novumbra oregonensis*, is also assigned to the genus (Cavender 1969). The Olympic Mudminnow is conspicuous as the smallest, most range-restricted species of esocid. It occurs in the Chehalis River drainage, Washington, in direct tributaries of southern Puget Sound, and in lowland habitats of the Olympic Peninsula from North Bay of Grays Harbor to Ozette Lake (Harris 1974). The Olympic Mudminnow distribution reflects the glacial refugia that existed at the margins of the Vashon Glacier during the Pleistocene (1.8–0.01 mya) (Fig. 19.6). Morphological differences among populations suggest limited dispersal since that time (Meldrim 1968). Genetic evidence indicates that Olympic Mudminnow populations in eastern Puget Sound represent undocumented introductions of the species from an unknown location on the southern Olympic Coast (DeHaan et al. 2014). As with other Mudminnow species, the Olympic Mudminnow is strongly associated with shallow, sluggish water bodies, dense vegetation, and fine substrates (Meldrim 1968).

Fossil locations of *Novumbra* suggest bogs, swamps, and freshwater marshes were the preferred habitat since the Oligocene (33.9–23.03 mya) (Schultz 1929, 1930).

### Genus *Dallia*

The three currently recognized species of *Dallia* are native to western Alaska and the northeastern Siberian Chukot, although controversy exists over the validity of the two forms restricted to Asia (Mecklenburg et al. 2002; Campbell & López 2014). The Alaska Blackfish, (can'giiq in the Yup'ik language) (Fig. 19.7), is the only member of the genus occurring in North America (Fig. 19.8). The complete geographic range of *D. pectoralis* covers the northeastern portion of the Chukotsky (Chukchi) Peninsula in Asia to the coastal areas of the Bristol Gulf in the far northeast of Russia, the coastal plains of the Arctic and Bering Sea drainages of western Alaska, and St. Lawrence, St. Matthew, and Nunivak Islands in the Bering Sea. The two other species in the genus, the Palkhykay Blackfish, *Dallia delicatissima*, and the Amguema Blackfish, *Dallia admirabilis*, are endemic to the northern coastal drainages of the Chukotka Peninsula, Amguyema River drainage, in far northeastern Siberia (Chereshnev & Balushkin 1981; Gudkov 1998).

From a zoogeographic perspective, the genus is unique among strictly freshwater fishes in being restricted to the Beringia Ice Age refugium. The distribution of the Alaska Blackfish is mysteriously circumscribed without evident barriers to its post-glacial dispersal along Arctic Coastal lowlands (toward the Mackenzie or Kolyna Rivers) or upstream in the Yukon River beyond its present limit near Fairbanks (Lindsey & McPhail 1986). Differences in chromosome numbers between populations of the Alaska Blackfish from



Figure 19.7. Male Alaska Blackfish, *Dallia pectoralis*, about 203 mm TL, captured from ditches near the vicinity of Anchorage, Alaska, by K. Stoops in 1982 (courtesy of John Brill).

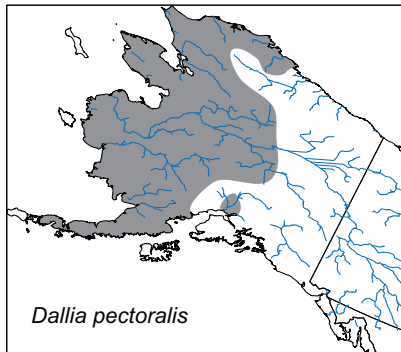


Figure 19.8. Geographic range of the Alaska Blackfish, *Dallia pectoralis*, in North America, including an introduced population near Anchorage, Alaska.

the Yukon and Colville River drainages and genetic structure revealed by mitochondrial DNA analyses suggest the presence of undescribed taxonomic units (see genetics section) (Crossman & Ráb 1996; Campbell & Lopez 2014).

### Genus *Umbra*

The genus *Umbra* includes three extant species of Mudminnows; of these, two are endemic to North America (Fig. 19.9) and one to Europe (European Mudminnow, *Umbra krameri*). The Central Mudminnow, *Umbra limi* (Fig. 19.10), inhabits the Great Lakes region, Hudson Bay, the upper and middle Mississippi River drainage, mostly northern tributaries of the Ohio River, and sparsely occurs in the Missouri River drainage, Iowa, South Dakota, and Missouri. The Eastern Mudminnow, *Umbra pyg-*

*maea* (Fig. 19.11), occurs in Atlantic Coast drainages from New York to South Carolina (Page & Burr 2011). Problematic specimens of *Umbra pygmaea* from south of Okefenokee Swamp in Baker County, Florida, have higher dorsal- and anal-fin ray counts than either *U. pygmaea* or *U. limi* (Laerm & Freeman 2008).

### Esociforms as Non-natives

The native distribution of species of *Esox* has been altered as a result of introduction and extirpation. The Northern Pike and Muskellunge are introduced extensively outside of their natural ranges because of their value to recre-

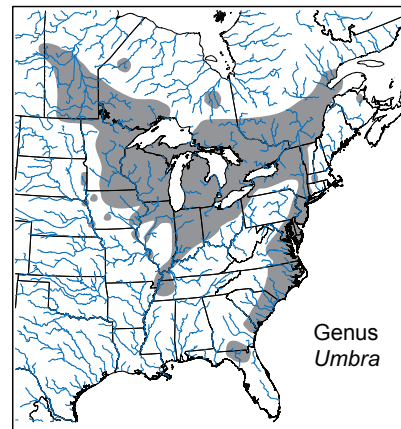


Figure 19.9. Geographic range of *Umbra* in North America.



Figure 19.10. Male (upper) and female (lower) Central Mudminnows, *Umbra limi*, during the breeding season (photographs taken April 2008, Kankakee County, Illinois, by and used with permission of Uland Thomas).