

Northern Pike (*Esox lucius*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, February 2019
Web Version, 8/26/2019



Photo: Ryan Hagerty/USFWS. Public Domain – Government Work. Available: <https://digitalmedia.fws.gov/digital/collection/natdiglib/id/26990/rec/22>. (February 1, 2019).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2019a):

“Circumpolar in fresh water. North America: Atlantic, Arctic, Pacific, Great Lakes, and Mississippi River basins from Labrador to Alaska and south to Pennsylvania and Nebraska, USA [Page and Burr 2011]. Eurasia: Caspian, Black, Baltic, White, Barents, Arctic, North and Aral Seas and Atlantic basins, southwest to Adour drainage; Mediterranean basin in Rhône drainage and northern Italy. Widely distributed in central Asia and Siberia eastward [*sic*] to Anadyr drainage (Bering Sea basin). Historically absent from Iberian Peninsula, Mediterranean France, central Italy, southern and western Greece, eastern Adriatic basin, Iceland, western Norway and northern Scotland.”

Froese and Pauly (2019a) list *Esox lucius* as native in Armenia, Azerbaijan, China, Georgia, Iran, Kazakhstan, Mongolia, Turkey, Turkmenistan, Uzbekistan, Albania, Austria, Belgium, Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Moldova, Monaco,

Netherlands, Norway, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Sweden, Switzerland, United Kingdom, Ukraine, Canada, and the United States (including Alaska).

From Froese and Pauly (2019a):

“Occurs in Erqishi river and Ulungur lake [in China].”

“Known from the Selenge drainage [in Mongolia] [Kottelat 2006].”

“[In Turkey:] Known from the European Black Sea watersheds, Anatolian Black Sea watersheds, Central and Western Anatolian lake watersheds, and Gulf watersheds (Firat Nehri, Dicle Nehri). [...] Gölü/Western Lakes watersheds and Gulf watersheds.”

“[In Turkmenistan:] Found in Amu Darya basin. Disappeared from the Atrek River and small rivers of the western Kopet Dag [Sal'nikov 1998].”

“Occurs in Odra and Morava river basins [in Czech Republic] [Hanel 2003].”

“Common throughout the country [Denmark] [Frier 1994].”

“[In Estonia:] Common in the Gulf of Riga and Gulf of Finland [Ojaveer and Pihu 2003].”

“Occurs through the country [Finland]. Local stocks complemented through culture of juveniles for stock enhancement [Finnish Game and Fisheries Research Institute 1993].”

“Occurs throughout France. Vulnerable [Keith et al. 1992] because of the reduction of its natural area of reproduction due to channels built on the waterways [Billard 1997].”

“[In Germany:] Known from the Danube drainage [Kottelat and Freyhof 2007]. Common in the Neckar in 1850 [Günther 1853].”

“Occurs in Thessaly, and Thrace rivers [Economidis 1991]. Historically absent from southern and western Greece [Kottelat and Freyhof 2007].”

“Reported as introduced to Ireland [Welcomme 1988]. Regarded as native to Ireland based on genetic diversity study within and among pike populations in Ireland waterbodies which clarifies their relationships with populations from other European locations [Pedreschi et al. 2014].”

“Recorded as locally abundant in the Ombrone river [Italy] and is being stocked [Bianco and Ketmaier 2001]. Found in northern Italy; historically absent from central Italy [Kottelat and Freyhof 2007].”

“Historically absent from western Norway [Kottelat and Freyhof 2007]. Northern distribution reported with large specimens observed in smallish ponds and slow rivers.”

“[In Russia:] Most abundant in the basins of the Volga, Ob and Irtysh rivers [Reshetnikov et al. 1997]. Reported from Kamchatka [Pietsch et al. 2000].”

“Known from Danube drainage [in Slovakia] [Kottelat and Freyhof 2007].”

“In all larger lakes and rivers [in Switzerland].”

“Historically absent from northern Scotland [Kottelat and Freyhof 2007]. [...] Found in England, Wales, and Scotland [Maitland and Lyle 1996].”

“Occurs in most provinces and territories [in Canada]; absent only in New Brunswick, Nova Scotia and Prince Edward Island [Coker et al. 2001].”

In addition to the countries listed by Froese and Pauly (2019a), GISD (2017) lists *Esox lucius* as native in Belarus, Canada, Jersey, Kyrgyzstan, Liechtenstein, and San Marino.

Status in the United States

From Fuller and Neilson (2019):

“Native Range: Atlantic, Arctic, Pacific, Great Lakes, and Mississippi River basins from Labrador to Alaska and south to Pennsylvania, Missouri, and Nebraska (Page and Burr 1991). Native to Montana in the South Saskatchewan River Drainage (Holton and Johnson 1996).”

From Froese and Pauly (2019a):

“Ranges from western Alaska eastward [Morrow 1980]. Except in the Ahrnklin River drainage, pike do not occur naturally west of the continental divide [Morrow 1980].”

“Known from Atlantic, Great Lakes, and Mississippi River basins from Maine to Montana and south to Pennsylvania and Nebraska [Page and Burr 2011].”

According to Fuller and Neilson (2019), nonindigenous occurrences of *Esox lucius* have been reported in the following States, with range of years and hydrologic units in parentheses:

- Alaska (1972-2018; Anchorage, Lower Kenai Peninsula, Lower Susitna River, Matanuska, South Central Alaska, Upper Kenai Peninsula, Upper Susitna River, Yentna River)
- Arizona (1967-2004; Big Chino-Williamson Valley, Bill Williams, Canyon Diablo, Havasu Canyon, Lower Colorado Region, Lower Lake Powell, Silver, Upper Santa Cruz, Upper Verde, Verde)
- Arkansas (1973-1988; Beaver Reservoir, Fourche La Pave, Illinois, Lower Little Arkansas, North Fork White, Upper Ouachita)
- California (1891-2007; Honcut Headwaters-Lower Feather, Middle Fork Feather, San Diego)
- Colorado (1882-2016; Alamosa-Trinchera, Animas; Big Thompson, Blue, Cache La Poudre, Colorado Headwaters, Colorado Headwaters-Plateau, East-Taylor; Fountain, Horse, Huerfano, Lower Gunnison, Lower Yampa, McElmo, Middle South Platte-Cherry)

Creek, Middle South Platte-Sterling, Piedra; Rio Grande Headwaters, San Luis, South Fork Republican, South Platte, South Platte Headwaters, St. Vrain, Upper Arkansas, Upper Arkansas-John Martin Reservoir, Upper Dolores, Upper Green-Flaming Gorge Reservoir, Upper Gunnison, Upper San Juan, Upper White, Upper Yampa)

- Connecticut (1940-1992; Lower Connecticut, New England Region, Thames)
- Delaware (1888-1981; Brandywine-Christina, Upper Chesapeake)
- Georgia (1969; Upper Oconee)
- Idaho (1892-2013; Clearwater, Coeur d'Alene Lake, Lower Boise, Lower Clark Fork, Lower Kootenai, Pend Oreille, Pend Oreille Lake, Spokane, St. Joe, Upper Spokane)
- Illinois (1986-1997; Big Muddy, Embarras, Mackinaw, Salt)
- Kansas (1962-1967; Crooked, Elk, Lower Big Blue, Neosho Headwaters, North Fork Ninnescah, Prairie Dog, South Fork Ninnescah, Upper Cimarron-Bluff, Upper Saline, Upper Smoky Hill)
- Kentucky (1975-1986; Green, Kentucky, Kentucky Lake, Licking, Licking, Little Scioto-Tygart, Lower Kentucky, Lower Levisa, Lower Tennessee, Pond)
- Maine (1810-2009; Lower Androscoggin, Lower Kennebec, Lower Penobscot, New England Region, Presumpscot, Upper Androscoggin)
- Maryland (1976-1999; Conococheague-Opequon, Upper Chesapeake, Youghiogheny)
- Massachusetts (1991-2005; Blackstone, Cape Cod, Charles, Chicopee, Concord, Farmington, Housatonic, Hudson-Hoosic, Merrimack River, Middle Connecticut, Miller, Narragansett, New England Region, Quinebaug)
- Missouri (1996-1997; Lake of the Ozarks, Meramec, Sac, Upper Black)
- Montana (1950-2015; Battle, Beaver, Beaver, Beaverhead, Big Dry, Big Muddy, Big Porcupine, Big Sandy, Bitterroot, Blackfoot, Boxelder, Bullwhacker-Dog, Charlie-Little Muddy, Fisher, Flathead Lake, Flatwillow, Fort Peck Reservoir, Frenchman, Judith, Lodge, Lower Bighorn, Lower Clark Fork, Lower Flathead, Lower Milk, Lower Musselshell, Lower Tongue, Lower Yellowstone, Lower Yellowstone-Sunday, Marias, Middle Clark Fork, Middle Kootenai, Middle Milk, Milk, Missouri-Poplar, Mizpah, O'Fallon, Pend Oreille, Peoples, Poplar, Porcupine, Prairie Elk-Wolf, Redwater, Rosebud, Sage, South Fork Flathead, Stillwater, Sun, Swan, Upper Little Missouri, Upper Milk, Upper Missouri, Upper Missouri-Dearborn, Upper Tongue, West Fork Poplar, Whitewater, Willow, Yaak)
- Nebraska (1951-2000; Frenchman, Lower South Platte, Red Willow, Upper Republican, West Fork Big Blue)
- Nevada (1978-2017; Granite Springs Valley, Lower Humboldt, Middle Carson, Pilot-Thousand Springs, Pine, South Fork Humboldt, Spring-Step toe Valleys, Truckee)
- New Hampshire (1810-2002; Black-Ottawaquechee, Contoocook, Middle Connecticut, New England, Pemigewasset, Upper Androscoggin, Upper Connecticut-Mascoma, Waits, West)
- New Jersey (1952-1992; Cohansey-Maurice, Mid-Atlantic Region)
- New Mexico (1965-2010; Animas, Cimarron, Conchas, Elephant Butte Reservoir, Pecos Headwaters, Rio Grande-Albuquerque, Rio Grande-Santa Fe, Upper Beaver, Upper Canadian, Upper Pecos, Upper Rio Grande, Upper San Juan, Upper San Juan)
- New York (1986-2001; Chenango, Lower Hudson, Mohawk, Upper Susquehanna)

- North Carolina (1976-1991; Albemarle, Middle Roanoke, Roanoke, Roanoke Rapids, Upper Yadkin)
- North Dakota (1981-2005; Lake Sakakawea, Painted Woods-Square Butte, Upper Lake Oahe)
- Ohio (1981-2005; Lower Great Miami, Muskingum, Upper Scioto)
- Oklahoma (1973-1976; Lower Cimarron, Lower Neosho, Upper Cimarron)
- Oregon (1994; Pacific Northwest Region)
- Pennsylvania (1983-1986; Bald Eagle, Lower Monongahela, Susquehanna)
- Rhode Island (1992; New England Region)
- South Dakota (1959-2001; Bad, Cedar, Crow, Fort Randall Reservoir, Grand, Little White, Lower Belle Fourche, Lower Lake Oahe, Lower Moreau, Lower White, Medicine, Medicine Knoll, Middle Cheyenne-Elk, Middle Cheyenne-Spring, North Fork Snake, Snake, South Fork Grand, Turtle, Upper Lake Oahe, Upper Moreau, Vermillion, West Missouri Coteau)
- Tennessee (1939; Lower Clinch, South Fork Holston, Watts Bar Lake)
- Texas (1967-1992; Amistad Reservoir, Austin-Travis Lakes, Buchanan-Lyndon B. Johnson Lakes, Lower Angelina, Lower Trinity-Tehuacana, Middle Brazos-Palo Pinto, Upper Neches, Upper Salt Fork Red, Upper West Fork Trinity, Yegua)
- Utah (1982-2015; Lower Green-Diamond, Lower Lake Powell, Middle Sevier, Upper Colorado-Kane Springs, Upper Lake Powell, Utah Lake)
- Vermont (1847-2000; Black-Ottawquechee, Hudson-Hoosic, Mettawee River, St. Francois River, Upper Connecticut, Upper Connecticut-Mascoma, West, White)
- Virginia (1894-1994; Hampton Roads, James, Lower James, Lower Rappahannock, Lynnhaven-Poquoson, Middle Potomac-Anacostia-Occoquan, Pamunkey, Potomac, Rivanna, Roanoke, Roanoke Rapids, Shenandoah, South Fork Holston, Upper Clinch, Upper Dan, Upper James, Upper Roanoke, York)
- Washington (1970-2018; Banks Lake, Franklin D. Roosevelt Lake, Hangman, Kettle, Lake Washington, Lower Spokane, Pend Oreille)
- West Virginia (1986-1995; Big Sandy, Cacapon-Town, Conococheague-Opequon, Little Kanawha, Little Muskingum-Middle Island, Lower Kanawha, Potomac, Upper Kanawha, Upper Monongahela, Upper Ohio-Wheeling, West Fork)
- Wisconsin (1983; Ontonagon, Upper Wisconsin)
- Wyoming (1966-1996; Belle Fourche, Middle North Platte-Scotts Bluff, North Platte, Upper Belle Fourche, Upper Green-Flaming Gorge Reservoir)

From Fuller and Neilson (2019):

“Established in many localities. Extirpated in California (Hubbs et al. 1979).”

Means of Introductions in the United States

From Froese and Pauly (2019a):

“Illegal transplants in the 1970's by private individuals placed pike in the Sustina River drainage [Alaska] [Morrow 1980].”

From Fuller and Neilson (2019):

“This species has been intentionally stocked as a sport fish in most areas. In some cases, introductions were illegal, and these include such sites as Coeur d'Alene Lake, Idaho; Keyhole Reservoir, Wyoming; and Beaver Creek Reservoir, Bitterroot River, and Flathead River, Montana (McMahon and Bennett 1996), and lakes in Alaska (Bell, personal communication). McMahon and Bennett (1996) gave a table of western reservoirs with introduced populations and the method of introduction for each one. First stocked in Arizona in 1967 (Rinne 1995). In addition to being stocked as a sport fish, Pflieger (1997) stated that *Esox lucius* was stocked in Missouri reservoirs to introduce a large predator that could more effectively prey on the large populations of carp and gizzard shad present in such artificial environments.”

Remarks

From Fuller and Neilson (2019):

“When Northern Pike are stocked in lakes containing native muskellunge *E. masquinongy*, the two species may hybridize. Although the male tiger muskellunge are sterile, females are often fertile and are capable of backcrossing (Becker 1983). [...] This species has been documented to naturally hybridize with *E. niger* (Herke et al. 1990).”

From CABI (2019):

“It is known to hybridise with amur pike (*E. reichertii*) as well as grass pickerel (*E. vermiculatus*).”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Fricke et al. (2019):

“**Current status:** Valid as *Esox lucius* Linnaeus 1758.”

From ITIS (2019):

“Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Protacanthopterygii
Order Esociformes

Family Esocidae
Genus *Esox*
Species *Esox lucius* Linnaeus, 1758”

Size, Weight, and Age Range

From Froese and Pauly (2019a):

“Maturity: L_m 37.6, range 25 - 63 cm
Max length : 137 cm FL male/unsexed; [IGFA 2001]; 150.0 cm TL (female); common length : 40.0 cm TL male/unsexed; [Muus and Dahlström 1968]; common length :55 cm TL (female); max. published weight: 28.4 kg [IGFA 2001]; max. published weight: 28.4 kg; max. reported age: 30 years [Muus and Dahlström 1968]”

Environment

From Froese and Pauly (2019a):

“Freshwater; brackish; demersal; potamodromous; depth range 0 - 30 m [Scott and Crossman 1998], usually 1 - 5 m [Scott and Crossman 1998]. [...]; 10°C - 28°C [estimated water temperature tolerances] [Eaton et al. 1995]; [...]”

Climate/Range

From Froese and Pauly (2019a):

“74°N - 36°N, 167°W - 180°E”

CABI (2019) lists the preferred climate for *Esox lucius* as temperate.

Distribution Outside the United States

Native

A portion of the native range of *Esox lucius* is inside the United States. See Section 1 for a full description of the native range of *E. lucius*.

From Froese and Pauly (2019a):

“Circumpolar in fresh water. North America: Atlantic, Arctic, Pacific, Great Lakes, and [...] from Labrador [...] [Page and Burr 2011]. Eurasia: Caspian, Black, Baltic, White, Barents, Arctic, North and Aral Seas and Atlantic basins, southwest to Adour drainage; Mediterranean basin in Rhône drainage and northern Italy. Widely distributed in central Asia and Siberia eastward [*sic*] to Anadyr drainage (Bering Sea basin). Historically absent from Iberian Peninsula, Mediterranean France, central Italy, southern and western Greece, eastern Adriatic basin, Iceland, western Norway and northern Scotland.”

Froese and Pauly (2019a) list *Esox lucius* as native in Armenia, Azerbaijan, China, Georgia, Iran, Kazakhstan, Mongolia, Turkey, Turkmenistan, Uzbekistan, Albania, Austria, Belgium, Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany,

Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Sweden, Switzerland, United Kingdom, Ukraine, and Canada.

From Froese and Pauly (2019a):

“Occurs in Erqishi river and Ulungur lake [in China].”

“Known from the Selenge drainage [in Mongolia] [Kottelat 2006].”

“[In Turkey:] Known from the European Black Sea watersheds, Anatolian Black Sea watersheds, Central and Western Anatolian lake watersheds, and Gulf watersheds (Firat Nehri, Dicle Nehri). [...] Gölü/Western Lakes watersheds and Gulf watersheds.”

“[In Turkmenistan:] Found in Amu Darya basin. Disappeared from the Atrek River and small rivers of the western Kopet Dag [Sal'nikov 1998].”

“Occurs in Odra and Morava river basins [in Czech Republic] [Hanel 2003].”

“Common throughout the country [Denmark] [Frier 1994].”

“[In Estonia:] Common in the Gulf of Riga and Gulf of Finland [Ojaveer and Pihu 2003].”

“Occurs through the country [Finland]. Local stocks complemented through culture of juveniles for stock enhancement [Finnish Game and Fisheries Research Institute 1993].”

“Occurs throughout France. Vulnerable [Keith et al. 1992] because of the reduction of its natural area of reproduction due to channels built on the waterways [Billard 1997].”

“[In Germany:] Known from the Danube drainage [Kottelat and Freyhof 2007]. Common in the Neckar in 1850 [Günther 1853].”

“Occurs in Thessaly, and Thrace rivers [Economidis 1991]. Historically absent from southern and western Greece [Kottelat and Freyhof 2007].”

“Reported as introduced to Ireland [Welcomme 1988]. Regarded as native to Ireland based on genetic diversity study within and among pike populations in Ireland waterbodies which clarifies their relationships with populations from other European locations [Pedreschi et al. 2014].”

“Recorded as locally abundant in the Ombrone river [Italy] and is being stocked [Bianco and Ketmaier 2001]. Found in northern Italy; historically absent from central Italy [Kottelat and Freyhof 2007].”

“Historically absent from western Norway [Kottelat and Freyhof 2007]. Northern distribution reported with large specimens observed in smallish ponds and slow rivers.”

“[In Russia:] Most abundant in the basins of the Volga, Ob and Irtysh rivers [Reshetnikov et al. 1997]. Reported from Kamchatka [Pietsch et al. 2000].”

“Known from Danube drainage [in Slovakia] [Kottelat and Freyhof 2007].”

“In all larger lakes and rivers [in Switzerland].”

“Historically absent from northern Scotland [Kottelat and Freyhof 2007]. [...] Found in England, Wales, and Scotland [Maitland and Lyle 1996].”

“Occurs in most provinces and territories [in Canada]; absent only in New Brunswick, Nova Scotia and Prince Edward Island [Coker et al. 2001].”

In addition to the countries listed by Froese and Pauly (2019a), GISD (2017) lists *Esox lucius* as native in Belarus, Canada, Jersey, Kyrgyzstan, Liechtenstein, and San Marino.

Introduced

From Froese and Pauly (2019a):

“Widely introduced and translocated throughout Europe [Kottelat and Freyhof 2007].”

“Introduced to Lake Tana [Ethiopia] in 1938 [Getahun 2007].”

“Established in the Atlas mountains [Morocco].”

“Established in high altitude areas [in Tunisia].”

“Introduced into Uluabat [in Turkey]”

“Recorded from the São Miguel Lake [Azores Islands].”

“Introduced [in central Italy].”

“Established in impoundments on Oued Fodac [Algeria] [Lever 1996].”

“Introduction reportedly failed to establish [in Madagascar] [Stiassny and Raminosa 1994].”

“[*Esox lucius*] has been translocated to areas within the country [Russia] for stocking in open waters where they have widely established self-sustaining populations [Bogutskaya and Naseka 2002].”

GISD (2017) lists *Esox lucius* as alien and established in Albania, Ethiopia, Ireland, Isle of Man, Madagascar, Morocco, Azores, Portugal, Spain, Tunisia, and Uganda.

From NIES (2019):

“Import, transport and keeping [in Japan] are prohibited by the Invasive Alien Species Act. Import to UK and New Zealand are regulated.”

Means of Introduction Outside the United States

From CABI (2019):

“*E. lucius* has been introduced to waters outside its native range for centuries, mainly due to its popularity as a sport fish. The first recorded introduction of this species was into Ireland during the sixteenth century (Harvey, 2009), although many other transfers were un-recorded or illegal (Aguilar et al. 2005). The many introductions within Europe, and from Europe to other continents, have not all be [*sic*] listed, although some records have been gathered. Welcomme (1988) cites introductions into Ireland, Spain and Italy within Europe, and, further afield, to Madagascar, Morocco, Tunisia and Uganda (Harvey, 2009).”

“Throughout this species’ global introduction, *E. lucius* has been introduced into lakes predominantly as a fisheries target, with other attempts (usually unsuccessful) into rivers. In Canada, once it is introduced into a new habitat, *E. lucius* will disperse naturally, taking advantage of whatever pathways exist (Kerr and Lasenby, 2001). There are also numerous examples in the literature of this species spreading throughout interconnected lake and river systems.”

From NIES (2019):

“Distributed as pet animal in past.”

Short Description

From Froese and Pauly (2019a):

“Dorsal soft rays (total): 17-25; Anal soft rays: 10 - 22; Vertebrae: 57 - 65. Diagnosed from all other freshwater fishes in Europe by the combination of the following characters: long snout; large mouth; dorsal fin origin slightly in front of anal origin; and lateral line with 105-148 scales [Kottelat and Freyhof 2007]. Distinguished by its long, flat, 'duck-bill' snout; its large mouth with many large, sharp teeth; and the rearward position of its dorsal and anal fins [Morrow 1980]. Gill rakers present only as patches of sharp teeth on gill arches; lateral line notched posteriorly [Morrow 1980]. Dorsal located far to the rear; anal located under and arising a little behind dorsal; pectorals low on body, base under opercle; pelvic fins low on body; paired fins rounded, paddle-shaped [Morrow 1980]. Caudal fin with 19 rays [Spillman 1961].”

From CABI (2019):

“*E. lucius* has an elongated body which is green to brown on the dorsal surface with lighter flanks bearing whitish spots. [...] The duckbill-shaped head of *E. lucius* accounts for 25-30% of an average total length of 46-76 cm (Scott and Crossman, 1973). On the underside of each side

of the lower jaw, there are five sensory pores. The body and most of the head are covered with small cycloid scales. The eyes are yellow and highly mobile (Lefevre, 1999).”

Biology

From Froese and Pauly (2019a):

“Occurs in clear vegetated lakes, quiet pools and backwaters of creeks and small to large rivers [Page and Burr 1991, 2011]. Usually solitary and highly territorial. Enters brackish water in the Baltic. Adults feed mainly on fishes, but at times feed heavily on frogs and crayfish [Morrow 1980]. Cannibalism is common. In arctic lakes, it is sometimes the only species present in a given water body. In such cases, juveniles feed on invertebrates and terrestrial vertebrates; large individuals are mainly cannibals [Kottelat and Freyhof 2007]. Cannibalistic as juveniles [Billard 1997]. Feces of pike are avoided by other fish because they contain alarm pheromones. Deposits feces at specific locations, distant from its foraging area [Kottelat and Freyhof 2007]. Eggs and young are preyed upon by fishes, aquatic insect larvae, birds, and aquatic mammals [Scott and Crossman 1998]. Does not generally undertake long migrations, but a few may move considerable distances [Morrow 1980]. Oviparous [Breder and Rosen 1966]. [...] Locally impacted by habitat alterations [Kottelat and Freyhof 2007].”

“Spawners move inshore or upstream to the marsh areas to spawn [Morrow 1980]. Generally, spawning occurs during the day. The sexes pair and a larger female is usually attended by one or two smaller males. They swim through and over the vegetation in water usually less than 17.8 cm, releasing eggs and sperm simultaneously at irregular intervals [Scott and Crossman 1998]. Eggs are deposited in flooded areas and on submerged vegetation over a period of 2-5 days [Kottelat and Freyhof 2007]. Only 5 to 60 eggs are released at a time [Morrow 1980]. This act is repeated every few minutes for up to several hours, after which the fish rest for some time before resuming. During the resting period, both male and female may take new mates, or they may continue together for several days until all eggs are extruded. Spawned-out adults may stay on the spawning grounds for as long as 14 weeks, but most leave within 6 [Morrow 1980].”

From NatureServe (2019):

“Spawns in spring as soon as ice begins to break up. Produces a single clutch per year. Eggs hatch in 12-14 days at typically prevailing temperatures. Males sexually mature at 1-2 years in south, at age 5 in north; females mature at 2-3 years in south, at age 6 in north.”

“Adults solitary except at spawning.”

Human Uses

From Froese and Pauly (2019a):

“Excellent food fish; utilized fresh and frozen; eaten pan-fried, broiled, and baked [Frimodt 1995]. Valuable game fish [Page and Burr 1991]. In spite of numerous attempts to culture this species, it was never entirely domesticated and does not accept artificial food [Billard 1997].”

“Commercially taken from Lake Peipus and the Võrtsjärv [in Estonia] [Anonymous 1999].”

“Several companies offers guided pike fishing trips in Finnmark [Norway], northernmost county [...] (Bjørn Ivar Fresvik (pers.comm. 08/08).”

“Important food fish in early-mediaeval times [in Poland] [Klyszejko et al. 2004].”

From CABI (2019):

“Throughout Europe and North America *E. lucius* is a highly sought-after recreational fishing species, as well as a commercially sought-after species in many countries.”

Diseases

Spring viraemia of carp virus and viral hemorrhagic septicemia are OIE-reportable diseases (OIE 2019).

USDA APHIS (2006) lists an outbreak of viral hemorrhagic septicemia in *Esox lucius* in Lake St. Clair, Michigan in June 2006.

From CABI (2019):

“Over the years, fish pathologists have been greatly interested in the *E. lucius* as it hosts a lot of parasites such as fungi, protozoa, various worms, leeches, molluscs and crustacea. Pike are also susceptible to numerous bacterial and viral diseases and tumorous lesions. 18 species of metazoan parasite, including the common bacterium *Pseudomonas hydrophila* (Scott and Crossman, 1973), the trematode worm *Uvulifer ambloplitis* and the nematode *Raphidascaris acus* (found in the gastrointestinal tract and liver; Poole and Dick, 1986) were identified by Watson and Dick (1980).”

From Froese and Pauly (2019a):

“This fish can be heavily infested with parasites, including the broad tapeworm which, if not killed by thorough cooking, can infect human; is used as an intermediate host by a cestode parasite which results to large losses in usable catches of lake whitefish (*Coregonus clupeaformis*) in some areas; also suffers from a trematode which causes unsightly cysts on the skin [Frimodt 1995].”

“Pike Fry Rhabdovirus, Viral diseases”

Froese and Pauly (2019b) list *Argulus foliaceus*, *Azygia tereticollis*, *Bucephalus markewitschi*, *Centrovarium lobotes*, *Cyanthovcephalus truncatus*, *Derogenes elegans*, *Diphyllbothrium dentriticum*, *D. latum*, *Diplostomum parvulum*, *Ergasilus luciopercarum*, *E. seiboldi*, *Gyrodactylus lucii*, *Ichthyophthirius multifiliis*, *Lernaea cyprinacea*, *L. esocina*, *Nicolla skrjabini*, *Paracoenogonimus ovatus*, *Phyllodistomum folium*, *Rhipidocotyle fennica*, *Salmincola extensa*, *Sphaerostoma bramae*, *Tracheliastes polycolpus*, *Triaenophorus crassus*, *T. nodulosus*, *Trichodina domerguei*, *Tylodelphys clavata* as additional parasites of *Esox lucius*.

Poelen et al. (2014) list the following as additional parasites and diseases of *Esox lucius*: *Myxidium lieberkuehni*, *Henneguya psorospermica*, *H. lobosa*, infections pancreatic necrosis virus, spring viraemia of carp, *Trypanosoma carassii*, *T. remaki*, *Piscicola milneri*, *P. geometra*, *Azygia angusticauda*, *Azygia* sp., *A. lucii*, *A. longa*, *Diplostomulum* sp., *Myzobdella* sp., *Tetracotyle* sp., *Uvulifer* sp., *Echinorhynchus lateralis*, *Echinorhynchus* sp., *E. cinctulus*, *E. salmonis*, *Neochinorhynchus strigosus*, *N. tumidus*, *N. rutili*, *N. cylindratus*, *N. tenellus*, *Raphidascaris* sp., *Clinostomum marginatum*, *Posthodiplostomum minimum*, *Tylodelphys scheuringi*, *Allocreadium isoporum*, *Leptorhynchoides thecatus*, *Triaenophorus nodulosus*, *T. meridionalis*, *T. robustus*, *Pomphorhynchus* sp., *Contracaecum* sp., *C. brachyurus*, *C. spiculigerum*, *Crepidostomum* sp., *C. cornatum*, *Diphyllobothrium* sp., fish tapeworm (*D. latum*), *Taenia* sp., *Taeniidae* sp., *Trichostrongylidae* sp., *Echinococcus* sp., fox tapeworm (*E. multilocularis*), *Proteocephalus* sp., *P. esocis*, *P. percae*, *Tetraonchus monenteron*, *Schistocephalus solidus*, *Diplostomum spathaceum*, spiny-headed worms (*Acanthocephala* sp.), *Bothriocephalus* sp., *B. latus*, *Horismenus* sp., *Eustrongylides excisus*, *Philometra obturans*, *Desportesius brevicaudatus*, *Acanthocephalus lucii*, *A. anguillae*, *A. clavula*, *Camallanus lacustris*, *Dioctophyma renale*, *Ligula* sp., *Fessisentis tichiganensis*, *Proterometra* sp., *Cryptogonimus* sp., *Eudistoma* sp., *Neascus oneidensis*, *Ancyrocephalus* sp., *Digenea* sp., pike fry sprivivirus, and *Alloccryptobia* sp.

Threat to Humans

From Froese and Pauly (2019a):

“This fish can be heavily infested with parasites, including the broad tapeworm which, if not killed by thorough cooking, can infect human; [...]”

3 Impacts of Introductions

From Pofuk et al. (2017):

“Recent field observations in the Cetina basin [Croatia] by anglers indicated a decline of the endemic Illyrian chub *Squalius illyricus* Heckel and Kner, 1858 and minnow-nase *Chondrostoma phoxinus* Heckel, 1843 due to pike [*Esox lucius*] predation (J. Budinski, pers. comm.).”

From Heins et al. (2016):

“Our results demonstrate significant, directional phenotypic changes in life-history traits of threespine stickleback over time following the introduction of northern pike into Scout Lake [Alaska]. All life-history traits showed substantial rates of phenotypic evolution, from -0.134 to -0.162 haldanes. Haldanes measure evolutionary rates in standard deviations per generation; thus, over the approximately 6.5 generations covered by our study, each trait shifted by almost one full standard deviation. Over such an interval, these rates and shifts would be considered relatively large (Hendry and Kinnison, 1999; Hendry et al., 2008).”

“Our data, therefore, demonstrate the apparent strong effect of introduced pike through increasing predatory pressure on the stickleback population over time, driving substantial shifts

in stickleback life history. The life-history shifts appear to stem from both consumptive and non-consumptive effects of predatory pressure. In addition, the decrease in salmonid populations following the cessation of stocking in 2005 (R. Massengill, personal communication) may have led to a subsequent acceleration of the effects on the stickleback population.”

“Consistent with life-history theory, the size of reproducing threespine stickleback females declined following pike introduction; and the majority of females shifted from reproducing at two years of age in 1999–2001 to reproducing at one year of age in 2008–2009. The first of two decreases in body size occurred within a few years of the introduction of pike and likely was driven by a large and rapid increase in pike abundance due to reproduction of the individuals introduced into the lake.”

“Our data suggest that non-consumptive influences on reproductive performance of individual females may play a major, if not final, role in the local extinction of stickleback populations.”

From von Hippel (2008):

“The ADF&G [Alaska Department of Fish and Game] has suspended or curtailed salmonid stocking programs for many lakes because of predation by introduced pike.”

“Pike have the potential to reduce stickleback diversity, either by causing evolution of more robust body armor in armor-reduced populations or by causing extinction of populations. Either way, rare phenotypes are lost. Pike appear to be affecting stickleback populations in the Cook Inlet Basin [Alaska] through both evolution and extinction. Pike appear to have caused appreciable morphological evolution of at least one aspect of armored structures (dorsal spines, pelvic spines, lateral plates) or trophic structures (gill raker number, indicating a diet shift) in most threespine stickleback populations occupying lakes recently invaded by pike (Patankar, 2004). Furthermore, in Prator Lake [Alaska], pike introduction led to a rapid decline and local extinction of a rare threespine stickleback population lacking pelvic spines, just six years after the first observation of pike in 1996 (Figure 2 [in source material]; Patankar et al., 2006).”

“Within two years of their appearance in fish samples in a Swedish lake, northern pike decimated the native ninespine stickleback population (Byström et al., 2007); clearly threespine stickleback are not the only sticklebacks vulnerable to pike. More generally, it is now apparent that exotic predatory fishes are capable of extinguishing native stickleback populations within a few years of their introduction (e.g., Hadley Lake, Hatfield, 2001a; Prator Lake, Patankar et al., 2006).”

From Byström et al. (2007):

“This is also supported by the results in our study [in Sweden] which show large differences in stickleback densities in our lake depending on whether sticklebacks coexisted together with char or pike. Furthermore, pike introductions or invasions in relatively small lakes have been suggested to be responsible for extirpation of local lake-living allopatric populations of brown trout (*Salmo trutta* L.) (Spens, 2006). Thus, we suggest that pike likely imposed a strong predatory impact on young char but not the other way around. This asymmetry in predation efficiency in favour of pike together with the similar diets for both char and pike as single top

predators suggest that when pike invaded the lake, the system could be characterised as an intraguild predation (IGP) system (sensu van de Wolfshaar, De Roos & Persson, 2006), with pike as the IG predator, char as intermediate consumer and sticklebacks and to some extent *Gammarus* as main shared resources [...].”

“The difference in stickleback densities between years with either char or pike as top predator in the system further suggest that pike is a more efficient forager on sticklebacks than char. Thus, a combination of both predation and competition from pike likely caused the exclusion of char from the system and possible future reinvasions or reintroductions of char in this system are most likely to fail (cf. van de Wolfshaar et al., 2006).”

From Froese and Pauly (2019a):

“Interfere and hybridize with the endemic *E[sox]. casalpinus* [in Italy] [Bianco 2014].”

“[In Spain:] Believed to have caused the extinction of 11 fish species native to the Daimiel region [Roberts 1998]. Reported to be responsible for the local extirpation of almost all fish species in some habitats, where they maintain high population densities and feed predominantly on crayfish [Kottelat and Freyhof 2007].”

From Fuller and Neilson (2019):

“The piscivorous Northern Pike has been shown to significantly reduce prey density and has the potential to cause large-scale changes in fish communities, even resulting in species elimination (He and Kitchell 1990). A study conducted in Wisconsin showed introduced pike mostly affected four minnow species; redbelly dace *Phoxinus eos*, finescale dace *P. neogaeus*, fathead minnow *Pimephales promelas*, and brassy minnow *Hybognathus hankinsoni*. Pike apparently had less effect on other species in the pond (He and Kitchell 1990). Impacts can be either direct, such as by predation, or indirect, such as by causing prey fish to alter their behavior (He and Kitchell 1990). In Montana, Northern Pike commonly deplete their prey and become stunted (McMahon and Bennett 1996). A study conducted by T. Jones (University of Montana) in 1990, found Northern Pike eliminated most other fishes except for the pumpkinseed *Lepomis gibbosus*, which was likely protected by its deep body shape and stiff spines, making it difficult prey (McMahon and Bennett 1996). Northern Pike may be responsible for declines of native westslope cutthroat trout *Oncorhynchus clarki lewisi* and bull trout *Salvelinus confluentus* in the Stillwater lakes in Montana (McMahon and Bennett 1996). Northern Pike are reported to be "a problem" in the Yampa River in Colorado (Whitmore 1997). [...] In Maine, the pike's presence in Pushaw Lake is suspected of destroying one of the state's premier landlocked salmon populations (Boucher 2003). The Pushaw Lake population may gain access to the Piscataquis River. Since the Northern Pike preys upon the Atlantic salmon, the populations of this and other native species may be threatened. The presence of Northern Pike, along with other introduced piscivores, reduced the richness of native minnow communities in Adirondack lakes (Findlay et al. 2000).”

“When Northern Pike are stocked in lakes containing native muskellunge *E. masquinongy*, the two species may hybridize. Although the male tiger muskellunge are sterile, females are often fertile and are capable of backcrossing (Becker 1983). Northern Pike are replacing native

muskellunge in many Wisconsin lakes (Becker 1983). It is also believed that because Northern Pike generally spawn a month earlier than muskellunge, the older pike may prey on younger muskellunge (Gilbert, personal communication).”

From CABI (2019):

“For example, the spread within the Saskatchewan River drainage in Montana (Dos Santos, 1991) and migration through the Trent Canal system in Ontario, which extended its range to the Kawartha Lakes, resulted in a subsequent reduction in numbers of muskellunge (*Esox masquinongy*) (DFO 2006).”

“Pike aquaculture is used primarily as a source of fingerlings used to stock water bodies for recreational fishing, although in Finland, commercial pike fishery has also benefited from these stockings (Mann 1996); there is therefore an economic benefit for both recreational and commercial fishermen, as well as the creation of jobs in the aquaculture industry.”

4 Global Distribution

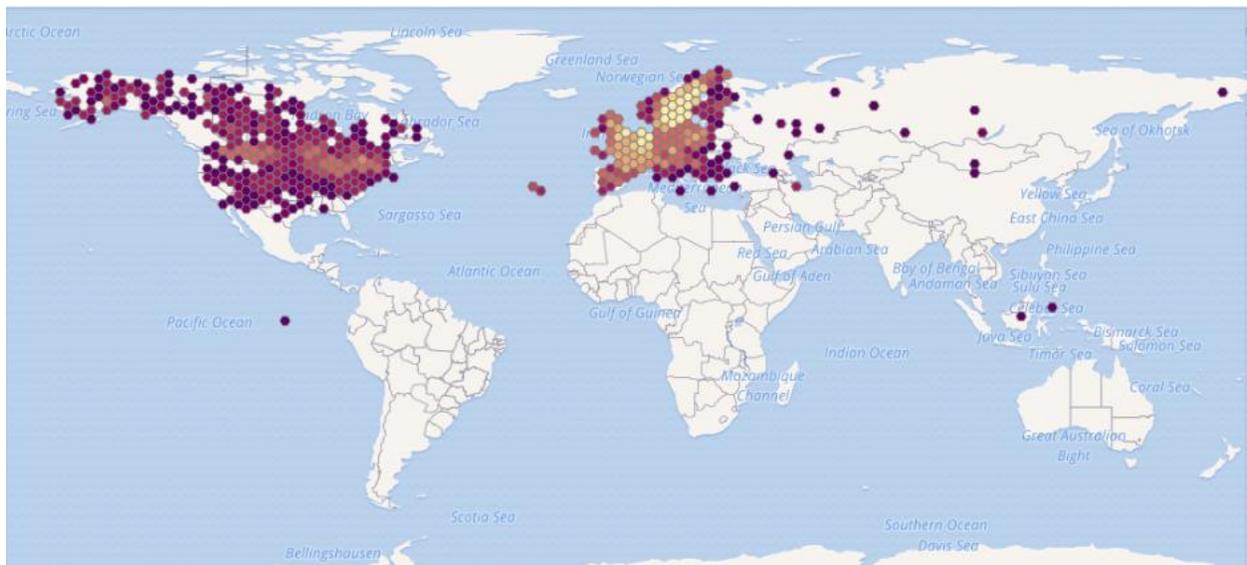


Figure 1. Known global distribution of *Esox lucius*. Map from GBIF Secretariat (2019). The locations in the northern Atlantic Ocean are valid observations from the Azores Islands and were used to select source points for the climate match. The observations in the Pacific, west of South America, and in Indonesia were not used to select source points for the climate match; the locations are marine.

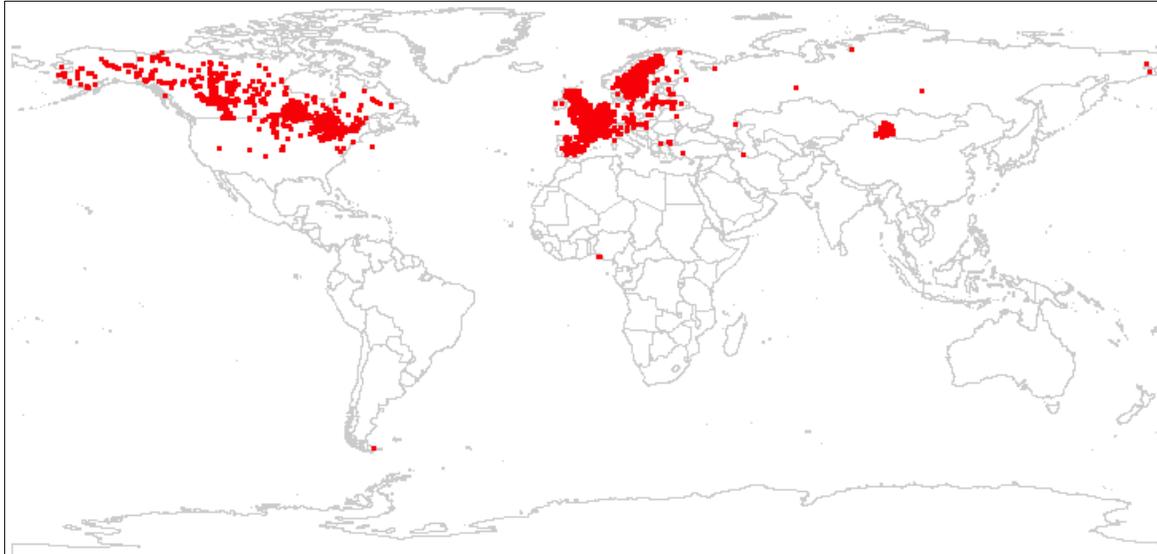


Figure 2. Additional known global distribution of *Esox lucius*. Map from Froese and Pauly (2019a). The observations in southern Argentina and on the Atlantic coast of Nigeria were not used to select source points in the climate match. No corroborating records for the presence of *Esox lucius* in either country were found.

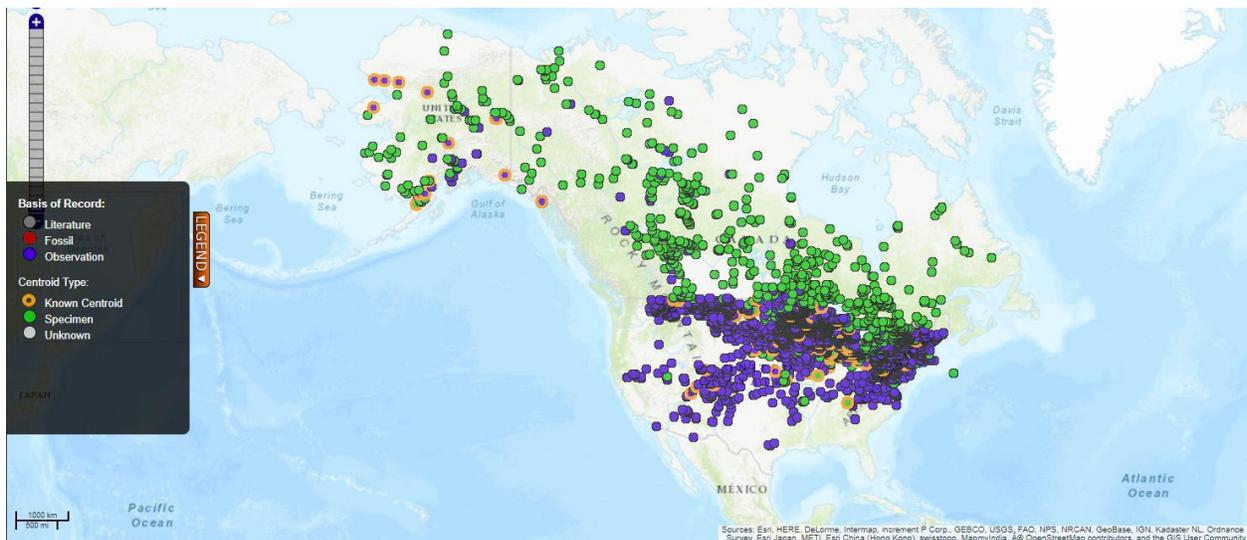


Figure 3. Additional known distribution of *Esox lucius* in North America. Map from BISON (2019). The observations in California were not used as source points in the climate match since *Esox lucius* is listed as extirpated in the State (Fuller and Neilson 2019).

5 Distribution Within the United States

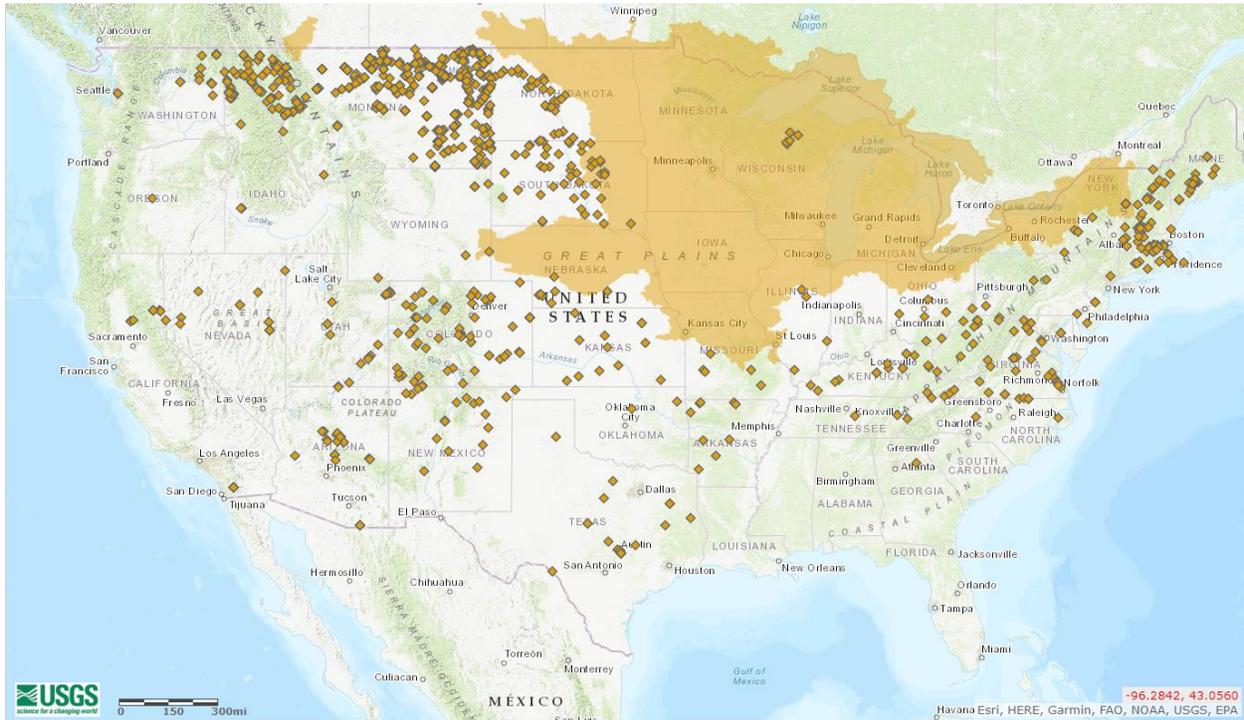


Figure 4. Known distribution of *Esox lucius* in the contiguous United States. Map from Fuller and Neilson (2019). The observations in California were not used as source points in the climate match since *Esox lucius* is listed as extirpated in the state.



Figure 5. Known distribution of *Esox lucius* in Alaska. Map from Fuller and Neilson (2019).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Esox lucius* to the contiguous United States was mostly high. The coastal area and just west of the Cascade Mountains in the Pacific Northwest had a low match along with the Pacific Coast of northern California. The southern tip of Florida also had a low match. Most of California, the Gulf Coast, and peninsular Florida had medium matches. Everywhere else had a high match. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for contiguous United States was 0.968, high (scores 0.103 and greater are classified as high). All States had high individual Climate 6 scores.

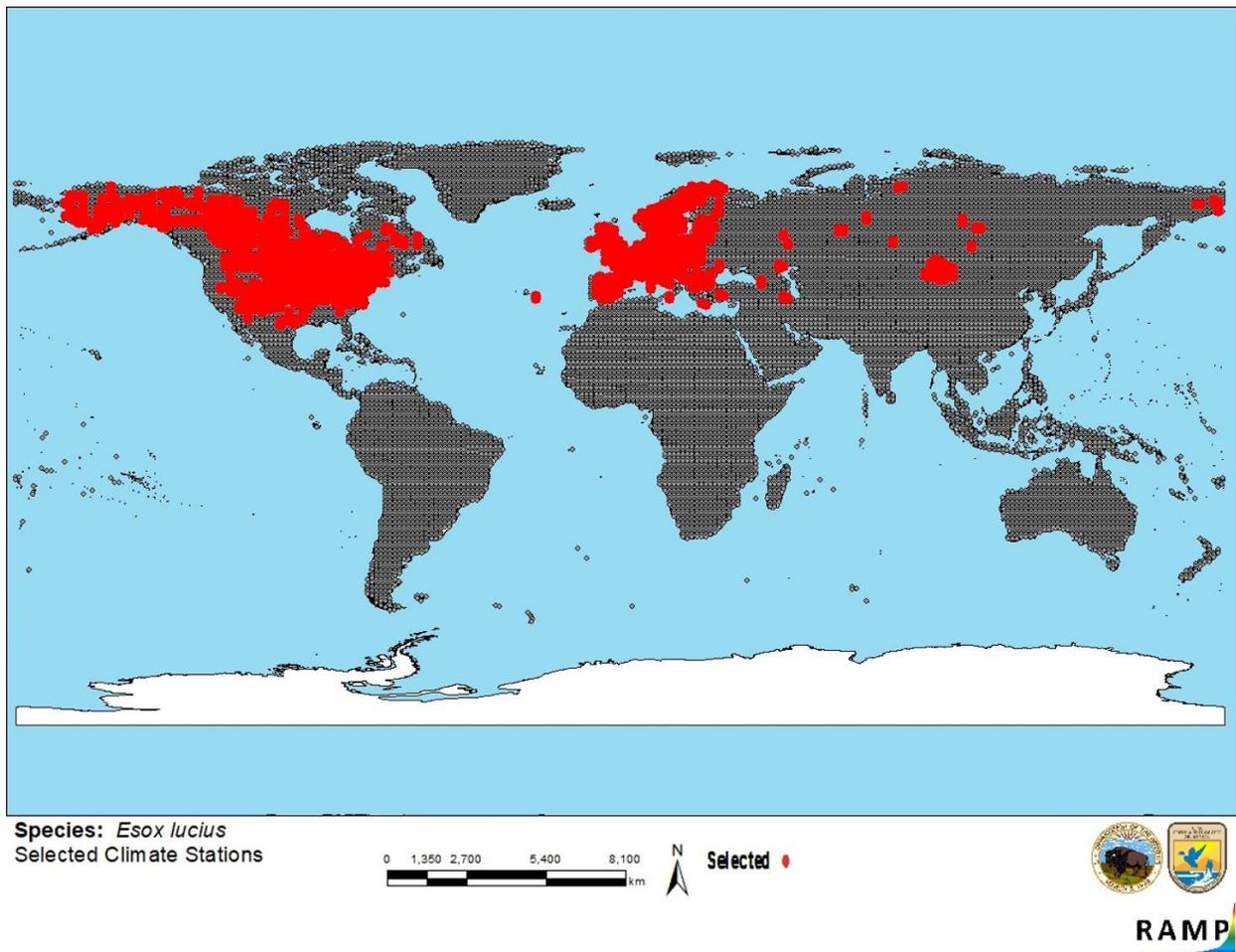


Figure 6. RAMP (Sanders et al. 2018) source map showing weather stations in the northern hemisphere selected as source locations (red; North America, Europe, Asia) and non-source locations (gray) for *Esox lucius* climate matching. Source locations from BISON (2019), Froese and Pauly (2019), Fuller and Neilson (2019), and GBIF Secretariat (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

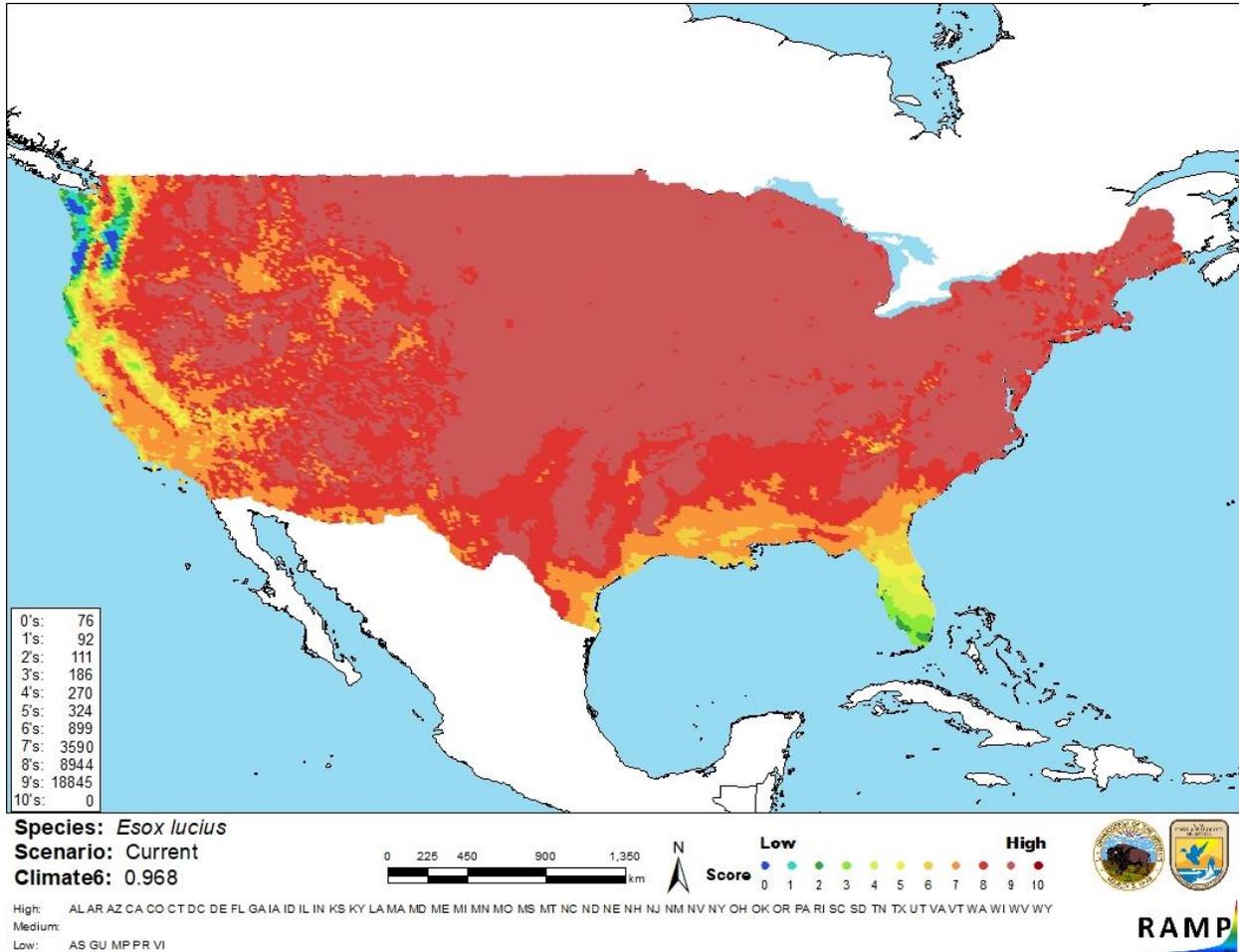


Figure 7. Map of RAMP (Sanders et al. 2018) climate matches for *Esox lucius* in the contiguous United States based on source locations reported by BISON (2019), Froese and Pauly (2019), Fuller and Neilson (2019), and GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
$0.000 \leq X \leq 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

7 Certainty of Assessment

The certainty of assessment for *Esox lucius* is high. The biology and ecology of the species is well documented. The global distribution is also documented, including representative georeferenced observations to use as source locations for the climate match. There are many records of introduction with most resulting in establishment. The impacts of those introductions have been described in peer-reviewed literature.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Northern Pike (*Esox lucius*) is a species of predatory fish that is native to areas across the northern hemisphere, including some portions of Alaska and the contiguous United States. *E. lucius* is a large species that preys on other fish, including other predatory fish. The species is an important recreational fish and it is consumed by humans. *E. lucius* is susceptible to many diseases, two of which, viral hemorrhagic septicemia and spring viraemia of carp virus, are OIE-reportable diseases. *E. lucius* can also be infected with broad tapeworm that can cause infection in humans who eat under cooked fish. The history of invasiveness is high. *E. lucius* has a long and well documented history of introductions, mainly through intentional stocking for sport fishing. Most of those introductions have established populations that then had severe impacts on the native systems. *E. lucius* has been shown to be the cause of multiple species extirpations and is suspected as the cause in many more. *E. lucius* has also caused changes in the life history of prey species. The climate match is high. Virtually all of the contiguous United States had a high match except for southern Florida and the Northwest, which had low matches. The certainty of assessment is high. The biology, ecology, and invasion history of *E. lucius* is well documented in peer-reviewed literature. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information:** *Esox lucius* is host for many diseases, including two OIE-reportable diseases, viral hemorrhagic septicemia and spring viraemia of carp virus. It is also host for a tapeworm which can cause infection in humans when consumed. *E. lucius* is native to many northern areas of the United States.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

BISON. 2019. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. Available: <https://bison.usgs.gov>. (February 2019).

Byström, P., J. Karlsson, P. Nilsson, T. van Kooten, J. Ask, and F. Olofsson. 2007. Substitution of top predators: effects of pike invasion in a subarctic lake. *Freshwater Biol.* 52:1271-1280.

CABI. 2019. *Esox lucius* (pike) [original text by M. J. Godard]. In *Invasive Species Compendium*. CAB International, Wallingford, U.K. Available: <https://www.cabi.org/ISC/datasheet/83118>. (February 2019).

- Fricke, R., W. N. Eschmeyer, and R. van der Laan, editors. 2019. Eschmeyer's catalog of fishes: genera, species, references. Available: <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>. (February 2019).
- Froese, R., and D. Pauly, editors. 2019a. *Esox lucius* Linnaeus, 1758. FishBase. Available: <https://www.fishbase.de/summary/Esox-lucius.html>. (February 2019).
- Froese, R., and D. Pauly, editors. 2019b. *Esox lucius* Linnaeus, 1758. In World Register of Marine Species. Available: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=154210>. (February 2019).
- Fuller, P., and M. Neilson. 2019. *Esox lucius* Linnaeus, 1758. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: <https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=676>. (February 2019).
- GBIF Secretariat. 2019. GBIF backbone taxonomy: *Esox lucius* Linnaeus, 1758. Global Biodiversity Information Facility, Copenhagen. Available: <https://www.gbif.org/species/2346633>. (February 2019).
- GISD (Global Invasive Species Database). 2017. Species profile: *Esox lucius*. Invasive Species Specialist Group, Gland, Switzerland. Available: <http://www.iucngisd.org/gisd/speciesname/Esox+lucius>. (February 2019).
- Heins, D. C., H. Knoper, and J. A. Baker. 2016. Consumptive and non-consumptive effects of predation by introduced northern pike on life-history traits in threespine stickleback. *Evolutionary Ecology Research* 17:355–372.
- ITIS (Integrated Taxonomic Information System). 2019. *Esox lucius* Linnaeus, 1758. Integrated Taxonomic Information System, Reston, Virginia. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=162139#null. (February 2019).
- NatureServe. 2019. NatureServe Explorer: an online encyclopedia of life, version 7.1. NatureServe, Arlington, Virginia. Available: <http://explorer.natureserve.org>. (February 2019).
- NIES (National Institute for Environmental Studies). 2019. *Esox lucius*. In Invasive species of Japan. National Research and Development Agency, National Institute for Environmental Studies, Tsukuba, Japan. Available: <https://www.nies.go.jp/biodiversity/invasive/DB/detail/50950e.html>. (February 2019).
- OIE (World Organisation for Animal Health). 2019. OIE-listed diseases, infections and infestations in force in 2019. Available: <http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/>. (February 2019).

- Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.
- Pofuk, M., D. Zanella, and M. Piria. 2017. An overview of the translocated native and non-native fish species in Croatia: pathways, impacts and management. *Management of Biological Invasions* 8(3):425–435.
- Sanders, S., C. Castiglione, and M. Hoff. 2018. Risk assessment mapping program: RAMP, version 3.1. U.S. Fish and Wildlife Service.
- USDA APHIS. 2006. Viral hemorrhagic septicemia in the Great Lakes. Emerging disease notice. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Fort Collins, Colorado. Available: https://www.aphis.usda.gov/animal_health/emergingissues/downloads/vhsgreatlakes.pdf. (February 2019).
- Von Hippel, F. A. 2008. Conservation of Threespine and Ninespine stickleback radiations in the Cook Inlet Basin, Alaska. *Behaviour* 145(4/5):693–724.

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

- Aguilar, A., J. D. Banks, K. F. Levine, and R. K. Wayne. 2005. Population genetics of northern pike (*Esox lucius*) introduced into Lake Davis, California. *Canadian Journal of Fisheries and Aquatic Sciences* 62:1589–1599.
- Anonymous. 1999. Systematic list of Estonian fishes. Online. (January 2000).
- Becker, G. C. 1983. *Fishes of Wisconsin*. University of Madison Press, Madison, Wisconsin.
- Bianco, P. G. 2014. An update on the status of native and exotic freshwater fishes of Italy. *Journal of Applied Ichthyology* 30(1):62–77.
- Bianco, P. G., and V. Ketmaier. 2001. Anthropogenic changes in the freshwater fish fauna of Italy, with reference to the central region and *Barbus graellsii*, a newly established alien species of Iberian origin. *Journal of Fish Biology* 59(Supplement A):190–208.
- Billard, R. 1997. *Les poissons d'eau douce des rivières de France. Identification, inventaire et répartition des 83 espèces*. Lausanne, Delachaux & Niestlé.
- Bogutskaya, N. G., and A. M. Naseka. 2002. An overview of nonindigenous fishes in inland waters of Russia. *Proc. Zool. Inst. Russ. Acad. Sci.* 296:21–30.

- Boucher, D. 2003. Illegal fish stockings threaten Maine lakes and rivers. Available: <http://www.state.me.us>.
- Breder, C. M., and D. E. Rosen. 1966. Modes of reproduction in fishes. T.F.H. Publications, Neptune City, New Jersey.
- Coker, G. A., C. B. Portt, and C. K. Minns. 2001. Morphological and ecological characteristics of Canadian freshwater fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2554.
- DFO. 2006. Northern Pike. Department of Fisheries and Oceans, Canada. Available: www.dfo-mpo.gc.ca/zone/underwater_sous-marin/nor_pike/pike-brochet_e.htm.
- Dos Santos, J. M. 1991. Ecology of a riverine pike population. Pages 155–159 *In* J. L. Cooper, editor. Warmwater Fisheries Symposium I. Ecology of a riverine pike population. U.S. Forest Service, General Technical Report.
- Eaton, J. G., J. H. McCormick, B. E. Goodno, D. G. O'Brien, H. G. Stefany, M. Hondzo, and R. M. Scheller. 1995. A field information-based system for estimating fish temperature tolerances. *Fisheries* 20(4):10–18.
- Economidis, P. S. 1991. Check list of freshwater fishes of Greece (recent status of threats and protection). Hellenic Society for the Protection of Nature, Special Publication.
- Findlay, C. S., D. G. Bert, and L. Zheng. 2000. Effect of introduced piscivores on native minnow communities in Adirondack lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 57:570–580.
- Finnish Game and Fisheries Research Institute. 1993. Kalanviljely vuonna 1992. (Fish culture in 1992). Riista-ja Kalatalouden Tutkimuslaitos. Ympäristö 1993:3.
- Frier, J.-O. 1994. Danmark. Danske ferskvandsfisk og deres udbredelsesområde. Pages 4–6, 83–99 *In* J.-O. Frier, editor. Truede ferskvandsfiskearter i Norden. TemaNord 1994:625. Nordisk Ministerråd, København. (In Danish.)
- Frimodt, C. 1995. Multilingual illustrated guide to the world's commercial coldwater fish. Fishing News Books, Osney Mead, Oxford, England.
- Getahun, A. 2007. An overview of the diversity and conservation status of the Ethiopian freshwater fauna. *Journal of Afrotropical Zoology Special Issue*:87–96.
- Günther, A. 1853. Die Fische des Neckars. Verlag von Ebner & Seubert, Stuttgart, Germany.
- Hanel, L. 2003. The ichthyofauna of the Czech Republic: development and present state. *Matthias Belivs University Proceedings* 3(1):41–71.

- Harvey, B. 2009. A biological synopsis of Northern Pike (*Esox lucius*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2885.
- Hatfield, T. 2001a. Status of the stickleback species pair, *Gasterosteus* spp., in Hadley Lake, Lasqueti Island, British Columbia. Canadian Field-Naturalist 15:579–583.
- He, X., and J. F. Kitchell. 1990. Direct and indirect effects of predation on a fish community: a whole lake experiment. Transactions of the American Fisheries Society 119:825–835.
- Hendry, A. P., and M. T. Kinnison. 1999. Perspective: the pace of modern life: measuring rates of contemporary microevolution. Evolution 53:1637–1653.
- Hendry, A. P., T. J. Farrugia, and M. T. Kinnison. 2008. Human influences on rates of phenotypic change in wild animal populations. Molecular Ecology 17:20–29.
- Herke, S. W., I. Kornfield, P. Morand, and J. R. Moring. 1990. Molecular confirmation of hybridization between Northern Pike (*Esox lucius*) and Chain Pickerel (*E. niger*). Copeia 1990(3):846–850.
- Holton, G. D., and H. E. Johnson. 1996. A field guide to Montana fishes, 2nd edition. Montana Department of Fish, Wildlife and Parks, Helena.
- Hubbs, C. L., W. I. Follett, and L. J. Dempster. 1979. List of the fishes of California. California Academy Science, Occasional Papers 133.
- IGFA. 2001. Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, Florida.
- Jones. 1990. [Source material did not give full citation for this reference.]
- Keith, P., J. Allardi, and B. Moutou. 1992. Livre rouge des espèces menacées de poissons d'eau douce de France et bilan des introductions. Muséum national d'Histoire naturelle, Paris, Secrétariat de la Faune et de la Flore, Conseil Supérieur de la Pêche, CEMAGREF and Ministère de l'Environnement.
- Kerr, S. J., and T. A. Lasenby. 2001. Esocid stocking: an annotated bibliography and literature review. Ontario Ministry of Natural Resources, Fish and Wildlife Branch, Peterborough, Canada.
- Klyszejko, B., Z. Chelkowski, B. Chelkowska, and A. Sobocinski. 2004. Identification of fish remains from early-mediaeval layers of the vegetable market excavation site in Szczecin, Poland. Acta Ichthyologica et Piscatoria 34(1):85–102.
- Kottelat, M. 2006. Fishes of Mongolia. A check-list of the fishes known to occur in Mongolia with comments on systematics and nomenclature. The World Bank, Washington, D.C.

- Kottelat, M., and J. Freyhof. 2007. Handbook of European freshwater fishes. Publications Kottelat, Cornol, Switzerland, and Freyhof, Berlin.
- Lefevre, R. 1999. *Esox lucius*. Animal Diversity Web. Available: http://animaldiversity.ummz.umich.edu/site/accounts/information/Esox_lucius.html.
- Lever, C. 1996. Naturalized fishes of the world. Academic Press, California.
- Maitland, P. S., and A. A. Lyle. 1996. Threatened freshwater fishes of Great Britain. Pages 9–21 *In* A. Kirchhofer, and D. Hefti, editors. Conservation of endangered freshwater fish in Europe. Birkhäuser Verlag, Basel, Switzerland.
- Mann, R. H. K. 1996. Pike: biology and exploitation. Pages 219–241 *In* J. F. Craig, editor. Fisheries and economics. Chapman and Hall, London.
- McMahon, T. E., and D. H. Bennett. 1996. Walleye and Northern Pike: boost or bane to northwest fisheries? *Fisheries* 21(8):6–13.
- Morrow, J. E. 1980. The freshwater fishes of Alaska. University of British Columbia, Animal Resources Ecology Library.
- Muus, B. J., and P. Dahlström. 1968. Süßwasserfische. BLV Verlagsgesellschaft, München.
- Ojaveer, E., and E. Pihu. 2003. Estonian natural fish waters. Pages 15–27 *In* E. Ojaveer, E. Pihu, and T. Saat, editors. Fishes of Estonia. Estonian Academy Publishers, Tallinn.
- Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
- Page, L. M., and B. M. Burr. 2011. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Harcourt, Boston.
- Patankar, R. 2004. The effects of exotic pike (*Esox lucius*) on Threespine Stickleback (*Gasterosteus aculeatus*) populations in South Central Alaska. Master's thesis. University of Alaska, Anchorage.
- Patankar, R., F. A. von Hippel, and M. A. Bell. 2006. Extinction of a weakly armoured Threespine Stickleback (*Gasterosteus aculeatus*) population in Prator Lake, Alaska. *Ecology of Freshwater Fish* 15:482–487.
- Pedreschi, D., M. Kelly-Quinn, J. Caffrey, M. O'Grady, and S. Mariani. 2014. Genetic structure of pike (*Esox lucius*) reveals a complex and previously unrecognized colonization history of Ireland. *Journal of Biogeography* 41:548–560.
- Pflieger, W. L. 1997. The fishes of Missouri, revised edition. Missouri Department of Conservation, Jefferson City.

- Pietsch, T. W., K. Amaoka, D. E. Stevenson, E. L. MacDonald, B. K. Urbain, and J. A. López. 2000. Freshwater fishes of the Kuril Islands and adjacent regions. International Kuril Island Project, University of Washington Fish Collection, Washington.
- Poole, B. C., and T. A. Dick. 1986. *Raphidascaris acus* (Bloch, 1779) in Northern Pike, *Esox lucius* L., Walleye, *Stizostedion vitreum vitreum* (Mitchill), and Yellow Perch, *Perca flavescens* (Mitchill), from central Canada. *Journal of Wildlife Diseases* 22(3):435–436.
- Reshetnikov, Y. S., N. G. Bogutskaya, E. D. Vasil'eva, E. A. Dorofeeva, A. M. Naseka, O. A. Popova, K. A. Savvaitova, V. G. Sideleva, and L. I. Sokolov. 1997. An annotated checklist of the freshwater fishes of Russia. *Journal of Ichthyology* 37(9):687–736.
- Rinne, J. N. 1995. The effects of introduced fishes on native fishes: Arizona, Southwestern United States. Pages 149–159 *In* D. P. Philipp, J. M. Epifano, J. E. Marsden, J. E. Claassen, and R. J. Wolotina, Jr, editors. Protection of aquatic diversity. Proceedings of the World Fisheries Congress, Theme 3. Oxford & IBH Publishing Company, New Delhi.
- Roberts, T. R. 1998. Freshwater fugu or pufferfishes of the genus *Tetraodon* from the Mekong basin, with descriptions of two new species. *Ichthyological Research* 45(3):225–234.
- Sal'nikov, V. B. 1998. Anthropogenic migration of fish in Turkmenistan. *Journal of Ichthyology* 38(8):591–602.
- Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184.
- Scott, W. B., and E. J. Crossman. 1998. Freshwater fishes of Canada. Galt House Publications, Oakville, Ontario.
- Spens, J. 2006. Can historical names and fishers' knowledge help to reconstruct fish populations in lakes? Pages 328–347 *In* B. Neis, I. Baird, and N. Haggan, editors. Fishers' knowledge. UNESCO, Paris.
- Spillman, C.-J. 1961. Faune de France: Poissons d'eau douce. Fédération Française des Sociétés Naturelles, Tome 65. Paris.
- Stiassny, M. L. J., and N. Raminosa. 1994. The fishes of the inland waters of Madagascar. Pages 133–148 *in* G. G. Teugels, J.-F. Guégan, and J.-J. Albaret, editors. Biological diversity of African fresh- and brackish water fishes. Geographical overviews presented at the PARADI Symposium, Senegal, November 1993. *Annales du Musée Royal de l'Afrique Centrale: Sciences Zoologiques* 275.
- Van De Wolfshaar, K. E., A. M. De Roos, and L. Persson. 2006. Size-dependent interactions inhibit coexistence in intraguild predation systems with life-history omnivory. *American Naturalist* 168:62–75.

Watson, R. A., and T. A. Dick. 1980. Metazoan parasites of pike, *Esox lucius* Linnaeus, from southern Indian Lake, Manitoba, Canada. *Journal of Fish Biology* 17(3):255–261.

Welcomme, R. L. 1988. International introductions of inland aquatic species. FAO Fisheries Technical Paper 294.

Whitmore, S. 1997. Aquatic nuisance species in Region 6 of the Fish and Wildlife Service. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Management Assistance Office, Pierre, South Dakota.