Zander (*Sander lucioperca*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, September 2012
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1 Native Range and Status in the United States

Native Range

From Larsen and Berg (2014):

"*S. lucioperca* occurs naturally in lakes and rivers of Middle and Eastern Europe from Elbe, Vistula, north from Danube up to the Aral Sea and the northernmost observations of native populations were recorded in Finland up to 64° N. *S. lucioperca* naturally inhabits Onega and Ladoga lakes, brackish bays and lagoons of the Baltic sea. The distribution range in the Baltic area is supposed to be equivalent to the range of the post-glacial Ancylus Lake, which during the period 9200-9000 BP had a water level 100-150 m above the present sealevel of the Baltic Sea (Salminen et al. 2011). The most southern populations are known from regions near the Caucasus, inhabiting brackish and saline waters of Caspian, Azov and Black Seas (Bukelskis *et al.*, 1998). Historic evidence from 1700 and 1800 (two sources) suggests the existence of one natural population in Denmark, in Lake Haderslev Dam and the neighbouring brackish Haderslev Fiord on the east coast of the Jutland peninsula (Berg 2012)."

From Froese and Pauly (2019a):

"Occur in adjacent or contiguous drainage basins to Afghanistan; Amu Darya river [Coad 1981]."

Status in the United States

From Fuller and Neilson (2019):

"Although it was thought that zander stocked into a North Dakota lake did not survive (e.g., Anderson 1992), the capture of a fish in August 1999, and another 2+ year old fish in 2000 shows that at least some survived and reproduced. Five young-of-the-year fish were collected in 2005. As of 2009, the state reports that they are established in Spiritwood Lake. The North Dakota Game and Fish Department (NDGFD) reports capture of yearlings and 2-year olds, although they [say] the population is very small. Genetic sampling of fish has found that all are pure zander, there has been no hybridization. Spiritwood Lake is normally a closed basin, however it was connected to the James River due to flooding in 1998–2001. Sampling by NDGFD did not find any evidence that zander escaped the lake during the flood (L. Schlueter, personal communication)."

"Courtenay et al. (1986) listed this species from New York, but the record was based on an unconfirmed report."

Fuller and Neilson (2019) have records of observations for *Sander lucioperca* in Spiritwood Lake, North Dakota from 1989 to 2018.

Sander lucioperca was officially listed as an injurious wildlife species in 2016 under the Lacey Act (18.U.S.C.42(a)(1)) by the U.S. Fish and Wildlife Service (USFWS 2016). The importation of the zander into the United States, any territory of the United States, the District of Columbia, the Commonwealth of Puerto Rico, or any possession of the United States, or any shipment between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any possession of the United States is prohibited.

Means of Introductions in the United States

From Fuller and Neilson (2019):

"Stocked for sport fishing."

"The history of its introduction into North Dakota is not well documented in the scientific literature. Apparently the North Dakota Game and Fish Department had been interested in zander as a sport fish for many years and that agency chose Spiritwood Lake as the site of an experimental release because the water body was completely enclosed (Anderson 1992). In 1987, prior to the lake introduction, the state had hatched eggs imported from Holland, but the resulting fry were destroyed for fear that they carried pike fry rhobdo [*sic*] virus (Anonymous 1987a; Lohman 1989). Those wanting to introduce zander thought that it would be a boon to the fisheries of North America (e.g., Anderson 1992), whereas others expressed strong reservations (e.g., Wright 1992). Some fisheries personnel in states surrounding North Dakota and nearby Canadian provinces expressed doubts concerning the species' introduction, particularly because its effect on native species was unknown and because of its potential to spread (e.g., Wingate 1992)."

Remarks
A previous version of this ERSS was published in 2012. Revisions were done to incorporate new information and to bring the document in line with current standards.

The valid name *Sander lucioperca* and the synonym *Stizostedion lucioperca* (Fricke et al. 2019) were used to search for information for this ERSS. Both names have been used recently in the literature. The official common name for this species is Zander but it is also commonly referred to as pikeperch in English literature.

From Fuller and Neilson (2019):

"Concern exists that zander and walleye could hybridize. So far there has been no evidence of that happening (L. Schlueter, personal communication)."

From CABI (2019):

"It is known to hybridize with *Sander volgensis* (Specziar et al., 2009; Müller et al., 2010) and also perch (*Perca fluviatilis*) (Kahilainen et al., 2011)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing
From Fricke et al. (2019):

"**Current status:** Valid as *Sander lucioperca* (Linnaeus 1758)."

From ITIS (2019):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Percoidei
Family Percidae
Genus *Sander*
Species *Sander lucioperca* (Linnaeus, 1758)"

Size, Weight, and Age Range

From Larsen and Berg (2014):

"*S. lucioperca* obtains a maximum length of 100-130 cm which corresponds to a weight of about 15-20 kg. Maximum age is inversely correlated to growth rate. Slow-growing *S. lucioperca* in the northern part of the distribution area reach 20-24 years of age, while faster-growing *S. lucioperca* in the southern part only reach about 8-9 years (Sonesten 1991)."

From Froese and Pauly (2019a):

"Maturity: L_m 36.7, range 28 - 46 cm"

Environment

From Larsen and Berg (2014):

"*S. lucioperca* is found in lakes, moderately running waters and brackish coastal waters with salinities up to ca. 12 ‰. It thrives in turbid, moderately eutrophic waters with high oxygen content. *S. lucioperca* is also found in clear waters if the depth is sufficient to enable it to seek refuge during daytime (Sonesten 1991)."

From Fuller et al. (2019):

"*S. lucioperca* lives in freshwater and brackish water with salinities <12 ppm (Abdolmalaki and Psuty 2007) and inhabits water with temperatures from <4-30°C (Çelik et al. 2005). […] This species can tolerate salinities 29-32 ppt after a gradual increase over six hours (Brown et al. 2001)."

"This species is abundant in Egirdir Lake (Turkey), which freezes over in January, and has water temperatures 4-5°C in December and February (Çelik et al. 2005). This species also inhabits Estonian lakes that are frozen from November through April, and which may have an oxygen deficit under the ice (Kangur et al. 2007)."

Climate/Range

From Froese and Pauly (2019a):

"Temperate; […]; 67°N - 36°N, 1°W - 75°E."

Distribution Outside the United States

Native

From Larsen and Berg (2014):

"*S. lucioperca* occurs naturally in lakes and rivers of Middle and Eastern Europe from Elbe, Vistula, north from Danube up to the Aral Sea and the northernmost observations of native populations were recorded in Finland up to 64° N. *S. lucioperca* naturally inhabits Onega and Ladoga lakes, brackish bays and lagoons of the Baltic sea. The distribution range in the Baltic area is supposed to be equivalent to the range of the post-glacial Ancylus Lake, which during the period 9200-9000 BP had a water level 100-150 m above the present sealevel of the Baltic Sea (Salminen et al. 2011). The most southern populations are known from regions near the Caucasus, inhabiting brackish and saline waters of Caspian, Azov and Black Seas (Bukelskis et al., 1998). Historic evidence from 1700 and 1800 (two sources) suggests the existence of one natural population in Denmark, in Lake Haderslev Dam and the neighbouring brackish Haderslev Fiord on the east coast of the Jutland peninsula (Berg 2012)."

From Froese and Pauly (2019a):

"Occur in adjacent or contiguous drainage basins to Afghanistan; Amu Darya river [Coad 1981]."

Introduced

From Innal and Erk'akan (2006):

"The first recorded introductions of this species [*Sander lucioperca*] were in Eğirdir Lake and Marmara Lake [Turkey] in 1955. DSI [State Water Works] is responsible for the introduction of *Sander lucioperca* into Apa Reservoir (Konya), Ayrancı Reservoir (Konya), Çubuk 2 Dam Lake (Ankara), Demirköprü Dam Lake (Manisa), Mamasın Dam Lake (Nigde) Sarımsaklı Dam Lake (Kayseri), Hirfanlı Dam Lake (Kırsehir), Damsa Dam Lake (Kırsehir), Seyhan Dam Lake (Adana), Lake Gölcük (Isparta), Selevir Dam Lake (Afyon) (Anonymous 1988)"

From Larsen and Berg (2014):

"*S. lucioperca* has been introduced into several European countries, among others the Netherlands and Turkey (Welcomme 1988), France (Daszkiewic[z] 1999, Keith & Allardi 2001) Italy (Gandolfi et al. 1991) and Spain (Elvira 1995). It was first introduced into the UK in 1878 by the Ninth Duke of Bedford (Cacutt 1979). He stocked 23 *S. lucioperca* into two lakes at Bedfordshire from a lake in Schleswig-Holstein in Germany. In 1910 the first reproducing population was established."

"The first human introduction of the species in Denmark was in 1879, where 20 *S. lucioperca* from Lake Brogdorf in south Schleswig, Germany, were stocked into the Odense River in Funen. The fish did not survive. In 1898, 200 *S. lucioperca* were successfully stocked into Lake Søgård in southern Jutland. Today more than 70 Danish lakes and rivers contain self-reproducing stocks of *S. lucioperca* (Otterstrøm 1912, Dahl 1982).

In the other three Nordic countries, Sweden, Norway and Finland, *S. lucioperca* is, even though it is native to these countries, the most commonly introduced none-salmonid fish species in new lakes. This has increased the present range of the originally southernly distributed *S. lucioperca* northwards in these countries. Ca. 2500 lakes > 4 ha have an introduced population of *S. lucioperca* (Rask *et al*. 2000, Tammi *et al*. 2003). In Sweden alone, more than 92 lakes and rivers contain *S. lucioperca* populations as a result of stocking (Filipsson 1994)."

"The only known natural distribution areas of the species in Lithuania is in the Curonian Lagoon and the lower River Nemunas (Bukelskis *et al*., 1998; Virbickas 2000). From there this species was introduced into Lake Dysnai before 1940. Numerous successful introductions into many water bodies followed. Currently large populations of pike-perch inhabit the Curonian Lagoon, Kauno, Antalieptes reservoirs, Sartai, Dysnai, Dviragis Lakes, the River Nemunas, etc. (Bukelskis *et al*., 1998).

In Latvia *S. lucioperca* occur naturally in coastal waters and inner waters connected to the sea. It also occurs naturally in a few lakes and in artificial reservoirs, where populations have established themselves after stocking. *S. lucioperca* has been stocked in at least 94 (12 %) lakes in Latvia, some artificial reservoirs on the Daugava, and the southern part of the Gulf of Riga from 1904 to 1996 (Nature of Latvia [no date])."

"In 1881-1882, *S. lucioperca* was first stocked in western Germany, especially in Lake Constance and in the Rhine (Lehmann 1931). In later years *S. lucioperca* has also been introduced into other areas of Germany."

"Since the end of the 19th century *S. lucioperca* has been successfully introduced into more than 30 moraine lakes in south-eastern and southern Estonia (Ojaveer et al. 2003)."

From Froese and Pauly (2019a):

"Occurs in Erqishi and Yili rivers, Bosten lake [Walker and Yang 1999], Fuhai Lake and Xinjiang [Institute of Hydrobiology, Academia Sinica, Shanghai Natural Museum and Ministry of Agriculture of China 1993] [China]. Outside distributional range, status assumed as introduced."

"Reportedly introduced to the Tigris River, Namak Lake, Lake Urmia and Gulf basins [Iran] [Coad 1995]."

"Introduced in Lake Balkhash and Irtysh river [Kazakhstan] [Mitrofanov and Petr 1999]."

"Occurs [introduced] in Lake Issyk-kul [Kyrgystan]."

"[…] introduced from the Ural river to the mid-courses of those rivers and basins of other rivers of Uzbekistan [Khurshut 2001]."

"Recorded from the São Miguel Lake [Azores Islands]."

"Naturalized in Flanders [Belgium] [Verreycken et al. 2007]."

"Introduced in Strymon drainage [Greece] [Kottelat and Freyhof 2007]."

"Widely introduced outside Europe in Anatolia, Ob, and Amur drainages (Asian Russia) [Kottelat and Freyhof 2007]. Fish that were introduced into the Novosibirsk Reservoir dispersed downstream the Ob river to the Ob and Taz estuaries. Those that were transferred to Lake

Khanka later dispersed into the Amur basin. It is periodically recorded in the Black Sea along the Caucasian shoreline from the Bay of Novorossiik to Tuapse [Reshetnikov et al. 1997]. This has been translocated to areas within the country for stocking in open waters. It has rapidly expanded its range and is now widely established in the country [Russia] [Bogutskaya and Naseka 2002]."

"Reintroduced in [Algeria in] 1986 and 1991. Total sites of introduction 11, total number of introduction events 11[not established] [Kara 2011]."

"Recorded from 137 localities during the survey for the fish Atlas of Switzerland [Zaugg et al. 2003]."

"Early attempts to introduce the species in 1939 [in Morocco] met with no success. The species was subsequently introduced into several lakes and was successful in the El Kansera reservoir."

"Reintroduced [and established] in 1990 [in Tunisia]. Species has high potential."

"Listed as introduced species [in Croatia, Slovenia] without any major information."

In addition to the areas mentioned above, Froese and Pauly (2019a) report that *Sander lucioperca* has been introduced and established in the wild in Portugal and introduced but establishment unknown in Cyprus.

CABI (2019) lists *Sander lucioperca* as introduced to and present in Bulgaria.

From NIES (2019):

"Imported to Japan as pet animal in past."

Means of Introduction Outside the United States

From Larsen and Berg (2014):

"*S. lucioperca* has been introduced for both commercial and recreational fishing – the fish is very tasty and has high market and angling value. Furthermore, the species has been used for biomanipulation in order to reduce the number of unwanted fish, usually cyprinids (Lappalainen *et al*. 2003)."

"Most introductions of *S. lucioperca* have been done in lakes. From the lakes the fish have migrated into larger rivers (e.g. River Gudenaa in Denmark; Koed 2001), and in some cases have, through migration, established themselves in neighbouring lakes to the lakes where they were first introduced."

From Innal and Erk'akan (2006):

"Çildir (2001) reported that in 1955 approximately 10,000 young *Sander lucioperca* (= Zander) of 10–15 cm length imported from Austria were translocated into Lake Eğirdir by the Hydro

Biological Research Institute (University of Istanbul). The apparent aim was to improve the fisheries of the lake."

Short Description

From Larsen and Berg (2014):

"There are no spines on the gill cover. The mouth has many small teeth and fewer large teeth for catching the prey. The species has two dorsal fins – one with 13 to 18 spines and one with 1-2 spines and 21 to 22 soft rays. The caudal fin has 17 soft rays and the anal fin has 2-3 spines and 10-14 soft rays […]."

From CABI (2019):

"*S. lucioperca* has a long slender body with the back and flanks are green to blue-grey to brown-black, the belly is white to bluish and fins are yellow-grey. The dorsal and caudal fins have rows of black spots on the membranes, largest and most distinctive on the spiny dorsal fin. Other fins are pale yellow. […] Several dark bands run vertically from the back down each side (Maitland, 2004)."

From Froese and Pauly (2019a):

"[…]; Vertebrae: 45 - 47. Distinguished from congeners in Europe by the following combination of characters: 1-2 enlarged canine teeth in anterior part of each jaw; second dorsal fin with 18-22½ branched rays; and 80-97 scales on lateral line [Kottelat and Freyhof 2007]."

Biology

From Larsen and Berg (2014):

"Mature (maturation at age 2-5 years) *S. lucioperca* migrate to the spawning area shortly before spawning. The migrations are generally short 10-30 km or absent, but can be rather long, up to 250 km (Sonesten 1991, Koed 2001, Lappalainen et al. 2003).

The spawning takes place in lakes and rivers on a substrate consisting of stone, gravel, sand or clay preferably with plant roots. *S. lucioperca* spawn in pairs in springtime (generally in May) when water temperature reaches about 10-14 °C. For optimal egg development water temperature must be between 12-20 °C, oxygen concentration above 4.5 mg O_2/l, and salinity less than 3 ‰ (Muus & Dahlstrøm 1984, Sonesten 1991, Lappalainen *et al*. 2003). Populations of *S. lucioperca* living in coastal areas enter adjacent freshwaters for spawning. Sea spawning is, however, observed in the northern part of the Gulf of Riga, where the salinity is sufficiently low (Nature of Latvia [no date]).

After hatching (about 110 degree-days) the larvae have a length of 4-5 mm. They feed on small zooplankton, but at a length of 10-25 mm the fry initiate piscivory. When *S. lucioperca* reaches 10 cm the diet almost solely comprises fish (Sonesten 1991)."

From Froese and Pauly (2019a):

"Feed mainly on gregarious, pelagic fishes. […] Homing is well developed, even nearby populations may be relatively isolated. Spawn in pairs at dawn or night."

"Ontogenetic changes in its food composition are quite pronounced. Larvae measuring 6-8 mm consume small invertebrates. The consumption of fish is observed at an average length of 29 mm. Characteristically cannibalistic, particularly under conditions of an inadequate availability of other prey or under conditions of a large supply of their own young [Khlopnikov 1992]."

Human Uses

From Froese and Pauly (2019a):

"Popularly fished by sport fishers. Its flesh is succulent [Billard 1997]. Utilized fresh or frozen and eaten steamed, broiled and microwaved [Frimodt 1995]."

"It is the subject of extensive pond breeding [in France], partly for restocking purposes [Billard 1997]."

"Important food fish in [Poland in] early-medieval times [Klyszejko et al. 2004]."

From Larsen and Berg (2014):

"In Sweden *S. lucioperca* is still stocked to support fisheries, both within and outside the area of its natural range. 322 permits for stocking *S. lucioperca* were issued in Sweden in the period 1995-2001 (Laikre & Palmé 2005)."

"*S. lucioperca* is a valuable fish – it has a high market value and is a target species in angling. After its introduction to Danish lakes, it soon became an economically very important species in commercial fisheries. At present the value of commercial inland fisheries in Denmark is very low while the value and social importance of recreational fisheries (both local angling and angling tourism) is increasing (Jacobsen *et al*. 2004). In the Turkish Lake Egredir, the value of commercial fisheries increased several fold after the introduction of *S. lucioperca*, both because all the indigenous fish species had a very low commercial value compared to *S. lucioperca* and due to a drastic increase in the population of *Astacus leptodactylus*. In 1981 fisheries yield were 310 tonnes of *S. lucioperca* and 1573 tonnes of *A. leptodactylus* (Crivelli 1995). Before 1965 the commercial catch of *A. leptodactylus* was zero. In Latvia, where the species is native, a commercially important coastal fishery takes place. The annual catch is 30 - 80 tons, mostly in the southern part of the Gulf of Riga. The species is also a quite common catch for anglers in some freshwater bodies, mainly in the areas where it is regularly restocked (Nature in Latvia [no date])."

"*S. lucioperca* is still protected by the Danish Fishery Act by both a closed season and minimum size limit, due to its importance to commercial and recreational fisheries."

From NIES (2019):

"Imported to Japan as pet animal in past."

Diseases

Infection with epizootic hematopoietic necrosis virus is an OIE-reportable disease (OIE 2019).

From Singh et al. (2014):

"Some other species like *Esox lucius*, *Sander lucioperca* and *Ameiurus melus* are also susceptible to EHNV [epizootic hematopoietic necrosis virus] infection [Jensen et al. 2011]."

From Fuller and Neilson (2019):

"[…] the resulting fry were destroyed for fear that they carried pike fry rhobdo virus (Anonymous 1987a; Lohman 1989)."

From Bovo (2010):

"During summer 2009 VER [viral encephalopathy and retinopathy] was diagnosed in a farm rearing pike-perch (*Sander lucioperca*) […]."

From CABI (2019):

"Eslami et al. (2011) reported *Anisakis* from the gastro-intestinal tract. […] Mokhayer (1976) records the acanthocephalan *Corynosoma caspicum*. Jalali and Molnár (1990) record the monogenean *Ancyrocephalus paradoxus*. Masoumian et al. (2005) recorded the protozoan parasite *Trichodina perforata*. Pazooki et al. (2007) recorded various parasites, including *Diplostomum spathaceum* and *Argulus foliaceus*. Barzegar et al. (2008) recorded the digenean eye parasite *Diplostomum spathaceum* from this fish. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Achtheres percarum* on this species. Azadikhah et al. (2009) found 6 parasite species including two *Trichodina* spp. from the gills and *Vorticella* sp. on the skin; other parasites included *Gyrodactylus* sp. and *Argulus foliaceus* from the gills, and *Diplostomum spathaceum* from the lens of the eyes. Rolbiecki (1993) noted the parasitic metazoa of pikeperch in Poland to include *Achteres percarum*, *Ancyrocephalus paradoxus*, *Argulus foliaceus*, *Azygia lucii*, *Bothriocephalus* sp., *pleroceroid*, *Brachyphallus crenatus*, *Bucephalus polymorphus*, *Bunodera luciopercae*, *Camallanus lacustris*, *Camallanus truncates*, *Corynosoma semerme*, *Diplostomum spathaceum*, *Ichthyocotylurus playcephalus*, *Neoechinorhynchus rutile*, *Piscicola geometra*, *Pomphorhynchus laevis* and *Tylodelphys clavata*."

Saleh et al. (2012) list *Sander lucioperca* as a host for zander rhabdovirus.

Cinkova et al. (2010) list *Sander lucioperca* as a host for pike-perch iridovirus.

Pękala et al. (2015) isolated *Shewanella putrefaciens* from *Sander lucioperca*.

Froese and Pauly (2019b) list *Sander lucioperca* as a host for the following additional pathogens: *Achtheres sandrae*, *Ascaris truncatula*, *Bucephalus markewitschi*, *Caligus lacustris*, *C. minimus*, *Ergasilus seiboldi*, *Glugea dogieli*, *Neoergasilus japonicus*, *Paracoenogonimus ovatus*, and *Rhipidocotyle campanula*.

Poelen et al. (2014) list *Sander lucioperca* as a host for the following pathogens: *Acanthocephalus anguillae*, *A. clavula*, *A. lucii*, *Acanthostomum imbutiformis*, *Ancyrocephalus cruciatus*, *A. percae*, eel swimbladder nematode (*Anguillicola crassus*), *Anisakis schupakovi*, herring worm (*A. simplex*), *Apatemon annuligerum*, *Apophallus muehlingi*, *A. donicus*, *Ascaris velocissima*, *Ascocotyle colceostoma*, *Aspidogaster limacoides*, *Bothriocephalus acheilognathi*, *Bunocotyle cingulata*, *Caryophyllaeides fennica*, *Clinostomum complanatum*, *Contracaecum squalii*, *Corynosoma strumosum*, *Cosmocephalus obvelatus*, *Cotylurus pileatus*, *C. variegatus*, *Crowcrocaecum skrjabini*, *Cyathocephalus truncatus*, *Dactylogyrus anchoratus*, *Desmidocercella numidica*, *Diclybothrium armatum*, Fish tapeworm (*Diphyllobothrium latum*), *Diplostomum clavatum*, *D. chromatophorum*, *D. commutatum*, *D. helveticum*, *D. baeri*, *D. paracaudum*, *D. mergi*, *D. volvens*, *Diplozoon paradoxum*, *Echinorhynchus salmonis*, proboscis worm (*E. gadi*), *E. cinctulus*, *Eubothrium crassum*, *Eustrongylides excisus*, frog virus, *Gasterostomum fimbriatum*, *Gnathostoma hispidum*, *Goussia desseri*, *Gyrodactylus lucii*, *G. luciopercae*, *G. longiradix*, *G. cernuae*, *Hemiurus luehei*, *Henneguya creplini*, *Hepaticola petruschewskii*, *Ichthyocotylurus variegatus*, *I. pileatus*, *I. erraticus*, *Lecithaster tauricus*, *Ligula intestinalis*, *Metagonimus yokogawai*, *Metorchis xanthostomus*, *Myxobolus sandrae*, *Neoechinorhynchus rutile*, *Paracuaria tridentate*, *Paratenuisentis ambiguus*, *Philometra obturans*, *Phyllodistomum pseudofolium*, *P. angulatum*, *Porrocaecum reticulatum*, *Proteocephalus cernuae*, *P. percae*, sealworm (*Pseudoterranova decipiens*), *Pulvinifer macrostomum*, *Pygidiopsis gentata*, *Raphidascaris acus*, *Rhipidocotyle illense*, *Sanguinicola volgensis*, *Schulmanella petruschewskii*, *Streptocara crassicauda*, *Triaenophorus nodulosus*, and *T. crassus*.

Threat to Humans

From Larsen and Berg (2014):

"Human health effects
High concentrations of toxic compounds from algae-preventing (anti-fouling) paints have been reported in some of the Finnish coastal *S. lucioperca* populations." [In other words, the zanders eat algae on boat hulls treated with antifouling paint and accumulate the toxic compounds in their bodies. People eating the zanders may ingest the toxic compound.]

From CABI (2019):

"Eslami et al. (2011) reported *Anisakis* from the gastro-intestinal tract. This parasite can infest man if fish is eaten smoked, salted or fried at temperatures below 50°C."

3 Impacts of Introductions

From Larsen and Berg (2014):

"In the springtime *S. lucioperca* also predate on smolts of sea-trout (*Salmo trutta*) and salmon (*Salmo salar*) when they migrate to the sea. Studies from River Gudenaa, Denmark has shown that predation on smolts in the lower part of the river has an adverse effect on the population of sea-trout (Jepsen *et al*. 2000, Koed 2001, Koed *et al*. 2002)."

"Schulze *et al*. (2006) found that the perch (*Perca fluviatilis*) population in a shallow, mesotrophic lake with natural occurrence of perch and pike (*Esox lucius*) were negatively affected by *S. lucioperca* introduction. In an experiment they showed that perch was forced away from its preferred habitat, the pelagic zone, by *S. lucioperca*. As the littoral zone was already occupied by pike, the perch population was "sandwiched" between pike and the introduced *S. lucioperca*. As perch has been found to be the most important predator to control the density of zooplanktivorous 0+ cyprinids in Danish lakes, the introduction of *S. lucioperca* must be considered as negative and indeed has been observed to result in reduced environmental conditions compared to the expected in eutrophic Danish lakes (Jerl Jensen, pers. comm.)."

"Several authors have reported reduced population densities of cyprinids as a result of *S. lucioperca* introduction. Jeppesen *et al*. (2001) found evidence of this in a paleolimnologic study in the Danish Lake Skanderborg, where *S. lucioperca* was introduced in 1903-04. After this a permanent reduction in cyprinid densities was found. […] Cowx (1997) found that introducing *S. lucioperca* to English rivers created a crash in the cyprinid fish community."

"Brabrand and Faafeng (1993) showed how young roach shifted from pelagic to littoral habitats as a result of *S. lucioperca* introduction in a Norwegian lake. An indirect effect of the changed behaviour of roach was increased infection rate of roach with the ectoparasite *Ichthyophthirius multifiliis*, as roach was more often exposed to the free swimming state of *Ichthyophthirius multifiliis* when living in shallow water near the substrate compared to their previously more pelagic lifestyle (Brabrand *et al*. 1994)."

From Pavličević et al. (2016):

"The most important impact of pikeperch [*Sander lucioperca*], 28 years after its invasion in the Neretva River watershed, is the extinction of native endemic Neretvan bleak [*Alburnus neretvae*], in the artificial reservoirs. The bleak was abundant, even in the artificial reservoirs, before the pikeperch introduction. Bleak was the major prey during the first period of pikeperch invasion."

From Schulze et al. (2006):

"The lake-wide piscivore biomass increased 1.42–1.64 times as a result of pikeperch stocking and the accompanying increase in northern pike abundance. The biomass of piscivorous fish in the pelagic area almost doubled as a result of pikeperch stocking in comparison with the period before stocking when large perch was the sole pelagic predator. Therefore, a severe density-mediated perturbation could be expected. Beyond the density-mediated effects on the prey fish population (consumption rates of predators), changes in a behavioral trait (reduced diel horizontal migration of small roach) were also observed. Furthermore, among the residential predators, the introduced pikeperch induced both density-mediated effects (cannibalism and intraguild predation) and changes in habitat use and prey selectivity."

"Pikeperch stocking affected habitat use and diet composition of piscivorous perch. […] However, there was a strong tendency for perch to increasingly respond to the pelagic presence of pikeperch by shifting their daytime habitat towards a stronger use of the littoral area as a higher proportion of perch was caught in nearshore areas in 2002 as compared with 2001, and the differences were even more pronounced in comparison with the situation before pikeperch stocking (Haertel et al. 2002)."

"Northern pike may have even benefited from stocking with pikeperch. In direct comparison between the pikeperch-free and the pikeperch periods, northern pike abundance was significantly higher in 2002 than the years before pikeperch stocking, and biomass almost doubled after the pikeperch introduction."

From Anseeuw et al. (2019):

"The introduction of this predatory fish in Western Europe created a crash in some cyprinid fish communities. Populations of native piscivorous fish species (*Esox lucius*, *Perca fluviatilis*) were locally depleted due to interspecific competition. The pike-perch is also a vector of the *Bucephalus polymorphus* parasite, that can affect native cyprinid fish species; however, a massive outbreak of this parasite has never been reported from Belgium."

From Innal and Erk'akan (2006):

"Çildir (2001) reported that in 1955 approximately 10,000 young *Sander lucioperca* (= Zander) of 10–15 cm length imported from Austria were translocated into Lake Eğirdir by the Hydro Biological Research Institute (University of Istanbul). The apparent aim was to improve the fisheries of the lake. The fishery was widely practiced in central Europe at the time before transplantation and ten fish species were reported to exist in the lake: *Cyprinus carpio, Vimba vimba*, *Capoeta pestai*, *Acanthorutilus handlirschi*, *Thylognathus klatti*, *Aphanius chantrei*, *Cobitis taenia*, *Orthrias angorae, Schizothorax propyhlax* and *Pararhodeus niger*. Of these *S. prophylax* and *P. niger* were apparently misidentified since these fish are not among the fauna of Turkey. However they are presumed to represent *Phoxinellus zeregi* and *P. anatolicus*, respectively. Twenty three years later [after the 1955 introduction] in 1978 the only significant population left in the lake (apart from Zander) was carp (*Cyprinus carpio*), *Vimba vimba* and *Varicorhinus pestai* (= *Capoeta pestai*). Zander is the only species with a large stock, while carp and *Vimba vimba* catches have declined sharply. Most recent data evaluations indicate while *P. anatolicus, O. angorae, Seminoemacheilus lendli* and *Hemmigramocapoeta kemali* are still surviving in some numbers, *Phoxinellus egridiri*, *P. handlirschi*, *P. zeregi* are suspected to have gone extinct. After introduction of Zander to Beysehir Lake, the number of fish species have been decreasing drastically. The three species presumed extinct were endemic to Turkey."

From CABI (2019):

"*S. lucioperca* is a vector of the trematode *Bucephalus polymorphus* which caused a decrease in native cyprinid populations in some French basins in the 1960s and 1970s (Lambert, 1997) and recently in water systems newly colonized by zebra mussel (*Dreissena polymorpha*) the primary host of this parasite."

"In the UK, *S. lucioperca* requires a licence under the Import of Live Fish Act (1980) to keep or release (i.e. fisheries)."

From Froese and Pauly (2019a):

"Since the entrance into force of the new Federal legislation on fishery [Switzerland] the introduction of the species is restricted [FAO 1997]."

From NIES (2019):

"Import, transport and keeping are prohibited by the Invasive Alien Species Act [of Japan]."

4 Global Distribution

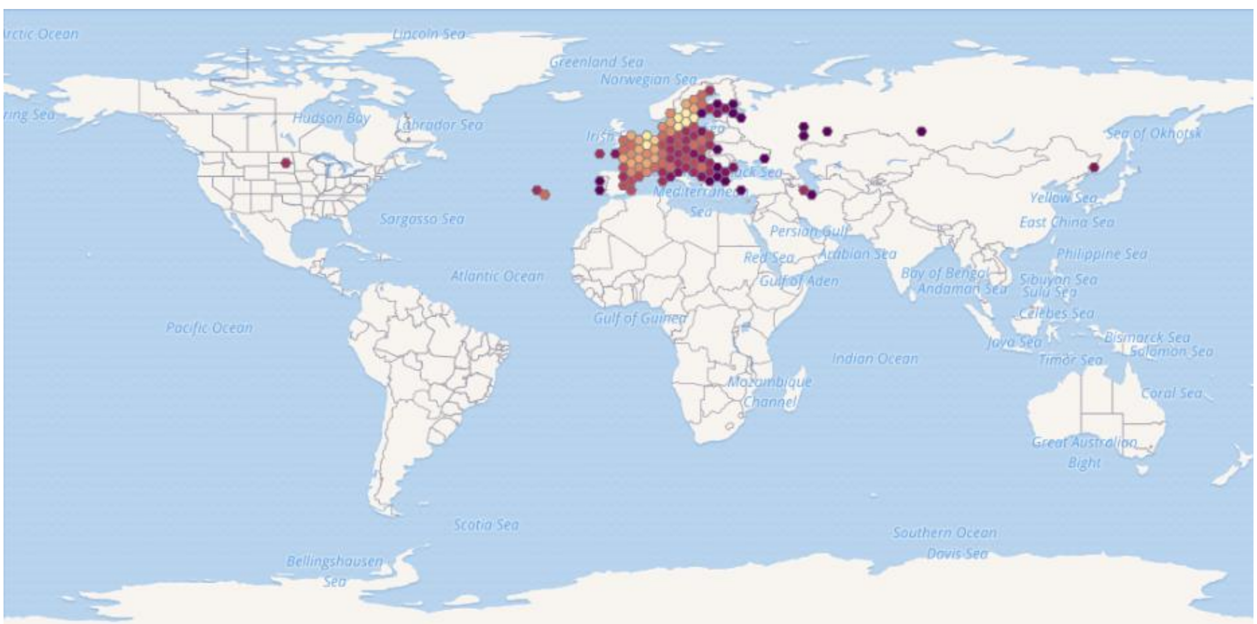

Figure 1. Known global distribution of *Sander lucioperca*. Locations are in Europe, Asia, and North America. Map from GBIF Secretariat (2019).

5 Distribution Within the United States

Figure 2. Known distribution of *Sander lucioperca* in the United States. Map from Fuller and Neilson (2019).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Sander lucioperca* to the contiguous United States was mainly medium. There were areas of high match in southern New England, the southern Appalachian Mountains, Great Lakes basin, and northern Midwest. There were small patches of high match throughout the Great Plains and along the Pacific Coast. There were areas of low match in Florida and along the Gulf Coast, along the southern border, in the Southwest, the Pacific Northwest, and small patches in New England and the Great Plains. Everywhere else had a medium match. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for contiguous United States was 0.554, high (scores 0.103 and greater are classified as high). All States had high individual Climate 6 scores except for Alabama, Kansas, South Carolina, and Texas, which had medium scores, and Florida, Louisiana, and Mississippi, which had low scores.

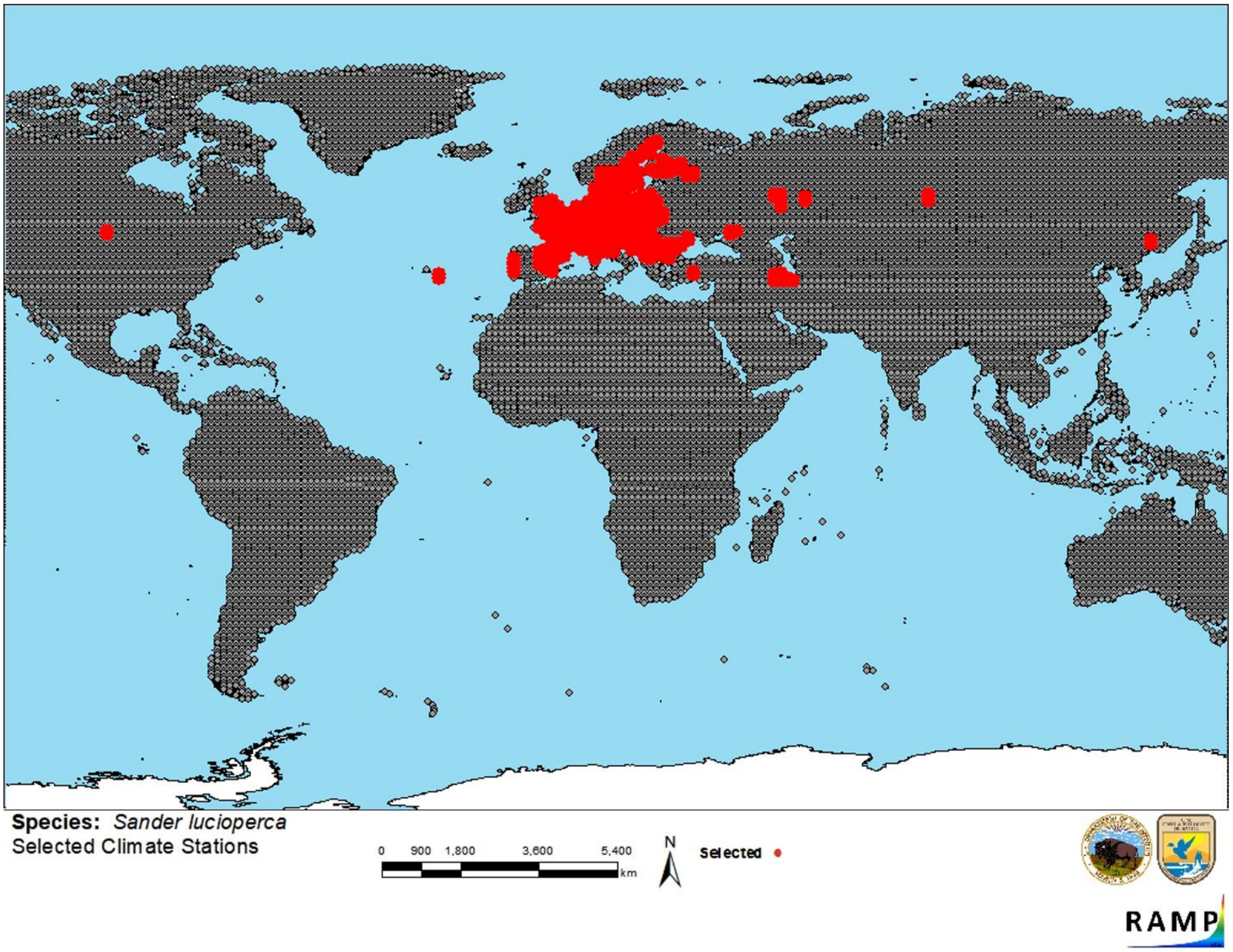

Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations in the northern hemisphere selected as source locations (red; United States, Europe, Russia, China, Turkey, Iran) and non-source locations (gray) for *Sander lucioperca* climate matching. Source locations from Fuller and Neilson (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.

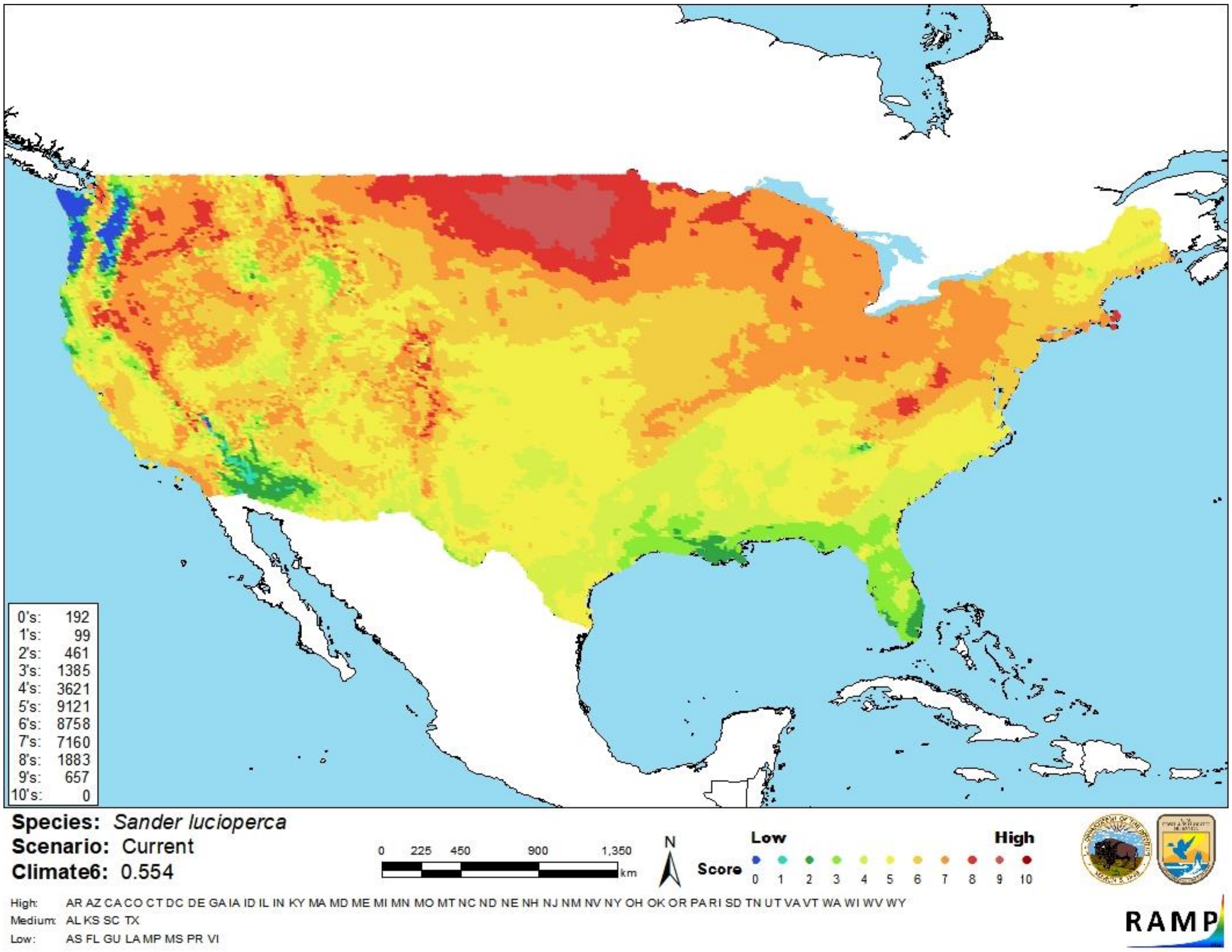

Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Sander lucioperca* in the contiguous United States based on source locations reported by Fuller and Neilson (2019) and GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

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≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Certainty of assessment for this species is high. Information on the biology, ecology, history of introductions, and impacts of this species is readily available from peer-reviewed literature. There is a history of introductions resulting in established populations. Information on negative impacts to multiple species is available from peer-reviewed, scientifically defensible sources.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Zander (*Sander lucioperca*) is a large, predatory piscivorous fish that is native to Eastern Europe and western Asia. *S. lucioperca* has been used as a food source, for recreational fisheries, and as a top-down ecosystem engineer. *S. lucioperca* is susceptible to and host for many pathogens, including epizootic hematopoietic necrosis virus, which is an OIE-reportable disease. The history of invasiveness for *S. lucioperca* is high. In Europe, *S. lucioperca* has established in many introduced areas. Impacts from these introductions include reduced populations of prey fish and competitor fish, as well as trophic and behavioral changes, and in the case of some Turkish lakes, extirpation of endemic species. It was introduced to Spiritwood Lake, North Dakota, in the United States and established a population but has not spread. In 2016, *S. lucioperca* was listed as Injurious Wildlife under the Lacey Act by the U.S. Fish and Wildlife Service. The overall climate match is high. Most of the northern half of the contiguous United States had high matches; low matches were concentrated along the southern border and Gulf region. The certainty of assessment is high. Information is available from 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:** *Sander lucioperca* is susceptible and a host for epizootic hematopoietic necrosis virus, an OIE-reportable disease. *S. lucioperca* is listed as Injurious Wildlife by the U.S. Fish and Wildlife Service.
- **Overall Risk Assessment Category: High**

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