Bighead Carp (*Hypophthalmichthys nobilis*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
Revised, June 2018
Web Version, 8/16/2018

Photo: A. Benson, USGS. Public domain. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=551. (June 2018).

1 Native Range and Status in the United States

Native Range

From Jennings (1988):

"The bighead carp is endemic to eastern China, […] in the lowland rivers of the north China plain and South China, including the Huai (Huai Ho), Yangtze, Pearl, West (Si Kiang), Han Chiang and Min rivers (Herre 1934; Mori 1936; Chang 1966; Chunsheng et al. 1980)."

Status in the United States

From Nico et al. (2018):

"This species has been recorded from within, or along the borders of, at least 18 states. There is evidence of reproducing populations in the middle and lower Mississippi and Missouri rivers and the species is apparently firmly established in the states of Illinois and Missouri (Burr et al. 1996; Pflieger 1997). Pflieger (1997) received first evidence of natural reproduction, capture of young bighead carp, in Missouri in 1989. Burr and Warren (1993) reported on the taking of a postlarval fish in southern Illinois in 1992. Subsequently, Burr et al. (1996) noted that bighead carp appeared to be using the lower reaches of the Big Muddy, Cache, and Kaskaskia rivers in Illinois as spawning areas. Tucker et al. (1996) also found young-of-the-year in their 1992 and 1994 collections in the Mississippi River of Illinois and Missouri. Douglas et al. (1996) collected more than 1600 larvae of this genus from a backwater outlet of the Black River in Louisiana in 1994. The first open water record of this species in Arkansas is based on two specimens taken from the Arkansas River in 1986; however, as of the late 1980s there has been no evidence of natural reproduction in that state (Robison and Buchanan 1988). According to Dill and Cordone (1997), there is evidence that the California ponds containing Chinese carp have spilled since 1989, opening the door for bighead carp and grass carp to gain access to the Sacramento River. The West Virginia record involved a single fish taken in 1997 (Hoeft, personal communication). Harvest of bighead carp by commercial fishermen in Missouri has been somewhat erratic. In 1993, the species accounted for 0.6 percent (3,348 pounds) of the reported commercial fish harvest, a decline from the previous year (Robinson 1995)."

According to Nico et al. (2018), *Hypopthalmichthys nobilis* has been reported from the following states (year of last reported observation is indicated in parentheses): Alabama (2007), Arizona (2007), Arkansas (2016), California (1992), Colorado (2004), Florida (2017), Illinois (2017), Indiana (2017), Iowa (2018), Kansas (2014), Kentucky (2017), Louisiana (2015), Minnesota (2018), Mississippi (2015), Missouri (2018), Nebraska (2017), New Jersey (2010), North Carolina (2011), Ohio (2018), Oklahoma (2017), Pennsylvania (2014), South Dakota (2015), Tennessee (2017), Texas (2010), Virginia (1996), West Virginia (2016), and Wisconsin (2018). Detailed nonindigenous occurrence information is available in the USGS Nonindigenous Aquatic Species database (https://nas.er.usgs.gov).

From CABI (2018):

"Reproduction of bighead carp in the Mississippi River system was first documented in 1989. The bighead carp have reportedly become well established in the Missouri River and their proportion in the commercial harvest has increased since 1990. Bighead carp are now found within or along the borders of at least 23 states in the USA and are reportedly growing in number in many midwestern rivers (Ramussen, 2000a; Nico and Fuller, 2005, 2010). Hence, there is a vigorous campaign in the USA […] against the spread of non-native, invasive fish species, which includes bighead carp, for the protection of native species and biodiversity. Moreover, state code and permit programmes control the importation, stocking, sale and possession of bighead carp in some states (Ramussen, 2000a, b). More recently, four bighead carp have been reportedly caught in Lake Erie and there are valid reasons to be concerned that the fish might soon become established in the Great Lakes (Egan, 2004)."

From U.S. Office of the Federal Register (2011):

"The U.S. Fish and Wildlife Service (Service) adds the bighead carp (*Hypophthalmichthys nobilis*), a large fish native to eastern Asia, to the list of injurious fish, mollusks, and crustaceans. The importation into the United States and interstate transportation between States, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the United

States of all forms of live bighead carp, gametes, viable eggs, and hybrids thereof is prohibited, except by permit for zoological, education, medical, or scientific purposes (in accordance with permit regulation at 50 CFR 16.22) or by Federal agencies without a permit solely for their own use."

"This rule is effective March 22, 2011."

"The Asian Carp Prevention and Control Act (Pub. L. 111–307) was passed by the Senate on November 17, 2010, and by the House of Representatives on December 1, 2010, and signed into law by President Obama on December 14, 2010. The law amends the Lacey Act (18 U.S.C. 42) by adding the bighead carp (*Hypophthalmichthys nobilis*) to the list of injurious animals contained therein. The statutory prohibitions and exceptions for this species went into effect upon signature into law. This rule adds the bighead carp to the list of injurious fish, mollusks, and crustaceans at 50 CFR 16.13."

Means of Introductions in the United States

From Nico et al. (2018):

"Bighead carp were first imported into the United States in 1973 by a private fish farmer in Arkansas who wanted to use them in combination with other phytophagous fishes to improve water quality and increase fish production in culture ponds. In 1974 the Arkansas Game and Fish Commission and Auburn University, Alabama, obtained stock to assess their potential benefits and impacts (Jennings 1988). The species first began to appear in open waters, the Ohio and Mississippi rivers, in the early 1980s, likely as a result of escapes from aquaculture facilities (Jennings 1988). In April 1994, several thousand bighead carp, along with a few black carp *Mylopharyngodon piceus*, escaped into the Osage River, Missouri, when high water flooded hatchery ponds at an aquaculture facility near Lake of the Ozarks (Anonymous 1994). Fish that escaped into the Missouri River have increased and spread, since 1990, into the lower Kansas River of Kansas, and elsewhere (Cross and Collins 1995). The species may have dispersed into Oklahoma waters from fish illegally brought into southeast Kansas by a commercial fish farmer in 1988 (Pigg et al. 1993). According to Pigg et al. (1997), collections in the Grand River of Oklahoma since 1991 indicate a gradual downstream dispersal. The species was illegally stocked along with grass carp in one or a few ponds in California; these were brought into the state by a commercial aquaculturist. The live fish were reportedly transported in a concealed compartment under a load of black bass in the fall of 1989 from a fish grower in Oklahoma or Arkansas (Dill and Cordone 1997). The species was illegally stocked in Cherry Creek Reservoir, Colorado (P. Walker, personal communication)."

Remarks

From Lamer et al. (2010):

"Hybridization between bighead carp and silver carp appears to be a relatively uncommon phenomenon within their native ranges, even where the species' ranges overlap (Kolar et al. 2007). Yet, the capacity for interbreeding between these species is well established in aquaculture and experimental settings with prevailing fertility and the absence of well-reinforced reproductive barriers (Green and Smitherman 1984; Marian et al. 1986; Slechtova et al. 1991;

Almeida-Toledo et al. 1995). For example, Voropaev (1978) and Green and Smitherman (1984) reported that first generation (F_1) reciprocal hybrids between these two species could be cultured as a high-quality food fish and for water quality improvement in aquaculture production ponds. Moreover, these artificial and captive F_1 hybrids displayed improved performance in terms of growth rate, disease resistance, and survival rate over that of intercrossing parental species (Voropaev 1978; Green and Smitherman 1984). Importantly, any observed hybrid superiority in terms of growth and fitness in the F_1 generation disappeared in later generations and, in fact, the performance of hybrids fell below that observed for either parental species (Voropaev 1978)."

"Where bighead carp and silver carp have been introduced or escaped from captivity, interspecific hybrids have been suspected and putatively identified based on a suite of morphological traits, the identifications later being confirmed with diagnostic molecular probes (Marian et al. 1986; Slechtova et al. 1991; Almeida-Toledo et al. 1995; Mia et al. 2005). Although interspecific hybrids are routinely, albeit incorrectly, presumed to be sterile, Asian carp hybrids are fertile and capable of second- or later-generation hybridization and backcrossing, which has led to extensive interbreeding and introgression (Brummett et al. 1988; Slechtova et al. 1991; Mia et al. 2005) and the potential formation of a hybrid swarm. In North American waters, the rapid expansion of bighead carp and silver carp may cause or accelerate introgression as densities continue to increase."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Deuterostomia
      Phylum Chordata
        Subphylum Vertebrata
          Infraphylum Gnathostomata
            Superclass Actinopterygii
              Class Teleostei
                Superorder Ostariophysi
                  Order Cypriniformes
                    Superfamily Cyprinoidea
                      Family Cyprinidae
                        Genus *Hypophthalmichthys*
                          Species *Hypophthalmichthys nobilis* (Richardson, 1845)"

From Eschmeyer et al. (2018):

"Current status: Valid as *Hypophthalmichthys nobilis* (Richardson 1845). Cyprinidae: Xenocypridinae."

Size, Weight, and Age Range

From Froese and Pauly (2018):

"Maturity: Lm 65.0, range 55 - 70 cm
Max length : 146 cm SL male/unsexed; [Kottelat and Freyhof 2007]; common length : 60.0 cm TL male/unsexed; [Baensch and Riehl 1991]; max. published weight: 40.0 kg [Kottelat and Freyhof 2007]; max. reported age: 20 years [Kottelat and Freyhof 2007]"

From Nico et al. (2018):

"Female bighead carp reach sexual maturity at three years of age, while males can reach sexual maturity in two years; however, this varies significantly with changing environmental conditions (Huet 1970; Kolar et al. 2007)."

From Jennings (1988):

"In China, bighead carp generally reach 0.75 to 1.5 kg in their second year and 3 to 4 kg in their third year (Dah-Shu 1957)."

"In the Soviet Union, bighead carp commonly weigh 20 kg (Nikol'skii 1970). The maximum size reported for the bighead carp in the Ukraine is 40 kg at age 9 (Baltagi 1979). In the United States, the bighead carp sometimes reaches 18 to 23 kg in 4 or 5 yr (Henderson 1978)."

Environment

From Froese and Pauly (2018):

"Freshwater; benthopelagic; potamodromous [Riede 2004]; depth range 5 - ? m. […] 4°C - 26°C [Li et al. 1990];"

From Jennings (1988):

"Bettoli et al. (1985) reported the preferred temperature range of bighead carp in a laboratory gradient as 25.0 °-26.9 °C, and the critical thermal maximum temperature as 38.8 °C. No information was found on the lower lethal temperature of bighead carp; however, considering their native range in China, they are able to tolerate extremes in water temperature, from temperate to tropical."

Climate/Range

From Froese and Pauly (2018):

"Temperate; […] 64°N - 18°S"

From Jennings (1988):

"The mean annual air temperature ranges from -4 °C in the Manchurian Plain Region to 24 °C in the South (Hseih 1973). Air temperature extremes are -30 °C to 16 °C during the coolest month (January), and between 20 °C and 30 °C during the warmest month (July)."

Distribution Outside the United States

Native

From Jennings (1988):

"The bighead carp is endemic to eastern China, […] in the lowland rivers of the north China plain and South China, including the Huai (Huai Ho), Yangtze, Pearl, West (Si Kiang), Han Chiang and Min rivers (Herre 1934; Mori 1936; Chang 1966; Chunsheng et al. 1980)."

Introduced

From Jennings (1988):

"Welcomme (1981) reported that the bighead carp is established in the Danube River of Europe. It is widespread in the river basin and supports a sport fishery."

"Japan imported bighead carp fry from Shanghai between 1915 and 1945 (Kuronuma 1954). In 1930, young bighead carp were identified in the River Tone, and later in Lake Kasumi. The bighead carp is believed to be established in these waters (Tsuchiya 1979)."

"In the Philippines, the bighead carp reportedly reproduces in the Pampanga River (Datingaling 1976); however, there is no record of its permanent establishment there."

"Tang (1960) collected bighead carp fry from the Ah Kung Tian Reservoir in Taiwan, suggesting natural reproduction; however, this incident could have been caused by unusual hydrological and climatic conditions."

From Huckstorf (2012):

"Introduced:
Afghanistan; Albania; Algeria; Armenia; Belarus; Bhutan; Brunei Darussalam; Bulgaria; Cambodia; Czech Republic; Denmark; Dominican Republic; Egypt; Estonia; Fiji; France; Germany; Greece; Hong Kong; Hungary; India; Indonesia; Iran, Islamic Republic of; Iraq; Israel; Italy; Japan; Jordan; Korea, Democratic People's Republic of; Lao People's Democratic Republic; Latvia; Malaysia; Mexico; Morocco; Mozambique; Myanmar; Nepal; Netherlands; Pakistan; Panama; Peru; Philippines; Poland; Romania; Russian Federation; Serbia; Singapore; Slovakia; Sri Lanka; Sweden; Switzerland; Taiwan, Province of China; Thailand; Turkey; Turkmenistan; Ukraine; United States; Uzbekistan; Viet Nam"

Means of Introduction Outside the United States

From Jennings (1988):

"It […] has been introduced worldwide as an important food fish. It also has been used in combination with other species of phytophagous fish to improve water quality and increase fish production, both in culture facilities and natural systems."

From CABI (2018):

"Introductions of bighead carp to most countries are actually secondary or tertiary transfers from countries other than China."

"Introduction of bighead carp in some European countries (e.g., Hungary and England) was initially inadvertent; bighead carp were mixed with shipments of grass carp (Jennings, [1988]). Subsequent introductions, however, were intentional for use in culture and/or nutrient removal (Stott and Buckley, 1978; Jennings, 1988). Similarly, initial introduction of bighead carp in India was accidental and the fish were confined to a fish farm of a government institute but they totally disappeared later (Shetty et al., 1989). Bighead carp reappeared in 1987 most likely through private trade from Bangladesh."

Short Description

From Jennings (1988):

"The general shape of the bighead carp […] is characterized as deep-bodied and moderately compressed laterally (Henderson 1976). It has no spines in the fins. The scales are cycloid and very small. Its coloration is dark gray above and off-white below with dark gray to black irregularly shaped and positioned splotches over the entire body. This pattern begins to show when the fish is about 8 weeks old. The head and mouth of the bighead carp are disproportionately large. The premaxillary and protruding mandible form rigid bony lips and the terminal mouth is not expandable. The eyes are located anteriorly on the head and have a definite ventral positioning. A smooth keel is between the base of the caudal fin and the pelvic fins."

"Berry and Low (1970) described the following morphometric and meristic characteristics for 20 bighead specimens (12.2-18.2 cm):"

"Body: Broad, moderately compressed; mean breadth/SL = 0.29.
Profile: Ventral more convex than dorsal. Abdominal keel prominent.
Head: Broad; mean length/SL = 0.36; mean width/SL = 0.17.
Snout: Slightly depressed and moderately long; mean length/SL = 0.10.
Mouth: Dorsal, lower jaw longer than upper.
Interorbital: Broad; mean width/SL = 0.16.
Caudal peduncle: Moderately long; mean length/SL = 0.20; mean height/SL = 0.11.
Scales: Cycloid, oblong, very small; margins entire; focus central.
Dorsal fin: 2/8; rounded, origin behind ventrals and nearer to base of caudal than to tip of snout.
Pectoral fin: 1/17-19; Reaches beyond ventral origin.
Ventral fin: 1/8-9.

Anal fin: 2/12-14; rounded.
Caudal fin: 5-6/17/4—7 (unbranched rays/branched rays/unbranched rays).
Lateral line: 98-100 scales along lateral line; 26-28 scales above lateral line; 16-19 scales below lateral line. Complete, markedly ventrally convex, running along middle of caudal peduncle."

From Froese and Pauly (2018):

"Differs from *Hypophthalmichthys molitrix* by having scaled keel from pelvic to anal, 240-300 long gill rakes, head length 27-35% SL, dark overall coloration, flank with dark, large, very irregularly shaped blotches, fin bases and inferior parts of head and belly yellowish [Kottelat and Freyhof 2007]."

Biology

From Huckstorf (2012):

"In its natural distribution range, inhabits rivers with marked water-level fluctuations, overwinters in middle and lower stretches. Lives up to 20 years. Spawns for the first time at 5-6 years, 550-700 mm SL and 5-10 kg, earlier and smaller in subtropical areas. Migrates long distances upriver at the beginning of a rapid flood and water-level increases (in April-July depending on locality). Spawns during floods. Stops spawning if condition change and starts again with increase of water level. Spawns in upper water layer or even at water surfaces. Females spawn up to 1.1 million eggs in 1-3 portions depending on duration of high-water period. Eggs are yellowish, transparent, and hatch after about 2 days at temperatures around 25°C while drifting downstream in the deep open-water layer. If the river flow is blocked or if available river stretches are too short, eggs cannot drift long enough and fail to develop. After spawning, adults leave the river and migrate back to forage habitats. Larvae drift downstream and settle in floodplain lakes, shallow shores and backwaters with little or no current. In autumn-winter, when temperatures falls to 10°C, juveniles and adults form separate large schools and move downstream to deeper places in the main course of river to overwinter. Feed mostly on zooplankton, also algae. Often crossed with *H. molitrix* (source: Kottelat and Freyhof 2007)."

From Nico et al. (2018):

"Bighead carp is a powerful filter-feeder with a wide food spectrum that grows fast and reproduces quickly (Xie and Chen 2001), which makes this species a strong competitor. The diet of this species overlaps with that of planktivorous species (fish and invertebrates) and to some extent with that of the young of virtually all native fishes. Bighead carp are thought to deplete plankton stocks for native larval fishes and mussels (Laird and Page 1996). Bighead carp lack a true stomach which requires them to feed almost continuously (Henderson 1976)."

Human Uses

From Jennings (1988):

"Bighead carp have been introduced into several countries in central and eastern Europe […]. In these countries it is used for food production and water quality control (Krupauer 1971)."

From Froese and Pauly (2018):

"Fisheries: highly commercial; aquaculture: commercial; aquarium: public aquariums"

From Huckstorf (2012):

"*Hypophthalmichthys nobilis* is a commercially important fish species in China with high abundance in the catch (Wu et al. 2000). It is also used in aquaculture. Marketed fresh and frozen."

Diseases

From Jennings (1988):

"A number of protozoan parasites are known to infect bighead carp at these [fry and fingerling] stages of development (Molnar 1971; Lucky 1984). *Cryptobia branchialis* is a flagellate that infects the gills. Sporozoa include *Eimeria sinensis* and *E. cheni*, which infect the intestine; *Myxobolus pavlovskii*, which infects the gills, and *Chloromyxutn cyprini*. Ciliates include *Chilodonella cyprini*, *Ichthyophthirius multifilis*, *Trichodinella epizootica*, *Trichodina* sp., and *Apiosoma cylindriformis*, all of which infect the gills of bighead carp fry."

""White-skin disease" of bighead carp is caused by the bacterium *Pseudomonas dermoalba*, and is recognized by a whitening of the skin at the base of the dorsal and caudal fins. […] The most infectious fungal disease is caused by *Saprolegnia*, and is characterized by a cotton-like growth on the epidermis; it develops mainly as a result of the fish being stressed."

"*Ichthyophthirius multifilis*, which parasitizes the skin and gill epithelium, is characterized by the presence of small white tubercles on the body. Lesions of the cornea and blindness may also occur. This disease often causes mass mortalities in culture situations. Trichodiniasis is a disease caused by infusoria of the genera *Trichodina*, *Trichodinella*, and *Tripartiella*. These protozoans infect the skin and gills of bighead carp and inhibit circulation. Migala (1978) discovered several species of these genera, as well as other ciliates, infecting bighead carp reared in ponds in Poland. Another protozoan that parasitizes the gill epithelium of bighead carp is *Myxobolus pavlovskii*."

"Trematodes reported to parasitize bighead carp include *Dactylogyrus* sp., which infects the gill filaments; *Diplostomum* sp., the metacercariae of which parasitize the eyes; and *Posthodiplostomum* sp., in which the larva infects the skin and subcutaneous tissue, depositing a black pigment around the cyst it forms in the skin. This infection is termed black-spot disease (Bauer et al. 1973; Musselius 1979)."

"The bighead carp also may be parasitized by cestodes, including *Ligula intestinalis* and *Diagrama interrupta*, which occur in the body cavity. Diagrammosis is reported in culture situations in the Soviet Union (Bauer et al. 1973). In China, the bighead carp is reported to be a carrier of *Bothriocephalis gowkongensis*, an intestinal parasite that causes mass mortalities of numerous pond cultured species (Bauer et al. 1973)."

"The bighead carp is parasitized by the copepod *Lemaea*, which attaches to the body surface, musculature, or gills, forming a deep ulcer, abscess, or fistula at the point of attachment. Harding (1950) first described this infection in bighead carp from Singapore, and Shariff (1981) reported its occurrence in the eyes and on the body surface of bighead carp in Malaysia. The copepod *Sinergasilus lieni* parasitized the gill filaments of bighead carp, compressing and rupturing the gill tissue and resulting in embolism and necrosis (Bauer et al. 1973)."

Threat to Humans

From Froese and Pauly (2018):

"Potential pest"

3 Impacts of Introductions

From Nico et al. (2018):

"The impact of this species in the United States is not adequately known. Because bighead carp are planktivorous and attain a large size, Laird and Page (1996) suggested these carp have the potential to deplete zooplankton populations. As Laird and Page pointed out, a decline in the availability of plankton can lead to reductions in populations of native species that rely on plankton for food, including all larval fishes, some adult fishes, and native mussels. Adult fishes most at risk from such competition in the Mississippi and Missouri rivers are paddlefish *Polyodon spathula*, bigmouth buffalo *Ictiobus cyprinellus*, and gizzard shad *Dorosoma petenense* (Burr et al. 1996; Pflieger 1997; Whitmore 1997; Tucker et al. 1998; Schrank et al. 2003). A study by Sampson et al. (2009) found that Asian carp (silver and bighead carps) had dietary overlap with gizzard shad and bigmouth buffalo, but not much of one with paddlefish."

"Asian carps have been shown to affect zooplankton communities (Burke et al. 1986, Lu et al. 2002, Cooke et al 2009; Calkins et al. 2012; Freedman et al. 2012; Sass et al. 2014)."

"Freedman et al. (2012) showed that resource use and trophic levels of the fish community change when Asian carps are present. They also demonstrated an impact on Bigmouth Buffalo and found isotopic values similar to Bluegill, Gizzard Shad, and Emerald Shiner."

"Irons et al. (2007) showed significant declines in body condition of Gizzard Shad and Bigmouth Buffalo following invasion by Silver and Bighead carps. They state that ultimately, declines in body condition may decrease fecundity."

From Irons et al. (2007):

"Despite variable recruitment, Asian carps abundance and biomass have increased since 2000, as evidenced by commercial landings, and Asian carps now dominate the fish community on La Grange Reach. Previous research suggests dietary overlap among bighead and silver carps and two native Illinois River fishes, gizzard shad *Dorosoma cepedianum* and bigmouth buffalo *Ictiobus cyprinellus*. Total length and mass data from *c.* 5000 fishes were used to test for changes in gizzard shad and bigmouth buffalo body condition after Asian carps establishment and investigate potential competitive interactions and changes in fitness. Analyses revealed significant declines in body condition of gizzard shad (-7%) and bigmouth buffalo (-5%) following the Asian carps invasion from 2000 to 2006. Segmented regression analyses showed no significant change in the rate of decline in gizzard shad condition after 2000, whereas the rate of decline in bigmouth buffalo condition increased significantly after 2000. Statistically significant differences in gizzard shad condition after Asian carps establishment (2000–2006) was observed, whereas condition of bigmouth buffalo was significantly lower in all years following Asian carps establishment as compared to 2000. Declines in gizzard shad and bigmouth buffalo condition were significantly correlated with increased commercial harvest of Asian carps and poorly correlated with other abiotic and biotic factors (e.g. temperature, chlorophyll a and discharge) that may influence fish body condition. These results may suggest that Asian carps are influencing native planktivore body condition, and future research should focus on determining whether food is limited in the Illinois River for native planktivores and other fish species."

From Sass et al. (2014):

"In lentic systems, bighead and silver carp have been observed to reduce total zooplankton abundances and particularly those of larger-bodied zooplankters, such as cladocerans and copepods (Fukushima et al., 1999; Shao et al., 2001; Stone et al., 2000; Yang et al., 1999)."

"The objective of our study was to test for bighead and silver carp effects on zooplankton community composition and biomass within the Illinois River using two complementary comparative studies. First, we tested for differences in zooplankton community samples collected and archived prior to the establishment of bighead and silver carp (1994–2000) with samples collected following the establishment of these invasive fishes (2009–2011) in the La Grange reach, Illinois River. Second, we tested for differences in zooplankton community composition and biomass among six reaches of the Illinois River that varied in bighead and silver carp relative abundances during 2009–2011."

"Mean total zooplankton, cladoceran, and copepod abundances (55 μm filter) decreased significantly between pre- and post-bighead and silver carp establishment time periods in the La Grange reach, Illinois River […]. Mean rotifer abundance (55 μm filter) increased significantly among time periods […]. Mean total zooplankton abundance decreased from 166.1 to 121.7/L before and after bighead and silver carp establishment, respectively ($N = 257$, $T_{255} = 2.17$, $P = 0.03$). Between time periods, the mean rotifer abundance increased from 75.2 to 117.0/L ($N = 257$, $T_{255} = 2.16$, $P = 0.03$). Mean cladoceran and copepod abundances declined significantly from 19.7 to 2.0 and from 71.2 to 2.7/L, respectively prior to and after bighead and silver carp establishment in the La Grange reach, Illinois River (cladocerans, $N = 257$, $T_{255} = 13.15$, $P < 0.001$; copepods, $N = 257$, $T_{255} = 16.52$, $P < 0.001$)."

"Our results suggest that the establishment of invasive bighead and silver carp is correlated with an alteration of the zooplankton community to potentially benefit themselves. Increases in rotifer abundances directly benefit bighead and silver carp because their capacities to filter very small particles far exceed those of many native fishes and rotifers are a dominant prey item in their diets (Sampson et al., 2009; Williamson and Garvey, 2005)."

4 Global Distribution

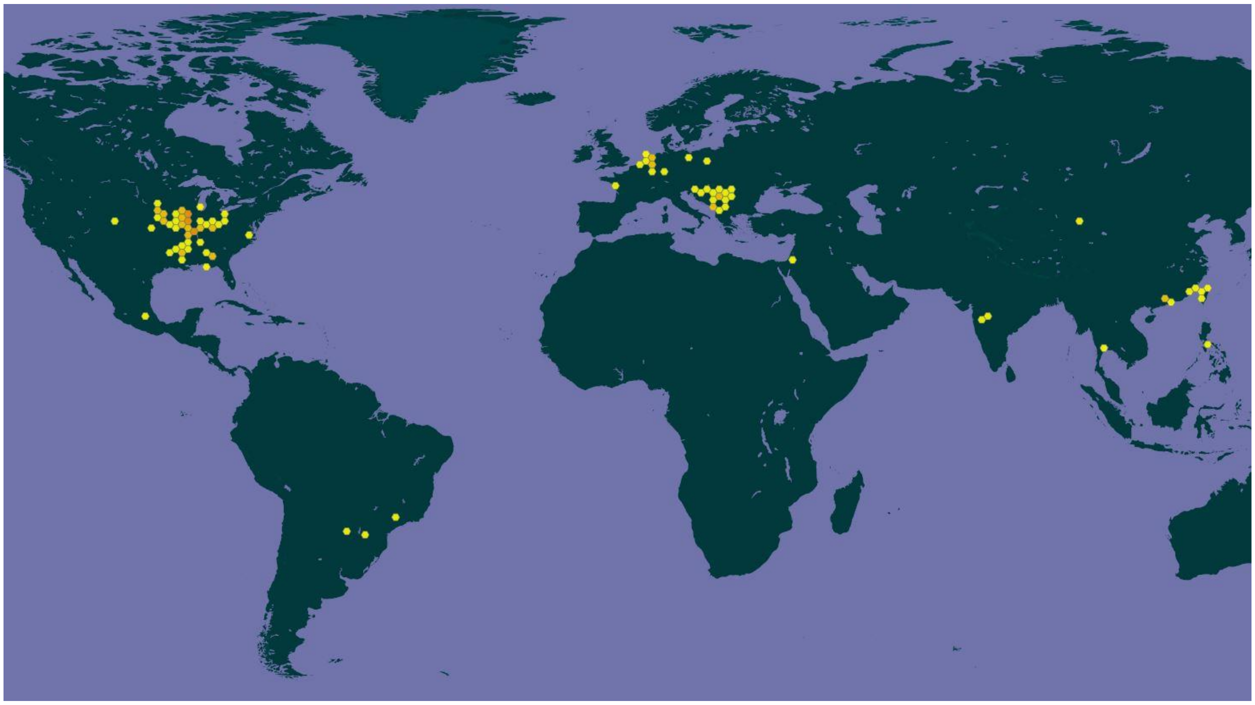

Figure 1. Known global distribution of *Hypophthalmichthys nobilis*, reported from the United States, Mexico, Brazil, Paraguay, France, Belgium, The Netherlands, Germany, Poland, Slovenia, Croatia, Serbia, Romania, Montenegro, Kosovo, Macedonia, Israel, India, China, Taiwan, Laos, Thailand, and the Philippines. Map from GBIF Secretariat (2018). Points in South America were excluded from climate match analysis because they were outside the documented introduced range of this species. A point in north-central China was excluded because of a coordinate error.

5 Distribution Within the United States

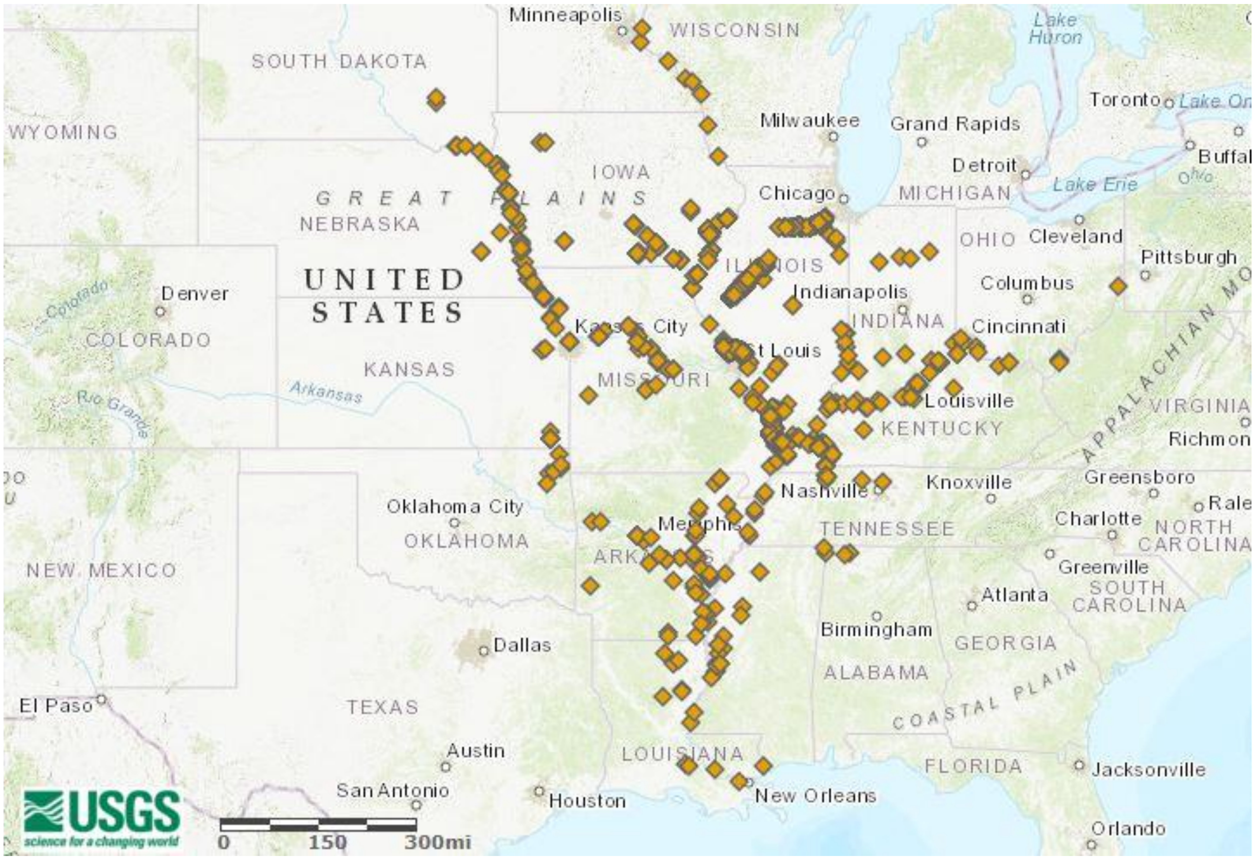

Figure 2. Known distribution of *Hypophthalmichthys nobilis* in the United States. Map from Nico et al. (2018). All points represent established occurrences.

6 Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.704, which is a high climate match. The climate match was high in every state in the contiguous U.S. except for Maine, which had a medium climate match. The area of highest match was in the general area of the Mississippi River basin, which is the established range of *Hypophthalmichthys nobilis* in the U.S.

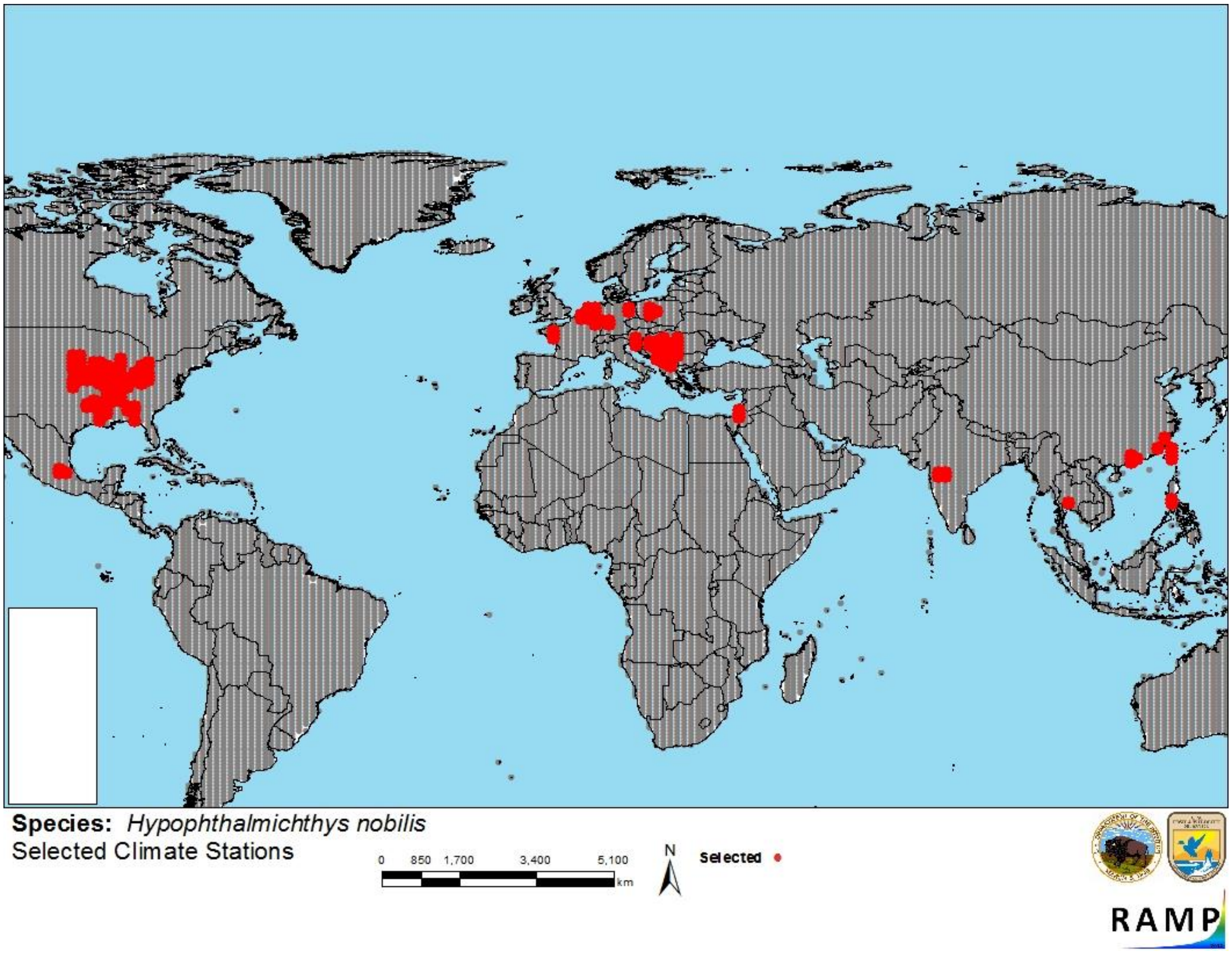

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations across the globe selected as source locations (red; U.S., Mexico, Belgium, The Netherlands, Germany, France, Poland, Slovenia, Austria, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Albania, Macedonia, Bulgaria, Romania, Israel, India, Thailand, Laos, China, Taiwan, and the Philippines) and non-source locations (gray) for *Hypophthalmichthys nobilis* climate matching. Source locations from GBIF Secretariat (2018) and Nico et al. (2018).

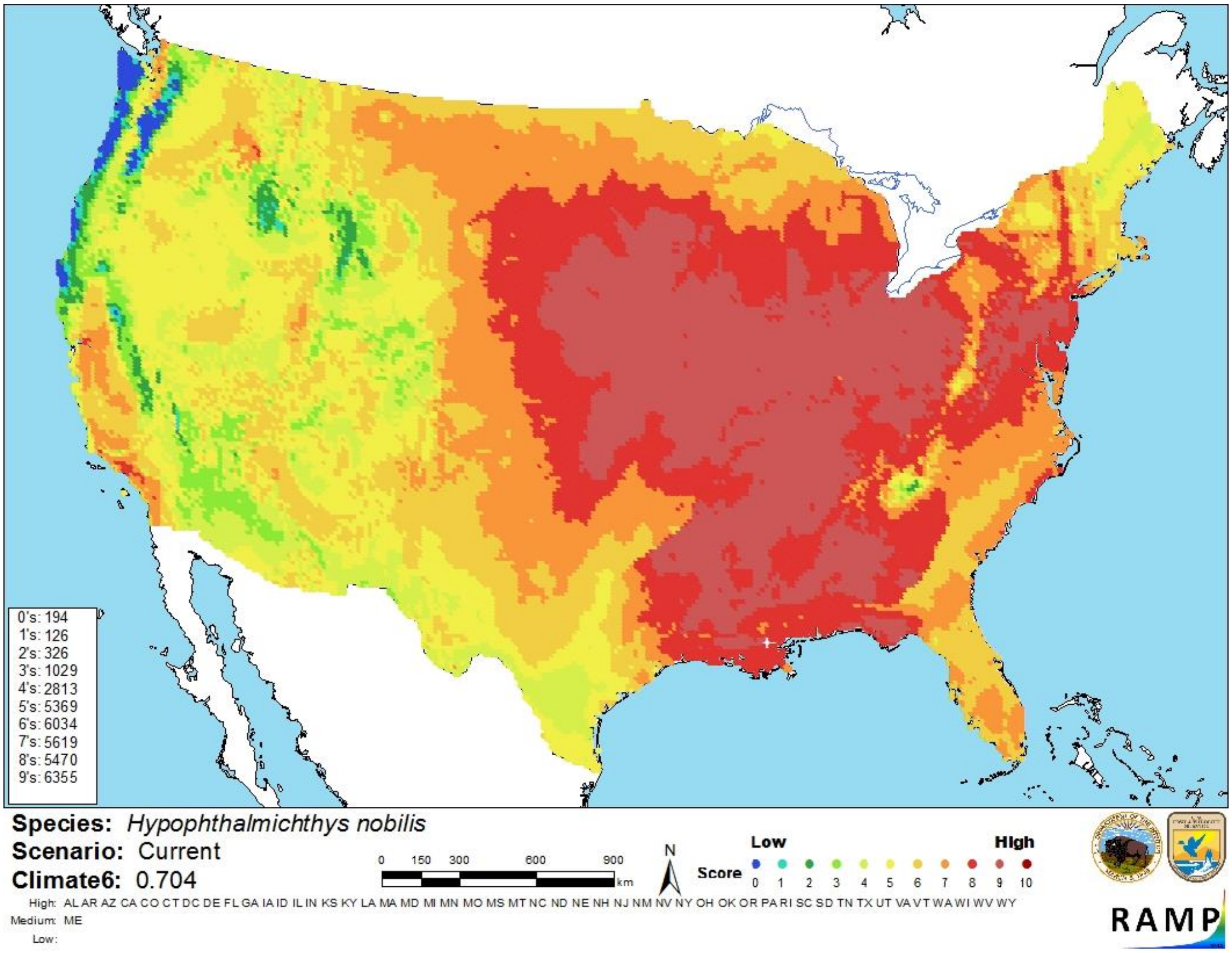

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Hypophthalmichthys nobilis* in the contiguous United States based on source locations reported by GBIF Secretariat (2018) and Nico et al. (2018). 0= Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

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

There is adequate information available on the biology, ecology, and distribution of *Hypophthalmichthys nobilis.* Although the overall impact of this species on ecosystems in the contiguous U.S. is not fully understood, several credible scientific sources have documented negative impacts of this species in the contiguous U.S. The invasive history of this species in the U.S. has been extensively documented, and its established distribution is well-known. It often occurs with its congener *H. molitrix,* and because of their similarity, available research does not distinguish between impacts of these two species. Because of these factors, the certainty of this assessment is medium.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Hypophthalmichthys nobilis, the Bighead Carp, is a carp species native to China. This species has a high history of invasiveness: since being introduced to the U.S. via aquaculture in the 1970s, it has escaped captivity and spread rapidly in the Mississippi and Missouri River basins. Negative impacts to the U.S. caused by *H. nobilis* and its congener *H. molitrix* include alterations to the zooplankton community and lowered body condition of native planktivores. *H. nobilis* has a high climate match with the contiguous U.S. Certainty of this assessment is medium because information available on negative impacts of this species to the U.S. did not distinguish between the effects of *H. nobilis* and *H. molitrix*. Despite this, the overall risk assessment category is still High.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Medium**
- **Overall Risk Assessment Category: High**

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