

# Silver Carp (*Hypophthalmichthys molitrix*)

## Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, March 2024  
Revised, April 2024  
Web Version, 4/2/2026

Organism Type: Fish  
Overall Risk Assessment Category: High



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<https://www.flickr.com/photos/usfwsmtmprairie/33920420648/> (February 2024).

## 1 Native Range and Status in the United States

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### Native Range

From Nico et al. (2024):

“Several major Pacific drainages in eastern Asia from the Amur River of far eastern Russia south through much of eastern half of China to Pearl River, possibly including northern Vietnam (Berg 1949; Li and Fang 1990).”

From Bonham and Kurwie (2024):

“*Hypophthalmichthys molitrix* naturally occurs in the temperate fresh waters of China. It inhabits the river systems of the Yangtze, West River, Pearl River, Kwangsi and Kwangtung in South and Central China, and also the Amur Basin in the east of Russia (Jhingran and Pullin, 1988).”

## Status in the United States

From Bonham and Kurwie (2024):

“[*Hypophthalmichthys molitrix*] is now present in many states in the Mississippi basin, with a few records from other states (US Geological Survey, 2022); there has been uncertainty about the extent to which breeding takes place (US Geological Survey, 2022), but the species is reported as having 'increased exponentially in the Mississippi River Basin' (Chapman, 2010), as being 'well established' there (Invasive Carp Regional Coordinating Committee, 2022), and as having been reproducing in the Upper Mississippi system by 2000 (Koel et al, 2000).”

Nico et al. (2026) report introductions of *H. molitrix* resulting in at least one established population in each of the following U.S. States: Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, Ohio, Oklahoma, Tennessee, and Wisconsin. They report failed introductions in Colorado, Hawaii, Nevada, and Puerto Rico; and introductions with unknown status in North Dakota, South Dakota, Texas, and West Virginia.

From Nico et al. (2024):

“Rinne (1995) listed Silver Carp as introduced to Arizona in 1972 and denoted it as established. Apparently in reference to the same record, William Silvey of the Arizona Game and Fish Department recently informed us that the only Silver Carp documented in Arizona open waters was a population inhabiting an urban lake in Chandler during the early 1970s. However, further investigation has shown that it was most likely a bighead x grass carp hybrid population (P. Marsh, pers.comm.). That population, along with a large population of diploid grass carp, was exterminated in 1975 or 1976 by personnel from the Arizona Game and Fish Department and Arizona State University (W. Silvey, personal communication).”

From Chapman et al. (2021):

“Of 27,157 USFWS [environmental DNA (eDNA)] samples [taken 2013-2019] five (<0.001%) were positive for silver carp eDNA, including one in the Maumee River, the largest tributary of Lake Erie, and one in the Kalamazoo River, a tributary of Lake Michigan. Jerde et al. (2013) tested 2011 samples and found six detections (using a marker which does not distinguish between bighead and silver carp), with four detections out of 48 samples in Sandusky Bay and two detections out of 48 samples in North Maumee Bay. [...] There is no other evidence of the presence of silver carp in Lake Erie.”

From ICRCC (2025):

“There is currently no evidence to suggest that the Great Lakes are home to self-sustaining populations of [...] silver carp.”

According to FAO (2026), *H. molitrix* was introduced to Guam in 1974. The current status of the species in the wild in Guam is unknown.

No records of *Hypophthalmichthys molitrix* in live trade in the United States were found.

## Regulations

*Hypophthalmichthys molitrix* is federally listed as an injurious species under the Lacey Act (U.S. Office of the Federal Register 2007).

*Hypophthalmichthys molitrix* is regulated in Arizona (Arizona Game and Fish Commission 2022), Arkansas (AGFC 2022), California (CDFW 2021), Colorado (CPW 2023), Connecticut (Connecticut DEEP 2020), Florida (FFWCC 2022), Hawaii (HDOA 2019), Idaho (IDDA 2022), Illinois (Illinois DNR 2015), Indiana (Indiana DNR 2022), Iowa (Iowa NRC 2015), Kansas (KDWP 2023), Kentucky (KDFWR 2022), Louisiana (LDWF 2022; Louisiana Revised Statutes 2022), Maryland (Code of Maryland Regulations 2022), Michigan (Michigan Compiled Laws 2022), Minnesota (Minnesota DNR 2022), Montana (Montana FWP 2023), Nebraska (Nebraska Game and Parks Commission 2023), Nevada (Nevada Board of Wildlife Commissioners 2022), New Hampshire (NHFG 2022), New Jersey (NJFW 2022), New Mexico (NMDGF 2023), New York (New York DEC 2022), North Carolina (North Carolina DEQ 2022), North Dakota (North Dakota Game and Fish Department 2023), Ohio (ODNR 2022), Oklahoma (ODWC 2023), Pennsylvania (PFBC 2022), South Dakota (South Dakota GFP 2022), Tennessee (TWRA 2022), Virginia (Virginia DWR 2022), and Wisconsin (Wisconsin DNR 2022), Wyoming (WGFD 2022). It is regulated at the genus level (*Hypophthalmichthys*) in Oregon (ODFW 2022) and Texas (TDPW 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

## Means of Introductions within the United States

From Nico et al. (2024):

“This species was imported and stocked for phytoplankton control in eutrophic water bodies and also apparently as a food fish. It was first brought into the United States in 1973 when a private fish farmer imported silver carp into Arkansas (Freeze and Henderson 1982). By the mid 1970s the silver carp was being raised at six state, federal, and private facilities, and by the late 1970s it had been stocked in several municipal sewage lagoons (Robison and Buchanan 1988). By 1980 the species was discovered in natural waters, probably a result of escapes from fish hatcheries and other types of aquaculture facilities (Freeze and Henderson 1982). The occurrence of silver carp in the Ouachita River of the Red River system in Louisiana was likely the result of an escape from an aquaculture facility upstream in Arkansas (Freeze and Henderson 1982). The

Florida introduction was probably a result of stock contamination, a silver carp having been inadvertently released with a stock of grass carp being used for aquatic plant control (Middlemas 1994). In a similar case, the species was apparently introduced accidentally to an Arizona lake as part of an intentional, albeit illegal, stock of diploid grass carp (W. Silvey, personal communication). Pearson and Krumholz (1984) suggested that individuals taken from the Ohio River may have come from plantings in local ponds or entered the Ohio River from populations originally introduced in Arkansas.”

## Remarks

This ERSS was previously published in April 2019. Revisions were completed to incorporate new information and conform to updated standards.

From Froese and Pauly (2024):

“Often confused with *Hypophthalmichthys nobilis* [Kottelat and Freyhof 2007].”

From Nico et al. (2024):

“Silver carp are unlikely to be confused with native cyprinids due to size and unusual position of the eye. They are most similar to bighead carp (*H. nobilis*) but have a smaller head, and upturned mouth without teeth, a keel that extends forward past pelvic fin base, lack the dark blotches characteristic of bighead carp and have highly branched gill rakers.”

“Juvenile fish lack spines in fins. Metalarvae and early juvenile [sic] are similar to bighead carp (*Hypophthalmichthys nobilis*) but pectoral fin extends only to base of pelvic fin (as opposed to beyond in the pelvic fin in bighead)”

From ICRCC (2024):

“Silver carps are closely related to bighead carps and have been known to hybridize (cross-breed) with that species and produce viable, reproductive offspring.”

## 2 Biology and Ecology

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### Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2024):

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 molitrix* (Valenciennes in Cuvier and Valenciennes, 1844)

According to Fricke et al. (2024), *Hypophthalmichthys molitrix* (Valenciennes 1844) is the current valid name for this species.

## Size, Weight, and Age Range

From Froese and Pauly (2024):

“120 cm TL [total length] male/unsexed [Page and Burr 2011]; common length: 18.0 cm SL [standard length] male/unsexed [Nichols 1943]; max. published weight: 50.0 kg [Billard 1997]; max. reported age: 20 years [Nico et al. 2020].”

From Nico et al (2024):

“Size: 1 m and 27 kg”

“In their native range, silver carp reach maturity at between 4 and 8 years old but are noted in North America to mature as early as just 2 years old. They can live to 20 years.”

## Environment

From Froese and Pauly (2024):

“Freshwater; brackish; benthopelagic; potamodromous [Riede 2004]; depth range 0 - 20 m [Shao and Lim 1991].”

“In aquaculture, it can survive brackish water (up to 7 ppt) when released into estuaries and coastal lakes [Kottelat and Freyhof 2007].”

From Nico et al. (2024):

“They can tolerate salinities up to 12 ppt and low dissolved oxygen (3mg/L).”

## Climate

From Froese and Pauly (2024):

“Subtropical; 6°C - 30°C [Shao and Lim 1991]; 63°N - 8°N, 73°E - 148°E [FAO 2019a]”

## Distribution Outside the United States

### Native

From Nico et al. (2024):

“Several major Pacific drainages in eastern Asia from the Amur River of far eastern Russia south through much of eastern half of China to Pearl River, possibly including northern Vietnam (Berg 1949; Li and Fang 1990).”

From Bonham and Kurwie (2024):

“*Hypophthalmichthys molitrix* naturally occurs in the temperate fresh waters of China. It inhabits the river systems of the Yangtze, West River, Pearl River, Kwangsi and Kwangtung in South and Central China, and also the Amur Basin in the east of Russia (Jhingran and Pullin, 1988).”

### Introduced

From Kolar et al. (2005):

“The Silver Carp has been widely introduced throughout the world. The species has been imported into or has spread by way of connected waterways to at least 88 countries and territories [...]. Of these introductions, there are reproducing populations of Silver Carp in 24 countries (or 27% of all countries where introduced). The database of introductions of aquatic species maintained by the FAO (2004) lists another 23 countries not thought to have reproducing populations that stock Silver Carp annually. There are an additional 33 countries in which Silver Carp are either believed to be “probably established” (n=11) or are “probably not” established (n=22; [...]). There are an additional 23 countries in which the Silver Carp fails to have reproducing populations [...]. It remains unknown whether Silver Carp have become established in eight countries in which they have been introduced [...]. In comparison to other reviews, Li et al. (1990) reported that Silver Carp have been introduced into 34 countries.”

According to Kolar et al. (2005), *H. molitrix* is “established in open waters (i.e., having naturally reproducing populations)” in Afghanistan, Cyprus, Czech Republic, Hungary, India, Iraq, Israel, Italy, Japan, Kazakhstan, Kyrgyzstan, Latvia, Pakistan, Poland, Romania, Russian Federation, Slovakia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Vietnam, and [former] Yugoslavia.

From Holčik (1991):

“Thus, the naturalization of the grass carp (*Ctenopharyngodon idella*) and the silver carp (*Hypophthalmichthys molitrix*) was successful only in two rivers in the European USSR [Union of Soviet Socialist Republics], the Kuban' and the Volga (Motenkov 1966; Kazanchev 1981) [now Russia], in the Terek River flowing from Caucasus Mountains (Abdusamadov 1986), and, probably also in the Tisza River in Hungary (Toth and Biro 1984), although many attempts were made to acclimatize them, especially in the USSR.”

From Sugunan (1995):

“It is significant to note that despite its entry into a number of Indian reservoirs, by accident or otherwise, silver carp failed to get naturalised anywhere except Gobindsagar [Himachal Pradesh, India].”

Ellender and Weyl (2014) report *H. molitrix* as established in South Africa.

From NIES (2024):

“Established in Tone-Edo River System and Yodogawa River System [Japan]. However, constantly released in many lakes.”

FAO (2026) reports *H. molitrix* as established through natural reproduction in Iran.

From Lusk et al. (2010):

“The occurrence of the remaining acclimatized alien species [in the Czech Republic] ([including] *Hypophthalmichthys molitrix* [...]) in natural ecosystems and fishponds depends on stocking fish obtained from artificial spawning and cultures.”

In contrast to Kolar et al. (2005), above, Witkowski and Grabowska (2012) report that *H. molitrix* presence in Poland depends on artificial reproduction.

Jonsson and Jonsson (2016) report *H. molitrix* as introduced with no natural reproduction in Sweden.

Pofuk et al. (2017) report *H. molitrix* as “acclimatized only in restricted areas” in Croatia.

Cowx et al. (2026) report *H. molitrix* as being an established aquaculture species but not established in the wild in countries of the Mekong Basin (Laos, Thailand, Cambodia, Vietnam, and the upper Lancang region in China). Other sources (above) report that *H. molitrix* is established in the wild and possibly native in Vietnam.

FAO (2026) reports *H. molitrix* as established or probably established through continuous restocking, not through natural reproduction, in Algeria, Ethiopia, Jordan, Lebanon, Saudi Arabia, and Turkey.

FAO (2026) also reports *H. molitrix* as “probably not established” in Italy.

Additionally, Froese and Pauly (2024) report *H. molitrix* as introduced and **probably established** (but not confirmed) in Armenia, Bangladesh, Bhutan, Dominican Republic, France, Greece, Korea, Mongolia, Morocco, Myanmar, and Poland; introduced and **probably not established** in Albania, Belgium, Brazil, Costa Rica, Cuba, Denmark, Fiji, Germany, Honduras, Mexico, Netherlands, New Zealand, Panama, Peru, Philippines, Rwanda, and Tunisia; introduced and **not established** in Austria, Bulgaria, Egypt, Estonia, Indonesia, Lesotho,

Madagascar, Malawi, Malaysia, Mozambique, Nigeria, Singapore, Sri Lanka, Switzerland, Taiwan, Tanzania, and the United Kingdom; and introduced with **unknown** status in Argentina, Colombia, Haiti, Jamaica, Mauritius, Moldova, Nepal, Papua New Guinea, Zambia, and Zimbabwe.

Additionally, Bonham and Kurwie (2024) report *Hypophthalmichthys molitrix* as introduced and **present** in Lithuania and Slovenia with no comment on establishment status; and introduced and **absent** in Algeria.

## Means of Introduction Outside the United States

From Kolar et al. (2005):

“The most common reason for introducing Silver Carp outside its native range has been for aquaculture (61 introductions [...]); however, other vectors have been responsible for some introductions. Escapes or releases from aquaculture facilities have resulted in naturally reproducing populations in open waters. For example, the escape of approximately 47 Silver Carp in 1971 into the Himalayan region of India, after flooding inundated the Deoli Fish Farm near the tail end of Gobindsagar Reservoir resulted in the establishment of the species in the reservoir (Sehgal 1989; Tripathi 1989). [...] Other potential, although not documented, pathways for introductions include activities of animal rights activists and escapes or releases from live-haul trucks.”

“Silver Carp have also been introduced throughout regions of the world for various other reasons. They have been stocked in open waters to increase fish production by filling the planktivorous “vacant niche” (11 introductions [...]; Wilamovski 1972; Mukhamedova 1977; Spataru 1977; Opuszynski 1979b; Shetty et al. 1989; Salikhov and Kamilov 1995; Mahboob and Sheri 1997; Moreau and Costa-Pierce 1997). They have also been stocked into lakes, reservoirs, and ponds to control phytoplankton or macrophytes and to improve water quality (19 introductions [...]; Leventer and Teltsch 1990). In addition, Silver Carp have been introduced by way of contamination of fishes of other species imported for stocking.”

From Crookes et al. (2020):

“Silver carp (*Hypophthalmichthys molitrix* (Valenciennes, 1844)) was first introduced to South Africa in 1975, when individuals from a German population were donated to the Marble Hall experimental fish farm adjacent to the Olifants River (Lübcker et al. 2014). It was suspected to have spread into the wider Olifants system, including the Olifants River, Lake Flag Boshielo (an impoundment on the Olifants River), and the Massingir dam, Mozambique (Sara et al. 2018), although the extent of its overall distribution remains uncertain.”

## Short Description

From Bonham and Kurwie (2024):

“*Hypophthalmichthys molitrix* is a large, rather heavily built cyprinid, laterally compressed when small but becoming increasingly robust and thick-bodied with growth. It is covered with small cycloid scales of a uniform silver coloration. The lateral line curves downwards very markedly in

the abdominal region, more or less following the profile of the belly. There are between 95 and 103 scales (some references quote 120) in the lateral line.”

“There is a single, smallish, flag-like dorsal fin (nine rays); the dorsal fin origin is behind the pelvic fin insertion. The anal fin is rather longer and shallower (15-17 rays). The moderately long and flattened caudal peduncle supports a deeply forked, strong caudal fin. The pelvic fins (seven or eight rays) are smallish, triangular and abdominal. The pectoral fins (15-18 rays) are rather larger, reaching back to the insertion of the pelvic fins. Small specimens do not have spines on their fins, whereas large specimens have a hard, stiff spine with fine serrations on the posterior margin, at the front end of the pectoral, and moderately strong spines on the dorsal and anal fins (the New Zealand introduced variety seems to lack the spines).”

“Keels extend from isthmus to anus. The eyes are low on the head with their lower margin below the mouth corner level. The mouth is terminal, with no barbels, and is relatively large, upturned and toothless.”

From Nico et al. (2024):

“They are a very [sic] silvery in color when young and when they get older they fade from a greenish color on the back to silver on the belly.”

## **Biology**

From Nico et al. (2024):

“Spawning occurs at temperatures greater than 18°C. A mature female can lay up to 5 million eggs per year. Eggs require current to stay suspended, with a minimum length of spawning river estimated at 100km and a current speed of 70cm/s.”

From Bonham and Kurwie (2024):

“*Hypophthalmichthys molitrix* typically swims just beneath the water surface (Man and Hodgkiss, 1981). It is an active species and is well known for its habit of leaping clear of the water when disturbed (Skelton, 1993).”

“*Hypophthalmichthys molitrix* is well recognized as a filter feeder. Its highly modified gill apparatus enables it to do this efficiently, as does its greatly elongated alimentary canal which enables it to properly digest this food. It is reported to be able to filter 10-16% of its body weight in plankton per day at moderate water temperatures; feeding ceases at low temperatures and activity increases with rising temperature. Growth rates are closely related to water temperatures (McDowall, 1990). The species feeds best in eutrophic waters where phytoplankton densities are very high, often such that the water has a distinctly green coloration and a high level of turbidity. Feeding is not restricted entirely to filtering plankton from the water, as the fish are also observed also to feed on the concentrated algal mass or scum at the surface of the water. It has been reported that adult silver carp efficiently graze on phytoplankton (particles more than 20 µm) and that zooplankton is an essential source of food for this species (Domaizon and Devaux, 1999). In Lake Kinneret in Israel, they feed on phytoplankton from February to August and

predominately on zooplankton from September to January, a response to a decrease in phytoplankton biomass in summer to autumn. Cladocerans and cyclopoid copepods dominate the biomass of zooplankton taken (Spataru and Gophen, 1985). The ability to take cyclopoids is due to the large mouth, strong sucking power and high filtration rate when feeding. Food is taken passively rather than selectively (Coad, 2004).”

“In its natural range, *Hypophthalmichthys molitrix* migrates upstream to breed. It requires cool flowing water to breed. Spawning takes place after a sharp rise in water level and current speed. It breeds naturally in the flowing rivers of China during April-July. In the Tone River of Japan, where it has established itself, it spawns naturally during June-July. In the Terek River of Dagestan in the Caucasus region of southern Russia, the spawning migration begins at the end of April at 16-17°C, with a peak between the middle of May and the beginning of June. Eggs are first found in the drift in the second week of June (Coad, 2004). Spawning in the Syr Darya River, Kazakhstan was reported to occur in April-May at temperatures between 18-22°C; the fish spawn in small group of 15-25 at dusk and dawn (Alikunhi, 1963; Kamilov and Salikhov, 1996).”

“The species does not spawn naturally in ponds and tanks in many parts of the world. [...] In Cuttack, India, pond-reared fully ripe males were reported to be available during April-May, and females a little later, during May-July (Alikunhi, 1963, from Jhingran and Pullin, 1988).”

From Froese and Pauly (2024):

“Found in their natural range in rivers with marked water-level fluctuations and overwinters in middle and lower stretches, swimming just beneath the surface. They feed in shallow (0.5-1.0 m deep) and warm (over 21°C) backwaters, lakes and flooded areas with slow current on phytoplankton and zooplankton [Billard 1997; Etnier and Starnes 1993].”

## Human Uses

From Jawdhari et al. (2022):

“Silver carp, *Hypophthalmichthys molitrix* (Valenciennes 1844) is one of the most commonly raised freshwater fish species throughout the world due to its wide availability, low cost of aquaculture production, high feed efficiency ratio, and nutritional value [Valipour et al. 2017]. [...] carp of the genus *Hypophthalmichthys* are valued as food resource [sic] not only in eastern and southern Asia, where they are considered a common aquaculture species, but also in global aquaculture production [Kolar et al. 2007].”

“*Hypophthalmichthys molitrix* (Valenciennes 1844) [...] known as silver carp [...] play an important economic role in freshwater fish farming. [...] Iran, Bangladesh, China, and India are the top producers and exporters [NAIK AKI 2019].”

From Bonham and Kurwie (2024):

“Global aquaculture production of *Hypophthalmichthys molitrix* has grown steadily over time with just over 400,000 tonnes being produced in 1980, 1.5 million tonnes in 1990, 3 million

tonnes in 2000, over 4.7 million tonnes in 2017 (FAO, 2019b) and over 4.8 million tonnes in 2019 (FAO, 2021). The species is now one of the major species produced in world aquaculture, third only to grass carp (*Ctenopharyngodon idella*) and the shrimp *Penaeus vannamei*; it accounted for 10% of world production in 2016 (Food and Agriculture Organization, 2018).”

“Although *Hypophthalmichthys molitrix* has often been introduced for plankton control, its ability to control algal blooms is rather controversial, because it can efficiently filter algae >20 µm in size, so the number of the smaller algae increases as a result of lack of grazing by the fish and increased nutrients. Some noxious blue-green algae are controlled by *H. molitrix* [...] but others are not and can even be exacerbated (because they pass through the gut of the fish unharmed, and pick up nutrients on the way).”

## Diseases

***Hypophthalmichthys molitrix* has been documented as susceptible to spring viraemia of carp virus and as a carrier of koi herpesvirus. Both diseases are listed by the World Organisation for Animal Health (2024).**

From Ashraf et al. (2016):

“Natural SVCV [spring viraemia of carp virus] infections have been reported in other cyprinid fish, including [...] silver carp (*Hypophthalmichthys molitrix*) [...] (Fijan 1984; Shchelkunov and Shchelkunova 1989; Ahne *et al.*, 2002).”

From Matras et al. (2019):

“[...] the presence of KHV [koi herpesvirus] DNA has been reported (although no infection has been demonstrated) in the following species: [...] silver carp (*Hypophthalmichthys molitrix*) [...]”

From Kolar et al. (2005):

“[...] both Bighead and Silver carps are hosts for the Asian carp tapeworm [*Bothriocephalus acheilognathi*, now recognized as *Schyzocotyle acheilognathi*], a cestode capable of being transferred to other fishes of several different orders. Although this tapeworm has minimal effects on the host carps, it is capable of causing severe damage to the intestines of novel hosts that can lead to death.”

“Although several species (e.g., *Myxobolus pavlovskii*, Lucky 1978; El-Matbouli and Hoffmann 1991; and trichodiniasis, Bauer et al. 1973) occur primarily in high-density culture situations, the diseases and parasites cited in Bykhovskaya-Pavlovskaya et al. (1964) occur in Silver Carp collected from natural or artificial waterways.”

According to Bonham and Kurwie (2024), *H. molitrix* is also susceptible to anchor worm disease (*Lernaea* sp.), gill fluke disease (*Dactylogyrus* spp.), trichodinosis (*Trichodinella* sp.), *Myxobolus* infection, whirling disease (*Myxobolus cerebralis*), enteric redmouth disease (*Yersinia ruckeri*), vertical scale disease (*Pseudomonas punctata*).

Kolar et al. (2005) and Poelen et al. (2014) list dozens of additional diseases and parasites affecting *H. molitrix*.

## Threat to Humans

From Li et al. (2021):

“Silver carp are notorious for being easily frightened by boats and personal watercraft, and the vibration from boat propellers causes silver carp to jump up to 3 m out of the water. Boaters and water skiers in areas of the Mississippi River and Illinois River have been reported to [sic] seriously injured by jumping carp (Garvey et al., 2015).”

From Kolar et al. (2005):

“Some disease-causing agents harbored by Silver Carp pose health risks to humans. The psychotropic pathogen *Listeria monocytogenes* has been found in market and fish farm samples of Silver Carp (Akhondzadeh Basti and Zahrae Salehi 2003). *Clostridium botulinum* was found in 1.1% of fresh and smoked samples of Silver Carp from the Mazandaran Province (Safari and Khandagi 1999). Ebrahimzadeh Mousavi et al. (2000) found the toxigenic fungi *Aspergillus flavus*, *Alternaria*, *Penicillium*, and *Fusarium* from Silver Carp and from pond water in which they were raised at a fish farm in northern Iran. In addition, live *Salmonella* sp. can be found in Silver Carp for at least 14 days after transfer to clean water and should, therefore be considered as a potential carrier for *Salmonella* (*S. typhimurium*; Bocek et al. 1992).”

## 3 Impacts of Introductions

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From Kolar et al. (2005):

“In India, the introduction of Silver Carp into several reservoirs has resulted in the decline of native planktivores. The accidental establishment of Silver Carp in the Gobindsagar Reservoir in 1971 has generated animated debate from ecologists and fishery managers because of the propensity of the species to negatively affect native planktivorous species, particularly Catla [*Catla catla*] and Rohu [*Labeo rohita*] (Shetty et al. 1989; Sugunan 1997; Esmaceli and Johal 2003). After the introduction of Silver Carp, commercial fish catches from the reservoir changed dramatically (Petr 2002). Silver and Common carps dominated catch within 10 years of establishment (Petr 2002). At first, as the catch of Silver Carp increased, catches of Catla and Rohu declined, as did total catch (Shetty et al. 1989). [...] Then, from 1987 to 1993, total catch from Gobindsagar Reservoir increased each year (Petr 2002). Between 1974 and 1975 (before introduction of Silver Carp) and 1992-93 (15 years after Silver Carp were introduced), catch of the indigenous Golden Mahseer (*Tor putitora*) in Gobindsagar Reservoir declined from 16.8% to 0.5% of the catch (although total catches increased over the same period from 28.7 tons of Golden Mahseer in 1974-75 to 46 tons in 1992-93; Sugunan 1995).”

“After their introduction into the Aral Sea Basin in the 1960s, Silver Carp fry quickly became 85-90% of total larval fish present in the basin (Pavlovskaya 1995). During the same period, larvae of the Aral Barbel (*Barbus brachycephalus*) declined from 80% to 0.04% of larval fishes

in the basin (Pavlovskaya 1995). Although the Amu Dar'ya and other catchment rivers of the Aral Sea Basin historically harbored 43 species of fishes in the 1960s, only 22 species were collected in the early 1980s (though some of the extirpated species required riverine habitat lost by water removal for irrigation)."

"Costa-Pierce (1992) reported that economically important planktivores such as Able de Heckel (*Leucaspis delineatus*) and Bleak (*Alburnus alburnus*), as well as piscivorous (as adult) Zander (*Sander lucioperca*) were "nearly wiped out" by dense stocking of Silver Carp into a lake in Germany in 1977. Zander populations rebounded dramatically after the removal of Silver Carp."

From Phelps et al. (2017):

"Results from two decades of long-term monitoring throughout much of the Mississippi River suggest that Silver Carp relative abundance has increased while relative abundance (Bigmouth Buffalo [ $F_{3, 8240} = 6.44, P < 0.01$ ] and Gizzard Shad [ $F_{3, 8240} = 31.04, P < 0.01$ ]) and condition (Bigmouth Buffalo [slope = -0.11;  $t = -1.71; P = 0.1014$ ] and Gizzard Shad [slope = -0.39;  $t = -3.02; P = 0.0073$ ]) of native planktivores have declined. Floodplain lake qualitative evaluations yielded similar results; floodplain lake fish communities were likely altered (i.e., reductions in native species) by Silver Carp."

"[In this study's laboratory experiments] Silver Carp, Bigmouth Buffalo, and Gizzard Shad had high survival when in presence of conspecifics, but in the presence of Silver Carp, Gizzard Shad had low survival and Bigmouth Buffalo exhibited negative growth."

"The injurious responses in fish communities are associated with high Silver Carp densities and not mere presence."

From Bonham and Kurwie (2024):

"The risk of human injuries from leaping *Hypophthalmichthys molitrix* may, by impacting recreational activities, have adverse economic impacts as well. [Invasive] carp in general may have significant impacts on commercial fisheries, and measures to control them can be very expensive (e.g. 10 million dollars to install an electrical barrier to keep them out of the North American Great Lakes) (Oregon State University, 2010)."

This species is federally prohibited from importation under the Lacey Act by the U.S. Fish and Wildlife Service (U.S. Office of the Federal Register 2007). At the state level, at least 36 U.S. states regulate this species. See section 1.

## 4 History of Invasiveness

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The History of Invasiveness for *Hypophthalmichthys molitrix* is classified as High. *Hypophthalmichthys molitrix* has been widely introduced and is now established in more than 20 countries outside its native range including the United States. Negative impacts have been documented from multiple reliable sources. *H. molitrix* establishment and rapid population growth have been associated with declines of native planktivorous fish in several countries. The

species can also cause human injury due to its propensity to leap from the water in the presence of boats.

## 5 Global Distribution

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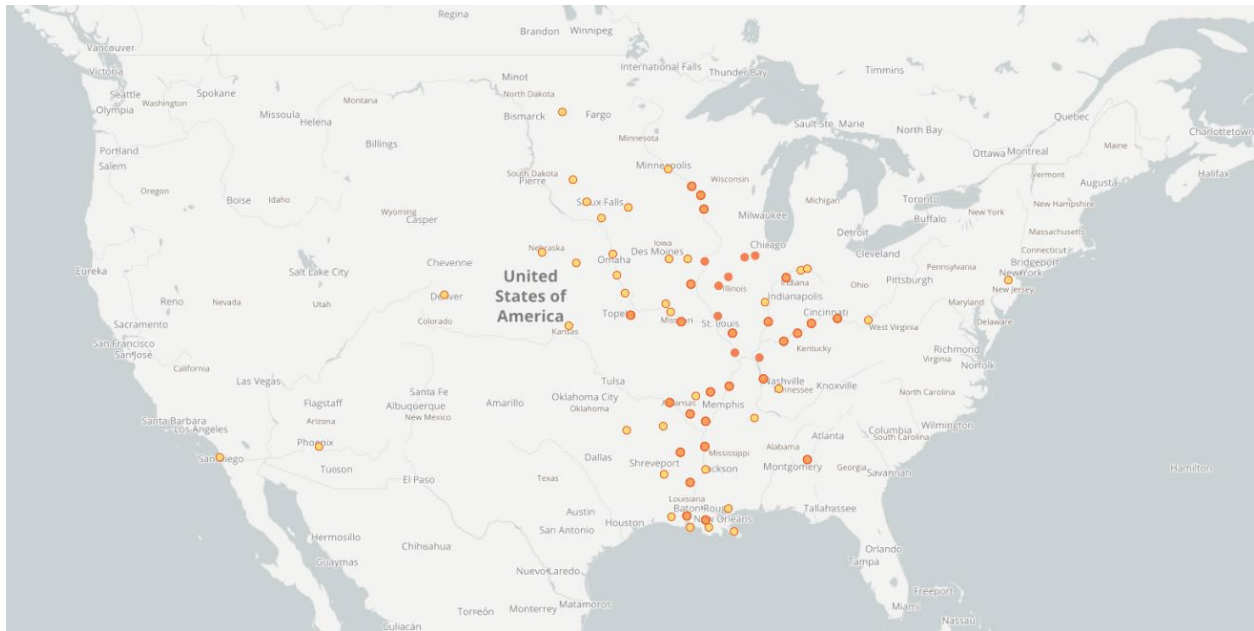


**Figure 1.** Reported global distribution of *Hypophthalmichthys molitrix*. Map from GBIF Secretariat (2023). Observations are heavily concentrated in the United States, Europe, and eastern Asia. Observations are also recorded in Brazil, New Zealand, and southern Africa. Reported observations in the following locations do not represent known established populations and were not included in the source points for the climate matching analysis: Algeria, Austria, Bangladesh, Belgium, Brazil, Cambodia, Croatia, Denmark, France, Germany, Italy, northern Japan, Laos, Mexico, Mozambique, Nepal, Netherlands, New Zealand, Poland, Slovenia, southern South Africa, South Korea, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, and the western and northeastern United States (see section 6). A point in north-central China was also excluded from the climate matching analysis because it represented a country centroid rather than an actual occurrence location.

Sugunan (1995) provides an additional occurrence in Gobindsagar Reservoir, northern India.

## 6 Distribution Within the United States

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**Figure 2.** Reported distribution of *Hypophthalmichthys molitrix* in the United States. Map from GBIF-US (2024). Observations are reported from Alabama, Arizona, Arkansas, California, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, West Virginia, and Wisconsin. The points in east-central Alabama, Arizona, California, Colorado, Kansas, New Jersey, North Dakota, South Dakota, and West Virginia were not included as source points for the climate matching analysis because they do not represent established populations.

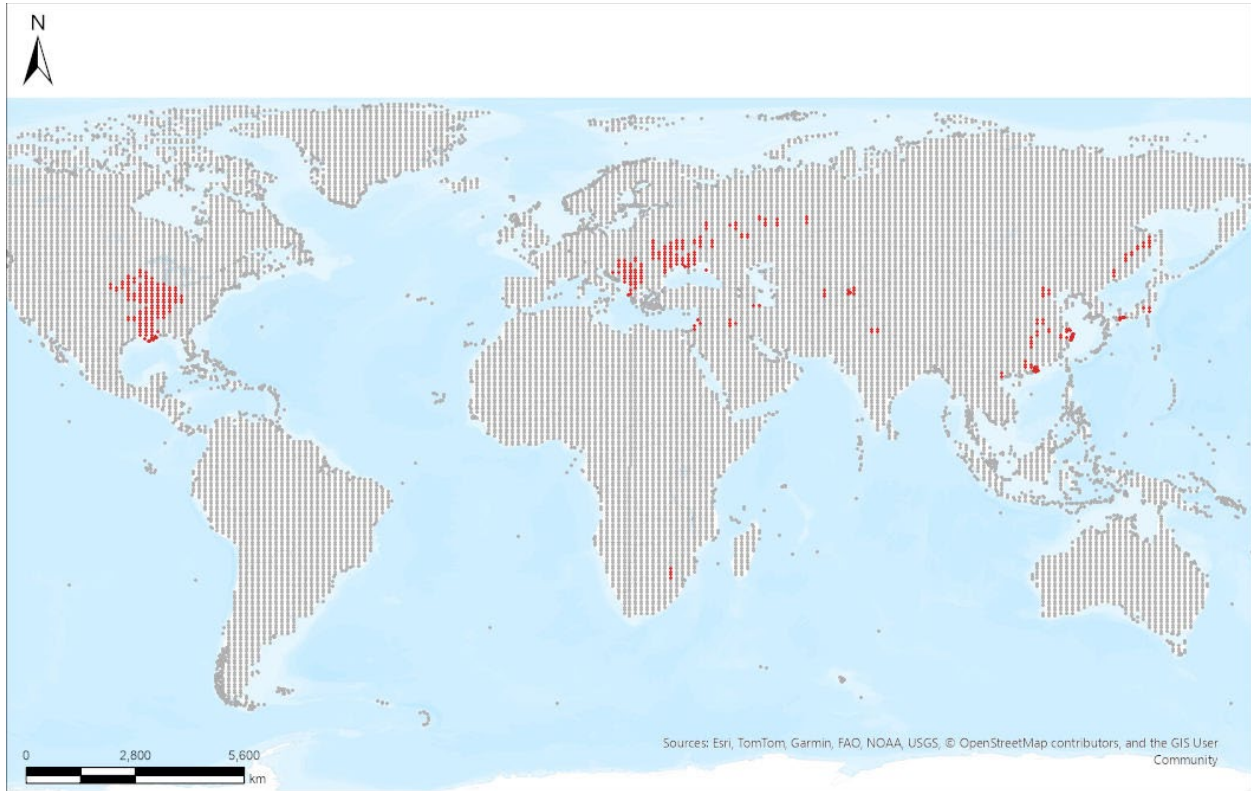
## 7 Climate Matching

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### Summary of Climate Matching Analysis

The climate match for *Hypophthalmichthys molitrix* was medium to high in all regions of the contiguous United States. The highest matches were found in the Mississippi, Missouri, and Ohio River Basins where this species is currently established. There were also areas of high match in the Great Lakes, Appalachian Mountains, Mid-Atlantic region, Great Basin, southern California, and isolated parts of the Rocky Mountains. Areas with the lowest match were in the coastal Pacific Northwest and along the Cascade and Sierra Nevada ranges. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.963, indicating that Yes, there is establishment concern for this species beyond where it is already established. The Climate 6 score is calculated as: (count of target points with scores  $\geq 6$ )/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Hypophthalmichthys molitrix* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

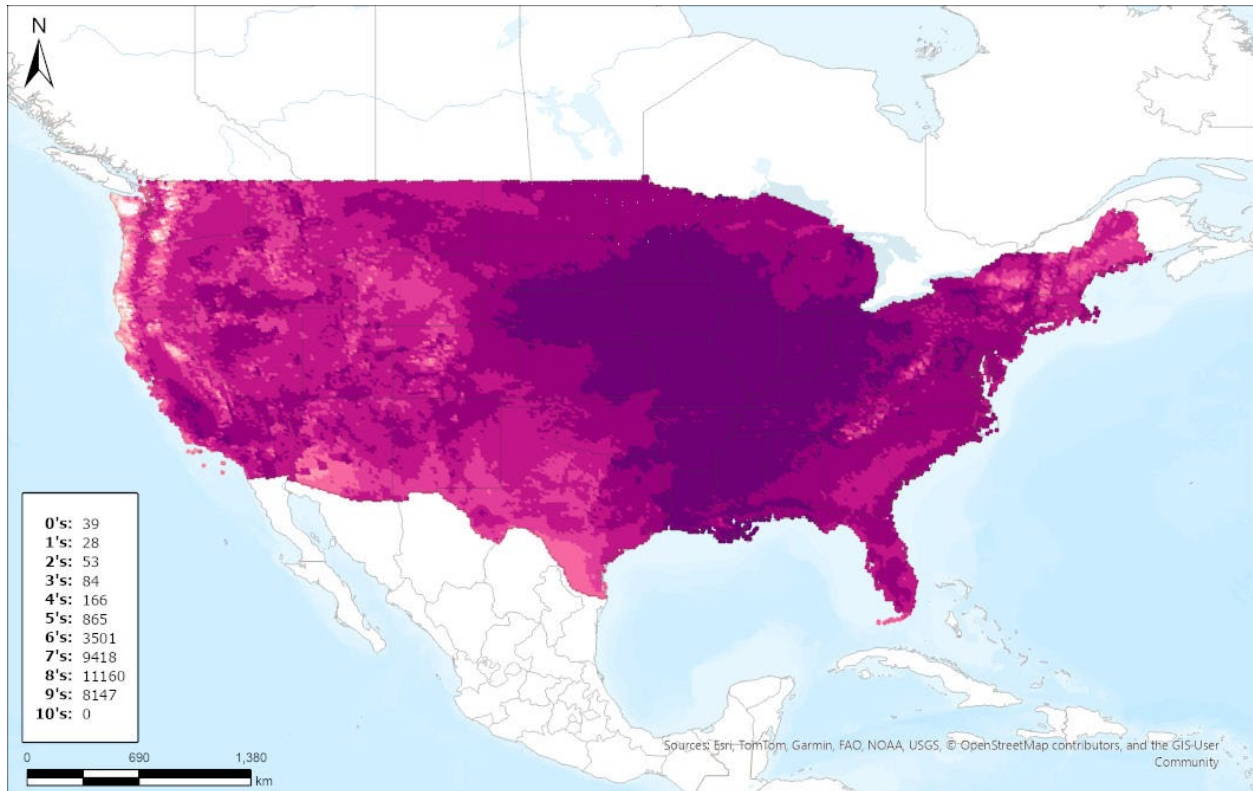


Species: *Hypophthalmichthys molitrix*      Selected Climate Stations ●



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**Figure 3.** RAMP (Sanders et al. 2023) source map showing global weather stations selected as source locations (red; North America: United States; Europe: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Moldova, Montenegro, North Macedonia, Romania, Russia, Serbia, Ukraine; Asia: China, India, Iran, Iraq, Israel, Japan, Kyrgyzstan, Lebanon, Syria, Tajikistan, Uzbekistan, Vietnam; Africa: South Africa) and non-source locations (gray) for *Hypophthalmichthys molitrix* climate matching. Source locations from GBIF Secretariat (2023) and Sugunan (1995). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.



Species: *Hypophthalmichthys molitrix*

Current

Climate 6 Score: 0.963



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**Figure 4.** Map of RAMP (Sanders et al. 2023) climate matches for *Hypophthalmichthys molitrix* in the contiguous United States based on source locations reported by GBIF Secretariat (2023) and Sugunan (1995). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

## 8 Certainty of Assessment

The Certainty of Assessment for *Hypophthalmichthys molitrix* is classified as High. There is abundant information available on the biology, ecology, and impacts of introduction of this species. It is sometimes difficult to determine where this species has established self-sustaining populations versus where its presence is maintained through continuous stocking or regular escape from captivity. However, these uncertainties are not substantial enough to reduce confidence in the history of invasiveness or establishment concern warranted for this species.

## 9 Risk Assessment

### Summary of Risk to the Contiguous United States

*Hypophthalmichthys molitrix*, Silver Carp, is a fish that is native to China and southeastern Russia. It is a large-bodied fish that grows rapidly and reaches sexual maturity in as little as two years in the United States. Due to its ability to control algae and plankton growth, *H. molitrix* is

often introduced outside its native range for aquaculture purposes. In the United States, it became established in multiple parts of the Mississippi River Basin in the late twentieth century after escaping from aquaculture facilities. *H. molitrix* is now listed as an injurious species under the Lacey Act in the United States, and at least 36 U.S. States regulate the species. This species is also established in numerous other countries across Europe, Asia, and Africa. *H. molitrix* has had substantial negative impacts where introduced, including on native planktivorous fish, human health, and commercial fishing and aquatic recreation industries. The History of Invasiveness for *H. molitrix* is classified as High. The climate matching analysis for the contiguous United States indicates establishment concern for this species, both within the Ohio, Missouri, and Mississippi River drainages where it is currently established and in the Great Lakes, Mid-Atlantic, and Southwest regions where it is not yet established. The Certainty of Assessment for this ERSS is classified as High due to the abundance of peer-reviewed and agency publications available documenting the impacts of introduction of this species within the continental United States and across the globe. The Overall Risk Assessment Category for *Hypophthalmichthys molitrix* in the contiguous United States is High.

## Assessment Elements

- **History of Invasiveness (see Section 4): High**
- **Establishment Concern (see Section 7): Yes**
- **Certainty of Assessment (see Section 8): High**
- **Remarks, Important additional information: May cause injury to humans as a result of jumping out of the water in the presence of boats. Listed as an injurious species by the U.S. Fish and Wildlife Service under the Lacey Act. Documented as susceptible to spring viremia of carp virus and a carrier of koi herpesvirus, diseases listed by the World Organisation for Animal Health.**
- **Overall Risk Assessment Category: High**

## 10 Literature Cited

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**Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.**

[AGFC] Arkansas Game and Fish Commission. 2022. Certain exotic species prohibited. Arkansas Game and Fish Commission Code Book 26.13.

Arizona Game and Fish Commission. 2022. Restricted live wildlife. Arizona Administrative Code R12-4-406.

Ashraf U, Lu Y, Lin L, Yuan J, Wang M, Liu X. 2016. Spring viraemia of carp virus: recent advances. *Journal of General Virology* 97:1037–1051.

Bonham V, Kurwie T. 2024. *Hypophthalmichthys molitrix* (silver carp). CABI Invasive Species Compendium. Wallingford, United Kingdom: CAB International. Available: <https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.79036#sec-2> (February 2024).

- [CDFW] California Department of Fish and Wildlife. 2021. Restricted species laws and regulations manual 671. Available: <https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=28427&inline> (October 2022).
- Chapman DC, Benson AJ, Embke HS, King NR, Kočovský PM, Lewis TD, Mandrak NE. 2021. Status of the major aquaculture carps of China in the Laurentian Great Lakes Basin. *Journal of Great Lakes Research* 47:3–13.
- Code of Maryland Regulations. 2022. Classification of nonnative aquatic organisms. Section 08.02.19.04.
- Connecticut [DEEP] Department of Energy and Environmental Protection. 2020. Importation of fish, birds, and quadrupeds. *Regulations of Connecticut State Agencies* 26-55.
- Cowx IG, Lai QT, Vu AV, Tao J, Sukumasavin N, Phouthavong K, Ngor PB, Hughes K. 2026. Accounting for non-native freshwater fish in the Mekong River: towards a better understanding for management. *Reviews in Fisheries Science & Aquaculture*.
- [CPW] Colorado Parks and Wildlife. 2023. Possession of aquatic wildlife. 2 Code of Colorado Regulations 406-0, Article VIII #012.
- Crookes S, Heer T, Castaneda RA, Mandrak NE, Heath DD, Weyl OLF, MacIsaac HJ, Foxcroft LC. 2020. Monitoring the silver carp invasion in Africa: a case study using environmental DNA (eDNA) in dangerous watersheds. *NeoBiota* 56:31–47.
- Ellender BR, Weyl OLF. 2014. A review of current knowledge, risk and ecological impacts associated with non-native freshwater fish introductions in South Africa. *Aquatic Invasions* 9:117–132.
- [FAO] Fisheries and Agriculture Organization of the United Nations. 2026. *Hypophthalmichthys molitrix*. Rome: FAO Fisheries and Aquaculture Division. Available: <https://www.fao.org/fishery/en/introsp/search> (March 2026).
- [FFWCC] Florida Fish and Wildlife Conservation Commission. 2022. Conditional nonnative species list. Tallahassee: Florida Fish and Wildlife Conservation Commission. Available: <https://myfwc.com/wildlifehabitats/nonnatives/conditional-species-list/> (October 2022).
- Fricke R, Eschmeyer WN, van der Laan R, editors. 2024. Eschmeyer’s catalog of fishes: genera, species, references. California Academy of Science. Available: <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (March 2024).
- Froese R, Pauly D, editors. 2024. *Hypophthalmichthys molitrix* (Valenciennes, 1844). FishBase. Available: <https://www.fishbase.ca/summary/274> (March 2024).

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Hypophthalmichthys molitrix* (Valenciennes, 1844). Copenhagen: Global Biodiversity Information Facility. Available: <https://www.gbif.org/species/2362473> (February 2024).

GBIF-US. 2024. Species occurrences: *Hypophthalmichthys molitrix*. Available: <https://doi.org/10.15468/dl.d3jf3u> (April 2024).

[HDOA] Hawaii Department of Agriculture. 2019. Non-domestic animal import rules. Hawaii Administrative Rules Chapter 4-71.

Holčík J. 1991. Fish introductions in Europe with particular reference to its Central and Eastern part. Canadian Journal of Fisheries and Aquatic Sciences 48(Supplement 1):13–23.

[ICRCC] Invasive Carp Regional Coordinating Committee. 2024. Silver carp. USA: Invasive Carp Regional Coordinating Committee. Available: <https://invasivecarp.us/SilverCarp.html> (April 2024).

[ICRCC] Invasive Carp Regional Coordinating Committee. 2025. Frequently asked questions. USA: Invasive Carp Regional Coordinating Committee. Available: <https://icrcc.fws.gov/apps/faq/frequently-asked-questions> (March 2026).

[IDDA] Idaho Department of Agriculture. 2022. Rules governing invasive species and noxious weeds. Idaho Administrative Code 02.06.09.

Illinois [DNR] Department of Natural Resources. 2015. Injurious species. 17 Illinois Administrative Code chapter 1, part 805.

Indiana [DNR] Department of Natural Resources. 2022. Aquatic invasive species possession rules. Indianapolis: Indiana Department of Natural Resources. Available: [https://www.in.gov/dnr/fish-and-wildlife/files/fw-AIS\\_PossessionRules.pdf](https://www.in.gov/dnr/fish-and-wildlife/files/fw-AIS_PossessionRules.pdf) (October 2022).

Iowa [NRC] Natural Resource Commission. 2015. Aquatic invasive species. Iowa Administrative Code 571-90.

[ITIS] Integrated Taxonomic Information System. 2024. *Hypophthalmichthys molitrix* (Valenciennes in Cuvier and Valenciennes, 1844). Reston, Virginia: Integrated Taxonomic Information System. Available: [https://www.itis.gov/servlet/SingleRpt/SingleRpt?search\\_topic=TSN&search\\_value=163691](https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=163691) (February 2024).

Jawdhari A, Florin Mihăilescu D, Fendrihan S, Jujea V, Stoilov-Linu V, Negrea B-M. 2022. Silver carp (*Hypophthalmichthys molitrix*) (Asian silver carp) presence in Danube Delta and Romania – a review with data on natural reproduction. Life 12:1582.

- Jonsson B, Jonsson N. 2016. Fennoscandian freshwater fishes: diversity, use, threats and management. Pages 101–119 in Craig JF, editor. Freshwater fisheries ecology. First edition. Hoboken, New Jersey: John Wiley & Sons.
- [KDFWR] Kentucky Department of Fish and Wildlife Resources. 2022. Importation, possession, and prohibited aquatic species. 301 Kentucky Administrative Regulations 1:122.
- [KDWP] Kansas Department of Wildlife and Parks. 2023. Importation and possession of certain wildlife; prohibition, permit requirement, and restrictions. Kansas Administrative Regulations 115-18-10.
- Kolar CS, Chapman DC, Courtenay WR Jr, Housel CM, Williams JD. 2005. Asian carps of the genus *Hypophthalmichthys* (Pisces, Cyprinidae) — a biological synopsis and environmental risk assessment. Report to the U.S. Fish and Wildlife Service.
- Li D, Prinyawiwatkul W, Tan Y, Luo Y, Hong H. 2021. Asian carp: a threat to American lakes, a feast on Chinese tables. *Comprehensive Reviews in Food Science and Food Safety* 20:2968–2990.
- [LDWF] Louisiana Department of Wildlife and Fisheries. 2022. Invasive noxious aquatic plants. Louisiana Administrative Code Title 76, Section 1101.
- Lusk S, Lusková V, Hanel L. 2010. Alien fish species in the Czech Republic and their impact on the native fish fauna. *Folia Zoologica* 59:57–72.
- Louisiana Revised Statutes. 2022. Exotic fish; importation, sale, and possession of certain exotic species prohibited; permit required; penalty. Title 56, section 319.
- Matras M, Stachnik M, Borzym E, Maj-Paluch J, Reichert M. 2019. Potential role of different fish species as vectors of koi herpesvirus (CyHV-3) infection. *Journal of Veterinary Research* 63:507–511.
- Michigan Compiled Laws. 2022. Transgenic and nonnative organisms. Chapter 324, part 413.
- Minnesota [DNR] Department of Natural Resources. 2022. Minnesota invasive species laws. Saint Paul: Minnesota Department of Natural Resources. Available: <https://www.dnr.state.mn.us/invasives/laws.html> (October 2022).
- Montana [FWP] Department of Fish, Wildlife, and Parks. 2023. Exotic wildlife. Administrative Rules of Montana 12.6.22.
- Nebraska Game and Parks Commission. 2023. Aquatic invasive species. Lincoln: Nebraska Game and Parks Commission. Available: <http://outdoornebraska.gov/aquaticinvasivespecies/> (October 2023).

- Nevada Board of Wildlife Commissioners. 2022. Hunting, fishing and trapping; miscellaneous protective measures. Nevada Administrative Code 503.
- New York [DEC] Department of Environmental Conservation. 2022. Prohibited and regulated invasive species. 6 New York Codes, Rules and Regulations 575.3.
- [NHFG] New Hampshire Fish and Game Department. 2022. The importation, possession and use of all wildlife. New Hampshire Code of Administrative Rules Fis 800.
- Nico L, Nunez G, Baker E, Alsip P, Redinger J. 2024. *Hypophthalmichthys molitrix* (Valenciennes in Cuvier and Valenciennes, 1844). Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: <https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=549> (March 2024).
- Nico L, Nunez G, Baker E, Alsip P, Redinger J, Neilson M. 2026. *Hypophthalmichthys molitrix* (Valenciennes in Cuvier and Valenciennes, 1844). Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: <https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=549> (March 2026).
- [NIES] National Institute for Environmental Studies. 2024. *Hypophthalmichthys molitrix*. Invasive species of Japan. Tsukuba, Japan: National Research and Development Agency, National Institute for Environmental Studies. Available: <https://www.nies.go.jp/biodiversity/invasive/DB/detail/50060e.html> (April 2024).
- [NJFW] New Jersey Division of Fish and Wildlife. 2022. Fish code. New Jersey Administrative Code 7:25-6.
- [NMDGF] New Mexico Department of Game and Fish. 2023. Director's species importation list. Santa Fe: New Mexico Department of Game and Fish. Available: <https://www.wildlife.state.nm.us/download/enforcement/importation/information/Importation-Info-Directors-Species-Importation-List-1-3-2023.pdf> (October 2023).
- North Carolina [DEQ] Department of Environmental Quality. 2022. Possession of certain fishes. 15A North Carolina Administrative Code 10C .0211.
- North Dakota Game and Fish Department. 2023. ANS species list. Bismarck: North Dakota Game and Fish Department. Available: <https://gf.nd.gov/ans/species> (October 2023).
- [ODFW] Oregon Department of Fish and Wildlife. 2022. Importation, possession, confinement, transportation and sale of nonnative wildlife. Oregon Administrative Rules 635-056.
- [ODNR] Ohio Department of Natural Resources. 2022. Ohio's injurious aquatic invasive species. Publication 5490 R0120. Available: <https://ohiodnr.gov/static/documents/wildlife/fish-management/Injurious%20Aquatic%20Invasive%20Species.pdf> (October 2022).

- [ODWC] Oklahoma Department of Wildlife Conservation. 2023. Restriction on aquatic species introduction. 800 Oklahoma Administrative Code 20.
- [PFBC] Pennsylvania Fish and Boat Commission. 2022. Aquatic invasive species. Harrisburg: Pennsylvania Fish and Boat Commission. Available: <https://www.fishandboat.com/Resource/AquaticInvasiveSpecies/Pages/default.aspx> (October 2022).
- Phelps QE, Tripp SJ, Bales KR, James D, Hrabik RA, Herzog DP. 2017. Incorporating basic and applied approaches to evaluate the effects of invasive Asian Carp on native fishes: a necessary first step for integrated pest management. *PLoS ONE* 12:e0184081.
- Poelen JH, Simons JD, Mungall CJ. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.
- Pofuk M, Zanella D, Piria M. 2017. An overview of the translocated native and non-native fish species in Croatia: pathways, impacts and management. *Management of Biological Invasions* 8:425–435.
- Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.
- South Dakota [GFP] Game, Fish and Parks. 2022. SD least wanted: laws and regulations. Pierre: South Dakota Game, Fish and Parks. Available: <https://sdleastwanted.sd.gov/laws/default.aspx> (October 2022).
- Sugunan VV. 1995. Reservoir fisheries of India. Rome: FAO. FAO Fisheries Technical Paper 345.
- [TDPW] Texas Parks and Wildlife. 2022. Invasive, prohibited and exotic species. Austin: Texas Parks and Wildlife. Available: [https://tpwd.texas.gov/huntwild/wild/species/exotic/prohibited\\_aquatic.phtml](https://tpwd.texas.gov/huntwild/wild/species/exotic/prohibited_aquatic.phtml) (October 2022).
- [TWRA] Tennessee Wildlife Resources Agency. 2022. Rules and regulations of live wildlife. Rules of the Tennessee Wildlife Resources Agency 1660-01-18.
- U.S. Office of the Federal Register. 2007. Injurious wildlife species; silver carp (*Hypophthalmichthys molitrix*) and largescale silver carp (*Hypophthalmichthys harmandi*). Code of Federal Regulations, Title 50, Part 16. Washington, D.C.: U.S. Government Printing Office.
- [USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedure: how to prepare an “Ecological Risk Screening Summary.” Version 3. Available: <https://www.fws.gov/media/standard-operating-procedures-how-prepare-ecological-risk-screening-summary-2024> (March 2026).

Virginia [DWR] Department of Wildlife Resources. 2022. Importation requirements, possession, and sale of nonnative (exotic) animals. 4 Virginia Administrative Code 15-30-40.

[WGFD] Wyoming Game and Fish Commission. 2022. Regulation for aquatic invasive species. Wyoming Administrative Rules Chapter 62.

Wisconsin [DNR] Department of Natural Resources. 2022. Invasive species identification, classification and control. Wisconsin Administrative Code NR 40.

Witkowski A, Grabowska J. 2012. The non-indigenous freshwater fishes of Poland: threats to the native ichthyofauna and consequences for the fishery: a review. *Acta Ichthyologica et Piscatoria* 42(2):77–87.

World Organisation for Animal Health. 2024. Animal diseases. Paris: World Organisation for Animal Health. Available: <https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/> (February 2024).

## 11 Literature Cited in Quoted Material

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**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.**

Abdusamadov AS. 1986. Biologiya belogo amura *Ctenopharyngodon idella* (Val.), belogo tolstolobika *Hypophthalmichthys molitrix* (Val.) i pëstrogo tolstolobika *Aristichthys nobilis* (Rich.) akklimatizirovanykh v Terskom raione Kaspiiskogo basseina. [Biology of the grass carp, silver carp and bighead carp in the Terek region of the Caspian basin.] *Voprosy Ikhtiologii* 26:425–433.

Ahne W, Bjorklund HV, Essbauer S, Fijan N, Kurath G, Winton JR. 2002. Spring viremia of carp (SVC). *Diseases of Aquatic Organisms* 52:261–272.

Akhondzadeh Basti A, Zahrae Salehi T. 2003. Incidence of *Listeria monocytogenes* in fresh and smoked fish in Iran. Pages 163–165 in Phillips B, Megrey BA, Zhou Y, editors. *Proceedings of the Third World Fisheries Congress; feeding the world with fish in the next millennium—the balance between production and the environment*. Bethesda, Maryland: American Fisheries Society.

Alikunhi KH. 1963. Induced spawning of Chinese carps *Ctenopharyngodon idellus* (C. &V.) and *Hypophthalmichthys molitrix* (C. &V.) in ponds at Cuttack India. *Proceedings/Indo-Pacific Fisheries Council* 10(2):181–204.

Bauer ON, Musselius VA, Strelkov YA. 1973. *Diseases of pond fishes*. Translated from Russian by the Israel Program for Scientific Translations. Springfield, Virginia: U.S. Department of Commerce, National Technical Information Service.

- Berg LS. 1949. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th edition. Translated from Russian, 1962-1965, by Israel Program for Scientific Translations, Jerusalem, Israel, for the Smithsonian Institution and the National Science Foundation.
- Billard R. 1997. Les poissons d'eau douce des rivières de France. Identification, inventaire et répartition des 83 espèces. Lausanne, France: Delachaux & Niestle.
- Bocek AJ, Brady YJ, Rogers WA. 1992. Exposure of silver carp, *Hypophthalmichthys molitrix*, to *Salmonella typhimurium*. *Aquaculture* 103:9–16.
- Bykhovskaya-Pavlovskaya IE, Gusev AV, Dubinina MN, Izyumova NA, Smirnova TS, Sokolovskaya IL, Shtein GA, Shul'man SS, Epshtein VM. 1964. Key to parasites of freshwater fish of the U.S.S.R. Translated from Russian by the Israel Program for Scientific Translations. Washington, D.C.: U.S. Department of the Interior, National Science Foundation.
- Chapman D. 2010. Facts about invasive bighead and silver carps. Columbia, Missouri: USGS Columbia Environmental Research Center. Available: <https://pubs.usgs.gov/fs/2010/3033/pdf/FS2010-3033.pdf>.
- Coad BW. 2004. Freshwater fishes in Iran. Species accounts – Cyprinidae – *Abramis*. Available: <http://www.briancoad.com>.
- Costa-Pierce BA. 1992. Review of the spawning requirements and feeding ecology of silver carp (*Hypophthalmichthys molitrix*) and reevaluation of its use in fisheries and aquaculture. *Reviews in Aquatic Sciences* 6:257–273.
- Domaizon I, Devaux J. 1999. Experimental study of the impacts of silver carp on plankton communities of eutrophic Villerest Reservoir (France). *Aquatic Ecology* 33:193–204.
- Ebrahimzadeh Mousavi HA, Khosrari AR, Azari Takami G. 2000. A survey of fungal flora of cultivated cyprinids in Sefrid Rood Fish Farmed Center. *Journal of the Faculty of Veterinary Medicine, University of Tehran* 55:57–60.
- El-Matbouli M, Hoffmann RW. 1991. Experimental transmission of *Myxobolus cerebralis* and *Myxobolus pavlovskii* and the development in tubificids. *Fischereiforschung* 29:70–75.
- Esmaceli HR, Johal MS. 2003. Age, growth, and fisheries of silver carp *Hypophthalmichthys molitrix* (Val., 1844) in Gobindsagar Reservoir, India. Pages 127–138 in Phillips B, Megrey BA, Zhou Y, editors. *Proceedings of the Third World Fisheries Congress: feeding the world with fish in the next millennium—the balance between production and environment*. American Fisheries Society Symposium 38. Bethesda, Maryland: American Fisheries Society.
- Etnier DA, Starnes WC. 1993. *The fishes of Tennessee*. Knoxville: University of Tennessee Press.

- FAO. 2004. Fisheries global information system. Database on introductions of aquatic species. Available:  
[http://www.fao.org/figis/servlet/static?dom=root&xml=introsp/introsp\\_search.xml](http://www.fao.org/figis/servlet/static?dom=root&xml=introsp/introsp_search.xml).
- FAO. 2019a. *Hypophthalmichthys molitrix*. Available:  
<http://www.fao.org/fi/website/FISearchAction.do> (September 2019).
- FAO. 2019b. Global aquaculture production. Rome: FAO Fisheries and Aquaculture Department. Available: <http://www.fao.org/fishery/statistics/global-aquaculture-production/en>.
- FAO. 2021. FAO yearbook 2019: fishery and aquaculture statistics: aquaculture production. Rome: Food and Agriculture Organization of the United Nations. Available:  
[https://www.fao.org/fishery/static/Yearbook/YB2019\\_USBcard/navigation/index\\_content\\_aquaculture\\_e.htm](https://www.fao.org/fishery/static/Yearbook/YB2019_USBcard/navigation/index_content_aquaculture_e.htm).
- Fijan N. 1984. Vaccination of fish in European pond culture: prospects and constraints. *Symposia Biologica Hungarica*. 23:233–241.
- Food and Agriculture Organization. 2018. The state of world fisheries and aquaculture 2018: meeting the sustainable development goals. Rome: Food and Agriculture Organization of the United Nations. Available: <http://www.fao.org/3/I9540EN/i9540en.pdf>.
- Freeze M, Henderson S. 1982. Distribution and status of the bighead carp and silver carp in Arkansas. *North American Journal of Fisheries Management* 2:197–200.
- Garvey JE, Sass GG, Trushenski J, Glover D, Brey MK, Charlebois PM, Levensgood J, Roth B, Whitley G, Secchi S, Bouska W, MacNamara R. 2015. Fishing down the bighead and silver carps: reducing the risk of invasion to the Great Lakes. U.S. Fish and Wildlife Service and the Illinois Department of Natural Resources.
- Invasive Carp Regional Coordinating Committee. 2022. Silver carp. USA: Invasive Carp Regional Coordinating Committee. Available: <http://invasivecarp.us/SilverCarp.html>.
- Jerde CL, Chadderton WL, Mahon AR, Renshaw MA, Corush J, Budny ML, Mysorekar S, Lodge DM. 2013. Detection of Asian carp DNA as part of a Great Lakes basin-wide surveillance program. *Canadian Journal of Fisheries and Aquatic Sciences* 70:522–526.
- Jhingran VG, Pullin RSV. 1988. A hatchery manual for the common, Chinese and Indian major carps. Manila, Philippines: Asian Development Bank, International Center for Living Aquatic Resources Management.
- Kamilov BG, Salikhov TV. 1996. Spawning and reproductive potential of the silver carp *Hypophthalmichthys molitrix* from Syr Darya River. *Journal of Ichthyology* 36:600–606.

- Kazancheev EN. 1981. Ryby Kaspiiskogo morya. [Fishes of the Caspian Sea.] Moscow: Lëgkaya i Pishhevaya Promyshlennost'.
- Koel TM, Irons KS, Ratcliff E. 2000. Asian carp invasion of the Upper Mississippi river system. U.S. Geological Survey. Available: [http://www.umesc.usgs.gov/reports\\_publications/psrs/psr\\_2000\\_05.html](http://www.umesc.usgs.gov/reports_publications/psrs/psr_2000_05.html).
- Kolar CS, Chapman, DC, Courtenay JWR, Housel CM, Williams JD, Jennings DP. 2007. Bigheaded carps: a biological synopsis and environmental risk assessment. Bethesda Maryland: American Fisheries Society. Special Publication 33.
- Kottelat M, Freyhof J. 2007. Handbook of European freshwater fishes. Cornol, Switzerland: Publications Kottelat and Berlin: Freyhof.
- Leventer H, Teltsch B. 1990. The contribution by silver carp (*Hypophthalmichthys molitrix*) to the biological control of Netofa reservoirs. *Hydrobiologia* 191:47–55.
- Li S, Fang F. 1990. On the geographical distribution of the four kinds of pond-cultured carps in China. *Acta Zoologica Sinica* 36:244–250.
- Li S, Wu L, Wang J, Chou Q, Chen Y. 1990. Comprehensive genetic study of Chinese carps. Shanghai: Shanghai Scientific and Technical Publishers.
- Lübcker N, Zengeya TA, Dabrowski J, Robertson MP. 2014. Predicting the potential distribution of invasive silver carp *Hypophthalmichthys molitrix* in South Africa. *African Journal of Aquatic Sciences* 39:157–165.
- Lucky Z. 1978. Occurrence of *Myxobolus pavlovskii*, the parasite of *Hypophthalmichthys molitrix* and *Aristichthys nobilis* in fish ponds in Czechoslovakia. *Acta Veterinaria* 47:203–207.
- Mahboob S, Sheri AN. 1997. Growth performance of major, common and some Chinese carps under composite culture system with special reference to pond fertilization. *Journal of Aquaculture in the Tropics* 12:201–207.
- Man SH, Hodgkiss IJ. 1981. Hong Kong freshwater fishes. Hong Kong: Wishing Printing Company.
- McDowall RM. 1990. New Zealand freshwater fishes: a natural history and guide. Auckland, New Zealand: Heinemann Reed.
- Middlemas K. 1994. Local angler hooks a peculiarity. Panama City, Florida: The News Herald. 25 September.
- Moreau J, Costa-Pierce B. 1997. Introduction and present status of exotic carp in Africa. *Aquaculture Research* 28:717–732.

- Motenkov Yu. 1966. Razmnozhenie tolstolobika v Kubani. [Reproduction of the silver carp in the Kuban' River.] Rybovodstvo i Rybolovstvo 1966:16–17.
- Mukhamedova AF. 1977. The level of standard metabolism of young silver carp, *Hypophthalmichthys molitrix*. Journal of Ichthyology 17:292–298.
- [NAIK AKI] National Agricultural Research and Innovation Center Research Institute of Agricultural Economics. 2019. Statistical reports. Harvest reports. Available: [http://repo.aki.gov.hu/3584/1/Lehalaszas\\_2019\\_kiadvany.pdf](http://repo.aki.gov.hu/3584/1/Lehalaszas_2019_kiadvany.pdf) (June 2021). (In Hungarian.)
- Nichols JT. 1943. The freshwater fishes of China. Natural history of Central Asia: Volume IX. New York: The American Museum of Natural History.
- Nico LG, Fuller P, Li P. 2020. *Hypophthalmichthys molitrix* (Valenciennes in Cuvier and Valenciennes, 1844). Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: <https://nas.er.usgs.gov/queries/factsheet.aspx?speciesID=549>.
- Opuszynski K. 1979b. Silver carp, *Hypophthalmichthys molitrix* (Val.) in carp ponds. 3. Influence on ecosystem. Ekologia Polska 27:117–133.
- Oregon State University. 2010. Asian carps. Corvallis: Oregon State University. Available: <https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/invasive-species/toolkit/asian-carp-factsheet.html>.
- Page LM, Burr BM. 2011. A field guide to freshwater fishes of North America north of Mexico. Boston: Houghton Mifflin Harcourt.
- Pavlovskaya LP. 1995. Fishery in the lower Amy-Dar'ya under the impact of irrigated agriculture. Pages 42–57 in Petr T, editor. Inland fisheries under the impact of irrigated agriculture: Central Asia. FAO Fisheries Circular 894.
- Pearson WD, Krumholz LA. 1984. Distribution and status of Ohio River fishes. Oak Ridge, Tennessee: Oak Ridge National Laboratory. ORNL/sub/79-7831/1.
- Petr T. 2002. Cold water fish and fisheries in countries of the high mountain arc of Asia (Hindu Kush-Pamir-Karakoram-Himalayas). A review. Pages 1–38 in Petr T, Swar DB, editors. Cold water fisheries in the Trans-Himalayan countries. FAO. Fisheries Technical Paper 431.
- Riede K. 2004. Global register of migratory species – from global to regional scales. Final report of the R&D-Projekt 808 05 081. Bonn, Germany: Federal Agency for Nature Conservation.

- Rinne JN. 1995. The effects of introduced fishes on native fishes: Arizona, southwestern United States. Pages 149–159 in Philipp DP, Epifanio JM, Marsden JE, Claussen JE, editors. Protection of aquatic biodiversity. Proceedings of the World Fisheries Congress, Theme 3. Lebanon, New Hampshire: Science Publishers.
- Robison HW, Buchanan TM. 1988. Fishes of Arkansas. Fayetteville: University of Arkansas Press.
- Safari R, Khandagi A. 1999. Evaluation and isolation of *Clostridium botulinum* type E from fresh and smoked *Cyprinus carpio*, *Rutilus frisii kutum*, and *Hypophthalmichthys molitrix*. Iranian Journal of Fisheries Sciences 7(4):19–23. (In Farsi.)
- Salikhov TV, Kamilov BG. 1995. Ichthyofauna of the Mid-Syr Dar'ya basin. Journal of Ichthyology 35(6):61–71.
- Sara JR, Marr SM, Chabalala NM, Smit WJ, Erasmus LJC, Luus-Powell WJ. 2018. Human health risks of metalloids and metals in muscle tissue of silver carp *Hypophthalmichthys molitrix* (Valenciennes, 1844) from Lake Flag Boshielo, South Africa. African Journal of Aquatic Science 43:405–411.
- Sehgal KL. 1989. Present status of exotic coldwater fish species in India. Pages 41–47 in Mohan JM, editor. Exotic aquatic species in India. Asian Fisheries Society, Indian Branch. Special Publication 1.
- Shao KT, Lim PL. 1991. Fishes of freshwater and estuary. Encyclopedia of field guide in Taiwan. Volume 31. Taipei: Recreation Press. (In Chinese.)
- Shchelkunov IS, Shchelkunova TI. 1989. *Rhabdovirus carpio* in herbivorous fishes: isolation, pathology, and comparative susceptibility of fishes. Pages 333–348 in Ahne W, Kurstak E. Viruses of lower vertebrates. Berlin: Springer.
- Shetty HPC, Nandeesh MC, Jhingran AG. 1989. Impact of exotic aquatic species in Indian waters. Pages 45–55 in De Silva SS, editor. Exotic aquatic organisms in Asia. Proceedings of the workshop on introduction of exotic aquatic organisms in Asia. Asian Fisheries Society. Special Publication 3.
- Skelton PH. 1993. A complete guide to the freshwater fishes of southern Africa. Southern Book Publishers.
- Spataru P. 1977. Gut contents of silver carp–*Hypophthalmichthys molitrix* (Val.)–and some trophic relations to other fish species in a polyculture system. Aquaculture 11:137–146.
- Spataru P, Gophen M. 1985. Feeding behaviour of silver carp *Hypophthalmichthys molitrix* Val. and its impact on the food web in Lake Kinneret, Israel. Hydrobiologia 120:53–61.

- Sugunan VV. 1997. Fisheries management of small water bodies in seven countries in Africa, Asia, and Latin America. Food and Agriculture Organization of the United Nations. Fisheries Circular 993 FIRI/c933.
- Toth J, Biro P. 1984. Exotic fish species acclimatized in Hungarian natural waters. EIFAC Technical Paper 42(Supplement 2):550–554.
- Tripathi SD. 1989. *Hypophthalmichthys molitrix* (Val.) and *Ctenopharyngodon idella* (Val.) – exotic elements in freshwater carp polyculture in India. Pages 27–33 in Mohan JM, editor. Exotic aquatic species in India. Asian Fisheries Society, Indian Branch. Special Publication 1.
- US Geological Survey. 2022. Nonindigenous Aquatic Species Database. Gainesville, Florida: U.S. Geological Survey. Available: <http://nas.er.usgs.gov>.
- Valipour K, Ariaii F, Khademi Shurmasti PD, Nemati M. 2017. Effect of chitosan edible coating enriched with *Eucalyptus* essential oil and  $\alpha$ -tocopherol on silver carp fillets quality during refrigerated storage. *Journal of Food Safety* 37:1–8.
- Wilamowski A. 1972. Structure of the gill apparatus and the suprabranchial organ of *Hypophthalmichthys molitrix* Val. (silver carp). *Bamidgeh* 24:87–99.

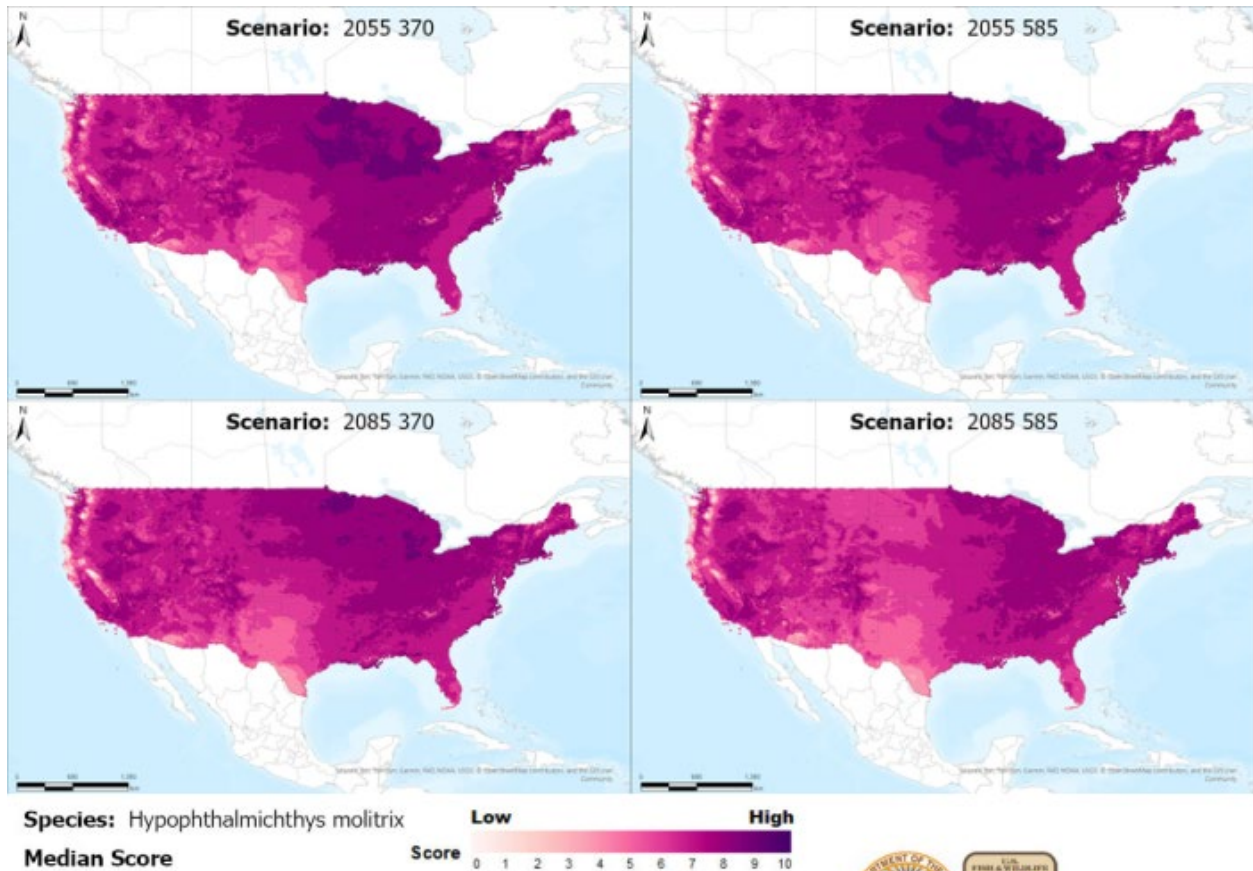
# Appendix

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## Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2023) and Sugunan (1995).

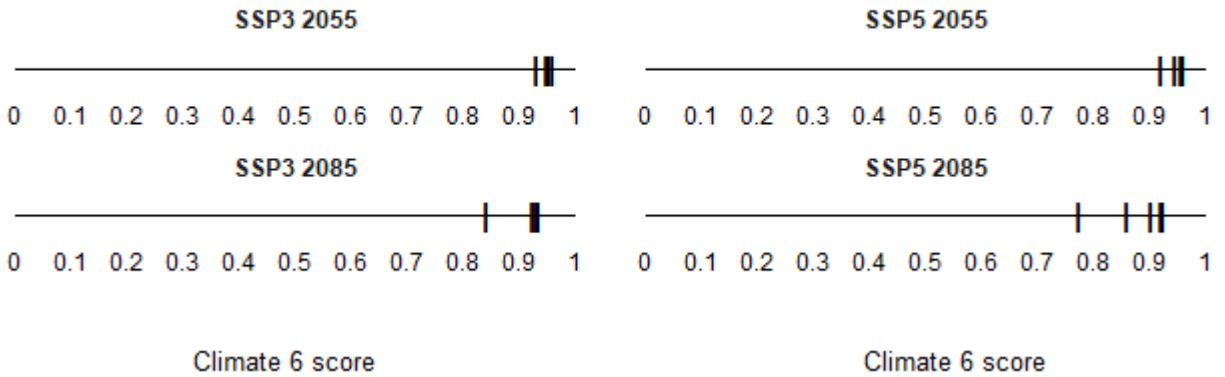
Under the future climate scenarios (figure A1), on average, high climate match for *Hypophthalmichthys molitrix* was projected to occur in the Appalachian Range, Great Basin, Great Lakes, Mid-Atlantic, Northeast, Northern Plains, Southeast, and Southern Atlantic Coast regions of the contiguous United States. The projected climate match was particularly high in the Great Lakes region at the 2055 time step. The Southern Plains, Northern Pacific Coast, and California all had areas of low match under all future scenarios. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.771 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.958 (model: IPSL-CM6A-LR, SSP3, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.963, figure 4) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Primarily under the 2085 time step, areas within the Colorado Plateau, Northeast, Northern Pacific Coast, and Southwest saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenario except for a small region in southwestern Arizona at the 2055 time step. Under SSP5, 2085, areas within the Northern Plains and Southern Plains saw a large decrease in the climate match relative to current conditions. Additionally, under one or more time step and climate scenarios, areas within the Appalachian Range, California, Colorado Plateau, Great Lakes, Gulf Coast, Mid-Atlantic, Southeast, Southern Atlantic Coast, Southern Florida, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The extent of the areas of decreased climate match was much greater under time step 2085 than under time step 2055. Additional very small areas of large or moderate change may be visible on the maps (figure A3).



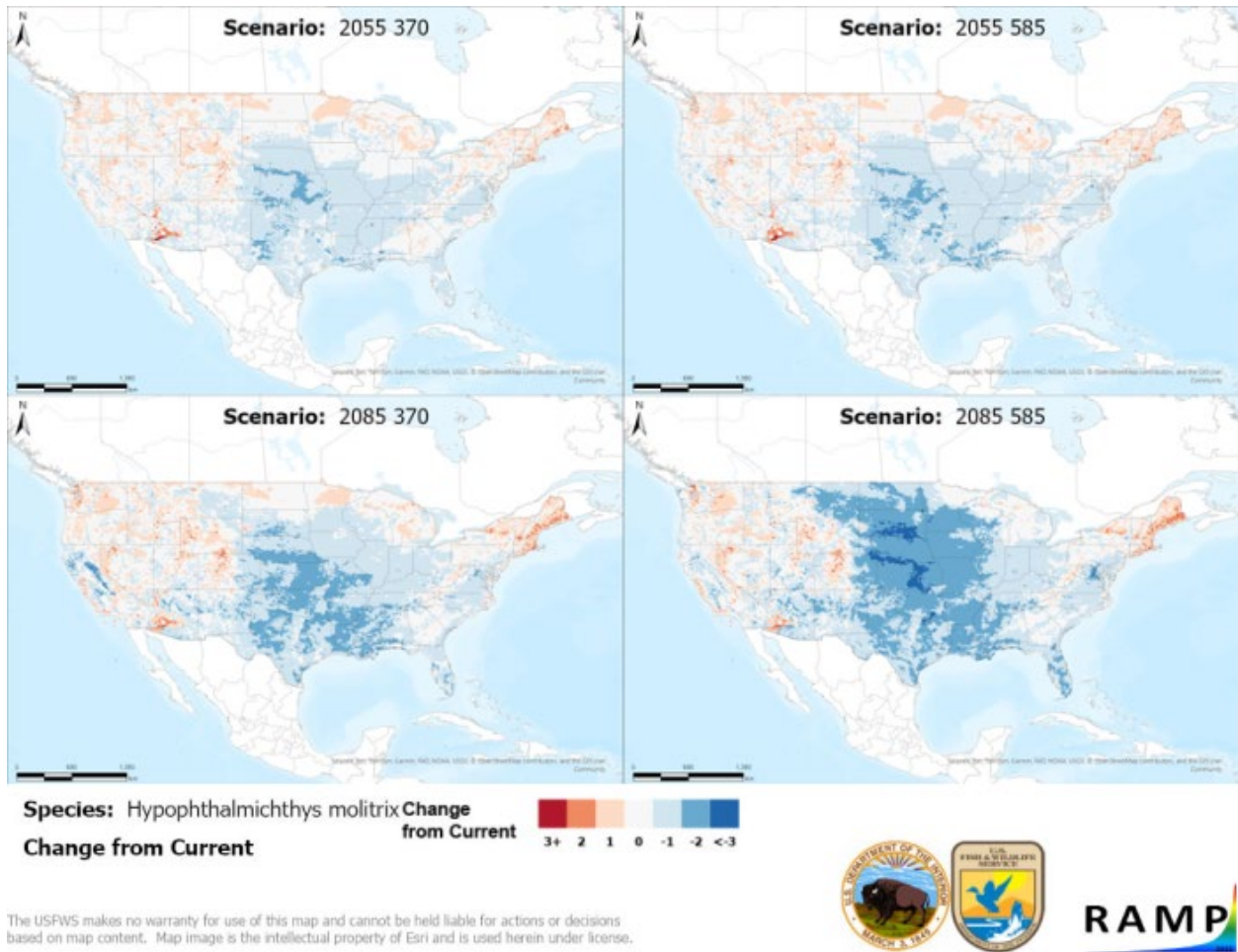
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**Figure A1.** Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Hypophthalmichthys molitrix* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023) and Sugunan (1995). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.



**Figure A2.** Comparison of projected future Climate 6 scores for *Hypophthalmichthys molitrix* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.



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**Figure A3.** RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Hypophthalmichthys molitrix* based on source locations reported by GBIF Secretariat (2023) and Sugunan (1995). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

## Literature Cited

- GBIF Secretariat. 2023. GBIF backbone taxonomy: *Hypophthalmichthys molitrix* (Valenciennes, 1844). Copenhagen: Global Biodiversity Information Facility. Available: <https://www.gbif.org/species/2362473> (February 2024).
- [IPCC] Intergovernmental Panel on Climate Change. 2021. Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder HP, Kessler M. 2018. Data from: Climatologies at high resolution for the earth's land surface areas. EnviDat. Available: <https://doi.org/10.16904/envodat.228.v2.1>.
- Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder P, Kessler M. 2017. Climatologies at high resolution for the Earth land surface areas. *Scientific Data* 4:170122.
- Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.
- Sugunan VV. 1995. Reservoir fisheries of India. FAO Fisheries Technical Paper No. 345. Rome: FAO.