Ayu (*Plecoglossus altivelis*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, February 2011
Revised, November 2018
Web Version, 10/15/2020

Organism Type: Fish
Overall Risk Assessment Category: Uncertain

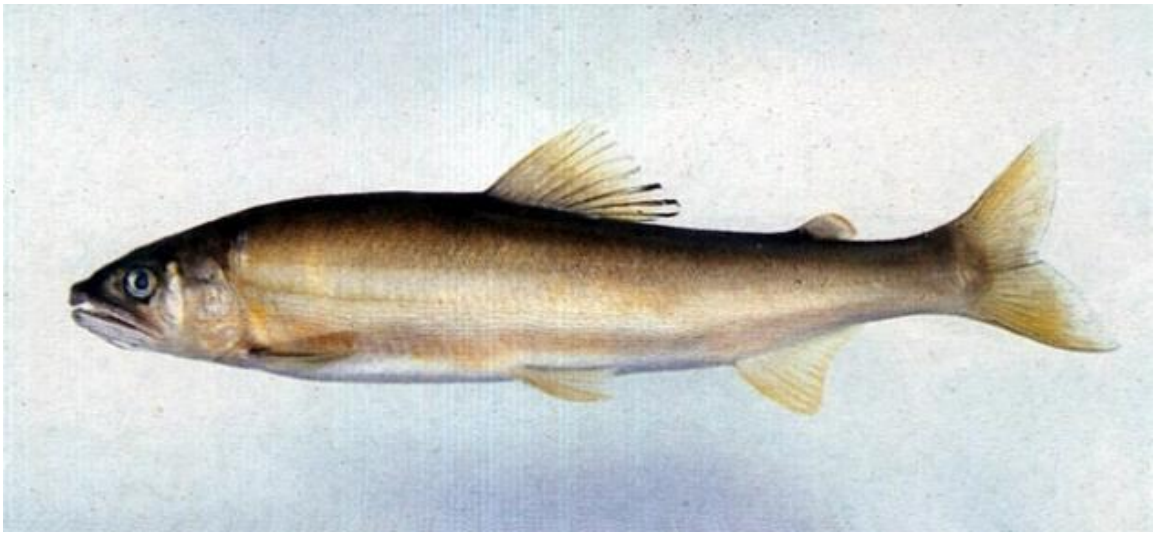

Photo: Fish Ecology Evolution Laboratory/The Fish Database of Taiwan. Licensed under Creative Commons BY-NC 3.0. Available: http://taieol.tw/data_objects/18352. (October 31, 2018).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2018a):

"Northwest Pacific: western Hokkaido in Japan southward to the Korean Peninsula, Taiwan and China."

"[In China:] Recorded from Yalu (Am-nok), Ming, Chefoo River, Yan dang shan and Ping Yang in Zhejiang Province, Ngao-Kiang, China's coast [Huang 2001] in the Donghai Sea and the Nanhai Sea [Hwang et al. 1988]. Inhabits mountain streams of Chekiang in April or May and goes back to the sea in August or September."

"[In Japan:] Occurs in western Hokkaido southward [Masuda et al. 1984; Yamada et al. 1995]. Found in Hokkaido's Ishikari river and the southern tributaries and river mouths [Chyung 1977]; Nansei-shoto [Nishida 1988]; Futatsukawa Creek, Fukuoka Prefecture [Nagata and Nakata 1988]; and Himi region from a habitat study conducted in Toyama Bay [Yamazaki et al. 2006]."

"[In North Korea:] Found in every river except Doo-man river, especially in the Chung-chun river [*sic*], Pyoung-buk province. North Korea's Am-nok river are very famous for this fish."

"[In South Korea:] Found in every river, especially in the Kyoung-nam province's Mil-ryang river and Jeon-nam province's Seom-jin river. Recorded from the Han, Nakdong and Sumjin rivers [Jang et al. 2002]."

"[In Taiwan:] Native *P. altivelis* had completely disappeared due to man-made destruction to its environment. Research institutes with the help of game fishing clubs introduced eyed eggs of this species for stocking reservoirs and rivers. It is now established in the wild [Liao and Lia 1989]."

"Known from northern Vietnam [Nakabo 2002]."

From Huckstorf (2012):

"In Japan, juveniles have been extensively stocked in many rivers for several decades. In the Nagara River, most stocked fish are juveniles from the landlocked population in Lake Biwa (70 %), and the rest comprise juveniles of the amphidromous wild population (10%) and hatchery-reared fish (20%) (Otake and Uchida 1998). In China, breeding experiments started at the end of the 20th century (Wang 1998)."

"Besides the typical amphidromous populations, landlocked population are also know from Lake Biwa (Azuma 1973) and several other lakes in Japan."

Status in the United States

From Froese and Pauly (2018a):

"About 250,000 were released in Hawaii, Kauai and Oahu [Maciolek 1984]."

Froese and Pauly (2018a) list *Plecoglossus altivelis* as not established in Hawaii.

According to Fuller et al. (2018), *P. altivelis* was introduced to Hawaii in 1925 and California in 1961 (stocked from 1961–1965, see below).

From Fuller et al. (2018):

"None of the fish in California survived (Shapovalov et al. 1981; Dill and Cordone 1997); it also failed to become established in Hawaii."

Means of Introductions in the United States

From Fuller et al. (2018):

"With approval from the California Fish and Game Commission, about 3,845,000 eggs and fry were stocked in California waters from 1961 through 1965 (Shapovalov et al. 1981; Dill and Cordone 1997). Relished as a food fish by Asians, Dill and Cordone (1997) stated that it was introduced to the state because it was felt to be a plant-eating fish expected to thrive in coastal streams considered marginal trout habitat. An estimated 250,000 fish were imported from Japan and intentionally stocked in Hawaii in 1925 and subsequent years, but failed to establish a reproducing population (Maciolek 1984)."

Remarks

Plecoglossus altivelis can live in marine environments (Froese and Pauly 2018a). This assessment is only for the brackish and freshwater areas of the species' range. The climate match was conducted using only brackish and freshwater source locations.

Plecoglossus altivelis has been intentionally stocked within the United States by State fishery managers to achieve fishery management objectives. State fish and wildlife management agencies are responsible for balancing multiple fish and wildlife management objectives. The potential for a species to become invasive is now one important consideration when balancing multiple management objectives and advancing sound, science-based management of fish and wildlife and their habitat in the public interest.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to Fricke et al. (2018), *Plecoglossus altivelis* is the valid name for this species.

From ITIS (2018):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Protacanthopterygii
Order Osmeriformes
Suborder Osmeroidei
Superfamily Osmeroidea
Family Osmeridae
Genus *Plecoglossus*
Species *Plecoglossus altivelis* (Temminck and Schlegel, 1846)

From Huckstorf (2012):

"Two subspecies are recognised and are considered junior synonyms: *Plecoglossus altivelis chinensis* Wu & Shan, 2005 (Shandong Province, China) and *Plecoglossus altivelis ryukyuensis* Nishida, 1988 (Ryukyu Islands, Japan)."

Size, Weight, and Age Range

From Froese and Pauly (2018a):

"Maturity: L_m 20.0, range 30 - 40 cm
Max length : 70.0 cm TL male/unsexed; [Chyung 1977]; common length : 15.0 cm SL male/unsexed; [Nichols 1943]; max. reported age: 3 years [Chyung 1977]"

From Huckstorf (2012):

"River forms live usually only one year whereas lake forms can live two or three years (Chyung 1975)."

Environment

From Froese and Pauly (2018a):

"Marine; freshwater; brackish; demersal; amphidromous [Riede 2004]; depth range 10 - ? m."

From Huckstorf (2012):

"Besides the typical amphidromous populations, landlocked population are also know from Lake Biwa (Azuma 1973) and several other lakes in Japan."

Climate

From Froese and Pauly (2018a):

"Subtropical; 44°N - 23°N"

Distribution Outside the United States

Native

From Froese and Pauly (2018a):

"Northwest Pacific: western Hokkaido in Japan southward to the Korean Peninsula, Taiwan and China."

"[In China:] Recorded from Yalu (Am-nok), Ming, Chefoo River, Yan dang shan and Ping Yang in Zhejiang Province, Ngao-Kiang, China's coast [Huang 2001] in the Donghai Sea and the Nanhai Sea [Hwang et al. 1988]. Inhabits mountain streams of Chekiang in April or May and goes back to the sea in August or September."

“[In Japan:] Occurs in western Hokkaido southward [Masuda et al. 1984; Yamada et al. 1995]. Found in Hokkaido's Ishikari river and the southern tributaries and river mouths [Chyung 1977]; Nansei-shoto [Nishida 1988]; Futatsukawa Creek, Fukuoka Prefecture [Nagata and Nakata 1988]; and Himi region from a habitat study conducted in Toyama Bay [Yamazaki et al. 2006].”

“[In North Korea:] Found in every river except Doo-man river, especially in the Chung-chun river [*sic*], Pyoung-buk province. North Korea's Am-nok river are very famous for this fish.”

“[In South Korea:] Found in every river, especially in the Kyoung-nam province's Mil-ryang river and Jeon-nam province's Seom-jin river. Recorded from the Han, Nakdong and Sumjin rivers [Jang et al. 2002].”

“[In Taiwan:] Native *P. altivelis* had completely disappeared due to man-made destruction to its environment. Research institutes with the help of game fishing clubs introduced eyed eggs of this species for stocking reservoirs and rivers. It is now established in the wild [Liao and Lia 1989].”

“Known from northern Vietnam [Nakabo 2002].”

From Huckstorf (2012):

“In Japan, juveniles have been extensively stocked in many rivers for several decades. In the Nagara River, most stocked fish are juveniles from the landlocked population in Lake Biwa (70 %), and the rest comprise juveniles of the amphidromous wild population (10%) and hatchery-reared fish (20%) (Otake and Uchida 1998). In China, breeding experiments started at the end of the 20th century (Wang 1998).”

“Besides the typical amphidromous populations, landlocked population are also know from Lake Biwa (Azuma 1973) and several other lakes in Japan.”

Introduced

From Froese and Pauly (2018a):

“Introduced to open waters [in Russia] however failed to establish self-sustaining populations [Bogutskaya and Naseka 2002].”

“Introduced from its native range to other regions in the country [China] (stocked in great inland waters) [Ma et al. 2003].”

From Huckstorf (2012):

“Introduced from its native range to other parts of China for aquaculture.”

According to Olenin (2018), *Plecoglossus altivelis* was introduced to the Black and Azov seas in Ukraine between 1960 and 1979. No information was given regarding the status of these introductions.

Means of Introduction Outside the United States

From Huckstorf (2012):

"Introduced […] for aquaculture."

Short Description

From Fuller et al. (2018):

"This species is characterized by the presence of an adipose fin; 10-12 dorsal rays; 9-17 anal rays; 5 or 6 branchiostegal rays; usually 59-64 vertebrae; no pelvic axillary process; and more than 300 pyloric caeca (Nelson 1984)."

From FAO (2018):

"Body elongate. Scales small and cycloid; lateral line complete with 145-169 scales. Mouth large; teeth on both jaws small and conical in juveniles; movable, broad, lamelliform (placoids) and 11 to 14 in number on each side in adults. First arch branchial with 46-49 gillrakers. Dorsal fin high, with 10-11 rays; adipose fin present. Anal fin with 14-15 rays. Pectoral with 14. Pelvic fin base below middle of dorsal fin. Vertebrae 59-63."

Biology

From Froese and Pauly (2018a):

"Typical amphidromous fish; appears in near shore from late autumn to spring [Yamada et al. 1995]. Found in lakes and rivers, preferring clean river water and can be found the entire river long, from the head to the mouth [Chyung 1977]. Ascends the river during March when the temperature is around 10°C [Chyung 1977]. Adults spawn in the spring, in the lower reaches of rivers. After spawning, some adults die while others return to the sea. Larvae enter the sea immediately after hatching and remain there during winter, feeding on plankton. In springtime, the young (5-7 cm TL) move upstream to the middle reaches of rivers to feed on algae. Fish (about 6-9 cm) start schooling at the river mouth and are insectivores and eat algae off small pebbles [Chyung 1977]; this is assisted by small leaf-like teeth which are loosely attached to the jaw with two ligaments [Adamicka 1984]. Those that are ready to spawn (about 20 cm TL) move downstream to the lower reaches of the river. Spawning adults from the sea migrate upstream to the lower reaches as well. Some fish spawn two or three years in succession, others only once [Masuda et al. 1984; Frimodt 1995]. River forms live usually only one year whereas lake forms can live two or three years [Chyung 1977]. Reaches maturity at 30-40 cm [Chyung 1977]."

"During spawning some fish go up the river and some fish spawn on the river shoreline above pebbles. Spawns at night and excavates a 10cm (diameter or depth?) pit. Eggs are around 1 mm in size and adhere to the sand or pebbles for 14 to 20 days before hatching. This fish is semelparous and releases eggs many times over a short period each time releasing ~10,000 eggs. Sometimes females that want to spawn but cannot, save their strength, and go to a deep stagnant pool. These females wait until spring before going up the river with young fish. After hatching,

the larvae are 6 mm and flow with the water current eating plankton. Juvenile fish will come again to the river in spring. These live in schools. When schools of *Plecoglossus altivelis* return to their river they guard their territory and eat food [Chyung 1977]. Reproductive mode varies between semelparity and iteroparity. Large females spawn once, while smaller females spawn twice during a two-week interval [Iguchi and Tsukamoto 2001]."

"Feeds on cladocera, rotifer, diatom, green and blue algae [Wang 1998]."

Human Uses

From Froese and Pauly (2018a):

"Highly esteemed food fish. Marketed fresh and consumed fresh, fried and broiled [Frimodt 1995]."

"Fisheries: highly commercial; aquaculture: commercial; gamefish: yes"

"[In China:] The flesh is delicate food to the natives. Sun dried fish is known as Hiang-Yu or Sian-Yu [Nichols 1943]."

"Introduced from its native range to other regions in the country [China] (stocked in great inland waters) [Ma et al. 2003]."

"Cultured throughout western Japan in sea cages."

From Huckstorf (2012):

"Fishery catches reached a peak of 18,101 tonnes in 1991, then declining rapidly to 3,406 tonnes by 2010 (FAO 2012)."

From FAO (2018):

"Most important species in Japanese freshwater fisheries, highly esteemed as food and game fish. Propagated commercially everywhere in western Japan. The total catch reported for this species to FAO for 1999 was 11 380 t. The countries with the largest catches were Japan (11 380 t).
Marketed fresh and consumed fresh, fried and broiled."

Diseases

Epizootic ulcerative syndrome is a 2018 OIE-reportable disease.

Yoshimizu (1996) lists *Cytophaga (Flexibacter) psychrophila* and erythrocyte inclusion body syndrome as diseases of *Plecoglossus altivelis*.

Crane and Hyatt (2011) list Hirame rhabdovirus as a disease of *P. altivelis*.

Harris et al. (2004) list *Gyrodactylus japonicus*, *G. plecoglossi*, and *G. tominagai* as parasites of *P. altivelis.*

From Froese and Pauly (2018a):

"Yellow Grub, Parasitic infestations (protozoa, worms, etc.)
Aeromonosis, Bacterial diseases"

Froese and Pauly (2018b) list *Argulus plecoglossi*, *Ergasilus plecoglossi*, *E. zacconis*, *Glugea plecoglossi*, *Ichthyascaris biwakoensis*, and *Neoplagioporus ayu* as additional parasites of *Plecoglossus altivelis*.

According to CABI (2018), *Plecoglossus altivelis* is a host for epizootic ulcerative syndrome.

Poelen et al. (2014) list *Glugea plecoglossi*, *Pythium flevoense*, *Listonella anguillarum*, *Flavobacterium psychrophilum*, *Edwardsiella ictaluri*, *Pseudomonas plecoglossicida*, *Proteocephalus plecoglossi*, *Metagonimus yokogawai*, *Mycobacterium marinum*, *Aeromonas hydrophila*, *Acanthocephalus opsariichthydis*, *Ichthyascaris biwakoensis*, *Exorchis oviformis*, *Clinostomum complanatum*, *Exorchis major*, *Pseudexorchis* sp., *Fibricola* sp., *Echinochasmus japonicas*, *Echinochasmus perfoliatus*, *Metagonimus miyatai*, *Metagonimus takahashii*, and *Raphidascaris gigi* as additional parasites of *Plecoglossus altivelis*.

Threat to Humans

From Froese and Pauly (2018a):

"Harmless"

3 Impacts of Introductions

Records of introductions were found but no information on realized or potential impacts of introduction was available.

4 History of Invasiveness

Records of introductions were found but the introductions either failed (Russia, California, and Hawaii) or there was no information available on the status of the introduction (China, Black and Azov seas). No information was found on documented or potential impacts of introduction. Due to the lack of a documented established, nonnative population, the history of invasiveness for *Plecoglossus altivelis* is No Known Nonnative Population.

5 Global Distribution

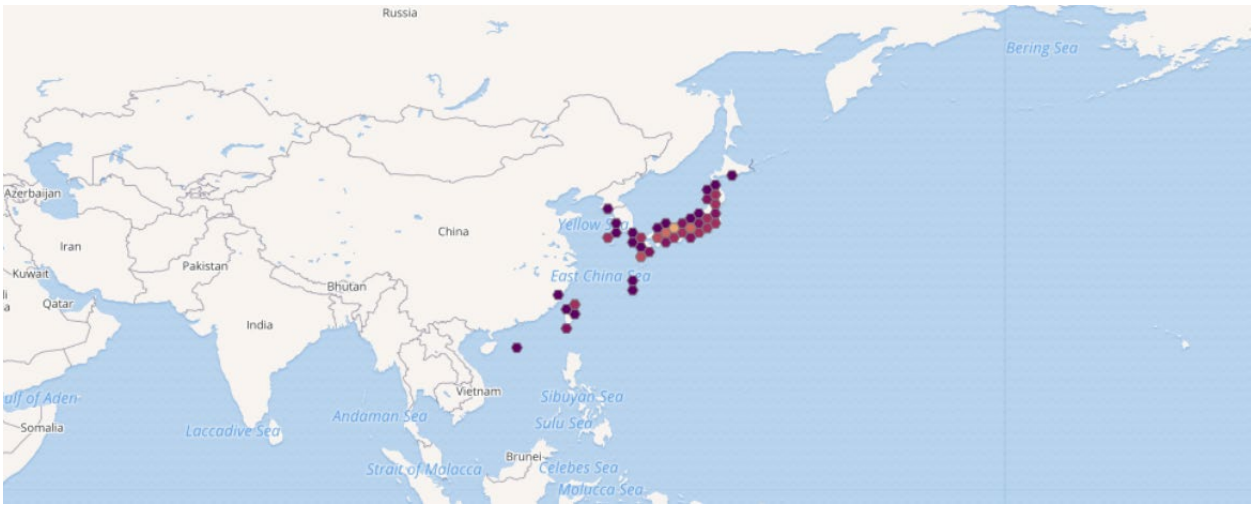

Figure 1. Known global distribution of *Plecoglossus altivelis*. Locations are in Japan, North Korea, South Korea, China, and Taiwan. Map from GBIF Secretariat (2018). Some of the observations in represent marine populations. Because the climate matching analysis (section 7) is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

Olenin (2018) listed an introduction of *P. altivelis* into the Black and Azov seas in Ukraine but no detailed observation information was given and the status of those introductions was not given. There is not enough information available regarding the existence of an established population in Ukraine to support using source points in Ukraine for the climate match.

The native range of *P. altivelis* is reported to include northern Vietnam but no georeferenced observations were found for the species in that area.

6 Distribution Within the United States

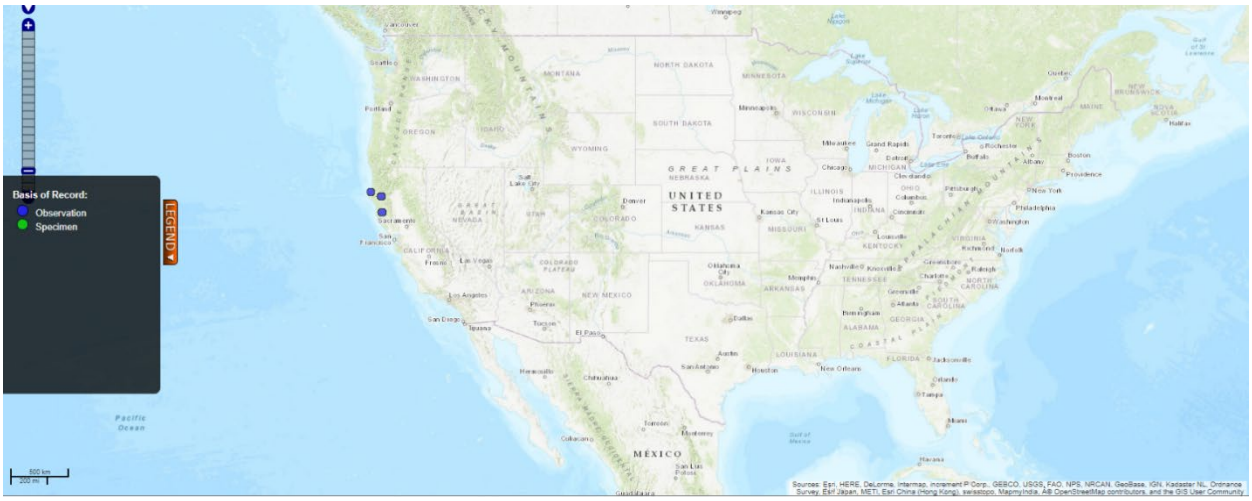

Figure 2. Known distribution of *Plecoglossus altivelis* in the contiguous United States. Map from BISON (2018).

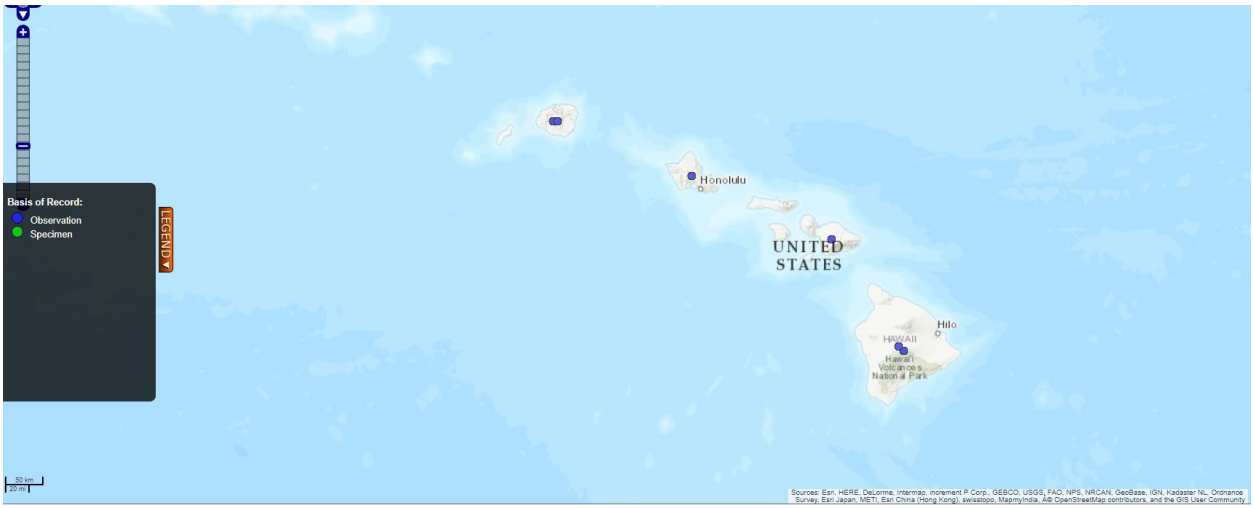

Figure 3. Known distribution of *Plecoglossus altivelis* in Hawaii. Map from BISON (2018).

The observations in Figures 2 and 3 represent failed introductions (Fuller et al. 2018) and were not used as source points for the climate match.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Plecoglossus altivelis* was low in the western half of the contiguous United States, in a portion of the interior Gulf States, and along the New England coast. The climate match had small areas of high match in northern Vermont and New Hampshire, along the North Carolina coast, a few areas along the coastline of Florida, and a few areas in the southern Appalachian Mountains. Everywhere else had a medium climate match. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for contiguous United States was 0.122, high (scores 0.103 or greater are considered high). The following states had high individual climate scores: Delaware, Florida, Illinois, Indiana, Kansas, Kentucky, Maine, Maryland, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Virginia, Vermont, and West Virginia.

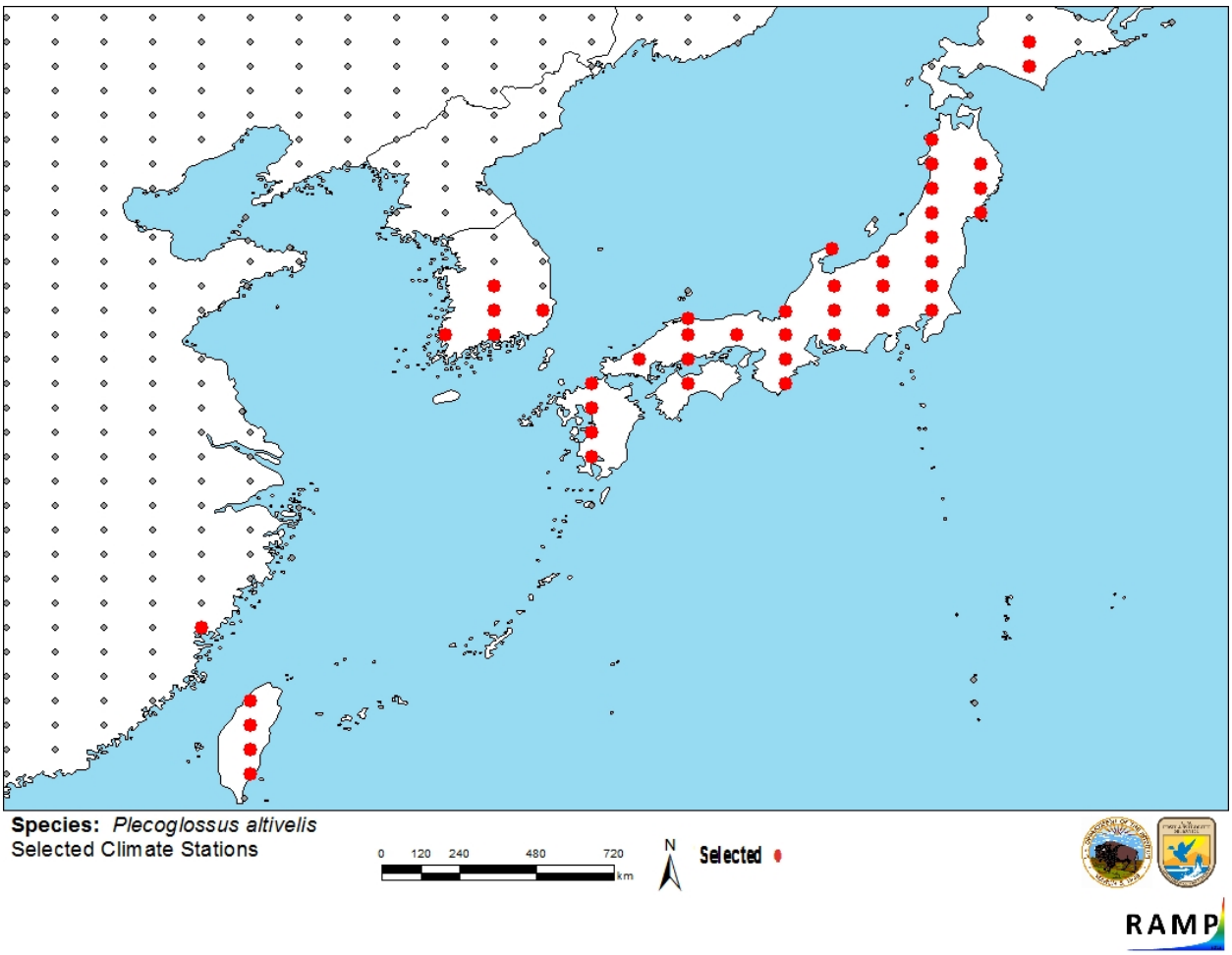

Figure 4. RAMP (Sanders et al. 2018) source map showing weather stations in eastern Asia selected as source locations (red; Japan, South Korea, China, Taiwan) and non-source locations (gray) for *Plecoglossus altivelis* climate matching. Source locations from GBIF Secretariat (2018). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

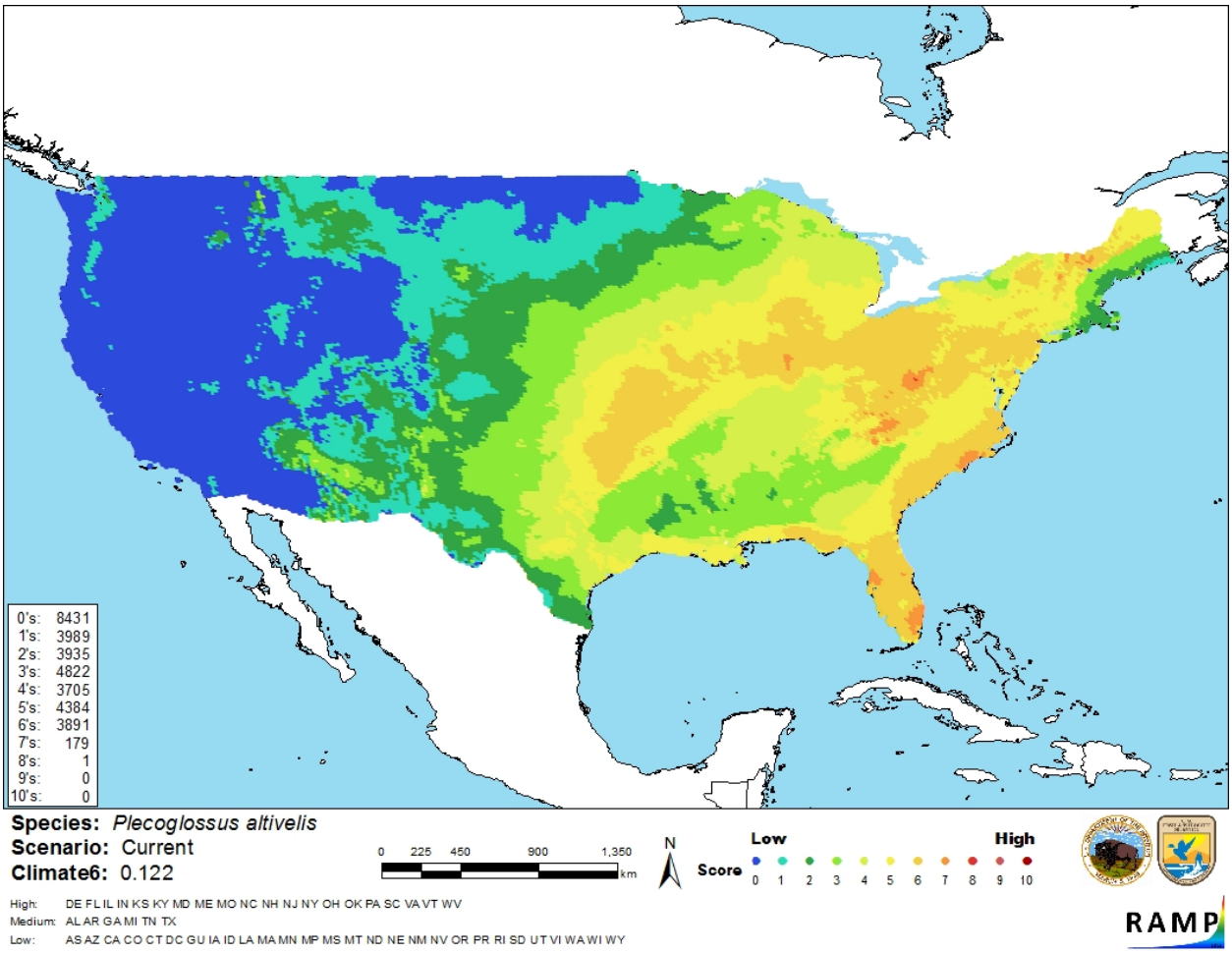

Figure 5. Map of RAMP (Sanders et al. 2018) climate matches for *Plecoglossus altivelis* in the contiguous United States based on source locations reported by GBIF Secretariat (2018). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

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

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

The certainty of assessment is low. There is some quality information available about the biology and ecology of *Plecoglossus altivelis*, including some peer-reviewed literature. A few records of introduction were found. However, there was no information on realized or potential impacts of introduction to evaluate.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Ayu (*Plecoglossus altivelis*) is a species of salmonid that is native to the western Pacific and eastern coastal areas of Asia, including Japan, the Korean Peninsula, China, and Taiwan. *P. altivelis* has both amphidromous and landlocked freshwater forms. The amphidromous form reproduces in freshwater and spends summer months foraging in freshwater. This assessment did not consider any marine information or use any marine locations for the climate match. *P. altivelis* is a highly prized commercial fish that has been caught at high levels in the past. It is used in commercial aquaculture throughout its range. The history of invasiveness for *P. altivelis* is classified as No Known Nonnative Population. *P. altivelis* was intentionally introduced to Hawaii and California in the early and mid-20th century; introductions failed to establish a population in both locations. Other introductions in China, Russia, and Ukraine were also the result of intentional stocking and either failed (Russia) or the status is unknown (China and Ukraine). No information was found on actual or potential impacts of introduction. The overall climate match for the contiguous United States is high. Most of the eastern United States, including the eastern Plains States, had medium to high matches, except for coastal New England and the interior areas of the Gulf States. The certainty of assessment is low due to lack of information. The overall risk assessment category is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): No Known Nonnative Population**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks/Important additional information:** *Plecoglossus altivelis* is a host for Epizootic ulcerative syndrome, an OIE-reportable disease.
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

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

BISON. 2018. Biodiversity Information Serving Our Nation. U.S. Geological Survey. Available: https://bison.usgs.gov (October 2018).

CABI. 2018. Epizootic ulcerative syndrome. *In* Invasive Species Compendium. Wallingford, U.K: CAB International. Available: https://www.cabi.org/ISC/datasheet/83971 (October 2018).

Crane M, Hyatt A. 2011. Viruses of fish: an overview of significant pathogens. Viruses 2011:2025–2046.

FAO. 2018. Species fact sheets: *Plecoglossus altivelis* (Temminck & Schlegel, 1846). Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Department. Available: http://www.fao.org/fishery/species/2124/en (October 2018).

Fricke R, Eschmeyer WN, van der Laan R, editors. 2018. Catalog of fishes: genera, species, references. California Academy of Science. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (October 2018).

Froese R, Pauly D, editors. 2018a. *Plecoglossus altivelis* (Temminck & Schlegel, 1846). FishBase. Available: https://www.fishbase.de/summary/Plecoglossus-altivelis.html (October 2018).

Froese R, Pauly D, editors. 2018b. *Plecoglossus altivelis*. In World Register of Marine Species. Available: http://www.marinespecies.org/aphia.php?p=taxdetails&id=293715 (October 2018).

Fuller PL, Nico LG, Neilson ME. 2018. *Plecoglossus altivelis* (Temminck and Schlegel, 1846). Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=797 (October 2018).

GBIF Secretariat. 2018. GBIF backbone taxonomy: *Plecoglossus altivelis* (Temminck & Schlegel, 1846). Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/4283980 (October 2018).

Harris PD, Shinn AP, Cable J, Bakke TA. 2004. Nominal species of the genus *Gyrodactylus* von Nordmann 1832 (Monogenea: Gyrodactylidae), with a list of principle host species. Systematic Parasitology 59:1–27.

Huckstorf V. 2012. *Plecoglossus altivelis*. The IUCN Red List of Threatened Species 2012: e.T62222A3110058. Available: https://www.iucnredlist.org/species/62222/3110058 (October 2018).

[ITIS] Integrated Taxonomic Information System. 2018. *Plecoglossus altivelis* (Temminck and Schlegel, 1846). Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=162027#null (October 2018).

[OIE] World Organisation for Animal Health. 2019. OIE-listed diseases, infections and infestations in force in 2019. Available: http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/ (June 2019).

Olenin S. 2018. *Plecoglossus altivelis altivelis*. In Editorial board. AquaNIS: information system on aquatic non-indigenous and cryptogenic species. Available: http://www.corpi.ku.lt/databases/index.php/aquanis/introductions/view/id/2435. (October 2018).

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.

Sanders S, Castiglione C, Hoff M. 2018. Risk Assessment Mapping Program: RAMP. Version 3.1. U.S. Fish and Wildlife Service.

Yoshimizu M. 1996. Disease problems of salmonid fish in Japan caused by international trade. Revue Scientifique et Technique (International Office of Epizootics) 15:533–549.

11 Literature Cited in Quoted Material

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.

Adamicka P. 1984. Der ayu (*Plecoglossus altivelis* T. et S.), ein interessanter Vertreter der japanischen Fischfauna. Österreichs Fischerei 37:140–147.

Azuma. 1973. [Source material did not give full citation for this reference.]

Bogutskaya NG, Naseka AM. 2002. An overview of nonindigenous fishes in inland waters of Russia. Proceedings of the Zoological Institute Russian Academy of Sciences 296:21–30.

Chyung. 1975. [Source material did not give full citation for this reference.]

Chyung M-K. 1977. The fishes of Korea. Seoul, Korea: Il Ji Sa Publishing.

Dill WA, Cordone AJ. 1997. History and status of introduced fishes in California, 1871–1996. Sacramento: California Department of Fish and Game. Fish Bulletin 178.

FAO. 2012. Species fact sheets: *Plecoglossus altivelis* (Temminck & Schlegel, 1846). Available: http://www.fao.org/fishery/species/2124/en (March 2012).

Frimodt C. 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Oxford, England: Fishing News Books, Osney Mead.

Huang Z. 2001. Marine species and their distribution in China's seas. Pages 404–463 in Vertebrata. Florida: Smithsonian Institution.

Hwang HC, Chen IY, Yueh PC. 1988. The freshwater fishes of China in colored illustrations, volume 2. Shanghai, China: Shanghai Sciences and Technology Press.

Iguchi K, Tsukamoto Y. 2001. Semelparous or iteroparous: resource allocation tactics in the ayu, an osmeroid fish. Journal of Fish Biology 58:520–528.

Jang M-H, Kim J-G, Park S-B, Jeong K-S, Cho G-I, Joo G-J. 2002. The current status of the distribution of introduced fish in large river systems of South Korea. International Review Hydrobiology 87(2–3):319–328.

Liao I-C, Lia H-C. 1989. Exotic aquatic species in Taiwan. Pages 101–118 in De Silva SS, editor. Exotic aquatic organisms in Asia. Proceedings of the Workshop on Introduction of Exotic Aquatic Organisms in Asia. Manila, Philippines: Asian Fisheries Society. Special Publication 3.

Ma X, Bangxi X, Yindong W, Mingxue W. 2003. Intentionally introduced and transferred fishes in China's inland waters. Asian Fisheries Science 16(3&4):279–290.

Maciolek JA. 1984. Exotic fishes in Hawaii and other islands of Oceania. Pages 131–161 in Courtenay Jr WR, Stauffer Jr JR, editors. Distribution, biology and management of exotic fishes. Baltimore: John Hopkins University Press.

Masuda H, Amaoka K, Araga C, Uyeno T, Yoshino T. 1984. The fishes of the Japanese Archipelago, volume 1. Tokyo: Tokai University Press.

Nagata Y, Nakata Y. 1988. Distribution of six species of bitterlings in a creek in Fukuoka Prefecture, Japan. Japanese Journal of Ichthyology 35:320–331.

Nakabo T. 2002. Fishes of Japan with pictorial keys to the species. English edition I. Tokyo: Tokai University Press.

Nelson JS. 1994. Fishes of the world, 3rd edition. New York: John Wiley and Sons.

Nichols JT. 1943. The freshwater fishes of China. Natural history of Central Asia: volume IX. New York: The American Museum of Natural History.

Nishida M. 1988. A new subspecies of the ayu, *Plecoglossus altivelis*, (Plecoglossidae) from the Ryukyu Islands. Japanese Journal of Ichthyology 35:236–242.

Otake and Uchida. 1998. [Source material did not give full citation for this reference.]

Riede K. 2004. Global register of migratory species - from global to regional scales. Bonn: Federal Agency for Nature Conservation. Final Report, Projekt 808 05 081.

Shapovalov L, Cordone AJ, Dill WA. 1981. A list of freshwater and anadromous fishes of California. California Fish and Game 67:4–38.

Shen SC, editor. 1993. Fishes of Taiwan. Department of Zoology, Taipei: National Taiwan University.

Wang S, editor. 1998. China red data book of endangered animals. Pisces. Beijing: National Environmental Protection Agency, Endangered Species Scientific Commission, Science Press.

Yamada U, Shirai S, Irie T, Tokimura M, Deng S, Zheng Y, Li C, Kim YU, Kim YS. 1995. Names and illustrations of fishes from the East China Sea and the Yellow Sea. Tokyo: Overseas Fishery Cooperation Foundation.

Yamazaki Y, Haramoto S, Fukasawa T. 2006. Habitat uses of freshwater fishes on the scale of reach system provided in small streams. Environmental Biology of Fishes 75:333–341.