Wakasagi (*Hypomesus nipponensis*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, July 2014
Revised, July 2019
Web Version, 11/8/2019

Photo: Daderot. Licensed under Creative Commons CC0 1.0 Universal Public Domain Dedication. Available: https://commons.wikimedia.org/wiki/File:Hypomesus_nipponensis_-_National_Museum_of_Nature_and_Science,_Tokyo_-_DSC06856.JPG. (July 2019).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2019):

"Asia: Japan to the Korean Peninsula (not confirmed by [Saruwatari et al. 1997])."

Froese and Pauly (2019) lists that *Hypomesus nipponensis* is native to Japan, Kuril Island, and Russia.

From Saruwatari et al. (1997):

"Distribution. Found in brackish and fresh water throughout the Japanese Archipelago, except for the Ryukyu and Ogasawara Islands […]. Small populations are present in various lakes in

California, originating from artificial transplantation of eggs in 1959, at a time when *H. nipponensis* and *H. transpacificus* were thought to be conspecific (see Wales 1962)."

From Chereshnev et al. (2001):

"Thus, our study confirms Klyukanov's viewpoint [Klyukanov 1966; Klyukanov 1970; Klyukanov 1997] that only two species of the genus *Hypomesus*— *H. japonicus* and *H. nipponensis*—inhabit Peter the Great Bay [Russia], […]."

"However, these authors did not give a morphological description of the smelt; hence, it is not improbable that in fact this species is *H. nipponensis*, which is widely distributed from Korea to the mouth of the Amur River [Russia] [Klyukanov 1970; Klyukanov 1977]."

Status in the United States

Froese and Pauly (2019) lists that *Hypomesus nipponensis* was introduced to California in 1959 from Japan.

According to Fuller et al. (2019), nonindigenous occurrences of *Hypomesus nipponensis* have been reported in California (1959-2014; Honey-Eagle Lakes; Lower American; Lower Klamath; Lower Sacramento; Madeline Plains; Mad-Redwood; Mojave; North Fork Feather; Santa Ana; Santa Margarita; Shasta; Suisun Bay; Upper Bear; Upper Cosumnes; Upper Sacramento; Upper Yuba).

From Fuller et al. (2019):

"Status: This species is established in several reservoirs and associated tributaries in California (Moyle 1976a; Shapovalov et al. 1981; Courtenay et al. 1986). It has not been recorded in Big Bear Lake since 1960 (Swift et al. 1993)."

From Dill and Cordone (1997):

"By August 1961, Freshwater Lagoon [California] was found to have a self-propagating population of wakasagi. Chemical treatment of Big Bear Lake [California] in 1960 resulted in the killing of some of its smelt, but none have been recorded since according to Swift et al. (1993). In April 1961, one was recorded from Shastina Reservoir [California]."

No records of *H. nipponensis* in trade in the United States were found.

Means of Introductions in the United States

From Froese and Pauly (2019):

"A shipment of 3,600,000 eyed Wakasagi eggs was introduced in 1959 [Lever 1996] by the California Department of Fish and Game as a forage fish for rainbow trout [Courtenay et al. 1984]."

From Dill and Cordone (1997):

"At the time, this fish [*H. nipponensis* when previously considered a subspecies of *H. transpacificus*] was considered to be native in California, resident primarily in the Sacramento-San Joaquin Delta, but difficult to secure. Reliance on a Japanese source was therefore made, and on 10 and 31 March 1959, air shipments of its eyed eggs on palm-fiber mats were received in San Francisco. The eggs were sent from Tokyo but had been taken at Suwa Reservoir about 70 miles to its east where they had been spawned artificially. Upon arrival, many of the eggs were dead, but enough were alive to furnish sizeable plants. Approximately 3,600,000 eggs had been shipped, but the number actually going into each of the six test waters was unknown: tributaries of Dodge Reservoir, Lassen County; Shastina (Dwinnell) Reservoir, Siskiyou County; Freshwater Lagoon, Humboldt County; Spaulding Reservoir, Nevada County; Jenkinson (Sly Park) Reservoir, El Dorado County; and Big Bear Lake, San Bernardino County."

Remarks

From Fuller (2019):

"Dill and Cordone (1997) reviewed its introduction history in California. In documenting the original introduction, Wales (1962) incorrectly identified the species as *Hypomesus olidus*. Several authors (e.g., Moyle 1976a; Lee et al. 1980 et seq.) treated the introduced wakasagi as a subspecies of *H. transpacificus* (i.e., as *H. t. nipponensis*). In California the wakasagi is generally considered a freshwater species, hence its often-used name "freshwater smelt" in that state; however, it has recently been discovered in brackish waters, further threatening the continued survival of the imperiled delta smelt (Dill and Cordone 1997)."

A previous version of this ERSS was published in 2014. Revisions were done to incorporate new information and to bring the document in line with current standards.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Fricke et al. (2019):

"**Current status:** Valid as *Hypomesus nipponensis* McAllister 1963."

From ITIS (2019):

"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 *Hypomesus*
Species *Hypomesus nipponensis* McAllister, 1963"

Size, Weight, and Age Range

From Froese and Pauly (2019):

"Max length : 17.0 cm TL male/unsexed; [Page and Burr 1991]"

Environment

From Froese and Pauly (2019):

"Marine; freshwater; brackish; pelagic; anadromous [Riede 2004]."

Climate/Range

From Froese and Pauly (2019):

"Temperate"

Distribution Outside the United States

Native

From Froese and Pauly (2019):

"Asia: Japan to the Korean Peninsula (not confirmed by [Saruwatari et al. 1997])."

Froese and Pauly (2019) lists that *Hypomesus nipponensis* is native to Japan, Kuril Island, and Russia.

From Saruwatari et al. (1997):

"Distribution. Found in brackish and fresh water throughout the Japanese Archipelago, except for the Ryukyu and Ogasawara Islands […]. Small populations are present in various lakes in California, originating from artificial transplantation of eggs in 1959, at a time when *H. nipponensis* and *H. transpacificus* were thought to be conspecific (see Wales 1962)."

From Chereshnev et al. (2001):

"Thus, our study confirms Klyukanov's viewpoint [Klyukanov 1966; Klyukanov 1970; Klyukanov 1997] that only two species of the genus *Hypomesus*— *H. japonicus* and *H. nipponensis*—inhabit Peter the Great Bay [Russia], […]."

"However, these authors did not give a morphological description of the smelt; hence, it is not improbable that in fact this species is *H. nipponensis*, which is widely distributed from Korea to the mouth of the Amur River [Russia] [Klyukanov 1970; Klyukanov 1977]."

Introduced

Froese and Pauly (2019) lists that *Hypomesus nipponensis* was introduced to China from Korea in the 1940s. The population status is unknown.

NIES (2019) states that *Hypomesus nipponensis* is introduced in Southern Japan which is outside of its native range.

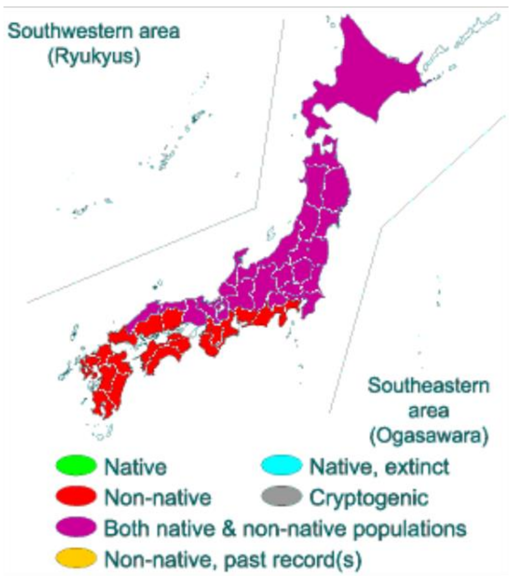

Figure 1. Map of Japan showing the native and non-native range of *Hypomesus nipponensis.* Map from NEIS (2019).

Means of Introduction Outside the United States

Froese and Pauly (2019) lists that *Hypomesus nipponensis* was introduced to China from Korea in the 1940s for aquaculture and fisheries.

From Sasaki et al. (2003):

"*H. nipponensis* are now distributed throughout Japan in more than 100 lakes and rivers due to artificial propagation of eggs [Hamada 1980]."

Short Description

From Saruwatari et al. (1997):

"Description. Dorsal fin rays 10 (8-11); anal fin rays 17 (12-19); pectoral fin rays 13(11-19); pelvic fin rays 8 (7-9); mid lateral-line scales 57 (54-60); transverse scales 15 (12-17); dorsal fin originating dorsal to vertebra 24 (22-25); pelvic fin originating ventral to vertebra 23 (22-25); anus located ventral to vertebra 38 (37-39) […]. Head length 23 (21-26)% of SL, depth 50 (44-

57)% of HL; snout length 32 (24-41)% of HL, width 23 (18-31)% of HL; gape of mouth 42 (34-47)% of HL; interorbital region slightly elevated, dorsal margin of eye located below dorsal margin of head; interorbital width 24 (19-28)% of HL; body depth at opercle 62 (54-72)% of HL; snout to dorsal fin origin 50 (46-54)% of SL; snout to pelvic fin origin 49 (44-54)% of SL; snout to anus 73 (68-80)% of SL; depth of caudal peduncle 29 (24-51)% of HL."

Biology

From Froese and Pauly (2019):

"Found in open water of impoundments and their tributaries, in fresh and brackish water. Primarily a brackish water species [Saruwatari et al. 1997]."

From Saruwatari et al. (1997):

"Life history. *Hypomesus nipponensis* is the most common osmerid in Japan. Although widely thought of as a freshwater fish, it is (together with *Salangichthys microdon*) primarily a brackish-water species (Saruwatari and Okiyama 1992). This misconception finds its root in the widespread transplantation of eggs throughout bodies of freshwater in Japan.

Spawning takes place in the spring. In mainland Honshu, Japan, most individuals mature and spawn in their first year. Post-spawning mortality is almost 100% (Sato 1952, 1953; Katayama and Kawasaki 1994; Katayama and Okata 1995; Katayama et al. 1996). In Hokkaido, some individuals do not mature until year two or even later."

From Lee et al. (2013):

"Pond smelt have flexible migratory behavior and the ability to utilize a wide range of habitats with differing salinities in their life history (Swanson et al. 2000; Arai et al. 2006)."

Human Uses

From Froese and Pauly (2019):

"Fisheries: commercial; aquaculture: commercial"

From Katayama et al. (2000):

"Pond smelt, *Hypomesus nipponensis* McAllister (revised by Saruwatari et al. 1997), inhabit fresh, brackish, and oceanic waters, and support substantial commercial fisheries in Japan (Hamada 1961, Shiraishi 1960, Katayama & Kawasaki 1994)."

From Lee et al. (2013):

"Pond smelt (*Hypomesus nipponensis*) are an important commercial and recreational fishery in Japan and Korea, which are distributed among a wide range of trophic conditions."

Diseases

No records of OIE-reportable diseases (OIE 2019) were found to be associated with *Hypomesus nipponensis.*

Poelen et al. (2014) lists *Proteocephalus tetrastomus*, *Diphyllobothrium hottai*, *Salvelinema salmonicola*, *Acanthocephalus,* and *Hysterothylacium aduncum* as parasites of *Hypomesus nipponensis* and lists *Hypomesus nipponensis* as hosts to *Proteocephalus tetrastomus,* and *Raphidascris gigi*.

Threat to Humans

From Froese and Pauly (2019):

"Potential pest [Lever 1996; no further information given]"

3 Impacts of Introductions

From Stanley et al. (1995):

"Two species of smelt (Osmeridae), *Hypomesus transpacificus* and *Spirinchus thaleichthys,* found in the Sacramento-San Joaquin estuary recently have declined in abundance, and *H. transpacificus* has been threatened by the introduction of nonnative *Hypomesus nipponensis*."

From Sasaki et al. (2003):

"Eyed eggs of *H. nipponensis* were exported to California in 1950s [Joseph 1962] and have established a spawning population in the Sacramento-San Joaquin estuary, threatening the endangered and endemic Delta Smelt, *H. transpacificus* [Peter and Herbold 1992]."

From Ricciardi and Simberloff (2009):

"Hybridization events can occur long after a species is introduced. For example, a Japanese smelt, the wakasagi *Hypomesus nipponensis*, intentionally introduced to reservoirs in California in 1959, was assumed to be innocuous until 35 years later, when it appeared in the Sacramento-San Joaquin estuary and began to hybridize with the endangered delta smelt *H. transpacificus* […] [Dill and Cordone 1997; Moyle 2002]."

From Trenham et al. (1998):

"This study confirms that *H. nipponensis* have invaded the Sacramento–San Joaquin estuary, and they sometimes hybridize with native *H. transpacificus*. This invasion is not surprising, given that *H. nipponensis* have been in the watershed since 1959 (Moyle 1976) and were collected from the Sacramento and American rivers below Folsom Reservoir in 1990 and 1991 (Moyle, unpublished data; J. Wang, CDFG, personal communication)."

"In their native Japan, *H. nipponensis* live in freshwater and brackishwater lakes, created by the damming of estuaries, and spawn in shallow sandy areas (Seki et al. 1981). Delta smelt spawn exclusively in the freshwater reaches of the delta (Moyle et al. 1992). Hybridization of the two species indicates that spawning of wakasagi now also occurs in the freshwater portions of the estuary."

"Interspecific hybrids are fairly common in fish and often occur when (1) one of the two species is rare compared with the other, so that the opportunity of finding a conspecific mate is limited, (2) the two species spawn in close proximity to each other and gametes become mixed as a result, and (3) one of the two species is an invading species (Hubbs 1955). In addition, disturbed habitats often promote hybridization through the breakdown of ecological isolating mechanisms (Moyle and Cech 1996). In the Sacramento–San Joaquin estuary, all of these conditions exist for the two *Hypomesus* species, and hybridization is occurring. In other fishes, hybrids are often sterile, have low survival compared with parental species, or have reduced fertility if they survive and are fertile (Moyle and Cech 1996). Under such conditions, the rarer of the parental species is expected to be most severely affected by hybridization, since a proportionately larger fraction of its total reproductive effort goes into the production of reduced fitness hybrids (Leary et al. 1993). The apparent lack of introgression between *H. transpacificus* and *H. nipponensis* suggests that hybrids are either sterile or inviable in the Delta system and, thus, that massive hybrid breakdown is not likely to be a management concern for delta smelt in the immediate future."

From Fisk and von Geldern (1983):

"Freshwater smelt [*H. nipponensis*] were introduced into several coldwater and combination reservoirs in California in 1959 in the hope they would provide forage for salmonids. […] A cursory, initial evaluation of one of these introductions into Lake Spaulding was positive to the extent that trout utilization of smelt was documented (Nicola and Borgeson 1970)."

"A subsequent 1972 introduction of smelt into Lake Almanor, a 26,000-acre impoundment containing kokanee [*Oncorhynchus nerka*], a variety of other salmonids, and centrarchid bass, resulted in the following: (i) virtual elimination of a prolific kokanee fishery; (ii) very extensive use of smelt by other salmonids (rainbow trout, brown trout (*S. trutta*), coho salmon); (iii) a doubling of the growth rate of coho salmon; and (iv) improvements in growth and size of smallmouth bass taken by anglers. Curiously, increased growth of rainbow trout and brown trout could not be demonstrated despite extensive utilization of smelt by both species."

"Smelt from Lake Almanor eventually migrated down the North Fork Feather River into Lake Oroville, a large "two-story" impoundment containing threadfin shad. Observed impacts were: (i) further declines in an existing kokanee fishery already adversely affected by threadfin shad; (ii) a very significant reduction in the shad population; (iii) very extensive use of smelt of forage by brown trout, coho salmon, and chinook salmon; and (iv) continuing use of threadfin shad as forage by rainbow trout. At this time, it is reasonable to state that smelt introductions have had positive impacts on trout and salmon fisheries sustained by stocking yearlings from hatcheries. It has been hypothesized, however, that young smelt and young centrarchid bass may be competitors because of the smelt's tendency to spawn early in the spring. Until this relationship can be accurately determined, we plan to discourage smelt introductions into water supporting centrarchid bass fisheries."

From Dill and Cordone (1997):

"Unlike the native delta smelt, now known as *Hypomesus transpacificus,* and *Hypomesus olidus,* which is not found in California, the introduced form is generally considered a freshwater species. However, the wakasagi may prove to be more tolerant of brackish water than anticipated. It has recently been observed from "... the lower American River (below Nimbus Dam), Cache Slough off of the Sacramento River and the Mokelumne River system and at the CVP [Central Valley Project] and SWP [State Water Project] fish salvage facilities in the south delta" (6 March 1995 letter from State biologist D. Sweetnam to fish researchers in the Sacramento-San Joaquin Estuary). This does not bode well for survival of the threatened delta smelt, particularly with the recent discovery of hybridization between it and the wakasagi.

The wakasagi is now established in other areas throughout the state, in most cases as a result of transplants (purposeful or accidental) from California waters."

4 Global Distribution

Figure 2. Known global distribution of *Hypomesus nipponensis*. Locations are in eastern Russia, the Korean Peninsula, Japan, and California. Map from GBIF Secretariat (2019). The population in Big Bear Creek, California (location in southern California) is not considered a currently established wild population as it has not been found since the 1960s and was not used to select source points for climate matching.

5 Distribution Within the United States

Figure 3. Known distribution of *Hypomesus nipponensis* in California. Darker and larger points indicate a large cluster of observations. Map from Fuller (2019). The population in Big Bear Creek, California is not considered an established wild population as it has not been found since the 1960s and was not used to select source points for climate matching.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Hypomesus nipponensis* was high to medium for the majority of the contiguous United States with patches of low match in Florida, Texas, the southwestern Great Plains states, Arizona, Washington, and in the southeast, inland from the Gulf coastal areas. A majority of the West Coast was a high match and there were patches of high match around the Great Lakes and long the northeastern border with Canada, along the southern Atlantic Coast and in the Northern Great Plains states. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.342, high (scores of 0.103 and greater are classified as high). A majority of the States had medium or high individual Climate 6 scores except for Louisiana, Mississippi, Nebraska, and Rhode Island, which had low individual scores.

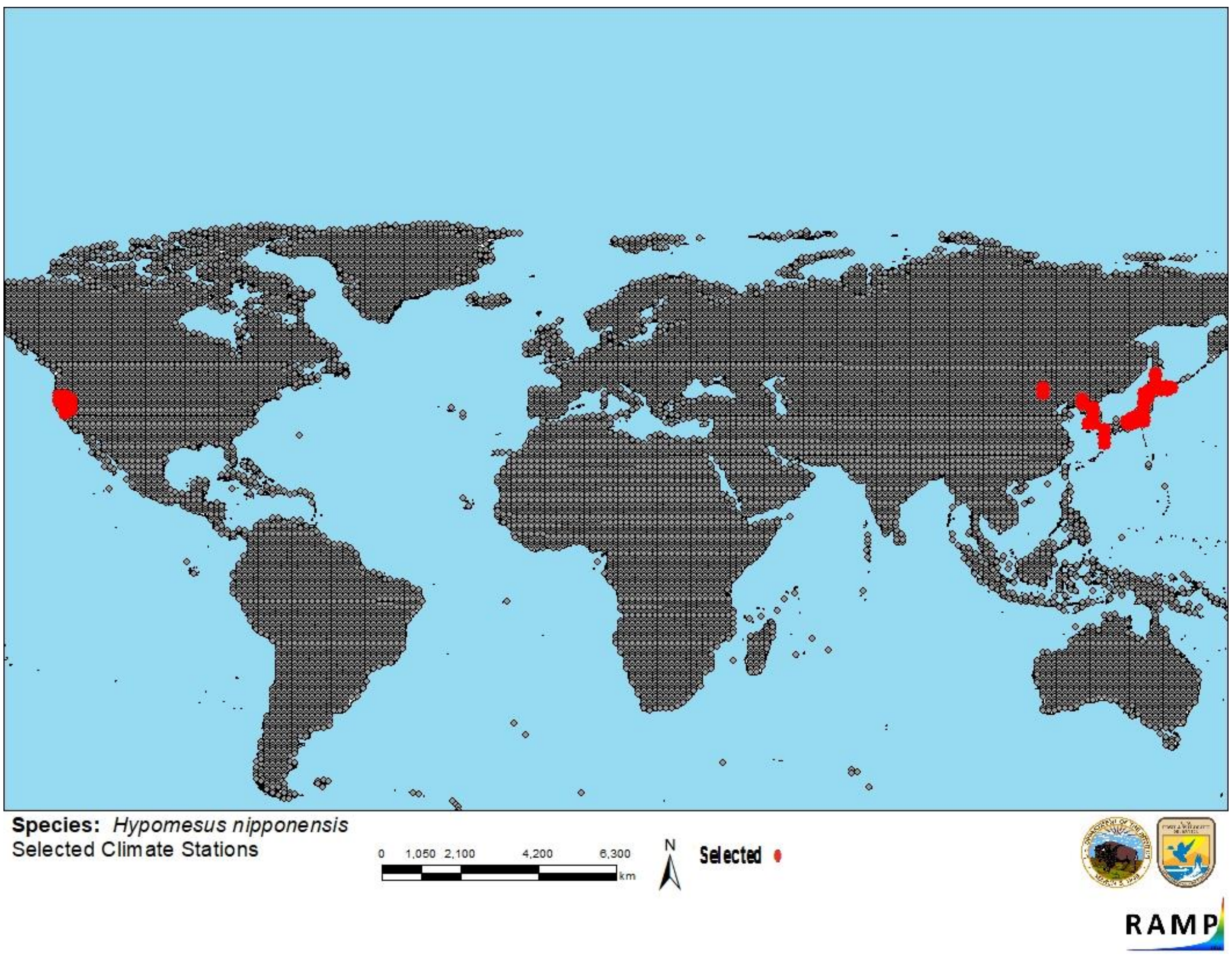

Figure 4. RAMP (Sanders et al. 2018) source map showing weather stations throughout the world selected as source locations (red; United States, Japan, Korea, Kuril Island, and Russia) and non-source locations (gray) for *Hypomesus nipponensis* climate matching. Source locations from GBIF Secretariat (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

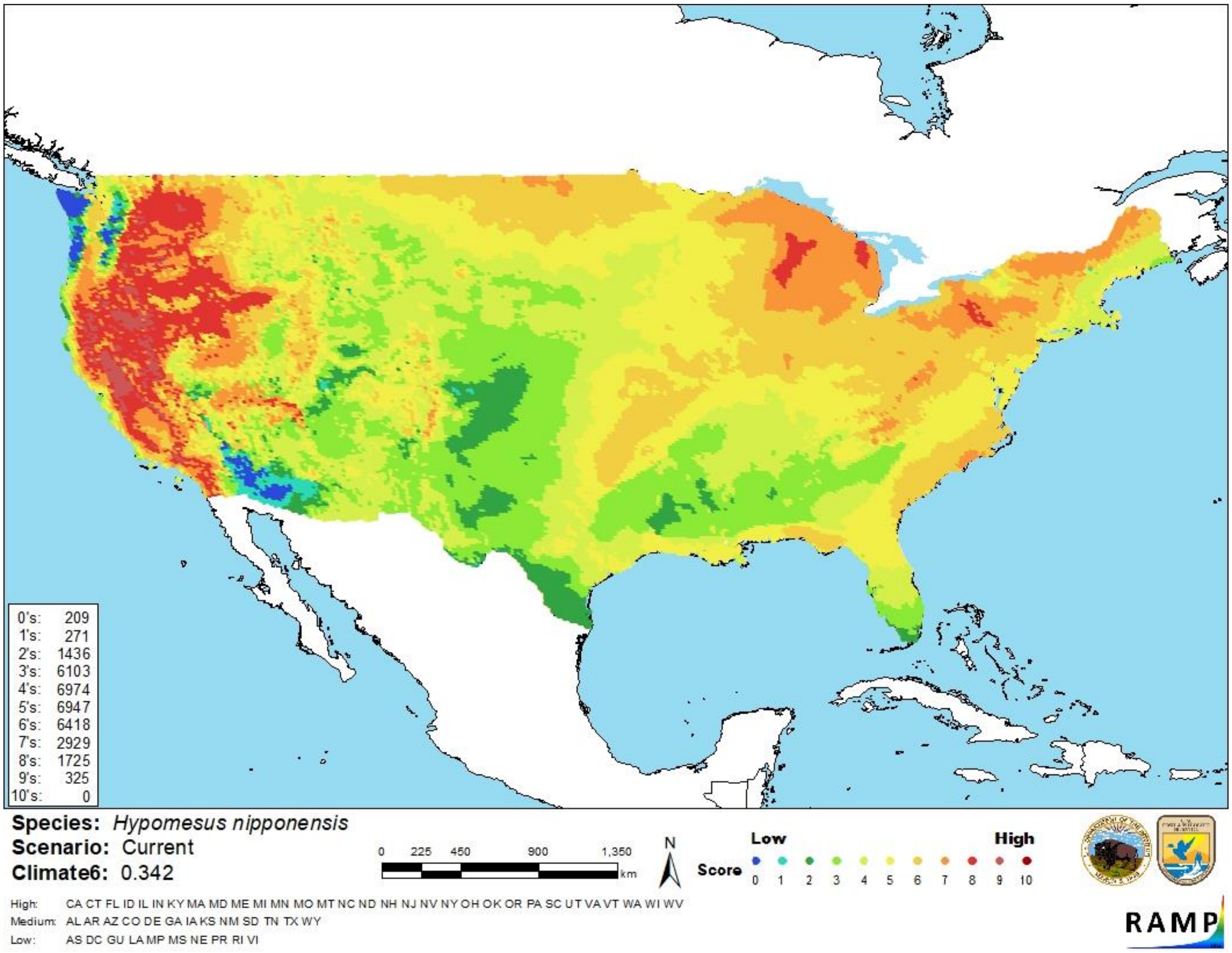

Figure 5. Map of RAMP (Sanders et al. 2018) climate matches for *Hypomesus nipponensis* in the contiguous United States based on source locations reported by GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

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

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

7 Certainty of Assessment

The certainty of assessment for *Hypomesus nipponensis* is medium. Information on the biology and distribution is readily available. Information on introductions and impacts from those introductions was found for *H. nipponensis.* However, the information on documented significant negative impacts comes from grey literature and the native status of the kokanee is uncertain so the certainty of assessment is medium and not high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The Wakasagi (*Hypomesus nipponensis*) is a freshwater and brackish water fish native to eastern Russia, the Korean Peninsula, and areas of Japan. *H. nipponensis* supports both commercial and recreational fisheries. *H. nipponensis* has been introduced in California and now has multiple established populations. There are a few descriptions of negative impacts due to its introduction, including negatively impacted Kokanee Salmon. It has hybridized with the federally listed Delta Smelt (*H. transpacificus*). History of invasiveness is high. Certainty of assessment is medium due to most of the impact information coming from grey literature. This species has a high climate match with the contiguous United States. The majority of the country has a high to medium climate match. Only Louisiana, Mississippi, Nebraska, and Rhode Island have low individual climate scores. The overall risk for this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Medium**
- **Remarks/Important additional information:** No additional remarks.
- **Overall Risk Assessment Category: High**

9 References

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

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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.

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