Pseudodiaptomus inopinus (a copepod, no common name)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
Revised, June 2018
Web Version, 8/30/2018

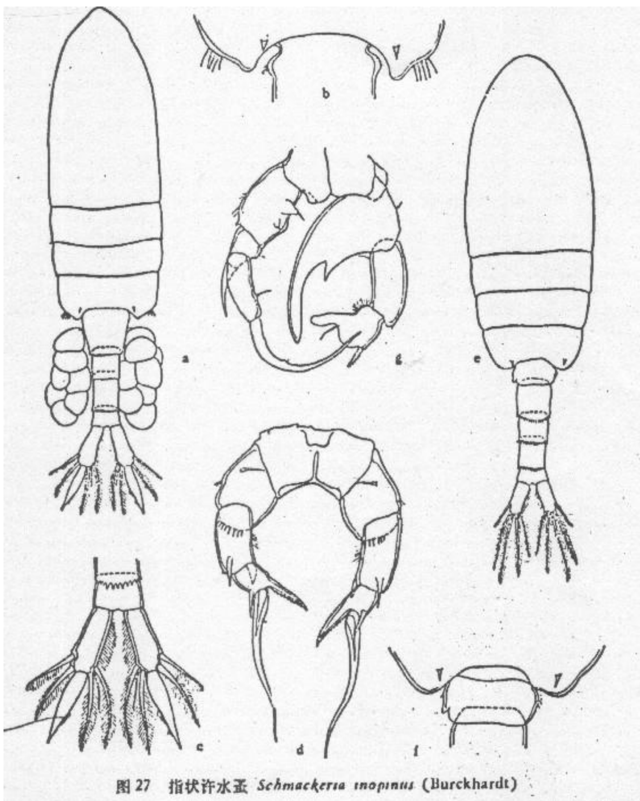

Photo: T. C. Walter. Licensed under CC BY-NC-SA 4.0. Available: http://www.marinespecies.org/aphia.php?p=image&tid=361260&pic=18487. (May 2018).

1 Native Range and Status in the United States

Native Range

From Fofonoff et al. (2018):

"*Pseudodiaptomus inopinus* was described from a freshwater lake in China (Sakaguchi and Ueda 2010). It is native to lakes and estuaries of Asia from Japan, Korea and Guangdong province, China (Cordell et al. 1992; Huang 2001; Sakaguchi et al. 2012)."

Status in the United States

From Fofonoff et al. (2018):

"In September 1990, all the life stages of *Pseudodiaptomus inopinus* were found in the Columbia River estuary, Oregon/Washington, and were fairly abundant at River Mile 12 to 23, but were rare or absent near the mouth (RM 2) or upriver (RM 23) where salinity ranged from 0 to 21 PSU (Cordell et al. 1992). In 1999, another introduced copepod, *P. forbesi*, appeared in the Columbia River and by 2002 it had largely replaced *P. inopinus* (Sytsma et al. 2004). From 2005 to 2013, this species was no longer found in plankton surveys of the Columbia River estuary (Cordell et al. 2008; Bollens et al. 2012; Dexter et al. 2015)."

"In 1991, Cordell and Morrison (1996) surveyed zooplankton in 18 smaller estuaries of the Pacific Northwest, from Campbell River, British Columbia to Coos Bay, Oregon and found specimens of *P. inopinus* in seven of them. Only a single specimen was collected in the Snonomish River, a tributary of Puget Sound. Established populations were found in Chehalis, Washington (WA); Willapa, WA; Youngs, Oregon (OR); Tillamook, OR; Yaquina, OR; Umpqua, OR; Coos, OR; and Coquille and Siuslaw, OR (Cordell et al. 2010)."

Means of Introductions in the United States

From GISD (2018):

"It was introduced to Pacific Northwest estuaries via ballast water between 1980 and 1990 and has rapidly expanded in range since then."

From Fofonoff et al. (2018):

"This copepod was found both in rivers with and without international shipping, suggesting either natural or human-aided dispersal along the coast, and probably an invasion of the Pacific coast some years before its detection. *Pseudodiaptomus inopinus* has been found in the ballast water of ships entering Puget Sound from Asian ports, and so, is likely to be introduced elsewhere on the West Coast (Cordell et al. 2009)."

From Dexter et al. (2018):

"Although introduction of *P. inopinus* to the United States almost certainly occurred through the discharge of ballast water from commercial vessels originating in Asia (the species' native range), the mechanisms and patterns of subsequent spread remain unknown. […] In order to elucidate the migration events shaping this invasion, we sampled the genomes of copepods from seven invasive and two native populations using restriction-site associated DNA sequencing. This genetic data was evaluated against spatially-explicit genetic simulation models to evaluate competing scenarios of invasion spread."

"Our results instead suggest that the North American invasion of *P. inopinus* has been structured via a series of infrequent and stochastic dispersal events. This conclusion is strongly supported by our genetic simulations and corresponding ABC analysis. At first glance, the stepping-stone model (model 1) appears to produce a slightly better fit for the observed genetic data than the pulsed-migration (model 3), with a Bayes factor (a pairwise comparison of probability) of 1.11. However, support falls strongly in favor of model 3 when overall goodness-of-fit is considered."

"The tight clustering of the North American samples on the PCA ordination […] suggests that these invasive populations arose from a common source population. […] Alternatively, the North American populations may have arisen from multiple source populations with subsequent admixture (and thus loss) of distinct genetic signatures occurring within the invaded range. However, this alternative interpretation is lacking in support given the evidence for limited gene flow within the invaded range."

Remarks

From Walter and Boxshall (2018):

"Synonymised names *Pseudodiaptomus japonicus* Kikuchi K., 1928 (synonym)
Schmackeria inopinus (Burckhardt, 1913) (synonym)"

The above synonyms were used, in addition to the valid scientific name, to search for information for this report.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Protostomia
Superphylum Ecdysozoa
Phylum Arthropoda
Subphylum Crustacea
Class Maxillopoda
Subclass Copepoda
Infraclass Neocopepoda
Superorder Gymnoplea
Order Calanoida
Family Pseudodiaptomidae
Genus *Pseudodiaptomus*
Species *Pseudodiaptomus inopinus* Burckhardt, 1913"

"Taxonomic Status:
Current Standing: valid"

Size, Weight, and Age Range

From GISD (2018):

"*Pseudodiaptomus inopinus* is typically 1-2mm long, […]"

Environment

From Fofonoff et al. (2018):

"It is characteristic of brackish water, and occurs from 0 to 26 PSU, and 10-31°C, but is rare above 5-8 PSU (Cordell et al. 1992; Cordell and Morrison 1996; Cordell et al. 2011; Sakaguchi et al. 2011)."

From Cordell et al. (2007):

"*Pseudodiaptomus inopinus* is geographically widespread throughout Asia and occurs in a variety of fresh water and estuarine habitats (Mashiko 1951, Shen & Song 1979, Oka et al. 1991). In Asian estuaries it is part of a plankton assemblage that occurs mainly in fluvialoligohaline reaches at salinities of 0 to 5 psu and is most abundant in autumn (Suh et al. 1991)."

From GISD (2018):

"\r\nIn [*sic*] its introduced habitat *P. inopinus* has only invaded coastal estuaries with relatively high temperatures, low elevation gradients and large salinity transition zones. It is confined predominantly to the lower salinity (<10 psu) reaches of estuaries, with peak abundances occurring in the 2-5 psu range (Bollens et al. 2002)."

Climate/Range

From Fofonoff et al. (2018):

"Cold temperate-Warm temperate"

Distribution Outside the United States

Native

From Fofonoff et al. (2018):

"*Pseudodiaptomus inopinus* was described from a freshwater lake in China (Sakaguchi and Ueda 2010). It is native to lakes and estuaries of Asia from Japan, Korea and Guangdong province, China (Cordell et al. 1992; Huang 2001; Sakaguchi et al. 2012)."

Introduced

This species has not been reported as introduced or established outside of its native range and the United States.

Means of Introduction Outside the United States

This species has not been reported as introduced or established outside of its native range and the United States.

Short Description

From Fofonoff et al. (2018):

"In adult *Pseudodiaptomus inopinus*, regardless of sex, the head carapace is fused with the 1st thoracic segment (Sakaguchi and Ueda 2010). In adult females, the antennules are symmetrical. Thoracic segments 4 and 5 are fused, and the prosomites on segments 2 to 4 have rows of fine spinules laterally along the posterior margins. The fused segments 4-5 have rounded corners and small spinelike process dorsally. The terminal end of segments 4-5 has a small bump, with several spinules and a row of spinules on the posterolateral corner on each side. The genital double-somite is 1.1 times longer than wide, with several spinules on each anterolateral projection, with long anterolateral setae and dorsolateral rows of spinules at one-third and two thirds anteriorly on each side. The posterior process of the genital flap is pointed and longer than that of the closely related *P. nansei* sp. nov. (Sakaguchi and Ueda 2010). The caudal rami are symmetrical. The medial terminal setae are greatly swollen, and equal in length to the rami. The 5th pair of swimming legs is symmetrical. The coxa (basal segment) of swimming leg 5 has spinules on posterior and anterior surfaces. The first exopodal segments have round distomedial processes. The second segments have inward pointing thum-blike distal processes. The terminal spine of the third segment lacks a notch at the base and has three terminal spines, including a short medial anterior spine with medial teeth (Fig. 7I in Sakaguchi and Ueda 2010). The length ranges from 1.38 to 1.44 mm and the egg masses are symmetrical (Shen 1979). Description based on Sakaguchi and Ueda 2010."

"In adult males, the left antenna has 22 segments, while the right has 20 segments, with segments 6-7 incompletely fused and segments 15-17 expanded. The 19th segment has a proximal ridge, covered with fine hairs. The 2nd to 4th thoracic segments have a group of minute spinules near the anteroventral corners. The 5th thoracic segment has a spinelike process dorsally, and posterolateral spinules on each corner. The second urosomite has a patch of minute spinules anterolaterally and ventral transverse rows of spinules. The 5th swimming legs (P5) are asymmetrical. The left P5 lacks spinules at the base of the distal smaller process of the basoendopod. The second exopodal segment (based on five specimens) varies from narrow to paddle-shaped. On the right P5, the 1st basipodite segment has two rows of spinules and the medial margin is produced into a small truncated triangular process. The 2nd basipodite segment has two small surface spinules. The right P5's first exopodal segment has a proximomedial spinule with a distolateral spine extending more than mid length of the second segment with small lateral spines. The third segment is not swollen proximally. The 1st and 2nd endopod segments have large external spines. The 3rd segment is elongate, with two medial knobs and serrated edges. The left P5 has a 1st basipodite segment similar to the right leg, but without the triangular process. The 2nd segment has the medial margin produced into a very long two-pronged process, with margins serrated between the two points. The longer point extends beyond the 1st segment of the endopod. The 2nd endopod has a serrated external spine. Two morphs occur: one which the distomedial end is a thumb-like process edge, separated from the lateral side by a shallow V-shaped notch; and the other in which the whole endopod is a broad paddle-shaped lobe. The body length ranges from 1.10 to 1.15 mm. Description based on Cordell et al. 2007 and Sakaguchi and Ueda 2010."

From Dexter et al. (2018):

"[…] *P. inopinus* copepodites can be readily distinguished from co-occurring copepods in the North American range via a characteristic arrangement of its caudal setae visible in all copepodite stages (Dexter, personal observation)."

Biology

From Fofonoff et al. (2018):

"Planktonic calanoid copepods mate in the water column. Males use their modified antenules and 5th pair of swimming legs to grasp the female and transfer spermatophores to the female's genital segment. Female *Pseudodiaptomus inopinus* carry eggs in two symmetrical clusters under the abdomen (Barnes 1983; Cordell et al. 1992; Cordell et al. 2007). Eggs hatch into nauplii which go through six stages. The first stage, NI, has 3 pairs of appendages and is unsegmented - each molt has additional appendages and/or more differentiation of segments. The sixth stage (NVI) molts into a first copepodite stage (CI), with the basic form of the adult, and fully differentiated feeding structures, but with only two pairs of swimming legs, and only one urosomal segment. The copepod goes through five additonal [sic] molts, with increasing numbers of swimming legs, urosomal segments, and sexual differentiation. The sixth (CVI) stage is the male or female adult (Uye and Onbe 1975; Barnes 1983)."

"*Pseudodiaptomus inopinus*, like many other copepods of its genus, is characteristic of estuaries with low-salinity waters (Walter 1989; Orsi and Walter 1991). It is capable of completing its life cycle in freshwater, and inhabits tidal fresh waters. Late copepodites and adults of the genus *Pseudodiaptomus* often have strong epibenthic tendencies, particularly by day, and when carrying eggs. Adult and late copepodites of *P. inopinus* migrated to the surface at night in the Chehalis River (Washingotn [*sic*]), apparently as a means of avoiding visual predators. In the Chehalis, major predators were mysids (*Neomysis mercedis*) and shrimps (*Crangon* spp.) (Cordell et al. 2007). Migration was not seen in the Columbia River (Oregon/Washington), which is more turbid than the Chehalis (Cordell et al. 1992). Adults may cling to hard surfaces using adhesive hairs on their antennules, and filter in place (Fofonoff, personal observation of *P. pelagicus*, Narragansett Bay). All life stages feed on phytoplankton, although adults may also capture ciliates, rotifers, and copepod nauplii (Barnes 1983)."

Human Uses

No information available.

Diseases

No information available. No OIE-listed diseases have been documented for this species.

Threat to Humans

No information available.

3 Impacts of Introductions

No scientifically credible negative impacts of introduction have been documented for *P. inopinus*, although some impacts have been suggested.

From Fofonoff et al. (2018):

"The impacts of *Pseudodiaptomus inopinus* in Pacific Northwest rivers are unclear. In the Columbia River, Oregon/Washington, it was displaced by *P. forbesi* within a decade. In the Chehalis River, Washington, where it reached high abundances by 1991, it reaches peak abundance in the fall, while the native Northeast Pacific form of '*Eurytemora affinis*' reaches its peak in the spring. While both species overlap, the temporal separation of the peak abundances may limit competition. *Pseudodiaptomus inopinus* was an important food for fish prey such as the mysid *Neomysis mercedis* and juvenile shrimp *Crangon* spp. in late summer and fall, but was rarely directly eaten by fishes. It is not clear to what extent *P. inopinus* has altered food webs in Pacific Northwest rivers."

From Cordell et al. (2007):

"*Pseudodiaptomus inopinus* may have encountered little competition for resources in its invaded habitats, because there appear to be few native holoplanktonic taxa that co-occur with it in the brackish-oligohaline regions of northeast Pacific estuaries."

From Dexter et al. (2018):

"In affected bodies of water, there are marked seasonal losses of zooplankton community diversity. Indeed, plankton surveys undertaken during late summer and early autumn have shown that, while non-invaded rivers exhibit a diverse assemblage of copepod species (>8 commonly abundant species), invaded rivers tend to be completely dominated by *P. inopinus* (Bollens et al. 2002; Cordell et al. 2008). It remains unclear if *P. inopinus* is the causal agent of these declines in diversity, or if the presence of a relatively depauperate community facilitated the establishment of *P. inopinus* at these locations. Curiously, *P. inopinus* appears to have been extirpated in the Columbia River, the presumed site of first introduction, potentially due to the establishment of a latter-arriving congeneric copepod, *P. forbesi* (Cordell et al. 2008; Bollens et al. 2012; Dexter et al. 2015)."

From Grosholz (2002):

"[…] the introduced Asian copepod *Pseudodiaptomus inopinus* has invaded many estuaries in the Pacific Northwest (USA) and is the dominant zooplankton in many of these [Cordell and Morrison 1996]. Although its ecological impact on primary production is likely to be significant, this impact has yet to be quantified."

4 Global Distribution

Figure 1. Known global distribution of *Pseudodiaptomus inopinus*, reported from eastern Asia and western North America. Map from GBIF Secretariat (2018).

5 Distribution Within the United States

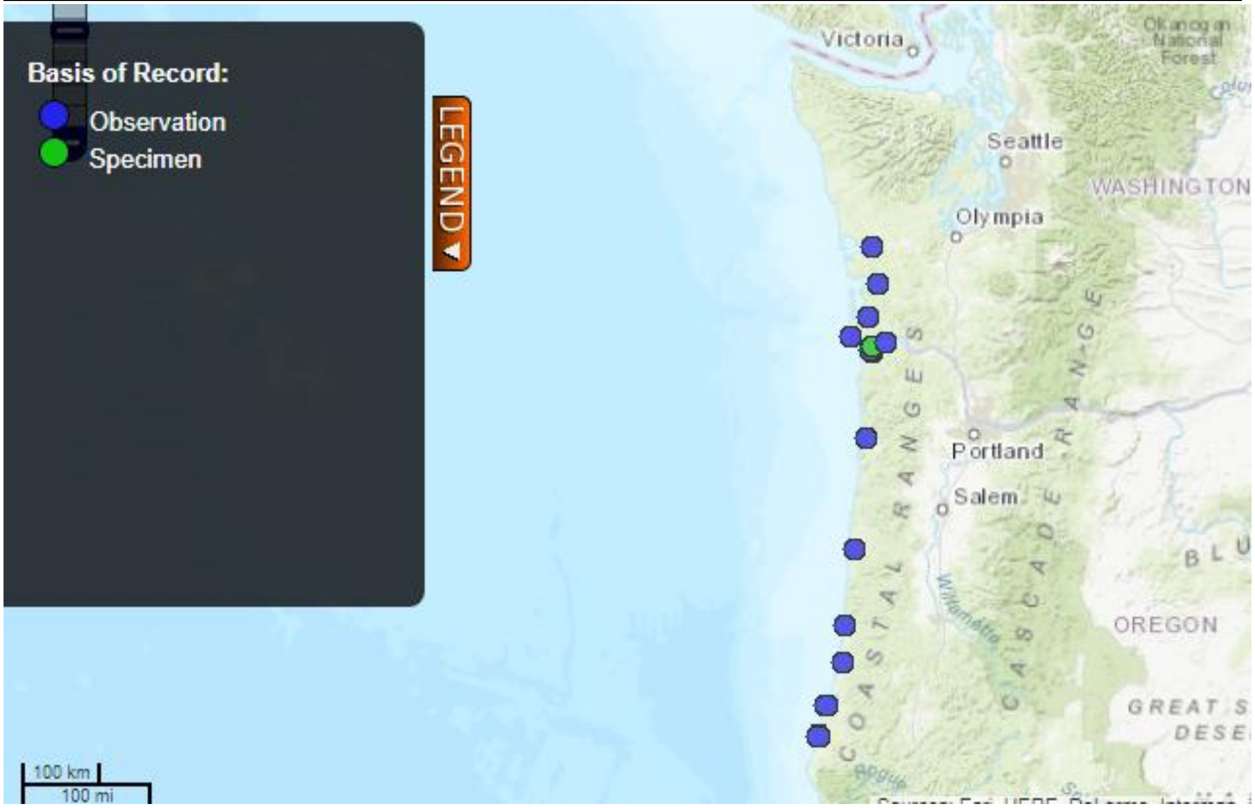

Figure 2. Known distribution of *Pseudodiaptomus inopinus* in the United States, reported from coastal Washington. Map from BISON (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.021, which is a medium climate match. The climate match was high in California, Oregon, and Washington, which is consistent with the current known distribution of *P. inopinus*. This species has been reported as established along the coast of Oregon and Washington. All other states in the contiguous U.S. had a low climate match.

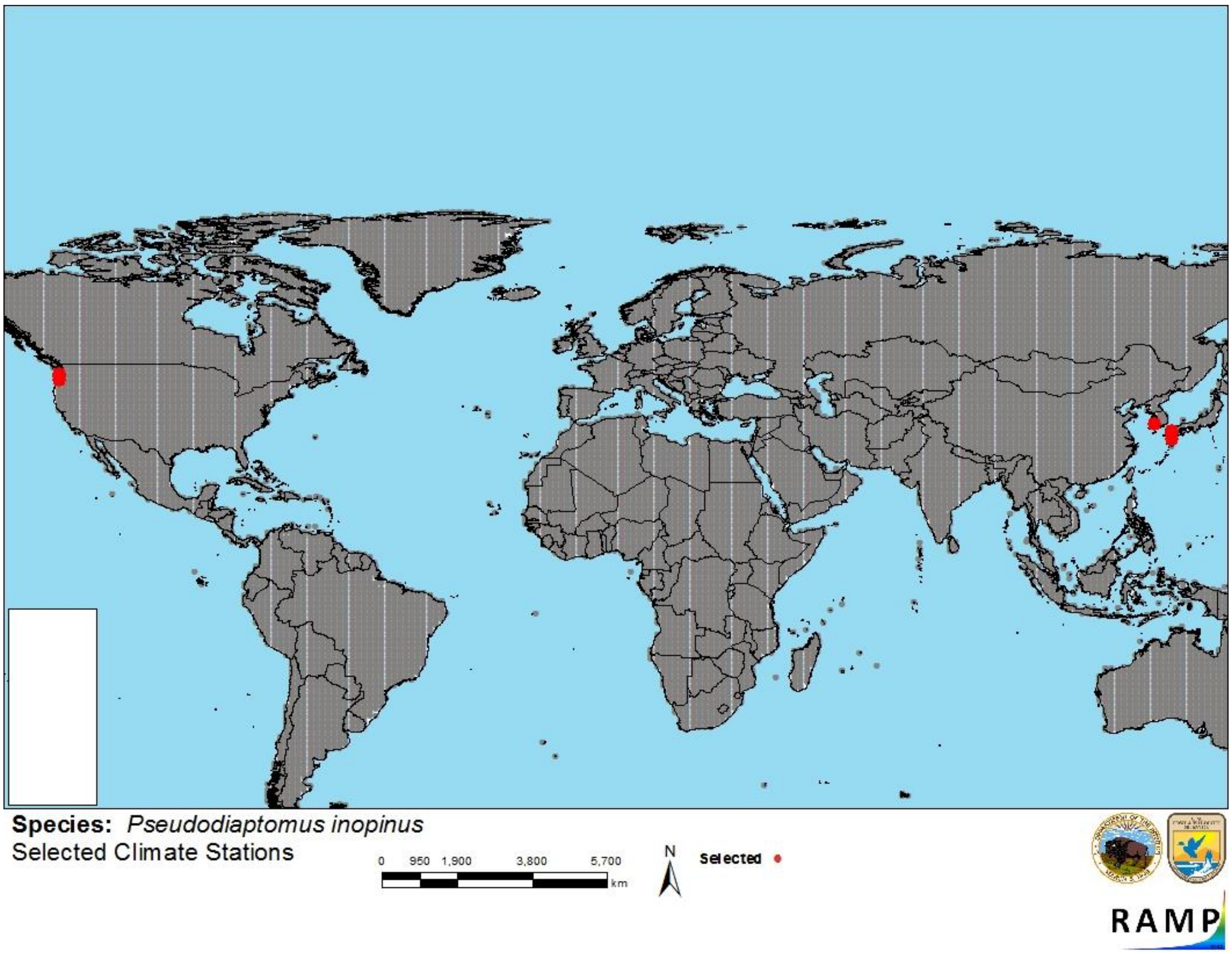

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red; United States, Japan, Korea) and non-source locations (gray) for *Pseudodiaptomus inopinus* climate matching. Source locations from GBIF Secretariat (2018).

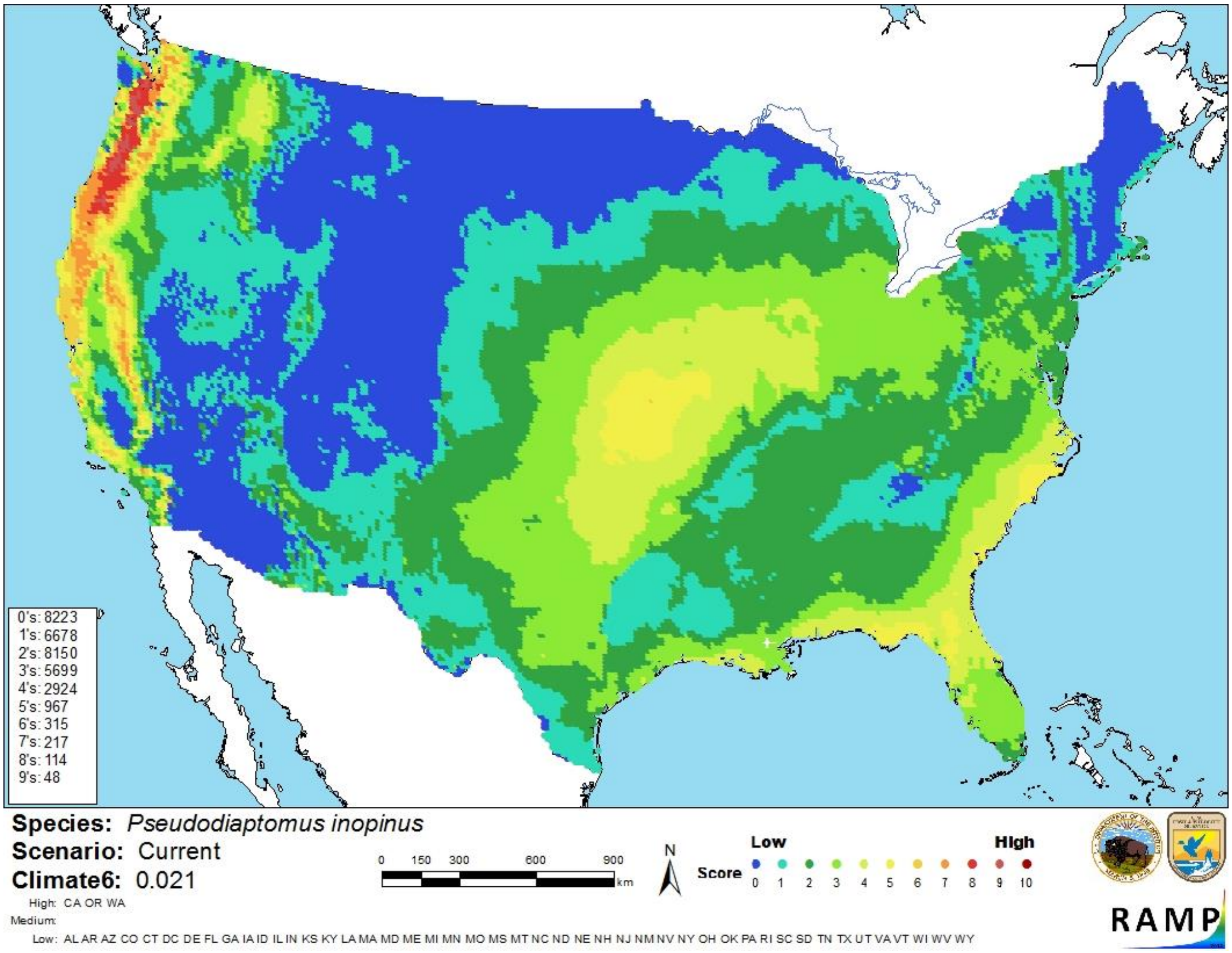

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Pseudodiaptomus inopinus* in the contiguous United States based on source locations reported by GBIF Secretariat (2018). 0= Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

The “High”, “Medium”, and “Low” climate match categories are based on the following table:

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

7 Certainty of Assessment

There is adequate information about the biology and distribution of *Pseudodiaptomus inopinus*. Its invasion of the Pacific Northwest has been documented in the scientific literature. Despite this, there is no definitive information available about impacts of introduction of this species. More information is needed to determine the impacts of this species in the United States. Certainty of this assessment is low.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Pseudodiaptomus inopinus, the Asian Calanoid Copepod, is a species native to Japan, Korea, and China. It has been introduced to the Pacific Northwest U.S. via ballast water from shipping vessels originating in Asia. It has become the dominant zooplankton species in some Pacific Northwest rivers, but it is not clear if it has outcompeted native species. *P. inopinus* has a medium climate match with the contiguous U.S. Further information is needed to determine what impacts this species is having where introduced, so the certainty of this assessment is low. The overall risk assessment category is also therefore uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): None Documented**
- **Climate Match (Sec. 6): Medium**
- **Certainty of Assessment (Sec. 7): Low**
- **Overall Risk Assessment Category: Uncertain**

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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10 References Quoted But Not Accessed

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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