Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Hediste diadroma*

Common Name *a clam worm*

Phylum	Annelida
Class	Polychaeta
Order	Phyllodocida
Family	Nereididae

Species Occurrence by Ecoregion

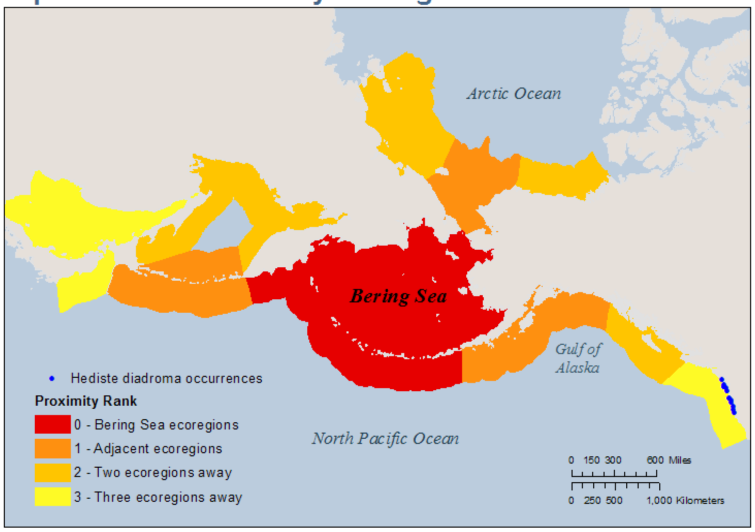

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Final Rank 38.83

Data Deficiency: 10.50

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	9.75	30	0
Anthropogenic Influence:	4.75	10	0
Biological Characteristics:	18.75	25	5.00
Impacts:	1.5	25	5.50
Totals:	34.75	89.50	10.50

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	NA	Minimum Salinity (ppt)	4
Maximum Temperature (°C)	NA	Maximum Salinity (ppt)	34
Minimum Reproductive Temperature (°C)	18	Minimum Reproductive Salinity (ppt)	4
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	20

Additional Notes

Hediste diadroma is a polychaete worm with an elongated, cylindrical body that gradually tapers towards the posterior end. In their native range (Japan), individuals are up to 150 mm in length (Sato and Nakashima 2003), but the largest specimen observed in North America is 43 mm (Nishizawa et al. 2014). Females are green in color and males are yellow and white with a prominent dorsal blood vessel (Hanafiah et al. 2006). When breeding, H. diadroma undergoes a morphological change, as the body wall becomes thin and transparent. Morphological identification of sexually immature Hediste spp. is very difficult. H. diadroma is Native to the Northwest Pacific (Japan). The first reported introduction to North America was on the west coast of Washington and Oregon in 2009. Its abundance, geographical distribution, and ecological impacts in North American waters is unknown.

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

Choice: C Little overlap – A small area (<25%) of the Bering Sea has temperatures suitable for year-round survival

Score: 1.25 of 3.75

High uncertainty? ✔

Ranking Rationale:
Temperature thresholds required for survival are unknown. Because this species can reproduce in cold waters, we assume that there is at least some suitable year-round habitat in the Bering Sea. We therefore ranked this species as "Little overlap" with "High Uncertainty".

Background Information:
General surival requirements were not available in the literature. Reproductive temperature range is from 5 to 20°C (Hanafia et al. 2006, qtd. in Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

1.2 Survival requirements - Water salinity

Choice: A Considerable overlap – A large area (>75%) of the Bering Sea has salinities suitable for year-round survival

Score: 3.75 of 3.75

High uncertainty? ✔

Ranking Rationale:
Salinities required for year-round survival occur over a large (>75%) area of the Bering Sea. We ranked this question with "High Uncertainty" to indicate disagreements in model estimates.

Background Information:
Based on field observations, salinity range for H. diadroma is 4 to 34 ppt (Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

1.3 Establishment requirements - Water temperature

Choice: D No overlap – Temperatures required for reproduction do not exist in the Bering Sea

Score: 0 of 3.75

Ranking Rationale:
Temperatures required for metamorphosis do not exist in the Bering Sea.

Background Information:
The temperature range required for reproduction of H. diadroma is 5°C to 20°C (Hanafia et al. 2006 as qtd. in Fofonoff et al. 2003). In a laboratory setting, immature animals required temperatures of 18°C for metamorphosis (Nishizawa et al 2014).

Sources:
NEMESIS; Fofonoff et al. 2003 Nishizawa et al. 2014

1.4 Establishment requirements - Water salinity

Choice: D No overlap – Salinities required for reproduction do not exist in the Bering Sea

Score: 0 of 3.75

High uncertainty? ✔

Ranking Rationale:
Physiological salinity requirements are unknown. However, this species appears to undergo early life stages in brackish waters < 20 ppt. These salinities do not exist in the Bering Sea.

Background Information:
H. diadroma are typically found in brackish waters during reproduction and immature worms are most abundant in mesohalinehabitats of 4 to 19 ppt.

Sources:
NEMESIS; Fofonoff et al. 2003

1.5 *Local ecoregional distribution*

Choice: D Present in an ecoregion greater than two regions away from the Bering Sea

Score: 1.25 of 5

Ranking Rationale:
Washington is the closest known occurrence record to the Bering Sea.

Background Information:
H. diadroma has been observed in Washington, Oregon and California (NEMESIS; Fofonoff et al 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

1.6 *Global ecoregional distribution*

Choice: C In few ecoregions globally

Score: 1.75 of 5

Ranking Rationale:
Limited distribution.

Background Information:
H. diadroma is native to the Northwest Pacific (China and Japan). The first reported introduction to North America was on the west coast of Washington and Oregon in 2009. It has been reported in Washington, Oregon and at least one location in California (NEMESIS; Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

1.7 *Current distribution trends*

Choice: C Established outside of native range, but no evidence of rapid expansion or long-distance dispersal

Score: 1.75 of 5

Ranking Rationale:
Well established in North America but is limited by its dispersal ability

Background Information:
Range expansion along the west coast of North America is likely the result of repeated introductions from its native range to the U.S. (Tosuji and Furota 2016). No information was found on natural dispersal distances in the literature.

Sources:
Torchin et al. 2005 Tosuji and Furota 2016

Section Total - Scored Points:	9.75
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

2. Anthropogenic Transportation and Establishment

2.1 Transport requirements: relies on use of shipping lanes (hull fouling, ballast water), fisheries, recreation, mariculture, etc. for transport

Choice: B

Has been observed using anthropogenic vectors for transport but has rarely or never been observed moving independent of anthropogenic vectors once introduced

Score: 2 of 4

Ranking Rationale:

Transportation has been observed in ballast water, however dispersal away from ports has not been observed.

Background Information:

The introduction of H. diadroma to the western U.S. is thought to be the result of transportation by ballast water (Nishizawa et al. 2014).

Sources:

Nishizawa et al. 2014

2.2 Establishment requirements: relies on marine infrastructure, (e.g. harbors, ports) to establish

Choice: B

Readily establishes in areas with anthropogenic disturbance/infrastructure; occasionally establishes in undisturbed areas

High uncertainty? ✔

Score: 2.75 of 4

Ranking Rationale:

Information is lacking on the distribution and dispersal of this species in its introduced range. This species can establish in natural habitats away from anthropogenic infrastructure, but the extent to which it does that is unknown.

Background Information:

This species can spread outside of major international shipping areas where it is likely to have been introduced (Nishizawa et al. 2014). Nishizawa et al. (2014) sampled six sites in Oregon and Washington. All of these sites were near roads, but one was near the relatively remote Willapa National Wildlife Refuge.

Sources:

Nishizawa et al. 2014

2.3 Is this species currently or potentially farmed or otherwise intentionally cultivated?

Choice: B

No

Score: 0 of 2

Ranking Rationale:

Background Information:

H. diadroma is not currently farmed or intentionally cultivated.

Sources:

None listed

Section Total - Scored Points:	4.75
Section Total - Possible Points:	10
Section Total -Data Deficient Points:	0

3. Biological Characteristics

3.1 Dietary specialization

Choice: **A** Generalist at all life stages and/or foods are readily available in the study area

Score: 5 of 5

Ranking Rationale:
Can feed on a variety of things found readily in the Bering Sea.

Background Information:
H. diadroma is a surface-deposit feeder that feeds on detritus, benthic microalgae and settling phytoplankton (Kanaya et al. 2008). It has the ability to secrete a mucous net that is used to trap planktonic particles for food (Toba and Sato 2013).

Sources:
Kanaya et al. 2008   Toba and Sato 2013

3.2 Habitat specialization and water tolerances

Does the species use a variety of habitats or tolerate a wide range of temperatures, salinity regimes, dissolved oxygen levels, calcium concentrations, hydrodynamics, pollution, etc?

Choice: **B** Requires specialized habitat for some life stages (e.g., reproduction)

Score: 3.25 of 5

Ranking Rationale:
Requires estuaries with sandy or muddy tidal flats for adult life stages.

Background Information:
In its native range, H. diadroma is found in estuaries where it burrows into sandy or muddy tidal flats. H. diadroma is tolerant of a wide range of salinities (Sato and Nakashima 2003) and temperatures, with different habitats used during different life stages.

Embryos and larvae are planktonic and need high salinities (>20 ppt) during development; at these life stages, individuals are found in the sea. Young return to brackish waters ~1 month after fertilization, where they adopt a benthic lifestyle (Sato and Nakashima 2003).

Changes in the spatial distribution of H. diadroma following the 2011 tsunami suggests that this species preferred sandy, oxidized substrates (post-tsunami), rather than the pre-tsunami habitat, a hypertrophic lagoon whose muddy substrate was high in hydrogen sulfide (Kanaya et al. 2015).

Sources:
Sato and Nakashima 2003   Kanaya et al. 2015

3.3 Desiccation tolerance

Choice: **U** Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

3.4 *Likelihood of success for reproductive strategy*

i. Asexual or hermaphroditic ii. High fecundity (e.g. >10,000 eggs/kg) iii. Low parental investment and/or external fertilization iv. Short generation time

Choice: **A** — High – Exhibits three or four of the above characteristics

Score: 5 of 5

Ranking Rationale:
High fecundity, low parental investment and external fertilization, and short generation time.

Background Information:
H. diadroma has a diadromous, migratory lifecycle. Individuals exhibit reproductive swarming behavior during the spawning season which occurs during winter or early spring (January to April). Swarming has been reported as late as June in northern Japan (Sato and Nakashima 2003). Gametes release and fertilization occur in salt water near river entrances. Females release 10,000 to 1 million eggs per individual, and adults die after spawning (lifespan: 1 year).

Sources:
Sato and Nakashima 2003

3.5 *Likelihood of long-distance dispersal or movements*

Consider dispersal by more than one method and/or numerous opportunities for long or short distance dispersal e.g. broadcast, float, swim, carried in currents; vs. sessile or sink.

Choice: **A** — Disperses long (>10 km) distances

Score: 2.5 of 2.5

Ranking Rationale:
Dispersal primarily occurs during the larval stage and can travel using tides, up to distance of 45 km.

Background Information:
Adults are largely sessile for majority of their life, living in self-constructed burrows. Adults engage in migratory, seaward movements when it is time to spawn, but the distance they travel during those movements is unknown. Based on sampling distances and study area description, distances of up to 45 km are possible, and coincide with tidal movements (Kikuchi and Yasuda 2006). Larval stage is long-lived and planktonic, and resides in the sea.

Sources:
Kikuchi and Yasda 2006

3.6 *Likelihood of dispersal or movement events during multiple life stages*

i. Can disperse at more than one life stage and/or highly mobile ii. Larval viability window is long (days v. hours) iii. Different modes of dispersal are achieved at different life stages (e.g. unintentional spread of eggs, migration of adults)

Choice: **B** — Moderate – Exhibits one of the above characteristics

Score: 1.75 of 2.5

Ranking Rationale:
Dispersal occurs primarily during one lifestage (larval), however, that stage is relatively long (1 month).

Background Information:
In the Nanakita River estuary in northeastern Japan, the life cycle of H. diadroma includes several movements along a salinity gradient: (1) benthic adults in euryhaline estuaries, (2) reproductive swarming of mature adults around river mouths, (3) small eggs developing into free-swimming larvae under relatively high salinity (favorable salinity 22–30 psu), (4) planktonic larval life at sea, lasting 1 month, and (5) upstream migrations and settlement of larvae into brackish waters.
Besides their reproductive swarming behaviour, adults are likely relatively sedentary, living in burrows that they construct

Sources:
NEMESIS; Fofonoff et al. 2003

3.7 Vulnerability to predators

Choice: **D** — Multiple predators present in the Bering Sea or neighboring regions

Score: **1.25** **of** **5**

Ranking Rationale:
H. diadroma has numerous predators, many of which exist in the Bering Sea.

Background Information:
In its native range, H. diadroma is a major dietary component of five migratory shorebirds (Iwamatsu et al. 2007 as qtd. In Fofonoff et al. 2003).
H. diversicolor, which is a closely related species in Europe, is highly prone to predation by birds, large crabs (Carcinus maenas), shrimps and small fish (gobies) that migrate onto the mudflats from lower tidal levels (Scaps 2002).

Sources:
NEMESIS; Fofonoff et al. 2003   Scaps 2002

Section Total - Scored Points:	18.75
Section Total - Possible Points:	25
Section Total -Data Deficient Points:	5

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: **D** No impact

Score: 0 of 2.5

Ranking Rationale:
No literature to suggest that H. diadroma, or closely related species have an impact on community composition.

Background Information:
H. diversicolor, a closely related European species, is associated with large numbers of heterotrophic bacteria and a higher concentration of chlorophyll a. Oxygen availability in burrow environments may affect growth and population sizes of associated organisms. A study on the island of Sylt found that the density of small, benthic organisms near burrows was nearly 8X greater than reference (non-burrow) sites at the same sediment depth. Diversity was not affected by H. diversicolor burrows.

In OR and WA, H. diadroma co-occurs with a native species H. limnicola (Nishizawa et al. 2014). At many sites, Hediste diadroma has replaced H. limnicola in the more saline intertidal portions of estuaries, while H. limnicola remains dominant at salinities below 5 PSU and in subtidal habitats (Tosuji and Furota 2016, qtd. in Fofonoff et al. 2003)

Sources:
Anderson and Meadows 1978 Nishizawa et al. 2014 NEMESIS; Fofonoff et al. 2003

4.2 Impact on habitat for other species

Choice: **C** Limited – Has limited potential to cause changes in one or more habitats

Score: 0.75 of 2.5

Ranking Rationale:
May increase biogeochemical cycling.

Background Information:
H. diadroma is a burrowing species which may have a limited effect on habitat for other species by increasing oxygen and sediment transport in areas it inhabits (Kristensen and Hansen 1999).

Sources:
Kristensen and Hansen 1999

4.3 Impact on ecosystem function and processes

Choice: **C** Limited – Causes or potentially causes changes to food webs and/or ecosystem functions, with limited impact and/or within a very limited region

Score: 0.75 of 2.5

High uncertainty? ☑

Ranking Rationale:
If H. diadroma is similar to H. diversicolor, it may alter sediment biogeochemistry and element cycling in small areas.

Background Information:
H. diversicolor, a closely related European species, affects ecosystem processes through its feeding and burrowing behaviors, which transport solutes and water, and promote oxygenation and microbial growth. This aids in the release of carbon dioxide and ammonium (Kristensen and Hansen 1999). Also increases nutrient and heavy metal fluxes in the water column (Scaps 2002).

Sources:
Kristensen and Hansen 1999 Scaps 2002

4.4 Impact on high-value, rare, or sensitive species and/or communities

Choice: D No impact

Score: 0 of 2.5

Ranking Rationale:
To date, no impacts on high-value, rare, or sensitive species have been reported for H. diadroma.

Background Information:
No information available in the literature.

Sources:
None listed

4.5 Introduction of diseases, parasites, or travelers

What level of impact could the species' associated diseases, parasites, or travelers have on other species in the assessment area? Is it a host and/or vector for recognized pests or pathogens, particularly other nonnative organisms?)

Choice: U Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

4.6 Level of genetic impact on native species

Can this invasive species hybridize with native species?

Choice: D No impact

Score: 0 of 2.5

Ranking Rationale:
To date, no impacts on genetic hybridization have been reported for H. diadroma.

Background Information:
No genetic hybridization has been reported for H. diadroma in the literature.

Sources:
None listed

4.7 Infrastructure

Choice: U Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

4.8 Commercial fisheries and aquaculture

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on commercial fisheries and aquaculture have been reported, and given the ecology of H. diadroma, none would be expected.

Background Information:
No information available in the literature.

Sources:
None listed

4.9 Subsistence

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on subsistence activities have been reported for H. diadroma, and given the ecology of H. diadroma, none would be expected.

Background Information:
No information available in the literature.

Sources:
None listed

4.101 Recreation

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on recreation have been reported for H. diadroma, and given the ecology of H. diadroma, none would be expected.

Background Information:
No information available in the literature.

Sources:
None listed

4.11 Human health and water quality

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on human health or water quality have been reported for H. diadroma, and given the ecology of H. diadroma, none would be expected.

Background Information:
No information available in the literature.

Sources:
None listed

Section Total - Scored Points:	1.5
Section Total - Possible Points:	24.5
Section Total -Data Deficient Points:	5.5

5. Feasibility of prevention, detection and control

5.1 History of management, containment, and eradication

Choice: **B** Not attempted

Score: of

Ranking Rationale:

Background Information:
No attempts to manage, contain or eradicate H. diadroma are mentioned in the literature.

Sources:
None listed

5.2 Cost and methods of management, containment, and eradication

Choice: **B** Major short-term and/or moderate long-term investment

Score: of

Ranking Rationale:
To comply with ballast water regulations, vessels will have to equip themselves with an onboard ballast water treatment system. These systems represent a major short-term cost for vessel owners (up to $3 million), with additional costs over time to maintain and replace equipment (e.g. chemicals, filters, UV light bulbs).

Background Information:
No species-specific methods have been reported in the literature. However, methods to deatil with ballast water have been tested.

The costs associated with purchasing a ballast water treatment system depend on the volume of water that needs to be treated. Systems with a pump capacity of 200-250 m^3/h can cost from $175,000 to $490,000. The estimated price for larger systems with a pump capacity of around 2000 m^3/h range from $650,000 to nearly $3 million.

Sources:
Zagdan 2010

5.3 Regulatory barriers to prevent introductions and transport

Choice: **C** Regulatory oversight and/or trade restrictions

Score: of

Ranking Rationale:
Alaska does not have state regulations on ballast water management, but two federal regulations (USCG and EPA) require mandatory reporting and either exchange or treatment of ballast water.

Background Information:
State regulations: Alaska does not have a state regulations related to the management of aquatic invasive species in discharged ballast water. It relies on the U.S. Coast Guard (USCG) to enforce national standards. In Alaska, data from 2009-2012 show moderate to high compliance with USCG reporting requirements (qtd. in Verna et al. 2016).

Federal regulations: In the U.S., ballast water management (treatment or exchange) and record-keeping is mandatory and regulated by the USCG, with additional permitting by the Environmental Protection Agency (EPA). Certain vessels (e.g. small vessels or those traveling within 1 Captain of the Port Zone) are exempt from USCG and EPA regulations

Sources:
EPA 2013 Verna et al. 2016

5.4 Presence and frequency of monitoring programs

Choice: **A** No surveillance takes place

Score: of

Ranking Rationale:
No species-specific monitoring exists for H. diadroma.

Background Information:

Sources:
None listed

5.5 Current efforts for outreach and education

Choice: **A** No education or outreach takes place

Score: of

Ranking Rationale:
No species-specific educational materials were found for H. diadroma.

Background Information:

Sources:
None listed

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

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- Kikuchi, E., and K. Yasuda. 2006. Comparison of the life cycles of two sympatric estuarine polychaetes, Hediste diadroma and H. atoka (Polychaeta: Nereididae), in the Nanakita River estuary, northeastern Japan. Limnology 7:103-115.

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