Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Limnoithona tetraspina*

Common Name *a copepod*

Phylum	Arthropoda
Class	Maxillopoda
Order	Cyclopoida
Family	Cyclopettidae

Final Rank 34.26

Data Deficiency: 10.25

Species Occurrence by Ecoregion

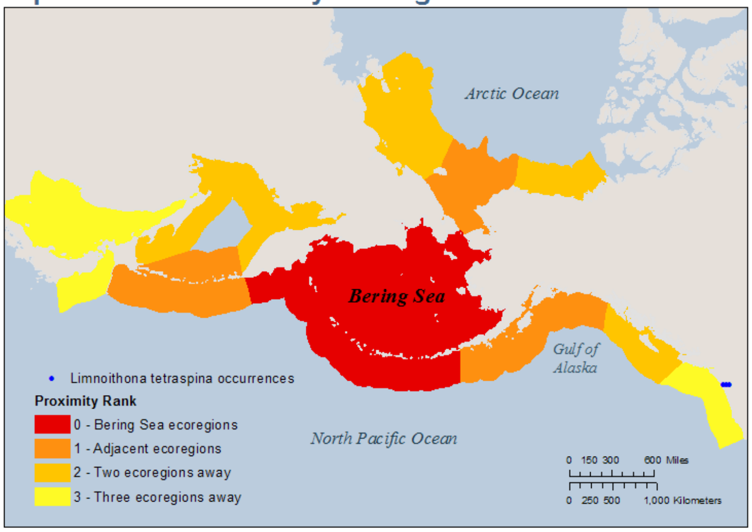

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	7.5	26	3.75
Anthropogenic Influence:	2	6	4.00
Biological Characteristics:	18	28	2.50
Impacts:	3.25	30	0
Totals:	30.75	89.75	10.25

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	4	Minimum Salinity (ppt)	1
Maximum Temperature (°C)	NA	Maximum Salinity (ppt)	30
Minimum Reproductive Temperature (°C)	NA	Minimum Reproductive Salinity (ppt)	NA
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	NA

Additional Notes

Limnoithona tetraspina is a copepod native to the Yangtze River Delta, China. Introduced populations are found in Iraq and the North American Pacific coast. In San Francisco Bay, California; it quickly replaced another non native copepod, L. sinensis. It prefers estuarine waters and can tolerate a wider range of salinities than L. sinensis. It may adversely affect larval fish who rely on copepods for food by replacing the larger native copepods.

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:
Temperatures required for year-round survival occur in a limited area (<25%) of the Bering Sea. We ranked this question with "High Uncertainty" to indicate disagreements in model estimates.

Background Information:
L. tetraspina is a warm-temperate-subtropical species and has a minimum temperature threshold of 4°C (Bollens et al. 2012).

Sources:
Bollens et al. 2012   NEMESIS; Fofonoff et al. 2003

1.2 Survival requirements - Water salinity

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

Score: 0 of 3.75

High uncertainty? ✔

Ranking Rationale:
Year-round salinity requirements do not exist in the Bering Sea. Because thresholds are based on geographic distribution rather than physiological tolerances, we ranked this question with "High uncertainty".

Background Information:
Based on field observations, the salinity range for this species is from 1 ppt to 30 ppt (Orsi and Ohtsuka 1999; Bouley and Kimmerer 2006; Bollens et al. 2011)

Sources:
NEMESIS; Fofonoff et al. 2003   Orsi and Ohtsuka 1999   Bollens et al. 2002   Bouley and Kimmerer 2006

1.3 Establishment requirements - Water temperature

Choice: **U** Unknown/Data Deficient

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

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:
Reproductive salinity requirements for this species are unknown. However, this species has been collected from waters with salinities between 1 and 30 ppt; these salinities do not exist in the Bering Sea. Because thresholds are based on geographic distribution rather than physiological tolerances, we ranked this question with "High uncertainty".

Background Information:
This species has been found in salinities from 1 ppt to 30 ppt (Orsi and Ohtsuka 1999; Bouley and Kimmerer 2006; Bollens et al. 2011)

Sources:
Orsi and Ohtsuka 1999   Bouley and Kimmerer 2006   Bollens et al. 2011   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:
Present in Washington, Oregon, and California.

Background Information:
Limoithona tetraspina has been observed in San Franciso Bay, California; Grays River, Washington; and Columbia River, Oregon (Bollens et al. 2011; Sytsma et al. 2004).

Sources:
Bollens et al. 2011 Sytsma et al. 2004 NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: C In few ecoregions globally

Score: 1.75 **of** 5

Ranking Rationale:
Occurrence records exist for China, Iraq, California and Washington only.

Background Information:
Limnoithona tetraspina was first described in the Yangtze River Delta, China (Orsi and Ohtuska 1999). It's full native range is not known, but it appears to not exist in interior freshwaters. It has been introduced to Shat al Arab estuary, Iraq; San Francisco Bay, California; Grays River, Washington; and Columbia River Oregon (Bollens et al. 2011; Sytsma et al. 2004; Fofonoff et al. 2003).

Sources:
Orsi and Ohtsuka 1999 Bollens et al. 2011 Sytsma et al. 2004 NEMESIS; Fofonoff et al. 2003

1.7 Current distribution trends

Choice: B History of rapid expansion or long-distance dispersal (prior to the last ten years)

Score: 3.25 **of** 5

Ranking Rationale:
Dispersal distances appear to be limited, however, population expansion where it is introduced is relatively great.

Background Information:
In 1993 L. tetraspina was collected in Suisan Bay at Chipps Island, CA. By 1999 it could be found throughout the San Francisco Bay area ranging from San Pablo Bay to the South Bay (Bollens et al. 2011). In 2003 it was discovered in the Grays River, Washington and the Columbia River, Oregon (Sytsma et al. 2004).

Sources:
Bollens et al. 2011 Sytsma et al. 2004 NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	7.5
Section Total - Possible Points:	26.25
Section Total -Data Deficient Points:	3.75

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:

Observed in ballast water; little observation of species expanding its range naturally after introduction.

Background Information:

Long distance dispersal is achieved through ballast water. L. tetraspina has been observed in the ballast water of ships arriving in Puget Sound (Cordell et al. 2008; Lawrence and Cordell 2010).

Sources:

Cordell et al. 2008 Lawrence and Cordell 2010

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

Choice: **U**

Unknown

Score: **of**

Ranking Rationale:

Background Information:

In its introduced range, this species has been reported from San Francisco Bay, the Sacramento-San Joaquin River, the Columbia River and Grays River. Habitat preferences and establishment patterns with respect to anthropogenic disturbances are unknown.

Sources:

NEMESIS; Fofonoff et al. 2003

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

Choice: **B**

No

Score: 0 **of** 2

Ranking Rationale:

Background Information:

This species is not currently farmed or intentionally cultivated.

Sources:

None listed

Section Total - Scored Points:	2
Section Total - Possible Points:	6
Section Total -Data Deficient Points:	4

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:
Preys on numerous taxa readily available in the Bering Sea.

Background Information:
L. tetraspina is a raptorial feeder that consumes algae, ciliates, rotifers, and copepod nauplii (Barnes 1983 as qtd. in Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

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:
Restricted to subtidal habitats.

Background Information:
Lives in subtidal habitats but can tolerate a wide range of salinities. The lower limit of temperatures was 4˚C in North America. Dissolved oxygen, calcium, pollution tolerances, etc. are unknown.

Sources:
NEMESIS; Fofonoff et al. 2003

3.3 Desiccation tolerance

Choice: **A** Highly tolerant (>7 days) of desiccation at one or more stages during its life cycle

Score: 5 of 5

High uncertainty? ☑

Ranking Rationale:
No species-specific research has been published on the desiccation tolerance for L. tetraspina; tolerance is being inferred from studies of other copepod species.

Background Information:
Desiccation tolerance has been investigated in the lab for numerous copepods including the Cyclopoida family. These studies suggest that both coepodids and adult copepod populations exhibit resistance to desiccation for at least 1 month (Zhen et al. 1994).

Sources:
NEMESIS; et al. 2003 Zhen et al. 1994

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: **C** Low – Exhibits none of the above characteristics

Score: 1.75 **of** 5

High uncertainty? ✔

Ranking Rationale:

Sexual reproduction, moderate parental investment (brood eggs), generation time unknown, fecundity unknown.

Background Information:

Sexual reproduction. Females brood eggs on abdomen (Barnes 1983 as qtd. In Fofonoff et al. 2003). In lab experiments, development took ~21 days but was suspected to be longer in natural conditions (Gould and Kimmerer 2010).

Sources:

NEMESIS; Fofonoff et al. 2003 Gould and Kimmerer 2010

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: **U** Unknown

Score: **of**

Ranking Rationale:

Background Information:

No information available in the literature.

Sources:

None listed

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:

Can disperse at more than one life stage but uses the same modes of dispersal at each stage (swimming).

Background Information:

L. tetraspina mates in the water column. Females will then brood eggs (Barnes 1983 as qtd. in Fofonoff et al. 2003) until they hatch as a free-swiming nauplii. The nauplii then undergoes 6 stages of growth where it progressively gains appendages and higher differentiation of its body segments. (Uchima 1979 as qtd. in Fofonoff et al. 2003). Under experimental conditions, develoment took 21 days but was suspected to be longer in natural conditions (Gould and Kimmerer 2010).

Sources:

NEMESIS; Fofonoff et al. 2003 Gould and Kimmerer 2010

3.7 Vulnerability to predators

Choice: **D**	Multiple predators present in the Bering Sea or neighboring regions	**Score:** 1.25 **of** 5

Ranking Rationale:

Numerous predators, several of which exist in the Bering Sea.

Background Information:

L. tetraspina is a planktonic species, which are important for larval fish as a food source. Its small size may deter visual predators and it also may be nutritionally poor as it lacks high quality lipids found in the larger copepods (Winder and Jassby 2011).

Sources:

Winder and Jassby 2011 NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	18
Section Total - Possible Points:	27.5
Section Total -Data Deficient Points:	2.5

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: **B**

Moderate – More than one trophic level; may cause declines but not extirpation

Score: 1.75 of 2.5

Ranking Rationale:
May cause changes in planktonic community; has the potential to affect fish populations by interferring with large copepod prey abundance.

Background Information:
In low-salinity regions of estuaries, L. tetraspina replaces local copepods (Orsi and Ohtsuka 1999). By replacing the local copepods L. tetraspina may also effect copepod predators, such as fish larvae, due to its small size and lower nutritional composition (Fofonoff et al. 2003).

Sources:
Orsi and Ohtsuka 1999 NEMESIS; Fofonoff et al. 2003

4.2 Impact on habitat for other species

Choice: **D**

No impact

High uncertainty? ☑

Score: 0 of 2.5

Ranking Rationale:
To date, no impacts on habitat for other species have been reported for L. tetraspina, and given its ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
NEMESIS; Fofonoff et al. 2003

4.3 Impact on ecosystem function and processes

Choice: **D**

No impact

Score: 0 of 2.5

Ranking Rationale:
Alterations to planktonic communities is not expected to affect ecosystem function and processes.

Background Information:
In low-salinity regions of estuaries, L. tetraspina replaces local copepods (Orsi and Ohtsuka 1999). By replacing the local copepods L. tetraspina may also effect copepod predators, such as fish larvae, due to its small size and lower nutritional composition (Fofonoff et al. 2003).

Sources:
Orsi and Ohtsuka 1999 NEMESIS; Fofonoff et al. 2003

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

Choice: C Limited – Has limited potential to cause degradation of one more species or communities, with limited impact and/or within a very limited region

Score: 0.75 **of** 2.5

Ranking Rationale:
Has an impact on critically endangered species in California, however, susceptible species are unknown for the Bering Sea.

Background Information:
L. tetraspina is a smaller copepod that will hinder visual predators such as the critically endangered Delta Smelt (Sullivan et al. 2016). It is also has a lower nutritional composition as its prey lack high-quality lipids found in the prey of the larger copepods (Winder and Jassby 2011). Because L. tetraspina can replace local copepods, these effects may be exacerbated.

Sources:
Sullivan et al. 2016   Winder and Jassby 2011   NEMESIS; Fofonoff et al. 2003

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: D No impact

Score: 0 **of** 2.5

High uncertainty? ☑

Ranking Rationale:
To date, no known diseases, parasites, or travelers have been reported for L. tetraspina.

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

High uncertainty? ☑

Ranking Rationale:
To date, hybridization has not been reported for L. tetraspina, and given its biology, hybridization would not be expected.

Background Information:
No information available in the literature.

Sources:
None listed

4.7 *Infrastructure*

Choice: D No impact

Score: 0 **of** 3

Ranking Rationale:
To date, no impacts on infrastructure have been reported for L. tetraspina, and given its ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
NEMESIS; Fofonoff et al. 2003

4.8 Commercial fisheries and aquaculture

Choice: **C**

Limited – Has limited potential to cause degradation to fisheries and aquaculture, and/or is restricted to a limited region

Score: **0.75** **of** **3**

Ranking Rationale:

L. tetraspina is a smaller, less nutritous species that replaces local copepods.

Background Information:

The replacement of larger copepods by the smaller L. tetraspina may adversely affect larval fishes that selectively prefer larger copepods such as the Delta Smelt (Hypomesus transpacificus) (Sullivan et al. 2016). L. tetraspina may also have a lower nutritional composition as the prey it consumes does not have high quality lipids found in the prey of larger copepods (Winder and Jassby 2011).

Sources:

Sullivan et al. 2016   Winder and Jassby 2011   NEMESIS; Fofonoff et al. 2003

4.9 Subsistence

Choice: **D**

No impact

Score: **0** **of** **3**

Ranking Rationale:

To date, no impacts on subsistence have been reported for L. tetraspina, and given its ecology, none would be expected.

Background Information:

No information available in the literature.

Sources:

NEMESIS; Fofonoff et al. 2003

4.101 Recreation

Choice: **D**

No impact

Score: **0** **of** **3**

Ranking Rationale:

To date, no impacts on recreation have been reported for L. tetraspina, and given its ecology, none would be expected.

Background Information:

No information available in the literature.

Sources:

NEMESIS; Fofonoff et al. 2003

4.11 Human health and water quality

Choice: **D**

No impact

Score: **0** **of** **3**

Ranking Rationale:

To date, no impacts on human health and water quality have been reported for L. tetraspina, and given its ecology, none would be expected.

Background Information:

No information available in the literature.

Sources:

NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	3.25
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

5. Feasibility of prevention, detection and control

5.1 History of management, containment, and eradication

Choice: **C** Attempted; control methods are currently in development/being studied

Score: of

Ranking Rationale:
No history of management, containment, or eradication found. Efforts to limit or restrict ballast water discharge is the primary preventative method known.

Background Information:
Ballast water exchange is the method currently used by most ships to reduce the spread of species by ballast water. However, it is considered a short-term or "stop-gap" option until more effective, technology-based methods become available e.g., ballast water treatment systems (Ruiz and Reid 2007). The treatment of ballast water is an active area of research as vessels are forced to comply with new regulations.

Sources:
Ruiz and Reid 2007

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:
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. No species-specific regulations exist for L. tetraspina.

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 (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:
Verna et al. 2016   EPA 2013

5.4 Presence and frequency of monitoring programs

Choice: A No surveillance takes place

Score: of

Ranking Rationale:

Background Information:
No species-specific monitoring exists for L. tetraspina.

Sources:
None listed

5.5 Current efforts for outreach and education

Choice: A No education or outreach takes place

Score: of

Ranking Rationale:

Background Information:
No species-specific outreach or education exists for L. tetraspina.

Sources:
None listed

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

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