Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Limnoria tripunctata*

Common Name *a wood-boring isopod*

Phylum	Arthropoda
Class	Malacostraca
Order	Isopoda
Family	Limnoriidae

Final Rank 50.00

Data Deficiency: 2.50

Species Occurrence by Ecoregion

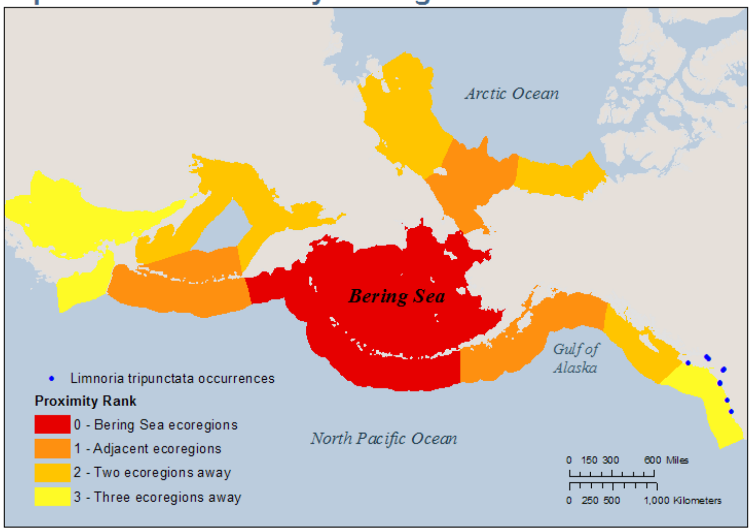

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	18.25	30	0
Anthropogenic Influence:	6.75	10	0
Biological Characteristics:	19.25	30	0
Impacts:	4.5	28	2.50
Totals:	48.75	97.50	2.50

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	2	Minimum Salinity (ppt)	19
Maximum Temperature (°C)	30	Maximum Salinity (ppt)	50
Minimum Reproductive Temperature (°C)	15	Minimum Reproductive Salinity (ppt)	31*
Maximum Reproductive Temperature (°C)	30	Maximum Reproductive Salinity (ppt)	35*

Additional Notes

Limnoria tripunctata is a small wood-boring isopod that is globally distributed. It is almost cylindrical in shape and adults are up to 3.4 mm long and white to pink in color. Distinguished from other species in the genus by the possession of three bumps on the telson that are visible under a dissecting microscope (Reish et al. 2015).

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

Ranking Rationale:
Temperatures required for year-round survival occur in a limited area (<25%) of the Bering Sea.

Background Information:
Lab experiments suggest a temperature range of 2°C to 30°C required for survival, with an upper limit of 44°C (Quayle 1992; Beckman and Menzies 1960).

Sources:
Quayle 1992   Beckman and Menzies 1960   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

Ranking Rationale:
Salinities required for year-round survival occur over a large (>75%) area of the Bering Sea.

Background Information:
Experimental data suggests that the salinity threshold for survival of L. tripunctata is 19-50ppt (Quayle 1992). But, when salinity drops below 20 PSU, L. tripunctata is rare or absent (Becker 1971, as qtd. In Fofonoff et al. 2003; Lum 1981). In laboratory settings, optimum range appears to 36-50 PSU (Eltringham 1961; Lum 1981).

Sources:
Quayle 1992   NEMESIS; Fofonoff et al. 2003   Lum 1981   Eltringham 1961

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 reproduction do not exist in the Bering Sea.

Background Information:
Experimental studies suggest the temperature threshold for reproduction of L. tripunctata is 15 to 30°C (Quayle 1992; Beckman and Menzies 1960).

Sources:
Quayle 1992   Beckman and Menzies 1960   NEMESIS; Fofonoff et al. 2003

1.4 Establishment requirements - Water salinity

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

Score: 3.75 **of** 3.75

High uncertainty? ✔

Ranking Rationale:
Although salinity thresholds are unknown, this species is a marine organism that does not require freshwater to reproduce. We therefore assume that this species can reproduce in saltwater (31 to 35 ppt). These salinities occur in a large (>75%) portion of the Bering Sea.

Background Information:
No information available in the literature.

Sources:
None listed

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:

Background Information:
Closest known occurrence is on Vancouver Island, British Columbia, from Victoria to Quadra Island (50.2°N). Recorded at various sites throughout the North American West Coast, from BC to Mexico.

Sources:
NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: A In many ecoregions globally

Score: 5 **of** 5

Ranking Rationale:
Wide global distribution.

Background Information:
Native range is unknown. Considered cryptogenic in Asia, where it is widely distributed and found in China, Japan, the Philippines, India, and several Pacific islands including Fiji, Guam, and Papua New Guinea. Recorded in Australia and New Zealand. In Africa, found off the coasts of South Africa, Kenya, and Ghana. In Europe, recorded as far north as the English Channel, south to Italy and France. Recorded in the Adriatic, Mediterranean, and Red Seas, and possibly in the Black Sea. In North America, found on the east coast from Massachusetts to the Caribbean Sea, south to Costa Rica. Also recorded in Uruguay and Argentina. On the West Coast, considered invasive from British Columbia south to the Panama Canal and Hawaii.

Sources:
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:
Recent documentation of long-distance dispersal and range expansion.

Background Information:
First described on the West Coast from Los Angeles Harbor, CA in 1871. Appears to have extended its range north in the later decades of the 20th century. It was not found north of San Francisco in 1950s surveys, which included sampling in Coos Bay, OR and Puget Sound, WA (Menzies 1957; Wallour 1960, as qtd. In Fofonoff et al. 2003). However, it was reported in Coos Bay in 1983 (Carlton 1989, as qtd. In Fofonoff et al. 2003), Yaquina Bay, Willapa Bay and the Straits of Georgia in 1964 (Quayle 1992), and Puget Sound in 1998 (Cohen et al. 1998). Because it requires several weeks of ~15ºC to reproduce, its ability to colonize northern waters is uncertain.

Sources:
NEMESIS; Fofonoff et al. 2003 Menzies 1957 Quayle 1992 Cohen et al. 1998

Section Total - Scored Points:	18.25
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: A Has been observed using anthropogenic vectors for transport and transports independent of any anthropogenic vector once introduced

Score: 4 of 4

Ranking Rationale:
Most occurrences are related to hull fouling and oyster culturing.

Background Information:
Its spread is correlated with oyster culturing, although there are at least 5 occurrences in British Columbia that are not related to the oyster culture. It is believed that they are spread through the wooden boxes used to transport oysters (Quayle 1992). Another likely vector is hull fouling.

Sources:
Quayle 1992 NEMESIS; Fofonoff et al. 2003

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

Score: 2.75 of 4

High uncertainty? ☑

Ranking Rationale:
Establishes where there is wood, from either anthropogenic or natural sources. Information for this species is lacking.

Background Information:
L. quadripunctata, a closely related species, requires a supply of wood either from fallen trees or humans to establish (Cragg 2010). May limit the ability of wood borers to spread and establish to new sites.

Sources:
Cragg 2010

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:	6.75
Section Total - Possible Points:	10
Section Total -Data Deficient Points:	0

3. Biological Characteristics

3.1 Dietary specialization

Choice: **B**

Generalist or specialist at different life stages and/or foods are moderately available in the study area

Score: **3.25** of **5**

Ranking Rationale:

L. tripunctata is a specialist that eats primarily wood, which may be restricting, however, wood as a food source is fairly abundant in most environments.

Background Information:

Digests non-cellulosic carbohydrates in wood, as well as some cellulose. Fungi and bacteria found in wood may complement a wood-only diet (Quayle 1992).

Sources:

Quayle 1992

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 wood in the environment as food and habitat.

Background Information:

L. tripunctata is a shallow water species found from the water surface to 18 m deep. Deeper waters are preferred especially when surface salinity is low or when tidal fluctuation is high. It also prefers estuary benthos where it is commonly found at the bases of pilings (Hiebert 2015). It prefers rough surfaces of softer wood infected with fungi (Becker 1971 as qtd. in Fofonoff et al. 2003). It thrives in creosote treated timber as it harbors a greater number and diversity of bacteria over untreated wood (Quayle 1992). Cannot tolerate turbid waters (Shupe 2012).

Sources:

Shupe 2012   Hiebert 2015   NEMESIS; Fofonoff et al. 2003   Quayle 1992

3.3 Desiccation tolerance

Choice: **B**

Moderately tolerant (1-7 days) during one or more stages during its life cycle

Score: **3.25** of **5**

Ranking Rationale:

Background Information:

Limnoria spp. can survive without water for about 24 hours and are not affected by a temporary aeration (Iljin 1992, qtd. in Shalaeva 2012).

Sources:

Shalaeva 2012

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: B Moderate – Exhibits one or two of the above characteristics

Score: 3.25 of 5

Ranking Rationale:

Sexual reproduction, low fecundity, short generation time.

Background Information:

Separate sexes, internal fertilization. Young are brooded by the female (Becker 1971 as qtd. In Fofonoff et al. 2003). After 2-4 weeks of development (Borges et al. 2014), they hatch as small adults with no larval stage (Boyko and Wolff 2014 as qtd. in Hiebert 2015). First brood occurs at the end of the first year with up to three broods per female per year (Johnson and Menzies 1956). Average brood size ranges from 5 to 10 eggs per female (Quayle 1992). Average lifespan is two years (Quayle 1992).

Sources:

Hiebert 2015 Quayle 1992 NEMESIS; Fofonoff et al. 2003 Johnson and Menzies 1956 Borges et al. 2014

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: C Disperses short (< 1 km) distances

Score: 0.75 of 2.5

Ranking Rationale:

Migrations are limited to a few meters.

Background Information:

All life history stages of Limnoria participate in both active migration and passive dispersal (Miranda and Thiel 2008). However, because this species has internal fertilization and direct development, there is no egg or planktonic larval stage that can disperse. Instead, Limnoria spp. disperse primarily as young adults; juveniles undergo a regular, seasonal “migration” (active swimming behavior) (Johnson and Menzies 1956; Eltringham and Hockley 1961). These migrations, however, typically occur over a few meters or less (Vinogradov et al. 2006, qtd. in Shalaeva 2012 – information on Limnoria spp. in general). For the wood-dwelling species L. lignorum, Johnson (1935) expressed that he “believed that the principal means of dispersal within an infected area is by regular seasonal migration. …. These migrations must not be understood as occurring over any considerable distances but rather as a matter of only a few meters or less” (qtd. in Miranda and Thiel 2008). Based on field experiments of tropical Limnoria spp. in Chile, Miranda and Thiel (2008) inferred that migrations occur over distances of meters or tens of meters.

Although adults can move freely from place to place, they are largely sessile, spending most of their time burrowed in wood (Quayle 1992). They have limited swimming abilities: maximum swimming distance was 3 m at 18°C and 28 ppt (Quayle 1992).

Transport at all stages can be assisted via infected driftwood and water currents (Quayle 1992).

Sources:

Eltringham and Hockley 1961 Johnson and Menzies 1956 Quayle 1992 Miranda and Thiel 2008 Shalaeva 2012

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:
Ability to disperse via different modes at difference life stages, however, dispersal is extremely limited.

Background Information:
Direct development and internal fertilization. L. tripunctata larvae resemble small adults (though they are incapable of swimming at first; Hiebert 2015). All life stages are capable of active (swimming/crawling) and passive dispersal (e.g. via rafting or water currents), though migration is most common in juveniles (Johnson and Menzies 1956). Migration is seasonal: in England, it occurred in late May and early June (Eltringham and Hockley 1961). In addition, migration of L. tripunctata is more frequent at night than during the day (Johnson and Menzies 1956). In general, L. tripunctata has poor swimming abilities (Quayle 1992). Temporal events such as storms, as well as weather and ocean current patterns, may allow for long-distance dispersal (Miranda and Thiel 2008).

Sources:
Eltringham and Hockley 1961   Hiebert 2015   Johnson and Menzies 1956   Miranda and Thiel 2008   Quayle 1992

3.7 *Vulnerability to predators*

Choice: **B** Few predators only in its home range, and not suspected in the Bering Sea or neighboring regions

Score: 3.75 of 5

Ranking Rationale:
Few predators are known for this species.

Background Information:
There are no known natural enemies that regulate populations of limnoriids (Becker 1971 as qtd. In Fofonoff et al. 2003), but some polychaete worms are known to predate on them (Reish 1954 as qtd. In Hiebert 2015).

Sources:
Cragg 2010   NEMESIS; Fofonoff et al. 2003   Hiebert 2015

Section Total - Scored Points:	19.25
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: **U** Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

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:
Not expected to negatively impact habitat for local species. May create new habitat for other species.

Background Information:
By burrowing in wood, L. tripunctata creates habitat for other species. Limnoria burrows can be inhabited by non-borers such as the commensal isopod, Caecijaera; the sphaeromatid isopod, Gnorimosphaeroma; the amphipod, Chelura; and the copepod Donsiella, none of which are borers (Menzies 1957; Hiebert 2015). The Teredo, a boring mollusk, can also co-occur in Limnoria wood burrows. Wood infested with L. tripunctata showed a community of turbellarians, nematodes, Dinophilus, Polydora, copepods, and amphipods after only 4-6 months submerged (Sleeter and Coull 1973).

Sources:
Hiebert 2015 Menzies 1957 Sleeter and Coull 1973

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

Ranking Rationale:
Processes wood debris, releasing energy stored in submerged wood and driftwood.

Background Information:
L. tripunctata is a wood-boring invertebrate which affects its environment by accelerating the degradation of wood and controlling the availability of food and space for various organisms in sunken wood communities by (1) serving as prey, (2) carving out cavities that are used as shelters by other organisms, (3) facilitating the build-up of degradation-related hydrogen sulfide, (4) promoting secondary production in the surrounding sediment, and (5) increasing the surface/volume ratio of the wood, which in turn accelerates the leaching of labile components such as proteins, tannins and terpenoids (Nishimoto et al. 2015). The crustacean isopod family Limnoriidae play key roles in wood fragmentation.

Sources:
Shalaeva 2012 Nishimoto et al. 2015

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 L. tripunctata, and given its ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
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: C Limited – Has limited potential to spread one or more organisms, with limited impact and/or within a very limited region

Score: 0.75 of 2.5

Ranking Rationale:
Is host to one known parasite.

Background Information:
L. tripunctata is host to Mirofolliculina limnoriae, an ectoparasite which slows the feeding, swimming, and growth of L. tripunctata (Delgery et al. 2006). Effects of M. limnoriae on other species are unknown.

Sources:
NEMESIS; Fofonoff et al. 2003 Delgery et al. 2006

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:

Background Information:
In Southampton Water, England, three species of Limnoria occur together. These species do not appear to interbreed (Eltringham and Hockley 1958, qtd. in Eltringham and Hockley 1961). No further information found.

Sources:
Eltringham and Hockley 1961

4.7 Infrastructure

Choice: B Moderate – Causes or has the potential to cause degradation to infrastructure, with moderate impact and/or within only a portion of the region

Score: 1.5 of 3

Ranking Rationale:
Damages wooden pilings, docks, and ship hulls.

Background Information:
Damage to pilings, docks, and other infrastructure by L. tripunctata has been reported in Florida, California, British Columbia, England, and Portugal. Can reduce the lifespan of a creosote-treated wood piling to approximately 6 years instead of a possible 40 years (Beckman et al. 1957, qtd. in Fofonoff et al. 2003). A piling of intermediate size has been estimated to contain a population of 200, 000 animals, each capable of consuming 20 g of wood per year (Menzies and Turner 1957, qtd. in Quayle 1992). May cause damage to important historical or heritage sites (Shalaeva 2012). No information found on economic costs.

Sources:
NEMESIS; Fofonoff et al. 2003 Quayle 1992 Shalaeva 2012

4.8 Commercial fisheries and aquaculture

Choice: D No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on fisheries or aquaculture have been reported for L. tripunctata, and given its ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
NEMESIS; Fofonoff et al. 2003

4.9 Subsistence

Choice: D No impact

Score: 0 of 3

Ranking Rationale:
To date, no immpacts on subsistence have been reported for L. tripunctata, and given tis ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
NEMESIS; Fofonoff et al. 2003

4.101 Recreation

Choice: C Limited – Has limited potential to cause degradation to recreation opportunities, with limited impact and/or within a very limited region

Score: 0.75 of 3

Ranking Rationale:
Can deteriorate wooden strucures associated with recreation.

Background Information:
L. lignorum, a closely related species, is known to cause damage to wooden structures. This may result in unexpected failures, which may lead to impacts on recreation such as destruction of docks.

Sources:
Shalaeva 2012

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 L. tripunctata, and given its ecology, none would be expected.

Background Information:

No information available in the literature.

Sources:

None listed

Section Total - Scored Points:	4.5
Section Total - Possible Points:	27.5
Section Total -Data Deficient Points:	2.5

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:

Control methods are being used and are successful.

Background Information:

In British Columbia, creosote-treated marine piling, properly installed and maintained, provides adequate protection against gribbles, including L. tripunctata (Quayle 1992). To combat the invasion of wood borers in Los Angeles Harbor, wood pilings were covered with 6 mm inner wrap of polyethylene and 20-30 mm of polyvinylchloride outer wrap, which killed any existing borers and fouling organisms by suffocation and prevented new infestations (Reish et al. 2015). L. tripunctata is still present in Los Angeles Harbor on wood pilings that have not been wrapped (Reish et al. 2015).

Sources:

Quayle 1992 Reish et al. 2015

5.2 *Cost and methods of management, containment, and eradication*

Choice: **C** Easy and inexpensive (minor investment)

Score: of

Ranking Rationale:

Prevention methods include: chemical treatment, covering, and wrapping of wooden structures, as well as switching construction materials from wood to concrete.

Background Information:

To prevent wood borers, pilings can be treated with creosote and other wood treatments; however, Limnoria tripunctata is capable of penetrating creosoted wood pilings (Lee and Miller 1980, qtd. in Reish et al. 2015), especially in warmer waters, which causes deterioration and leaching of creosote (Shupe 2012). Moreover, these treatments can contain toxic compounds, which add to the environmental impacts of this species (Becker 1971 as qtd. In Fofonoff et al. 2003).

The use of certain copper or tin salts can provide effective protection from Limnoria attack, but their use is limited by environmental regulations. A dual treatment consisting of a pressure treatment with copper salt (1.0 to 1.5 pcf of CCA or ACZA) followed by a pressure treatment with marine-grade creosote (20 pcf), can be effective against creosote-resistant Limnoria species. Movable wooden structures and boats can also be protected by an unbroken covering of marine paint. When borers have gained entrance into wooden vessels, they can be killed by running the boats into fresh water or dry dock for at least 30 days.

In British Columbia, creosote-treated marine piling, properly installed and maintained, provides adequate protection against gribbles, including L. tripunctata (Quayle 1992). Increased use of log barges rather than rafts for transporting logs and dry land sorting are ways to reduce marine borer populations. Replacement of float logs by pontoons of synthetic materials also helps.

To combat the invasion of wood borers in Los Angeles Harbour, creosote-treated wood pilings are covered with 6 mm inner wrap of polyethylene and 20-30 mm of polyvinylchloride outer wrap, which successfully kills any existing borers and fouling organisms by suffocation and prevents new infestations (Reish et al. 2015). Using concrete instead of wood as construction material has also helped reduce wood boring infestations. Picking up and discarding floating wood and debris may help limit the presence of wood boring species (Reish et al. 2015).

Sources:

Quayle 1992 Reish et al. 2015 Shupe 2012 NEMESIS; Fofonoff et al. 2003

5.3 *Regulatory barriers to prevent introductions and transport*

Choice: **A** Little to no regulatory restrictions

Score: of

Ranking Rationale:

Background Information:

No regulations in place to prevent spread of L. tripunctata.

Sources:

None listed

5.4 *Presence and frequency of monitoring programs*

Choice: A No surveillance takes place

Score: of

Ranking Rationale:

Background Information:
No surveillance currently takes place for L. tripunctata.

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 educational material found online.

Sources:
None listed

Section Total - Scored Points:
Section Total - Possible Points:
Section Total -Data Deficient Points:

Literature Cited for *Limnoria tripunctata*

- Cragg, S. 2010. Limnoria quadripunctata (gribble). CABI Invasive Species Compendium. Available from: http://www.cabi.org/isc/datasheet/109147 Accessed 13-Dec-2016.
- Eltringham, S. K., and A. R. Hockley. 1961. Migration and reproduction of the wood-boring isopod, Limnoria, in Southampton. Limnology and Oceanography 6(4): 467-481.
- Hiebert, T. C. 2015. Pseudopolydora kempi. In Hiebert, T.C., Butler, B.A., and A.L. Shanks, editors. Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. University of Oregon Libraries and Oregon Institute of Marine Biology,
- Hiebert, T.C. 2015. Nippoleucon hinumensis. In: Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. T.C. Hiebert, B.A. Butler and A.L. Shanks, eds.. University of Oregon Libraries and Oregon Institute of Marine Biology, C
- Hiebert, T. C. 2015. Limnoria tripunctata. In Hiebert, T.C., Butler, B.A., and A.L. Shanks, editors. Oregon Estuarine Invertebrates: Rudys' Illustrated Guide to Common Species, 3rd ed. University of Oregon Libraries and Oregon Institute of Marine Biology,
- Johnson, M. W., and R. J. Menzies. 1956. The migratory habits of the marine gribble Limnoria tripunctata Menzies in San Diego Harbor, California. Biological Bulletin 110(1): 54-68.
- Johnson, M.W., and R.J. Menzies. 1956. The migratory habits of the marine gribble Limnoria tripunctata Menzies in San Diego Harbor, California. Biological Bulletin 110(1): 54-68.
- Miranda, L., and M. Thiel. 2008. Active and passive migration in boring isopods Limnoria spp. (Crustacea, Peracarida) from kelp holdfasts. Journal of Sea Research 60:176-183.
- Miranda, L., and M. Thiel. 2008. Active and passive migration in boring isopods Limnoria spp. (Crustacea, Peracarida) from kelp holdfasts. Journal of Sea Research 60: 176-183.
- Fofonoff, P. W., G. M. Ruiz, B. Steves, C. Simkanin, and J. T. Carlton. 2017. National Exotic Marine and Estuarine Species Information System. http://invasions.si.edu/nemesis/. Accessed: 15-Sep-2017.
- Nishimoto, A., Haga, T., Asakura, A., and Y. Shirayama. 2015. An experimental approach for understanding the process of wood fragmentation by marine wood borers in shallow temperate waters. Marine Ecology Progress Series 538:53-65.
- Quayle, D. B. 1992. Marine wood borers in British Columbia, Canadian Special Publication of Fisheries and Aquatic Sciences 115:1-55.
- Quayle, D. B. 1992. Marine wood borers in British Columbia. Canadian Special Publication of Fisheries and Aquatic Sciences 115:1-55.
- Reish, D. J., Gerlinger, T. V., and R. R. Ware. 2015. Comparison of the marine wood borer populations in Los Angeles Harbor in 1950-1951 with the same populations in 2013-2014. Bulletin of the Southern California Academy of Sciences 114(3):123-128.
- Shalaeva, E. 2012. Limnoria lignorum. CABI Invasive Species Compendium. Available online: http://www.cabi.org/isc/datasheet/109146 Accessed 14-Dec-2016.
- Shupe, T. F. 2012. Marine Wood Borers. LSU AgCenter, Louisiana State University College of Agriculture. Available online: http://www.lsuagcenter.com/topics/environment/forestry/forest_products/marine-wood-borers Accessed 14-Dec-2016.
- Menzies, J. 1957. The marine borer family Limnoriidae (Crustacea, Isopoda). Part I: Northern and Central America: Systematics, distribution, and ecology. Bulletin of Marine Science of the Gulf and Caribbean 7(2):101-200.

- Cohen, A., Mills, C., Berry, H., Wonham, M., Bingham, B., Bookheim, B., et al. 1998. Puget Sound expedition: A rapid assessment survey of non-indigenous species in the shallow waters of Puget Sound. Washington State Department of Natural Resources and U.S

- Beckman, C., and R. Menzies. 1960. The relationship of reproductive temperature and the geographical range of the marine woodborer Limnoria trupunctata. Biological Bulletin 118(1): 9-16.

- Lum, J. A. S. 1981. The distribution of the wood boring isopod Limnoria in Texas estuaries and bays in relation to environmental factors. PhD Thesis, Texas A&M University, College Station, Texas, U.S.A. 133 pp.

- Eltringham, S. K. 1961. The effect of salinity upon the boring activity and survival of Limnoria (Isopoda). Journal of the Marine Biological Association of the United Kingdom 41: 785-797.

- Borges, L. M. S., Merckelbach, L. M., and S. M. Cragg. 2014. Biogeography of wood-boring crustaceans (Isopoda: Limnoriidae) established in European coastal waters. PLoS ONE 9(10): e109593. doi:10.1371/journal.pone.0109593

- Delgery, C. C., Cragg, S. M., Busch, S., and E. A. Morgan. 2006. Effects of the epibiotic heterotrich ciliate Microfolliculina limnoriae and of moulting on faecal pellet production by the wood-boring isopods, Limnoria tripunctata and Limnoria quadripuncta

- Sleeter, T. D., and B. C. Coull. 1973. Invertebrates associated with the marine wood boring isopod, Limnoria tripunctata. Oecologia 13(1):97 102.