Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Bugula neritina*

Common Name *brown bryozoan*

Phylum	Bryozoa
Class	Gymnolaemata
Order	Cheilostomatida
Family	Bugulidae

Final Rank 62.63

Data Deficiency: 5.00

Species Occurrence by Ecoregion

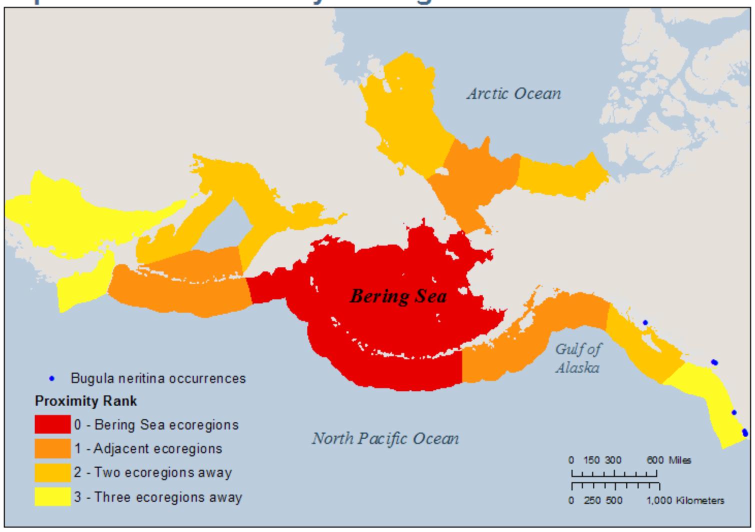

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	25	30	0
Anthropogenic Influence:	6	10	0
Biological Characteristics:	21.5	25	5.00
Impacts:	7	30	0
Totals:	59.50	95.00	5.00

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	2	Minimum Salinity (ppt)	18
Maximum Temperature (°C)	30.6	Maximum Salinity (ppt)	40
Minimum Reproductive Temperature (°C)	7	Minimum Reproductive Salinity (ppt)	31*
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	35*

Additional Notes

Bugula neritina is a widespread, colonial bryozoan and a common fouling organism. It is a species complex comprised of at least three species that can only be distinguished through molecular work. Colonies branch out in a shrub-like pattern and are dark red to purple or brown. They can grow over 100 mm in height.

Reviewed by Linda McCann, Research Technician, Smithsonian Environmental Research Center, Tiburon, CA

Review Date: 12/15/2017

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. Thresholds are based on geographic distribution, which may not represent physiological tolerances; we therefore ranked this question with "High uncertainty".

Background Information:

Based on geographic distribution, this species is thought to tolerate temperatures from 2°C to 30.6°C (Zerebecki and Sorte 2011). Populations of this species have different temperature tolerances depending on where they live. Populations from Massachusetts had a higher temperature threshold than populations from California (26.4°C versus 24.4°C; Sorte et al. 2011).

Sources:

Zerebecki and Sorte 2011   Sorte et al. 2011

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. Thresholds are based on geographic distribution, which may not represent physiological tolerances; we therefore ranked this question with "High uncertainty".

Background Information:

B. neritina is a marine species that can tolerate salinities from 18 to 40 ppt (based on geographic distribution).

Sources:

NEMESIS; Fofonoff et al. 2003

1.3 Establishment requirements - Water temperature

Choice: **A**

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

Score: 3.75 **of** 3.75

High uncertainty? ☑

Ranking Rationale:

Because this species is reported from warm-temperate to tropical waters, upper reproductive limits are unlikely to be exceeded in the Bering Sea. Temperature requirements for maturation of gametes and spawning are unknown, but larvae can metamorphose at temperatures as low as 7°C. We ranked this species as "High Uncertainty" to indicate lack of data, as well as disagreements in model estimates.

Background Information:

Based on laboratory experiments, Lynch (1947) determined that the optimal temperature for larvae was 16°C. Larvae survived and metamorphosed in 7°C water (lowest treatment tested), but exhibited behavioral changes, a prolonged free-swimming period (from < 1 hour to 5+ hours), and greatly reduced activity levels (Lynch 1947).

Sources:

Lynch 1947

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:
Larvae placed in seawater exhibited normal behaviours (Lynch 1947). B. neritina is a marine species that does not require fresh or brackish water to spawn (Fofonoff et al. 2003).

Sources:
Lynch 1947   NEMESIS; Fofonoff et al. 2003

1.5 Local ecoregional distribution

Choice: **C** — Present in an ecoregion two regions away from the Bering Sea (i.e. adjacent to an adjacent ecoregion)

Score: 2.5 **of** 5

Ranking Rationale:
This species was recently found in Ketchikan, AK.

Background Information:
On the West Coast of North America, this species occurs from Mexico to Oregon (Fofonoff et al. 2003). It was reported in Washington state in 1994, but it is unclear whether it is established there (Cohen 2011). B. neritina was discovered in Ketchikan, AK in 2016, but has not been found since (Jurgens et al. 2018; L. McCann, pers. comm.). It is therefore unclear whether this species is established in southeast AK (L. McCann, pers. comm.).

Sources:
Jurgens et al. 2018   NEMESIS; Fofonoff et al. 2003   Cohen 2011

1.6 Global ecoregional distribution

Choice: **A** — In many ecoregions globally

Score: 5 **of** 5

Ranking Rationale:
This species is widespread and is found on every continent except Antarctica.

Background Information:
The native range of this species is unknown, but it is thought to be native to warm-temperate and tropical waters of Central and South America, the Mediterranean, and along the Atlantic coast of Africa. It is also considered cryptogenic in the northwestern Pacific (from Japan to Hong Kong), in India and in the Middle East. In western North America, it is considered introduced from CA to AK, and in the east from MA to VA. It is considered introduced in southern Africa (Namibia, South Africa), in Atlantic Europe (U.K. to Spain), and on several Pacific islands including New Zealand, Australia, and Hawaii.

Sources:
NEMESIS; Fofonoff et al. 2003

1.7 Current distribution trends

Choice: **A**

Recent rapid range expansion and/or long-distance dispersal (within the last ten years)

Score: 5 **of** 5

Ranking Rationale:

This species has been rapidly expanding its range worldwide. It was recently found in Ketchikan, AK.

Background Information:

This species has been expanding its range for the past 60 years (Ryland et al. 2011). On the West Coast of North America, it was first collected in San Francisco Bay in the 1980s, and has expanded its range northward since then, reaching Oregon by 1986 (Fofonoff et al. 2003). Although reported from Washington state, it is unclear whether it is established there (Cohen 2011). It was recently discovered in Ketchikan, AK, which is the northernmost record in North America and perhaps worldwide (Jurgens et al. 2018).

Sources:

NEMESIS; Fofonoff et al. 2003 Ryland et al. 2011 Jurgens et al. 2018 Cohen 2011

Section Total - Scored Points:	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: **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:

This species has been introduced worldwide by anthropogenic vectors. Because adults are sessile and the free-swimming larval stage is very short-lived, it is unlikely that this species can travel long distances on its own.

Background Information:

This species has been transported globally by ship fouling and hitchhiking on oysters (Mackie et al. 2006; Cohen 2011; Ryland et al. 2011). Marine debris, including tsunami debris, is also a potential transport vector (L. McCann, pers. comm.). Because the free-swimming larval stage is short-lived (2 to 10 hours), it is unlikely to be transported in ballast water (Cohen 2011).

Sources:

Cohen 2011   Ryland et al. 2011   Mackie et al. 2006

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

Choice: **A**

Readily establishes in areas with anthropogenic disturbance/infrastructure and in natural, undisturbed areas

Score: 4 of 4

Ranking Rationale:

This species can establish on both natural and anthropogenic substrates.

Background Information:

This species has been reported from several anthropogenic and natural substrates, including oysters, seaweed, tunicates, rocks, ship hulls, and docks (Walters 1992; Fofonoff et al. 2003).

Sources:

NEMESIS; Fofonoff et al. 2003   Walters 1992

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

Choice: **B**

No

Score: 0 of 2

Ranking Rationale:

This species is not farmed or cultivated.

Background Information:

Sources:

NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	6
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:
Food items for this species are readily available in the Bering Sea.

Background Information:
B. neritina is a suspension feeder. It uses its tentacles to capture phytoplankton and organic particles.

Sources:
NEMESIS; Fofonoff et al. 2003 CABI 2017

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: **A** Generalist; wide range of habitat tolerances at all life stages

Score: 5 of 5

Ranking Rationale:
This species has a global distribution, and has been reported on a variety of substrates. It is not known to have specific habitat requirements.

Background Information:
This species has been reported from many types of substrates, including ship hulls, docks, bivalve shells, and rocks (Fofonoff et al. 2003). Larvae are planktonic, and prefer to settle on heterogeneous surfaces such as bumpy or rough surfaces with many refuges (Walters 1992; Marshall and Keough 2003). This species is usually found at shallow depths up to 12 m (depending on light penetration; Conradi et al. 2000). B. neritina is tolerant of a range of salinities (Fofonoff et al. 2003). It has a high tolerance to copper, which is used in antifouling paints (Piola and Johnston 2006).

Sources:
NEMESIS; Fofonoff et al. 2003 Marshall and Keough 2003 Piola and Johnston 2006 Conradi et al. 2000 Walters 1992

3.3 Desiccation tolerance

Choice: **U** Unknown

Score: of

Ranking Rationale:
No information found.

Background Information:
Anecdotal evidence from San Francisco, CA suggest that this species is fairly tolerant of desiccation (L. McCann, pers. comm.). An assessment for B. turbinata, which is also a branching bryozoan, believed B. turbinata was likely highly intolerant to air exposure, but no tests have been conducted (Tyler-Walters 2005).

Sources:
Tyler-Walters 2005

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:

This species can reproduce asexually and is hermaphroditic. Fertilization is internal, but parental investment is otherwise low. Colonies are highly fecund and likely produce hundreds of planktonic larvae, which become sexually mature within a few weeks.

Background Information:

This species can reproduce asexually and is hermaphroditic (Fofonoff et al. 2003) and exhibits internal fertilization (Walters 1992). Only one larva is brooded per zooid (Walters 1992). As a proxy for fecundity, Mathew et al. (2016) estimated ~700 ovicells per colony, while Burgess and Marshall (2011) estimated a maximum of 631 ovicells, and estimated that populations increased by 187 to 210 zooids for every additional individual produced. Individuals reach sexual maturity within 2-4 weeks (Wendt 1998; Keough and Chernoff 1987). Colonies can live anywhere from 5-6 weeks to > 1 year (Wendt 1998; Cohen 2011).

Sources:

NEMESIS; Fofonoff et al. 2003 Walters 1992 Mathew et al. 2016 Burgess and Marshall 2011 Wendt 1998 Keough and Chernoff 1987 Cohen 2011

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:

This species has a short-lived planktonic stage. Its spatial distribution suggests that dispersal is highly limited.

Background Information:

Keough (1989) observed a strongly clumped spatial distribution in both adult and juveniles, and he suggested that this species has limited dispersal abilities. In some cases, Keough and Chernoff (1987) did not find any individuals on suitable substrate (seagrass), even though large populations were present < 100 m away. Larvae are non-feeding, planktonic and short-lived. Most larvae settle on suitable substrates within a few hours (Keough 1989; Walters 1992). In a field study by Burgess and Marshall (2011), less than 19% of individuals had a long larval stage (> 6.5 hours), with a maximum of 32 hours.

Sources:

Keough 1989 Keough and Chernoff 1987 Walters 1992 Burgess and Marshall 2011

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

Score: 0.75 of 2.5

Ranking Rationale:
Only the short-lived larval stage is free-swimming. Adults are sessile. Natural dispersal in this species is very limited.

Background Information:
Adults are sessile and eggs are brooded internally (Walters 1992). The larval stage is free-swimming but short-lived, with most individuals settling on substrates within a few hours of release (Keough 1989; Walters 1992). This species is highly patchy, both spatially and temporally, and very likely has limited natural dispersal abilities (Keough and Chernoff 1987; Keough 1989).

Sources:
Walters 1992 Keough 1989 Keough and Chernoff 1987

3.7 Vulnerability to predators

Choice: **A** Lacks natural predators

Score: 5 of 5

Ranking Rationale:
This species is preyed upon by several taxa found in the Bering Sea.

Background Information:
This species is predated upon by fish, sea urchins, crabs, and shrimp (Keough and Chernoff 1987; Walters 1992; Mcgovern and Hellberg 2003; Dumont et al. 2011).

Sources:
Keough and Chernoff 1987 Walters 1992

Section Total - Scored Points:	21.5
Section Total - Possible Points:	25
Section Total -Data Deficient Points:	5

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: **C** Limited – Single trophic level; may cause decline but not extirpation

Score: 0.75 of 2.5

High uncertainty? ✔

Ranking Rationale:
No impacts on natural communities have been reported to date; however, several studies highlight the strong competitive abilities of B. neritina, which suggests that this species may be able to outcompete other bryozoans or fouling organisms in the Bering Sea. Warming sea temperatures may increase the competitive ability of this species.

Background Information:
B. neritina is a dominant and highly competitive member of the fouling community (Sorte and Stachowicz 2011; Hart and Marshall 2013). In an examination of fouling plates around the world, B. neritina was a consistently strong competitor, exhibiting high growth even when space was limited (Lord 2017). However, this species was more present on panels at warm sea temperatures (20 to 24°C) than at cooler sites (Lord 2017). B. neritina Both field and laboratory studies suggest that, in introduced parts of its range, warming sea temperatures may give B. neritina a competitive advantage over native species by enhancing growth and recruitment (Sorte et al. 2010, Sorte and Stachowicz 2011). In Bodega Harbor, CA B. neritina has become more abundant than its native counterpart, Bugula californica (Sorte et al. 2010), though competition between the two species has not been documented.

Sources:
Hart and Marshall   Sorte and Stachowicz 2011   Lord 2017   Sorte et al. 2010

4.2 Impact on habitat for other species

Choice: **B** Moderate – Causes or has potential to cause changes to one or more habitats

Score: 1.75 of 2.5

Ranking Rationale:
By fouling substrates, this species may reduce available habitat for some organisms through competition for space. Conversely, it may create secondary settlement habitat for others. Several species are known to use B. neritina as habitat.

Background Information:
In Algeciras Bay, Spain, several crustaceans were found living on B. neritina, including tanaids, cumaceans, and the invasive amphipod Jassa marmorata (Conradi et al. 2000). The polychaete Hydroides elegans was found on B. neritina in Hong Kong (Bryan et al. 1998).

Sources:
Conradi et al. 2000   Bryan et al. 1998

4.3 Impact on ecosystem function and processes

Choice: **D** No impact

Score: 0 of 2.5

Ranking Rationale:
This species is not expected to impact ecosystem function in the Bering Sea.

Background Information:
No information found.

Sources:
NEMESIS; Fofonoff et al. 2003

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

Choice: D No impact

Score: 0 of 2.5

Ranking Rationale:
This species is not expected to impact ecologically valuable species in the Bering Sea.

Background Information:
No information found.

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

High uncertainty? ☑

Ranking Rationale:
B. neritina may inadvertently facilitate the transport of other species that live on it.

Background Information:
B. neritina has symbiotic relationships with bacteria that produce chemical compounds known as bryostatins (Mcgovern and Hellberg 2003). Several taxa have been found living on B. neritina, including amphipods, cumaceans and polychaetes (Bryan et al. 1998; Conradi et al. 2000). The invasive amphipod Jassa marmorata has been found on B. neritina (Conradi et al. 2000).

Sources:
Mcgovern and Hellberg 2003 Bryan et al. 1998 Conradi et al. 2000

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:
This species is not expected to hybridize with native species in the Bering Sea.

Background Information:
No information found.

Sources:
NEMESIS; Fofonoff et al. 2003

4.7 Infrastructure

Choice:		Score:
B	Moderate – Causes or has the potential to cause degradation to infrastructure, with moderate impact and/or within only a portion of the region	1.5 of 3

Ranking Rationale:

Moderate impacts on infrastructure are expected given its abundance as a fouling organism.

Background Information:

This species is a common member of the fouling community and has been reported on ship hulls, pilings, docks, and power plants (Fofonoff et al. 2003). This species is highly resistant to copper, which is used in many anti-fouling paints (Piola and Johnston 2006). Fouling organisms on ships cause drag and reduce maneuverability. They are estimated to cost the U.S. Navy over $50 million a year in fuel costs due to increased drag (Cleere 2001).

Sources:

NEMESIS; Fofonoff et al. 2003   Piola and Johnston 2006   Cleere 2001

4.8 Commercial fisheries and aquaculture

Choice:		Score:
C	Limited – Has limited potential to cause degradation to fisheries and aquaculture, and/or is restricted to a limited region	0.75 of 3

Ranking Rationale:

By fouling mussels and equipment, this species can negatively affect the weight and growth of economically important shellfish species. Shellfish aquaculture is currently a small industry in Alaska that occurs only in a restricted area of the Bering Sea.

Background Information:

In southeastern Brazil, B. neritina was one of the most abundant fouling organisms on Perna perna mussels (de Sá et al. 2007). Mussels that were fouled were shorter and smaller than cleaned mussels, though the difference, according to the authors, was small: 5.4 mm in final length and 1.7 g in weight of the meat (de Sá et al. 2007). Antoniadou et al. (2013) also reported B. neritina as a common fouling organism on the shells of the Mediterranean mussel Mytilus galloprovincialis. Similarly to de Sá et al. (2007), they observed a negative, but weak, effect of fouling on mussel condition (Antoniadou et al. 2013).

According to the Pacific Shellfish Institute, the shellfish industry in Alaska is estimated at $1 million. Revenues from shellfish are most important in southeast (Gulf of Alaska, Wrangell to Haines) and southwest Alaska (Aleutians East through Lake and Peninsula; Mathis et al. 2015).

Sources:

Antoniadou et al. 2013   Mathis et al. 2015   de Sá et al. 2007   PSI Alaska 2017

4.9 Subsistence

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

Score: 0.75 of 3

Ranking Rationale:
This species may negatively affect the growth of bivalves by fouling shells and equipment such as mussel lines.

Background Information:
In southeastern Brazil, B. neritina was one of the most abundant fouling organisms on Perna perna mussels (de Sá et al. 2007). Mussels that were fouled were shorter and smaller than cleaned mussels, though the difference, according to the authors, was small: 5.4 mm in final length and 1.7 g in weight of the meat (de Sá et al. 2007). Antoniadou et al. (2013) also reported B. neritina as a common fouling organism on the shells of the Mediterranean mussel Mytilus galloprovincialis. Similarly to de Sá et al. (2007), they observed a negative, but weak, effect of fouling on mussel condition (Antoniadou et al. 2013).

Compared to salmon and finfish, shellfish such as oysters, clams, and mussels comprise a smaller percentage of subsistence catch in the Bering Sea (when measured by weight; Mathis et al. 2015). Although shellfish comprised almost 20% of subsistence catch in the Aleutians West, most municipalities in the Bering Sea recorded low percentages (< 5%).

Sources:
Antoniadou et al. 2013   Mathis et al. 2015   de Sá et al. 2007

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:
B. neritina may negatively affect mussel growth by fouling shells and may consequently degrade recreational harvest opportunities.

Background Information:
In southeastern Brazil, B. neritina was one of the most abundant fouling organisms on Perna perna mussels (de Sá et al. 2007). Mussels that were fouled were shorter and smaller than cleaned mussels, though the difference, according to the authors, was small: 5.4 mm in final length and 1.7 g in weight of the meat (de Sá et al. 2007). Antoniadou et al. (2013) also reported B. neritina as a common fouling organism on the shells of the Mediterranean mussel Mytilus galloprovincialis. Similarly to de Sá et al. (2007), they observed a negative, but weak, effect of fouling on mussel condition (Antoniadou et al. 2013).

Sources:
de Sá et al. 2007   Antoniadou et al. 2013

4.11 Human health and water quality

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
This species is not expected to negatively impact human health or water quality in the Bering Sea.

Background Information:
Bacteria found in Bugula neritina produce chemical compounds known as bryostatins. These compounds are being studied for use in cancer and HIV treatments.

Sources:
NEMESIS; Fofonoff et al. 2003   Mcgovern and Hellberg 2003

Section Total - Scored Points:	7
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:

Methods to control species that foul bivalves, aquaculture equipment, and/or ship hulls are currently being studied.

Background Information:

Control of B. neritina and other fouling species has been attempted on mussel farms in New Zealand using acetic acid treatments (Forrest et al. 2007). B. neritina is thought to have been introduced worldwide by ship fouling, and it is tolerant to copper, which is used as an agent in many anti-fouling paints (Piola and Johnston 2006; Ryland et al. 2011). Hull fouling technologies that treat and/or safely dispose of marine organisms, without being toxic to the environment, are currently being studied (Hagan et al. 2014).

Sources:

Piola and Johnston 2006   Ryland 1977   Hagan et al. 2014   Forrest et al. 2007

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

Choice: **A** Major long-term investment, or is not feasible at this time

Score: 0 of

Ranking Rationale:

Given the weak effect of B. neritina on mussel growth, the costs of cleaning would have to be weighed against the lost profits arising from smaller mussels. Current technologies to prevent the transport of marine invasive species are being developed, and require major long-term investments.

Background Information:

This species can be transported via several anthropogenic vectors, including fouling, hitchhiking, and marine debris. Methods to control the spread of marine invasive species are being studied, and currently necessitate major long-term investments (Zagdan 2010; Hagan et al. 2014). On shellfish farms, B. neritina was still alive on ropes treated with 2% acetic acid, but no individuals were found when ropes were treated with a 4% solution (Forrest et al. 2007). Because B. neritina had only a small effect on mussel growth, de Sá et al. (2007) wondered whether physical removal is a cost-effective method for shellfish growers.

Sources:

Forrest et al. 2007   de Sá et al. 2007   Zagdan 2010   Hagan et al. 2014

5.3 *Regulatory barriers to prevent introductions and transport*

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

Score: of

Ranking Rationale:

Compliance with hull fouling regulations is voluntary. No regulations exist to prevent the spread of invasive species by hitchhiking.

Background Information:

In the U.S., Coast Guard regulations require masters and ship owners to clean vessels and related infrastructure on a “regular” basis (CFR 33 § 151.2050). However, because the word “regular” is not defined, regulations are hard to enforce and compliance remains largely voluntary (Hagan et al. 2014). Cleaning of recreational vessels is also largely voluntary, although state and federal programs are in place to encourage owners to clean their boats (e.g. Davis 2016).

Sources:

CFR 2017   Hagan et al. 2014   Davis 2016

5.4 Presence and frequency of monitoring programs

Choice: **B**

Surveillance takes place, but is largely conducted by non-governmental environmental organizations (e.g., citizen science programs)

Score: of

Ranking Rationale:

Monitoring for invasive tunicates is conducted by Plate Watch and KBNERR, which are non-governmental agencies.

Background Information:

In Alaska, Plate Watch and Kachemak Bay National Estuarine Research Reserve (KBNERR) conduct monitoring for non-native tunicates and other invasive or harmful species. These programs involve teachers, students, outdoor enthusiasts, environmental groups and professional biologists to detect invasive species. Plate Watch found B. neritina on one of its fouling plates in Ketchikan, AK in 2016 (Jurgens et al. 2018; L. McCann, pers. comm.).

Sources:

Jurgens et al. 2018   iTunicate Plate Watch 2016

5.5 Current efforts for outreach and education

Choice: **C**

Educational materials are available and outreach occurs only sporadically in the Bering Sea or adjacent regions

Score: **0** of

Ranking Rationale:

Following the discovery of B. neritina on a fouling plate in southeastern Alaska, Plate Watch wrote an article about this species, with photos and tips for identification, in its March 2017 newsletter.

Background Information:

Plate Watch and the Kachemak Bay National Estuarine Research Reserve (KBNERR) provide training opportunities for identifying and detecting non-native fouling organisms, and public education events on coastal and marine ecosystems more generally. "Bioblitzes" were held in Southeast AK in 2010 and 2012; these events engage and educate the public on marine invasive species. Outreach activities were conducted on the Pribilof Islands for Bering Sea Days in 2017. Field identification guides for native and non-native tunicates, as well as common fouling organisms, are readily available.

Sources:

McCann 2017   iTunicate Plate Watch 2016

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

Literature Cited for *Bugula neritina*

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