Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Caprella mutica*

Common Name *Japanese skeleton shrimp*

Phylum	Arthropoda
Class	Malacostraca
Order	Amphipoda
Family	Caprellidae

Final Rank 64.95

Data Deficiency: 8.00

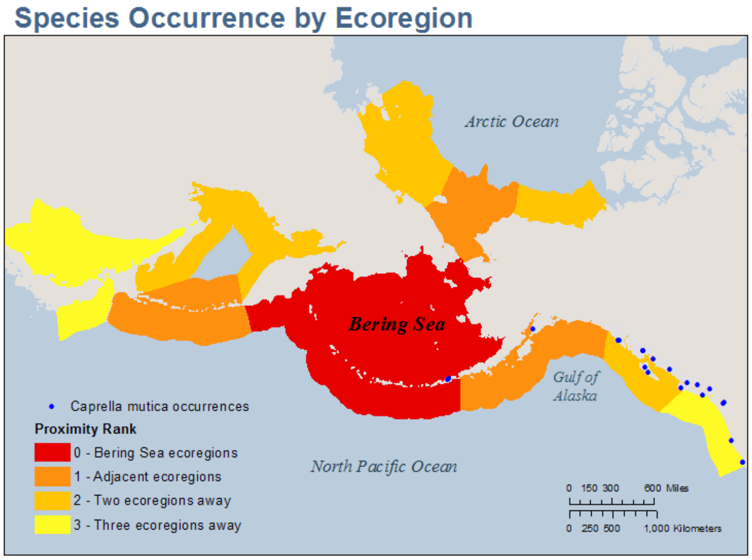

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	28.25	30	0
Anthropogenic Influence:	8	10	0
Biological Characteristics:	18.75	30	0
Impacts:	4.75	22	8.00
Totals:	59.75	92.00	8.00

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	-2	Minimum Salinity (ppt)	11
Maximum Temperature (°C)	28	Maximum Salinity (ppt)	40
Minimum Reproductive Temperature (°C)	4	Minimum Reproductive Salinity (ppt)	31*
Maximum Reproductive Temperature (°C)	20	Maximum Reproductive Salinity (ppt)	35*

Additional Notes

First described from sub-boreal areas of north-east Asia in 1935 and has since spread to both northern and southern hemispheres. C. mutica is frequently associated with man-made structures and is found in abundance on boat hulls, navigation/offshore buoys, floating pontoons and aquaculture infrastructure. Likely dispersed via hull fouling, presence in ballast water and sea chests, or accidental introduction linked to aquaculture (e.g. import of Pacific oyster spat).

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

Choice: **A**

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

Score: 3.75 **of** 3.75

Ranking Rationale:

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

Background Information:

Caprella mutica tolerates water temperatures from -1.8 to 28°C as determine by both field distribution and experimental laboratory experiments. Although lethargic at low temperatures (2°C), no mortality was observed, and the species is known to survive at temperatures as low as −1.8°C (Ashton et al. 2007)

Sources:

Ashton 2006 Boos et al. 2011 NEMESIS; Fofonoff et al. 2003 Ashton et al. 2007

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:

Caprella mutica is a polyhaline-euhaline species that tolerates water salinity from 14.6 to >40 ppt, based on experimental laboratory experiments. In addition, it has been documented to tolerate salinities as low as 11 psu in the field in the northern Sea of Japan (Schevchenko et al. 2004, cited by Turcotte and Sainte Marie 2009). C. mutica is tolerant to a wide range of temperatures and salinities. 100% mortality was observed at 30°C (48 h exposure), and at salinities lower than 15 (48 h exposure). The upper salinity threshold was greater than the highest salinity tested (40 ppt), thus it is unlikely that salinity will limit the distribution of C. mutica in open coastal waters, though it might exclude this species from brackish water environments such as estuaries (Ashton et al 2007).

Sources:

Ashton 2006 NEMESIS; Fofonoff et al. 2003 Turcotte and Sainte-Marie 2009 Ashton et al. 2007

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

Ranking Rationale:

Temperatures required for reproduction occur over a large (>75%) area of the Bering Sea.

Background Information:

The reproductive temperature range of Caprella mutica is 4°C to20°C. In a lab setting, hatchlings maintained at 4°C died after 4 months (Boos et al. 2011).

Sources:

Boos et al. 2011

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 found.

Sources:

None listed

1.5 Local ecoregional distribution

Choice: **A** Present in the Bering Sea

Score: 5 **of** 5

Ranking Rationale:

There is one documented case of Caprella mutica in the Bering Sea (NEMESIS).

Background Information:

Present in Dutch Harbor, Unalaska Island. Also found in Kachemak Bay. See Ashton et al. (2008) for a summary of sampled sites and occurrences in Alaska.

Sources:

Ashton et al. 2008   NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: **A** In many ecoregions globally

Score: 5 **of** 5

Ranking Rationale:

Background Information:

Caprella mutica is indigenous to sub-boreal waters of north-east Asia (Peter the Great Bay, Russia and northern Japan), and has been found in 14 ecoregions outside of the three ecoregions in which it is considered a native species. C. mutica has been introduced along the entire western coast of North America, from California to Alaska. It is also found along the Atlantic, in northeastern North America (Maine north to PEI and Nova Scotia). In Europe, C. mutica is found from Spain to Norway, and during 2004, it was discovered in New Zealand.

C. mutica is unlikely to survive in the central and eastern Baltic Sea due to low salinities (below 19ppt, FIMR 2006), and based on current knowledge it is not expected to become established in the Mediterranean Sea on account of the high summer seawater temperatures (Cook et al. 2006).

Sources:

NEMESIS; Fofonoff et al. 2003   Cook et al. 2007   Boos et al. 2011

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:

History of rapid expansion and disperal throughout Europe.

Background Information:

C. mutica is one of the most rapidly invading species in Europe. It has extended its range along both the North and Celtic Sea coasts, and the English Channel in less than 14 years. European dispersal from its original location in the Netherlands includes a 1200km range expansion to the west coast of Norway, and a 1000km expansion to the west coast of Ireland (Boos el a. 2011).

Sources:

Boos et al. 2011   Cook et al. 2007

Section Total - Scored Points:	28.25
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:

C. mutica has been observed using numerous anthropogenic vectors, and short-range natural dispersal has been observed in natural habitats near populations established on artifical structures.

Background Information:

Transport in ballast water and sea chests, or via ship fouling, have been proposed as possible means of introduction. C. mutica (Fofonoff et al. 2003) also has the tendency to cling to clothes and working gear when removed from the substrate (Coolen et al. 2016). In addition, it often attaches to brown alga Sargassum muticum, which has been used as packing material when exporting Pacific Oysters (Crassostrea gigas) (Turcotte and Saint-Marie 2009).

Within its native environment, C. mutica may be found attached to the macroalgae (Ulva spp. and Cladophora spp.) which are regularly found attached to ships hulls (Mineur et al. 2007). It has also been observed with other algae present at high densities on recreational boat hulls (Fofonoff et al. 2003).

A modelling exercise by Coolen et al. (2016) found a strong association between C. mutica and nearshore waters, as well as shallow water objects giving C. mutica a high potential for encounters with microalgae rafts. It is suggested that this association may have contributed to its dispersal in European waters.

Individuals have been found swimming short distances and small numbers of individuals have been observed up to 1km from a source population (M. Janke, pers. comm. 2007, qtd. in Boos et al. 2011).

Sources:

NEMESIS; Fofonoff et al. 2003   Turcotte and Saint-Marie 2009   Boos et al. 2011   Coolen et al. 2016

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 **of** 4

Ranking Rationale:

In its introduced range, this species is more commonly associated with anthropogenic substrates and disturbed areas than with natural habitats.

Background Information:

Frequently fouls organisms that grow on anthropogenic substrates (reviewed in Boos et al. 2011). In its introduced range, this species is abundant on anthropogenic structures, but tends to be rare in natural habitats (reviewed in Boos et al. 2011).

Sources:

Boos et al. 2011

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

Choice: **B**	No	**Score:** 2 **of** 2

Ranking Rationale:

Background Information:

Sources:

None listed

Section Total - Scored Points:	8
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:

Has the ability to feed on a variety of things that are readily available in the study area.

Background Information:

C. mutica is primarily a detritivore, but can also filter feed, and has been observed feeding on a variety of different sessile and mobile benthic organisms including hydroids, bryozoans, gammarid amphipods and even conspecifics (Boos et al. 2011). Can be highly opportunistic in its feeding strategy in non-native habitats (Boos et al. 2011).

Caprellids can feed in a variety of ways, including filtering small particles from the water, browsing on small filamentous algae, scraping tissue from large algae, scavenging, and predation (Turcotte and Sainte Marie 2009). Caprella mutica appears to be capable of using all these modes of feeding, which may contribute to its success as an invader (Cook et al. 2007, Turcotte and Sainte-Marie 2009; Cook et al. 2010; Best et al. 2013).

Under laboratory conditions, can survive for up to 20 days without additional food.

Sources:

Boos et al. 2011   Cook et al. 2007   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: **A**

Generalist; wide range of habitat tolerances at all life stages

Score: 5 **of** 5

Ranking Rationale:

Tolerates a wide range of temperatures and salinities and has been recorded in a variety of environments.

Background Information:

Non-native populations of C. mutica have been recorded from environments with a variety of flow regimes, including those experiencing strong tidal and wind currents (e.g., exposed fish farms) and those that are more sheltered (e.g., enclosed bays and harbours) (Ashton 2006; Shucksmith 2007 – qtd. in Boos et al. 2011).

Found in artificial environments that have been enriched with nutrients by fish feed (Boos et al. 2011). An experiment by Ashton et al. (2010, qtd. in Boos et al. 2011) found that, compared to populations in nutrient enriched environments, populations at the other two sites which experienced no artificial nutrient enrichment were significantly less abundant and had a shorter period of summer population growth.

C. mutica is tolerant to a wide range of temperatures and salinities.

Sources:

Ashton et al. 2007   Boos et al. 2011   Cook et al. 2007   Coolen et al. 2016

3.3 Desiccation tolerance

Choice: **C**	Little to no tolerance (<1 day) of desiccation during its life cycle	**Score:** **1.75 of** **5**

Ranking Rationale:

Can survive slight desiccation, however is intolerant to most aerial exposure.

Background Information:

C. mutica is intolerant to aerial exposure during summer months and will die within an hour of emergence from water (Cook, pers. obs.). However, cool and damp conditions typically found in anchor lockers or bundles of mooring lines and fish farm netting are likely to prolong their survival out of water for up to 7 h (Boos and Cook, pers. obs.).

Sources:

Boos et al. 2011

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, high fecundity, moderate parental investment, short generation time.

Background Information:

On average, females reach sexual maturity 53 days after birth (at 14°C), and 1 month at 16°C (Boos et al. 2011). The average lifespan was 90-180 days, with most females producing two broods before death (Cook et al. 2007; Boos et al. 2011). However, estimated brooding time and lifespan varies greatly in the field, with varying temperature and food conditions (Turcotte and Sainte Marie 2009). Boos (2009, qtd. in Boos et al. 2011) recorded a maximum number of seven successful broods at 16°C.

Field studies in both native (Fedotov 1991) and European introduced ranges (Ashton 2006), have both confirmed a positive relationship between brood size and body size in female C. mutica. Both authors reported maximum numbers of more than 300 eggs per single clutch in individual females, reflecting much higher fecundities under natural than laboratory conditions, where average clutch sizes of 40 eggs have been recorded (qtd. in Boos et al. 2011).

Sources:

Boos et al. 2011 Cook et al. 2007 NEMESIS; Fofonoff et al. 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: **B** Disperses moderate (1-10 km) distances

Score: 1.75 **of** 2.5

Ranking Rationale:

Naturally disperses 500m - 5km using free-swimming and drifting on large algal mats.

Background Information:

C. mutica spends its entire life cycle attached to a substrate but can move short distance from one substrate to another (Buschbaum and Gutow 2005). C. mutica does not have a free-swimming, planktonic larval stage (young hatch onto the substrate in the form of small adults), however, short-range dispersal may be achieved through free-swimming of adults, and long-range dispersal may be achieved by attachment to floating artificial structures.

Short-range dispersal may be achieved through short-distance swimming or current-driven dispersal following disturbance from the substrate (Ashton 2006, qtd. in Cook 2007; Boos et al. 2011). C. mutica has been observed swimming short distances in the laboratory and field (E Cook, Scottish Association of Marine Science, UK, personal observation, 2008), however, the maximum distance of dispersal for this method is unknown (Cook 2007). Individuals have been found swimming short distances and small numbers of individuals have been observed up to 1km from a source population (M. Janke, pers. comm. 2007, qtd. in Boos et al. 2011). Turcotte and Saint-Marie (2009) argue that the swimming capacities of C. mutica are very limited, and would only allow for dispersal of < 100 m. C. mutica have been observed in natural habitats adjacent to source populations that are located on artificial structures, and these populations are likely established due to free-swimming dispersal (Boos et al. 2011).

Long-range dispersal may be achieved by attachment to floating artificial structures (e.g. boats) or floating marine algae. Buschbaum and Gutow (2005) propose that C. mutica may have colonised Helgoland using algal rafts, and Ashton (2006, qtd. in Coolen et al. 2006) showed this species' ability to use drifting algae for dispersal over distances > 5 km. On the west coast of Scotland, Ashton (2006) found C. mutica on 27% of the drifting mats of macroalgae that were collected (qtd. in Cook 2007). The maximum number of individuals on one algal mat was 71, including ovigerous females and males (Ashton 2006, qtd. in Cook 2007). This dispersal mechanism is most likely used in the spring and summer months, when large quantities of algae are produced along the continental shelf (Thiel and Haye, 2006).

Sources:

Cook et al. 2007   Buschbaum and Gutow 2005   Cook 2007   Coolen et al. 2016   Turcotte and Sainte-Marie 2009

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:

Females brood young which restricts dispersal to adults only.

Background Information:

Because C. mutica does not have a planktonic larval stage, modes of dispersal are the same throughout its life (swimming or current drifting if disturbed from substrate attachment, or rafting on algae). According to Turcotte and Sainte-Marie (2009), swimming ability is limited, and medium-scale dispersal is likely only achievable via rafting or passive dispersal.

Sources:

Turcotte and Sainte-Marie 2009

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, many of which exist in the the Bering Sea.

Background Information:

In general, natural predators of caprellids are primarily fish species. Additional predators include invertebrates such as crabs, nudibranchs, starfish and hydrozoans (reviewed in Turcotte and Saint-Marie 2009). Specific predators identified include European green crab (Carciunus maenas) and goldsinny wrasse (Ctenolabrus rupestris) and painted greenling (Oxylebius pictus) (Page et al. 2007, Boos et al. 2011).

Sources:

Boos et al. 2011   Turcotte and Sainte-Marie 2009   Page et al. 2007

Section Total - Scored Points:	18.75
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

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

High uncertainty? ☑

Ranking Rationale:

Predation on tunicates and competition with native caprellids have been observed, however the impact on native tunicates in the Bering sea in uncertain.

Background Information:

C. mutica has been observed preying on invsaive tunicates and competing with native caprellids. In the northern Atlantic (NA-S3, Gulf of St Lawrence), high densities of C. mutica have been documented to inhibit settlement of the invasive tunicate Ciona intestinalis on fouling plates; because Ciona intestinalis is an invasive tunicate in that region, C. mutica has been proposed as a biocontrol agent. In Bodega Harbor (NEP-V), caging experiments and feeding trials showed that Caprella mutica was a significant predator on recruits of Ciona intestinalis (Rius et al. 2014).
Similarly, fouling plate studies detected a negative correlation between newly settled tunicates (Ciona intestinalis) and caprellids (Caprella mutica and C. linearis), suggesting possible predation by caprellids on tunicate larvae (Collin and Johnson 2014).

In laboratory-based competition experiments between Caprella mutica and two ecologically similar native caprellids, Caprella linearis and Pseudoprotella phasma, C. mutica successfully displaced both species from homogeneous artificial habitat patches after 48 hours (Shucksmith et al. 2009). Patches that contained a refuge reduced the number of C. linearis being displaced, but only when C. mutica was at a low density. Based on their findings, Shucksmith et al. (2009) suggested that the non-native C. mutica can displace ecologically similar native species when the resource space is limited, and even when the density of C. mutica was significantly (10 times) lower than the density of C. linearis. However, a modelling exercise by Coolen et al. (2016) found that the habitat preference of C. linearis does not fully overlap with that of C. mutica in the North Sea, and that the two species are likely to be able to co-exist in this region.

Sources:

Boos et al. 2011   Cook et al. 2007   Coolen et al. 2016   NEMESIS; Fofonoff et al. 2003   Page et al. 2007   Shucksmith et al. 2009

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

High uncertainty? ☑

Ranking Rationale:

May displace native caprellids however very little information is available.

Background Information:

Studies on ecological impacts are limited and no ecological impacts have been reported in the literature (Fofonoff et al. 2003), however, C. mutica can establish very dense populations that can displace native caprellids (Shucksmith et al. 2009).

Sources:

NEMESIS; Fofonoff et al. 2003   Shucksmith et al. 2009

4.3 *Impact on ecosystem function and processes*

Choice: **D** No impact

Score: 0 **of** 2.5

High uncertainty? ☑

Ranking Rationale:
No impacts have been reported, however the literature is lacking.

Background Information:
Studies on ecological impacts are limited and no impacts on ecosystem function or processes have been reported in the literature (Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003

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

Choice: **U** Unknown

Score: **of**

Ranking Rationale:
Lacking information.

Background Information:
No impacts to high-value, rare or sensitive species and/or communities have been reported in the literature (Fofonoff et al. 2003). C. mutica is known to occur in marine protected areas in the UK (e.g. Firth of Lorne, west coast of Scotland), but the impact of this species on the habitats within these areas is unknown (Cook 2007).

Sources:
NEMESIS; Fofonoff et al. 2003 Cook 2007

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:
No disease, parasites or travelers are expected to be associated with C. mutica but the literature is lacking.

Background Information:
There are no reports of disease, parasites or travelers associated with C. mutica.

Sources:
None listed

4.6 *Level of genetic impact on native species*

Can this invasive species hybridize with native species?

Choice: **U** Unknown

Score: **of**

Ranking Rationale:

Background Information:
No information is available in the literature.

Sources:
None listed

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:

Has the potential to foul gear and infrastructure.

Background Information:

To date, no studies have assessed the economic impacts of C. mutica (Boos et al. 2011), and no economic impacts have been reported for the Chesapeak Bay region (Fofonoff et al. 2003). In Europe and Atlantic Canada, high densities of C. mutica can foul gear such as ropes, nets, water intake pumps and ship hulls, and may interfere with the settlement of mussel spate (Boos et al. 2011; Turcotte and Sainte-Marie 2009; Fofonoff et al. 2003).

Sources:

Boos et al. 2011   Turcotte and Sainte-Marie 2009   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

High uncertainty? ☑

Ranking Rationale:

Fouling may effect efficiency of fisheries and aquaculture. There may also be an impact on mussel farm production, however research is limited and results are uncertain.

Background Information:

High densities of C. mutica can foul gear such as ropes, nets, water intake pumps and ship hulls, and may interfere with the settlement of mussel spate (Boos et al. 2011; Turcotte and Sainte-Marie 2009; Fofonoff et al. 2003).

Mussel farmers observed reduced settlement of spat during periods where C. mutica was most abundant; however a causal connection could not be confirmed (Ashton 2006). Field and laboratory work (unpublished) indicates that high densities of C. mutica interfere with settlement of mussel spat (Turcotte and Sainte Marie 2009).

On the west coast of Scotland and Canada, C. mutica have been observed settling on mussel lines where juvenile mussels (Mytilus edulis), which are typically abundant, have declined. However, no studies have been performed to determine the relationship between the abundance of caprellids and the lack of juvenile mussels. In addition, preliminary studies suggest that other factors such as strong freshwater influence or natural predators may be responsible for the lack of juvenile mussels, and that the presence of C. mutica was a consequence of free settlement space (Boos et al. 2011).

Sources:

Ashton 2006   Boos et al. 2011   Turcotte and Sainte-Marie 2009   NEMESIS; Fofonoff et al. 2003

4.9 Subsistence

Choice: **U**

Unknown

Score: **of**

Ranking Rationale:

Background Information:

No information is available in the literature regarding the impact of C. mutica on subsistence activities.

Sources:

None listed

4.101 Recreation

Choice: **D** No impact

Score: 0 of 3

High uncertainty? ☑

Ranking Rationale:
No reports in literature, however lack of impact is uncertain.

Background Information:
There are no reports in the literature of C. mutica having an impact on recreational activities, and given the biology, none would be expected.

Sources:
None listed

4.11 Human health and water quality

Choice: **D** No impact

Score: 0 of 3

High uncertainty? ☑

Ranking Rationale:
No reports in literature, however lack of impact is uncertain.

Background Information:
There are no reports in the literature of C. mutica having an impact on health or water quality, and given the biology, none would be expected.

Sources:
None listed

Section Total - Scored Points:	4.75
Section Total - Possible Points:	22
Section Total -Data Deficient Points:	8

5. Feasibility of prevention, detection and control

5.1 History of management, containment, and eradication

Choice: **B** Not attempted

Score: **of**

Ranking Rationale:
Management plans, containment and/or eradication have not been developed or attempted for C. mutica.

Background Information:
No species-specific plans are in place to control or eradicate this species. This species is transported by numerous vectors. Controlling the spread of invasive species that use these vectors for transport is an active area of research (Hagan et al 2014; Ruiz and Reid 2007).

Sources:
Hagan et al. 2014 Ruiz and Reid 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: **of**

Ranking Rationale:
No control methods currently exist, therefore controlling is not feasible at this time.

Background Information:
No control methods currently exist. Control methods, using freshwater, aerial exposure, traps and/or pheromones have not been tested as yet. However, it is likely that the former two methods would be the most promising for this and other nonnative marine invertebrates. Prevention methods including cleaning ship hulls and sterilizing ballast water (Molnar et al. 2008).

Sources:
Boos et al. 2011 Cook 2007 Molnar et al. 2008

5.3 Regulatory barriers to prevent introductions and transport

Choice: **B** Regulatory oversight, but compliance is voluntary

Score: **of**

Ranking Rationale:
This species is transported by numerous vectors and no species-specific regulations are currently in place. Although there are federal regulations for both ballast water and hull fouling, compliance with federal fouling regulations remains voluntary.

Background Information:
In the U.S., Coast Guard regulations require masters and ship owners to engage in practices that will reduce the spread of invasive species, including cleaning ballast tanks and removing fouling organisms from hulls, anchors, and other infrastructure on a “regular” basis (CFR 33 § 151.2050). However, the word “regular” is not defined, which makes the regulations hard to enforce. As a result of this technical ambiguity, compliance with ship fouling regulations remains largely voluntary (Hagan et al. 2014).
Source: CFR, Hagan

Sources:
CFR 2017

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:

Limited in North America to non species-specific monitoring by non-governmental organizations.

Background Information:

Monitoring for C. mutica is well established in Europe, however, there is no information to suggest that active education or outreach is taking place in North America. In New England, Salem Sound Coastwatch provides an ID card for C. mutica and engages volunteers to conduct invasive species monitoring in coastal habitats; however, these events are not specific to C. mutica.

Sources:

Salem Sound Coast Watch

5.5 Current efforts for outreach and education

Choice: **B**

Some educational materials are available and passive outreach is used (e.g. signs, information cards), or programs exist outside Bering Sea and adjacent regions

Score:

of

Ranking Rationale:

Outreach in North America is limited to information cards produced for New England.

Background Information:

Monitoring for C. mutica is well established in Europe, however, there is no information to suggest that active education or outreach is taking place in North America. In New England, Salem Sound Coastwatch provides an ID card for C. mutica and engages volunteers to conduct invasive species monitoring in coastal habitats; however, these events are not specific to C. mutica.

Monitoring for C. mutica is conducted on a regular basis in the UK, Belgium and the Netherlands. A monthly monitoring programme for C. mutica at a fish farm and marina in the Lynne of Lorne, west coast of Scotland has been conducted since 2004. In the UK, public awareness has been largely funded by a charitable trust, the Esmée Fairbairn Foundation, with support from the UK government environment agencies, which has enabled the establishment of a marine non-native species website including C. mutica, production of leaflets, posters, splash-proof ID guides and popular articles and public lectures throughout the UK.

Sources:

Salem Sound Coast Watch   Cook 2007

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

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