Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Crepidula onyx*

Common Name *onyx slippersnail*

Phylum Mollusca
Class Gastropoda
Order Neotaenioglossa
Family Calyptraeidae

Final Rank 46.84
Data Deficiency: 5.00

Species Occurrence by Ecoregion

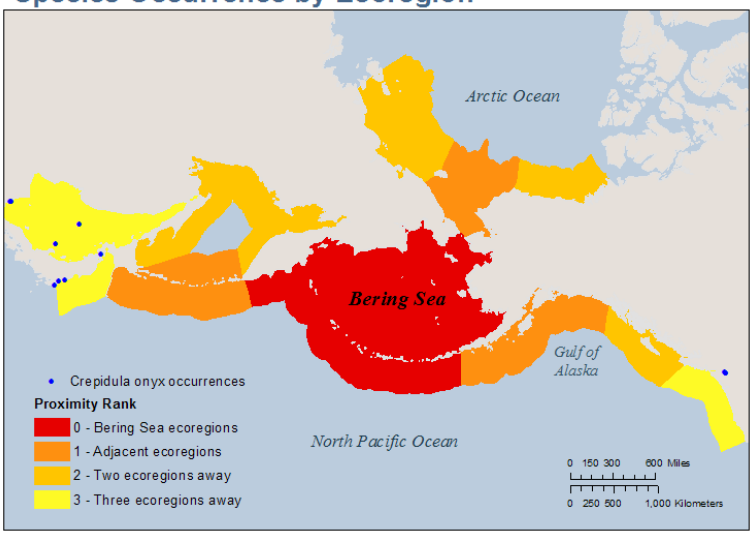

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	13.75	30	0
Anthropogenic Influence:	8	10	0
Biological Characteristics:	20.5	25	5.00
Impacts:	2.25	30	0
Totals:	44.50	95.00	5.00

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	10	Minimum Salinity (ppt)	10
Maximum Temperature (°C)	30	Maximum Salinity (ppt)	45
Minimum Reproductive Temperature (°C)	15	Minimum Reproductive Salinity (ppt)	15
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	45

Additional Notes

Crepidula onyx is a marine snail with a thick, oval shell. The shell has concentric growth lines and its color ranges from tan to dark brown. The inside of the shell is brown and glossy. Shells can measure up to 60 mm. It inhabits intertidal and shallow subtidal areas, and attaches itself to a variety of substrates, including rock, mud, and mollusk shells. Individuals may even grow on top of one another. It is native to the west coast of America from California to Peru.

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

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

Score: **0** of **3.75**

High uncertainty? ☑

Ranking Rationale:
Temperature requirements do not exist year-round in 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:
This species is found in warm-temperate and tropical waters. Its distribution suggests that it cannot tolerate low water temperatures. Temperature tolerances of 10 to 22°C have been cited (SWIMS 2017), but it is obviously capable of tolerating higher temperatures. It has been introduced in Hong Kong where water temperatures range between 15 and 30°C, and larvae have been successfully reared at temperatures between 20 and 30°C (Zhao 2002).

Sources:
Zhao 2002 SWIMS 2017

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:
Crepidula onyx is a marine species. Preliminary experiments by Zhao (2002) found that C. onyx could not survive at salinities below 10 ppt. Adults have been cultured at 35 ppt (Zhao et al. 2003). 30% and >15% of larvae reached metamorphosis when exposed to salinities of 35 and 45 ppt, suggesting that this species has a high tolerance to elevated salinities (Zhao 2002).

Sources:
Zhao 2002 Zhao et al. 2003

1.3 Establishment requirements - Water temperature

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

Score: **0** of **3.75**

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

Background Information:
Experiments by Zhao (2002) on Hong Kong populations found that no larvae metamorphosed at 15°C. Larvae exposed to temperatures of 20, 25, and 30°C all underwent metamorphosis. Higher temperatures were associated with faster development rates (Zhao 2002).

Sources:
Zhao 2002

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

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

Background Information:
Can tolerate a broad range of salinities. Under controlled conditions, larvae were able to metamorphose at salinities between 15 and 32 ppt (Zhao 2002). Neither larvae nor juveniles exhibited stress responses when exposed to salinities > 30 ppt. ~30% and >15% of larvae reached metamorphosis when exposed to salinities of 35 and 45 ppt, respectively (Zhao 2002).

Sources:
Zhao 2002

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:
This species has been reported in WA.

Background Information:
Crepidula onyx is native to the west coast of the America, from southern California to Peru. It has been introduced to Puget Sound, WA but is reported as rare. Its establishment in WA may be dependent upon warmer waters in restricted areas of the bay.

Sources:
NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: C

In few ecoregions globally

Score: 1.75 **of** 5

Ranking Rationale:
This species is largely restricted to warm-temperate and tropical waters on both coasts of the Pacific Ocean.

Background Information:
Crepidula onyx is a warm-temperate and tropical species. It is native to the west coast of the America, from southern California to Peru. It has been introduced to Puget Sound, WA. It has also been introduced in Asia, where it has been reported in Japan, Hong Kong, China, and South Korea.

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:

This species spread rapidly in eastern Asia following its discovery in the late 1970s, but no recent expansions have been reported.

Background Information:

This species spread rapidly in Japan, China, and Korea following its introduction to the west Pacific (Fofonoff et al. 2003). A recent assessement in Hong Kong reported that C. onyx had not expanded its range in the region since the 1980s (Astudillo et al. 2014). Although it is found in WA, it is considered rare and its expansion northward is likely limited by its low tolerance for cold water temperatures (Fofonoff et al. 2003). No reports of recent range expansions were found.

Sources:

NEMESIS; Fofonoff et al. 2003 Astudillo et al. 2014

Section Total - Scored Points:	13.75
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

2. Anthropogenic Transportation and Establishment

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

Choice: **A** — Has been observed using anthropogenic vectors for transport and transports independent of any anthropogenic vector once introduced

Score: 4 of 4

High uncertainty? ☑

Ranking Rationale:
This species uses anthropogenic vectors for transport, but it can disperse naturally once introduced. There is a lack of information on its natural movements and dispersal patterns.

Background Information:
This species can be transported by hull fouling and ballast water (Fofonoff et al. 2003; Molnar et al. 2008). This species can disperse locally through its planktonic larval stage (Molnar et al. 2008).

Sources:
Molnar et al. 2008 NEMESIS; Fofonoff et al. 2003

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 has been found growing on anthropogenic and natural substrates in its introduced range.

Background Information:
Adults attach themselves to natural and anthropogenic substrates including rocks, bivalve shells, and ship hulls. In Hong Kong, this species was found in areas associated with high human activity (piers, marinas), but individuals were seen on rocks rather than on the pier (Astudillo et al. 2014).

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

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

Choice: **B** — No

Score: 0 of 2

Ranking Rationale:
This species is not intentionally farmed.

Background Information:

Sources:
NEMESIS; Fofonoff et al. 2003

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:
Food items are readily available in the Bering Sea.

Background Information:
C. onyx is a filter feeder. It eats phytoplankton and detritus.

Sources:
NEMESIS; Fofonoff et al. 2003

3.2 Habitat specialization and water tolerances

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

Choice: A

Generalist; wide range of habitat tolerances at all life stages

Score: 5 of 5

Ranking Rationale:
This species can establish on a variety of substrates in lower tidal zones, and can tolerate high levels of human disturbance and a broad range of salinities. Its northward expansion may be limited by its higher temperature requirements.

Background Information:
This species can grow on a variety of a substrates. It has a broad salinity range, but it is likely sensitive to cold temperatures (Fofonoff et al. 2003). It has been reported for low intertidal to subtidal zones (Zhao and Qian 2002). This species is common in Hong Kong, an area with high levels of human disturbance and strong seasonal fluctuations in salinity and temperature (Astudillo et al. 2014). This species has a tolerance to mild levels of hypoxia; however, dissolved oxygen (DO) levels below 2 mg O2/l is lethal for larvae (Li and Chiu 2013).

Sources:
NEMESIS; Fofonoff et al. 2003 Zhao and Qian 2002 Astudillo et al. 2014 Li and Chiu 2013

3.3 Desiccation tolerance

Choice: U

Unknown

Score: of

Ranking Rationale:
This species' tolerance to desiccation is unknown.

Background Information:
No information found. This species is associated with low intertidal and subtidal habitats (Zhao and Qian 2002), which may suggest that this species has a low tolerance to desiccation.

Sources:
Zhao and Qian 2002

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:
C. onyx is cyclically hermaphroditic and highly fecund. Eggs are brooded. This species grows rapidly and has a short generation time.

Background Information:
C. onyx is a protandic hermaphrodite with a pelagic larval stage (Zhao 2002). Eggs are brooded by the female for about 10 days (Zhao et al. 2003). In its native range, C. onyx produced 6 to 8 broods per year with 5000 to 20 000 larvae in each brood (Coe 1949, qtd. in Zhao 2002). This species lives 2 to 3 years (Coe 1942, qtd. in Woodruff et al. 1986). It grows rapidly, reaching a shell length of 6 to 60 mm within its first year (Woodruff et al. 1986). Males are sexually mature at minimum shell lengths of 6 to 10 mm (Woodruff et al. 1986).

Sources:
Zhao 2002 Woodruff et al. 1986

3.5 Likelihood of long-distance dispersal or movements

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

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

Score: 2.5 of 2.5

High uncertainty? ☑

Ranking Rationale:
The dispersal potential of C. onyx is unknown. However, genetic studies on a closely related species with similar reproductive traits suggest that the larval stage of this species may be able to disperse long (>10 km) distances.

Background Information:
In both its native and introduced range, adults have an aggregated distribution and are often found growing close or on top of each other (Zhao 2002). A study on a closely related species, Crepidula fornicata, was found to have strong dispersal abilities, with populations more than 100 km apart showing no significant genetic differentiation (Viard et al. 2006).

Sources:
Zhao 2002 Viard et al. 2006

3.6 Likelihood of dispersal or movement events during multiple life stages

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

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

Score: 1.75 of 2.5

Ranking Rationale:
This species' has a long-lived larval stage that is likely capable of long-distance dispersal.Eggs are brooded by females and adults are largely sessile.

Background Information:
Adults are capable of localized movement by crawling on the substrate. Larvae are long-lived and free-swimming. Eggs are brooded by females.

Sources:
Zhao 2002 NEMESIS; Fofonoff et al. 2003

3.7 Vulnerability to predators

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

Score: 1.25 **of** 5

High uncertainty? ☑

Ranking Rationale:
While no species-specific information was found, information on a closely related species suggest that C. onyx would have many predators in the Bering Sea.

Background Information:
No species-specific information found. A closely related species, C. fornicata, is preyed upon by starfish, crabs, fish, and marine snails (CABI 2017).

Sources:
CABI 2017

Section Total - Scored Points:	20.5
Section Total - Possible Points:	25
Section Total -Data Deficient Points:	5

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
No impacts have been reported for this species.

Background Information:
This species has been found attached to the shells of oysters and mussels, but does not seem to have any negative impacts on these species.

Sources:
NEMESIS; Fofonoff et al. 2003 Molnar et al. 2008

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:
Although no impacts have been reported, this speciesis a common fouling organism and is known to occur at high densities. By fouling substrates, this species may reduce available habitat for some organisms or, conversely, create secondary settlement habitat.

Background Information:
No impacts have been reported. Dense aggregations of individuals have been reported for this species (Huang et al. 1999, qtd. in Zhao 2002).

Sources:
NEMESIS; Fofonoff et al. 2003 Molnar et al. 2008 Zhao 2002

4.3 Impact on ecosystem function and processes

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
No impacts have been reported for this species.

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003 Molnar et al. 2008

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

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
No impacts have been reported for this species.

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003 Molnar et al. 2008

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**

Ranking Rationale:
This species is not known to transport diseases, parasites, or hitchhikers.

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003 Molnar et al. 2008

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 impacts have been reported. We did not find reports of hybridization between any Crepidula species. There are a few Crepidula species in Alaska.

Sources:
None listed

4.7 Infrastructure

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

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

Ranking Rationale:
Although no species-specific impacts have been reported, this species can foul anthropogenic substrates such as docks and ship hulls. Fouling organisms can impose high maintenance costs.

Background Information:
No impacts have been reported, but C. onyx is a common member of the fouling community (Fofonoff et al. 2003; Astudillo et al. 2014). 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 Astudillo et al. 2014 Cleere 2001

4.8 Commercial fisheries and aquaculture

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

Score: 0.75 of 3

Ranking Rationale:
Because this species fouls oyster and mussel shells, it may impact the growth and/or commercial value of this species. Shellfish aquaculture is currently a small industry in Alaska that occurs only in a restricted area of the Bering Sea.

Background Information:
Although no species-specific impacts have been reported, this species is known to foul oyster and mussel shells (Zhao 2002; Fofonoff et al. 2003). A closely related species, Crepidula fornicata, has had economic impacts on shellfish farming in Europe (CABI 2017).

Sources:
Zhao 2002 NEMESIS; Fofonoff et al. 2003 CABI 2017

4.9 Subsistence

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
This species is not expected to impact subsistence resources in the Bering Sea.

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003

4.101 Recreation

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
This species is not expected to impact recreational opportunities in the Bering Sea.

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003

4.11 Human health and water quality

Choice: D — No impact

Score: 0 of 3

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

Background Information:
No impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	2.25
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

5. Feasibility of prevention, detection and control

5.1 History of management, containment, and eradication

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

Score: [ ] of [ ]

Ranking Rationale:
No species-specific plans are in place to control or eradicate this species. This species is transported by ballast water and ship fouling. Controlling the spread of invasive species that use these vectors for transport is an active area of research.

Background Information:
We did not find any management plans that were specific to this species.

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:
This species can be transported by ballast water and ship fouling. Methods to control the spread of invasive species via these vectors are being developed, and currently necessitate major long-term investments.

Background Information:

Sources:
Zagdan 2010 Hagan et al. 2014

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:

Sources:
CFR 2017 Hagan et al. 2014

5.4 Presence and frequency of monitoring programs

Choice: A — No surveillance takes place

Score: [ ] of [ ]

Ranking Rationale:
No surveillance takes place for this species.

Background Information:

Sources:
None listed

5.5 Current efforts for outreach and education

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

Score: _____ **of** _____

Ranking Rationale:

There are no outreach or education programs developed for this species.

Background Information:

Sources:

None listed

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

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Literature Cited for *Crepidula onyx*

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