Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Philine auriformis*

Common Name *tortellini snail*

Phylum	Mollusca
Class	Gastropoda
Order	Cephalaspidea
Family	Philinidae

Final Rank 49.71

Data Deficiency: 12.50

Species Occurrence by Ecoregion

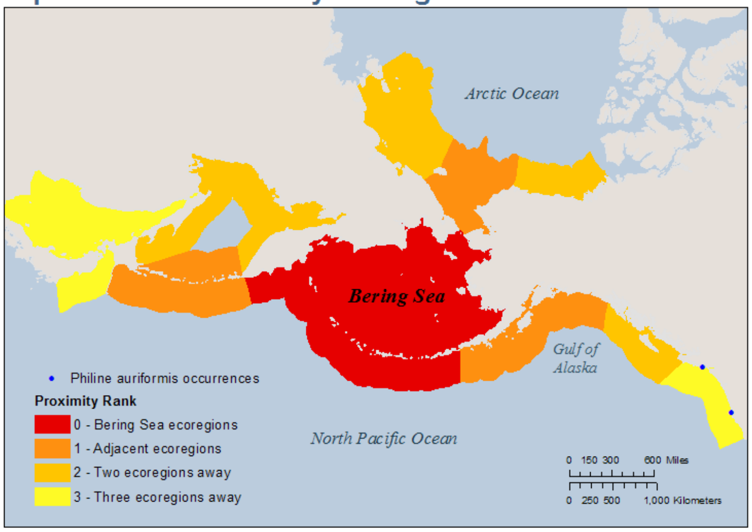

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	13.75	23	7.50
Anthropogenic Influence:	8	10	0
Biological Characteristics:	20.25	25	5.00
Impacts:	1.5	30	0
Totals:	43.50	87.50	12.50

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	NA	Minimum Salinity (ppt)	18
Maximum Temperature (°C)	NA	Maximum Salinity (ppt)	35
Minimum Reproductive Temperature (°C)	NA	Minimum Reproductive Salinity (ppt)	31*
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	35*

Additional Notes

Philine auriformis is a carnivorous sea slug that measures between 15 to 30 mm. Its body is transluscent white to off-white in color. At least two invasive Philine species occur in the western US, and it can be difficult to differentiate between these species.

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

Choice: U Unknown/Data Deficient

Score: of

Ranking Rationale:
Temperatures required for survival are unknown.

Background Information:
P. auriformis inhabits warm- to cold-temperate climates in its native and introduced range. Its temperature tolerance is unknown.

Sources:
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

High uncertainty? ☑

Score: 3.75 of 3.75

Ranking Rationale:
Although salinity thresholds are unknown, this species is a marine organism. We therefore assume that it can survive in saltwater (31 to 35 ppt); these salinities occur in a large (>75%) portion of the Bering Sea.

Background Information:
P. auriformis is a marine species. Its salinity requirements are unknown.

Sources:
NEMESIS; Fofonoff et al. 2003

1.3 Establishment requirements - Water temperature

Choice: U Unknown/Data Deficient

Score: of

Ranking Rationale:
Reproductive temperature requirements are unknown.

Background Information:
No information found.

Sources:
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

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:
NEMESIS; Fofonoff et al. 2003

1.5 Local ecoregional distribution

Choice: D Present in an ecoregion greater than two regions away from the Bering Sea

Score: 1.25 of 5

Ranking Rationale:
This species occurs as far north as southern British Columbia.

Background Information:
This species is found in California, Oregon, and on Vancouver Island (BC).

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 native to New Zealand and has only been reported to the west coast of North America.

Background Information:
This species is native to New Zealand. It is introduced and established in California and Oregon, and has been found on Vancouver Island, BC. No other introductions have been reported.

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 along the coast of the western United States following its introduction in the 1990s.

Background Information:
This species was introduced to CA in the 1990s, and spread rapidly from San Francisco Bay, CA to Coos Bay, OR in five years (Krug et al. 2012). Based on genetic analyses, Krug et al. (2012) believe that there was only one site of introduction, and that the spread of P. auriformis along the coast was due to natural dispersal.

Sources:
Krug et al. 2012

Section Total - Scored Points:	13.75
Section Total - Possible Points:	22.5
Section Total -Data Deficient Points:	7.5

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:

This species was first introduced to the western United States via anthropogenic vectors, but has spread naturally since then.

Background Information:

Krug et al. (2012) suggests that it was transported on ship hulls; however, because P. auriformis prefers soft substrates, Gosliner (1995) thinks transport via ballast water is a more likely vector. Based on genetic analyses, Krug et al. (2012) believe that the spread of P. auriformis along the US West Coast was due to natural dispersal.

Sources:

Krug et al. 2012 Gosliner 1995

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:

Populations have been found in both anthropogenic and natural sites.

Background Information:

P. auriformis prefers soft-bottom substrates and open-ocean sites, and is not a fouling species. It has been recorded from many harbours in CA, but is also found in Elkhorn Slough, a research reserve and relatively remote natural area (Wasson et al. 2001).

Sources:

Wasson et al. 2001

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:	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:
This species is an opportunistic predator and prey items are readily available in the Bering Sea.

Background Information:
P. auriformis preferentially prey on small, infaunal bivalves, but they are flexible and opportunistic consumers that eat foraminifera, gastropods and ophiuroids when bivalves are scarce (Gosliner 1995; Krug et al. 2012).

Sources:
Krug et al. 2012 Gosliner 1995

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 been collected from a range of habitats and is found from intertidal zones to depths > 300 m. It can tolerate a broad range of salinities, and has been reported in high-nutrient areas caused by human activities.

Background Information:
Found in intertidal areas on in the open ocean (>300 m depth), and on soft-bottom substrates including mudflats and eelgrass beds (Fofonoff et al. 2003; Krug et al. 2012). As an adult, Philine auriformis burrows in the substrate. The burying depth is unknown – some authors claim that it is shallowly buried (i.e. upper inch of the substrate), but others say it is often found at a depth of six inches below the sediment (qtd. in Cadian and Ranasinghe 2003). Based on trawling surveys, Cadien and Ranasinghe (2003) suggest that P. auriformis can occupy a wide range of substrate types.

P. auriformis has been recorded in Elkhorn Slough, an area where water quality is influenced by runoff from adjacent farmlands, and where extremely high nutrient, pesticide, and coliform bacterial levels have been documented (Wasson et al. 2001).

It can likely tolerate a wide range of salinities (18 to 30 PSU), but its temperature tolerance is unknown. This species has a restricted global distribution: has only been recorded in New Zealand, Australia (where it is not established), and along the west coast of the United States.

Sources:
Wasson et al. 2001 Krug et al. 2012 NEMESIS; Fofonoff et al. 2003 Cadien and Ranasinghe 2003

3.3 Desiccation tolerance

Choice: **U** Unknown

Score: of

Ranking Rationale:
This species' desiccation tolerance is unknown.

Background Information:
No information found.

Sources:
NEMESIS; Fofonoff et al. 2003

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

High uncertainty? ✔

Ranking Rationale:

This species is hermaphroditic and short-lived. Fertilization is internal. Fecundity is unknown.

Background Information:

P. auriformis is a simultaneous hermaphrodite, but is not known to self-fertilize. Fertilization is internal (Fofonoff et al. 2003). Individuals lay one or more egg masses that are attached to the substrate by a long thin stalk. Eggs hatch into larvae and are probably plankotrophic (Gosliner 1995). Most individuals appear to live for about a year (M. Chow, pers. comm., qtd. in Cadien and Ranasinghe 2003), though some individuals can survive for at least two years. Estimates on fecundity could not be found.

Sources:

Gosliner 1995 Cadien and Ranasinghe 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: A Disperses long (>10 km) distances

Score: 2.5 of 2.5

Ranking Rationale:

This species has a long-lived larval stage and is predicted to have long-distance dispersal abilities. Genetic analyses confirm that this species spread naturally from southern California to British Columbia.

Background Information:

Shanks (2009) estimates that the larval duration of Philine spp. is 30-40 days, and estimates a dispersal distance of 260 km. Genetic analyses reveal that this species was introduced once to the United States (San Francisco Bay), and subsequently spread all the way to Vancouver Island (Krug et al. 2012). The long-lived larval stage is believed to have facilitated this species' rapid dispersal (Krug et al. 2012). Adults burrow in the substrate. Most nudibranchs move by crawling or gliding on the ocean floor, though some can swim short distances by flexing their muscles (Rudman 2001).

Sources:

Shanks 2009 Krug et al. 2012 Rudman 2001

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:

This species has a long-lived larval stage. Natural dispersal likely only occurs during this larval stage.

Background Information:

Larval stage is long-lived (30-40 days), and is likely the main life stage at which dispersal occurs (Shanks 2009). Based on general information on nudibranchs, adult stage is likely not very mobile (Rudman 2001). Eggs are attached to the substrate, and there are no reports about egg masses detaching and drift away.

Sources:

Shanks 2009 Rudman 2001

3.7 Vulnerability to predators

Choice:		Score:
B	Few predators only in its home range, and not suspected in the Bering Sea or neighboring regions	**3.75** of **5**

High uncertainty? ✔

Ranking Rationale:

This species appears to have few predators in its introduced range.

Background Information:

P. auriformis has few natural predators. Philine spp. secrete an acidic discharge making them unpalatable to predators (Chow 2001, qtd. in Krug et al. 2012). Cadien and Ranasinghe (2003) noted an apparent lack of predators when P. auriformis first invaded the Southern California Bight.

Sources:

Cadien and Ranasinghe 2003   Krug et al. 2012

Section Total - Scored Points:	20.25
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

Ranking Rationale:

This species may have caused the decline of small bivalves when it was first introduced and occurred at very high densities. Populations of P. auriformis have declined since then, and no further impacts have been reported.

Background Information:

In Palo Verde, CA, a significant decline in the densities of small infaunal bivalves (the preferred prey of P. auriformis) was correlated with the introduction of Philine auriformis (Cadien and Ranasinghe 2003). However, the initial high population density and large individual sizes of P. auriformis populations in the Southern California Bight region did not persist. By 1996 had declined to relatively low levels (Cadien and Ranasinghe 2003). Moreover, while prey populations have declined, these declines were localized in areas where bivalve populations were unnaturally dense due to organic enrichment. As an opportunistic predator, P. auriformis may have impacts on other prey species (Krug et al. 2012), but no further impacts have been reported.

Sources:

Cadien and Ranasinghe 2003   Krug et al. 2012

4.2 Impact on habitat for other species

Choice: **D**

No impact

Score: 0 of 2.5

Ranking Rationale:

This species is not expected to alter habitat in the Bering Sea.

Background Information:

No impacts have been reported.

Sources:

NEMESIS; Fofonoff et al. 2003

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:

This species is an opportunistic predator that could potentially affect benthic food webs in intertidal and open ocean sites. Adults burrow in the substrate, and in so doing, may increase bioturbation.

Background Information:

When bivalves are scarce, P. auriformis easily switches to other prey items including foraminifera, gastropods, and brittle stars (Krug et al. 2012).

Sources:

Krug et al. 2012

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

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

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. There are no native Philine species in Alaska.

Sources:
NEMESIS; Fofonoff et al. 2003

4.7 Infrastructure

Choice: D No impact

Score: 0 of 3

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

Background Information:
This species is not a member of the fouling community and no impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003

4.8 Commercial fisheries and aquaculture

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
This species is not expected to impact commercial fishing in the Bering Sea.

Background Information:
This species does not feed on commercially important bivalve species, and no impacts have been reported.

Sources:
NEMESIS; Fofonoff et al. 2003

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 subsistence resources 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:	1.5
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 believed to be transported by ballast water or 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 numerous vectors. Methods to control the spread of invasive species via these vectors are being developed, and currently necessitate major long-term investments.

Background Information:

Sources:
Hagan et al. 2014   Zagdan 2010

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 is taking place for this species.

Background Information:
No information found.

Sources:
None listed

5.5 Current efforts for outreach and education

Choice: **A**

No education or outreach takes place

Score: of

Ranking Rationale:
No outreach or education programs are in place for this species.

Background Information:
No information found.

Sources:
None listed

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

Literature Cited for *Philine auriformis*

- 33 CFR § 151.2050 Additional requirements - nonindigenous species reduction practices
- Hagan, P., Price, E., and D. King. 2014. Status of vessel biofouling regulations and compliance technologies – 2014. Maritime Environmental Resource Center (MERC) Economic Discussion Paper 14-HF-01.
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