Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Polydora cornuta*

Common Name *whip mudworm*

Phylum	Annelida
Class	Polychaeta
Order	Canalipalpata
Family	Spionidae

Species Occurrence by Ecoregion

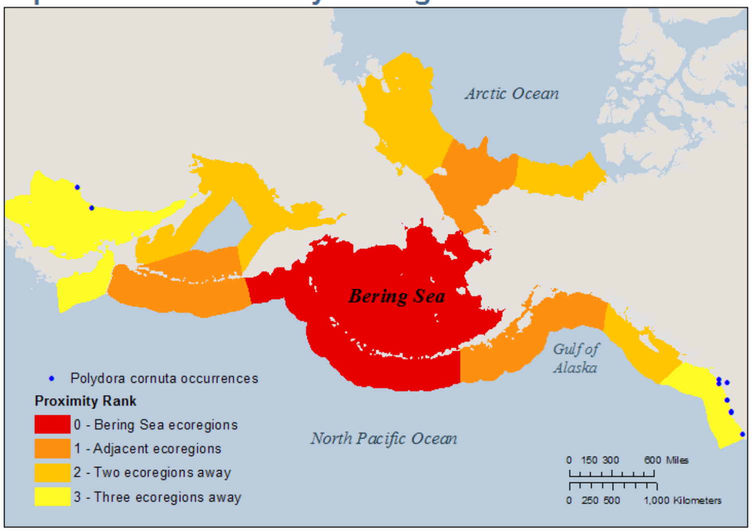

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Final Rank 51.25

Data Deficiency: 0.00

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	20.5	30	0
Anthropogenic Influence:	4.75	10	0
Biological Characteristics:	23	30	0
Impacts:	3	30	0
Totals:	51.25	100.00	0.00

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	-2	Minimum Salinity (ppt)	2
Maximum Temperature (°C)	29	Maximum Salinity (ppt)	75
Minimum Reproductive Temperature (°C)	10	Minimum Reproductive Salinity (ppt)	5
Maximum Reproductive Temperature (°C)	29	Maximum Reproductive Salinity (ppt)	75

Additional Notes

Polydora cornuta is a species complex of tube-building polychaete worms. Adult individuals have up to 90 segments, can be between 12 to 32 mm long, and are light tan in color.

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

High uncertainty? ✔

Ranking Rationale:
Temperatures 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:
This species' temperature range is from -2 to 29˚C (based on geographic distribution), though it can probably tolerate warmer temperatures.

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

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:
This species has been collected in water with salinities between 2 and 75 PSU. It is abundant at salinities above 5 PSU.

Sources:
NEMESIS; Fofonoff et al. 2003

1.3 Establishment requirements - Water temperature

Choice: C Little overlap – A small area (<25%) of the Bering Sea has temperatures suitable for reproduction

Score: 1.25 of 3.75

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

Background Information:
This species requires a minimum reproductive temperature of 10˚C (based on laboratory experiments; Orth 1971 qtd. in Fofonoff et al. 2003).

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

High uncertainty? ✔

Ranking Rationale:
Although upper 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:
This species requires a minimum reproductive salinity of 5 PSU.

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 is currently found from California to southern British Columbia.

Background Information:
This species is currently found in southern BC, and in the U.S. Pacific Northwest from WA to CA.

Sources:
NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: A In many ecoregions globally

Score: 5 of 5

Ranking Rationale:
Polydora cornuta has a global distribution. It is found on both coasts of North America, in Europe, South America, parts of Asia, Australia, and New Zealand.

Background Information:
This species' is found in cold- to warm-temperate waters around the world. It is considered cryptogenic in eastern North America, where it occurs from Quebec and Newfoundland south to the Caribbean; it is also considered cryptogenic in Atlantic Europe, where it is found in the Netherlands, Germany, and the U.K., south to Portgual. In Europe, it has also been reported in the Mediterranean, Aegean, and Black Seas. In the southern hemisphere, it is found in South America, Australia, New Zealand. In Asia, it occurs from Taiwan to southern Russia (Peter the Great Bay). It is invasive on the western coast of North America, where it occurs from southern British Columbia to Mexico.

Sources:
NEMESIS; Fofonoff et al. 2003

1.7 Current distribution trends

Choice: C Established outside of native range, but no evidence of rapid expansion or long-distance dispersal

Score: 1.75 of 5

Ranking Rationale:
Although this species has a widespread distribution, accounts of its geographic spread suggest that its dispersal is likely due to introductions by human vectors.

Background Information:
This species is being introduced worldwide via ballast waster and hull fouling, and has been transported extensively as a result of human activities (Radashevsky and Selifonova 2013).

Sources:
Radashevsky and Selifonova 2013

Section Total - Scored Points:	20.5
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 can transport by ballast water, hull fouling, and hitchhiking. Its geographic spread is attributed to introduction by humans (Radashevsky and Selifonova 2013).

Background Information:

Polydora cornuta was initially introduced to the west coast of North America with introductions of Eastern oysters (Crassostrea virginica). Nowadays, the most likely vectors of introductions are via hull fouling and ballast water (Radashevsky and Selifonova 2013).

Sources:

NEMESIS; Fofonoff et al. 2003   Radashevsky and Selifonova 2013

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

Choice: **B**

Readily establishes in areas with anthropogenic disturbance/infrastructure; occasionally establishes in undisturbed areas

Score: 2.75 **of** 4

Ranking Rationale:

In its introduce range, this species is more commonly associated with anthropogenic substrates than natural habitats.

Background Information:

This species is most often associated with anthropogenic habitats, although it can also settle on natural habitats such as soft-bottom substrates and oyster reefs. A survey of 174 invertebrate species in southern Brazil only found Polydora cornuta on artificial substrates (Bumbeer and da Rocha 2016). This species is tolerant of disturbance and polluted areas, which may facilitate its establishment in anthropogenic areas (Radashevsky and Selifonova 2013).

Sources:

Bumbeer and da Rocha 2016   NEMESIS; Fofonoff et al. 2003   Radashevsky and Selifonova 2013

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 intentionally cultivated.

Background Information:

Sources:

NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	4.75
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 has broad dietary preferences, and foods are readily available in the Bering Sea.

Background Information:
Larvae feed on phytoplankton, while adults switch between suspension and deposit feeding, consuming detritus, microalgae, and plankton. Predation on bivalve veligers has also been records.

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 exhibits a broad range of habitat and water tolerances.

Background Information:
This species can tolerate a wide range of temperatures and salinities, and can establish in disturbed or polluted areas (Radashevsky and Selifonova 2013). It can also tolerate hypoxic conditions and is often exposed to environmental extremes.

Sources:
Radashevsky and Selifonova 2013 NEMESIS; Fofonoff et al. 2003

3.3 Desiccation tolerance

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

Score: 1.75 of 5

High uncertainty? ✔

Ranking Rationale:
The desiccation tolerance of this species is unknown, but studies on related spionid polychaetes suggests that this group has a low tolerance to air exposure.

Background Information:
No species-specific information has been found. In Tasmania, infestation of abalones by two polychaetes (Boccardia knoxi and Polydora hoplura) was significantly reduced when fouled abalones were exposed to air for 3 to 8 hours (Lleonart et al. 2003). On average, less than 4 individuals of B. knoxi survived after being exposed to air for 8 hours.

Sources:
Lleonart 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: **A** High – Exhibits three or four of the above characteristics

Score: 5 **of** 5

Ranking Rationale:
This species exhibits external fertilization, high fecundity, and short generation time. Reproduction is sexual and sexes are separate.

Background Information:
Sexes are separate. Sperm is released in packets called spermatophores; these packets are then taken by females to fertilize her deposited eggs. Eggs are brooded in tubes built by females (Levin 1984). Females can store sperm, and a single spermatophore packet can fertilize several spawning events (Rice et al. 2008). Although single brood sizes are small (between 50 and 200 eggs; Levin 1984), Rice et al. (2008) estimated that P. cornuta females could produce between 26 000 and >31 000 eggs in 90 days under laboratory conditions. Larvae are planktonic. Development rates are affected by temperature and food supply. At 10°C, larvae settled within 60 days; time to settlement decreased to 16-28 days at 12°C, and 12 days at 28°C (qtd. in Fofonoff et al. 2003). Under laboratory conditions, sexual maturity occurred within 33 days at 18°C. Average adult survival was 13 months under controlled conditions.

Sources:
NEMESIS; Fofonoff et al. 2003 Rice et al. 2008 Levin 1984

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:
P. cornuta is considered capable of long-distance dispersal, but no quantitative estimates are provided.

Background Information:
Levin (1984) identified the planktonic larval stage as this species' main mode of dispersal. While she considers P. cornuta as a long-distance disperser, she does not define or estimate "long-distance".

Sources:
Levin 1984

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: A High – Exhibits two or three of the above characteristics

Score: 2.5 **of** 2.5

Ranking Rationale:
Larvae are free-swimming and long-lived. Smaller individuals may be dispersed via sediment transport. Adults are sessile and live in tubes; eggs are laid and fertilized in these tubes.

Background Information:
The larval stage is planktonic and long-lived: larvae can remain in the water column for up to 60 days at 10°C, and at least 1 week at 20°C. Levin (1984) considered the larval stage as this species' main dispersal stage, but Shull (1997) documented dispersal of small, recently settled individuals via bedload transport. Adults live in tubes that they build in the substrates, and eggs are deposited and fertilized in these tubes (Rice et al. 2008).

Sources:
NEMESIS; Fofonoff et al. 2003 Rice et al. 2008 Levin 1984 Shull 1997

3.7 *Vulnerability to predators*

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

Score: 1.25 **of** 5

Ranking Rationale:
This species is preyed upon by several species present in the Bering Sea ecoregion.

Background Information:
P. cornuta is preyed upon by fishes and invertebrates including shrimps and crabs.

Sources:
NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	23
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

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:
Although P. cornuta can become a dominant species in certain habitats, its presence has not been linked to the decline or extirpation of other species. At high densities, similar species are known to compete with native polychaetes.

Background Information:
P. cornuta fouls bivalve shells and has been documented feeding on oyster larvae (although species ID is tentative; Breese and Phibbs 1972); however, the effect on oyster fitness and populations is unknown (Fofonoff et al. 2003).

Polydora cornuta is tolerant of polluted sites, and is thus a strong competitor in eutrophic habitats. Once introduced, it can quickly become the dominant species in polluted habitats (Dagli and Ergen 2008; Karhan et al. 2008) and can occur at high densities of several thousand individuals/m2 (Karhan et al. 2008). However, the competitive abilities of P. cornuta in these sites are difficult to determine, because many other polychaetes perform poorly in polluted water (Fofonoff et al. 2003).

A similar tube-building species, Polydora limicola, competed with at least three native species in the Black Sea where it was introduced and became dominant (Losovskaya and Zolotarev 2003).

Sources:
NEMESIS; Fofonoff et al. 2003   Breese and Phibbs 1972   Dagli and Ergen 2008   Karhan et al. 2008   Losovskaya and Zolotarev 2003

4.2 *Impact on habitat for other species*

Choice: **D** No impact

Score: 0 of 2.5

Ranking Rationale:
Impacts on habitat have not been reported for this species.

Background Information:

Sources:
NEMESIS; Fofonoff et al. 2003   Losovskaya and Zolotarev 2003

4.3 *Impact on ecosystem function and processes*

Choice: **D** No impact

Score: 0 of 2.5

Ranking Rationale:
Impacts on ecosystem functions or processes have not been reported for this species.

Background Information:

Sources:
NEMESIS; Fofonoff et al. 2003

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

Choice: C Limited – Has limited potential to cause degradation of one more species or communities, with limited impact and/or within a very limited region

Score: 0.75 of 2.5

High uncertainty? ✔

Ranking Rationale:
Although it may feed on oyster larvae, Polydora cornuta has not been shown to affect population numbers, and no reports exist from natural settings.

Background Information:
Breese and Phipps (1972) claimed that P. cornuta ate significant amounts of oyster larvae in a hatchery facility. However, the identification of the polychaete worm was uncertain.

Sources:
Breese and Phibbs 1972

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 introduce parasites, diseases or hitchhikers.

Background Information:

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

High uncertainty? ✔

Ranking Rationale:
Geographically distinct populations of P. cornuta are able to hybridize under controlled conditions. The ability for P. cornuta to hybridize with other species is unknown, as is the effect of hybridization on populations. Alaska is home to ~50 species of tube-building polychaetes.

Background Information:
The taxonomy of this species complex remains unresolved. In some cases, individuals from geographically distinct populations (e.g., California and Florida) can hybridize under experimental conditions (Rice et al. 2008).

Sources:
Rice et al. 2008 AFSC 2016

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:
P. cornuta is a common fouling organism. Fouling organisms impose substantial economic costs for shipping and other marine industries.

Background Information:
P. cornuta is a common and abundant fouler of docks, ships, and other infrastructure. Fouling organisms cost the U.S. Navy over $50 million a year in fuel costs due to drag (Cleere 2001).

Sources:
NEMESIS; Fofonoff et al. 2003 Cleere 2001

4.8 *Commercial fisheries and aquaculture*

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
This species is not predicted to impact commercial fisheries in the Bering Sea.

Background Information:
Although P. cornuta feeds on oyster larvae (Breese and Phibbs 1972), impacts to the fishing or shellfish industry have not been reported (Fofonoff et al. 2003).

Sources:
Breese and Phibbs 1972 NEMESIS; Fofonoff et al. 2003

4.9 *Subsistence*

Choice: **D** No impact

Score: 0 of 3

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

Background Information:

No impacts have been reported. This species is considered a pollution indicator because of its ability to tolerate polluted areas.

Sources:

NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	3
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 Polydora worms are being tested.

Background Information:
Several methods to control Polydora worms have been tested, including exposure to air and freshwater, chemical methods, and physical removal (Haskin and Calvo 2014).

Sources:
Haskin and Calvo 2014

5.2 Cost and methods of management, containment, and eradication

Choice: **B** Major short-term and/or moderate long-term investment

Score: of

Ranking Rationale:
Control of Polydora sp. infestation on oyster farms requires a moderate investment sustained over time. To date, treatment methods are not fully effective at controlling infestations.

Background Information:
For a mid-sized oyster farm, controlling Polydora sp. infestation requires approximately 700 hours of labor, and an additional $2000 per year for equipment and supplies (Haskin and Calvo 2014). Treatments are still being developed and need to be repeated (Haskin and Calvo 2014).

Sources:
Haskin and Calvo 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:
We did not find any information to suggest that Polydora cornuta is being monitored in Alaska.

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:

We did not find any information on outreach or education programs for this species.

Background Information:

Sources:

None listed

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

Literature Cited for *Polydora cornuta*

- AFSC. 2016. Polychaete Tube Worms. Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration. Available from: http://www.afsc.noaa.gov/groundfish/HAPC/PolychaeteTubeWorms_synopsis.htm Accessed 16-Feb-2017.
- Breese, W.P., and F. D. Phibbs. 1972. Ingestion of bivalve molluscan larvae by the polychaete annelid Polydora ligni. Veliger 14:274.
- Bumbeer, J., and R. M. da Rocha. 2016. Invading the natural marine substrates: A case study with invertebrates in South Brazil. Zoologia 33(3): e20150211.
- 33 CFR § 151.2050 Additional requirements - nonindigenous species reduction practices
- Cleere, G. 2001. Battling the barnacle (and other ship-fouling critters). 2001 Media Releases, Office of Naval Research, Arlington, VA. Available from: https://www.onr.navy.mil/en/Media-Center/Press-Releases/2001/Battling-the-Barnacle.aspx Accessed 11-Jan
- Dagli, E. and Z. Ergen. 2008. First record of Polydora cornuta Bosc, 1802 (Polychaeta: Spionidae) from the Sea of Marmara, Turkey basin. Aquatic Invasions 3:231-233.
- 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.
- Haskin, B., and L. Calvo. 2014. Methods to control bio-fouling of cultured eastern oysters, Crassostrea virginica, by the tube-building polychaete worm, Polydora cornuta. Prepared for Sustainable Agriculture Research & Education (SARE), Report FNE13-780,
- Karhan, S. U., Kalkan, E., Simboura, N., Mutlu, E., and M. Bekbolet. 2008. On the occurrence and established populations of the alien polychaete Polydora cornuta Bosc, 1802 (Polychaeta: Spionidae) in the Sea of Marmara and the Bosphorus Strait (Turkey). M
- Levin, L. A. 1984. Life history and dispersal patterns in a dense infaunal polychaete assemblage: Community structure and response to disturbance. Ecology 65(4):1185-1200.
- Lleonart, M., Handlinger, J., and M. Powell. 2003. Treatment of spionid mud worm (Boccardia knoxi Rainer) infestation of cultured abalone. Aquaculture 217:1-10.
- Losovskaya, G. V., and V. N. Zolotarev. 2003. The polychaete Polydora limicola in benthic communities of the Black Sea. Russian Journal of Marine Biology 29(4):248-250.
- Fofonoff, P. W., G. M. Ruiz, B. Steves, C. Simkanin, and J. T. Carlton. 2017. National Exotic Marine and Estuarine Species Information System. http://invasions.si.edu/nemesis/. Accessed: 15-Sep-2017.
- Radashevsky, V. I., and Z. P. Selifonova. 2013. Records of Polydora cornuta and Streblospio gynobranchiata (Annelida, Spionidae) from the Black Sea. Mediterranean Marine Science 14(2):261-269. doi: 10.12681/mms.415
- Rice, S. A., Karl, S., and K. A. Rice. 2008. The Polydora cornuta complex (Annelida: Polychaeta) contains populations that are reproductively isolated and genetically distinct. Invertebrate Biology 127(1):45-64.
- Shull, D. H. 1997. Mechanisms of infaunal polychaete dispersal and colonization in an intertidal sandflat. Journal of Marine Research 55:153 179.