Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Venerupis philippinarum*

Common Name *Japanese littleneck*

Phylum	Mollusca
Class	Bivalvia
Order	Veneroida
Family	Veneridae

Final Rank 63.24

Data Deficiency: 7.50

Species Occurrence by Ecoregion

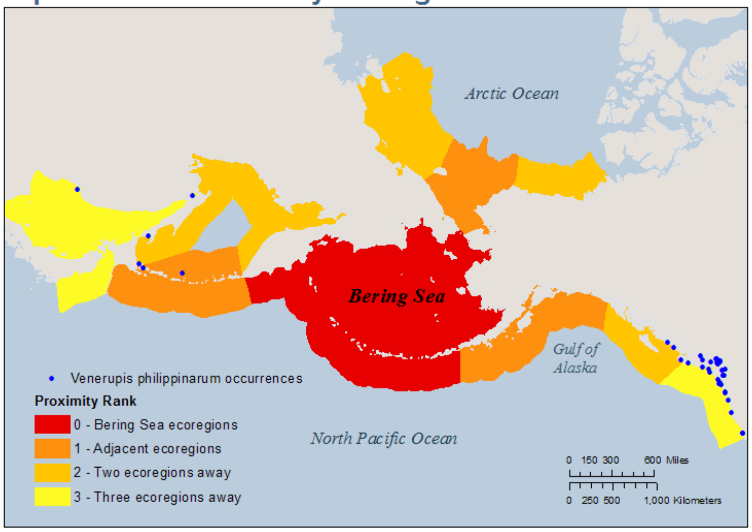

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	22.5	30	0
Anthropogenic Influence:	10	10	0
Biological Characteristics:	21.25	25	5.00
Impacts:	4.75	28	2.50
Totals:	58.50	92.50	7.50

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	0	Minimum Salinity (ppt)	12
Maximum Temperature (°C)	37	Maximum Salinity (ppt)	50
Minimum Reproductive Temperature (°C)	18	Minimum Reproductive Salinity (ppt)	24
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	35

Additional Notes

V. philippinarum is a small clam (40 to 57mm) with a highly variable shell color; however, the shell is often predominantly cream-colored or gray. It is often variegated, with concentric brown lines, or patches. The interior margins are deep purple, while the center of the shell is pearly white, and smooth

Reviewed by Nora R. Foster, NRF Taxonomic Services, Fairbanks AK

Review Date: 9/27/2017

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

Choice: **B** Moderate overlap – A moderate area (≥25%) of the Bering Sea has temperatures suitable for year-round survival

Score: 2.5 of 3.75

High uncertainty? ✔

Ranking Rationale:
Temperatures required for year-round survival occur in a moderate area (≥25%) of the Bering Sea. Lower threshold is based on geographic distribution, which may not represent physiological tolerances; moreover, models disagree with respect to their estimates of suitable area. We therefore ranked this question with "High uncertainty".

Background Information:
Based on field observations, the lower temperature tolerance is 0°C (Kamenev and Nekrasov 2012). Based on experiments, the upper temperature tolerance is 37°C (Shin et al. 2000 qtd. in Fofonoff et al. 2003).

Sources:
NEMESIS; Fofonoff et al. 2003   Kamenev and Nekrasov 2012

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:
Based on experiments, the lower limit of salinity tolerance is 12. 5 ppt (Elston et al. 2003) with survival decreasing below 19.2 PSU (Shin et al. 2000 qtd. in Fofonoff et al. 2003; Carregosa et al. 2014). Based on field observations, the upper limit of salinity tolerance is 50 ppt (Breber 2002 qtd in Fofonoff et al. 2003; Carregosa et al. 2014).

Sources:
Elston et al. 2003   Carregosa et al. 2014   NEMESIS; Fofonoff 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:
The temperature range required for reproduction of V. philippinarum is 18°C to 30°C (Toba et al. 1992 as qtd. in Inoue et al. 2012).

Sources:
NEMESIS; Fofonoff et al. 2003   Inoue et al. 2012

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:
The salinity range required for reproduction of V. philippinarum is experimentally determined to be 24 ppt to 35 ppt (Food and Agricultural Organization 2003).

Sources:
FAO 2013 NEMESIS; Fofonoff et al. 2003

1.5 Local ecoregional distribution

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

Score: 2.5 **of** 5

Ranking Rationale:

Background Information:
Found in British Columbia (Vancouver Island). This species is native to the Sea of Okhotsk (Kuril and Sakhalin Islands in southern Russia).

Sources:
NEMESIS; Fofonoff et al. 2003

1.6 Global ecoregional distribution

Choice: A In many ecoregions globally

Score: 5 **of** 5

Ranking Rationale:
Wide global distribution.

Background Information:
It has a wide native range from southern Russia to India, Sri Lanka, and the Philippines. It has been introduced to Hawaii, the West Coast of North America (from California to British Columbia's Vancouver Island), Europe (English Channel to southern Italy), the Mediterranean, Tahiti and Fiji.

Sources:
NEMESIS; Fofonoff et al. 2003

1.7 Current distribution trends

Choice: **A** — Recent rapid range expansion and/or long-distance dispersal (within the last ten years)

Score: 5 of 5

Ranking Rationale:

Evidence of recent range expansion and long-distance dispersal.

Background Information:

In British Columbia: First found in Ladysmith Harbour in 1936. In 30 years, spread throughout the Strait of Georgia and along the entire western coast of Vancouver Island and have become one of the major intertidal bivalves. In the 1960s, clams spread to the Queen Charlotte Strait and in 1970s to the central coastal area (Bendell 2014). Further expansion in B.C. may be limited by thermal tolerance thresholds.

Following introduction in northern Italy's Venice Lagoon, V. philippinarum spread naturally along the Adriatic coast at a rate of 30 km/year (Breber 2002, qtd. in Sweet and Sewell 2011).

Sources:

Bendell 2014   Sweet and Sewell 2011

Section Total - Scored Points:	22.5
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: **A**

Has been observed using anthropogenic vectors for transport and transports independent of any anthropogenic vector once introduced

Score: 4 of 4

Ranking Rationale:

Long-distance dispersal due to anthropogenic means. Can also disperse naturally.

Background Information:

In British Columbia, was unintentionally introduced, having "hitch-hiked" on Pacific oyster seed in the mid-1930s (Quayle and Bourne 1972, qtd. in Bendell 2014). Can also be transported via ballast water. Natural spread from aquaculture nets to wild habitat has been reported. Currently found in southern Russia and Japan, and along the west coast of North America from B.C. to California.

Sources:

Bendell 2014 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:

Can establish in anthropogenic areas (e.g. in cultivation) and in undisturbed areas.

Background Information:

Spread to multiple sites in British Columbia following accidental introduction in 1936. Natural spread following introduction has also occurred in northern Italy (Breber 2002, qtd. in Sweet and Sewell 2011). Natural spread from aquaculture nets to wild habitat has been reported.

Sources:

Bendell 2014 Sweet and Sewell 2011

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

Choice: **A**

Yes

Score: 2 of 2

Ranking Rationale:

Background Information:

Is intensively farmed and recreationally harvested in both its native and introduced range.

Sources:

FAO 2013 NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	10
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:
Consumes numerous taxa, many of which exist in the Bering Sea.

Background Information:
Filter feeder. Larvae and juveniles feed mostly on phytoplankton. In adults, range of feeding habits has been reported: phytoplankton, benthic microalgae (primarily pennate diatoms), and terrestrial organic matter (Breber 2002 qtd. In Fofonoff et al. 2003; Kasai et al. 2004; Sakamaki and Richardson 2008). The importance of these items varies by site, suggesting opportunistic feeding.

Sources:
Kasai et al. 2004   NEMESIS; Fofonoff et al. 2003   Sakamaki and Richardson 2008

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:
Tolerant of a wide range of temperatures and salinities.

Background Information:
V. philippinarum is a burrowing bivalve that prefers coarse sand and gravel. It can be found in shallow, subtropical to cool temperate areas. It also has wide temperature and salinity tolerances.

Sources:
NEMESIS; Fofonoff et al. 2003

3.3 Desiccation tolerance

Choice: **U** — Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

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:
Sexual reproduction, high fecundity, low parental investment, external fertilization, short generation time.

Background Information:
V. philippinarum undergoes sexual, external fertilization. First spawning can occur as early as 1 year, especially in warmer climates where it occurs year round. In cooler climates first spawn may not occur until 2 to 3 years and only once or twice a year (Yap 1977; Ponurovsky and Yakolev 1992). Females can produce up to 2.4 million eggs that, when fertilized, develop into a planktonic larvae that settles to the sediment as a clam in 12 to 24 days (Toba et al. 1992 qtd. in Inoue et al. 2012).

Sources:
Inoue et al. 2012 NEMESIS; Fofonoff et al. 2003 Ponurovsky and Yakolev 1992 Yap 1977

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:
Disperses widely at planktonic stage. Populations were observed expanding up to 30 km/year.

Background Information:
V. philippinarum is a broadcast spawner. Adults are sessile and shallowly burrowed on the sea floor, but larvae are planktonic, long-lived (~ 2 weeks), and disperse widely (Kasuya et al. 2004). Larvae are capable of active swimming. A modeling exercise showed that vertical swimming behaviour over relatively short distances (metres) could potentially affect dispersion patterns over many kilometres (Herbert et al. 2012). Realized dispersal distance is highly dependent on currents (Herbert et al. 2012). Following introduction to the Venice Lagoon, V. philippinarum has spread along the Adriatic coast at a rate of 30 km/year (Breber 2002, qtd. in Sweet and Sewell 2011).

Sources:
Herbert et al. 2012 Kasuya et al. 2004 Sweet and Sewell 2011

3.6 *Likelihood of dispersal or movement events during multiple life stages*

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

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

Score: 2.5 of 2.5

Ranking Rationale:
Highly mobile as larvae, larval viability window is long.

Background Information:
Broadcast spawning and a free-swimming, planktonic larval stage that lasts ~2-3 weeks. Once larvae have attached to the substrate, are more or less sessile (though they can move vertically in the substrate).

Sources:
NEMESIS; Fofonoff et al. 2003

3.7 Vulnerability to predators

Choice:		Score:
D	Multiple predators present in the Bering Sea or neighboring regions	1.25 of 5

Ranking Rationale:

Numerous predators, many of which exist in the Bering Sea.

Background Information:

Due to its relatively shallow burrows and shorter siphon, V. philippinarum has been widely predated upon by snails, starfish, crabs, fishes, diving ducks, shorebirds, sea otters, and raccoons (Cohen 2005; Dudas et al. 2005; Cloern et al. 2007; Lewis et al. 2007; Gillespie et al. 2012).

Sources:

Cloern et al. 2007 Cohen 2005 Dudas et al. 2005 Gillespie et al. 2012 Lewis et al. 2007 NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	21.25
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:
Effect on phytoplankton i.e. more than one trophic level is purely speculative. Declines, but not extirpation, of native bivalves have been reported. In many cases, this decline has been linked to the artificially high densities of V. philippinarum and other factors such as pollution and disease have not been ruled out.

Background Information:
V. philippinarum has outcompeted and replaced native species such as the Pacific Littleneck (Leukona staminea) in British Columbia and the clam Ruditapes decussatus in Europe (Bendell 2014; Pranovi et al. 2006).
Other studies have also pointed out that at lower densities, that occur outside of farmed locations, V. philippinarum has little to no direct negative impacts on the Pacific littleneck or Ruditapes decussatus (Byers 2005 qtd. in Sweet and Sewell 2011; Bidegain and Juanes 2013).

Sources:
Bendell 2014   Bidegain and Juanes 2013   NEMESIS; Fofonoff et al. 2003   Pranovi et al. 2006   Sweet and Sewell 2011

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:
Documented changes in habitat are caused by destructive aquaculture practices. to V. philippinarum's farming practices. The effects of "wild" V. philippinarum on habitat is unknown.

Background Information:
The use of vibrating rakes for cultivation causes disturbance and resuspension of sediments (Nunes and Markandya 2008).

Sources:
NEMESIS; Fofonoff et al. 2003   Nunes and Markandya 2008

4.3 *Impact on ecosystem function and processes*

Choice: **B** Moderate – Causes moderate changes to food webs or ecosystem functions in several areas, or causes severe effects in only one or a few areas (e.g., in areas where species occurs at high densities)

Score: 1.75 of 2.5

Ranking Rationale:
Impacts nutrient flows, favoring algal growth. Burrowing activities increase sediment erosion.

Background Information:
A comparison between farmed and unfarmed sites in northern Italy, where V. philippinarum occurs at very high densities (2000-2500 individuals/m2), found that the presence of V. philippinarum had a strong impact on nutrient flows through respiration and excretion activities, and by reducing surface sediments. Rapid nutrient recycling stimulated by the high biodegradability of clam feces and pseudofeces could favour macroalgal growth, while demand for O2 and production of CO2 could lead to anoxia (Bartoli et al. 2001).
Laboratory experiments studying the relationship between bioturbation and sediment stability found a significant correlation between mean erosion rate and density of V. philippinarum (Sgro et al. 2005). Effects of density on sediment erosion were more pronounced at the lower current velocities. Study concluded that burrowing activity of V. philippinarum reduces sediment stability, particularly at relatively low current velocities (25 cm/s), and at densities below those currently found in some clam cultivation areas (Sgro et al. 2005).

Sources:
Bartoli et al. 2001   NEMESIS; Fofonoff et al. 2003   Sgro et al. 2005

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

Choice: **U** Unknown

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

4.5 Introduction of diseases, parasites, or travelers

What level of impact could the species' associated diseases, parasites, or travelers have on other species in the assessment area? Is it a host and/or vector for recognized pests or pathogens, particularly other nonnative organisms?)

Choice: **C** Limited – Has limited potential to spread one or more organisms, with limited impact and/or within a very limited region

Score: 0.75 of 2.5

Ranking Rationale:
Carries lots of disease and parasites, but all seem native to Pacific Northwest, and mostly detrimental to Europe.

Background Information:
Supports numerous parasites, including a variety of bacteria, protozoans, trematodes, and the introduced parasitic copepod Mytilicola orientalis (Bower et al. 1992; Marshall et al. 2003; Gillespie et al. 2012). M. orientalis is considered an invasive species in western North America. M. orientalis (red worm) parasitizes mussels, including Mytilus edilus (blue mussel), which is found in Alaska.

Is also associated with Perkinsus protozoan parasites and Brown Ring Disease (BRD) that are responsible for mass mortalities of both V. philippinarum and R. desussatus in Spain, and France (Sagrista et al. 1996; Cigarria et al. 1997; Bower 2007 qtd. in Sweet and Sewell 2011).

Sources:
Bower et al. 1992   Cigarria et al. 1997   Gillespie et al. 2012   Marshall et al. 2003   NEMESIS; Fofonoff et al. 2003   Sagrista et al. 1996   Sweet and Sewell 2011

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:
Hybridization occurs with other Venerupis spp. No native Venerupis spp. in Bering Sea.

Background Information:
The only report of hybridization is with V. decussata in Ria de Vigo, Spain. The extent and significance of this is unknown (Hurtado et al. 2011).

Sources:
Hurtado et al. 2011   NEMESIS; Fofonoff et al. 2003

4.7 Infrastructure

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
No impacts have been reported to date. Given its ecology, we do not expect this species to impact infrastructure in the Bering Sea.

Background Information:
No information to suggest impact on infrastructure. V. philippinarum burrows in the substrate and is therefore not a fouling organism like other bivalves.

Sources:
NEMESIS; Fofonoff et al. 2003

4.8 Commercial fisheries and aquaculture

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
Has no negative impact on commercial fisheries and positive effects on aquaculture.

Background Information:
V. philippinarum is one of the most widely cultivated clam species in the world, including in its introduced ranges, because it can be cultured in dense populations in shallow waters (Breber 2002 qtd. in Sweet and Sewell 2011; Gillespie et al. 2012; Food and Agricultural Organization 2013).

No negative impacts on other commercial fisheries has been reported. In some parts of Europe, V. philippinarum was introduced to make up for declining or highly variable yields of native clam species.

Sources:
FAO 2013 Gillespie et al. 2012 NEMESIS; Fofonoff et al. 2003 Sweet and Sewell 2011

4.9 Subsistence

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on subsistence have been reported for V. philippinarum, and given its ecology, none would be expected.

Background Information:
No information available in the literature.

Sources:
None listed

4.101 Recreation

Choice: **D** No impact

Score: 0 of 3

Ranking Rationale:

Background Information:
Frequently harvested by recreational shellfishers in British Columbia, Washington, and California.

Sources:
NEMESIS; Fofonoff et al. 2003

4.11 Human health and water quality

Choice:		Score:
C	Limited – Has limited potential to pose a threat to human health, with limited impact and/or within a very limited region	0.75 of 3

Ranking Rationale:

Cases of PSP and other shellfish syndromes are rare in Alaska. Current regulations and safety procedures greatly reduce the risk of bacterial transmission, especially in cultivated mussels. Recreational harvesting of shellfish in the Bering Sea is limited.

Background Information:

All bivalves can bioaccumulate toxins in their tissues as a result of consuming toxic dinoflagellates. Consuming raw or cooked bivalves can lead to Paralytic Shellfish Poisoning (PSP), which can cause health issues and even death (NIMPIS 2009). The state of Alaska discourages harvesting on untested beaches (ADEC 2013).

Sources:

NIMPIS 2009   ADEC 2013

Section Total - Scored Points:	4.75
Section Total - Possible Points:	27.5
Section Total -Data Deficient Points:	2.5

5. Feasibility of prevention, detection and control

5.1 History of management, containment, and eradication

Choice: **A** Attempted; control methods are not successful

Score: of

Ranking Rationale:
Control methods were tested and unsuccessful.

Background Information:
To prevent spread due to cultivation, it has been suggested to use triploid V. philippinarum as they show reduced fecundity. Unfortunately, sterilization is not reliably achieved (Laing and Utting 1994; Jensen et al. 2005 qtd. in Sweet and Sewell 2011).

Eradication measures are also extreme as removal requires dredging, which is not even guaranteed to be successful on top of the expense and damage to the local environment (Sweet and Sewell 2011).

Sources:
Laing and Utting 1994   Sweet and Sewell 2011

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:

Background Information:
There are no proven methods of control or eradication for this species. Dredging is a possible eradication method, but would cause massive and unacceptable environmental harm.

Sources:
Sweet and Sewell 2011

5.3 Regulatory barriers to prevent introductions and transport

Choice: **C** Regulatory oversight and/or trade restrictions

Score: of

Ranking Rationale:
Transport of bivalve species is regulated in Alaska. U.S. federal regulations require mandatory reporting and ballast water treatment or exchange.

Background Information:
Regulations exist regarding the transport and introduction of shellfish in water bodies. Under Alaska law, a permit must be obtained from the Alaska Department of Fish and Game (ADF&G) in order to collect, possess, or transport shellfish for educational, scientific, or propagative uses. Ballast water management is mandatory and regulated by the U.S. Coast Guard (CFR 33 § 151.2).

Sources:
ADF&G 2016

5.4 *Presence and frequency of monitoring programs*

Choice: A No surveillance takes place

Score: of

Ranking Rationale:

Background Information:
No specific efforts for V. phillipinarum found.

Sources:
None listed

5.5 *Current efforts for outreach and education*

Choice: A No education or outreach takes place

Score: of

Ranking Rationale:

Background Information:
No specific efforts for V. phillipinarum found.

Sources:
None listed

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

Literature Cited for *Venerupis philippinarum*

- NIMPIS. 2009. National Introduced Marine Pest Information System. Available from: http://www.marinepests.gov.au/nimpis
- ADEC. 2013. Paralytic Shellfish Poisoning Fact Sheet. Alaska Department of Environmental Conservation. Available from: http://dec.alaska.gov/eh/fss/Food/Docs/fact_PST_6-4-2013_final%20(2).pdf. Accessed 02-Jan-2017.
- Bower, S. M., Blackbourn, J., and G. R. Meyer. 1992. Parasite and symbiont fauna of Japanese littlenecks, Tapes philippinarum (Adams and Reeve, 1850), in British Columbia. Journal of Shellfish Research 11:13-19
- 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.
- ADF&G. 2016. Invasive Pike in Southcentral Alaska: What Can be Done about Unwelcome Pike? Alaska Department of Fish & Game. Available from: http://www.adfg.alaska.gov/index.cfm?adfg=invasivepike.options Accessed 03-November-2016.
- Marshall, D. J., Pechenik, J. A., and M. J. Keough. 2003. Larval activity levels and delayed metamorphosis affect post-larval performance in the colonial ascidian Diplosoma listerianum. Marine Ecology Progress Series 246:153–162.
- Cohen, A. N. (2005). Exotics guide. San Francisco Estuary Institute, Oakland CA.
- Kamenev, G. M., and D. A. Nekrasov. 2012. Bivalve fauna and distribution in the Amur River estuary—A warm-water ecosystem in the cold water Pacific region. Marine Ecology Progress Series 455:195-210.
- Elston, R. A., Cheney, D. P., MacDonald, B. F., and A. D. Suhrbier. 2003. Tolerance and response of Manila Clam, Venerupis phillipinarum (A. Adams and Reeve, 1850) to low salinity. Journal of Shellfish Research 22(3): 667-674.
- Carregosa, V., Figueira, E., Gil, A. M., Pereira, S., Pinto, J., Soares, A. M. V. M., and R. Freitas. 2014. Tolerance of Venerupis philippinarum to salinity: Osmotic and metabolic aspects. Comparative Biochemistry and Physiology, Part A 171: 36-43.
- Inoue, N., Nanbu, R., Hasegawa, N., Higano, J., Kuwahara, H., and H. Sekiguchi. 2012. SEM observations on larval shell morphology of Manila clam Ruditapes philippinarum and their utility. Fish Science Journal 78:1237-1243.
- Food and Agricultural Organization (FAO). 2013. Cultured Aquatic Species Information Programme, Ruditapes philippinarum (Adams & Reeve, 1850). Available from: http://www.fao.org/fishery/culturedspecies/Ruditapes_philippinarum/en
- Bendell, L. I. 2014. Evidence for declines in the native Leukoma staminea as a result of the intentional introduction of the non-native Venerupis philippinarum in coastal British Columbia, Canada. Estuaries and Coasts 37: 369-380.
- Sweet, N., and J. Sewell. 2011. GB Non-native Organism Risk Assessment Scheme for Ruditapes philippinarum. Great Britain Non Native Species Secretariat, Department for Environment Food & Rural Affairs, the Scottish Government, and the Welsh Assembly Gover
- Kasai, A., Horie, H., and W. Sakamoto. 2004. Selection of food sources by Ruditapes philippinarum and Mactra veneriformis (Bivalva: Mollusca) determined from stable isotope analysis. Fisheries Science 70:11-20.
- Ssakamaki, T., and J. S. Richardson. 2008. Effects of small rivers on chemical properties of sediment and diets for primary consumers in estuarine tidal flats. Marine Ecology Progress Series 360:13-24.
- Ponurovsky, S. K., and Y. M. Yakolev. 1992. The reproductive biology of the Japanese Littleneck, Tapes philippinarum (A. Adams and Reeve, 1850) (Bivalvia: Veneridae). Journal of Shellfish Research 11(2):265-277.

- Yap, W. G. 1977. Population biology of the Japanese Little-neck Clam, Tapes philippinarum, in Kaneohe Bay, Oahu, Hawaiian Islands. Pacific Science 31(3):223-244.
- Herbert, R. J. H., Willis, J., Jones, E., Ross, K., Hubner, R., Humphreys, J., Jensen, A., and J. Baugh. 2012. Invasion in tidal zones on complex coastlines: modelling larvae of the non-native Manila clam, Ruditapes philippinarum, in the UK. Journal of Bi
- Kasuya, T., Hamaguchi, M., and K. Furukawa. 2004. Detailed observation of spatial abundance of clam larva Ruditapes philippinarum in Tokyo Bay, Central Japan. Journal of Oceanography 60:631-636.
- Cloern, J. E., Jassby, A. D., Thompson, J. K., and K. A. Hieb. 2007. A cold phase of the East Pacific triggers new phytoplankton blooms in San Francisco Bay. Proceedings of the National Academy of Sciences of the United States of America 104(47): 18561-18
- Dudas, S. E., McGaw, I. J., and J. F. Dower. 2005. Selective crab predation on native and introduced bivalves in British Columbia. Journal of Experimental Marine Biology and Ecology 325: 8-17.
- Gillespie, G. E., Bower, S. A., Marcus, K. L., and D. Kieser. 2012. Biological synopsises for three exotic mollusks, Manila clam (Venerupis philippinarum), Pacfic oyster (Crassostrea gigas) and Japense scallop (Mizuhopecten yessoensis) licensed for Aquacu
- Lewis, T. L., Esler, D. and S. W. Boyd. 2007. Effects of predation by sea ducks on clam abundance in soft-bottom intertidal habitats. Marine Ecology Progress Series 329:131-144.
- Bidegain, G., and J. A. Huanes. 2013. Does expansion of the introduced Manila clam Ruditapes philippinarum cause competitive displacement of the European native clam Ruditapes decussatus? Journal of Experimental Marine Biology and Ecology 445: 44-52.
- Pranovi, F., Granceschini, G., Casale, M., Zucchetta, M., Torricelli, P., and O. Giovanardi. 2006. An ecological imbalance induced by a non-native species: the Manila clam in the Venice Lagoon. Biological Invasions 8:595-609.
- Nunes, P. A. L. D., and A. Markandya. 2008. Economic value of damage caused by marine bio-invasions: lessons from two European case studies. ICES Journal of Marine Science 65:775-780.
- Bartoli, M., Nizzoli, D., Viaroli, P, Turolla, E., Castaldelli, G., Fano, E. A., and R. Rossi. 2001. Impact of Tapes philippinarum farming on nutrient dynamics and benthic respiration in the Sacca di Goro. Hydrobiologia 455: 203-212.
- Sgro, L., Mistri, M., and J. Widdows. 2005. Impact of the infaunal Manila clam, Ruditapes philippinarum, on sediment stability. Hydrobiologia 550:175-182.
- Cigarria, J., Rodriguez, C., and J. M. Fernandez. 1997. Impact of Perkinsus sp. on Manila clam Ruditapes philippinarum beds. Diseases of Aquatic Organisms 29: 117-120.
- Sagrista, E., Durfort, M., and C. Azevedo. 1996. Ultruastructural data on the life cycle of the parasite, Perkinsus atlanticus (Apicomplexa), on the clam, Ruditapes philippinarum, in the Mediterranean. Scientia Marina 60(2-3):283-288.
- Hurtado, N. S., Perez-Garcia, C., Moran, P., and J. J. Pasante. 2011. Genetic and cytological evidence of hybridization between native Ruditapes decussatus and introduced Ruditapes philippinarum (Mollusca, Bivalvia, Veneridae) in NW Spain. Aquaculture 311
- Laing, I., and S. D. Utting. 1994. The physiology and biochemistry of diploid and triploid Manila clam (Tapes philippinarum Adams & Reeve) larvae and juveniles. Journal of Experimental Marine Biology and Ecology 184:159-169.
- Marshall, D. J., Pechenik, J. A., Keough, M. J. (2003). Larval activity levels and delayed metamorphosis affect post-larval performance in the colonial ascidian Diplosoma listerianum. Marine Eoclogy Progress Series, 246, 153-162.