Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Scientific Name: *Palaemon macrodactylus*

Common Name *oriental shrimp*

Phylum	Arthropoda
Class	Malacostraca
Order	Decapoda
Family	Palaemonidae

Final Rank 49.87

Data Deficiency: 3.75

Species Occurrence by Ecoregion

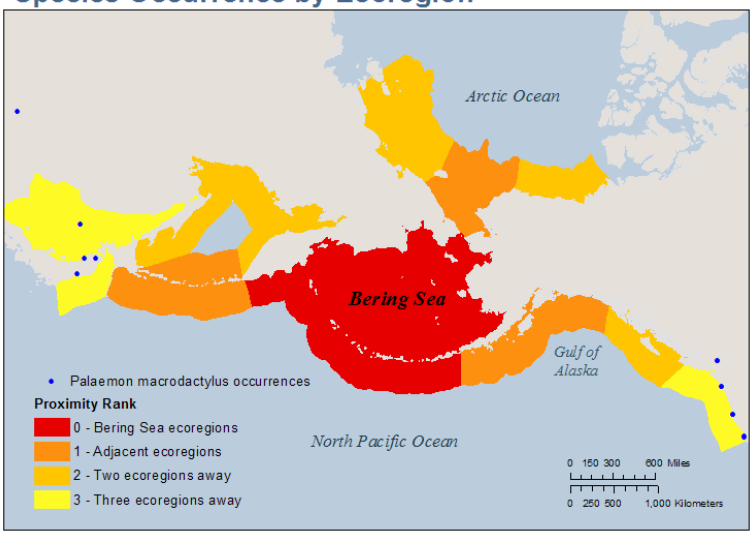

Figure 1. Occurrence records for non-native species, and their geographic proximity to the Bering Sea. Ecoregions are based on the classification system by Spalding et al. (2007). Occurrence record data source(s): NEMESIS and NAS databases.

Category Scores and Data Deficiencies

Category	Score	Total Possible	Data Deficient Points
Distribution and Habitat:	20	26	3.75
Anthropogenic Influence:	6.75	10	0
Biological Characteristics:	20.5	30	0
Impacts:	0.75	30	0
Totals:	48.00	96.25	3.75

General Biological Information

Tolerances and Thresholds

Minimum Temperature (°C)	2	Minimum Salinity (ppt)	0.7
Maximum Temperature (°C)	33	Maximum Salinity (ppt)	51
Minimum Reproductive Temperature (°C)	NA	Minimum Reproductive Salinity (ppt)	3
Maximum Reproductive Temperature (°C)	NA	Maximum Reproductive Salinity (ppt)	34

Additional Notes

Palaemon macrodactylus is commonly known as the Oriental shrimp. Its body is transparent with a reddish hue in the tail fan and antennary area. Females tend to be larger than males and have more pigmentation, with reddish spots all over their body, and a whitish longitudinal stripe that runs along the back. Females reach a maximum size of 45-70 mm, compared to 31.5-45 mm for males (Vazquez et al. 2012, qtd. in Fofnoff et al. 2003).

1. Distribution and Habitat

1.1 Survival requirements - Water temperature

Choice: C — Little overlap – A small area (<25%) of the Bering Sea has temperatures suitable for year-round survival

Score: 1.25 of 3.75

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

Background Information:
The optimal temperature range for survival is between 14 and 26°C (Newman 1963). However, this species can tolerate temperatures from 2°C (Ashelby 2011) to 33°C (experimental data, Lejeusne et al. 2014).

Sources:
NEMESIS; Fofonoff et al. 2003 Ashelby 2011 Lejeusne et al. 2014 Newman 1963

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:
The salinity threshold for survival of P. macrodactylus is 0.7 PSU to 51 PSU.

Sources:
NEMESIS; Fofonoff et al. 2003

1.3 Establishment requirements - Water temperature

Choice: U — Unknown/Data Deficient

Score: of

Ranking Rationale:

Background Information:
No information available in the literature.

Sources:
None listed

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 threshold for reproduction of P. macrodactylus is 3 to 34 PSU (Fofonoff et al. 2003).

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:
Closest known occurences in British Columbia and the Sea of Japan.

Background Information:
On North America's Pacific coast, currently ranges from Boundary Bay, British Columbia (49ºN) south to the Tijuana Estuary (San Diego County), California. Also found in the Sea of Japan, north to Peter the Great Bay.

Sources:
Ashelby et al. 2013

1.6 Global ecoregional distribution

Choice: A

In many ecoregions globally

Score: 5 of 5

Ranking Rationale:
Wide global distribution.

Background Information:
Native to northeast Asia (Japan, Korea, Peter the Great Bay in southern Russia). First introduction was in San Francisco Bay in 1957. Now found in Australia, Atlantic and North Sea coasts of Europe (south to Spain), the Black Sea, the Mediterranean Sea, Argentina, and the eastern U.S.

Sources:
Ashelby et al. 2013

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:
Recent documentation of long-distance dispersal and recent range expansion.

Background Information:
First found in San Francisco Bay in 1957. 5 years later it was discovered in Los Angeles Harbor in 1962 (Cohen and Carlton 1995). This may be due to introductions from either San Francisco Bay or Asia (Standing 1981), or as a natural dispersal event, going undetected in between the two locations (Ashelby et al. 2013).

Sources:
Ashelby et al. 2013 Cohen and Carlton 1995 Standing 1981

Section Total - Scored Points:	20
Section Total - Possible Points:	26.25
Section Total -Data Deficient Points:	3.75

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:

Readily transported in ballast water with an ability to disperse once established.

Background Information:

As most recent records are from the vicinity of large, international harbors, it is most likely that introduction to these regions is shipping mediated, as a result of transport in ballast water or as a fouling organism within sea water intakes or sea chests. However, there are some reports that suggest P. macrodactylus has dispersed to areas independently of human activities (Lavesque et al. 2010).

Sources:

Ashelby et al. 2013 Lavesque et al. 2010

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:

Frequently establishes in ports or harbors, with few records outside of known shipping areas.

Background Information:

Often uses manmade structures e.g. pilings, walls, debris as habitat (Crooks et al. 2016). In its introduced range, most records are near international harbours or in areas of high shipping traffic, but others, such as France's Arcachon Bay, may be the result of passive transport by water currents (Lavesque et al. 2010).

Sources:

Lavesque et al. 2010 Crooks et al. 2016 NEMESIS; Fofonoff et al. 2003

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

Choice: A

Yes

Score: 2 of 2

Ranking Rationale:

Background Information:

P. macrodactylus is sold as food in Japan (Fofonoff et al. 2003). No market currently exists in North America.

Sources:

NEMESIS; Fofonoff et al. 2003

Section Total - Scored Points:	6.75
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:
Feeds on numerous taxa readily available in the Bering Sea.

Background Information:
P. macrodactylus predates on mysids, copepods, amphipods, barnacles, polychaetes, small bivalves, fish larvae, and insect larvae. While they are omnivorous, majority of their diet is made up of animals (Ashelby et al. 2013).

Sources:
Ashelby et al. 2013

3.2 Habitat specialization and water tolerances

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

Choice: A

Generalist; wide range of habitat tolerances at all life stages

Score: 5 of 5

Ranking Rationale:
Tolerates a wide range of temperatures and salinities and has been recorded in multiple habitats.

Background Information:
Tolerates wide ranges of temperature and salinity and is particularly tolerant of hypoxic conditions (González-Ortegón and Cuesta 2006). P. macrodactylus has been captured in freshwater (Siegfried 1980), whereas in Argentina, it inhabits fully saline (32-37PSU) conditions (Vázquez et al. 2012). In Mar del Plata Harbor, environmental conditions correspond to those of a polluted site with high water turbidity, low dissolved oxygen and low pH (Vázquez et al. 2012).

P. macrodactylus prey mainly at night. During the day, can often be found hiding under or in between rocks and crevices, reefs built by shellfish or polychaetes, or in dense algal vegetation.

Sources:
Ashelby et al. 2013 González-Ortegón and Cuesta 2006 Micu and Niţă 2009 Vázquez et al. 2012

3.3 Desiccation tolerance

Choice: C

Little to no tolerance (<1 day) of desiccation during its life cycle

Score: 1.75 of 5

Ranking Rationale:
Survives less than a day out of water.

Background Information:
No species-specific information was found in the literature regarding the desiccation tolerance of P. macrodactylus. Laboratory studies for other shrimp species suggest desiccation tolerances of up to 90 minutes (Athyaephyra desmaresti; Banha and Anastácio 2012) and 5 to 10 hours (Marsupenaeus japonicas; Duan et al. 2016).

Sources:
Banha and Anastácio 2012 Duan et al. 2016

3.4 Likelihood of success for reproductive strategy

i. Asexual or hermaphroditic ii. High fecundity (e.g. >10,000 eggs/kg) iii. Low parental investment and/or external fertilization iv. Short generation time

Choice: **B**

Moderate – Exhibits one or two of the above characteristics

Score: **3.25** **of** **5**

Ranking Rationale:

Sexual reproduction, internal fertilization, high fecundity, high parental investment and internal fertilization, short generation time.

Background Information:

P. macrodactylus have sexual reproduction during a long spawning season lasting from mid-April to October (Omori and Chida 1988). Females can spawn 1- 2 times per season in their first year. This increases to 5-9 times per season in their second year with a lifespan of two to three years (Omori and Chida 1988; Micu and Niţă 2009; Ashelby et al. 2013). Brood sizes range from 100 to 2000 (Siegfried 1980).

Sources:

Ashelby et al. 2013 Micu and Niţă 2009 Omori and Chida 1988 Siegfried 1980 Vázquez et al. 2009 NEMESIS; Fofonoff et al. 2003

3.5 Likelihood of long-distance dispersal or movements

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

Choice: **A**

Disperses long (>10 km) distances

Score: **2.5** **of** **2.5**

Ranking Rationale:

Can disperse up to 71 km.

Background Information:

Eggs are brooded internally and hatch as planktonic larvae. Larvae undergo 5 to 7 stages of development before metamorphosis into post-larvae or juveniles, which they reach between 10 to 18 days after hatching (Little 1969). Both larvae and post-larvae can swim; post-larvae can also crawl on the benthos (Little 1969).

Lavesque et al. (2010) proposed that adult and/or larvae P. macrodactylus could disperse to new sites up to 71 km for a source location over several years, if assisted by water currents. Ashelby et al. (2013) propose that colonization of new sites in Australia could have been achieved by natural dispersal: distances between the source location and new sites (20 to 50 km) are well within the natural dispersal distances proposed by Lavesque et al. (2010) based on European spread, and could have been easily achieved in the 10 years that elapsed between the introduction to Newcastle and the discovery at Vales Point. Similarly, Lejeusne et al. (2014b) propose that populations in the Guadalquivir River may have naturally dispersed to the Guadiana River (100 km west) over the course of 10 years.

Micu and Niţă (2009) suggest that adults are not extremely mobile: under laboratory conditions, they observed that the Asian prawn is more benthic and cryptic than native species, preferring to walk rather than swim whenever possible, hiding in deep and narrow recesses during the day, and hunting only at night. According to Ashelby (2011), P. macrodactylus is unlikely to reach distant locations via natural means, but once introduced to a region can spread naturally via larval dispersal or short migrations.

Sources:

Ashelby 2011 Ashelby et al. 2013 Lavesque et al. 2010 Lejeusne et al. 2014 Micu and Niţă 2009 Little 1969

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:

Can disperse at more than one life stage but are not highly mobile, larval viability window (planktonic larval stage) is long, different modes of dispersal are achieved at different life stages, however, significant migrations do not occur in this species.

Background Information:

No potential for egg dispersal, as fertilization is internal and eggs are brooded. Planktonic larval stage is long-lived (10 to 18 days), and all life stages are mobile. Larvae and adults can swim and/or crawl, and both can be passively transported by water currents (Lavesque et al. 2010). Significant migrations do not occur in this species, but annual expansions and contractions of the spatial distribution of this species within a waterway has been observed, as the species follows preferred salinity gradients (Béguer et al. 2011).

Sources:

Ashelby 2011 Lavesque et al. 2010 Béguer et al. 2011

3.7 Vulnerability to predators

Choice: **D**

Multiple predators present in the Bering Sea or neighboring regions

Score: **1.25** **of** **5**

Ranking Rationale:

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

Background Information:

In California, P. macrodactylus is an important prey item for the striped bass (Ganssle 1966 as qtd. in Ashelby 2011; Ricketts et al. 1968 as qtd. in Ashelby 2011). Its larvae is also a prey item for Crangon franciscorum (Siegfried 1980). Around the world it is likely that P. macrodactylus is preyed upon by fish and birds with its larvae preyed upon by other estuarine planktivores.

Sources:

Ashelby 2011 Siegfried 1980

Section Total - Scored Points:	20.5
Section Total - Possible Points:	30
Section Total -Data Deficient Points:	0

4. Ecological and Socioeconomic Impacts

4.1 Impact on community composition

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
May cause a decrease in local populations due to competitive effects.

Background Information:
In the Gironde Estuary, France, it was first noted that P. macrodactylus exploits a niche that is under-utilized by the native P. longiriostris (Béguer et al. 2011). However, competition between these two species was cited as a possible reason for the decline in abundance of P. longirostris (Béguer et al. 2012). This may be due to P. macrodactylus having a higher tolerance to hypoxia, a wider temperature range, and a more efficient metabolism than the native species (Gonzalez-Ortegon et al. 2010; Lejeusne et al. 2014).

In San Francisco Bay, crangonid shrimp dominate. P. macrodactylus, a palaemonid shriimp, is expected to have little impact as it occupies a different ecological niche. However, it has been noted that the two species do have a dietary overlap (Sitts and Knight 1979; Siegfried 1980). As of 1986 P. macrodactylus is now more numerous than the larger native Crangon spp. (Ricketts et al. 1968 as qtd. in Ashelby et al. 2013).

Sources:
Ashelby et al. 2013 Siegfried 1980 Gonzalez-Ortegon et al. 2010 Lejeusne et al. 2014 Béguer et al. 2011 Béguer et al. 2012 Sitts and Knight 1979

4.2 Impact on habitat for other species

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
To date, no impacts on habitat for other species have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

4.3 Impact on ecosystem function and processes

Choice: D — No impact

Score: 0 of 2.5

Ranking Rationale:
To date, no impacts ecosystem functions and processes have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

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

Choice: **D** No impact

Score: **0** of **2.5**

Ranking Rationale:
To date, no impacts on high-value, rare, or sensitive species have been reported for P. macrodactylus.

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:
P. macrodactylus is known to carry parasites and disease, however, transmission to native species has not been documented yet.

Background Information:
In Argentina, P. macrodactylus had high instances of infection by white spot syndrome virus (Martorelli et al. 2012). It also plays a role as a second intermediate host for Odhneria sp, a parasite (Martorelli et al. 2012). The spread of these parasites to native species has not yet been documented.

Sources:
Ashelby et al. 2013 Martorelli et al. 2012

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:
To date, no hybridization has been reported for P. macrodactylus.

Background Information:
A laboratory study observed hybridization between two Palaemon species (P. adspersus × P. squilla), however, viable offspring were not supported (Berglund). No species-specific studies have investigated the hybridization of P. macrodactylus, and no records of hybridization with native species have been reported.

Sources:
Berglund 1984

4.7 Infrastructure

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on infrastructure have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

4.8 Commercial fisheries and aquaculture

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on fisheries and aquaculture have been reported for P. macrodactylus.

Background Information:
There are no known negative economic impacts; however, its potential effect on fisheries of native shrimp species should be monitored. In France, P. longirostris is fished, and samples from commercial fishermen in 2005 and 2007 showed that approximately 95% of the collected shrimps belong to the native species P. longirostris (Béguer et al. 2011).

Sources:
Ashelby et al. 2013 Béguer et al. 2011

4.9 Subsistence

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on subsistence have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

4.101 Recreation

Choice: D — No impact

Score: 0 of 3

Ranking Rationale:
To date, no impacts on recreation have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

4.11 Human health and water quality

Choice: **D** No impact

Score: **0** of **3**

Ranking Rationale:
To date, no impacts on human health or water quality have been reported for P. macrodactylus.

Background Information:
No information available in the literature.

Sources:
None listed

Section Total - Scored Points:	0.75
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: B — Not attempted

Score: [ ] of [ ]

Ranking Rationale:

Background Information:
There are no published accounts of attempts to manage, contain or eradicate this species.

Sources:
None listed

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:
Eradication is most likely impossible.

Background Information:
P. macrodactylus is hard to control as it is a mobile species with pelagic larvae. As such, no species specific containment strategies have been suggested, tried, or developed. Non specific control measures would have an adverse effect on other fauna as well as P. macrodactylus.

Sources:
Ashelby 2011

5.3 Regulatory barriers to prevent introductions and transport

Choice: A — Little to no regulatory restrictions

Score: [ ] of [ ]

Ranking Rationale:
No regulation exist fro P. macrodactylus.

Background Information:
There are no monitoring programs specifically designed for detection or monitoring the spread of P. macrodactylus. This species my also be overlooked during routine monitoring surveys and rapid assessments. For example, in the UK, routine invertebrate sampling uses methods that would be unlikely to detect the species, while trawl and net samples that are capable of detecting this species are often examined for fish only.

Sources:
Ashelby 2011

5.4 Presence and frequency of monitoring programs

Choice: A — No surveillance takes place

Score: [ ] of [ ]

Ranking Rationale:

Background Information:
No surveillance or monitoring programs currently exist for P. macrodactylus.

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:

There are currently no education or outreach programs associated with raising awareness about P. macrodactylus. Ashelby (2011) suggests that awareness of P. macrodactylus is still largely confined to the scientific community and even within the scientific community, it is generally unknown and not present in most standard identification guides, therefore it may be easily overlooked.

Sources:

Ashelby 2011

Section Total - Scored Points:

Section Total - Possible Points:

Section Total -Data Deficient Points:

Bering Sea Marine Invasive Species Assessment

Alaska Center for Conservation Science

Literature Cited for *Palaemon macrodactylus*

- Ashelby, C. 2011. Palaemon macrodactylus. CABI Invasive Species Compendium. Accessed 12/06/2016.
- Ashelby, C.W., S. De Grave and M.L. Johnson. 2013. The global invader Palaemon macrodactylus (Decapoda, Palaemonidae): an interrogation of records and a synthesis of data. Crustaceana 86(5): 594-624.
- Ashelby, C.W., S. De Grave and M.L. Johnson. 2013. The global invader Palaemon macrodactylus (Decapoda, Palaemonidae): an interrogation of records and a synthesis of data. Crustaceana 86(5): 594-624.
- Banha, F. and P. M. Anastácio. 2012. Waterbird-mediated passive dispersal of river shrimp Athyaephyra desmaresti. Hydrobiologia 694: 197. doi:10.1007/s10750-012-1160-7
- Béguer, M., Bergé, J., Martin, J., et al. 2011. Presence of Palaemon macrodactylus in a European estuary: evidence for a successful invasion of the Gironde (SW France). Aquatic Invasions 6(3): 301-318.
- Berglund, A. 1984. Reproductive adaptations in two Palaemon prawn species with differing habitat requirements. Marine Ecology Progress Series 17: 77-83.
- Duan, Y., J. Zhang, H. Dong, Y. Wang, Q. Liu and H. Li. 2016. Effect of desiccation and resubmersion on the oxidative stress response of the kuruma shrimp Marsupenaeus japonicus. Fish & Shellfish Immunology 49: 91-99.
- González-Ortegón, E., J.A. Cuesta, E. Pascual and P. Drake. 2010. Assessment of the interaction between the white shrimp, Palaemon longirostris, and the exotic oriental shrimp, Palaemon macrodactylus, in a European estuary (SW Spain). Biological Invasions
- Lavesque, N., G. Bachelet and M. Béguer. 2010. Recent expansion of the oriental shrimp Palaemon macrodactylus (Crustacea: Decapoda) on the western coasts of France. Aquatic Invasions 5, Supplement 1: S103-S108.
- Lejeusne, C., Latchere, O., Petit, N., Rico, C., and A. J. Green. 2014. Do invaders always perform better? Comparing the response of native and invasive shrimps to temperature and salinity gradients in southwest Spain. Estuarine, Coastal and Shelf Science
- Little, G. 1969. The larval development of the shrimp, Palaemon macrodactylus Rathbun, reared in the laboratory, and the effect of eyestalk extirpation on development." Crustaceana 17(1): 69–87.
- 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.
- Omori, M. and Y. Chida. 1988. Life history of the caridean shrimp Palaemon macrodactylus with special reference to the difference in reproductive features among ages. Nippon Suisan Gakkaishi 54(3): 365-375.
- Siegfried, C.A. 1980. Seasonal abundance and distribution of Crangon franciscorum and Palaemon macrodactylus (Decapoda, Caridea) in the San Francisco Bay Delta. Biological Bulletin 159: 177-192.
- Siegfried, C.A. 1980. Seasonal abundance and distribution of Crangon franciscorum and Palaemon macrodactylus (Decapoda, Caridea) in the San Francisco Bay Delta. Biological Bulletin 159: 177-192.
- Vázquez, M.G., C.C. Bas and E.D. Spivak. 2012. Life history traits of the invasive estuarine shrimp Palaemon macrodactylus (Caridea: Palaemonidae) in a marine environment (Mar del Plata, Argentina). Scientia Marina 76(3): 507-516.

- Cohen, A. N., and J. T. Carlton. 1995. Nonindigenous aquatic species in a United States estuary: A case study of the biological invasions of the San Francisco Bay and Delta. SFEI Contribution No. 185. U.S. Fish and Wildlife Service, Washington, D.C.

- Newman, W. A. (1963). On the Introduction of an Edible Oriental Shrimp (Cardia, Palaemonidae) to San Francisco Bay. Crustaceana. 5(2), 119-132.

- Standing, J. D. 1981. Occurrences of shrimps (Natantia: Penaeidea and Caridea) in Central California and Oregon. Proceedings of the Biological Society of Washington 94(3):774-786.

- Crooks, J. A., Chang, A. L., and G. M. Ruiz. 2016. Decoupling the response of an estuarine shrimp to architectural components of habitat structure. PeerJ. 4, e2244.

- Béguer, M., Bergé, J., Gardia-Parége, C., Beaulaton, L., Castelnaud, G., Girardin, M., Boët, P. (2012). Long-Term Changes in Population Dynamics of the Shrimp Palaemon longirostris in the Gironde Estuary. Estuaries and Coasts. 35, 1082-1099.

- Sitts, R. M., Knight, A. W. (1979). Predation by the Estuarine Shrimps Crangon franciscorum Stimpson and Palaemon macrodactylus Rathbun. Biological Bulletin. 156(3), 356-368.

- Mortorelli, S. R., Alda, P., Marcotegui, P., Montes, M. M., La Sala, L. F. (2012). New locations and parasitological findings for the invasive shrimp Palaemon macrodactylus in temperate southwestern Atlnatic coastal waters. Aquatic Biology. 15, 153-157.