Chinese Mitten Crab (*Eriocheir sinensis*)
Aquatic Invasive Species
Risk Screening Summary

Washington Department of FISH & WILDLIFE

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Chinese Mitten Crab (*Eriocheir sinensis*) – Aquatic Invasive Species Risk Screening Summary

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Acknowledgement

The United States Fish and Wildlife Service's (USFWS) Ecological Risk Screening procedure was adapted for use in the development of the Aquatic Invasive Species Risk Screening Summary.

Aquatic invasive species risk screening summary

The Aquatic Invasive Species Risk Screening Summary evaluates a species' potential invasiveness in Washington.

Three criteria determine the species potential invasiveness:

1. The species has a history of invasion in other locations. Invasion requires documentation of establishment and spread of populations, as well as negative ecological or economic impacts.
2. The potential for the transport of the species into and within Washington.
3. Conditions in Washington are suitable for the survival and reproduction of the species.

These summaries provide an initial process to determine which species are more likely (**high risk**), about as likely as not (**moderate risk**), and less likely (**low risk**) to arrive, survive, reproduce, spread, and have a detrimental impact in Washington. Species for which there is insufficient information to make such a determination are classified as **uncertain risk**.

This summary does not necessarily identify locations in Washington where an aquatic invasive species is most likely to become established or address monitoring or mitigation strategies.

This summary is a partial review of the species summarized. The following resources may provide additional information:

- Centre for Agriculture and Biosciences International (CABI) Compendium: https://www.cabidigitallibrary.org/journal/cabicompendium
- Global Biodiversity Information Facility (GBIF): https://www.gbif.org/
- National Estuarine and Marine Exotic Species Information System (NEMESIS): https://invasions.si.edu/nemesis/
- United States Geological Survey (USGS) Nonindigenous Aquatic Species List: https://nas.er.usgs.gov/queries/SpSimpleSearch.aspx
- United States Fish and Wildlife Service (USFWS) Ecological Risk Screening Summaries https://www.fws.gov/library/categories/ecological-risk-screening

Taxonomy

Information from Bánki and others (2025).

Taxonomic Tree

Domain: Eukaryota
Kingdom: Animalia
Phylum: Arthropoda
Class: Malacostraca
Order: Decapoda
Family: Varunidae
Genus: *Eriocheir*
Species: *Eriocheir sinensis* (H. Milne Edwards, 1853)

Synonyms and Other Name(s)

Eriocheir sinensis f. acutifrons (Panning, 1938)
Eriocheir sinensis f. rotundifrons (Panning, 1938)
Eriocheir sinensis f. trilobata (Panning, 1938)
Eriocheir sinensis f. rostrata (Panning, 1933)
Grapsus nankin (Lin, 1926)
Grapsus nankin (Tu, Tu, Wu, Ling & Hsu, 1923)

Common Name(s)

Chinese mitten crab

Context for risk summary

On April 22, 2025, a commercial fisherman caught crab of unknown species in the Lower Columbia River east of Tongue Point. The specimen was given to the Oregon Department of Fish and Wildlife (ODFW), who identified the specimen as a Chinese mitten crab (*Eriocheir sinensis)*. This is the first confirmed detection of *E. sinensis* in Oregon, though a specimen was collected in the Columbia River at the Port of Ilwaco, Washington in 1997. Additional information on the detection can be found at the following website: Chinese mitten crab found in Lower Columbia River.

Species overview

Status in Washington

Classification under Washington Administrative Code (WAC) Chapter 220-640

E. sinensis is listed as a Prohibited Level 1 aquatic invasive species under Washington Administrative Code (WAC) Chapter 220-640-030. Per Revised Code of Washington (RCW) 77.135, Prohibited Level 1 species may not be possessed, introduced on or into a water body or property, or trafficked, without department authorization, a permit, or as otherwise provided by rule.

Distribution in Washington

In 1997, a confirmed specimen of *E. sinensis* was reported south of Ilwaco in the Columbia River. In 2002, an angler reported catching a mitten crab on their line near Kalama, though no photo or specimen were available for confirmation. Other reports of *E. sinensis* were ultimately determined to be other species, commonly the native hairy shore crab, *Hemigrapsus oregonensis.*

Biological overview

Native Range

Veilleux and De Lafontaine (2007)

"The Chinese mitten crab is endemic to the Yellow Sea region bordering China and Korea, in Eastern Asia. Its native habitats are the coastal rivers and estuaries running into the sea from North Korea (approximately lat. 40°N latitude) to Hong Kong (approximately lat. 22°N) in the south of China (Hymanson et al., 1999). The species is also present in South Korea and Japan and was introduced into Vietnam, extending its distribution in Asia. The Yangtze River is the largest river within its native range and specimens have been collected as far as 1400 km up in the river (Cohen and Weinstein, 2001). Most studies on the Chinese mitten crab in Asia have been conducted on the Yangtze River crab population (Hymanson et al., 1999)."

Habitat

Veilleux and De Lafontaine (2007)

"Estuaries supporting large mitten crab populations are all characterized by a large area of brackish waters for embryonic and larval development, and a large area of shallow productive waters for the growth of juveniles (Cohen and Weinstein, 2001). This describes well the Yangtze River, one of the major rivers used by mitten crab in its native China, which is considered an ideal habitat for mitten crab characterized by a long freshwater drainage with warm, slow moving water and a large estuary (Hymanson et al., 1999).

Throughout its life, the Chinese mitten crab will occupy different ecosystems depending on its life stage. Adult crabs are found in fresh, brackish and salt waters, but oviparous females are normally found in greatest number in saltwater (Rudnick et al., 2003). Larval stages are found in the open water of bays and estuaries. Juvenile crabs are uncommon in open water but are found in tidal tributaries within a few kilometres of open water and in freshwater (Rudnick et al., 2003). Around the world, the highest densities of crabs are principally found within estuaries and the lower part of rivers (Cohen and Weinstein, 2001; Rudnick et al., 2003). Fast-flowing cold water rivers are generally considered less suitable habitats for the species. In San Francisco Bay, individuals were also found in less ideal habitats such as concrete-lined channels, probably as a result of some density-dependent effect caused by the large population size (Rudnick et al., 2000).

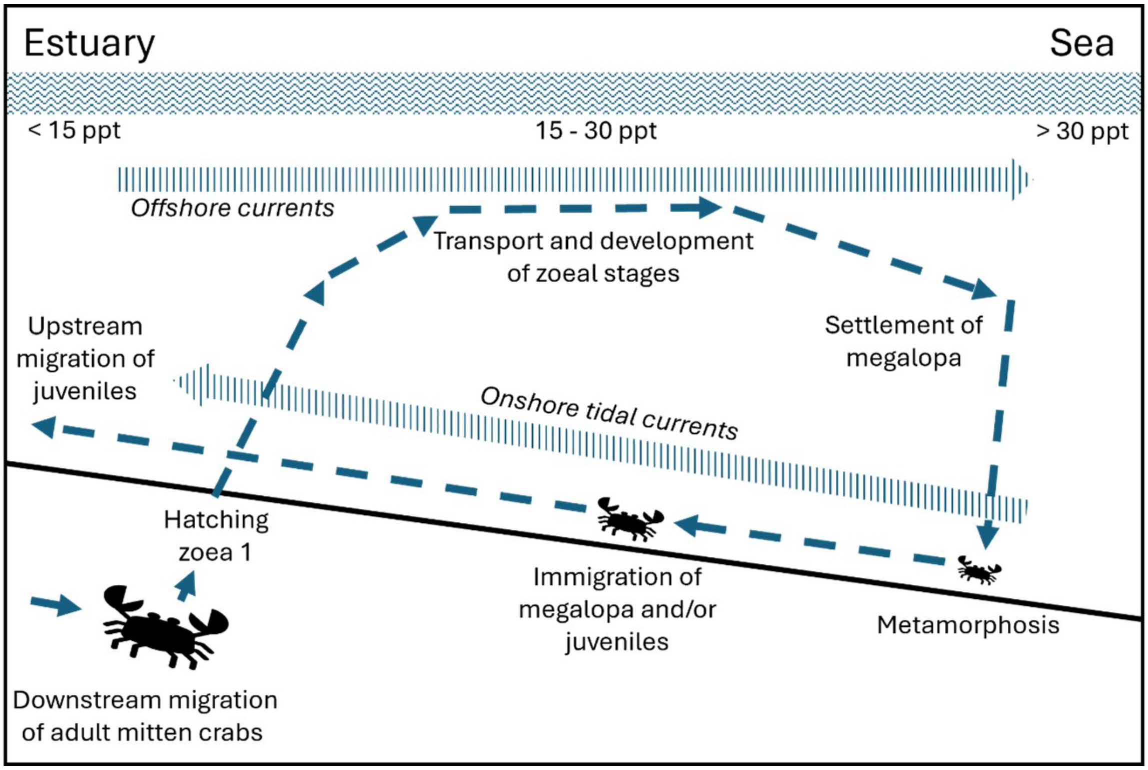
In the tidal zone of San Francisco Bay, juvenile mitten crabs were mainly found in low salinity areas (less than or equal to 3 PSU) with steep clay banks lined with cattails (*Typha* sp.) (Rudnick et al., 2000). Field observations revealed that crabs in the tidal zones prefer to make their burrows in stepper sloped banks (greater than 35°) as opposed to nearly flat banks (5°), and to select for fine sediment substrates such as silt and clay, in preference to coarser sediments such as gravel (Rudnick et al., 2003; 2005[…]). In freshwater habitats, juveniles were generally observed in shallow areas with slow moving water near deep pools with emergent macrophytes (Nepszy and Leach, 1973; Hymanson et al., 1999; Rudnick et al., 2000). Juveniles were also observed upstream from riffles but not in the riffle zone itself (Rudnick et al., 2000)."

Life history

Anger (1991)

"The hypothetical ontogenetic migrations in *Eriocheir sinensis* are summarised in a schematic diagram [Figure 1]. It assumes hatching of the prezoea and zoea I in lower estuaries, at salinities around 20 (ca 10 to 25) ‰S. Since early zoea larvae are mostly found near the water surface, due to certain behavioural responses to light, gravity, pressure and other factors (Sulkin 1984, Forward & Buswell 1989), they are likely to be transported by surface currents that have a net direction out of the estuary. Later zoeal development then takes place at increasing salinities in nearshore marine waters. The megalopa stage attains, like in all brachyuran decapods, an increasingly benthic behaviour, eventually leading to settlement on the sea floor. Since it still exhibits frequent swimming activity, it will be transported by onshore-directed, near-bottom counter currents toward the coast and inner parts of estuaries. After metamorphosis, the juvenile crab may stay in this environment for some time (maybe 1 yr; Panning 1938), or it may immediately begin to migrate upstream into river systems. This sequence of developmental changes in larval behaviour and salinity tolerance may ensure the retention of this species near estuaries and its return to freshwater habitats. Similar retention mechanisms have been found also in other estuarine crab species (Sulkin & van Heukelem 1982, Sulkin & Epifanio 1986; for recent discussion see Epifanio et al. 1989)."

Figure 1. Migrations of *Eriocheir sinensis* during reproduction, larval development, settlement, and early juvenile growth.

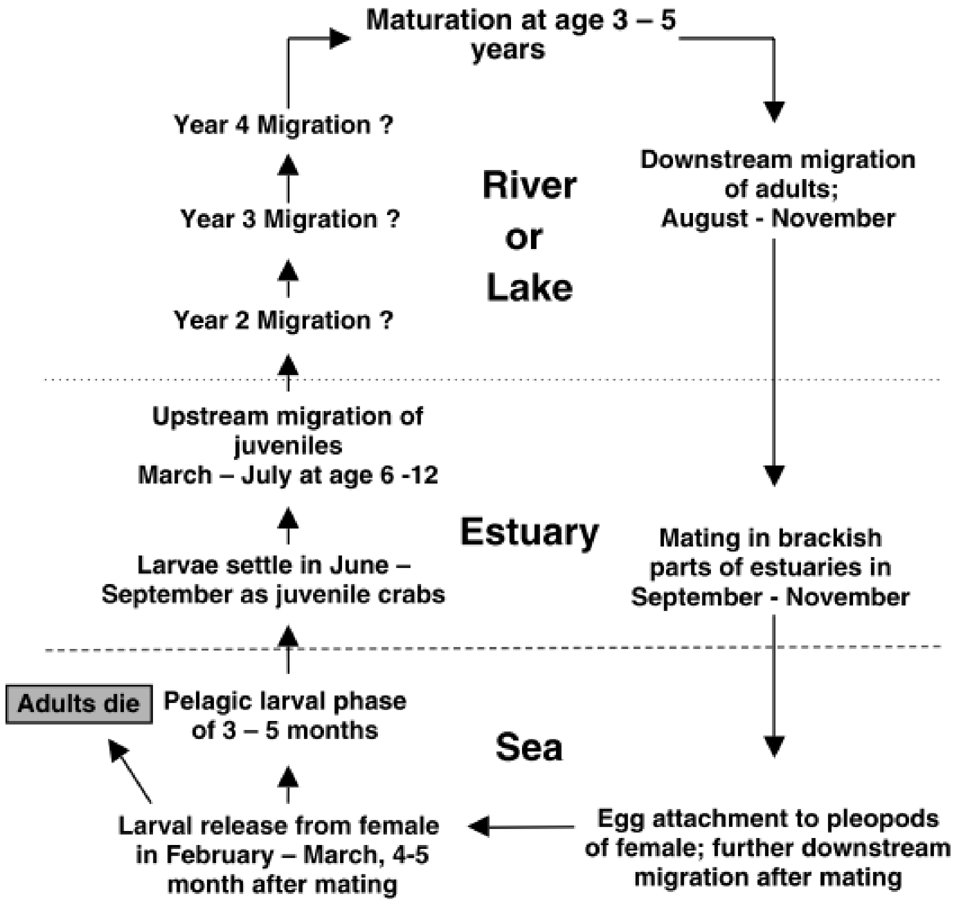


Graphical model of presumable ontogenetic migrations of *Eriocheir sinensis* during reproduction, larval development, settlement, and early juvenile growth in an estuary and the adjacent sea (Elbe, North Sea). Modified from Anger 1991.

Herborg and others (2005)

"*E. sinensis* is catadromous, spending most of its life in fresh- water, and only returning to estuaries to reproduce, after which it dies. The downstream migrations of sexually mature crabs occur from August to October in the rivers Elbe and Weser (Germany) (Peters 1933, 1938c) and from September to December in the River Thames (United Kingdom) (Robbins et al. 1999). After mating, the females migrate to higher estuarine salinities and release up to three batches of larvae in early spring (Peters 1933). This migratory behaviour has also been observed in more recent studies on *E. japonica* (Kobayashi and Matsuura 1999; Kobayashi 2001). Field data on the larval duration of *E. sinensis* are limited, but laboratory experiments indicate a period of ≈90 days from hatching to the megalopa (Anger 1991). Following the migration of juvenile mitten crabs upstream in the spring, individuals can reach rivers, lakes, and ponds as far as 1200 km from the coast (Peters 1933). *E. sinensis* reaches sexual maturity at 1–3 years in China (Jin et al. 2001) and 3–5 years in Europe (Schubert 1938). A proposed life cycle of the Chinese mitten crab in the northern Europe is shown in [Figure 2]."

Figure 2. Proposed life cycle for Eriocheir sinensis.



Based on historic observations from the Elbe (Panning 1938*) and laboratory experiments (Anger 1991). From Herborg and others 2005.*

Schoelynck and others (2021)

“The issues caused are partly a result of their omnivorous feeding and catadromous life cycle - they breed and hatch only in the salty water of estuaries and the coast and, as they grow, they migrate long distances inland along freshwater bodies such as rivers and canals (Herborg et al., 2003). In their native range, they have been found to migrate over 1,400 km inland along the Yangtze River (Dittel & Epifanio, 2009) and even in Europe (Germany), they have been observed travelling 15 km in a single day (Panning, 193[8])”

“The trends over 2 years were very similar: the spring [upstream] migration started around beginning of March (although occasional juveniles were caught as early as January) and abruptly stopped at the end of May. The autumn [downstream] migration is situated around October–November.”

“During the autumn migration, males arrive in the estuary generally 1 month before the females and also mature faster. Small crabs also start migrating earlier than large individuals (Fladung, 2000; Soes et al., 2007). This is also clearly visible in our data where male representatives were more dominant at the beginning of the autumn migration and more female representatives were found towards the end of the autumn migration. The sex ratio was around 50:50 for juveniles during the spring migration."

Physiological tolerances

Adult

Veilleux and De Lafontaine (2007)

"Because of its catadromous life cycle and its origin in temperate to subtropical countries, the Chinese mitten crab can tolerate a broad range of water temperatures and salinities. This physiological tolerance varies at different developmental stages but, overall, the adult crab can survive at water temperatures ranging from near 4° to 31–32°C and at salinities varying from 0 to 35 PSU (Cohen and Weinstein, 2001). The species has become abundant in river systems with winter estuary temperatures as low as 5°C and adjacent sea surface water temperatures below 0°C (Cohen and Weinstein, 2001)."

"Mitten crabs, both juveniles and adults, can survive for a relatively long time out of water (Velduizen and Stanish, 1999). Crabs can survive up to 35 days in wet meadows (Nepszy and Leach, 1973) and at least 10 days in their burrows during a drought (Velduizen and Stanish, 1999)."

Larvae

Anger (1991)

"Mitten crab larvae were able to develop from hatching through metamorphosis at temperatures ranging from 12 to 18 °C and at salinities from 15 to 32 ‰S, but not in all combinations of these conditions […]. At 6 and 9 °C (any salinity), complete mortality occurred within the first zoeal stage, with longest time of survival in intermediate salinities (20 to 25 ‰S). Rate or time, respectively, of larval survival increased at all salinities with increasing temperature […]. At temperatures ≤ 12 °C, 10 ‰S allowed no development beyond the zoea I stage, but in combination with 15 °C to zoea II, and with 18 °C to zoea IV. At a salinity of 15 ‰S, only the zoea III stage was reached at 12 °C, but the megalopa at 15 °C, and metamorphosis to the first juvenile stage at 18 °C. These data […] show clearly that not only the average level of survival but also the range of salinity tolerance increased with increasing temperature. "

Diet

Rudnick and Resh (2005)

"In our mesocosm experiments, both CMC [Chinese mitten crab, *E.sinensis*] and RSC [Red swamp crayfish, *Procambarus clarkia*] had direct, negative impacts on detritus, algae, and macroinvertebrates. Substantial predation on shallow-dwelling invertebrates in mesocosms supported a larger role for invertebrates in the diets of both CMC and RSC than is suggested by GCA [gut content analysis] alone. Isotope data indicated that the signatures of several plant and animal resources bracket the signatures obtained for both crustaceans."

"Results of the isotope study suggest a strong reliance of CMC on invertebrates, and a smaller role for terrestrially derived detritus and algae, in its intertidal habitat. In fresh water, these relationships are less clear because combinations of resources bracket CMC isotope values. However, several lines of evidence suggest that invertebrates remain important as a food source as CMC migrates into freshwater habitats. Although prevalence of invertebrate taxa in gut contents from both fresh and saline sites is low, invertebrates are more abundant in the guts of CMC collected from fresh water than from its intertidal habitat. In addition, a positive correlation of 15N values of crabs from intertidal habitat with their weight suggests that, as crabs grow larger, they may incorporate more high-nitrogen foods such as invertebrates into their diet. These findings are consistent with the results of a study of CMC in its native habitat that suggested the crabs increase consumption of animal matter as they age (Dan et al., 1984)."

Dittel and Epifanio (2009)

"Early studies on the feeding habits of *E. sinensis* described the crabs as opportunistic omnivores capable of eating a wide variety of invertebrates as well as algae and detritus (Thiel, 1938; Panning, 193[8]). More recent findings in San Francisco Bay indicate that *E. sinensis* prey on freshwater shrimp, and there are concerns that mitten crabs can feed on an endangered species of shrimp (*Syncaris pacifica*) in areas of the bay where these two species overlap (Rogers, 2000).

Additional studies in Coyote Creek at the south end of San Francisco Bay utilized stable isotope analysis to determine that mitten crabs relied mainly on invertebrate prey, although benthic algae and terrestrially derived detritus were also incorporated in the diet. Other work in San Francisco Bay indicates that mitten crabs prey on eggs of nest-building fish such as centrarchids and salmonids, which could have substantial effects on the salmon fishery (Veldhuizen and Stanish, 1999)."

Schoelynck et al (2021)

"They are omnivorous and opportunistic and feed on almost any organic food source they can find, which may pose a threat to the resident fauna and flora (Rogers, 2000; Schoelynck et al., 2020)."

Record of invasion outside of Washington

Introduced range

Invasive populations of *E. sinensis* have been found throughout Europe and United States, with detections occasionally occurring throughout the world. (GBIF Secretariat 2025; Figure 3). Georeferenced records of *E. sinensis* presence can be at the following website: GBIF Chinese Mitten Crab Records.

Figure 3. Global distribution (native and non-native detections) of Chinese mitten crab (*Eriocheir sinensis*) as of May 27, 2025.

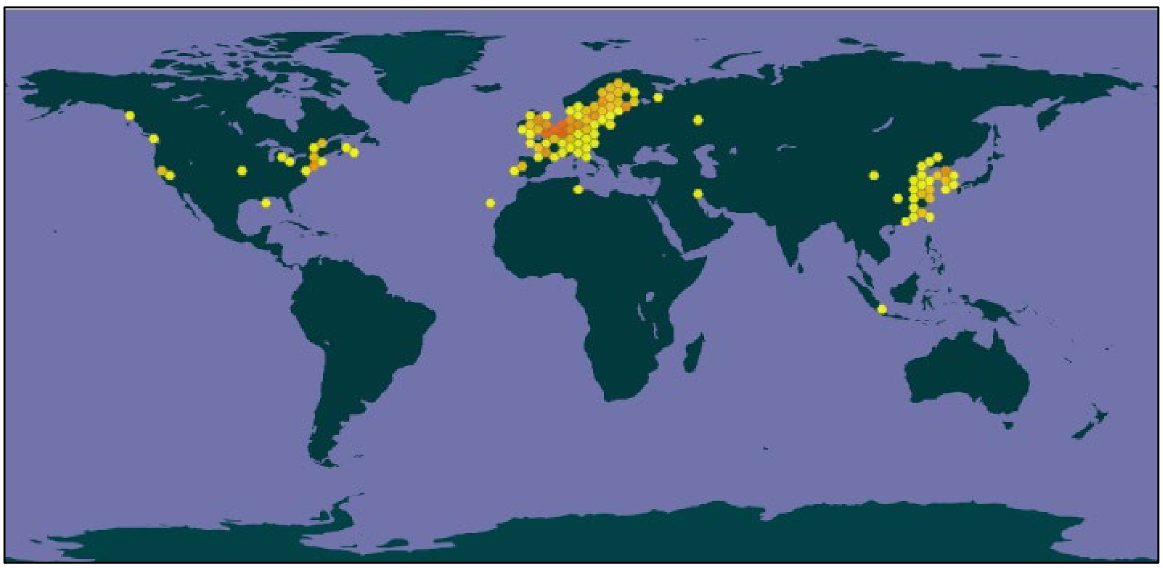


Image by GBIF Secretariat, 2025

Presence in the United States

Specimens of *E. sinensis* have been found in Alaska, California, Delaware, Louisiana, Maryland, New Jersey, New York, Oregon, and Washington (USGS 2025; Figure 4). The only known established populations on the West Coast are in the San Francisco Bay estuary and watershed (SERC 2025), though no specimens of *E. sinensis* have been recorded since 2019 (Hieb 2025). Validated records can be found at the following website: USGS Chinese Mitten Crab Map and Specimen Records.

Figure 4. Distribution of the Chinese mitten crab (Eriocheir sinensis) in the United States as of May 27, 2025.

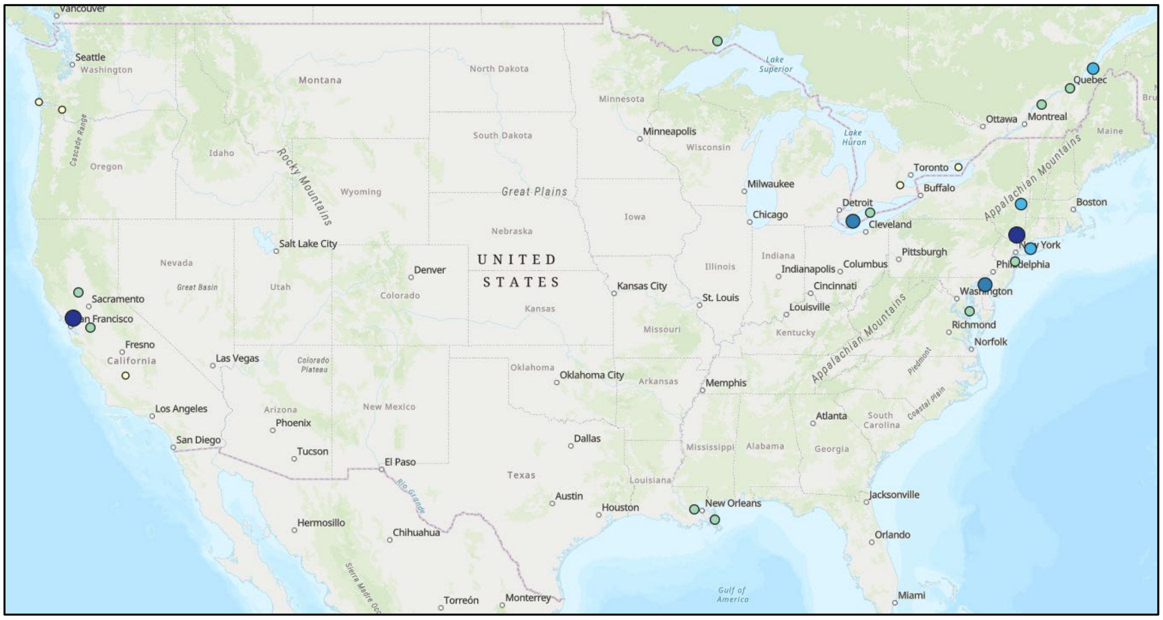


Image by USGS *2025. Please note that the April 22, 2025, detection in the Columbia River has yet to be added.*

Existing risk screening summary and assessments

Chinese mitten crab (*Eriocheir sinensis*) Ecological Risk Screening Summary. (USFWS 2018).
Risk summary available here.

Risk assessment for Chinese mitten crab (*Eriocheir sinensis*) in Canadian waters. (Therriault and others 2008). Risk assessment available here.

Pest Risk Assessment for Mitten Crabs in Oregon. (Draheim 2008) Risk assessment available here.

Ecological impacts

Competition

Veilleux and De Lafontaine (2007)

"Crayfish species, particularly rare or endangered ones, could be negatively affected by very abundant crab populations because of common freshwater habitat and diet shared by both species (Veldhuizen and Stanish, 1999; Rudnick et al., 2000)."

Gilbey and others (2008)

"The extensive use of boulders in the intertidal, and the high turnover of boulder-use throughout a tidal cycle, means that competition for shelter resources could occur between juvenile mitten crabs and native crabs, especially *C. maenas* during summer. Both species have been recorded from the midestuary below Greenwich, for example (M.J. Attrill, pers. Obs.). Certainly, *C. maenas* is the common resident crab species in the Thames (Attrill et al. 1999[…]) and intertidal refugia are key habitats utilised during ecdysis (Crothers 1968), so any competition for this resource from an introduced species could have consequences for native populations. Results from laboratory trials demonstrated that the juvenile *E. sinensis* successfully excluded native *Carcinus* of similar size from a mutual refuge, regardless as to whether it was the initial resident. It is possible that outcomes may be dependent on the time of day (McDonald et al. 2001); our results demonstrate *E. sinensis* is competitively superior during daylight periods."

Diseases

Schrimpf and others (2014)

"Transmission experiments and subsequent molecular diagnostics have proven that the Chinese mitten crab [*E. sinensis*] from the River Rhine is a) carrier of the crayfish plague pathogen and is b) capable of transmitting the pathogen to the noble crayfish. This study has identified a crustacean of the infraorder Brachyura as a confirmed transmitter of the crayfish plague pathogen, thereby refuting the assumption that only freshwater crayfish, order Decapoda can be infected with *A. astaci*."

Predation/Feeding

Rudnick and Resh (2005)

"The large volume of plant and algal detritus in gut contents of both species suggests that both RSC [Red swamp crayfish, *P. clarkia*] and CMC [Chinese mitten crab, *E. sinensis*] may play an important role in transforming organic detritus, which can both directly and indirectly impact freshwater benthic food webs by changing both the quantity and form of these nutrients available to other aquatic biota (Momot, 1984; Nyström, 2002)."

Veilleux and De Lafontaine (2007)

"The predation on fish eggs might be of concern (CMCWG, 2003); however, quantitative assessments of the potential impacts on fish population dynamics are lacking. Given that fish material made up only 2.4 % of crab gut contents analyzed in Germany (Thiel, 1938 cited in Panning, 1938), the impact on adult fish populations would presumably be low."

Dittel and Epifanio (2009)

"Early studies on the feeding habits of E. sinensis described the crabs as opportunistic omnivores capable of eating a wide variety of invertebrates as well as algae and detritus (Thiel, 1938; Panning, 193[8]). More recent findings in San Francisco Bay indicate that *E. sinensis* prey on freshwater shrimp, and there are concerns that mitten crabs can feed on an endangered species of shrimp (*Syncaris pacifica*) in areas of the bay where these two species overlap (Rogers, 2000)."

Economic impacts

Gollasch (2011)

"The negative impact of the mitten crab became especially clear during the mass occurrences in German waters. The mass developments lasted for approx. 30 years. Up to 140 t of juvenile crabs were caught annually during mass developments in the last century with a single fishing net collecting up to 50-60 kg of crabs per day (Fladung, pers. comm.). The monetary impact caused by this invader in German waters alone totals to approx. 80 million Euro since its first occurrence in 1912 (cost calculation adjusted from Fladung, pers. comm.). Cost items include:

- Catchment gear installation and maintenance,
- Impact on bank erosion and feeding, and
- Loss in commercial fisheries and pond-aquaculture (estuaries and in-land). Crabs feed on fishes caught in traps and nets. Nets will be damaged. In freshwater ponds the crabs feed on the cultured fish and their food.

Additional negative impacts are known, but cannot be quantified in monetary terms, i.e. impacts on biodiversity, recruitment of commercial species and an increased erosion rate due to crab burrowing activities in river embankments (Gollasch and Rosenthal in prep.)."

Damage to infrastructure

Rudnick and others (2000)

"In areas where crabs are particularly abundant, the burrows become tightly packed together and are often interconnected. The significant amount of sediment removed in areas with high densities of burrows can cause weakening of the bank, accelerate erosion and even cause banks to collapse (Panning, 1938; D. Rudnick, personal observation). The mitten crab was introduced into Germany at the turn of the century, and its high abundance in the coastal northern waterways caused extensive bank damage. Panning (1938) noted that the mitten crabs caused considerable damage to many banks and levees by causing the bank to cave in from such extensive sediment removal. This burrowing is of particular concern where waterways are controlled by human-made levees; weakening or destruction of such levees from extensive burrowing could pose serious threats to flood control and water supply efforts."

Dittel and Epifanio (2009)

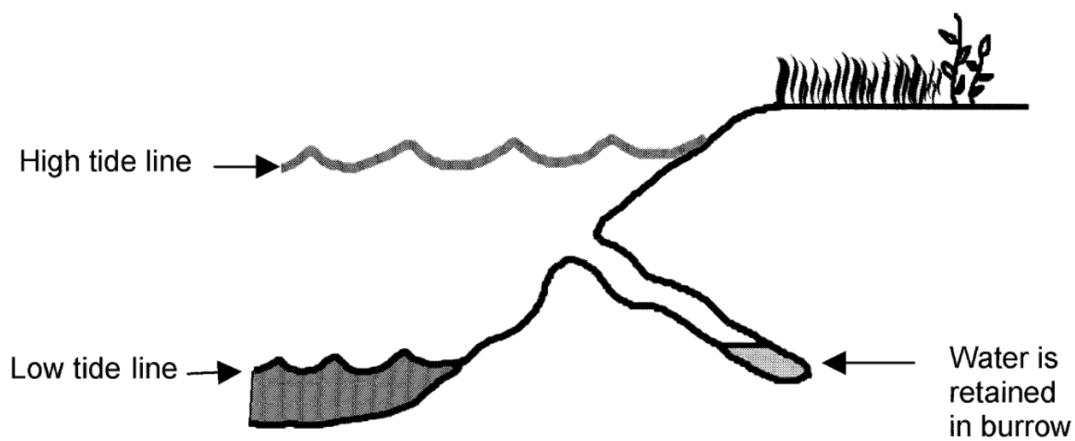
"Burrowing activity can affect the integrity of stream banks and can exacerbate loss of sediment to adjacent open water. Studies in German rivers have noted that burrowing by *E. sinensis* may result in collapsed levees and dikes due to sediment erosion, and similar impacts have been observed more recently in the Thames River in the United Kingdom (Dutton and Conroy, 1998; Rudnick et al., 2005[…])."

Rudnick and others (2005)

"Juvenile Chinese mitten crabs, *Eriocheir sinensis*, create burrows, in both their introduced ranges, in soft-sediment banks of intertidal portions of streams. When abundance is high, burrows can become very dense. In Europe, this behavior has been linked to erosion and bank collapse"

"Mitten crab burrows were found between the high and low tide lines in the transect study […]. On excavation, most burrows were found to consist of a tunnel that slopes downwards towards the end or terminal chamber(s) of the burrow [Figure 5]. The majority of crabs collected was taken from these terminal chambers, which tended to be larger than the tunnel itself. These chambers nearly always contained standing water or at least the soil surrounding the chamber was fully saturated."

Figure 5. Simplified drawing of an *Eriocheir sinensis* (H. Milne Edwards, 1853) burrow, showing placement between the high and low water lines and downward-sloping internal tunnel leading to a saturated terminal chamber.



This drawing does not incorporate the complexity of many mitten crab burrows that have multiple, interconnected tunnels and terminal chamber. From Rudnick and others 2005.

"As burrows are both expanded and rebuilt after the rainy season, sediment is continuously being lost to burrowing activities. Estimates of sediment removal suggest that, over the period of study, mitten crabs at these sites removed between 1 and 6% of the sediment of the first half-meter depth of the bank between the high and low tide lines (approximately 1.5 m bank height for all three streams). Over the three streams sampled, the average sediment loss from burrowing activity was about 3% per 0.5 m^3 of bank. If it is assumed that stream banks downstream of the study site were amenable to burrowing, then at least 2 km of stream bank, and both sides of the stream of these 2 km, is available, for a total of 4 km of bank. A gross estimate, therefore, yields about 90 m^3 of sediment removed as a result of burrowing activities in a given stream at the recorded level of burrowing activity over the two year period. This estimate does not include additional sediment loss that could result from bank slumping or collapse as banks are weakened by burrowing activities."

Fisheries impacts

Veldhuizen and Stanish (1999)

"In the San Francisco Estuary, the crab has been a nuisance to commercial bay shrimp trawlers and sport anglers for several years. In south San Francisco Bay, commercial shrimp trawlers find it time consuming to remove crabs from their nets (one fisherman twice caught over 200 crabs in a single tow during fall 1996). They are also concerned that a large catch of mitten crabs will damage their nets and the shrimp. Damaged shrimp are unsuitable for the bait market. Currently, shrimp trawlers are able to move to other areas in south San Francisco Bay with fewer crabs, but this option will diminish as the mitten crab population grows.

A commercial fishery for the introduced signal crayfish (*Pacifastacus leniusculus*) is located in the Sacramento-San Joaquin Delta. During fall 1998, when large numbers of adult mitten crabs migrated downstream, mitten crabs were caught in crayfish traps. If the mitten crab population continues to increase, the crab will become a serious pest by filling the traps and, thus, reducing the crayfish catch. In addition, the mitten crab overlaps in dietary and habitat preferences with the signal crayfish which may reduce crayfish abundance and growth rate.

The sport fishery in the Sacramento-San Joaquin Delta is also impacted by the increasing mitten crab population through loss of bait. The majority of complaints received by CDFG concerning the mitten crab are from recreational anglers."

Rudnick and Resh (2002)

"The results of this survey align closely with what is known about the life history of the Chinese mitten crab. Mitten crabs are present year-round in the brackish portions of tributaries, but reach their highest densities in their breeding grounds in winter months, also the time when respondents reported the highest numbers of crabs. Damage to and interference with commercial harvests is therefore concentrated in this season.

Juvenile and adult mitten crabs are benthic animals, grazing on detritus and other food sources at the bottom of the water column; therefore, the highest rates of capture should occur when using methods that collect animals from the bottom of the estuary, such as trawling. Benthic stationary traps, as are used in the crayfish industry, often do not attract crabs, as was observed in this survey and others and research that we have conducted [Rudnick et al. 2000]. The shrimp industry, which uses low-speed trawls to harvest shrimp, is the industry that reported the highest level of damage in this survey, and should be targeted for further research and identification of the Chinese mitten crab's effects on commercial fishing."

Human Health Impacts

Che and Cheung (1998)

"After conversion of the data using a wet weight: dry weight ratio of 3. 86 for *M. ensis* [a commercial shrimp *Metapenaeus ensis*] and 2.85 *for E. sinensis* (unpublished data), the measured levels in this study shows that concentrations of chromium, lead and zinc in *M. ensis* fall within the recommended limits but those in *E. sinensis* are slightly in excess."

Cohen (2003)

"From a U.S. public health perspective, there are two issues to consider: Could mitten crabs imported from Asia carry *P. westermani* to the U.S.? and could mitten crabs established in the U.S. serve as second intermediate hosts, if *P. westermani* were introduced? It appears that either *E. japonicus* or *E. sinensis* (at least from Korea or northeastern China) are potential carriers of *P. westermani*, especially of the triploid form, which is more pathogenic to humans, and which reproduces parthenogenetically and therefore may more easily become established. Both could also serve as second intermediate hosts for the triploid form, probably along with many of the crayfish species already present in the U.S. To the extent that the establishment of *P. westermani* would be a significant public health concern, appropriate cautionary measures should be taken."

Draheim (2008)

"Mitten crabs are a known secondary intermediate host to a parasite known as the Oriental lung fluke (*Paragonimus westermani*). Mammals, including humans, serve as the final host and can become infected by eating raw or inadequately cooked crabs. While the lung fluke has not been found in the San Francisco Bay mitten crab population (Chinese Mitten Crab Working Group 2003), in 2007 a small estuarine snail that can serve as the primary intermediate host (*Assiminea parasitological*) was found in Coos Bay providing the potential to complete the complex life cycle of the lung fluke. The risk of Oriental lung fluke transmission to humans is heightened by the value of the crabs as a seafood species. Mitten crabs may also pose a higher risk for bioaccumulation of contaminants in their tissues than marine crabs."

Nędzarek and others (2019)

"Bioaccumulation of elements in the bodies of Chinese mitten crabs from the Szczecin Lagoon depended mainly on the body part analyzed, and to a small extent on the season and sex. Exoskeleton and gills were the sites of the greatest accumulation of Ca, NA, Mg, Fe, Al, Cu, and Pb.

Due to the high content of essential metals (Fe, Cu, Zn) and low content of toxic elements, such as As, Pb, Cd and Ni, in edible parts, Chinese mitten crabs from the Szczecin Lagoon may be an attractive sources of nutrients performing important functions in metabolic processes, while not posing a threat to consumer health"

Gao and others (2022)

"Through the analysis of the heavy metal content in the Chinese mitten crab samples, it is believed that under normal eating conditions, these crab samples have no excessive eating health risks, and can be consumed regularly for nutritional benefits. However, some of the data obtained are worthy of in-depth analysis. For example, among Cr, Cu, Zn, Cd, and Pb metals, Cd has the highest food safety risk, which is worth noting. Moreover, a certain percentage of arsenic content is regarded as the inorganic arsenic content, which is highly toxic than the organic form of arsenic."

Summary

Populations of *E. sinensis* have become established in locations outside of their native range, primarily in Europe. California's Sand Francisco Bay Delta contains the populations of *E. sinensis* nearest to Washington, though their numbers are significantly reduced after their boom in the late 1990's (CDFW 2025). Ecological impacts include competition with and predation on invertebrate communities and disruption of local food webs. Economic impacts result primarily from impacts increasing bank erosion and impacts to commercial fisheries (e.g., damage to traps and nets, predation on target species, bait theft). *E. sinensis* could also impact human health (e.g., bioaccumulation of certain heavy metals, serving as intermediate hosts for as *Paragonimus westermani*).

Potential for transport into and within Washington

Means of introduction and spread

Veilleux and De Lafontaine (2007)

"It is now largely accepted that the worldwide spread of the Chinese mitten crab was due to human-mediated activities and not the result of natural causes (Cohen and Carlton, 1997). These authors identified 10 pathways (intentional and unintentional) that would explain the introduction and transfer of crab around the world:

- dispersal of larvae by currents
- passive dispersal of adults or juveniles on floating material
- transport of adults or juveniles by ship fouling
- transport of adults or juveniles in cargo
- transport of adults or juveniles on semi-submersible drilling platforms, barges and other long-distance slow-moving vessels
- transport of larvae or juveniles in ballast water
- transport of adults or juveniles in fisheries products
- transport of larvae in water with shipments of live fish

- escape or release from research, public, or private aquaria
- intentional transfer to develop a food resource

"Among all these vectors, two were considered to be the most likely pathways: the active transport and voluntary release of mitten crabs into new habitats to provide a new human food source, and the accidental release of crabs via ship ballast water discharge (Cohen and Carlton, 1997)."

Ballast and biofouling

Cohen and Carlton (1997)

"*Eriocheir sinensis* is thus a poor candidate for crossing oceans by natural means, either as planktonic larvae or as crabs rafting on floating material carried by ocean currents. Crabs are rare or absent from hull fouling on modern ships, and some vectors that may have translocated other crabs-such as transport on drilling platforms, shipment with fishery products or live fish, or transport for research and other aquarium use-have not been available for transporting *E. sinensis* between its source areas and San Francisco Bay, at least in recent decades. *Eriocheir sinensis* was probably introduced into San Francisco Bay either in ballast water or as an intentional planting to establish a food resource."

Veilleux and De Lafontaine (2007)

"The most probable unintentional vector for the introduction and transfer of the Chinese mitten crab is the transport by ship ballast waters. Presumably the uptake of pelagic larval stages would be responsible for the spread of the species via ballast water (Cohen and Carlton, 1997). In fact, the Chinese mitten crab was one of the first species reported in ballast tanks and was used as a first piece of evidence for the transport of living aquatic invasive species in ballast water (Carlton, 1985). In northern Europe, ship traffic from China headed for Hamburg (Elbe River) and Bremen (Weser River) has been frequent since the end of the 19th century, which may have very likely contributed to a founder specimens introduction via incoming ships from China (Herborg et al., 2003). The presence of the crab in southern France probably arose through shipping activities (Herborg et al., 2003)."

Therriault and others (2008)

"Literature reports have identified ballast water transport as the primary vector for global introductions of Chinese mitten crab. This vector also was identified as important for secondary spread of this species."

Intentional introduction

Hänfling and others (2002)

"The populations of the mitten crab in San Francisco Bay may originate from larvae in ballast water of large vessels but, since mitten crab is an important food species, it may also have arisen from intentional introductions (Cohen & Carlton 1997). Cohen & Carlton (1997) concluded from shipping data of large commercial vessels and human food consumption patterns that the most likely source of the introduction is Asia. Clearly, our genetic data provide an unexpected alternative hypothesis about the invasion history of the American populations of the mitten crab, i.e. the source may be Europe and not Asia. A possible mechanism for such a translocation could be the transport of mitten crab from Europe to America for food consumption since mitten crabs are caught and marketed by commercial fishermen in the river Elbe, Germany."

CMCWG (2003)

"A likely vector for dispersal of mitten crabs within the U.S. is the introduction of live crabs by humans. Live mitten crabs have been available for sale in seafood markets of New York City's Chinatown, fetching up to $40/pound (Jung 1998). In the fall of 1999 and again in 2001 illegally imported commercial shipments were intercepted coming into New York via airline transport (Sabia 1999, 2002). The demand for mitten crabs, particularly egg bearing females, provides an economic incentive for individuals to establish new populations of mitten crabs in U.S. waters. The presence of mitten crabs is likely to damage the aggregate economy of affected areas, even though limited individuals could profit from their introduction and harvest."

"Accidental or intentional human introduction is also a likely vector for the establishment of new mitten crab populations. The value of the mitten crab as a food item provides an economic incentive for individuals and commercial entities to establish crab populations that can support a fishery. The mitten crab is a highly valued food item in China and other Asian countries. Peaks in demand for mitten crabs are seasonal with increased activity between October and February when the most sought after crabs, females with ripe ovaries, are available. Mitten crabs have been found in carry-on luggage at Seattle, Los Angeles, and San Francisco airports […] and have been intercepted as illegal, live imports to markets in Los Angeles, New York and San Francisco (Cohen and Carlton 1997, Jung 1999). There is interest in establishing both commercial fisheries and aquaculture production of the mitten crab to meet the latent demand for this valued food item (CFGC 1999). Due to these financial incentives it is widely hypothesized that intentional releases of crabs into Bay-Delta have occurred in an effort to establish a harvestable population (Cohen and Carlton 1995, Rudnick et al. 2000)."

Natural diffusion

Herborg and others (2005)

"The average rate of range expansion upstream per river system in the UK during the peak period of range expansion (1995–1998) was 49 km per year. This is lower than values at the time of peak spread in northern Europe (562 km per year) and southern France (104 km per year) (Herborg et al. 2003) [Table 1]. These differences in rates may reflect differences in the river systems of continental Europe and the UK."

"Spread of *E. sinensis* between estuaries in close vicinity to each other, like the Elbe and Weser (≈60 km), could be caused by larval drift. Where estuaries are further apart, the duration of the pelagic larval phase, as well as the prevailing currents, have to be taken into consideration."

“Due to the limited knowledge on the larval biology of this species, it is difficult to determine a maximum distance of ‘natural spread’ along the coast as opposed to ‘unnatural’, human-aided transport.”

Table 1. GIS based measurements of the mean (±SD) annual spread of *Eriocheir sinensis* in river systems for northern continental Europe, southern France (both from (Herborg and others 2003) and the United Kingdom.

River Spread	Total observational period		Peak spread period	
	Period	km/year (± SD)	Period	km/year (± SD)
Northern Europe	1913-1956	196 (± 388)	1928-39	562 (± 599)
Southern France	1954-1960	104 (± 116)	NA	NA
United Kingdom	1973-1998	16 (±28)	1995-1998	49 (± 34)

Modified from Herborg *and others 2005.*

Veilleux and De Lafontaine (2007)

“Once Chinese mitten crabs have been introduced into a new habitat and are established, they can invade and colonize nearby water systems either by larval transport or migration by juveniles. Upon hatching in brackish waters, crab larval stages may drift considerably along coastal areas before settling into new habitats. Metamorphosed juveniles are capable of long upstream active migration that may introduce the crab into new freshwater systems adjacent to established population regions (Herborg et al., 2005). This natural drift pathway is believed to be responsible of the large spread of *E. sinensis* in northern Europe throughout the 20th century.”

Dittel and Epifanio (2009)

“Despite the abundance and impact of *E. sinensis* in invaded ecosystems, relatively few studies have addressed the larval biology of the species. Panning (193[8]) noted that zoeae are released in estuarine water and eventually move to fresh water during the megalopal stage. But the transport mechanisms proposed by Panning were purely conjectural and had little relation to our present understanding of estuarine circulation. More recently, Anger (1991) showed that salinity tolerance varied greatly among different larval stages of *E. sinensis*. Stage I zoeae were euryhaline, tolerating salinities between 10 and 30‰. However, the late zoeal stages required high salinity water, and euryhaline capabilities were not developed again until the megalopa stage. Anger suggested that larvae are hatched in low-salinity estuarine water and are transported to high-salinity coastal water where zoeal development occurs. He surmised that megalopae are then transported back to the estuary where they settle in juvenile habitat and eventually undergo upstream migration as juveniles. Under such circumstances, larvae would depend on favorable oceanographic conditions to recruit back into the estuary (Epifanio and Garvine, 2001).

An alternative dispersal scenario was proposed by Hanson and Sytsma (2008), who suggested that mitten crab larvae are retained within the estuary in their native habitat because rivers along the east coast of Asia experience low flow in the summer months when larval release occurs. However, there have been no direct investigations of larval transport in either native or invasive populations of *E. sinensis* (Veldhuizen and Stanish, 1999; Veldhuizen, 2001; Rudnick et al., 2000, 2003, 2005[…]), and there have been no investigations of vertical swimming behavior, which would determine the possibility of larval retention within the estuary (Park et al., 2004). Moreover, there has been no attempt to identify the physical processes responsible for the transport of mitten crab larvae in Asian, European, or North American populations."

Potential for overland transport to Washington

As noted by Cohen and Carlton (1997), active transport and voluntary release into new habitats is one of the most likely vectors for introducing *E. sinensis*. Despite the status of *E. sinensis* as a Prohibited Level 1 Species in Washington (may not be possessed or retained, introduced on or into a water body or property, transported, bought or sold, without department authorization, a permit, or as otherwise provided by rule), shipments of live crabs entering Washington have been intercepted by WDFW Police. While there is no documentation of the release of live *E. sinensis* in Washington, it is certainly within the realm of possibility.

Potential for maritime transport to Washington

Ballast water and biofouling overview

Washington state RCW Chapter 77.120 enables the Washington Department of Fish and Wildlife (WDFW) to regulate operations of vessels 300 gross tons and greater for the prevention of invasive species introductions via ballast water and biofouling. Fouling organisms may include invasive species and may spread by larval release or fragmentation from a fouled surface. Ballast water is essential to the safe operation of large oceangoing vessels that carry cargo between the world's ports. Water is typically pumped into ballast tanks at one port when cargo is offloaded and then pumped back out to another port when new cargo is loaded. Ballast water helps vessels maintain stability and maneuverability and can also harbor invasive species including the larvae of *E. sinensis*.

Required operations and reporting schedules are listed in WAC Chapter 220-650. In general, vessels arriving to Washington that intend to discharge ballast water must either conduct an open-ocean ballast water exchange at least 50 Nautical Miles (NM) for coastal voyages or 200 NM for transoceanic voyages from any shoreline or must treat all ballast water with a U.S. Coast Guard (USCG) Type Approved Ballast Water Management System (BWMS) that has been installed onboard. The process of BWMS type approval in the United States includes the issuance of a USCG Type Approval Certificate that includes specific installation and operational limitations that must be met for the BWMS to be operated legally in U.S. waters. Vessels are also required to clean and maintain their hulls for the prevention of biofouling accumulation in accordance with laws protecting water quality and must receive prior written approval from the Washington Department of Ecology and WDFW prior to conducting any in-water cleaning operation that could dislodge fouling organisms.

Eriocheir sinensis and commercial vessels in Washington

Ballast water is thought to be the primary pathway of *E. sinensis* introduction globally (Cohen and Carlton 1997). Washington receives numerous vessels and ballast water discharges from national and international ports with established *E. sinensis* populations or recent detections. Ports in San Francisco Bay have had recent detections of *E.* sinensis, and this coastal route makes up a significant portion of arrivals in Washington. According to the WDFW vessel records, vessels may take as little as two days between taking on ballast in the San Francisco Bay area and arriving in Washington ports. Shorter voyages are associated with greater risk that organisms such as *E. sinensis* larvae could survive in ballast tanks should they escape mortality from exchange or treatment. Washington also receives vessels arriving from transoceanic voyages from ports in the Western Pacific including China and South Korea. While these transoceanic voyages often result in a higher ballast age before discharge, *E. sinensis* have successfully survived and established after transoceanic voyages (Cohen and Carlton 1997). While this analysis focused on arrivals from the Pacific region, future warming and ice reduction in the arctic will result in an increase in arrivals from the North Sea. This pathway should be seriously considered in the future as parts of the North Sea are highly invaded with *E. sinensis* (Ewers et al. 2023).

Washington received a total of 9,463 arrivals from invaded ports from 2015 – present (Figure 6). While this does not necessarily indicate that all vessels were carrying or discharging ballast water from invaded areas, vessels from these ports may also carry adult *E. sinensis* in niche areas such as thruster housings, sea chests, and exposed portions of their hulls if antifouling coatings have been compromised. Arrivals to Washington from national and international ports with established *E. sinensis* populations or recent detections represented 24.6% of all arrivals to Washington waters during this evaluation period.

Total vessel arrivals from infested waters does not, in isolation, represent the risk of *E. sinensis* release in ballast water. Some vessel arrivals were not associated with ballast discharge, and others were carrying ballast sourced at ports not known to harbor *E. sinensis*. Nonetheless, a total of 5,039 vessels discharged ballast water from 2015 – present, with 61% of these discharging arrivals coming from transoceanic routes and 39% coming from coastal routes (Figure 7). These vessels discharged at least 86,172,660 MT of ballast water from infested ports, with 60% of this volume coming from transoceanic voyages and 40% coming from coastal voyages (Figure 8). Ballast water could represent a high-risk pathway for invasion by *E. sinensis* to Washington given the nature of commercial vessel traffic from affected regions.

Figure 6. Arrivals from ports with established *Eriocheir sinensis* populations or recent detections to Washington ports.

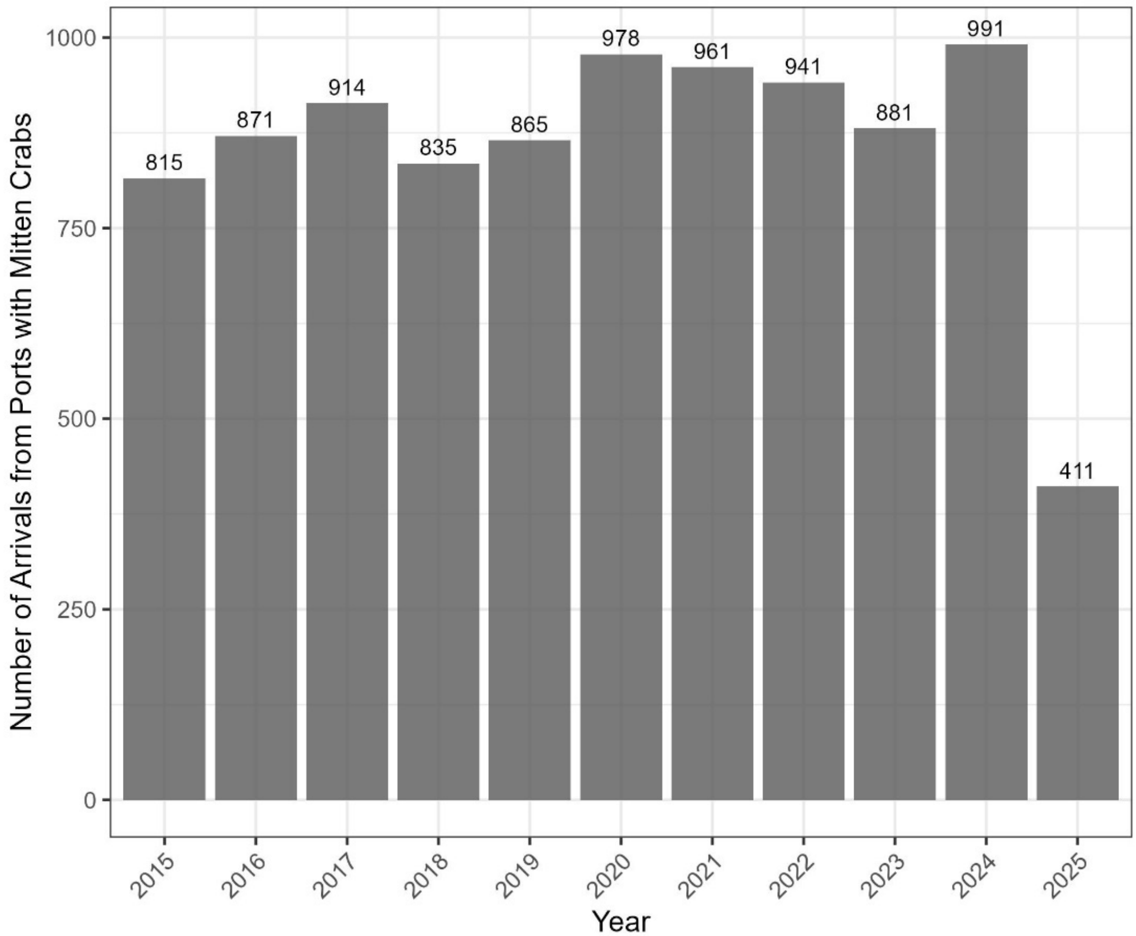
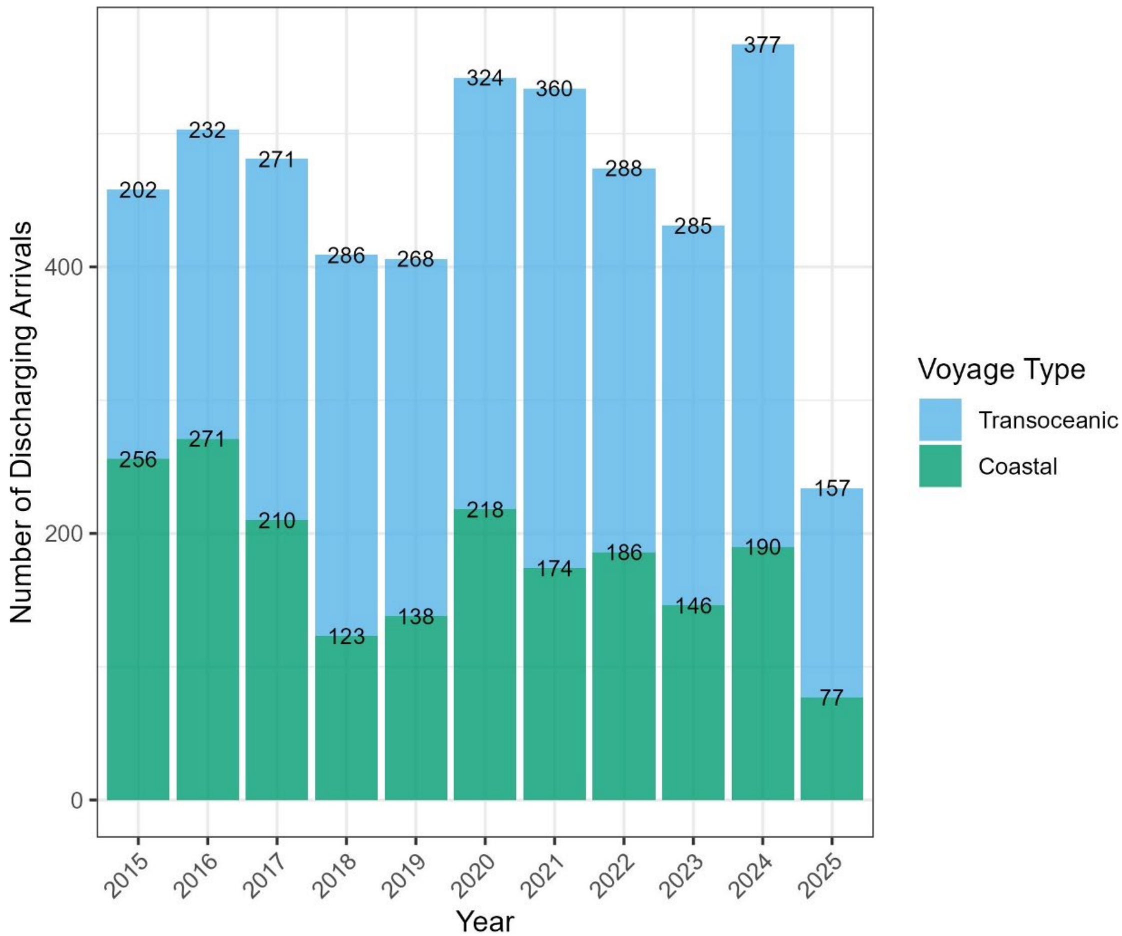
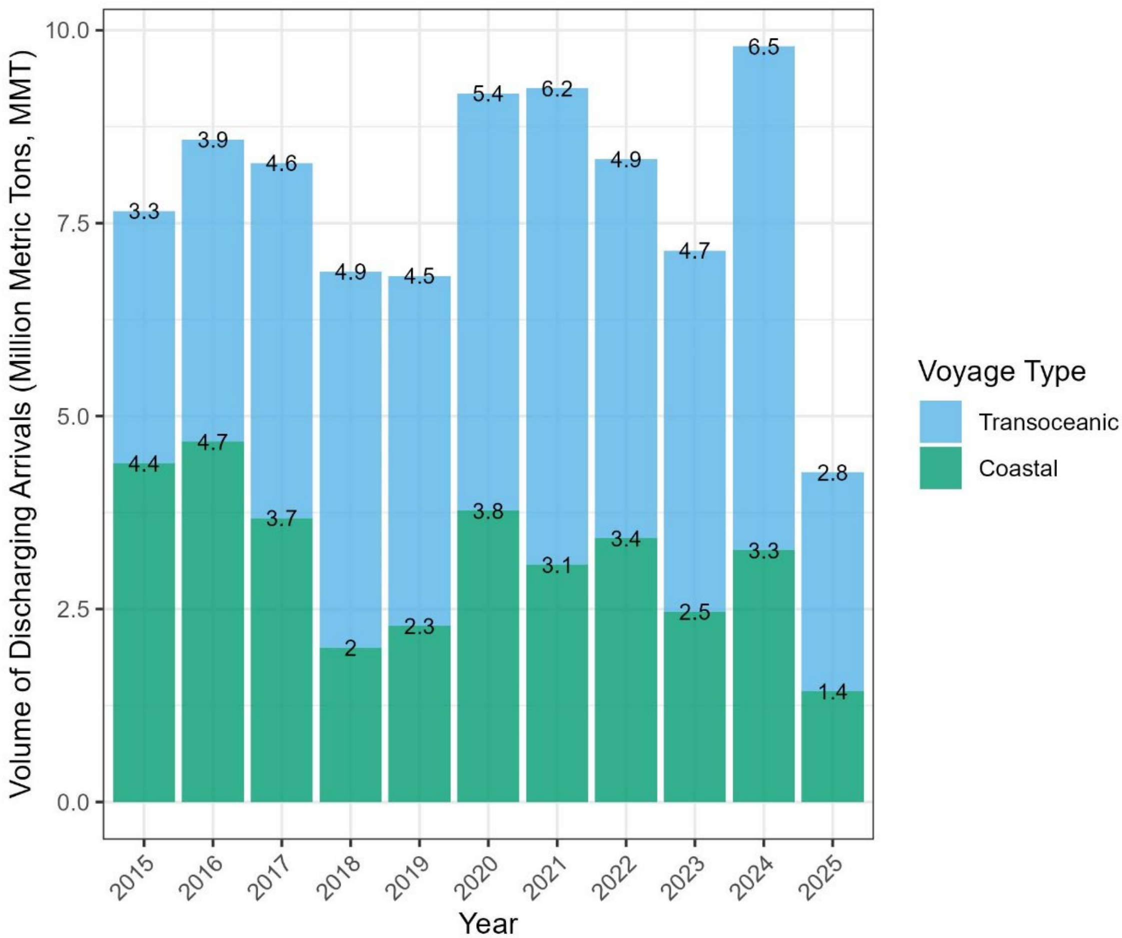


Figure 7. Discharging arrivals from ports with established *Eriocheir sinensis* populations or recent detections to Washington ports.



Green bars represent coastal voyages (from California) and blue bars represent transoceanic voyages (from China and South Korea). The labeled number indicates the total number of arrivals in a given year for each voyage type.

Figure 8. Discharge volumes from ports with established *Eriocheir sinensis* populations or recent detections to Washington ports.



Green bars represent coastal voyages (from California) and blue bars represent transoceanic voyages (from China and South Korea). The labeled number indicates the total volume of ballast water discharged in a given year for each voyage type measured in million metric tons.

Summary

The detection of *E. sinensis* in the Lower Columbia River east of Tongue Point marks the second confirmed specimen of this species collected in the Columbia River (the previous confirmed detection was at the Port of Ilwaco, Washington, in 1997). Whether these specimens were introduced into the Columbia River intentionally (e.g., attempting to create a fishery, aquarium release) or unintentionally (e.g., ballast or biofouling), it is irrefutable that *E. sinensis* could be transported into Washington.

If introduced, *E. sinensis* has the potential to spread through natural migration. Upstream expansion of *E. sinensis* is well documented, allowing expansion throughout the watershed. While there is the potential for natural coastal expansion, the lack of evidence of natural spread along the Pacific Coast (in contrast to the widespread expansion of the invasive European green crab, *Carcinus maenas*) suggests it is an unlikely vector for widespread range expansion for *E. sinensis*. However, human-mediated transport could facilitate the spread of *E. sinensis*, allowing for expansion exceeding their natural limitations.

Ballast water is a potential pathway for invasion by *E. sinensis* to Washington. Washington receives vessels arriving from short-duration coastal voyages from the San Francisco Bay Area, and transoceanic voyages from ports in the Western Pacific including China and South Korea. While transoceanic voyages often result in a higher ballast age before discharge, *E. sinensis* have successfully survived and established after transoceanic voyages. Ballast water could represent a high-risk pathway for invasion by *E. sinensis* to Washington given the nature of commercial vessel traffic from affected regions.

Conditions in Washington suitable for survival and reproduction

Cohen and Weinstein (2001)

"Summer and winter sea surface temperatures off the mouth of the Columbia River, and summer estuary temperatures, are within the range reported for watersheds with large mitten crab populations [Table 2]. Winter estuary temperatures (3-6°C) are slightly below this range, but as we lack estuary temperature data for the estuaries with the coldest winter sea surface temperatures (Liao and Hai river estuaries), the actual range may be broader. The size of the estuary, river and watershed, and the volume of discharge, are also within the range of watersheds with large mitten crab populations [Table 3]. The estuary is highly productive with extensive, shallow salt, brackish and freshwater habitat, which is favorable for mitten crabs. The low gradient, tidally-influenced reach of the lower river below Bonneville Dam has summer temperatures within the range (15-30°C) that supports good juvenile and adult growth. The Columbia River estuary and lower river thus appear to be highly suitable habitat for mitten crabs, capable of supporting an abundant population."

"To migrate up past any of the nine lowest dams [of the Columbia River, starting with Bonneville Dam] via their fish ladders, a mitten crab would have to climb up a long series of pools extending over several hundred meters, either going through the submerged orifices in the weirs between the pools or climbing over the weirs against flows of 2-3 m/s, then pass from the holding pools past counting stations to the river forebay behind the dam. Although crabs could pass from the ladders through the diffuser gratings into the auxiliary water systems (see Footnote 13), these provide no feasible route to the upstream side (Athearn pers. comm. 2001)."

Table 2. Latitude and temperature ranges for watersheds with large mitten crab, Eriocheir sinensis, populations, and data for assessed watersheds.

	Latitude (°N)	Sea Surface Temperature Winter (°C)	Sea Surface Temperature Summer (°C)	Estuary Temperature Winter (°C)	Estuary Temperature Summer (°C)
Range for watersheds with large mitten crab populations	28 to 54	≤0 to 10-13	14-15 to 26-27	4-6 to 14-15	16-22 to 23-25
Columbia	46.5	9-10	14-15	3-6	20-22
Rogue	42.5	10	14-15	7.5	20-21
Klamath	41.5	10-11	14-15	6-8	17-23
Texas Coastal Bend	26-29	20-22	28-29	8-16	23-32

Modified from *Cohen and Weinstein (2001).*

Table 3. Range of size and discharge data for watersheds with large mitten crab, Eriocheir sinensis, populations, and data for assessed watersheds.

	Estuary Area (km^2)	River Length (km)	Watershed Area (km^2)	Discharge Annual Mean (m^3/s)	Discharge (m^3/s)
Range for watersheds with large mitten crab populations	225 to 12,000	338 to 6,300	12,650 to 1,959,000	100 to 34,000	30 to 70,000
Columbia River estuary	≈ 500	1,984	660,500	7,300-7,800	2,000-15,000
Rogue River estuary	< 2	346	13,000	300	35-460
Klamath River estuary	< 2	-	40,400	-	45-3,800
Lavaca/Navidad rivers estuary	1,140	966	> 109,000	150-177	-
Nueces/Frio rivers estuary	538	507	> 43,500	25-34	-

Modified from *Cohen and Weinstein (2001).*

Hanson and Sytsma (2008)

"Habitat comparison

Systems with established mitten crab populations exhibited a wide habitat range, with watershed from 12,700 to 1,808,000 km^2 and estuary area from 200 to 1,328 km^2 and a relatively narrow mean flushing time from 23 to 65 days [Appendix Table 6]. The habitat data (watershed and estuary area and tidal intrusion) indicates that the Columbia River, Puget Sound, and Cook Inlet are within the range of systems with significant mitten crab populations [Table 4]. The salinity intrusion and flushing time indicates that Puget Sound, Taku, Chikat, and Stikine River estuaries and Cook Inlet can support larval development [Table 4]. Puget Sound and the Alaskan systems match all of the conditions found in systems with mitten crab populations.”

“Larval development

In San Francisco and Coos Bay, the larval period begins on October 1 and runs continuously through the summer. All other estuaries have an extended period of temperatures below 9°C that would preclude larval development until Spring [Appendix, Figure 11]. San Francisco Bay has the longest potential larval period of 293 days, from October 1 until July 20. In contrast, the potential larval period in Willapa Bay, Puget Sound, and Alaskan estuaries is 126, 63, and 25, respectively [Appendix Table 7]. For Alaskan waters, the average period for larval development begins on May 25 and ends on June 19. For sites north of the Columbia River an increase of 2°C doubles the length of the available period for larval development [Appendix, Figure 11] and has a limited effect on the average length of larval development [Appendix, Table 7].

Yaquina Bay, and Puget Sound do not have a sufficient number of days greater than 12°C (90 days) [Appendix, Figure 13]. Alaskan estuaries are below the minimal threshold for both 9 and 12°C [Appendix, Figures 12, 13]. All sites from Ketchikan south would meet the 9 and 12°C threshold with the inclusion of a 2°C temperature rise and two northern Alaskan sites, Valdez and Anchorage would meet the 12°C threshold [Appendix, Figures 12, 13].”

“Conclusion

The examination of the key factors necessary for larval development of mitten crabs, habitat suitability, and environmental condition suggests that the majority of PNW and Alaskan estuaries are not at risk of establishment of significant mitten crab populations. Puget Sound is the only estuary with the proper combination of habitat, salinity, flushing time, and temperature for larval development and maintenance of mitten crab populations. Alaskan waters were deemed at a low risk due to insufficient temperatures to support larval development. The potential for a period of increased temperatures due to global warming or natural warming trends may place Alaskan waters at a higher risk.”

Table 4. Habitat Values for the Pacific Northwest and Alaskan estuaries.

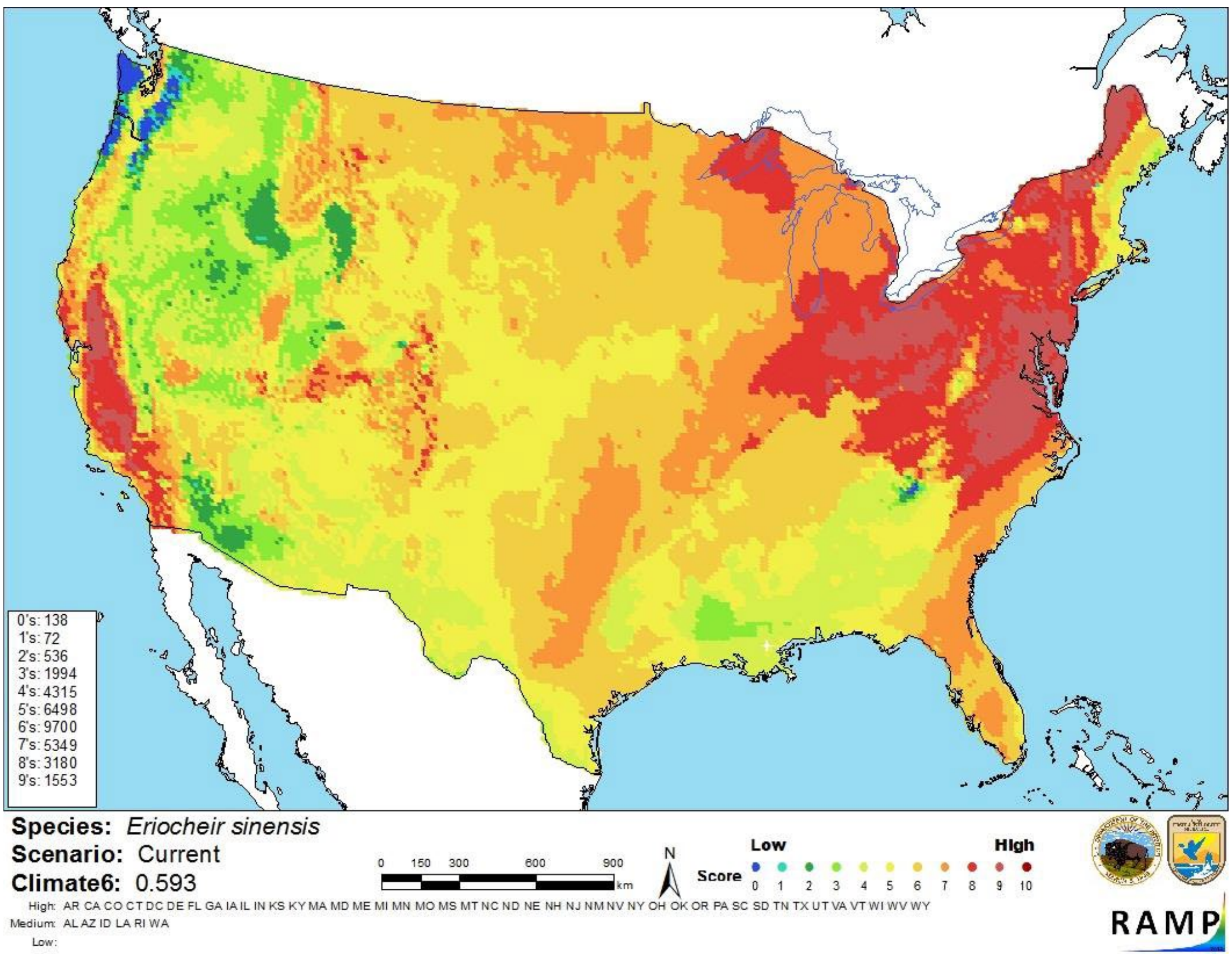
	Watershed area (1,000 km2)	**Estuary area (km2)**	**Tidal intrusion (km)**	**Maximum salinity intrusion (km)**	**Mean flushing time (days)**
	Min–Max 12.7–1,808	**Min–Max 200–1,328**	**Min–Max 100–326**	**Min–Max 67–107**	**Min–Max 23–65**
Rogue River	**13.2**	2.6	6	1	x
Coos Bay	2.7	33.7	54	30	**35**
Umpqua River	1.6	25.9	45	27	x
Siuslaw River	11.8	10.4	40	27	x
Alsea River	1.2	5.2	26	22	G
Yaquina River	0.6	12.9	41	32	7
Siletz River	0.9	5.2	38	21	x
Netarts Bay	0.04	5.2	8	8	2
Tillamook Bay	1.4	31.1	21	21	10
Nehalem Bay	2.2	5.2	25	23	x
Columbia River	**670**	**735.6**	**234**	43	3
Willapa Bay	1.9	**238.3**	45	40	x
Grays Harbor	6.3	150.2	50	45	x
Puget Sound	**237**	**2,632**	**>300**	**>300**	**152**
Taku estuary	**13**	17	-	-	-
Chikat estuary	**13**	18	-	-	-
Stikine estuary	**19**	88	-	-	-
Cook Inlet	**101**	-	-	-	-

Modified from *Hanson and Sytsma (2008). The range of values for estuaries with mitten crab populations is indicated by minimum and maximum values listed under each column. Bold indicates within range, – indicates estimated within range, x indicates estimated below range.*

USFWS (2018)

"The climate match for *Eriocheir sinensis* was low for small portions of the northwest, western Great Plains, and small patches in the southern eastern states. It was high for the mid-Atlantic, Northeast, Great Lakes Basin, portions of the Great Plains and Mid-west, south into Texas, and California; it was medium everywhere else [including Washington]. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the Continental U.S. was 0.593, high, and high in Arizona, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, and Wyoming [Figure 9]."

Figure 9. Map of Risk Assessment Mapping Program (RAMP) climate matches for *Eriocheir sinensis* in the contiguous United States.

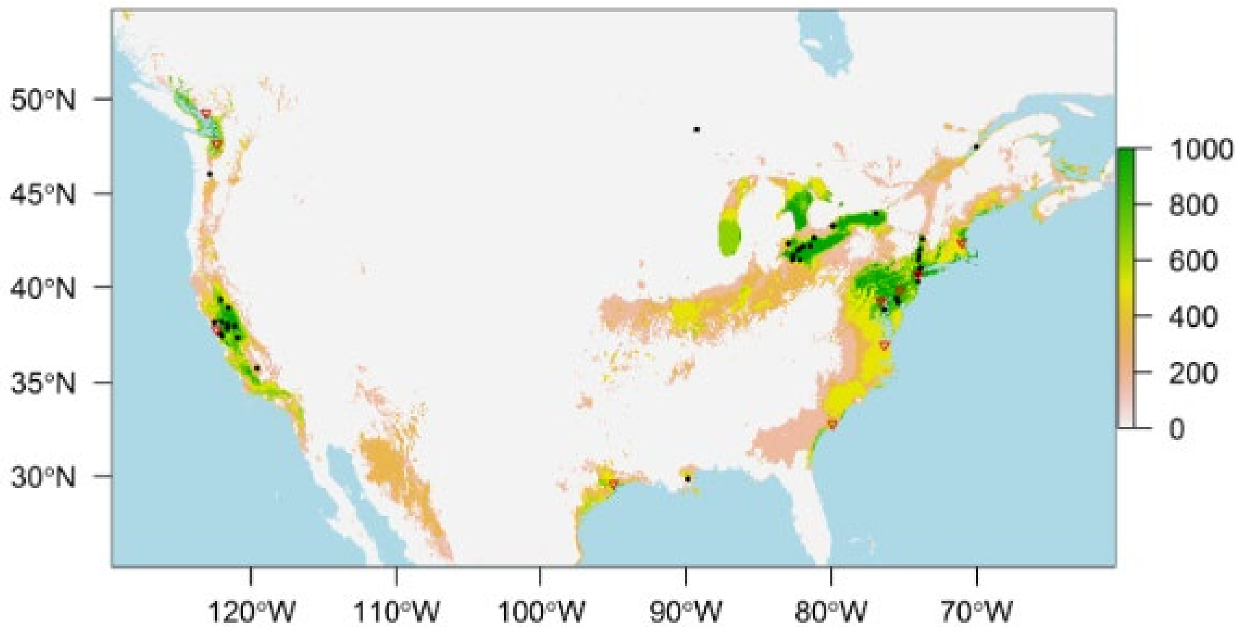


Map of RAMP *(Sanders and others 2014) climate matches for Eriocheir sinensis in the continental United States based on source locations reported by Clark and others (2006), Shakirova and others (2007), Garcia-de-Lomas and others (2010), and GBIF Secretariat (2016). Counts of climate match scores are tabulated on the left. 0 = Lowest match, 10 = Highest match.*

Zhang and others (2019)

"In North America, the potential distribution of this invasive crab [*E. sinensis*] was mainly predicted along the east and west coast of North America including San Francisco Bay, Chesapeake Bay and the Great Lakes [Figure 10]. New regions such as the Salish Sea coastal areas and North Carolina coastal areas were also predicted to be suitable for *E. sinensis* [Figure 10]."

Figure 10. The potential distribution of Chinese mitten crab, Eriocheir sinensis, in North America (Zhang and others 2019).



Habitat suitability map ranges from 0 to 1000 *[0 being completely unsuitable, 1000 being completely suitable] . Black points indicate the occurrence records used by Zhang and others (2019). Red triangles represent ports located in the areas predicted as suitable for this crab. Values on X and Y axes represent degrees of longitude and latitude, respectively.*

Summary

Cohen and Weinstein (2001) examined the potential distribution of *E. sinensis* in selected waters of the Western US and determined that conditions in the Columbia River were conducive to the survival of *E. sinensis*. However, Cohen and Weinstein (2001) concluded that dams along the Columbia River would likely prevent the upstream expansion of *E. sinensis* past the Bonneville Dam. Hanson and Sytsma (2008) performed a similar assessment, but incorporating larval development into their assessment of Pacific Northwest and Alaskan water. While Hanson and Sytsma (2008) conlcuded post-larval *E. sinensis* could survive in the Columbia River, conditions were unsuitable for the development of larvae and the establishment of a self-recruiting population in the Columbia River. Of the water bodies assessed, Puget Sound was the only location with the proper combination of habitat, salinity, flushing time, and temperature for larval development and maintenance of *E. sinensis* populations (Table 4).

Washington is a medium climate match for *E. sinensis* based on the analysis performed by USFWS (2018), with habitats on the open coast a poorer match than habitats the Puget Sound. A global potential habitat model developed by Zhang and others (2019) concluded habitat in the Salish Sea is suitable for *E. sinensis* though it is difficult to determine the exact habitat suitability values based on publicly available results (Figure 10).

Based on the results of these assessments, it seems plausible that *E. sinensis* could become established within certain locations in Washington.

Certainty of assessment

Information regarding *E sinensis'* distribution, ecology, and invasiveness is readily available from a variety of peer-reviewed sources. Overall, the certainty about this assessment is high.

Risk summary

Risk Criteria

Three criteria determine the species potential invasiveness:

1. The species has a history of invasion in other locations. Invasion requires documentation of establishment and spread of populations, as well as negative ecological and economic impacts.
2. The potential for the transport of the species into and within Washington.
3. Conditions in Washington are suitable for the survival and reproduction of the species.

Risk Levels

High risk: Species that are considered high risk meet all three risk criteria.

Moderate risk: Species that are considered high risk meet two of the risk criteria.

Low risk: Species that are considered high risk meet one or less of the risk criteria.

Uncertain risk: Species that are considered uncertain risk are considered uncertain risk are those where there is insufficient information available to confidently address one or more of the risk criteria.

Summary

History of invasion by the species in other locations

Populations of *E. sinensis* have become established in locations outside of their native range, primarily in Europe. California's Sand Francisco Bay Delta contains the populations of *E. sinensis* nearest to Washington, though their numbers are significantly reduced after their boom in the late 1990's (CDFW

2025). Ecological impacts include competition with and predation on invertebrate communities and disruption of local food webs. Economic impacts result primarily from impacts increasing bank erosion and impacts to commercial fisheries (e.g., damage to traps and nets, predation on target species, bait theft). *E. sinensis* could also impact human health (e.g., bioaccumulation of heavy metals, serving as intermediate hosts for as *Paragonimus westermani*).

Potential for the transport of the species into and within Washington

The detection of *E. sinensis* in the Lower Columbia River east of Tongue Point marks the second confirmed specimen of this species collected in the Columbia River (the previous confirmed detection was at the Port of Ilwaco, Washington, in 1997). Whether these specimens were introduced into the Columbia River intentionally (e.g., attempting to create a fishery, aquarium release) or unintentionally (e.g., ballast or biofouling), it is irrefutable that *E. sinensis* could be transported into Washington. If introduced, upstream expansion of *E. sinensis* would allow for expansion throughout a watershed. Human-mediated transport could facilitate the spread of *E. sinensis*, allowing for expansion exceeding their natural limitations.

Conditions in Washington are suitable for the survival and reproduction of the species

Climatic conditions in Washington appear suitable for the survival and potential reproduction of *E. sinensis.* Habitat suitability varies throughout the state. The Columbia River appears suitable for the survival of post-settlement *E. sinensis*, though may not allow for the establishment of a self-recruiting population. Puget Sound has been identified as suitable post-settlement crabs and larval development and could support the establishment of self-recruiting populations. A more refined assessment is needed to determine habitat suitability on a more refined scale.

Conclusion

Based on this risk screen, WDFW concludes there is a high risk of *E. sinensis* establishment, reproduction, and impact should it be introduced to the waters of Washington.

WDFW has determined that *E. sinensis*, poses a high invasive risk and should be a priority for prevention and expedited rapid response management actions.

WDFW is currently classified as Prohibited Level 1 Aquatic Invasive Species meaning it may not be possessed, introduced on or into a water body or property, or trafficked, without department authorization, a permit, or as otherwise provided by rule.

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Appendix

Potential monitoring and survey methods

Willis and others (2008)

“Methods of Sampling:

Methods of sampling mitten crabs need to differ between adults and juveniles to reflect their different diets and habitats. Adults migrate downstream in late summer to spawn. These crabs are sexually mature. Only juveniles migrate upstream. Juveniles are found in creeks, rivers, and tidal freshwater and brackish marshes and sloughs. Juveniles burrow and occupy burrows but also remain in the subtidal zone.

- Panning (1938) found that because juveniles are mostly vegetarian, capturing them with baited traps didn’t work and they had to be excavated from their burrows during low tides. Capturing juveniles in the USA has involved intertidal searches at low tide where all cavities such as burrows and root tunnels were excavated and all debris, driftwood and small puddles were examined. Juveniles were also successfully captured in ‘crab condos’, submerged artificial structures of PVC tube used for shelter.
- A comparison of trapping techniques by Veldhuizen et al 2000[b] suggested that traditional crab sampling techniques are not very effective for this species due to the change in diet between juveniles and adults, the diversity of habitats occupied, and their escape tendencies. For juvenile crabs she recommends using artificial shelter substrates (“crab condos”) made of 12 vertical PVC tubes (6 in long, 2 in diameter) and burrow searches for juveniles in the banks of silty, tidally influenced streams. Crab condos are typically submerged for 48 hours to allow the crabs to enter (Veldhuizen 2000[a]), but significant increases in catch are achieved with longer soak times (3, 5and 9 days).
- Beach seining for adults was possible in shallow intertidal areas and subtidal areas. Baited traps were not recommended for juvenile mitten crab, or for monitoring and detection programs where adult densities may be very low.

Various other baited traps, snares and ring nets have also been trailed, with variable success. Ring nets are most successful when densities of crabs are high. The crabs appear to be most active in the two weeks surrounding the full moon.”

Fyke nets

Schoelynck and others (2021)

“Fyke nets are most commonly used to catch Chinese mitten crabs. Although the technique has proven effective, there are some concerns about the number of bycatch of fish (Clark, 2011; Clark et al., 2017). Modifications of the net (e.g., larger mesh size) can mitigate this, but comes with the drawback that small crabs can escape (Clark et al., 2017). In addition, the placement and emptying of the fyke nets can be tricky, which is labor intensive and time consuming. They have to be emptied on a regular basis to release vulnerable species, to avoid clogging of the net and the escape of Chinese mitten crabs by cutting the net (Garcia-de-Lomas et al., 2010). A great disadvantage of the use of all these other methods is that it is difficult, if not impossible, to cover the entire cross-sectional area of the river from bank to bank. Therefore, crabs can easily pass, which can result in a severe underestimation of the population and a suboptimal removal of individuals."

Use of crab holes

Falkingham and others (2016)

"Objective: Determine whether conducting shoreline surveys for juveniles can identify the presence of mitten crab. It was proposed that manual searches of the river banks would be appropriate to detect and monitor the river Dee *E. sinensis* population (King, 2013). Juvenile mitten crabs have been shown to shelter under rocks above the waterline at low tide and similar intertidal shoreline surveys have been used on the Thames to investigate annual and seasonal variations in abundance (Gilbey, et al., 2008). A series of shoreline searches were conducted during summer and autumn 2014 to test this methodology."

"Juvenile Searches Sites suitable for juvenile surveys must have a high density of refugia, such as rocks on the surface of the sediment, on the intertidal riverbank and be safely accessible on foot. There are currently three sites identified as suitable for riverbank juvenile searches; the bank immediately down river of Chester Weir fish trap (SJ 407 657) […]; the bank down river from Crane Wharf NRW site, adjacent to The Cop park (SJ 328 682); and Sandycroft (SJ 397 663) […]. Juvenile mitten crabs have been recorded using refugia on the surface of sediment (Gilbey et al., 2008). Refugia which are submerged in the substrate, and which have no obvious opening to the underside, were not checked. Also, turning refugia resting in water disturbed the substrate, obscuring any potential juvenile crabs, so was avoided.

Surveys were conducted at low tides when the greatest area of river bank is exposed and refugia are most accessible. The timing of surveys also allowed more time to conduct surveys before survey sites were inundated by the tide. The suitability of refugia uncovered by the receding tide may change over time after high tide. Time after high tide was recorded for each survey to control for any effect it may have had on *E. sinensis* juvenile abundance. To quantify sampling effort total area surveyed was recorded. A GPS was used to plot the perimeter of the surveyed area from which the area (in m^2) was calculated. Alternatively, if a GPS was not available, the area was estimated by multiplying its width (from the lowest to highest point up the bank) by its length along the river. As the density of suitable refugia varied across survey sites, the number of refugia checked was also recorded. To avoid double checking refugia, each was marked once checked by scribing a line across it with chalk or in the silt on its surface […]. Times of survey start and finish were also recorded."

Rudnick and others (2000)

“In order to examine mitten crab distribution, we monitored fifteen sites in tributaries of the South Bay in 1995, and the same 15 and 57 additional sites in 1996 and again in 1999 […]. Sites were chosen to represent a wide range of salinities, habitat types and geographical locations throughout the South Bay watershed. At each site examined, the presence or absence of mitten crabs was established by burrow excavation, setting crab traps and visually inspecting the area for mitten crabs. Burrows were excavated by hand using trowels. The crab traps were made from rubber-coated wire mesh, were rectangular in shape and measured 60cm long x 15cm wide x 15cm high. Traps were baited with cat food and checked twenty-four hours after they were set. Visual inspection entailed daytime searches for mitten crabs in channel margins. We spent approximately one hour at each site before concluding that mitten crabs were likely absent from a site.”

Crab traps

Rudnick and others (2000)

“The crab traps were made from rubber-coated wire mesh, were rectangular in shape and measured 60cm long x 15cm wide x 15cm high. Traps were baited with cat food and checked twenty-four hours after they were set. Visual inspection entailed daytime searches for mitten crabs in channel margins. We spent approximately one hour at each site before concluding that mitten crabs were likely absent from a site.”

Otter trawls

Hieb (2025)

“Otter trawl sampling in brackish and marine salinities in fall and winter was most effective for [collecting] adult mitten crabs, which were migrating downstream. We have 2 long-term monitoring surveys that sample monthly with an otter trawl year round, plus more sporadic otter trawls conducted by an educational non-profit.’

Crab condos

Hewitt and McDonald (2013)

“Artificial habitat collectors are a non-baited alternative to baited traps, often specifically built to attract particular organisms. These devices are engineered to attract organisms by providing shelter with an animal’s natural habitat. Artificial habitat creates filled with dead oyster shells have been successfully used at capturing *R. harrisii* (Fowler et al. 2013) for monitoring invasive populations in Panama and Europe. Another successful non-baited sampling device used to target the Chinese mitten crab, *Eriocheir sinensis* (H. Milne Edwards, 1853), was the ‘crab condo’ (Veldhuizen 2000[a]). The condos were designed to imitate the burrows and crevices that mitten crabs typically inhabit. Veldhuizen (2000[a]) compared condos and crab traps while monitoring for mitten crabs and found that baited traps only captured 8 mitten crabs from 1,011 traps (<1% success rate) in contrast to condos, which captured 206 mitten crabs from 278 traps (74% success rate). However, condos have so far only been used for targeting mitten crabs (Morrisey et al. 2009; Veldhuizen 2000[a]).”

Figures and Tables

Dittel and Epifanio (2009)

Table 5. Duration and habitat of the life history stages of the mitten crab, Eriocheir sinensis.

Stage	Duration	Habitat
Adult (non-reproductive stage)	2-4 years	Lakes, levees, rivers, streams
Adult (reproductive stage)	4-10 months	Brackish open waters
Zoea Larva (five stages)	2-8 weeks	Estuarine/marine
Megalopa larva (one stage)	3-6 weeks	Estuarine/marine
Early Juvenile	6-12 months	Brackish open waters
Late Juvenile	12-24 months	Lakes, levees, rivers, streams

Reproductive stage includes mating and brooding. Modified from Dittel and Epifanio 2009.

Table 6. Habitat values for systems with established mitten crab populations in Asia, Europe, and the United States.

Location	Watershed area (1,000 km^2)	Estuary area (km^2)	Tidal intrusion (km)	Maximum salinity intrusion (km)	Mean flushing time (days)
Rhine	224	x	x	x	x
Schedlt	22	300	150	100	68
Gironde	85	625	160	75	53
Elbe	146	865	120	107	23
Ems	13	500	100	75	43
Thames	15	215	100	70	45
Humber	24	200	120	90	60
Weser	44	500	120	67	45
Tagus	82	325	z	z	25
Bay-Delta	120	1,170	135	100	40

Location	Watershed area (1,000 km²)	Estuary area (km²)	Tidal intrusion (km)	Maximum salinity intrusion (km)	Mean flushing time (days)
Yangtze	1,808	1,328	220	85	z
Hai he	264	z	z	z	z
Ouijang	18	z	326	z	z
Liao	57	z	z	z	z
Yalu	62	z	z	z	z

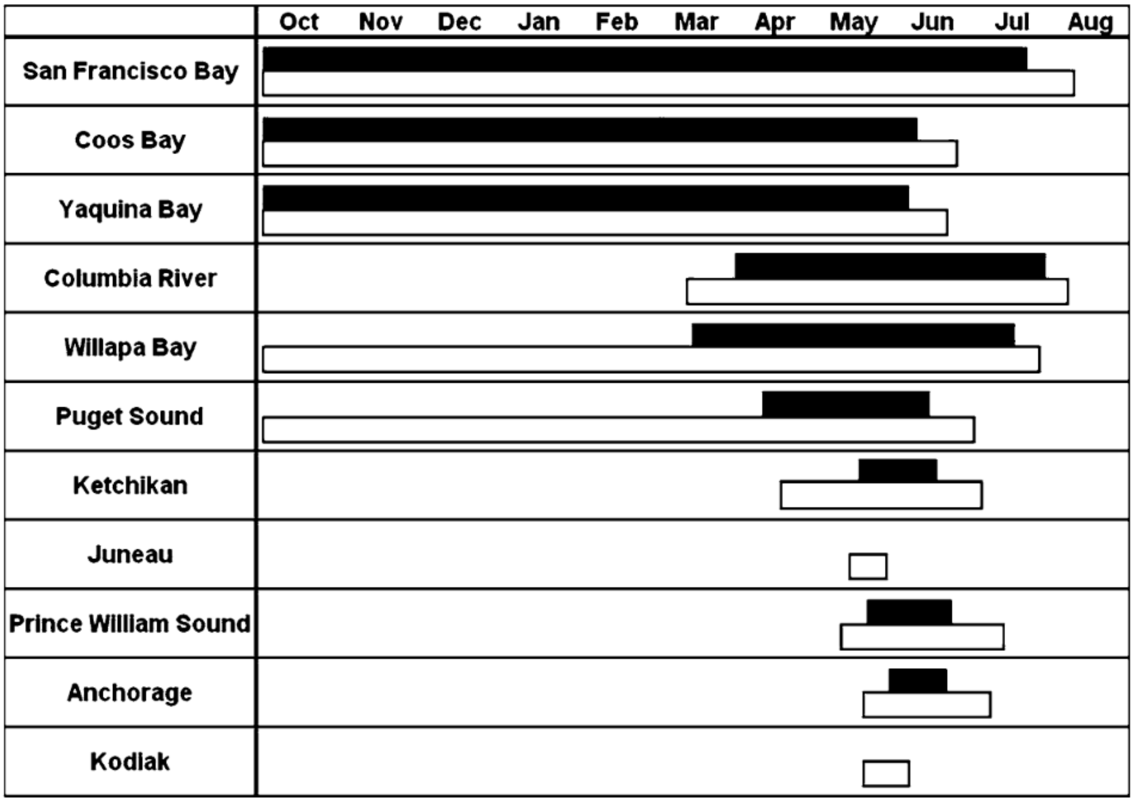
Modified from *Hanson and Sytsma (2008). x = Data not applicable, z = No data available.*

Table 7. Larval development times and periods for Pacific Northwest and Alaskan estuaries based on mean daily water temperature and mean daily water temperature with a 2°C increase.

	Development and temperature	San Francisco Bay	Coos Bay	Yaquina Bay	Columbia River	Willapa Bay	Puget Sound	Ketchikan	Juneau	Prince William Sound	Anchorage	Kodiak
Average Temperature	Average larval development (days)	68	99	102	55	66	98	82	na	75	77	na
	Potential start of larval development (month/day)	10/1	10/1	10/1	4/1	3/12	4/12	5/20	na	5/23	5/31	na
	Last start date for larval development (month/day)	7/20	6/6	6/4	7/29	7/15	6/13	6/15	na	6/24	6/18	na
	Total length of larval period (days)	293	249	248	120	126	63	27	16	33	19	na
Average Temperature +2°C	Average larval development (days)	47	77	78	48	77	87	70	99	59	63	90
	Potential start of larval development (month/day)	10/1	10/1	10/1	3/11	10/1	10/1	4/20	5/13	5/12	5/20	5/21
	Last start date for larval development (month/day)	8/6	6/25	6/22	8/5	7/26	6/30	7/4	5/26	7/10	7/6	6/4
	Total length of larval period (days)	310	268	265	148	299	273	76	14	60	48	15

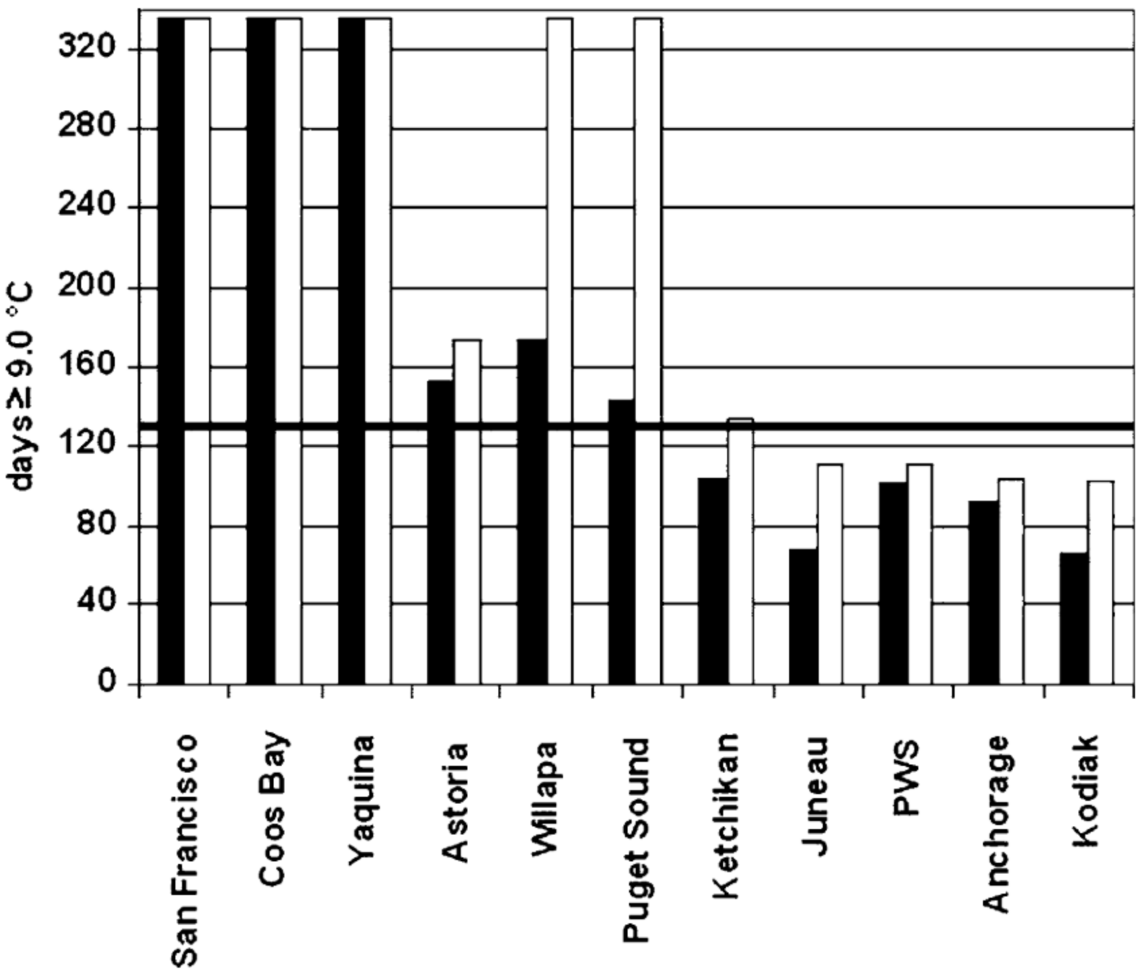
Modified from *Hanson and Sytsma (2008).*

Figure 11**. Bar graph indicating potential larval period in each estuary.**



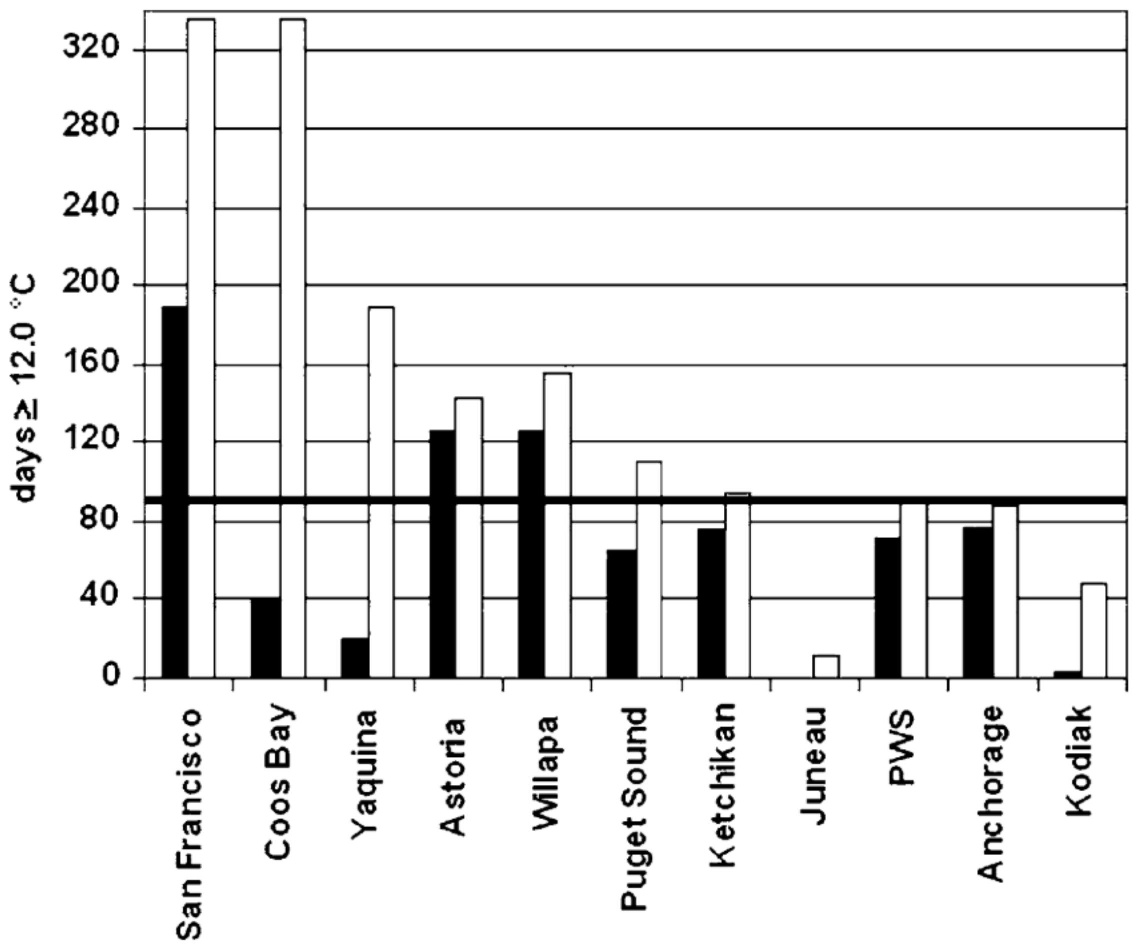
The Black bar indicates mean daily water temperature, and the white bar indicates mean daily temperature with a 2°C increase. From Hanson and Sytsma (2008).

Figure 12. Mean number of contiguous days greater than or equal to 9°C for Pacific Northwest and Alaskan estuaries.



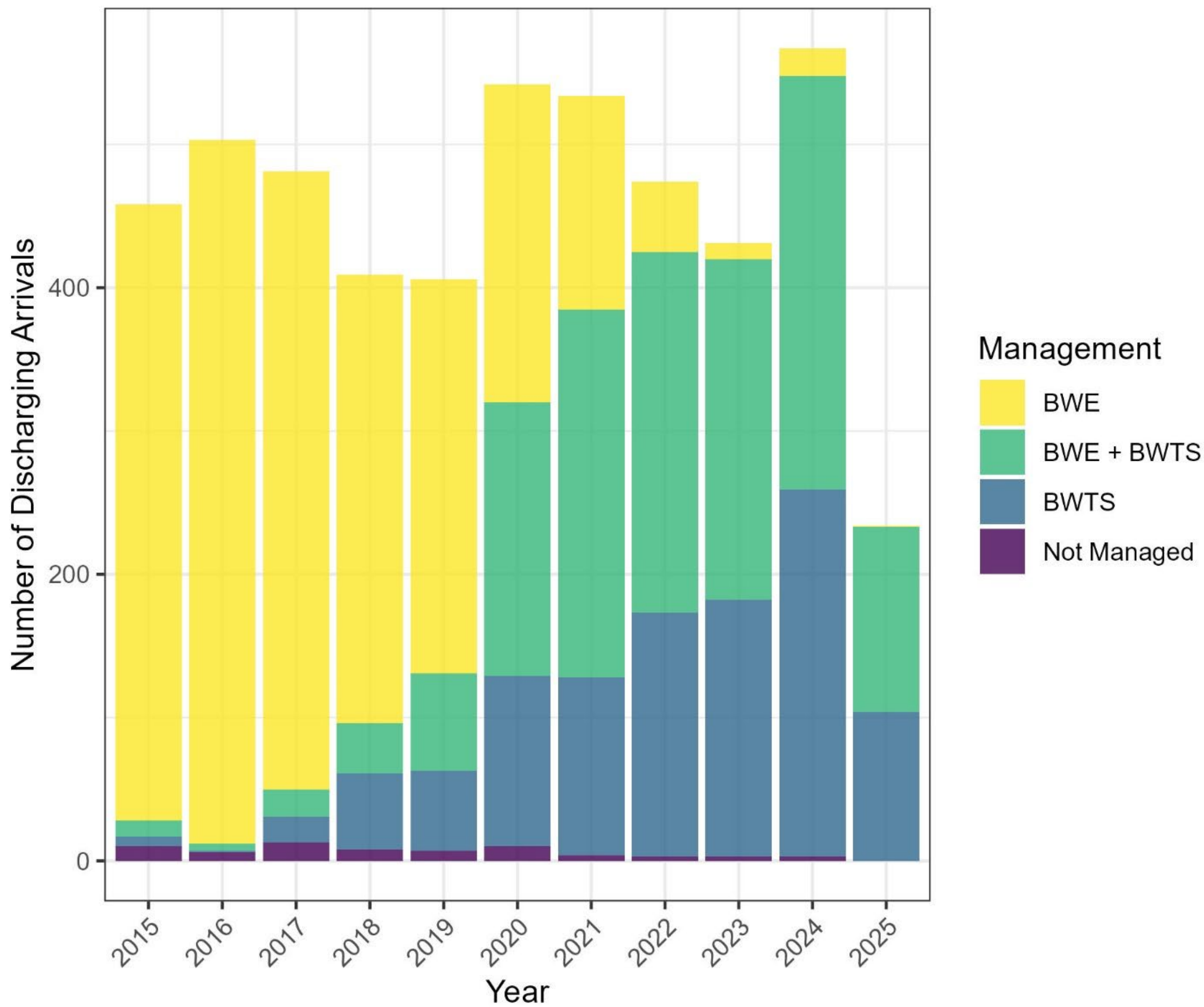
The number of days to complete larval development at 9°C (131 days) is indicated by the black bar. From *Hanson and Sytsma (2008).*

Figure 13. Mean number of contiguous days greater than or equal to 12°C for Pacific Northwest and Alaskan estuaries.



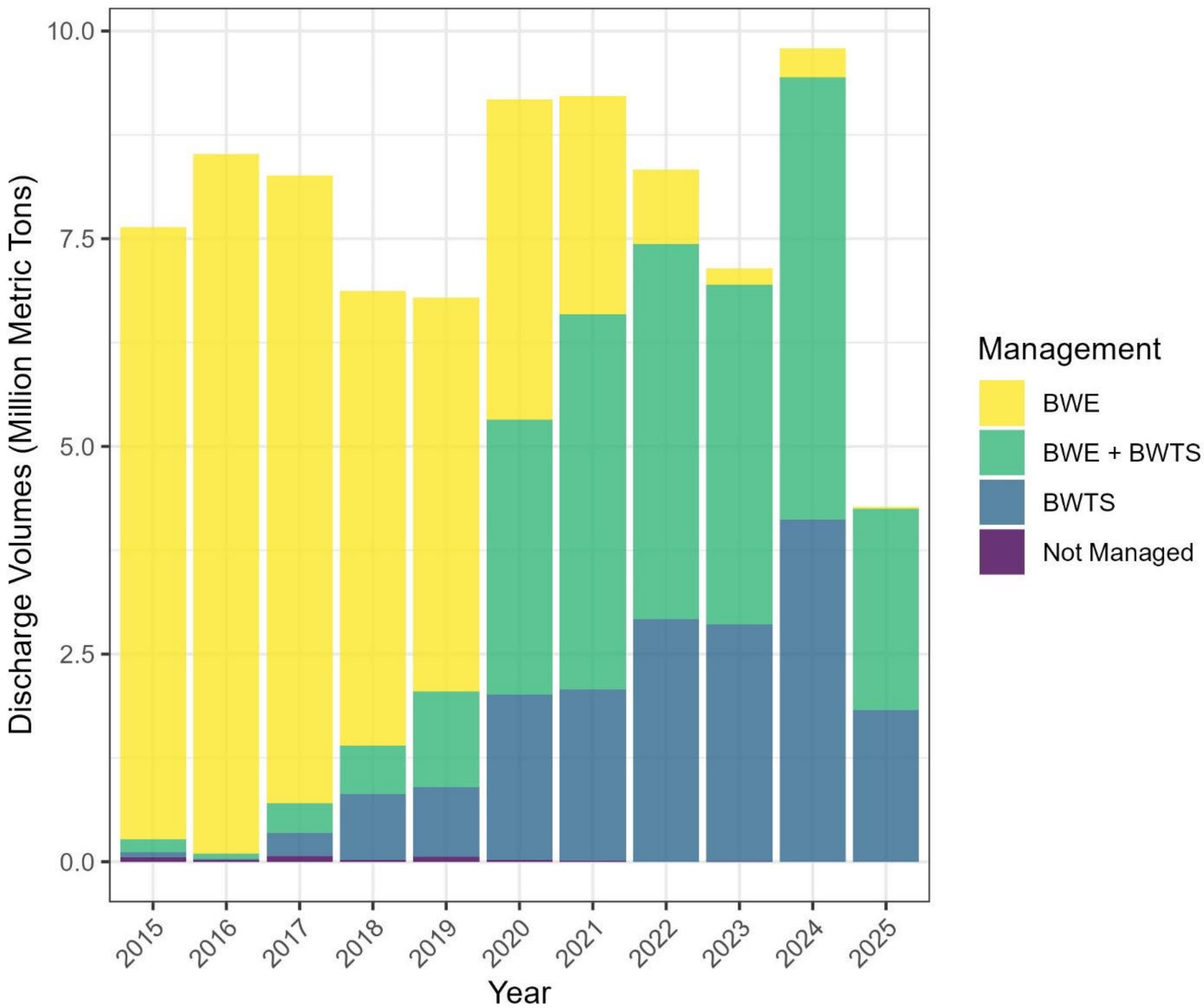
The Number of days to complete larval development at 12°C (90 days) is indicated by the black bar. From Hanson and Sytsma (2008).

Figure 14. Number of discharging arrivals from ports with established *Eriocheir sinensis* populations or recent detections to Washington ports and their management approach.



Yellow represents ballast water exhange only (BWE), green represents ballast water exchange and ballast water treatment combined (BWE + BWTS), blue represents ballast water treatment only (BWTS), and purple represents a lack of management.

Figure 15. Volume of water discharged from ports with established *Eriocheir sinensis* populations or recent detections to Washington ports and their management approach.



Yellow represents ballast water exhange only (BWE), green represents ballast water exchange and ballast water treatment combined (BWE + BWTS), blue represents ballast water treatment only (BWTS), and purple represents a lack of management.