U.S. Fish & Wildlife Service

Dark Falsemussel (*Mytilopsis leucophaeata*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, June 2023
Revised, July 2023
Web Version, 12/30/2024

Organism Type: Mollusk
Overall Risk Assessment Category: Uncertain

Photo: Robert Aguilar, Smithsonian Environmental Research Center. Licensed under Creative Common Attribution 2.0 Generic license. Available: https://commons.wikimedia.org/wiki/File:Mytilopsis_leucophaeata_%28I0840%29_%2814655960885%29.jpg (June 2023).

1 Native Range and Status in the United States

Native Range

From Rodrigues et al. (2022):

"The native range of *M. leucophaeata* has been reported as brackish systems in the Chesapeake Bay (USA) and Gulf of Mexico (latitudinal variation from 39°N to 18°N), […]"

From Fofonoff et al. (2018):

"[…] native to the east coast of North America from the Chesapeake Bay to Veracruz, Mexico."

Status in the United States

From Richardson and Hammond (2016):

"The natural endemic range of *Mytilopsis leucophaeata* is the Gulf of Mexico and temperate Atlantic coast of North America from Tampico, Mexico, northward to the Chesapeake Bay (Smith and Boss 1996; van der Velde et al. 2010)."

From NatureServe (2017):

"This species is native from Chesapeake Bay southward through the Gulf of Mexico but was introduced into the Hudson River, New York, as early as 1937 and later to the lower Charles River, Massachusetts, according to Rehder (1937), Jacobson (1953) and Carlton (1992). Benson et al. (2001) cite invasions in Alabama, Florida, Kentucky, and Tennessee."

"Introduced sites in New England include the Housatonic River in Shelton, Fairfield Co., Connecticut; the Charles River in Boston, Suffolk Co., Massachusetts; and the lower Hudson River basin, New York (Smith and Boss, 199[5]). In Alabama, it is locally abundant in upper Mobile Bay and parts of the Mobile Delta and is occasionally found far inland in the Tennessee River and Mobile Basin, presumably dispersed by barges although there is evidence that it reproduces in fresh water in Alabama (Williams et al., 2008)."

From Fofonoff et al. (2018):

"In 1937, two specimens were collected in the tidal Hudson River, near Haverstraw, New York (NY) (Rehder 1937). In 1952, an established population of *M. leucophaeata* was found near Haverstraw, and as far downriver as Englewood, New Jersey (Jacobson 1953). In 1992, *M. leucophaeata* was found from Tarrytown, NY (49 River Km, 5-9 PSU) to Newburgh, NY (99 River Km, 0-3 PSU) (Walton 1996). It was also found to be common in the tidal Housatonic River, upstream from Long Island Sound, at Shelton, Connecticut at 0.5-2 PSU (Smith and Boss 1995). In 1995, *M. leucophaeata* was found in the impounded section of the Charles River in Cambridge, Massachusetts, which receives brackish water through locks, at salinities of ~1 PSU (Smith and Boss 1995). This population appears to be established, with museum specimens collected in 2008 (Museum of Comparative Zoology 2012)."

"Two specimens were found in the upper Mississippi River in Illinois in the 1980s (Koch 1989, cited by Kennedy 2011a), but we know of no further records from this river system."

No records of *Mytilopsis leucophaeata* in trade in the United States were found.

Regulations
Mytilopsis leucophaeata is regulated in Alaska (ADFG 2022), Arizona (AGFC 2022), and Utah (Utah DWR 2020). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Kennedy (2011a):

"Human activity undoubtedly is responsible for range extensions in North America. Nuttall (1990) wrote that the apparent lack of fossil records from the U.S. Atlantic coast suggests that the northern part of the species' range results from introductions by humans. Koch (1989) proposed that the specimens in Illinois were transported by a barge arriving from the higher-salinity Gulf of Mexico, and Smith and Boss (1996) attributed the northward spread of the species into Connecticut and Massachusetts to introductions by boat traffic. However, although Pathy and Mackie (1993) and Therriault et al. (2004) claimed that the presence of dark falsemussels in the Hudson River was due to transport in ship ballast water, Rehder (1937) and Jacobson (1953) had not speculated on the transport mechanism in their reports of this range extension. It is perhaps more likely that the dark falsemussel arrived in the Hudson River with eastern oysters *Crassostrea virginica* to which it attaches and which, until disease became a concern, have been moved from place to place around the world, including along the U.S. Atlantic coast (Carlton and Mann 1996)."

Remarks

A previous version of this ERSS was published in 2019. Revisions were done to incorporate new information and conform to updated standards.

From Rodrigues et al. (2022):

"There are some divergences in the theories with respect to the *M. leucophaeata* native distribution range of *M. leucophaeata* [sic] (Kennedy 2011a); some authors (e.g., Pathy and Mackie 1993; Richardson and Hammond 2016) consider the Hudson River (41°12′49″N; 73°57′50″W) as an invaded area, while Marelli and Gray (1983) indicated based on literature records the Hudson River estuary as a native area."

From Richardson and Hammond (2016):

"[*Mytilopsis leucophaeata*] does not seem to pose a serious threat as a fouling species in its home range. In fact, according to Kennedy (2011a, 2011b), *M. leucophaeata* is generally uncommon in its home range, although it is sometimes encountered in large clumps. Only one short-term irruption has been reported from its home habitat, occurring in some tributaries of the upper Chesapeake Bay in 2004 [Kennedy 2011b]."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From MolluscaBase (2023):

Biota > Animalia (Kingdom) > Mollusca (Phylum) > Bivalvia (Class) > Autobranchia (Subclass) > Heteroconchia (Infraclass) > Euheterodonta (Subterclass) > Imparidentia (Superorder) > Myida (Order) > Dreissenoidea (Superfamily) > Dreissenidae (Family) > Dreisseninae (Subfamily) > *Mytilopsis* (Genus) > *Mytilopsis leucophaeata* (Species)

According to MolluscaBase (2023), *Mytilopsis leucophaeata* is the current accepted name for this species.

Size, Weight, and Age Range

From GISD (2023):

"[…] typically reaches 22 to 25 mm in length ([Kennedy, 2011a]; Laine et al, 2006)."

"[…] no individual [in Amsterdam Harbor] seemed to be older than a year and a few months (Vorstman, 1933)."

"[…] first year and even maximum sizes of 10-15 mm have also been reported [Kennedy, 2011a]."

Environment

From Rodrigues et al. (2022):

"In the native area, *M. leucophaeata* was found mainly on soft sediment samples (42%), over benthic fauna (31%), and rocks (17%); while in the invaded systems, the most colonized substrates were human constructions (28%), rocks (24%), and plastic materials (13%)."

From Neves et al. (2020):

"[…] the dark false mussel *Mytilopsis leucophaeata* thrives especially in brackish systems, such as coastal lagoons and estuaries, being apparently less tolerant to persist in true freshwater or marine systems ([Kennedy, 2011a]; van der Gaag et al., 2016)."

From GISD (2023):

"*Mytilopsis leucophaeata* generally inhabits oligohaline to mesohaline estuarine environments [Kennedy, 2011a]. It is strongly euryhaline and has been recorded from salinities of 0-25 PSU with an optimal range of 0.75-20.9 PSU (Verween et al, 2010). It is also fairly temperature tolerant and may tolerate [water] temperatures from 6.8°C to 37°C, but its optimum range, in which reproduction occurs, is between 15°C to 27°C (Verween et al, 2010; [Rajagopal et al, 2005a]; NOBANIS, 2011). It attaches to artificial and natural substrates including stones, woody debris, oysters, conduits, bottles, stone walls, wooden posts and other structures (Verween et al, 2010; [Kennedy, 2011a]).”

From Palomares and Pauly (2023):

“Benthic; brackish; depth range 0-55m [Rosenberg 2009].”

From NOBANIS (2023):

“[*Mytilopsis leucophaeata*] has been recorded from salinities ranging from <1ppt to almost full strength seawater, and is capable of surviving in full strength seawater in the laboratory, though most often it is found at salinities below 10ppt. Heat has been tried as a controlling measure because a temperature of 37° C will cause 100% mortality in 2 [hours] (Rajagopal et al., 2005[a]). Metabolic processes are affected at temperatures above 27° C.”

From Verween et al. (2007):

“At its place of origin, *M. leucophaeata* is restricted to warm, more temperate waters (Marelli and Gray, 1983) but in Europe, it endures much lower temperatures: the species has been found in fluctuating water temperatures ranging from of 5 °C in Finland (Laine et al., 2006) up to 30 °C in Miami (Siddall, 1980).”

Climate

From Rodrigues et al. (2022):

“[…] distribution of *M. leucophaeata* ranges from almost the polar seas of Finland (Forsström et al. 2016) to the tropical climate of Brazil (Rizzo et al. 2014) (Δ Lat=83°).”

Palomares and Pauly (2023) report a temperate climate zone for *M. leucophaeata*.

From Eeuwes et al. (2018):

“*M. leucophaeata* mainly occurs in oligohaline–mesohaline regions of estuaries in tropical, subtropical and temperate climates in its native range ([Kennedy 2011a]; Zhulidov et al. 2015).”

Distribution Outside the United States

Native

From Fernandes et al. (2022):

“[…] native from the Gulf of Mexico […]”

Palomares and Pauly (2023) lists *M. leucophaeata* native to Mexico (Hill et al. 2005), Cuba (Rosenberg 2009), and Belize (Thomas and Klebba 2007).

Introduced

From Fofonoff et al. (2018):

"[…] *Mytilopsis leucophaeata* was first collected in Antwerp, Belgium in 1835 (Nyst 1835, cited by Kennedy 2011a) […] Early invasions in northern Europe included the Amstel River, Amsterdam, Netherlands in 1895 (Wolff 2005); the Canal de Caen, Normandy in 1910 (Germain 1931, cited by Oliver et al. 1998), the Weser River and the Kiel Canal, Germany both in 1928 (Nehring 2002), and the Zuider Zee and Rhine Delta (Van Jutting 1936, 1943, cited by Wolff 2005). […] In 1962, it was found in the isolated Russian Baltic port of Kaliningrad (surrounded by Poland), but it is likely extinct there now (Brohmer 1962, cited by Laine et al. 200[6]). However, in the Baltic Sea, it is established in the Warnow River, Rostock, Germany (Darr and Zettler 2000, cited by Laine et al. 200[6]), the Gulf of Gdansk (in 2010, Dziubinska 2011), the Gulf of Finland (in 2003, Laine et al. 200[6]), and the Gulf of Bothnia, Sweden (in 2011, Werner in ICES Advisory Committee on the Marine Environment 2012). […] In the British Isles, *M. leucophaeata* was first found on an enclosed dock in Cardiff, Wales in 1996 (Oliver et al. 1998), and later found in the Thames estuary in 1999 (Bamber and Taylor 2002, cited by Heiler et al. 2010)."

"In 2002, [*M. leucophaeata*] was identified by molecular means in the Dniester lagoon on the Black Sea in Ukraine (Therriault et al. 2004). In 2009, it was found to be abundant in the southern Caspian Sea, near Bandar Anzali, Iran (Heiler et al. 2010)."

From Rodrigues et al. (2022):

"[*Mytilopsis leucophaeata*] invaded range extends from South America (Brazil), Eurasia (from Spain to Iran), and north of Africa, following a latitudinal variation from 60°N to 23°S […]"

From Neves et al. (2020):

"In Southeast Brazil, the dark false mussel *M. leucophaeata* was first recorded at the urban coastal Rodrigo de Freitas Lagoon in 2014 (Rizzo et al., 2014; Fernandes et al., 2018). [*Mytilopsis leucophaeata*] is now one of the most abundant macrofauna species occurring in hard substrata throughout the whole lagoon perimeter […]"

From Fernandes et al. (2022):

"The invasion of *M. leucophaeata* is widely documented in many regions around the globe, such as […] Caribbean (e.g., Mohammed et al. 2018; Lodeiros et al. 2019; Minchin and Cottier-Cook 2020), Brazil (e.g., Rizzo et al. 2014; Fernandes et al. 2020), Europe (e.g., Verween et al. 2010; Heiler et al. 2010; Zhulidov et al. 2015; Forsström et al. 2016), and the Ponto-Caspian region (e.g., Heiler et al. 2010; Mumladze et al. 2019; Zhulidov et al. 2021)"

From Eeuwes et al. (2018):

"[…] recorded in Belgium, The Netherlands, England, Wales, Germany, France, Spain, Poland, Lithuania, Russia, Sweden, Finland, Ukraine and Iran, mainly in estuaries (Heiler, Nahavandi, and Albrecht 2010; Zhulidov et al. 2015). In Europe, in the Baltic Sea, Gulf of Bothnia and in the Gulf of Finland […]"

Means of Introduction Outside the United States

From Neves et al. (2020):

"[…] unintentionally introduced by ballast water or attached to vessels hulls […]"

From Kennedy (2011a):

"[…] eastern oysters were commonly transported to Europe from Chesapeake Bay over time (Ingersoll 1887; Wolff and Reise 2002), allowing them to serve as a possible vector for introducing the dark falsemussel to the Continent. Now that the species is established in Europe, vectors other than ship traffic, such as transfers of associated organisms as well as transport of larvae by water circulation patterns, may contribute to future movements among sites."

Short Description

From GISD (2023):

"[*M. leucophaeata*] has a thick, rugrose [sic] periostractum [sic] covering its shell that is dark brown in adults and cream-colored in young specimens with fine to medium rough concentric lines. It commonly has "zebra stripes" and zig-zag patterns in juveniles (Verween *et al*, 2010; NOBANIS, 2011; Laine et al, 2006). Its shell shape is mytiliform and incurved with the anterior side depressed, hinge margin excavated, and teeth obsolete (Verween *et al*, 2010). The interior of the shell of *M. leucophaeata* is gray and has a shelf, or myophore, plate at the anterior with an apophysis, a small triangular tooth that serves as an attachment point for anterior retractor muscles, which is absent [in] many similar-looking mussels including the Zebra mussel *Dreissena polymorpha* (Verween *et al*, 2010; Zebra Mussel Information System, 2002)."

Biology

From Fofonoff et al. (2018):

"*Mytilopsis leucophaeata* is a small mussel which has separate sexes that release eggs and sperm into the water column, resulting in planktonic larvae. The first stage of larval development is a trochophore, followed by a shelled veliger. Spawning in Belgium began at 16-19ºC, and was prolonged, with individuals spawning several times from spring to fall, peaking in summer (Verween et al. 2010). The trochophore stage was reached within 8-24 h, and by 21- 48 h larvae had a D-shaped shell (Verween et al. 2010; Kennedy 2011b). Laboratory-reared larvae at 21-26°C began to settle at about 6 to 15 days from fertilization, and 194-210 µm in length (Siddall et al. 198[0]; Kennedy 2011b). […] Field and laboratory observations suggest that spawning and settlement can be stimulated by sudden decreases in salinity, such as occurs following heavy rains (Kennedy 2011a; Kennedy 2011b)."

“Postlarvae of *M. leucophaeata* often settle on a filamentous surface, such as vegetation, after which larvae move to hard surfaces such as logs, stones, shells, and artificial structures (Verveen et al. 2010; Kennedy 2011b).”

“They are vulnerable to predation by crabs and fishes, which may account for their frequent scarcity and the 'boom and bust' nature of their occurrences in Chesapeake Bay (Kennedy 2011b).”

From GISD (2023):

“The larvae of *Mytilopsis leucophaeata* are planktonic and have been found to metamorphose in about 6 days to 2 weeks depending on temperature (Sidall, 1980). It has been found to have an average growth rate of about 3-6 mm/year ([Verween, 2006b]).”

“*Mytilopsis leucophaeata* is a dioecious species that reproduces sexually by external fertilization (Zebra Mussel Information System, 2002). Reproduction may occur continuously in some locations or from the late spring to early fall in others ([Verween et al, 2009; Kennedy, 2011a]; NOBANIS, 2011). The minimum reported temperature required for spawning is about 13-15°C (NOBANIS, 2011; Verween et al, 2010).”

“*Mytilopsis leucophaeata* is a filter feeder that consumes phytoplankton, plant detritus, diatoms, and other organic matter (Verween et al, 2010; [Kennedy, 2011a]).”

From Verween et al. (2007):

“The optimal conditions, in which almost all embryos developed to D-shaped larvae […], were reached at 22°C and salinity 15 [parts per thousand (ppt)]. Surrounding this optimum, mortality was low (maximum 58%) in a rather wide range of temperature and salinity: 15 to 24°C and salinity 15 to 22 [ppt]. The limits of survival were found only at extreme temperatures of 10 and 30°C and salinities 0 and 25, indicating a broad tolerance of embryos to variation in temperature and salinity.”

Human Uses

No information was found on human uses of *Mytilopsis leucophaeata*.

Diseases

***Mytilopsis leucophaeata* has been documented as a carrier of *Enterocytozoon hepatopenaei* (EHP), shrimp microsporidian, a disease listed by the World Organisation of Animal Health (2023).**

From Munkongwongsiri et al. (2022):

“The results in this study revealed that *M. leucophaeata* can accumulate EHP [*Enterocytozoon hepatopenaei*] spores that are released from EHP-infected shrimp but that they do not become infected and so cannot amplify EHP. In that case, the mussels can be mechanical carrier [sic] for EHP and can transmit EHP to shrimp in the pond.”

From Kennedy (2011a):

"Little is known about parasites and symbionts of dark falsemussels, and only for North American forms. Wardle (1980a) discovered the symbiotic rhabdocoele *Paravortex gemellipara* in the digestive tract of one dark falsemussel (15 mm long) of four examined in a sample from the north shore of Galveston Island, Texas. […] In a second study, Wardle (1980b) found metacercariae of the fluke *Proctoeces maculatus* in 2 of 10 dark falsemussels and in 5 of 17 hooked mussels collected from Galveston Bay."

Threat to Humans

From GISD (2023):

"*Mytilopsis leucophaeata* is a biofouling species which commonly disturbs coolant water systems of industrial and power plants."

3 Impacts of Introductions

From Neves et al. (2020):

"Fishermen from Lagoon artisanal colony [Rodrigo de Freitas Lagoon, Southeast Brazil] have related *M. leucophaeata* invasion to an increase in water transparency of the lagoon, but with negative effects on fisheries."

"Reductions in phytoplankton abundance and chlorophyll *a* in combination with increased water transparency were significantly detected following *M. leucophaeata* invasion at Rodrigo de Freitas Lagoon."

From van der Gaag (2021):

"The biofiltration capacity of *M. leucophaeata* is regarded as a positive aquatic ecosystem service by cleaning the water as demonstrated at Rodrigo de Freitas Lagoon in Brasil (Neves et al. 2020)."

"In the cooling water systems of power plants and industrial facilities, *M. leucophaeata* causes severe problems by blocking pipes and condensers. Fouling on hulls of boats give a high flow resistance in the water. Removal of the fouling is expensive."

From GISD (2023):

"*Mytilopsis leucophaeata* is a biofouling species which commonly disturbs coolant water systems of industrial and power plants. Its rapid reproduction in such an ideal environment may result in extremely dense populations that clog water intakes and may damage or cause failure to systems [Rajagopal et al, 2002; Kennedy, 2011a; Verween et al, 2006b]. Specific examples of its biofouling have been reported from Belgium, Finland, and the Netherlands […]."

"*M. leucophaeata* also fouls boats, ropes, cages, and other marine equipment (Bergstrom, 2004). Aside from biofouling, dense populations *M. leucophaeata* alter ecosystems and likely have significant ecological effects similar to that of the more widely researched dreissenid Zebra mussel, (*Dreissena polymorpha*), which demand further investigation."

From Fofonoff et al. (2018):

"[…] significant ecological impacts have not been observed in invaded waters, either in the Northeast US (Hudson, Housatonic, and Charles Rivers), or in invaded European waters."

From Verween et al. (2006a):

"Pathy and Mackie (1993) posed that the ecological and economical threats of *M. leucophaeata* are less severe than those of the zebra mussel. However, the fact that they inhabit brackish waters makes them far more resistant to environmental changes (Siddall, 1980), which makes them potentially an even more robust fouler than *D. polymorpha*. Therefore, *M. leucophaeata* is more resistant to anti-fouling techniques than the freshwater *D. polymorpha*, as proven by Rajagopal et al. ([1997], [2003], [2005b]). A comparison of chlorine toxicity data with *M. leucophaeata*, *D. polymorpha* and *Mytilus edulis* shows that *M. leucophaeata* is the most tolerant species (Rajagopal et al., 2002)."

"*M. leucophaeata* adults are smaller than those of *D. polymorpha* adults, which makes the fouling problems less severe in density. On the other hand, *M. leucophaeata* is a long-lived species in comparison to *D. polymorpha*, which means that the adult population will remain a problem in the conduits for a longer time, which can introduce more severe problems in time. Knowledge on the cyclic presence of mussel larvae provides a basis for an ecologically and economically proper use of biocides (Relini, 1984). The strict timing of *M. leucophaeata* larvae in the harbour of Antwerp is an indication that to prevent new biofouling, a pointed dosage of biocides during the period of larval presence will be as effective as a continuous dosage throughout the year. This saving can lead to the exploration on the use of ecologically less harmful, but more expensive biocides. The long lifespan on the other hand states that even though larvae may be effectively combated, the adult population in the conduits will remain a noncombatable source of larvae for a long time. In summary, *M. leucophaeata* is a slower invader in Europe (Van der Velde et al., 2010) than *D. polymorpha* in the U.S. However once invaded, it is an even more severe fouling species than *D. polymorpha*, and as such it has to be taken in account that *M. leucophaeata* has most definitely the potential of becoming the brackish water equivalent of *D. polymorpha* in Europe."

Mytilopsis leucophaeata is regulated in the following U.S. States: Alaska, Arizona, and Utah. See section 1 for more information.

4 History of Invasiveness

The History of Invasiveness for *Mytilopsis leucophaeata* is classified as High. There are numerous records of introductions in New York, New Jersey, Illinois, Alabama, Florida, Kentucky, Tennessee, Connecticut, and Massachusetts. These introductions have led to established populations in New York, Connecticut, and Massachusetts. In addition to its nonnative range in the United States, *M. leucophaeata* has also been established in Europe, South America, and the Caribbean. Documentation of these introductions provide evidence of resulting negative impacts. *M. leucophaeata* introductions correlate with reduced phytoplankton abundance. However, the main impacts are due to the biofouling capability of the species on boats, marine equipment, and coolant water systems of industrial and power plants. Currently, this mollusk has not been found in live trade and trade or possession is regulated by a small number of U.S. States.

5 Global Distribution

Figure 1. Reported global distribution of *Mytilopsis leucophaeata*. Map from GBIF Secretariat (2023). Observations are reported from the east coast of the United States from Massachusetts to Florida, around the Gulf of Mexico, along the costs of Cuba and Central America, and on the coast of Brazil. Observations are also reported from central and northern Europe. Observations in central Iran, Panama, inland and Pacific Coast of Mexico, Kansas, Tennessee, Spain, central Germany were not used in the climate match analysis because the points did not represent established populations or had coordinates that did not match the collection location. Because the climate matching analysis (section 7) is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

Additional observations are provided in Heiler et al. (2010; Ukraine and Iran), Dziubinska (2011; Poland), and Zuhlidov et al. (2015; Azov Sea, Russia).

No georeferenced observation data were available for a known population in the Guadalquivir River, Spain (Heiler et al. 2010). Rodrigues et al. (2022) mentioned part of the introduced range included northern Africa; no georeferenced observations or further details were found for this report.

6 Distribution Within the United States

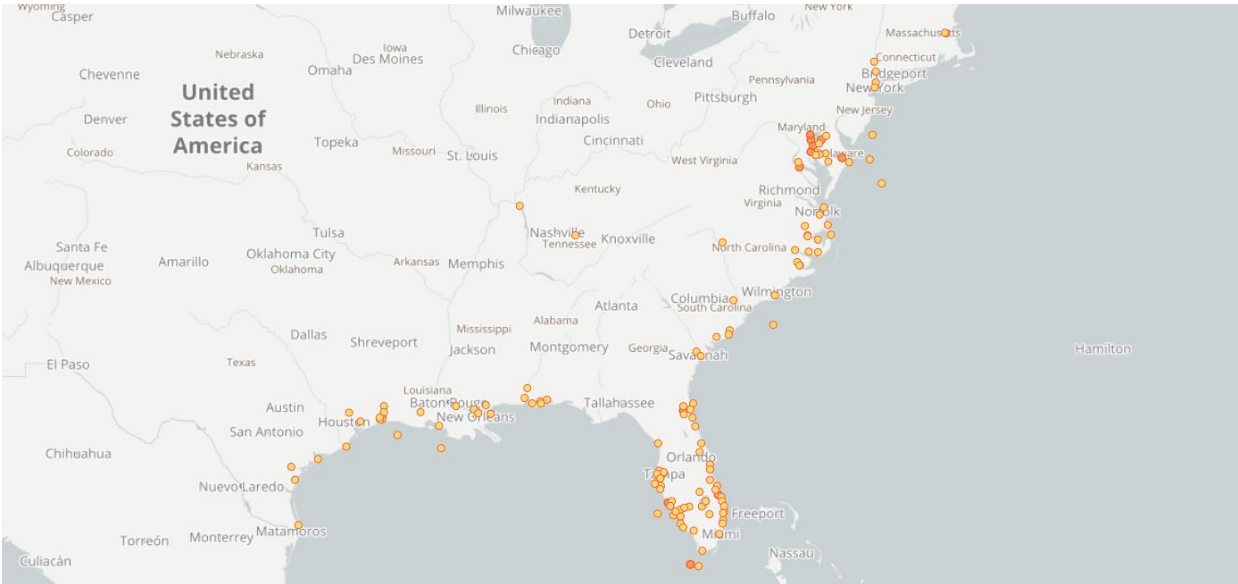

Figure 2. Reported distribution of *Mytilopsis leucophaeata* in the United States. Map from GBIF-US (2023). Observations are reported along the Gulf of Mexico and the Atlantic coast from Florida to Massachusetts, with records concentrated in Chesapeake Bay and around the Florida peninsula. Because the climate matching analysis (section 7) is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

Reported occurrences in Kentucky and central North Carolina do not represent established populations and were therefore excluded from the climate matching analysis (section 7).

7 Climate Matching

Summary of Climate Matching Analysis

Areas of medium to high climate match occurred across the contiguous United States. High matches occurred throughout the eastern half of the contiguous United States, most prominently along the Gulf of Mexico, Florida, and Atlantic coasts where *M. leucophaeata* is native. The high match along the Atlantic Coast extended north of the native range of the species. High matches also occurred in the southeastern United States, Midwest, and around the Great Lakes. Small patches of high match were also found in the Rocky Mountains. Areas of low match were found in the Southwest, the northern Pacific Coast, and in the Cascade and Sierra Nevada Mountain ranges. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.818, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024). Due to salinity requirements for survival of larvae (see Biology, above), the climate matching analysis in this case refers only to where the species can survive and not necessarily to where it can reproduce.

Projected climate matches in the contiguous United States under future climate scenarios are available for *Mytilopsis leucophaeata* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

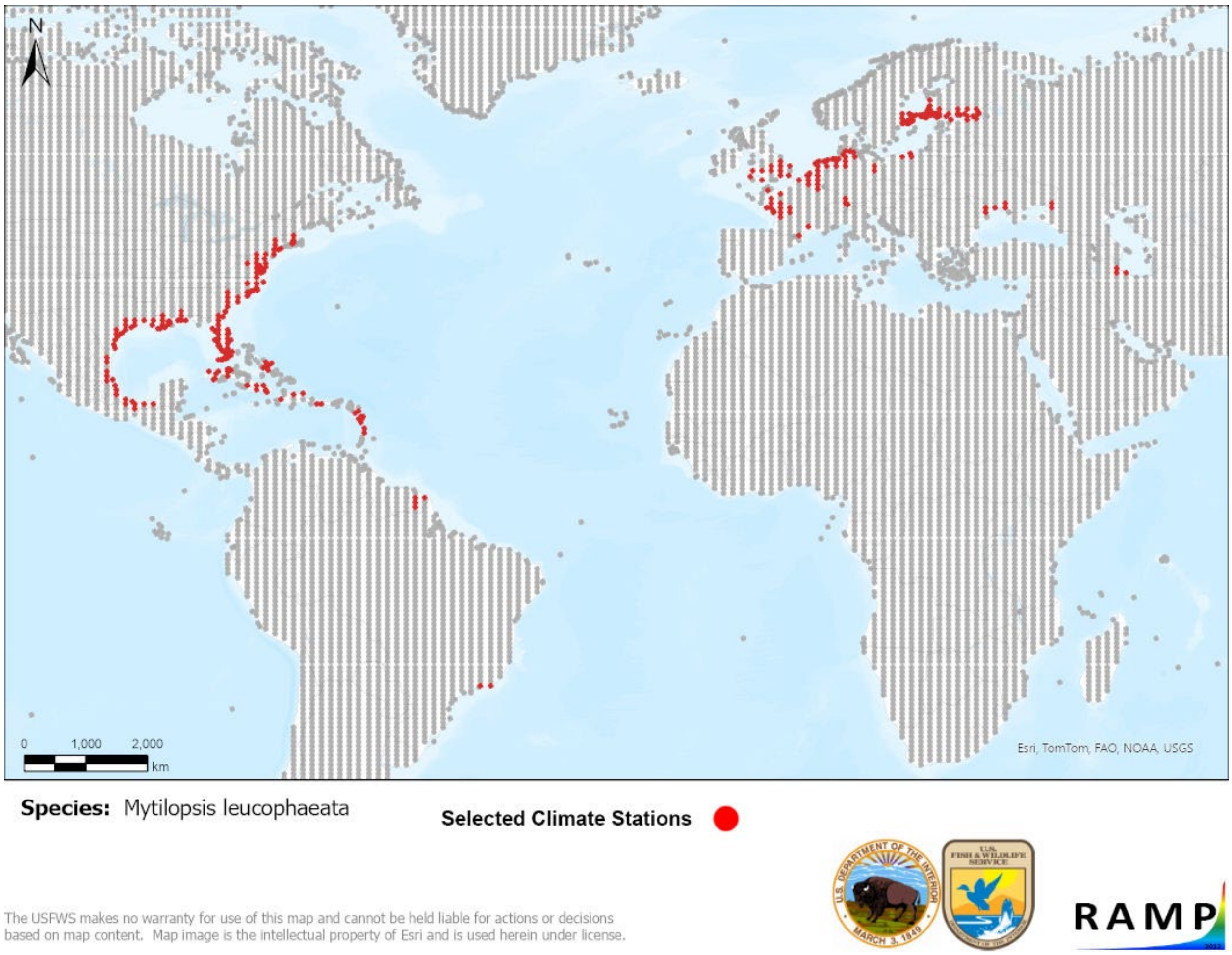

Figure 3. Global RAMP (Sanders et al. 2023) source map showing weather stations selected as source locations (red; United States, Mexico, Cuba, Brazil, French Guinea, the Antilles, Belgium, France, Germany, the Netherlands, United Kingdom, Poland, Russia, Sweden, Finland, Ukraine, and Iran) and non-source locations (gray) for *Mytilopsis leucophaeata* climate matching. Source locations from GBIF Secretariat (2023), Heiler et al. (2010), Dziubinska (2011), and Zuhlidov et al. (2015). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

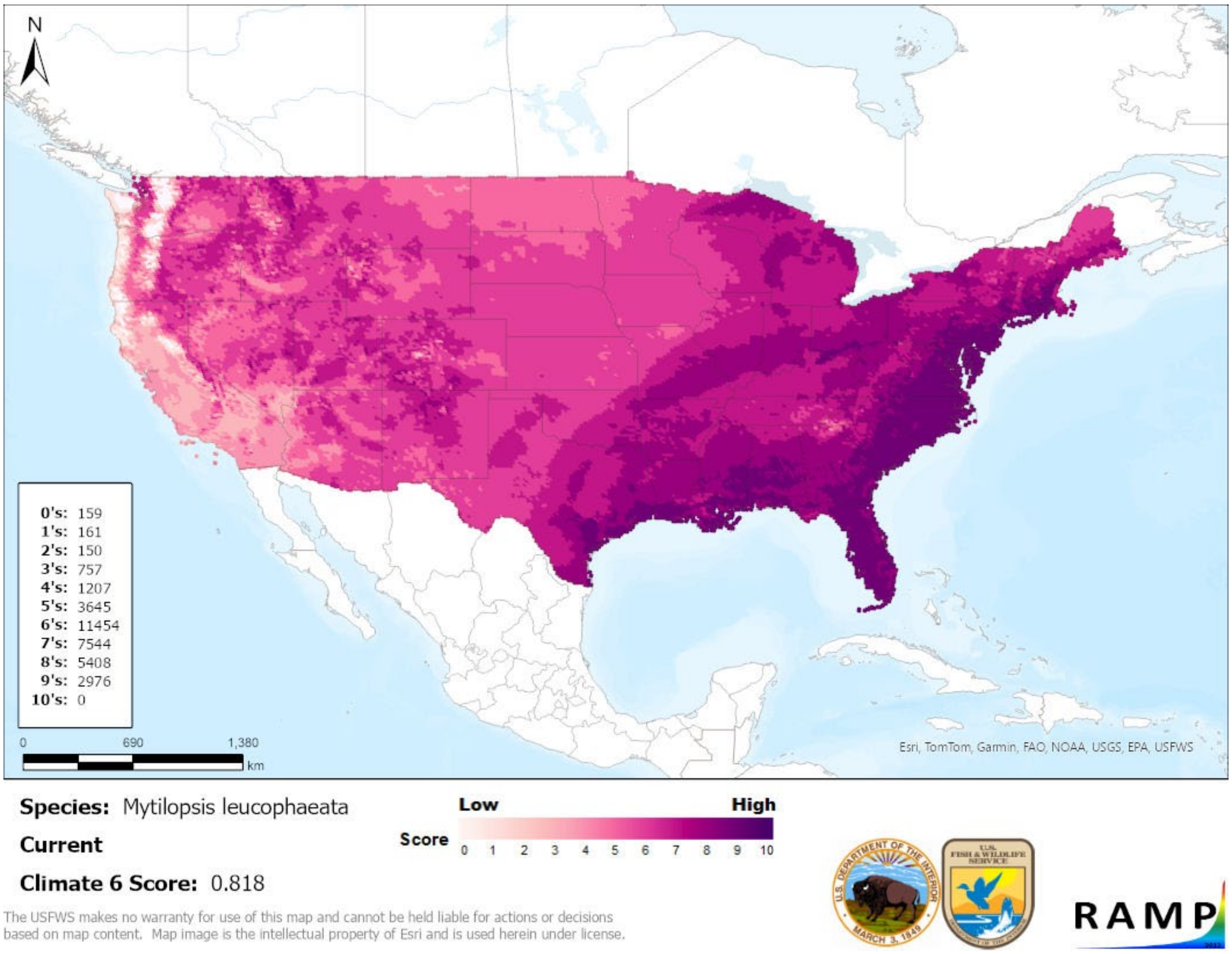

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Mytilopsis leucophaeata* in the contiguous United States based on source locations reported by GBIF Secretariat (2023), Heiler et al. (2010), Dziubinska (2011), and Zuhlidov et al. (2015). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Mytilopsis leucophaeata* is classified as Medium. Specific and quality information about the species' history of invasiveness and impacts of introduction was available from various peer-reviewed and scientifically defensible sources. While some areas of the described range were not represented in the climate matching analysis due to a lack of georeferenced observations, it is not thought to significantly impact the interpretation of the analysis. Due to salinity requirements for survival of larvae (see Biology, above) the climate matching analysis refers only to where the species can survive and not necessarily to where it can reproduce. The certainty of assessment was reduced from high to medium for this latter reason.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Mytilopsis leucophaeata, Dark Falsemussel, is a mollusk native to the brackish systems in the Gulf of Mexico and the Atlantic coast of North America. The native and introduced distributions of *M. leucophaeata* span tropical, subtropical, and temperate climates. Populations often occur in benthic, brackish waters across wide temperature and salinity ranges. Salinity levels of 0 ppt were observed to result in complete mortality of embryos. Introductions have occurred through transport in ship ballast water and "hitchhiking" via hull and marine equipment fouling. The History of Invasiveness for *Mytilopsis leucophaeata* is classified as High due to records of established nonnative populations and resulting negative impacts within these systems. *M. leucophaeata* is a known fouling species, blocking pipes and cooling systems of industrial facilities and covering boat hulls. The climate matching analysis for the contiguous United States indicates establishment concern for this species outside its native range. The highest matches occurred in its native range along the Atlantic Coast and Gulf of Mexico and expanded north along the Atlantic Coast and into the interior eastern areas of the contiguous United States. Due to salinity requirements for survival of larvae, the climate matching analysis refers only to where the species can survive and not necessarily to where it can reproduce. The Certainty of Assessment for this assessment is classified as Medium due to the uncertainty regarding areas where the species can reproduce and establish nonnative populations. The Overall Risk Assessment Category for *Mytilopsis leucophaeata* in the contiguous United States is Uncertain because the salinity required for the species' reproduction may limit establishment in many inland locations. In areas where both climate and salinity are adequate for establishment, this species may be considered high-risk.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Medium**
- **Remarks, Important additional information: Known carrier of *Enterocytozoon hepatopenaei* (EHP), shrimp microsporidian. *M. leucophaeata* embryos not known to survive in freshwater.**
- **Overall Risk Assessment Category: Uncertain**

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2023), Heiler et al. (2010), Dziubinska (2011), and Zuhlidov et al. (2015).

Under the future climate scenarios (figure A1), on average, high climate match for *Mytilopsis leucophaeata* was projected to occur within the native range of the species—Gulf Coast, Mid-Atlantic, and Southeast regions of the contiguous United States—along with the Appalachian Range, Great Lakes, and Northeast regions. However, lack of evidence for successful reproduction in freshwater may limit future establishment in these regions. Climate match in the Southeast decreased between the 2055 and 2085 time steps. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.572 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.775 (model: MPI-ESM1-2-HR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.818, figure 4) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the northern Northeast and coastal Northern Pacific Coast regions saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, areas within the coastal Northeast saw a large decrease in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Colorado Plateau, Great Basin, Gulf Coast, Mid-Atlantic, Northern Plains, Southeast, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3). The degree of change increased from the 2055 time step to the 2085 time step and from SSP3 to SSP5 within the 2085 time step.

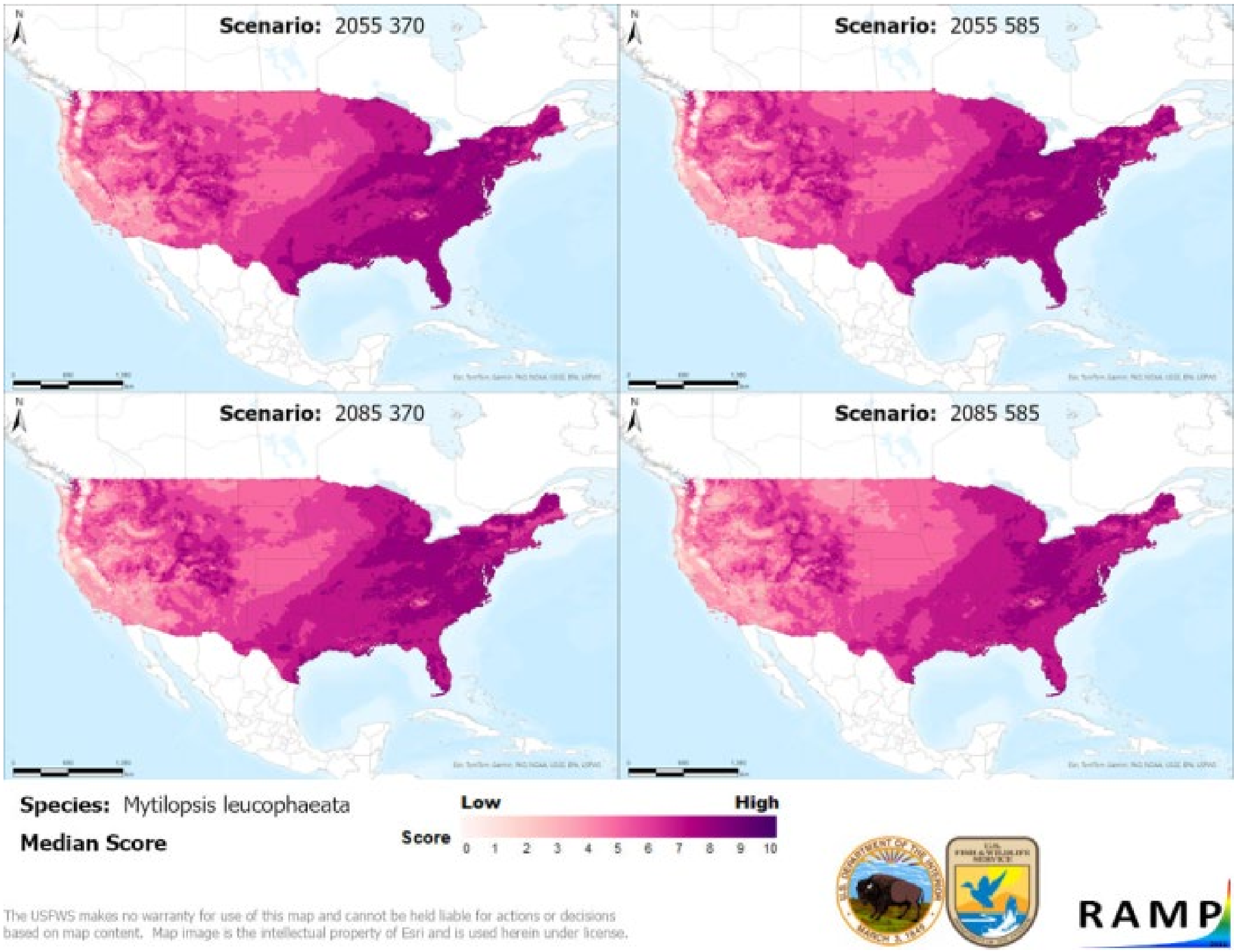

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Mytilopsis leucophaeata* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023), Heiler et al. (2010), Dziubinska (2011), and Zuhlidov et al. (2015). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

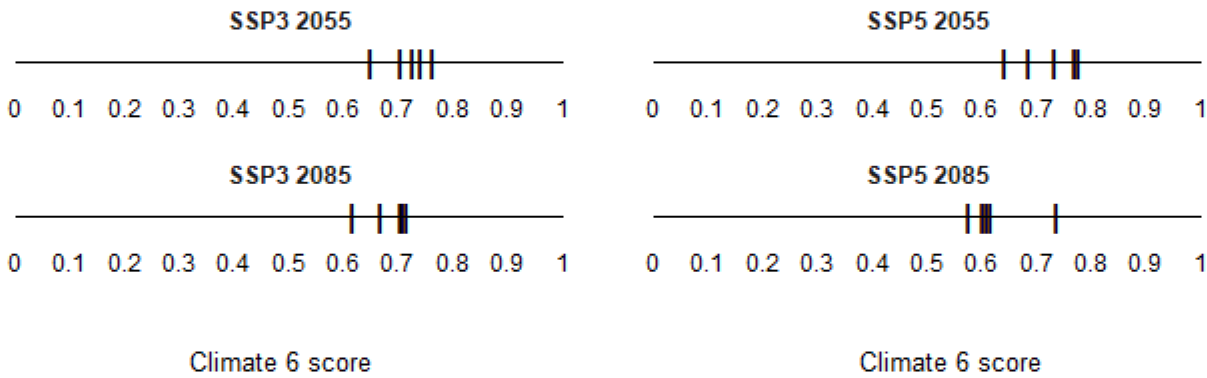

Figure A2. Comparison of projected future Climate 6 scores for *Mytilopsis leucophaeata* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

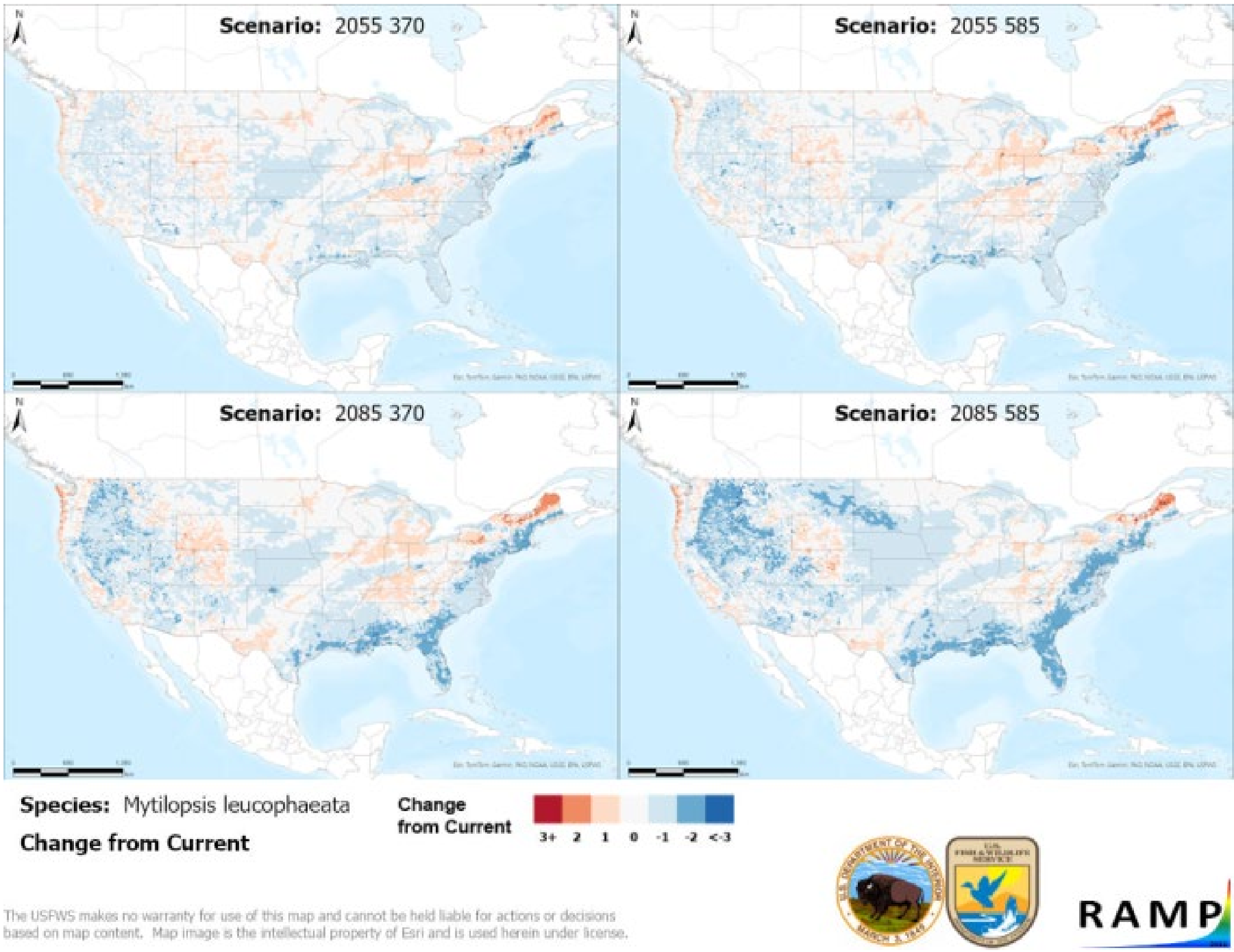

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Mytilopsis leucophaeata* based on source locations reported by GBIF Secretariat (2023), Heiler et al. (2010), Dziubinska (2011), and Zuhlidov et al. (2015). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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