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To cite this version:

Xavier De Montaudouin, Léa Baudot, Guillaume Bernard, Hugues Blanchet, Cécile Massé, et al.. Population dynamics of the potentially invasive Asian date mussel, Arcuatula senhousia, in Arcachon Bay, France. Estuarine, Coastal and Shelf Science, 2025, 324, 10.1016/j.ecss.2025.109448 . hal-05190026

HAL Id: hal-05190026
https://hal.science/hal-05190026v1

Submitted on 28 Jul 2025

Estuarine, Coastal and Shelf Science 324 (2025) 109448

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Population dynamics of the potentially invasive Asian date mussel, *Arcuatula senhousia*, in Arcachon Bay, France

Xavier de Montaudouin [a], Léa Baudot [a], Guillaume Bernard [c], Hugues Blanchet [a], Cécile Masse [b], Marie P.A. Fouet [a,*]

[a] *Université de Bordeaux, CNRS, EPOC, EPHE, UMR 5805, Station Marine d'Arcachon, 33120, Arcachon, France*
[b] *Patrimoine Naturel (PatriNat), OFB, MNHN, CNRS, IRD, 75005, Paris, France*
[c] *IFREMER, LER Arcachon-Anglet, 33120, Arcachon, France*

ARTICLE INFO

Keywords:
Arcuatula senhousia
Non-indigenous species
Population dynamics
Growth
Reproduction
Mortality
P/B ratio

ABSTRACT

Originated from Asia, *Arcuatula senhousia* has spread globally and is often reported as an invasive species that alters benthic communities and ecosystem functioning. However, very few studies have focused on the population dynamics of this ecosystem-engineering mytilid, partly due to the difficulty in monitoring cohorts of this short-lived, fast-growing species. Through a one-year monthly monitoring of mussel in two distinct locations in Arcachon Bay, France, we observed higher growth performance and P/B ratio at the station closer to the main river mouth, confirming the species preference for brackish, estuarine conditions. Post-recruitment mortality was particularly high, exceeding typical bivalve mortality rates, likely due to the vulnerability of this small species at the sediment surface. Trematode parasites, absent in our samples, were not implicated in mortality. In both locations, the reproductive phenology was similar, with a prolonged spawning season centred in the warmer months. As of 2024, *A. senhousia* remains a colonizing introduced species in Arcachon Bay with relatively low densities. However, vigilance is necessary, as its population dynamics resemble those observed in the few areas where these data are available and where this species has become invasive.

1. Introduction

Non-indigenous species (NIS) are recognized as major threats to marine diversity (Anton et al., 2019). By establishing at new habitats, they can alter community structure and ecosystem functioning (Katsanevakis et al., 2014). Mussels, in particular, tend to form dense aggregations by attaching to the substrate with byssal threads, often functioning as ecosystem engineers (Buschbaum et al., 2009; Jones et al., 1994). The Asian date mussel, *Arcuatula senhousia*, originating from Asia, has spread globally and continues to be recorded in new locations (Encarnaçao et al., 2024; Yasser et al., 2023). In Western Europe, this invasion has impacted both the Mediterranean Sea (Fortic et al., 2023) and the Atlantic Ocean (Massé et al., 2022). Indeed *A. senhousia* can severely alter the colonized ecosystem by creating reefs which can modify the habitat's architectural structure (Crooks and Khim, 1999) and thus, accumulate fine sediment, disturb biogeochemical and nutrient cycling (Bernard et al., 2020; Takenaka et al., 2018) and create changes in community structure (Crooks, 1998).

In Arcachon Bay, a lagoon in southwestern France, the presence of *A. senhousia* has been documented since 2002 (Bachelet et al., 2009), possibly resulting from a secondary introduction from a Mediterranean lagoon (Hoenselaar and Hoenselaar, 1989). After a 20-year lag time, the abundances of this species have increased considerably since 2018 (Coignard et al., in press). Due to its potential impact on associated communities (Como et al., 2018; Mistri et al., 2004; Munari, 2008) and ecosystem functioning (Bernard et al., 2020), monitoring the population dynamics of this species in the lagoon is essential. Overall, few studies have examined the population dynamics of this species based on year-round surveys (Mistri, 2002; Takenaka et al., 2016); research has largely focused on individual growth and reproductive phenology, often in separate studies (Allen and Williams, 2003; Crooks, 1996; Mastrototaro et al., 2003; Morton, 1974; Sgro et al., 2002; Watson et al., 2021).

In our study, we monitored *A. senhousia* populations in Arcachon Bay over the course of a year, at two stations with contrasting environmental conditions in terms of freshwater influence. The underlying objective

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* Corresponding author.
E-mail address: marie.fouet@u-bordeaux.fr (M.P.A. Fouet).

https://doi.org/10.1016/j.ecss.2025.109448
Received 5 December 2024; Received in revised form 17 July 2025; Accepted 19 July 2025

was to determine the population dynamics, including the Von Bertalanffy Growth Function (L∞ and K), mortality constant (Z), production (P), and P/B ratio, as well as reproductive phenology through the condition index and gonad maturity staging. This was done so as to determine if the population dynamics observed *for A. senhousia* in Arcachon Bay support a sustainable population which aligns with patterns seen in invasive populations of this species, at other locations globally.

2. Material and methods

2.1. Study area

Arcachon Bay is a 180 km^2 lagoon in the southwest of France. The inner lagoon comprises 110 km^2 of mudflats, which are covered by a large *Zostera noltei* seagrass beds. Arcachon Bay receives freshwater input primarily from the Leyre River and marine water through channels located at the southwest end of the lagoon. These oceanic and freshwater inputs, along with the slow renewal driven by tides, create salinity and temperature gradients within the bay. Water salinity and sediment temperature vary from 4 to 35, and from −2 to 44 °C, respectively (Dang et al., 2008). The sediment composition ranges from mud to muddy sands. *A. senhousia* specimens were collected monthly, during 12 sampling trips, from March 2023 to March 2024 at two stations in Arcachon Bay: Gujan (44°38′58″N, 1°06′50″W) and Arès (44°44′52″N, 1°07′49″W) (Fig. 1), both situated at an approximate tidal level of 2 m. Gujan and Arès belong to two distinct sub-areas, with Gujan being more influenced by continental conditions due to its proximity to the main river input (Fig. 1), compared to Arès (Binias et al., 2014). Both stations are characterized by a sandy-muddy sediment, but Gujan is sandier than Arès (mud content, Gujan: 61 % ± 23, Arès: 73 % ± 14; D50, Gujan: 76 ± 116, Arès: 21 ± 13).

2.2. Growth

At each sampling occasion, and each station, six cores (15 × 15 cm, surface = 225 cm^2, ~10 cm deep) were collected randomly within mussel patches and sieved through a 1 mm mesh. In the laboratory, mussels were sorted, counted, and their shell heights were measured with a calliper. Shell height histograms were constructed monthly for each station. From the size histograms, height–frequency data were analyzed using FISAT II software (Gayanilo et al., 2005). To analyze growth, a Modal class Progression Analysis was performed. Bhattacharya's method was used to identify cohorts by decomposing the polymodal size distribution into its normal distribution components. Cohorts were considered distinct if they had a separation index greater than 2. The temporal series of the average height for each modal group (cohort) was used to estimate the growth parameters of the von Bertalanffy Growth Function (VBGF) using the Appeldoorn method (Gayanilo et al., 2005).

$$H_t = H_\infty \times \left[1 - e^{(-K \times t)}\right]$$

where H_∞ is the asymptotic shell height (mm) and K is the growth coefficient (yr^{-1}).

The negative correlation between H_∞ and K makes comparisons based on individual parameters unreliable (Pauly and Munro, 1984). Therefore, it is more appropriate to compare the growth performance of bivalve population using the growth performance index *Φ'* (Valiky, 1990). The estimates H_∞ and K were used to calculate the growth performance index *Φ'* (Pauly et Munro, 198) using the equation:

$$\Phi' = 2 \times log_{10}(H_\infty) + log_{10}(K)$$

2.3. Reproduction

Since first maturity is achieved at a shell height of 14–16 mm (Mistri, 2002), only mussels with a shell height greater than 12 mm were dissected. During dissection, the stage of gonad development was estimated under a stereomicroscope, following a maturation scale ranging from 0 to 3 (Sgro et al., 2002). At stage 0, the gonad is translucent, and the sex cannot be identified. In stage 1, the gonads are translucent to whitish, indicating the early stages of maturation, sex cannot be identified. The gonads of mussels in stage 2 are more mature, and the sex is detectable. In stage 3, the gonads are fully mature, with distinct colours, whitish for males and orange for females.

Additionally, Condition Index (*CI*, in ‰), which provides information on gametogenesis (indicated by an increase in *CI*) and spawning

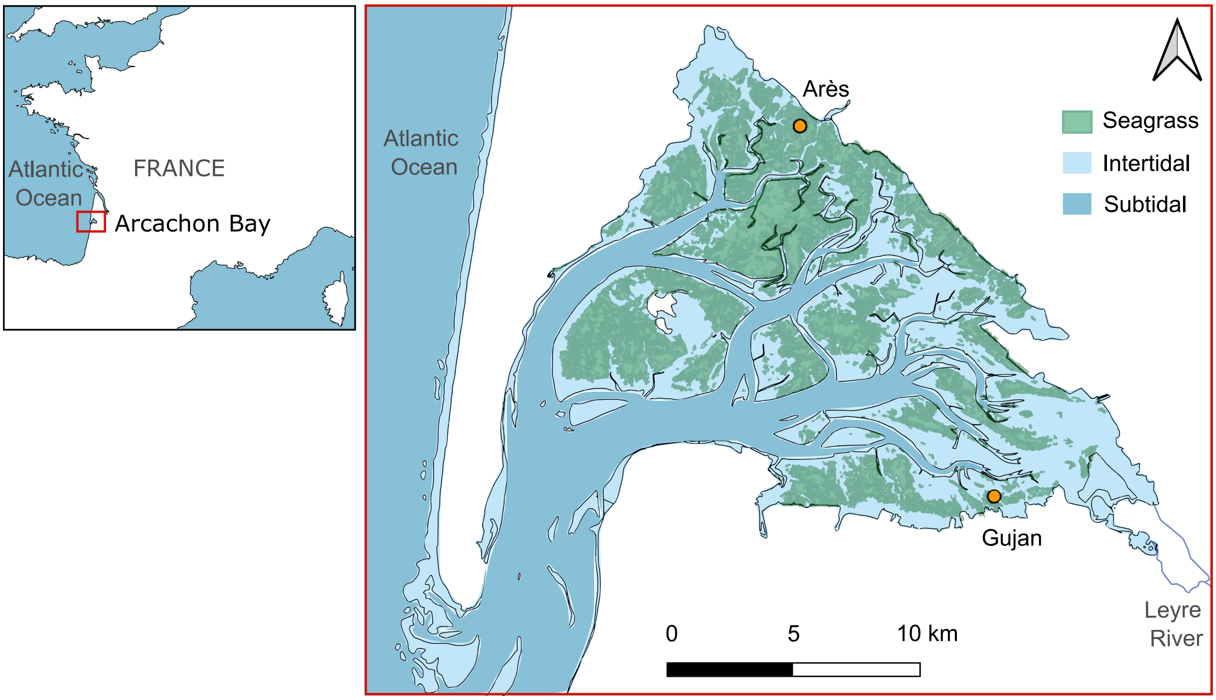

Fig. 1. Localization of Arcachon Bay and the two sampling sites, Arès and Gujan. Seagrass data are providing by Rigouin et al. (2022).

events (indicated by a decrease in *CI*), was evaluated (Walne and Mann, 1975). Each month, 20 individuals with a shell height greater than 20 mm were sampled from each station, retrieved from the cores. The *CI* was calculated using the following formula:

$$CI = \left[\frac{Flesh\ dry\ weight\ (in\ g)}{Shell\ dry\ weight\ (in\ g)}\right] \times 1000$$

2.4. Mortality

The number of individuals in each cohort was insufficient to estimate mortality through the decline in cohort abundance. Therefore, the instantaneous total mortality coefficient (*Z*) was estimated based on the 1-year population structure monitoring at Arès and Gujan. This approach used the height-converted catch curve method available in the FISAT II software (version 1.2.2, FAO-ICLARM) and the single negative exponential mortality model (Gayanilo et al., 2005). The height of pooled height-frequency samples were converted into ages using the parameters of the VBGF. Mortality was then calculated through linear regression analysis using the following equations:

$$N_t = N_0 \times e^{-Z \times t}$$

$$dN / dt = -Z \times t$$

where N_0 is the number of individuals at relative age 0, and *t* represents the age of the mussels.

2.5. Parasitism

Trematode parasites were examined in ten adult individuals retrieved from the cores, with a shell height greater than 20 mm, per station each month. Each mussel was dissected, and the flesh was placed between two glass slides, gently squeezed, and observed under a stereomicroscope.

2.6. Biomass, production and productivity

As with the mortality assessment, the number of individuals in each cohort was insufficient to calculate somatic production by cohort. Therefore, the annual mean biomass, annual somatic production, and the P/B ratio were evaluated from the population size structure monitoring for mussel populations at Arès and Gujan. The VBGF parameters (K and H_∞) used were those previously obtained (see Growth section). To calculate production and biomass, station-specific relationships between shell height and dry flesh weight were estimated. Mussels ranging in size from 6 to 39 mm were selected, and their dry flesh weight (48 h at 60 °C) and shell height were measured, resulting in the following equation:

$$log_{10}(SFDW) = -5.1739 + 2.77 \times log_{10}(H)$$

where SFDW is the shell-free dry weight (g), and H is the shell height (mm). The equation was based on 2026 observations, with an R^2 value of 0.91.

The mean annual biomass B (g SFDW. m^{-2}) was calculated using the following equation:

$$B = \sum (N_i \times M_i)$$

where N_i is the mean number of animals per m^2, and M_i is the mean individual somatic mass in size class i.

Total annual production P (g SFDW. m^{-2}. yr^{-1}) was calculated using the mass-specific growth rate method (Brey, 2001) based on the size-mass relation, the VBGF, and the pooled size-frequency distribution:

$$P = \sum (N_i \times M_i \times G_i)$$

where G_i is the mass-specific growth rate (yr^{-1}), represented by:

$$G_i = b \times K \times (H_\infty - H_i) / H_i$$

In this equation, b = 2.77 is the specific constant of the size-mass relation, K and H_∞, are the VBGF parameters and H_i is the mean height of class i.

The annual P/B ratio of *A. senhousia* populations was evaluated at each station using the annual total production and the annual mean biomass.

3. Results

In total, 1282 individuals were collected over the whole year of sampling in Gujan, and 1753 in Arès. In Gujan, density within mussel patches fluctuated between 200 and 1200 ind.m^{-2}, while these values were higher in Arès, and ranged from 320 to 2300 ind.m^{-2}. The population structure was similar to what has been observed in other monitoring efforts, showing a unimodal distribution in most cases, with no clear recruitment period but rather sporadic recruitment events, including some unsuccessful ones.

3.1. Growth

Shell growth was faster in Gujan ($\Phi' = 3.27$) than in Arès ($\Phi' = 2.90$) (Table 1). After one year, based on the site-specfic Von Bertalanffy growth function, mussels in Gujan could reach a size of 27 mm, while those in Arès only grew up to 18 mm.

3.2. Reproduction

At both stations, the maximum of the mean *CI* occurred in summer, ranging from 130 to 140 ‰ (June–August), coinciding with the peak of fully mature individuals (Fig. 2). The gradual decrease in *CI* between July and December–January suggests a relatively long spawning period. After the peak, the minimum CI value was higher in Gujan (90 ‰) compared to Arès (60 ‰). The minimum shell height at which stage 3 maturity was observed was 12 mm in Gujan and 14 mm in Arès (Table 1). The female-to-male sex ratio was 0.54 in Gujan and 0.40 in Arès (Table 1).

3.3. Mortality

The mortality constant (*Z*) for the youngest cohort (2023) was 10.63

Table 1
Values of the different parameters characterizing the *Arcuatula senhousia* population in Gujan and Arès. *CI*: condition index, DW: dry weight. H∞: asymptotic shell height, K: growth coefficient, Φ': growth performance index.

	Parameter	Unit	Gujan	Arès
Growth	H_∞	mm	34.21	26.4
	K	yr^{-1}	1.58	1.14
	Φ'		3.27	2.90
Reproduction	*CI* peak	‰	145, Jul 2023	134, Jul 2023
	CI minimum	‰	88, Jan 2024	64, Dec 2023
	Sex-ratio	F/M	0.54	0.40
	Min. size for maturity	mm	12	14
Mortality	*Z* cohort 2023	yr^{-1}	10.63	6.28
	Z cohort 2022	yr^{-1}	3.10	1.61
Production	*P*	g DW.m^{-2}. yr^{-1}	282	67
Biomass	*B*	g DW.m^{-2}. yr^{-1}	132	240
Productivity	*P/B*	yr^{-1}	2.14	0.28

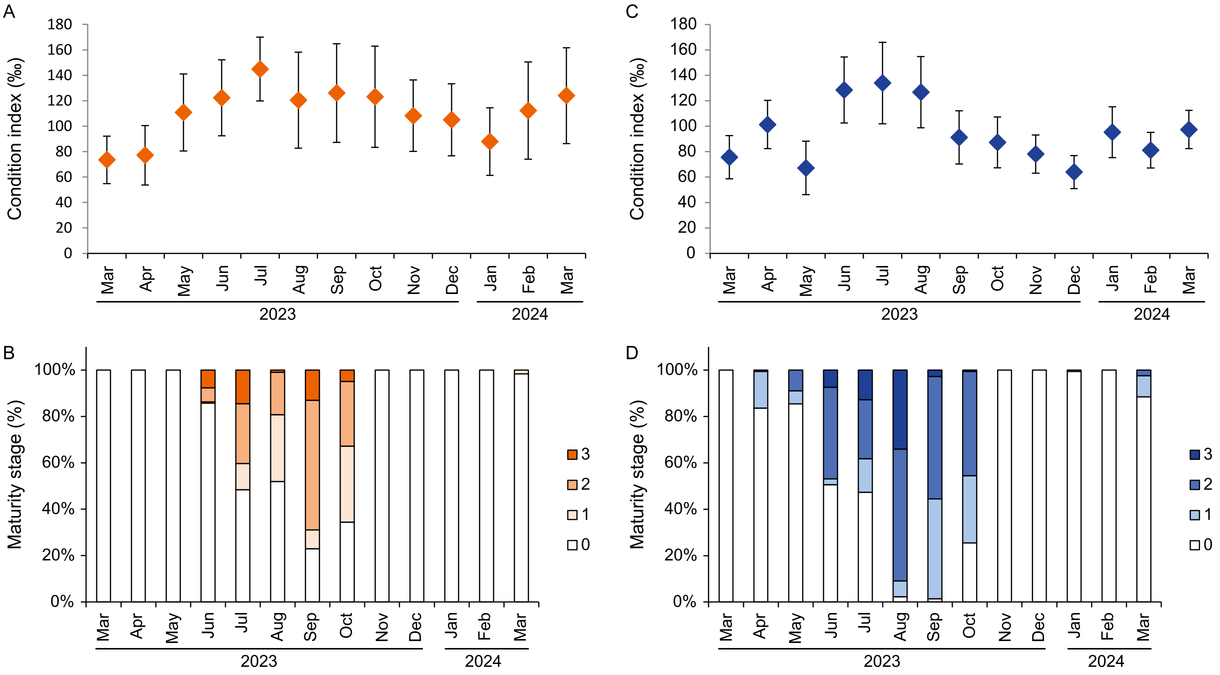

Fig. 2. Mean condition index (± standard deviation) of *Arcuatula senhousia* per month, in Gujan (A) and Arès (C), and percentage of individuals per maturity stage in Gujan (C) and Arès (D).

yr^{-1} in Gujan, indicating a 50 % mortality rate within 24 days. In Arès, the Z value is lower at 6.28 yr^{-1}, meaning that 50 % mortality was reached in 40 days (Table 1). For the older cohort (2022), Z values in Gujan and Arès were 3.10 yr^{-1} and 1.61 yr^{-1}, corresponding to 50 % of mortality in 81 and 157 days, respectively.

3.4. Parasitism

No mussels were found to be parasitized by trematodes in either Gujan or Arès.

3.5. Production and P/B ratio

Production (P) in Gujan was four times higher than in Arès, despite the mean yearly biomass (B) being nearly half as much. As a result, the P/B ratio was significantly higher in Gujan (2.14 yr^{-1}) compared to Arès (0.28 yr^{-1}) (Table 1).

4. Discussion

The abundance of mussels within patches at both stations ranged from 200 to 2300 $ind.m^{-2}$, depending on the month. These densities are relatively low compared to those reported in other ecosystems where the species is considered invasive, whether native as in Lake Nakaumi (Japan) (Yamamuro et al., 2000), or long-established following introduction. For example, densities exceeding 7000 $ind.m^{-2}$ have been recorded in San Diego (USA), where the species was first observed 30 years earlier (Crooks, 1996). In contrast, the lower abundances observed at our two stations are more comparable to those reported in recently invaded sites (within 3 years of initial observation), such as the Tarento Sea (Italy) with fewer than 4000 $ind.m^{-2}$ (Mastrototaro et al., 2003), Southampton (UK) with a maximum of 290 $ind.m^{-2}$ (Watson et al., 2021), and the Shatt Al-Basrah Canal (Iraq) with 102 $ind.m^{-2}$ (Yasser et al., 2023). However, in our case, the estimated introduction occurred approximately 20 years ago, around 2002 (Bachelet et al., 2009). Therefore, the current situation in Arcachon Bay resembles that of Sacca di Goro, where an initially slow population expansion was followed by a rapid population explosion (Mistri et al., 2004). Arcachon Bay may currently represent an intermediate stage between the lag time and a potential population explosion characteristic of full invasion. However, ecosystems with high species richness, such as Arcachon Bay (Blanchet, 2004), are generally known to resist NIS, due to the limited availability of vacant ecological niches (Chan and Briski, 2017; Marraffini and Geller, 2015). As a result, the lag phase may be prolonged, or effective biotic resistance may eventually develop. In addition, caution is warranted regarding the methodology used to estimate mussel abundance, as it is not always clear in the literature if samples were collected randomly or within mussel patches. In Arcachon Bay, a random sampling in the entire lagoon in 2021 yielded abundance values not exceeding 200 $ind.m^{-2}$ (Coignard et al., In press). Lastly, as extensively described by Coignard et al. (in press), environmental factors, such as consistently high current velocities in subtidal channels or temporary surges during storm events may limit the population growth of *A. senhousia*.

Detecting age classes (cohorts) from monthly shell-size distribution was challenging, as often noted in other studies with similar data (Crooks, 1996; Yamamuro et al., 2000). This difficulty is due to the species' biological traits, being short-lived (1–2 years maximum) (Crooks, 1996) but potentially exhibiting two simultaneous cohorts, a prolonged spawning period (Mastrototaro et al., 2003), and sporadic juvenile recruitment (Crooks, 1996; Yamamuro et al., 2000). Nonetheless, mussel growth was modelled using the VBGF, indicating that after one year, shell height reached 28 mm in Gujan and 18 mm in Arès. These values align with those recorded in other locations, such as San Diego, U. S.A. (17–23 mm) (Crooks, 1996), Tamaki Estuary, New Zealand (20 mm) (Creese et al., 1997), and Ashtamudi Lake, India (25 mm) (George and Nair, 1974a). The higher growth performance index observed in Gujan (3.27) compared to Arès (2.90) may be attributed, for a suspension feeder, to factors such as tidal level (Callaway et al., 2014; de Montaudouin, 1996) as well as food quality and quantity (Bacher et al., 2003; Duarte et al., 2010; Smaal, 1997). The tidal levels at both stations were similar. Stable isotopic analysis on another suspension feeder, potentially competitor (Como et al., 2016), *Ruditapes philippinarum*, provided limited evidence of trophic source differences between Gujan and Arès (Dang et al., 2009). Regarding food quantity, mussel density (Bachelet et al., 2009) and densities of other suspension feeders are also similar at both stations (Blanchet, 2004; Sanchez et al., 2018), minimizing intraspecific competition. However, Gujan and Arès lie within two distinct sub-systems of the lagoon, which differ in environmental, zooepidemiologic, and planktonic characteristics (Binias et al., 2014; Glé, 2007). Gujan is situated 6 km from primary freshwater input (the Leyre River), closer than Arès (12 km), and is thus more influenced by brackish conditions. These estuarine conditions in Gujan may be advantageous for *A. senhousia* growth and P/B, which shows a preference for brackish over oceanic waters (Hamza et al., 2022; Hosozawa et al., 2020). Finally, the superior mussel growth observed at the Gujan station may be linked to the higher water turnover in this sub-system. An unpublished study (SOGREAH, 2001) reported that approximately two-thirds of the water circulates through the Gujan area, compared to only one-third in the northwestern sub-system where the Arès station is located. Consistently, enhanced growth performance of another suspension feeder, *Crassostrea gigas*, has been documented in the south-eastern sub-system (including Gujan) relative to the northwestern part of the bay, regardless of tidal level (Maurer, 1989). Maurer (1989) attributed these differences to more extreme environmental conditions in areas with lower water turnover, a conclusion that aligns with Binias et al. (2014), who reported a higher frequency of both minimum and maximum temperature events in such areas.

The reproductive phenology was similar at both stations, with a peak of the condition index and maximum maturation observed in summer, followed by an extended spawning period also during the warmer season. This pattern aligns with findings from other studies (Sgro et al., 2002, 2005), although these processes may also begin earlier in spring, as the species can reproduce across a broad temperature range (Ishii et al., 2005; Watson et al., 2021). Size-frequency histograms may be difficult to interpret, with recruitment potentially failing or occurring over prolonged periods (Ishii et al., 2001; Yamamuro et al., 2000). Interestingly, the study revealed an unbalanced sex ratio favoring males, contrary to the female dominance in Solent (UK) (Watson et al., 2021) and the balanced ratio in India (George and Nair, 1974a). However, the minimum size at maturation was consistent with previous findings (Mistri, 2002).

Mortality rates (6.28–10.63 yr^{-1}) during the early months of benthic life were consistent with typical patterns for bivalves with a bentho-planktonic life cycle (notably high juvenile mortality), although values were comparatively high. Their position at or near the sediment surface likely increases vulnerability, similar to rates seen in the sympatric species *Cerastoderma edule* also living near the sediment surface (8.26–10.89 yr^{-1}) (Gam et al., 2010), but notably higher than those observed in the deeper-burrowing bivalve *R. philippinarum* (3.43–5.83 yr^{-1}) (Dang et al., 2010). Principal mortality sources include predation (by birds (Yamamuro et al., 1998) or gastropods (Kushner and Hovel, 2006; Marshall, 2009) and summer anoxia (Como et al., 2018; Mistri, 2002), factors which should be further investigated to understand the mortality rate variations between the two stations. Mussel flesh was also examined for trematode parasites, known to occur in this species' native distribution (George and Nair, 1974b). No trematodes were detected in Arcachon Bay, aligning with the Enemy Release Hypothesis (ERH), which suggests that introduced species are often free of their native parasites (Colautti et al., 2004). This lack or scarcity of infection in *A. senhousia* could contribute to its successful expansion (Miller et al., 2008).

Finally, the P/B ratio calculated for Gujan showed higher values, aligning with the previously discussed superior growth performance. The only available references (Mistri, 2002; Takenaka et al., 2016) reported values between 1.5 and 1.7 yr^{-1}, which are intermediate compared to those found in Arcachon Bay and fall within the typical range for molluscs or filter feeders (1.8 yr^{-1}) (Cusson and Bourget, 2005).

In conclusion, the *A. senhousia* population in Arcachon Bay currently forms patches with densities indicative of recent introductions. Population dynamics parameters (growth, reproduction, mortality, and P/B ratio) align closely with ecosystem observations where the species has become invasive. This suggests that a similar scenario may develop in Arcachon Bay. However, as a typical *r*-strategy species (short-lived, high mortality rates, rapid growth, and small size), *A. senhousia* could have a localized and short-term impact, as observed in New Zealand, with fluctuations in biomass over time (McDonald and Wells, 2010).

CRediT authorship contribution statement

Xavier de Montaudouin: Writing – original draft, Visualization, Investigation, Formal analysis. **Léa Baudot:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Guillaume Bernard:** Writing – review & editing, Funding acquisition, Conceptualization. **Hugues Blanchet:** Writing – review & editing, Project administration, Funding acquisition. **Cécile Masse:** Writing – review & editing, Project administration, Investigation, Funding acquisition. **Marie P.A. Fouet:** Writing – review & editing, Visualization, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors are thankful to OFB for the funding (grant number OFB-22-0143). Authors also thank the numerous colleagues and trainees for their help during the sampling field. Thanks also to previous Referees.

Data availability

Data will be made available on request.

References

Allen, B.J., Williams, S.L., 2003. Native eelgrass *Zostera marina* controls growth and reproduction of an invasive mussel through food limitation. Mar. Ecol. Prog. Ser. 25457–25467.

Anton, A., Geraldi, N.R., Lovelock, C.E., Apostolaki, E.T., Bennett, S., Cebrian, J., Krause-Jensen, D., Marbà, N., Martinetto, P., Pandolfi, J.M., Santana-Garcon, J., Duarte, C. M., 2019. Global ecological impacts of marine exotic species. Nat. Ecol. Evol. 3787–3800. https://doi.org/10.1038/s41559-019-0851-0.

Bachelet, G., Blanchet, H., Cottet, M., Dang, C., de Montaudouin, X., de Moura Queirós, A., Gouillieux, B., Lavesque, N., 2009. A round-the-world tour almost completed: first records of the invasive mussel *musculista senhousia* in the North-east Atlantic (southern Bay of Biscay). Mar. Biodivers. Records 21–24.

Bacher, C., Grant, J., Hawkins, A.J.S., Fang, J., Zhu, M., Besnard, M., 2003. Modelling the effect of food depletion on scallop growth in Sungo Bay (China). Aquat. Living Resour. 1610–24.

Bernard, G., Kauppi, L., Lavesque, N., Ciutat, A., Grémare, A., Massé, C., Maire, O., 2020. An invasive mussel (*Arcuatula senhousia*, Benson 1842) interacts with resident biota in controlling benthic ecosystem functioning. J. Mar. Sci. Eng. 8, 12. https://doi.org/10.3390/jmse8120963.

Binias, C., Do, V.T., Jude-Lemeilleur, F., Plus, M., Froidefond, J.M., de Montaudouin, X., 2014. Environmental factors contributing to the development of Brown Muscle Disease and perkinsosis in Manila clams (*Ruditapes philippinarum*) and trematodiasis in cockles (*Cerastoderma edule*) of Arcachon Bay. Mar. Ecol. 35 (Suppl. l), 67–77.

Blanchet, H., 2004. Structure et Fonctionnement Des Peuplements Benthiques du Bassin d'Arcachon, vol. 1. University, Bordeaux, p. 220.

Brey, T., 2001. Population dynamics in benthic invertebrates. A virtual handbook. http://www.awi-bremerhaven.de/Benthic/Ecosystem/Foodweb/Handbook/main.html.

Buschbaum, C., Dittmann, S., Hong, J.S., Hwang, I.S., Strasser, M., Thiel, M., Valdivia, N., Yoon, S.P., Reise, K., 2009. Mytilid mussels: global habitat engineers in coastal sediments. Helgol. Mar. Res. 63 (1), 47–58. https://doi.org/10.1007/s10152-008-0139-2.

Callaway, R., Grenfell, S., Bertelli, C., Mendzil, A., Moore, J., 2014. Size, distribution and sediment biodeposition of prolific bivalves in small estuaries. Estuar. Coast Shelf Sci. 150262–150270.

Chan, F.T., Briski, E., 2017. An overview of recent research in marine biological invasions. Mar. Biol. 164, 6. https://doi.org/10.1007/s00227-017-3155-4.

Coignard, S., Fouet, M.P.A., Massé, C., Blanchet, H., Bernard, G. The ongoing spread of the Asian date mussel (*Arcuatula senhousia*) within the French Atlantic coast:

colonisation dynamics and associated drivers in a historically invaded ecosystem (Arcachon Bay). Aquat. Invasions.

Colautti, R.I., Ricciardi, A., Grigorovich, I.A., MacIssac, H.J., 2004. Is invasion success explained by the enemy release hypothesis? Ecol. Lett. 7721–7733.

Como, S., Floris, A., Pais, A., Rumolo, P., Saba, S., Sprovieri, M., Magni, P., 2018. Assessing the impact of the Asian mussel *Arcuatula senhousia* in the recently invaded Oristano Lagoon-Gulf system (W Sardinia, Italy). Estuar. Coast Shelf Sci. 201123–201131. https://doi.org/10.1016/j.ecss.2015.11.024.

Como, S., Pais, A., Rumolo, P., Saba, S., Sprovieri, M., Magni, P., 2016. Effects of an invasive mussel, *Arcuatula senhousia*, on local benthic consumers: a laboratory ^{13}C-labeling study. Mar. Biol. 163, 6. https://doi.org/10.1007/s00227-016-2912-0.

Creese, R., Hooker, S., de Luca, S., Wharton, Y., 1997. Ecology and environmental impact of *Musculista senhousia* (Mollusca: bivalvia: mytilidae) in Tamak Estuary, Auckland, New Zealand. New. Zeal. J. Mar. Fresh 31 (2), 225–236. https://doi.org/10.1080/00288330.1997.9516760.

Crooks, J.A., 1996. The population ecology of an exotic mussel, *Musculista senhousia*, in a Southern California Bay. Estuaries 19 (1), 42–50. https://doi.org/10.2307/1352650.

Crooks, J.A., 1998. Habitat alteration and community-level effects of an exotic mussel. Musculista senhousia 162, 137–152.

Crooks, J.A., Khim, H.S., 1999. Architectural vs. biological effects of a habitat-altering, exotic mussel, *Musculista senhousia*. J. Exp. Mar. Biol. Ecol. 24053–24075.

Cusson, M., Bourget, E., 2005. Global patterns of macroinvertebrate production in marine benthic habitats. Mar. Ecol. Prog. Ser. 297, 1–14.

Dang, C., de Montaudouin, X., Gam, M., Paroissin, C., Caill-Milly, N., 2010. The Manila clam population in Arcachon Bay (SW France): can it be kept sustainable? J. Sea Res. 63108–63118.

Dang, C., de Montaudouin, X., Gonzalez, P., Mesmer-Dudons, N., Caill-Milly, N., 2008. Brown Muscle Disease (BMD), an emergent pathology affecting Manila clam *Ruditapes philippinarum* in Arcachon bay (SW France). Dis. Aquat. Organ. 80219–80228.

Dang, C., Sauriau, P.-G., Savoye, N., Caill-Milly, N., Martinez, P., Millaret, C., Haure, J., de Montaudouin, X., 2009. Determination of diet in Manila clams by spatial analysis of stable isotopes. Mar. Ecol. Prog. Ser. 387167–387177.

de Montaudouin, X., 1996. Factors involved in growth plasticity of cockles *Cerastoderma edule* (L.) identified by field survey and transplant experiments. J. Sea Res. 36, 3/4 251–265.

Duarte, P., Fernández-Reiriz, M.J., Filgueira, R., Labarta, U., 2010. Modelling mussel growth in ecosystems with low suspended matter loads. J. Sea Res. 64273–64286.

Encarnaçao, J., Teodósio, M.A., Morais, P., 2024. The arrival of a non-indigenous ecosystem engineer to a heavily invaded and flow-regulated estuary in Europe. Bioinvasions. Rec. 13 (1), 83–95. https://doi.org/10.3391/bir.2024.13.1.08.

Fortic, A., Rasheed, R.A., Almajid, Z., Badreddine, A., Báez, J.C., Belmonte-Gallegos, A., Bettoso, N., Borme, D., Camisa, F., Caracciolo, D., Çinar, M.E., Crocetta, F., Cetkovic, I., Dogan, A., Galiya, M., Los Huertos, A., Grech, D., Guallart, J., Gündeger, G., Kahric, A., Karachle, P.K., Kulijer, D., Lombarte, A., Markovic, O., Jiménez, E.M., Okudan, E.S., Orlando-Bonaca, M., Sartoretto, S., Spinelli, A., Kizilkaya, I.T., Virgili, R., 2023. New records of introduced species in the Mediterranean Sea (April 2023). Mediterr. Mar. Sci. 24, 1. https://doi.org/10.12681/mms.34016.

Gam, M., de Montaudouin, X., Bazaïri, H., 2010. Population dynamics and secondary production of the cockle *Cerastoderma edule*: comparison between Merja Zerga (Moroccan Atlantic Coast) and Arcachon (French Atlantic coast). J. Sea Res. 63191–63201.

Gayanilo, F.C., Sparre, P., Pauly, D., 2005. FAO-ICLARM Stock Assessment Tools II - Revised Version. FAO, Rome.

George, E.L., Nair, N.B., 1974a. The growth rate of the estuarine mollusc *Musculista arcuatula* Yamamoto and Habe (Bivalvia: mytilidae). Hydrobiologia 45, 239–248, 2-3.

George, E.L., Nair, N.B., 1974b. Observation on *Bucephalus* sp. parasitic in *Musculista arcuatula*. J. Invertebr. Pathol. 2463–2469.

Glé, C., 2007. Structure et dynamique des communautés microbiennes autotrophes et production primaire planctonique dans une lagune côtière macrotidale, le Bassin d'Arcachon. Facteurs de contrôle de type bottom-up 1, 309. University Bordeaux.

Hamza, H., Mammeria, A.B., Bairi, A., De Wit, R., Klein, J., 2022. First record of the invasive Asian date mussel *Arcuatula senhousia* (Benson, 1842) in El Mellah Lagoon (Southern coast of Algerian Basin, Western Mediterranean). Bioinvasions. Rec. 11 (3), 686–699. https://doi.org/10.3391/bir.2022.11.3.11.

Hosozawa, T., Kunii, H., Nakamura, M., Ojima, T., Sugiyama, Y., Yamaguchi, K., 2020. Spatial, temporal and vertical variation of distribution and major habitats in Asian mussel (*Arcuatula senhousia*) in a brackish river along Sea of Japan. Plankton Benthos Res. 15 (2), 121–131. https://doi.org/10.3800/pbr.15.121.

Ishii, R., Kawakami, S., Sekiguchi, H., Nakahara, Y., Jinnai, Y., 2001. Larval recruitment of the mytilid *Musculista senhousia* in ariake sound, Southern Japan. Venus 60, 1-2 37-55.

Ishii, R., Sekiguchi, H., Jinnai, Y., 2005. Vertical distributions of larvae of the clam *Ruditapes philippinarum* and the striped horse mussel *Musculista senhousia* in eastern Ariake Bay, southern Japan. J. Oceanogr. 61 (5), 973–978. https://doi.org/10.1007/s10872-006-0013-2.

Jones, C.G., Lawton, J.H., Shachak, M., 1994. Organisms as ecosystem engineers. Oikos 69373–69386.

Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M.E., Oztürk, B., Grabowski, J.H., Golani, D., Cardoso, A.C., 2014. Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. Aquat. Invasions 9 (4), 391–424.

Kushner, R.B., Hovel, K.A., 2006. Effects of native predators and eelgrass habitat structure on the introduced Asian mussel *Musculista senhousia* (Benson in Cantor) in southern California. J. Exp. Mar. Biol. Ecol. 332 (2), 166–177. https://doi.org/10.1016/j.jembe.2005.11.011.

Marraffini, M.L., Geller, J.B., 2015. Species richness and interacting factors control invasibility of a marine community. P. Roy. Soc. B.-Biol. Sci. 2821–7.

Marshall, D.J., 2009. Predatory and reproductive responses of the estuarine whelk *Thais gradata* (Caenogastropoda: Muricidae) to novel colonization by *Musculista senhousia* (Bivalvia: Mytilidae). J. Mar. Biol. Assoc. U. K. 891387–1393.

Massé, C., Jourde, J., Fichet, D., Sauriau, P.G., Dartois, M., Ghillebaert, F., Dancie, C., 2022. Northern range expansion of the Asian mussel *Arcuatula senhousia* (Benson, 1842) along the French Atlantic coasts. Bioinvasions. Rec. 11 (3), 700–709. https://doi.org/10.3391/bir.2022.11.3.12.

Mastrototaro, E., Matarrese, A., D'Onghia, G., 2003. Occurrence of *Musculista senhousia* (Mollusca: Bivalvia) in the Taranto seas (eastern-central Mediterranean sea). J. Mar. Biol. Assoc. U. K. 83, 6 1279–1280. https://doi.org/10.1017/s002531540300866x.

Maurer, D., 1989. Approche Des Relations Entre La Croissance De L'Huître *Crassostrea Gigas* Et Le Milieu Dans Le Bassin D'Arcachon. IFREMER report DRV 89.034-E, Arcachon.

McDonald, J.I., Wells, F.E., 2010. The apparent demise of the asian date mussel *Musculista senhousia* in Western Australia: or using acts of god as an eradication tool Biol. Invasions 12 (4), 715–719. https://doi.org/10.1007/s10530-009-9478-4.

Miller, A., Inglis, G.J., Poulin, R., 2008. Use of the introduced bivalve, *Musculista senhousia*, by generalist parasites of native New Zealand bivalves. New. Zeal. J. Mar. Fresh 42 (2), 143–151. https://doi.org/10.1080/00288330809509944.

Mistri, M., 2002. Ecological characteristics of the invasive Asian date mussel, *Musculista senhousia*, in the Sacca di Goro (Adriatic Sea, Italy). Estuaries 25 (3), 431–440. https://doi.org/10.1007/bf02695985.

Mistri, M., Rossi, R., Fano, E.A., 2004. The spread of an alien bivalve *Musculista senhousia* in the Sacca di Goro Lagoon (Adriatic Sea, Italy). J. Molluscan Stud. 70257–70261. https://doi.org/10.1093/mollus/70.3.257.

Morton, B., 1974. Some aspects of the biology, population dynamics, and functional morphology of *Musculista senhausia* Benson (Bivalvia, Mytilidae). Pac. Sci. 28.

Munari, C., 2008. Effects of the exotic invader *Musculista senhousia* on benthic communities of two Mediterranean lagoons. Hydrobiologia 61129–61143.

Pauly, D., Munro, J.L., 1984. Once more on the comparison of growth in fish and invertebrates. Fishbyte 2 (1), 21–22.

Sanchez, F., Caill-Milly, N., Lissardy, M., 2018. Campagne D'Évaluation Du Stock De Palourdes Du Bassin D'Arcachon - Année 2010. Ifremer, pp. 1–61.

Sgro, L., Munari, C., Angonese, A., Basso, S., Mistri, M., 2005. Functional responses and scope for growth of two non-indigenous bivalve species in the Sacca di Goro (northern Adriatic Sea, Italy). Ital. J. Zool. 72 (3), 235–239. https://doi.org/10.1080/11250000509356677.

Sgro, L., Turolla, E., Rossi, R., Mistri, M., 2002. Sexual maturation and larval development of the immigrant Asian date mussel, *Musculista senhousia*, in a Po River deltaic lagoon. Ital. J. Zool. 69 (3), 223–228. https://doi.org/10.1080/11250000209356463.

Smaal, A.C., 1997. Food supply and demand of bivalve suspension feeders in a tidal system. Groningen 235.

SOGREAH, 2001. Bassin d'Arcachon - Amélioration de l'hydraulique réflexion sur la programmation des travaux. SOGREAH report 71 1027 R - Syndicat Intercommunal du Bassin d'Arcachon 1–17.

Takenaka, R., Komorita, T., Tsutsumi, H., 2016. Secondary production of the Asian mussel, *Arcuatula* (*Musculista*)*senhousia*, population in the Midori River Tidal Flats, Kyushu, Japan. Jpn. J. Benthol. 7117–24.

Takenaka, R., Komorita, T., Tsutsumi, H., 2018. Accumulation of organic matter within a muddy carpet created by the Asian date mussel, *Arcuatula senhousia*, on the Midori River tidal flats, Japan. Plankton Benthos Res. 131–139. https://doi.org/10.3800/pbr.13.1.

Valiky, J.M., 1990. Determination and Comparison of Growth in Bivalves, with Emphasis on the Tropics and Thailand. Christian-Albrechts-Universität, Kiel, Germany.

Walne, P.R., Mann, R., 1975. Growth and biogeochemical composition in *Ostrea edulis* and *Crassostrea gigas*. 9th European Marine Biology Symposium, pp. 587–607.

Watson, G.J., Dyos, J., Barfield, P., Stebbing, P., Dey, K.G., 2021. Evidence for self-sustaining populations of *Arcuatula senhousia* in the UK and a review of this species' potential impacts within Europe. Sci. Rep.-U.K. 11, 1. https://doi.org/10.1038/s41598-021-86876-x.

Yamamuro, M., Hiratsuka, J., Ishitobi, Y., 2000. Seasonal change in a filter-feeding bivalve *Musculista senhousia* population of a eutrophic estuarine lagoon. J. Mar. Syst. 26 (2), 117–126. https://doi.org/10.1016/s0924-7963(00)00048-8.

Yamamuro, M., Oka, N., Hiratsuka, J., 1998. Predation by diving ducks on the biofouling mussel *Musculista senhousia* in a eutrophic estuarine lagoon. Mar. Ecol. Prog. Ser. 174101–174106.

Yasser, A.G., Naser, M.D., Abdul-sahib, I.M., Son, M.O., Oliver, P.G., 2023. First record of the invasive non-native Asian date mussel *Arcuatula senhousia* (Benson 1842) (Mollusca: bivalvia: mytilidae) from Shatt Al-Basra h Canal. Basrah, Iraq. Bioinvasions. Rec. 12, 1 265–271. https://doi.org/10.3391/bir.2023.12.1.22.