Title

Naked clams: a comprehensive analysis of their global potential for commercial aquaculture

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Abstract (250 words max)

"Blue foods" from aquaculture provide an invaluable source of nutrition but can be resource-intensive and relatively unsustainable to produce. Naked clam aquaculture, the farming of wood-boring bivalves of the family Teredinidae, offers a means to rapidly and sustainably convert wood into a low-environmental impact and nutrient-dense protein. Naked clam aquaculture is unique due to the ease in which culture can be performed with minimal infrastructure, making it an ideal candidate to alleviate protein scarcity even on small-scale family farms. Here we perform the first comprehensive global analysis of naked clam sizes and growth rates to identify optimal species for yield and suitable locations for aquaculture. We find that naked clam species grow at three times the rate of commercially farmed blue mussels (*Mytilus edulis*) and reach much greater final sizes (including species that exceed 1.5m in length), despite not being optimised for aquaculture. We also consolidate reports on the confirmed and suspected nutritional attributes of naked clams, including their high vitamin B_{12} levels and other health claims, and identify direction for further quantitative analysis and application to the food sector. To support the development of naked clam aquaculture globally, we outline a strategic roadmap addressing key research and development priorities, including species selection, growth optimisation and disease prevention. With their rapid growth, high yields and potential for scalability, naked clams represent a transformative opportunity to expand aquaculture that is both profitable and sustainable, while addressing critical challenges in global food security and human health.

1. Introduction

Nutritional security is an increasingly pertinent issue to our global population. According to Passarelli et al. 2024, at least two-thirds of the population worldwide (5 billion people) have inadequate micronutrient intakes [1]. However, concurrently, there is a push to minimise greenhouse gas emissions and reduce the land use of food production activities [2]. Unfortunately, conventional food production processes are often resource-intensive, major contributors to pollution, and detrimental to natural habitats - there is a sustainability issue at its core[3]. These issues are evident in the current aquaculture of "blue foods", which are foods sourced from aquatic environments [4]. Historically, aquaculture of shrimp and salmon for example has been environmentally costly due to a high dependence on wild-caught fishmeal and fish oil and a relatively high carbon footprint [5–7]. While we work towards more sustainable aquafeed, the increasing demand means that aquafeed still makes up a high proportion of the carbon footprint [8,9]. Shrimp production often requires deforestation of mangroves to make space for the aquaculture farms, and increased land clearing for soybean farm expansion to match the dietary needs of the shrimp, though it should be noted that there are ongoing efforts to reverse these impacts [10,11]. Salmon aquaculture can also result in nutrient pollution, with excess food and faeces raising nutrient levels, and creating anoxic water conditions that stress aquatic organisms.

Recently, salmon aquaculture operators have shifted towards stricter monitoring and regulations to limit such detrimental effects [12,13]. While "blue foods" play a critical role in improving food security, there is a need to work towards diversifying their supply and improving their sustainability [14]. A greater variety of farmed species could boost resilience against food system hazards such as disease, provide more options for new aquaculture setups, and bolster efficiency in current aquaculture setups through activities including polyculture and multitrophic aquaculture. This could help prevent issues such as sea lice causing Atlantic salmon mortalities from affecting seafood supply [15]. Species diversification also allows the use of a wider range of feedstocks, reducing supply chain stress on current feedstocks, as different aquaculture species have varying nutritional needs [7,16,17]. Bivalve aquaculture offers a low feed input, low pollution, low carbon alternative, but is itself a sector riddled with limitations on efficiency and output [17,18]. The shells of clams, mussels, oysters and scallops impose a biological constraint, as a significant proportion of their energy budget and growth is directed towards shell production, reducing the efficiency of meat yield for human consumption [19,20]. There is a need to continue to drive improvements in sustainability and meat yield efficiency across the bivalve aquaculture production sector, including exploration and adoption of alternative systems.

Naked clam aquaculture is a potential solution to some of these challenges and is emerging as an attractive solution to nutritional security [5,21]. Formerly known as "shipworms," naked clams are bivalves that typically bore into and consume wood, transforming the energy in wood to metabolic products such as proteins [21]. Unlike other bivalves, naked clams have highly reduced shells and elongated bodies that extend almost entirely outside of the shells. These wood-eating bivalves have undergone a rebrand to make them more appealing to consumers while addressing the scientific inaccuracy of their former name — after all, they are bivalves, not worms [21,22]. While sharing many of the advantages of other bivalve aquaculture systems, with a predicted low carbon footprint, and no need for aquafeeds from traditional sources [17,23], naked clams offer further potentially sector-changing benefits, which sets them apart from the other bivalves. They exhibit considerably faster growth rates and larger sizes compared to commonly farmed bivalves, enabling higher yields in shorter time frames [5,21]. [5] Rather than relying on conventional feeds, naked clams grow on wood – a completely sustainable resource. This includes low-grade wood and forestry materials left over from timber production that have limited commercial value, and even waste wood products intended for landfill. By converting these resources into high-quality protein, naked clam aquaculture not only enhances sustainability but also exemplifies circular economy principles, particularly in regions of high poverty and food insecurity, by repurposing underutilised low-cost byproducts into food.

Interestingly, naked clams may also be one of the first aquaculture species cultivated by humans. Evidence suggests they were farmed over 8,000 years ago by Aboriginal Australians and remain a prized delicacy worldwide [22,24,25]. Today, they are particularly popular across Southeast Asia and Northern Brazil, where they are renowned for their taste, versatility, and health benefits [5]. In the Philippines, they are known locally as 'tamilok', have been consumed with liquor, or dipped in coconut vinegar with salt and chili [26,27]. In Thailand, raw naked clams have been served in salads, mixed with fish sauce, chilies and shallots [28]. A recent social media survey on their perception and consumption found that 85% of people that try them – like them. These established culinary traditions underscore the potential for global expansion of naked clam aquaculture, provided sufficient industry and culinary support across the value chain [22]. The groundwork for naked clam aquaculture has already begun, with the development of the world's first laboratory-scale naked clam aquaculture system marking a pivotal step towards commercial production [5,21,22]. As demand for sustainable protein sources grows, naked clams offer an environmentally friendly alternative with vast untapped potential.

Naked clam aquaculture fundamentally relies upon the wood-boring ability of the organisms. This trait is facilitated by their unique biology and the ability to digest wood, fix nitrogen, and build proteins due to the presence of specialised symbiotic bacteria – extraordinary adaptations that underpin their ecological and aquaculture potential [29–31]. Historically, this ability to consume wood has had significant global consequences. During the Age of Sail, they were notorious for causing extensive damage to wooden ships (hence the name "shipworms"), fishing gear, piers, and sea defences [32–34]. Their destructive impact shaped history, with several notable events, including those involving explorers like Columbus and Cook, influenced by the havoc they wreaked on maritime infrastructure. Over centuries, this led to billions of dollars in damages and drove research focused almost exclusively on preventing their settlement and identifying wood resistant to biodegradation [35,36]. Damage from marine wood-borers and efforts to prohibit them still exist today [37].

This historical emphasis on mitigation, however, stands in stark contrast to contemporary efforts aimed at facilitating and optimising their growth for aquaculture. As a result, key aspects of naked clam biology remain poorly understood. Critical questions, such as how they consume wood, how large they can grow, how long they live, and what conditions optimise their growth, remain unanswered. It is vital to address these questions to select suitable species of naked clams and tailor the conditions of aquaculture to enhance their growth to maximise yield obtained.

One of the few available metrics for understanding naked clam growth comes from studies documenting the rate at which they degrade wood [38,39]. These degradation rates,

recorded across history to assess structural damage, offer indirect insight into their growth rates, a critical feature to understand in any effort of establishing commercial aquaculture [40,41]. However, a comprehensive inventory of degradation rates, growth rates, and size potential across naked clam species is still lacking. Similarly, comparative data with other commercially farmed bivalves are sparse, creating a critical knowledge gap that must be addressed to advance aquaculture efforts.

In this review, we provide the first comprehensive meta-analysis on the growth rates, sizes (hereon also referred to as yield), and global distribution of naked clams. Additionally, we provide an inventory of anecdotal nutritional benefits to guide future research and highlight the potential of naked clams as a scalable, sustainable, and nutritious food source. By shifting the focus from managing their impact as a pest to harnessing their potential as food, naked clams can be transformed from a destructive force of the past into a cornerstone of sustainable aquaculture for the future.

2. Methodology

Location data was gathered mainly from the Smithsonian Tropical Research Institute's InvertEBase as well as 21 publications (Appendix I) [24]. Growth, length, and anecdotal nutritional data on naked clams were obtained from an exhaustive search of both academic literature and material that is not commercially or academically published (grey literature). Google Scholar was used to search for academic publications and Google was used to search for grey literature [42]. The search terms used were "shipworms", "Teredo", "growth rate of shipworms", "length of shipworms", "weight gain rate of blue mussels", "shipworm nutritional profile", "blue mussel nutritional profile", "tamilok", "shipworm consumption", "shipworm wood destruction". Search data collected were logged in separate spreadsheets using Google Sheets (see Appendices I-III) [43]. A discovery curve approach was used to ensure the search was exhaustive [44]. In this approach, we searched for new publications until the number of new relevant publications found had plateaued near zero, where each new search yielded negligible added returns. It is also critical to point out that the search was conducted in English, as well as through the internet, thus publications in other languages and in journals that are not available online would not be obtained through the search. At search completion a total of 50 publications were obtained for use in the collation of naked clam length and growth rate data, and nine publications for use in the collation of anecdotal evidence on health.

Direct comparison of the growth rates of naked clams compared to conventionally farmed bivalves was facilitated by a conversion process. We used blue mussels (*Mytilus edulis*) as a representative for commercial bivalves to compare the growth rates of naked clams with commercial bivalves. As blue mussels have typical bivalve shells while naked clams feature highly reduced shells, and the general morphology of their soft edible tissues are

different, wet meat weight is used in the comparison. Rate of wet meat weight gain of the naked clams was derived by converting naked clam growth rate in mm/day using a length-to-weight conversion. A set of 8 data points from the species *Bankia carinata* was used because, to the best of our knowledge, it is the only available data for which both wet meat and length data available [40]. These data consist of length and corresponding wet weight, which allowed us to average the quotient of weight divided by length to obtain the conversion factor. [40]. This conversion factor is appropriate for the typical shipworm of the approximate morphology as *B.* carinata, but we acknowledge it will scale less optimally for very thin (e.g. Lyrodus medilobatus) or fat (e.g. Bankia setacea) naked clam species, and emphasise a need for further experimental research on this topic. Wet meat weight gain rates of blue mussels were obtained directly from Lander et al. (2012), which quantifies growth rates in high performing mussel farms [45]. Predicted lengths of naked clams were obtained by multiplying their growth rates (mm/day) by 183 days (6 months). Predicted wet meat weights of naked clams and blue mussels were obtained by similarly multiplying their wet meat weight gain rate (mg/day) by 183 days. Software packages were used for data processing without the assistance of artificial intelligence. R (4.3.2) and RStudio (2023.12.1) were used to generate boxplots, bar charts and a radar chart (see Appendices II-IV and Figures R Text file). Package fmsb was used to generate the radar chart[46].

Google Sheets was used to generate the table of anecdotal evidence. Google Images was used to find reference images of naked clams, from which Sketchbook was used to hand-illustrate diagrams of naked clams [47]. Google Slides was used to create the naked clam locality map and the flowchart.

3. Global Distribution, Growth Rate, & Sizes of Naked Clams

Our study provides a comprehensive-to-date inventory of the global distribution, growth rates, and reported sizes of naked clams. This aims to inform the potential development of commercial aquaculture by identifying which species may be best to cultivate and grow in each global region, and to encourage the development of the sector without moving species outside of their naturalised ranges.

The global distribution of naked clams is well documented [35,48]. However, species distribution with associated growth rate has never been undertaken and this is a fundamental gap in understanding potential target species for regionally focused aquaculture. We demonstrate that potential target species are distributed globally across almost all latitudes and longitudes (Figure 1). Some species have specific geographic regions. For example, *Nototeredo norvagica,* to our knowledge, is found in the North Atlantic and Mediterranean regions, having only been observed in Canada and Europe.

Comparatively, species such as *Teredo navalis* and *B. carinata* are cosmopolitan and have been documented globally. The number of species observed with recorded growth rates in different countries also varies. For instance, two naked clam species with growth rate data have been recorded in Canada, whilst growth data of naked clams has not been recorded in Great Britain.

It is important to note that bias in data collection likely plays a part in the disparity between the number of species recorded globally with at least one corresponding record of growth rate data. As a case in point, our data shows the United States of America (USA) has the highest recorded number of naked clams with associated growth rate (12 out of 17 species logged on the map). This is likely influenced by greater levels of research on naked clams in this region, the historic case studies documenting economic damage to wooden structures, and also the trend for a greater number of academic publications focused on the US and Western Europe [33,34,49]. The search for publications was also conducted in English, which limits the data collected from non-English sources. This could explain the reduced number of species located in non-English speaking countries such as China. In addition, our dataset only contained the distribution of naked clams that have at least one growth rate record with corresponding locality data. It is therefore only a subset of global naked clam distribution and does not reflect the true species richness of naked clams per region.

Growth rate is a critical factor when selecting local naked clam species for aquaculture. To this end, we have mapped growth rate data and geographic location in Figure 1, whereby larger circle sizes indicate greater growth rate on a proportional scale (with collative values available in Appendix 1). In regions where there are multiple species present, the fastest-growing species is likely preferable for aquaculture. For example, *Nausitora hedleyi* may be the preferred choice for aquaculture in India as its growth rate exceeds that of other species found locally. While we recognise that naked clam biodiversity is far higher than the 17 species recorded herein, our results provide a crucial foundation for identifying high value target species for aquaculture globally. Even so, it is still important that research continues to characterise the remainder of the 83 species in the Teredinidae family worldwide accepted by the World Register of Marine Species (https://www.marinespecies.org), in parallel with exploring the use of better understood species such as *N. hedleyi* and *Bankia setacea* for aquaculture [22]. It is also important to acknowledge that growth rates are highly dependent upon settlement density, temperature, salinity, wood type, density, toxicity, and silica content, and that a greater quantity of data with these metadata components, alongside the number of individuals measured would allow formal comparison of species in order to improve aquaculture optimisation. As naked clams are keystone species and ecosystem engineers, playing a

fundamental role in biodegradation, carbon cycling and habitat creation, further research on basic aspects of their biology has major importance beyond aquaculture [50,51].

Alongside the location-tagged growth rate data depicted in Figure 1, size and growth rate data of 29 species of naked clams, regardless of whether they have corresponding location data, has been extensively collated (Figures 2, 3, 4, also see Appendices II and III). It is expected that for aquaculture, larger naked clams may be more desirable as it would allow fewer individuals to yield the same amount of meat as many smaller individuals, whilst potentially requiring less effort to rear and harvest. Naked clam sizes are shown in Figure 2, and we find that *B. setacea* (median: 340mm, range: 11 to 980mm (2s.f.)) and *B. carinata* (median: 190mm, range: 8 to 300mm) have some of the largest reported sizes. *Bactronophorus thoracites*, *Bankia campanellata*, *N. norvagica* and *Psiloteredo megotara* may also potentially grow to considerable sizes – but we acknowledge here that more data points will be needed to confirm whether or not the available data represent the norm or are anomalies. Although some reports for *Kuphus polythalamius* suggest a middle-of-the road size (Fig. 2, median: 140mm, range: 34 to 1600mm) compared to other naked clams, this species has been reported to exceed 1600mm in length and up to 10 cm in width, making it the world's longest bivalve [52], and therefore of significant aquaculture potential. However, this potential must be weighed against the apparent obscurity and rarity of this giant, for which there exists very little information on basic aspects of the biology, biogeography and life history.

The shortest naked clam species studied so far include *Lyrodus medilobatus* (median: 25mm, range: 10 to 40mm), and such species may be less suitable for large scale production. It should be noted that short naked clams do not automatically equate to unsuitability for aquaculture. If the reproduction rates are high enough to produce many small individuals that can match the tissue volume of few large individuals, or if smaller individuals have other fitness advantages, like longer lifespans such as in the case for spawners (*B. carinata*) compared to short-term brooders (*T. parksi*), the species could still be a viable option [53].

Alongside absolute size, growth rate is a central component of selecting species to use in aquaculture. There is a desire for faster-growing species that provide greater yields and a more productive and competitive aquaculture sector. Meta-analysis of past literature on growth rates of different naked clams identifies species that may be most suitable for aquaculture. Our analysis found a large variation in growth rates between species, with the highest growth rates of 9.9mm/day and the lowest of 0.0083mm/day (Figure 3A). *Bankia gouldi* is one of the fastest growing species, with growth rates ranging from 0.03 to 6.2mm/day and a median of 2.6mm/day, with *B. setacea* growing relatively quickly as well, ranging from 0.33 to 4.1mm/day with a median of 2.0mm/day. *B.*

campanellata, *N. norvagica*, and *N. hedleyi* are also promising, though more data needs to be gathered to support the validity of the high growth rate data reported. On the other end of the spectrum, the genus *Lyrodus* grows generally more slowly, with variation within this group too; *Lyrodus bipartitus* (0.020mm/day) grows much slower than *L. pedicellatus* (median: 0.72mm/day, range: 0.17 to 1.19mm/day).

Further research is needed to better understand how growth rates correlate with each stage of the life cycle, as the data collected is not age specific. We also use the growth rates to report the predicted lengths of naked clams after 6 months (Figure 3B). This reveals impressive lengths of naked clams of up to 1800mm (1.8 metres!) (*N. hedleyi*), which further exemplifies their suitability to be farmed for mass food production. We acknowledge that these predicted sizes assume that naked clams grow constantly and consistently at their reported growth rates for 6 months. However, these predictions demonstrate the incredible potential of naked clams for mass food production, which could be further enhanced through optimisation of growth conditions.

To highlight the potential of naked clams as an aquaculture species, we compared their growth rates against a commercially farmed bivalve species - the blue mussel (*Mytilus edulis*). Converting the growth rate in terms of length (mm/day) into rate of gain of wet meat weight (mg/day) allows the comparison of growth rates between the vermiform-shaped naked clams and conventional bivalves. Following this analysis, 13 out of the 19 naked clam species analysed were found to have higher median wet meat weight gain rate than blue mussels (Figure 4A), with 14 out of the 19 species also having a higher mean wet meat weight gain rate than blue mussels. Most notably, one of the fastest growing species identified, *B. gouldi* (median: 35mg/day), grows at almost three times the rate of blue mussels (median: 12mg/day). This is despite the fact that blue mussels are a long-established food source with a developed mariculture production protocol, whilst naked clams are still an emerging food source. This suggests that the already superior growth rates of naked clams can be further boosted through optimisation.

Using these data to predict the wet meat weight of the bivalves after 6 months, the difference between the amount of wet meat available for harvest from naked clams and blue mussels is further emphasised, with species such as *B. setacea* and *T. navalis* generating particularly large wet meat outputs due to their high growth rates. We suggest that the potential for naked clams to deliver growth rates and biomass outputs far exceeding that of conventional bivalve aquaculture is a key factor that could support the potential success of a naked clam aquaculture sector. To provide perspective, In the United Kingdom alone, consumers purchased £8.7 billion worth of seafood in 2019 [54]. Hypothetically, if a new naked clam sector, buoyed by fast production rates, could capture

or add an additional 5% to this, it would be worth over £400 million, showing potential of naked clams to support a sustainable means of economic growth in aquaculture.

4. Nutritional Profile – Evidence and Anecdotes

Our review reveals that there is very little quantitative data available on naked clam nutritional profiles and health benefits, despite a wealth of anecdotal claims, highlighting this as a key area requiring further research.

The quantitative analyses done to date come solely from a publication by Willer et al 2023 in *npj Sustainable Agriculture*, and an article by Sinyo et al in 2022 in the *International Journal of the Bioflux Society* [21,55]. Nutritional profiling from Willer et al. (2023) reveals that naked clams contain comparable levels of carbohydrates, proteins, lipids and more Vitamin B_{12} than blue mussels for each unit of dry meat weight, with naked clams consisting of 26% proteins, 18% carbohydrates, 3.7% lipids, and 0.014% vitamin B_{12} in dry weight [21]. The Willer et al. 2023 paper also provided a complete fatty acid analysis [21]. Sinyo et al. (2022) found that the proximate content of the naked clam species *Teredo navalis* comprises 13% proteins, 45% carbohydrates, 1.1% lipids, and 0.056% crude fibre, with no data on vitamin B_{12} content [55]. This Sinyo et al. 2022 data is of limited quality and was not obtained using experimental protocols but rather calculated using a formula by the Association of Official Analytical Chemist (2005) [55,56]. We also highlight that the specimens used in this study were likely misidentified as *Teredo navalis* and are likely to be *Bactronophorus thoracites* based on images of the pallets. Further extensive nutritional profiling of naked clams is imperative to gain a better understanding of the variation in nutritional content across different species; *Teredo navalis* is just one species; as well as greater information on micronutrient content.

In comparison to the sparsity of quantitative data on naked clam nutritional profiles, there are a large range of anecdotal claims on their nutritional benefits, which, if formally quantified, could validate their purported health benefits and highlight their value in addressing global nutritional challenges. There are multiple reports stating that naked clams improve reproductive function and physical fitness (Table 1) and act as a general sickness tonic. These reports, including an extensive social media meta-analysis on sentiment and culinary practices, are mainly accounts from people who have been consuming them as a local delicacy, particularly in Australia, northern-Brazil, and south-east Asia [22]. For instance, the anecdotes collected by Tsuji (2021) were from interviews conducted with locals in the Philippines, who hold the belief that the naked clam *B. thoracites* has medicinal benefits [26]. These benefits included improvements in human breast milk quality and treating diarrhoea, with an indication that these features may possibly stem from the mangrove trees that the naked clams feed on.

Unfortunately, these anecdotal claims are either not yet or currently poorly backed by scientific evidence. Without formal evidence, claims that naked clams improve mothers' breast milk could simply be an association between the bivalve's milky white colour and the colour of milk. The presence of possibly Artificial Intelligence-generated research papers covering the nutritional profile of naked clams such as Leiwakabessy et al. (2024) further weakens the credibility of the information reported [57]. Thus, these anecdotal claims should be thoroughly and quantitatively researched to prove their validity and to provide formal scientific explanation. Ultimately, information from locals who have been eating naked clams can be useful in driving the direction of research, informing us of specific nutritional avenues to investigate. Anecdotal information on other aspects of naked clams such as taste (Tsuji 2021) is valuable as well, given developing methods to make the bivalve more palatable to the global population will likely be a key component to their success as a novel food [5,21,22]. In the past, research and development of niche cultural food has successfully introduced them to the global market, proving that this feat is possible with naked clams as well. One notable example is Tongkat Ali (*Eurycoma longifolia* Jack), a herbal medicine. Originally used in Southeast Asia for its medicinal properties like hormonal balance restoration, research into the herb unearthed the chemical compounds that are behind these effects [58,59]. This both proved the credibility of the locals' beliefs in Tongkat Ali's beneficial nature and opened an avenue for novel medicines to develop, growing the Tongkat Ali market into a multi-billion-dollar industry [60,61].

Anecdotes from locals can also be important in driving global acceptance and willingness to adopt naked clams as a novel food [22]. With descriptions of the bivalves tasting like oysters, a worldwide delicacy, the western world may be more inclined to try them [62]. This is supported by comparisons between naked clam dishes, such as Filipino kinilaw, and globally recognised dishes like ceviche[63]. The added familiarity of the dishes may reduce apprehension in incorporating naked clams into Western diets [64]. Thus, with further quantitative research, the existing anecdotal evidence may provide a useful steering role to help gradually build a more global market for sustainable naked clam protein.

5. Optimal Aquaculture Conditions

Naked clams have been a notorious menace to mariners, seafarers and coastal communities over centuries, causing incalculable damage to wooden structures (e.g. boats, fishing equipment, jetties, piers, sea defences, etc.) which continues to this day, although to a reduce level due to modern maritime engineering protection techniques [32–34,65]. Such was their impact that there exist several notable instances where they have changed the course of history, from Columbus to Cook [66]. As such, historical research on these animals has focussed on prohibiting their settlement and development, which is antithetical to contemporary efforts seeking to facilitate and optimise their growth for

aquaculture. It is within the context of this deficit that we provide the first meta-analysis on factors that promote their growth and provide a roadmap towards their optimisation for aquaculture to deliver on their immense potential as a scalable food source.

A potential step-by-step pathway to set up an aquaculture environment tailored to naked clams is presented in Figure 5. In brief, before considering the environmental conditions, prime locations for naked clam aquaculture must be identified. Naked clam aquaculture would likely be in open water coastal locations, or in terrestrial locations with the facilities and infrastructure to establish land-based tanks. It will also be important to set up aquaculture sites in areas with either high forestry activity for ease of obtaining leftover wood, or with the trade connections to sustainably obtain wood waste at low environmental and economic cost. It is also important to consider areas that struggle with poverty and food insecurity – which could hinder the prospect of setting up larger scale industrial aquaculture systems without appropriate backing and support. Financial aid from global organisations and programs such as the United Nations (International Fund for Agricultural Development) and the Global Agriculture and Food Security Program could ensure the projects are brought to fruition [67,68]. Equally, simpler, smaller-scale, family-level naked clam aquaculture operations could be an ideal solution to food insecurity in these regions that lack many industrial resources and infrastructure components seen as commodities in the developed world, with at the most basic level wood and saltwater being the only requirements for naked clam production. The location chosen would then determine the target species to be farmed (Fig. 1).

Temperature and salinity are important factors in determining the growth and survival of naked clams. High temperatures generally favour increased growth. For example, growth rates and boring activity of *T. navalis* have been observed to be higher in warmer waters of 15-25°C, dropping when the water temperatures fell below 15°C, with boring activity halting at temperatures below 5°C [69,70]. This has also been seen in other naked clams such as *T. furcifera*, where maximum increases in burrow length (29mm) occurred with the highest temperatures measured (30.9°C) [41]. Greater settlement of naked clams matched higher sea surface temperatures, with longer *T. navalis* recruitment period by 26 days [71]. It is worth noting that some species of naked clams such as *N. norvagica* can still thrive in colder temperatures, which may offer opportunities for cooler water farming [72]. Such species are usually found in northern parts of the world (Figure 1). Different species of naked clams have varying salinity tolerances as well. *T. navalis* was found to tolerate a salinity range of 7‰ to 39‰, with much lower activity when salinity dropped below 9‰, and a lethal threshold of 5‰ [72,73]. *T. bartschi* has a similarly wide salinity tolerance range of 7‰ to 45‰ [74,75]. Unlike *T. navalis* and *T. bartschi*, *B. carinata* has a narrower salinity tolerance range of 35‰ to 39‰ [72]. *N. hedleyi* was documented to attain maximum growth rates with salinity between 8‰ and 20‰, with relatively negligible

growth outside of this range [76]. Outside the ideal temperature and salinity ranges, the growth of naked clams will slow, or can cause mortality, which was observed when individuals were experimentally grown in setups outside of these ranges [69,73–76]. It is therefore important to find the optimal temperature and salinity ranges of any species being farmed, then set the conditions of the aquaculture to match these ranges.

The properties of wood (both chemical and physical), strongly impacts the settlement success and growth rates of naked clams. *L. pedicellatus* and *T. bartschi* in Venice were found to prefer European woods like Scots Pine over tropical woods such as Azobe [65]. *T. navalis* grew longer in softer fir wood (averaging 11.6 cm) compared to harder oak wood panels (averaging 7.0 cm) [77] – a broad trend across species [65,78]. The chemical content of wood consumed not only affects the taste of naked clams as stated in Table 1, but also influences their preference for the wood, with individuals preferring lower tannin *Xylocarpus granatum* over *Rhizophora apiculata* [79]. Wood grain orientation also affects boring rate, and therefore growth rate, where wood with minimal grain changes is preferred [65,80]. These considerations then need to be balanced against the durability of wood – which must be sturdy enough to resist rapid biodegradation and lasting long enough in an aquaculture set-up to minimise resource wastage. Southern pine and Douglas fir were found to be durable in marine environments, while Eastern white pines degraded more easily [80]. Choosing the correct wood to suit both the target naked clam species, and the optimal aquaculture conditions, is important for mass production.

Stocking density must also be optimised to maximise the growth rates and eventual size (yield) of naked clams in aquaculture. For fast-growing species with smaller overall sizes such as *B. gouldi* (Fig. 2, 3), growing many individuals in the same wooden panel is likely a more efficient use of space rather than few individuals, whilst moderating to avoid insufficient wood to fuel the growth of cohabiting naked clams, which would lead to reduced or stunted growth [40]. *B. setacea* was found to grow faster under uncrowded conditions, with mean monthly growth rates of 74 mm/month as compared to 43 mm/month under crowded conditions [81]. Different growth rates of *B. gouldi* individuals in the same estuary were also recorded as being dependent on the number of individuals settling in the same locality (immediate area) [41]. Overcrowding, when too many individuals cohabit the same piece of wood, can lead to the development of dwarfed individuals – termed stenomorphs [41,82]. This can be seen in both the stunted width of *B. setacea*, with a longer individual growing in a crowded panel attaining a smaller diameter than that of a smaller individual instead of growing proportionate to its length [81]. Stenomorphs not only grow slower than typical individuals but also stop growing at a younger age [41]. Thus, it is imperative to effectively control stocking density, maximising the usage the wooden substrate provided and avoiding conditions that lead to stenomorphs.

To further support the growth of naked clams, measures should be implemented to prevent disease. Disease may be caused by viruses, parasites and other microbes like fungi and bacteria which arise from decomposition of any dead naked clams in the stock [83]. With many naked clams living in the same pieces of wood, microbial growth from decay of a small proportion of the stock could have a detrimental impact on production output. To our knowledge, little pathological research has been done regarding naked clams, thus it is essential to investigate possible diseases and their causes before creating preventative measures.

While not necessary for survival, supplemental nutrient provision enhances growth of naked clams. This could be algal supplements such as BioBullets or phytoplankton already present in the water that the bivalves inhabit [17,21,79,84–87]. Further research on the nutritional profile and needs of the naked clams could allow the curation of a supplemental feed that supplies optimal amounts of nutrients to accelerate growth. Naked clams feature a symbiotic relationship with cellulolytic, nitrogen-fixing bacteria, which help digest lignocellulose and supply nitrogen to produce protein [88]. Studies on the ideal bacterial species, or potentially even selective breeding of the symbionts, could be undertaken to increase the efficacy of nutrient uptake and supply to the host.

While there is evidently further research needed to develop naked clam aquaculture, it is reassuring that other seafood aquaculture systems also faced similar initial challenges. For instance, oysters face several diseases such as Multinucleated Sphere Unknown (MSX) and Roseovarius Oyster Disease (ROD), which cause high mortality, lowering the production of oysters in aquaculture [89]. To combat the diseases, scientists have developed resistant forms of oysters and strict management guidelines [90]. Optimal conditions for aquaculture of different animals have also been researched extensively, obtaining essential information such as water temperature and salinity [91–93]. Lessons from the broader aquaculture industry will help address the recommended pathway we have outlined above, facilitating the advancement of naked clam aquaculture.

Conclusion

Naked clam aquaculture represents a transformative opportunity to expand the sustainable seafood sector and provides a solution to wider global nutritional security challenges. Our meta-analysis identifies 24 species with documented growth and size data, mapping their broad distribution across almost all latitudes and longitudes. Among these, several species grow big, fast. Remarkably, two species are recorded exceeding 1.5m in length, and two species grew at rates up to three times as fast as commercially farmed blue mussels. Yet unlike blue mussels, which have undergone decades of aquaculture refinement, naked clams have not yet been scientifically optimised for aquaculture, meaning their already exceptional growth rates and sizes likely represent a

conservative baseline rather than their full potential. Beyond their rapid growth, high yield and global scalability potential, naked clams hold significant promise as a nutrient-dense food source. Early nutritional analyses indicate they contain high levels of protein, vitamin B12, and beneficial fatty acids, surpassing blue mussels in key metrics. Anecdotal evidence also suggests additional health benefits, from improved reproductive health to enhanced physical fitness, and use as a traditional medicine to cure sickness. However, these claims require rigorous scientific validation, for which we identify direction for further quantitative analysis and application to the food sector. To unlock their full potential, we outline a strategic roadmap addressing species selection and aquaculture location, growth optimisation, and disease prevention. Temperature, salinity, wood substrate composition, and stocking density all play critical roles in maximising yields. Further research is needed to refine optimal aquaculture conditions. We envisage a future in which a mix of two aquaculture approaches - low-input, open-sea rearing systems, and intensive fully-optimized terrestrial systems – provide an opportunity for clam aquaculture in both developing and developed economies, and support an explosion in sustainable food production [20,94]. By shifting the narrative from historical pest management to controlled cultivation, naked clams can transition from maritime menace to aquaculture asset. With their rapid growth, minimal environmental footprint, and strong market potential, naked clams can and should redefine the future of bivalve aquaculture production.

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Author Contributions

J.R.J.P: writing – original draft; investigation. J.R.S: writing – review and editing; conceptualisation; supervision. D.F.W: writing – review and editing; conceptualisation; supervision.

Disclosures

D.F.W. and J.R.S. are Co-Founders and Directors of Naked Clam Limited, a UK registered aquaculture company.

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Appendices

Appendix I: Naked Clam Growth Rates by Location.

Species	Average growth rate (mm/day)	Average growth rate	Country	Location	Continent	References

	(2d.p.)	by country (mm/day) (2d.p.)				
Bankia bipalmulata	1.06	1.50	USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	1.06		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	1.64		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	2.69		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	2.08		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	1.18		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	0.91		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	1.93		USA	Waikiki, USA	North America	Edmondson, 1942[95]
Bankia bipalmulata	0.92		USA	Hanauma Bay, USA	North America	Edmondson, 1942[95]
Bankia carinata	0.43	1.26	India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia gouldi	6.17	3.34	USA	Beaufort, North Carolina, USA	North America	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	0.75		USA	Beaufort, North Carolina, USA	North America	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	1.25		USA	Beaufort, North Carolina, USA	North America	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	5.20		USA	Beaufort, North Carolina, USA	North America	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia indica	0.43		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia indica	0.62		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]

Bankia indica	0.93		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia indica	1.10		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia indica	3.04		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia indica	3.31		India	San Thome, Chennai, India	Asia	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia setacea	1.43	1.82	USA	Monterey Bay, USA	North America	Haderlie and Mellor, 1973[81]
Bankia setacea	1.57	1.57	Pacific	Pacific area	Australia	Isham et al., 1951[91]
Bankia setacea	4.07	2.55	Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92], Nair and Saraswathy, 1971[64]
Bankia setacea	0.85		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	1.60		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	1.90		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	2.55		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	2.69		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	2.85		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	3.91		Canada	Ladysmith Harbour, Canada	North America	Quayle, 1959[92]
Bankia setacea	2.47		USA	Monterey Bay, USA	North America	Haderlie and Mellor, 1973[81]

Bankia setacea	0.33		USA	Pacific coast, Friday Harbour, USA	North America	Johnson and Miller, 1935[93], Isham et al., 1951[91]
Bankia setacea	2.10		USA	San Francisco Bay, California, USA	North America	Kofoid and Miller, 1927[83]
Bankia setacea	0.77		USA	San Francisco Bay, California, USA	North America	Kofoid and Miller, 1927[83]
Bankia setacea	1.43		USA	Monterey Bay, California, USA	North America	Haderlie and Mellor, 1973[81]
Bankia setacea	2.47		USA	Monterey Bay, California, USA	North America	Haderlie and Mellor, 1973[81]
Bankia setacea	3.56		USA	Monterey Bay, California, USA	North America	Haderlie and Mellor, 1973[81]
Lyrodus affinis	1.53	1.89	USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.15		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.51		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.39		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	0.88		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.23		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.09		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.26		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.45		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.18		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.32		USA	Oahu, USA	North America	Edmondson, 1942[95]

Lyrodus affinis	1.28		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.45		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.86		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.87		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.72		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.50		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.40		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.35		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.38		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.33		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.49		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	1.62		USA	Oahu, USA	North America	Edmondson, 1942[95]
Lyrodus affinis	2.21		USA	Waikiki, USA	North America	Edmondson, 1942[95]
Lyrodus bipartitus	0.02	0.02	USA	North Carolina, USA	North America	Nair and Saraswathy, 1971[64]
Lyrodus pedicellatus	0.72	0.76	USA	Miami Beach, USA	North America	Isham et al., 1951[91]
Lyrodus pedicellatus	0.59		USA	San Diego, California, USA	North America	Gallager et al., 1981[94]
Lyrodus pedicellatus	0.32		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	0.82		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	1.05		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	0.73		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	1.03		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	0.88		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]

Lyrodus pedicellatus	0.91		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	1.19		USA	Honolulu Harbour, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	0.17		USA	Waikiki, USA	North America	Edmondson, 1942[95]
Lyrodus pedicellatus	0.72		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Nausitora hedleyi	9.93	3.30	India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.33		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.53		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.67		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	1.11		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	2.09		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	3.33		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	3.73		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	5.13		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	6.18		India	Cochin Harbour, India	Asia	Saraswathy and Nair, 1973[70]
Psiloteredo megotara	0.82	0.77	Denmark	Hirtshals, Denmark	Europe	Nair and Saraswathy, 1971[64]
Psiloteredo megotara	2.03	1.73	Norway	Trondheim, Norway	Europe	Nair and Saraswathy, 1971[64]
Psiloteredo megotara	0.71		Denmark	Hirtshals, Denmark	Europe	Nair and Saraswathy, 1971[64]

Psiloteredo megotara	1.43		Norway	Trondheim, Norway	Europe	Nair and Saraswathy, 1971[64]
Teredo bartschi	2.41	1.40	USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.64		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.96		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	0.86		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.19		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.63		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.47		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.78		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.51		USA	Pearl Harbour, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.01		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.28		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.40		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.12		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.97		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	0.94		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	0.77		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.21		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo bartschi	1.28		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]

Teredo bartschi	1.15		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
*Teredo furcifera**	0.94	0.94	India	Visakhapatnam harbour, India	Asia	Nair and Saraswathy, 1971[64]
Teredo navalis	0.67	0.67	Pacific	Pacific area	Australia	Isham et al., 1951[91]
Teredo navalis	0.08	0.94	USA	North Carolina, USA	North America	Nair and Saraswathy, 1971[64]
Teredo navalis	2.41	1.15	Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.80	1.80	Netherlands	Port of Rotterdam area, Netherlands	Europe	Paalvast, 2011[71]
Teredo navalis	1.86	1.86	Canada	Malpeque Bay, Canada	North America	Needler and Needler, 1940[95]
Teredo navalis	2.55		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.22		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.30		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.58		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.66		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.79		Japan	Uchinoumi, Naruto, Tokushima	Asia	Tsunoda, 1979[63]

				Prefecture, Japan		
Teredo navalis	0.80		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.84		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.94		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.95		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.96		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.03		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.08		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.13		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.15		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.22		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]

Teredo navalis	1.22		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.25		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.28		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.32		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	1.66		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	2.20		Japan	Uchinoumi, Naruto, Tokushima Prefecture, Japan	Asia	Tsunoda, 1979[63]
Teredo navalis	0.01		USA	Woods Hole, USA	North America	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.06		USA	Woods Hole, USA	North America	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.28		USA	Woods Hole, USA	North America	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.72		USA	Woods Hole, USA	North America	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	1.15		USA	Woods Hole, USA	North America	Grave, 1928[96], Nair

						and Saraswathy, 1971[64]
Teredo navalis	1.95		USA	Woods Hole, USA	North America	Grave, 1942[97]
Teredo navalis	3.24		USA	Woods Hole, USA	North America	Grave, 1942[97]
*Teredo parksi**	1.00	1.19	USA	Pearl Harbour, USA	North America	Kofoid and Miller, Chapter XVIII, 1927[77]
*Teredo parksi**	1.67		USA	Pearl Harbour, USA	North America	Kofoid and Miller, Chapter XVIII, 1927[77]
*Teredo parksi**	0.89		USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredo triangularis	0.43	0.43	USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1942[95]
Teredora princesae	0.54	0.54	USA	Kaneohe Bay, Oahu, USA	North America	Edmondson, 1962[98]
Nototeredo knoxi	0.76	0.76	USA	Woods Hole, USA	North America	Mann and Gallager, 1985[96]

*Note: Note we advise against these growth rates being formally compared as the sole evidence base for aquaculture species selection, as the datasets do not provide clarity on the number of individuals or environmental conditions, which affect growth rate. Additionally, *Teredo parksi*, a short-term brooder, is a cryptic sister species to *Teredo furcifera*, a long-term brooder. These two species have historically been treated as a single taxon in past literature. As such, reported data may not distinguish between them, and should be interpreted with this taxonomic ambiguity in mind.

Appendix II: Naked Clam Reported Sizes

Species	**Reported size (mm)**	**References**
Bactronophorus thoracites	400	Chan and Lau, 2021[97]
Bactronophorus thoracites	300	Leiwakabessy et al., 2022[98]
Bactronophorus thoracites	150	Leiwakabessy et al., 2022[98]
Bactronophorus thoracites	90	Leiwakabessy et al., 2022[98]
Bactronophorus thoracites	160	Lee et al., 2019[99], Leiwakabessy et al., 2022[98]
Bactronophorus thoracites	470	Lee et al., 2019[99], Leiwakabessy et al., 2022[98]
Bankia bipalmulata	5	Edmondson, 1942[95]

Bankia bipalmulata	35	Edmondson, 1942[95]
Bankia bipalmulata	60	Edmondson, 1942[95]
Bankia bipalmulata	65	Edmondson, 1942[95]
Bankia bipalmulata	75	Edmondson, 1942[95]
Bankia bipalmulata	85	Edmondson, 1942[95]
Bankia bipalmulata	95	Edmondson, 1942[95]
Bankia bipalmulata	135	Edmondson, 1942[95]
Bankia bipalmulata	150	Edmondson, 1942[95]
Bankia bipalmulata	175	Edmondson, 1942[95]
Bankia bipennata	150	Treneman et al., 2018[100]
Bankia bipennata	50	Treneman et al., 2018[100]
Bankia campanellata	259	Raveendran and Wagh, 1988[101]
Bankia carinata	255	Treneman et al., 2018[100]
Bankia carinata	23.13	MacIntosh, 2014[53]
Bankia carinata	26.15	MacIntosh, 2015[102]
Bankia carinata	8	Treneman et al., 2018[100]
Bankia carinata	302	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	9	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	23	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	142	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	224	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	257	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	274	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	290	Nair, 1960[40], Nair and Saraswathy, 1971[41]
Bankia carinata	191	Raveendran and Wagh, 1988[101]
Bankia gouldi	100	Sigerfoos, 1896[103], Sigerfoos, 1908[104]
Bankia gouldi	3	Sigerfoos, 1896[103], Sigerfoos, 1908[104]
Bankia gouldi	6	Sigerfoos, 1896[103], Sigerfoos, 1908[104]
Bankia gouldi	11	Sigerfoos, 1896[103], Sigerfoos, 1908[104]
Bankia gouldi	63	Sigerfoos, 1896[103], Sigerfoos, 1908[104]
Bankia gouldi	1	Mann and Gallager, 1985[96]
Bankia gouldi	2	Mann and Gallager, 1985[96]
Bankia gouldi	22	Mann and Gallager, 1985[96]

Bankia gouldi	35.5	Mann and Gallager, 1985[96]
Bankia gouldi	45	Mann and Gallager, 1985[96]
Bankia gouldi	11	Mann and Gallager, 1985[96]
Bankia gouldi	69.5	Mann and Gallager, 1985[96]
Bankia gouldi	178	Mann and Gallager, 1985[96]
Bankia gouldi	180	Mann and Gallager, 1985[96]
Bankia gouldi	139	Mann and Gallager, 1985[96]
Bankia gouldi	149	Mann and Gallager, 1985[96]
Bankia gouldi	5	Mann and Gallager, 1985[96]
Bankia gouldi	3.5	Mann and Gallager, 1985[96]
Bankia gouldi	80	Mann and Gallager, 1985[96]
Bankia gouldi	90	Mann and Gallager, 1985[96]
Bankia gouldi	26.5	Mann and Gallager, 1985[96]
Bankia gouldi	68	Mann and Gallager, 1985[96]
Bankia gouldi	79.5	Mann and Gallager, 1985[96]
Bankia gouldi	185	Mann and Gallager, 1985[96]
Bankia gouldi	240	Mann and Gallager, 1985[96]
Bankia gouldi	175	Mann and Gallager, 1985[96]
Bankia martensi	30	Almuna et al., 2001[105]
Bankia martensi	145	Almuna et al., 2001[105]
Bankia setacea	610	Quayle, 1959[106], Nair and Saraswathy, 1971[41]
Bankia setacea	10.5	Quayle, 1959[106]
Bankia setacea	36.9	Quayle, 1959[106]
Bankia setacea	86.4	Quayle, 1959[106]
Bankia setacea	139.6	Quayle, 1959[106]
Bankia setacea	223.1	Quayle, 1959[106]
Bankia setacea	340.3	Quayle, 1959[106]
Bankia setacea	419.4	Quayle, 1959[106]
Bankia setacea	482.6	Erlanson, 1936[78]
Bankia setacea	505	Quayle, 1959[106]
Bankia setacea	533.4	Erlanson, 1936[78]
Bankia setacea	25.4	Johnson and Miller, 1935[107], Isham et al., 1951[108]
Bankia setacea	39	Johnson and Miller, 1935[107], Isham et al., 1951[108]

Bankia setacea	920	Quayle, 1992[109]
Bankia setacea	976	Haderlie and Mellor, 1973[81]
Dicyathifer mannii	88	Loo et al., 2019[110]
Dicyathifer mannii	183	Castagna, 1961[111]
Kuphus polythalamius	635	Shipway et al., 2018[52]
Kuphus polythalamius	617	Shipway et al., 2018[52]
Kuphus polythalamius	478	Shipway et al., 2018[52]
Kuphus polythalamius	517	Shipway et al., 2018[52]
Kuphus polythalamius	108	Shipway et al., 2018[52]
Kuphus polythalamius	42	Shipway et al., 2018[52]
Kuphus polythalamius	141	Shipway et al., 2018[52]
Kuphus polythalamius	51	Shipway et al., 2018[52]
Kuphus polythalamius	199	Shipway et al., 2018[52]
Kuphus polythalamius	58	Shipway et al., 2018[52]
Kuphus polythalamius	77	Shipway et al., 2018[52]
Kuphus polythalamius	34	Shipway et al., 2018[52]
Kuphus polythalamius	1600	Wright, 1866[112], Shipway et al., 2018[52]
Lithoredo abatanica	5.5	Shipway et al., 2019[113]
Lithoredo abatanica	105.4	Shipway et al., 2019[113]
Lyrodus affinis	100	Edmondson, 1942[95]
Lyrodus affinis	115	Edmondson, 1942[95]
Lyrodus affinis	115	Edmondson, 1942[95]
Lyrodus affinis	120	Edmondson, 1942[95]
Lyrodus affinis	125	Edmondson, 1942[95]
Lyrodus affinis	125	Edmondson, 1942[95]
Lyrodus affinis	135	Edmondson, 1942[95]
Lyrodus affinis	140	Edmondson, 1942[95]
Lyrodus affinis	150	Edmondson, 1942[95]
Lyrodus affinis	150	Edmondson, 1942[95]
Lyrodus affinis	150	Edmondson, 1942[95]
Lyrodus affinis	150	Edmondson, 1942[95]
Lyrodus affinis	155	Edmondson, 1942[95]
Lyrodus affinis	160	Edmondson, 1942[95]

Lyrodus affinis	160	Edmondson, 1942[95]
Lyrodus affinis	170	Edmondson, 1942[95]
Lyrodus affinis	175	Edmondson, 1942[95]
Lyrodus affinis	175	Edmondson, 1942[95]
Lyrodus affinis	190	Edmondson, 1942[95]
Lyrodus affinis	200	Edmondson, 1942[95]
Lyrodus affinis	200	Edmondson, 1942[95]
Lyrodus affinis	230	Edmondson, 1942[95]
Lyrodus affinis	305	Edmondson, 1942[95]
Lyrodus affinis	5	Edmondson, 1942[95]
Lyrodus affinis	1	Edmondson, 1942[95]
Lyrodus affinis	115	Edmondson, 1942[95]
Lyrodus affinis	47	Edmondson, 1942[95]
Lyrodus affinis	3	Edmondson, 1942[95]
Lyrodus affinis	5	Edmondson, 1942[95]
Lyrodus affinis	5	Edmondson, 1942[95]
Lyrodus affinis	10	Edmondson, 1942[95]
Lyrodus medilobatus	40	Edmondson, 1942[95]
Lyrodus medilobatus	10	Edmondson, 1942[95]
Lyrodus pedicellatus	92.5	Isham et al., 1951[108]
Lyrodus pedicellatus	71.1	Gallager et al., 1981[114]
Lyrodus pedicellatus	12.7	Erlanson, 1936[78]
Lyrodus pedicellatus	25	Ryabchikov et al., 1961[115], Iljin, 2010[116]
Lyrodus pedicellatus	63	Ryabchikov et al., 1961[115], Iljin, 2010[116]
Lyrodus pedicellatus	20	Edmondson, 1942[95]
Lyrodus pedicellatus	25	Edmondson, 1942[95]
Lyrodus pedicellatus	40	Edmondson, 1942[95]
Lyrodus pedicellatus	40	Edmondson, 1942[95]
Lyrodus pedicellatus	50	Edmondson, 1942[95]
Lyrodus pedicellatus	50	Edmondson, 1942[95]
Lyrodus pedicellatus	73	Edmondson, 1942[95]
Lyrodus pedicellatus	75	Edmondson, 1942[95]
Lyrodus pedicellatus	75	Edmondson, 1942[95]

Lyrodus pedicellatus	98	Edmondson, 1942[95]
Lyrodus pedicellatus	45	Edmondson, 1942[95]
Lyrodus pedicellatus	2	Edmondson, 1942[95]
Lyrodus pedicellatus	3	Edmondson, 1942[95]
Nausitora hedleyi	505	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	4	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	9.3	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	10	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	13	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	15	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	15	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	17.3	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	34	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	84	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	115.3	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	208	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	285	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	434	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	490	Saraswathy and Nair, 1973[76]
Nausitora hedleyi	500	Saraswathy and Nair, 1973[76]
Nausitora oahuensis	55	Edmondson, 1942[95]
Nototeredo knoxi	3	Mann and Gallager, 1985[96]
Nototeredo knoxi	5	Mann and Gallager, 1985[96]
Nototeredo knoxi	30	Mann and Gallager, 1985[96]
Nototeredo knoxi	35	Mann and Gallager, 1985[96]
Nototeredo knoxi	56.5	Mann and Gallager, 1985[96]
Nototeredo knoxi	91	Mann and Gallager, 1985[96]
Nototeredo norvagica	863.6	Colgan, 1908[117]
Psiloteredo megotara	286	Nair and Saraswathy, 1971[41]
Psiloteredo megotara	1219.2	Sigerfoos, 1908[104]
Psiloteredo megotara	900	Iljin, 2010[116]
Psiloteredo megotara	100	Barashov and Zevina, 1964[118], Iljin, 2010[116]
Psiloteredo megotara	250	Barashov and Zevina, 1964[118], Iljin, 2010[116]

Teredo bartschi	4	Hoagland, 1983[119]
Teredo bartschi	132	Hoagland, 1983[119]
Teredo bartschi	90	Edmondson, 1942[95]
Teredo bartschi	95	Edmondson, 1942[95]
Teredo bartschi	110	Edmondson, 1942[95]
Teredo bartschi	115	Edmondson, 1942[95]
Teredo bartschi	115	Edmondson, 1942[95]
Teredo bartschi	120	Edmondson, 1942[95]
Teredo bartschi	120	Edmondson, 1942[95]
Teredo bartschi	120	Edmondson, 1942[95]
Teredo bartschi	120	Edmondson, 1942[95]
Teredo bartschi	130	Edmondson, 1942[95]
Teredo bartschi	130	Edmondson, 1942[95]
Teredo bartschi	142	Edmondson, 1942[95]
Teredo bartschi	150	Edmondson, 1942[95]
Teredo bartschi	155	Edmondson, 1942[95]
Teredo bartschi	160	Edmondson, 1942[95]
Teredo bartschi	175	Edmondson, 1942[95]
Teredo bartschi	175	Edmondson, 1942[95]
Teredo bartschi	190	Edmondson, 1942[95]
Teredo bartschi	230	Edmondson, 1942[95]
Teredo bartschi	90	Edmondson, 1942[95]
Teredo bartschi	2	Edmondson, 1942[95]
Teredo clappi	60	Miller, 1924[120]
Teredo clappi	9	Miller, 1924[120]
Teredo clappi	4	Miller, 1924[120]
Teredo fulleri	35	Edmondson, 1942[95]
*Teredo furcifera**	90	Nair and Saraswathy, 1971[41]
Teredo navalis	400	Grave, 1928[121], Nair and Saraswathy, 1971[41]
Teredo navalis	0.45	Imai et al., 1950[122]
Teredo navalis	0.67	Imai et al., 1950[122]
Teredo navalis	2	Imai et al., 1950[122]
Teredo navalis	7	Imai et al., 1950[122]

Teredo navalis	10.4	Imai et al., 1950[122]
Teredo navalis	15.6	Imai et al., 1950[122]
Teredo navalis	50.5	Imai et al., 1950[122]
Teredo navalis	368	Paalvast, 2011[77]
Teredo navalis	250	Tuente et al., 2002[69]
Teredo navalis	82	Willer et al., 2023[21]
Teredo navalis	32	Mann and Gallager, 1985[96]
Teredo navalis	9	Mann and Gallager, 1985[96]
Teredo navalis	17	Mann and Gallager, 1985[96]
Teredo navalis	152.5	Mann and Gallager, 1985[96]
Teredo navalis	20	Mann and Gallager, 1985[96]
Teredo navalis	196.5	Mann and Gallager, 1985[96]
Teredo navalis	6.5	Mann and Gallager, 1985[96]
Teredo navalis	148	Mann and Gallager, 1985[96]
Teredo navalis	23	Mann and Gallager, 1985[96]
Teredo navalis	228.5	Mann and Gallager, 1985[96]
Teredo navalis	4.5	Mann and Gallager, 1985[96]
Teredo navalis	9	Mann and Gallager, 1985[96]
Teredo navalis	32.5	Mann and Gallager, 1985[96]
Teredo navalis	33	Mann and Gallager, 1985[96]
Teredo navalis	51	Mann and Gallager, 1985[96]
Teredo navalis	124	Mann and Gallager, 1985[96]
Teredo navalis	179.5	Mann and Gallager, 1985[96]
Teredo navalis	193.5	Mann and Gallager, 1985[96]
Teredo navalis	142.5	Mann and Gallager, 1985[96]
Teredo navalis	350	Iljin, 2010[116]
Teredo navalis	150	Ryabchikov, 1957[123], Iljin, 2010[116]
Teredo navalis	180	Ryabchikov, 1957[123], Iljin, 2010[116]
Teredo navalis	480	Iljin, 2010[116]
*Teredo parksi**	16.09	MacIntosh, 2015[102]
*Teredo parksi**	11.94	MacIntosh, 2014[53]
*Teredo parksi**	175	Edmondson, 1942[95]
*Teredo parksi**	175	Edmondson, 1942[95]

*Teredo parksi**	200	Edmondson, 1942[95]
*Teredo parksi**	50	Edmondson, 1942[95]
*Teredo parksi**	230	Edmondson, 1942[95]
Teredo triangularis	60	Edmondson, 1942[95]
Teredora princesae	290	Edmondson, 1962[124]
Teredora princesae	70	Edmondson, 1962[124]
Teredora princesae	30	Treneman et al., 2018[100]
Teredora princesae	15	Treneman et al., 2018[100]
Teredora princesae	75	Edmondson, 1942[95]
Teredora princesae	10	Edmondson, 1942[95]
Teredora princesae	6	Edmondson, 1942[95]
Teredora princesae	18	Edmondson, 1942[95]
Teredothyra dominicensis	13	Shipway et al., 2014[125]
Teredothyra dominicensis	312	Shipway et al., 2014[125]
Teredothyra smithi	60	Treneman et al., 2018[100]
Teredothyra smithi	40	Treneman et al., 2018[100]
Teredothyra smithi	45	Treneman et al., 2018[100]

*Note: Note we advise against these growth rates being formally compared as the sole evidence base for aquaculture species selection, as the datasets do not provide clarity on the number of individuals or environmental conditions, which affect growth rate. Additionally, *Teredo parksi*, a short-term brooder, is a cryptic sister species to *Teredo furcifera*, a long-term brooder. These two species have historically been treated as a single taxon in past literature. As such, reported data may not distinguish between them, and should be interpreted with this taxonomic ambiguity in mind.

Appendix III: Naked Clam Growth Rates.

Species	**Growth rate (mm/day)(2d.p.)**	**References**
Bankia australis	1.23	Nair and Saraswathy, 1971[64]
Bankia bipalmulata	1.06	Edmondson, 1942[95]
Bankia bipalmulata	1.06	Edmondson, 1942[95]
Bankia bipalmulata	1.64	Edmondson, 1942[95]
Bankia bipalmulata	2.69	Edmondson, 1942[95]
Bankia bipalmulata	2.08	Edmondson, 1942[95]
Bankia bipalmulata	1.18	Edmondson, 1942[95]
Bankia bipalmulata	0.91	Edmondson, 1942[95]

Bankia bipalmulata	1.93	Edmondson, 1942[95]
Bankia bipalmulata	0.92	Edmondson, 1942[95]
Bankia campanellata	1.72	Nair and Saraswathy, 1971[64]
Bankia campanellata	2.00	Nair and Saraswathy, 1971[64]
Bankia carinata	0.43	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	0.43	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	0.62	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	0.93	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	1.10	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	3.04	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	3.31	Nair, 1960[26], Nair and Saraswathy, 1971[64]
Bankia carinata	1.07	Raveendran and Wagh, 1988[104]
Bankia carinata	0.43	Raveendran and Wagh, 1988[104]
Bankia gouldi	0.03	Manyak, 1982[119]
Bankia gouldi	0.75	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	1.25	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	3.85	Manyak, 1982[119]
Bankia gouldi	5.20	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia gouldi	6.17	Sigerfoos, 1896[89], Sigerfoos, 1908[90]
Bankia setacea	0.33	Johnson and Miller, 1935[93], Isham et al., 1951[91]
Bankia setacea	0.85	Quayle, 1959[92]
Bankia setacea	1.43	Haderlie and Mellor, 1973[75]
Bankia setacea	1.57	Nair and Saraswathy, 1971[64]
Bankia setacea	1.57	Isham et al., 1951[91]
Bankia setacea	1.60	Quayle, 1959[92]
Bankia setacea	1.67	Hiebert, 2015[120]
Bankia setacea	1.90	Quayle, 1959[92]
Bankia setacea	2.47	Haderlie and Mellor, 1973[75]
Bankia setacea	2.55	Quayle, 1959[92]
Bankia setacea	2.69	Quayle, 1959[92]
Bankia setacea	2.85	Quayle, 1959[92]
Bankia setacea	3.33	Hiebert, 2015[120]
Bankia setacea	3.91	Quayle, 1959[92]

Bankia setacea	4.07	Quayle, 1959[92], Nair and Saraswathy, 1971[64]
Bankia setacea	2.10	Kofoid and Miller, 1927[83]
Bankia setacea	0.77	Kofoid and Miller, 1927[83]
Bankia setacea	1.43	Haderlie and Mellor, 1973[81]
Bankia setacea	2.47	Haderlie and Mellor, 1973[81]
Bankia setacea	3.56	Haderlie and Mellor, 1973[81]
Lyrodus affinis	1.53	Edmondson, 1942[95]
Lyrodus affinis	2.15	Edmondson, 1942[95]
Lyrodus affinis	1.51	Edmondson, 1942[95]
Lyrodus affinis	1.39	Edmondson, 1942[95]
Lyrodus affinis	0.88	Edmondson, 1942[95]
Lyrodus affinis	2.23	Edmondson, 1942[95]
Lyrodus affinis	2.09	Edmondson, 1942[95]
Lyrodus affinis	2.26	Edmondson, 1942[95]
Lyrodus affinis	1.45	Edmondson, 1942[95]
Lyrodus affinis	1.18	Edmondson, 1942[95]
Lyrodus affinis	1.32	Edmondson, 1942[95]
Lyrodus affinis	1.28	Edmondson, 1942[95]
Lyrodus affinis	1.45	Edmondson, 1942[95]
Lyrodus affinis	2.86	Edmondson, 1942[95]
Lyrodus affinis	1.87	Edmondson, 1942[95]
Lyrodus affinis	1.72	Edmondson, 1942[95]
Lyrodus affinis	2.50	Edmondson, 1942[95]
Lyrodus affinis	2.40	Edmondson, 1942[95]
Lyrodus affinis	2.35	Edmondson, 1942[95]
Lyrodus affinis	2.38	Edmondson, 1942[95]
Lyrodus affinis	2.33	Edmondson, 1942[95]
Lyrodus affinis	2.49	Edmondson, 1942[95]
Lyrodus affinis	1.62	Edmondson, 1942[95]
Lyrodus affinis	2.21	Edmondson, 1942[95]
Lyrodus affinis	0.03	Edmondson, 1942[95]
Lyrodus affinis	0.05	Edmondson, 1942[95]
Lyrodus affinis	0.08	Edmondson, 1942[95]

Lyrodus affinis	0.19	Edmondson, 1942[95]
Lyrodus bipartitus	0.02	Nair and Saraswathy, 1971[64]
Lyrodus pedicellatus	0.24	Knight, 2018[121]
Lyrodus pedicellatus	0.55	Gallager et al., 1981[94]
Lyrodus pedicellatus	0.59	Gallager et al., 1981[94]
Lyrodus pedicellatus	0.72	Isham et al., 1951[91]
Lyrodus pedicellatus	0.32	Edmondson, 1942[95]
Lyrodus pedicellatus	0.82	Edmondson, 1942[95]
Lyrodus pedicellatus	1.05	Edmondson, 1942[95]
Lyrodus pedicellatus	0.73	Edmondson, 1942[95]
Lyrodus pedicellatus	1.03	Edmondson, 1942[95]
Lyrodus pedicellatus	0.88	Edmondson, 1942[95]
Lyrodus pedicellatus	0.91	Edmondson, 1942[95]
Lyrodus pedicellatus	1.19	Edmondson, 1942[95]
Lyrodus pedicellatus	0.17	Edmondson, 1942[95]
Lyrodus pedicellatus	0.72	Edmondson, 1942[95]
Nausitora hedleyi	0.00	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.13	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.20	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.33	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.40	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.53	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	0.67	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	1.11	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	2.09	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	3.33	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	3.73	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	5.13	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	6.18	Saraswathy and Nair, 1973[70]
Nausitora hedleyi	9.93	Saraswathy and Nair, 1973[70]
Nototeredo knoxi	0.76	Mann and Gallager, 1985[99]
Nototeredo norvagica	1.92	Charles et al., 2018[122]

Psiloteredo megotara	0.71	Nair and Saraswathy, 1971[64]
Psiloteredo megotara	0.82	Nair and Saraswathy, 1971[64]
Psiloteredo megotara	1.43	Nair and Saraswathy, 1971[64]
Psiloteredo megotara	2.03	Nair and Saraswathy, 1971[64]
Teredo bartschi	2.41	Edmondson, 1942[95]
Teredo bartschi	1.64	Edmondson, 1942[95]
Teredo bartschi	1.96	Edmondson, 1942[95]
Teredo bartschi	0.86	Edmondson, 1942[95]
Teredo bartschi	1.19	Edmondson, 1942[95]
Teredo bartschi	1.63	Edmondson, 1942[95]
Teredo bartschi	1.47	Edmondson, 1942[95]
Teredo bartschi	1.78	Edmondson, 1942[95]
Teredo bartschi	1.51	Edmondson, 1942[95]
Teredo bartschi	1.01	Edmondson, 1942[95]
Teredo bartschi	1.28	Edmondson, 1942[95]
Teredo bartschi	1.40	Edmondson, 1942[95]
Teredo bartschi	1.12	Edmondson, 1942[95]
Teredo bartschi	1.97	Edmondson, 1942[95]
Teredo bartschi	0.94	Edmondson, 1942[95]
Teredo bartschi	0.77	Edmondson, 1942[95]
Teredo bartschi	1.21	Edmondson, 1942[95]
Teredo bartschi	1.28	Edmondson, 1942[95]
Teredo bartschi	1.15	Edmondson, 1942[95]
Teredo bartschi	0.89	Edmondson, 1942[95]
*Teredo furcifera**	0.94	Nair and Saraswathy, 1971[64]
Teredo navalis	0.01	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.04	Imai et al., 1950[116]
Teredo navalis	0.06	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.08	Nair and Saraswathy, 1971[64]
Teredo navalis	0.22	Tsunoda, 1979[63]
Teredo navalis	0.27	Imai et al., 1950[116]

Teredo navalis	0.28	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.30	Tsunoda, 1979[63]
Teredo navalis	0.34	Imai et al., 1950[116]
Teredo navalis	0.50	Imai et al., 1950[116]
Teredo navalis	0.58	Tsunoda, 1979[63]
Teredo navalis	0.66	Tsunoda, 1979[63]
Teredo navalis	0.67	Isham et al., 1951[91]
Teredo navalis	0.72	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	0.79	Tsunoda, 1979[63]
Teredo navalis	0.80	Tsunoda, 1979[63]
Teredo navalis	0.84	Tsunoda, 1979[63]
Teredo navalis	0.91	Orton, 1914[123]
Teredo navalis	0.94	Tsunoda, 1979[63]
Teredo navalis	0.95	Tsunoda, 1979[63]
Teredo navalis	0.96	Tsunoda, 1979[63]
Teredo navalis	1.03	Tsunoda, 1979[63]
Teredo navalis	1.04	Imai et al., 1950[116]
Teredo navalis	1.08	Tsunoda, 1979[63]
Teredo navalis	1.13	Tsunoda, 1979[63]
Teredo navalis	1.15	Tsunoda, 1979[63]
Teredo navalis	1.15	Grave, 1928[96], Nair and Saraswathy, 1971[64]
Teredo navalis	1.22	Tsunoda, 1979[63]
Teredo navalis	1.22	Tsunoda, 1979[63]
Teredo navalis	1.25	Tsunoda, 1979[63]
Teredo navalis	1.28	Tsunoda, 1979[63]
Teredo navalis	1.32	Tsunoda, 1979[63]
Teredo navalis	1.66	Tsunoda, 1979[63]
Teredo navalis	1.75	Imai et al., 1950[116]
Teredo navalis	1.80	Paalvast, 2011[71]
Teredo navalis	1.86	Needler and Needler, 1940[95]
Teredo navalis	1.95	Grave, 1942[97]
Teredo navalis	2.20	Tsunoda, 1979[63]
Teredo navalis	2.41	Tsunoda, 1979[63]

Teredo navalis	2.55	Tsunoda, 1979[63]
Teredo navalis	3.24	Grave, 1942[97]
Teredo navalis	0.63	Iljin, 2010[112]
*Teredo parksi**	1.00	Kofoid and Miller, Chapter XVIII, 1927[77]
*Teredo parksi**	1.67	Kofoid and Miller, Chapter XVIII, 1927[77]
*Teredo parksi**	1.25	Edmondson, 1942[95]
*Teredo parksi**	1.68	Edmondson, 1942[95]
*Teredo parksi**	1.00	Edmondson, 1942[95]
*Teredo parksi**	0.89	Edmondson, 1942[95]
Teredo triangularis	0.43	Edmondson, 1942[95]
Teredora princesae	0.54	Edmondson, 1962[124]

*Note: Note we advise against these growth rates being formally compared as the sole evidence base for aquaculture species selection, as the datasets do not provide clarity on the number of individuals or environmental conditions, which affect growth rate. Additionally, *Teredo parksi*, a short-term brooder, is a cryptic sister species to *Teredo furcifera*, a long-term brooder. These two species have historically been treated as a single taxon in past literature. As such, reported data may not distinguish between them, and should be interpreted with this taxonomic ambiguity in mind.

Appendix IV: Naked Clams and Blue Mussels Wet Meat Weight Gain Rate

Species	**Wet meat weight gain rate (mg/day)(2d.p.)**
Bankia australis	16.85
Bankia bipalmulata	14.52
Bankia bipalmulata	14.49
Bankia bipalmulata	22.38
Bankia bipalmulata	36.78
Bankia bipalmulata	28.46
Bankia bipalmulata	16.07
Bankia bipalmulata	12.50
Bankia bipalmulata	26.35
Bankia bipalmulata	12.51
Bankia campanellata	23.46
Bankia campanellata	27.33
Bankia carinata	5.81
Bankia carinata	5.86

Bankia carinata	8.40
Bankia carinata	12.75
Bankia carinata	15.03
Bankia carinata	41.49
Bankia carinata	45.17
Bankia carinata	14.62
Bankia carinata	5.92
Bankia gouldi	0.41
Bankia gouldi	10.25
Bankia gouldi	17.08
Bankia gouldi	52.60
Bankia gouldi	71.05
Bankia gouldi	84.26
Bankia setacea	4.55
Bankia setacea	11.64
Bankia setacea	19.58
Bankia setacea	21.41
Bankia setacea	21.41
Bankia setacea	21.82
Bankia setacea	22.78
Bankia setacea	25.96
Bankia setacea	33.71
Bankia setacea	34.87
Bankia setacea	36.81
Bankia setacea	38.98
Bankia setacea	45.54
Bankia setacea	53.38
Bankia setacea	55.57
Bankia setacea	28.69
Bankia setacea	10.52
Bankia setacea	19.54
Bankia setacea	33.75
Bankia setacea	48.64

Lyrodus affinis	20.90
Lyrodus affinis	29.38
Lyrodus affinis	20.63
Lyrodus affinis	18.99
Lyrodus affinis	12.02
Lyrodus affinis	30.47
Lyrodus affinis	28.56
Lyrodus affinis	30.88
Lyrodus affinis	19.81
Lyrodus affinis	16.12
Lyrodus affinis	18.03
Lyrodus affinis	17.49
Lyrodus affinis	19.81
Lyrodus affinis	39.08
Lyrodus affinis	25.55
Lyrodus affinis	23.50
Lyrodus affinis	34.16
Lyrodus affinis	32.79
Lyrodus affinis	32.11
Lyrodus affinis	32.52
Lyrodus affinis	31.83
Lyrodus affinis	34.02
Lyrodus affinis	22.13
Lyrodus affinis	30.22
Lyrodus affinis	0.40
Lyrodus affinis	0.75
Lyrodus affinis	1.05
Lyrodus affinis	2.58
Lyrodus bipartitus	0.28
Lyrodus pedicellatus	3.25
Lyrodus pedicellatus	7.51
Lyrodus pedicellatus	8.06
Lyrodus pedicellatus	9.80

Lyrodus pedicellatus	4.44
Lyrodus pedicellatus	11.26
Lyrodus pedicellatus	14.40
Lyrodus pedicellatus	9.94
Lyrodus pedicellatus	14.01
Lyrodus pedicellatus	11.98
Lyrodus pedicellatus	12.47
Lyrodus pedicellatus	16.27
Lyrodus pedicellatus	2.30
Lyrodus pedicellatus	9.85
Nausitora hedleyi	0.00
Nausitora hedleyi	1.82
Nausitora hedleyi	2.73
Nausitora hedleyi	4.55
Nausitora hedleyi	5.47
Nausitora hedleyi	7.28
Nausitora hedleyi	9.11
Nausitora hedleyi	15.21
Nausitora hedleyi	28.51
Nausitora hedleyi	45.54
Nausitora hedleyi	51.00
Nausitora hedleyi	70.13
Nausitora hedleyi	84.44
Nausitora hedleyi	135.71
Nototeredo knoxi	10.33
Nototeredo norvagica	26.23
Psiloteredo megotara	9.73
Psiloteredo megotara	11.23
Psiloteredo megotara	19.47
Psiloteredo megotara	27.69
Teredo bartschi	32.93
Teredo bartschi	22.41
Teredo bartschi	26.78

Teredo bartschi	11.75
Teredo bartschi	16.26
Teredo bartschi	22.27
Teredo bartschi	20.08
Teredo bartschi	24.32
Teredo bartschi	20.63
Teredo bartschi	13.80
Teredo bartschi	17.49
Teredo bartschi	19.13
Teredo bartschi	15.30
Teredo bartschi	26.92
Teredo bartschi	12.84
Teredo bartschi	10.52
Teredo bartschi	16.53
Teredo bartschi	17.49
Teredo bartschi	15.71
Teredo bartschi	12.16
*Teredo furcifera**	12.77
Teredo navalis	0.11
Teredo navalis	0.60
Teredo navalis	0.83
Teredo navalis	1.11
Teredo navalis	2.96
Teredo navalis	3.63
Teredo navalis	3.80
Teredo navalis	4.15
Teredo navalis	4.65
Teredo navalis	6.83
Teredo navalis	7.88
Teredo navalis	9.02
Teredo navalis	9.11
Teredo navalis	9.84
Teredo navalis	10.77

Teredo navalis	10.98
Teredo navalis	11.53
Teredo navalis	12.46
Teredo navalis	12.88
Teredo navalis	12.94
Teredo navalis	13.05
Teredo navalis	14.06
Teredo navalis	14.21
Teredo navalis	14.76
Teredo navalis	15.47
Teredo navalis	15.66
Teredo navalis	15.75
Teredo navalis	16.70
Teredo navalis	16.70
Teredo navalis	17.13
Teredo navalis	17.43
Teredo navalis	17.99
Teredo navalis	22.73
Teredo navalis	23.84
Teredo navalis	24.59
Teredo navalis	25.41
Teredo navalis	26.59
Teredo navalis	29.99
Teredo navalis	32.97
Teredo navalis	34.89
Teredo navalis	44.31
Teredo navalis	8.61
*Teredo parksi**	13.66
*Teredo parksi**	22.78
*Teredo parksi**	17.08
*Teredo parksi**	22.99
*Teredo parksi**	13.66
*Teredo parksi**	12.13

Teredo triangularis	5.86
Teredora princesae	7.32
Mytilus edulis	15.56
Mytilus edulis	12.44
Mytilus edulis	7.34
Mytilus edulis	13.51
Mytilus edulis	9.62

*Note: These data are extrapolated from the wet weight to length conversion factor for one species, *B. carinata,* are not actual measurements, and that diameter differences are not taken into account. The conversion factor is appropriate for the typical shipworm of the approximate morphology as *B. carinata*, but we acknowledge it will scale less optimally for very thin (e.g. *Lyrodus medilobatus*) or fat (e.g. *Bankia setacea*) naked clam species, and emphasise a need for further experimental research on this topic.

Tables

Table 1: Anecdotal health properties of naked clams and suggested steps required to substantiate these properties

Anecdotal naked clam properties	Potential initial tests to substantiate properties	References
In *Teredo navalis, s*aturated fatty acid methyl esters (FAMEs) stearic acid (C18:0) and palmitic acid (C16:0) were dominant, followed by monounsaturated FAMEs oleic acid (C18:1) and palmitoleic acid (C16:1) in high abundance.	Test for increased cholesterol levels, blood pressure and decreased heart disease risk after naked clam consumption. Test for improved mood by conducting interviews with human subjects before and after naked clam consumption.	Willer et al., 2023[21]
(With regards to the anecdote in the previous row) Oleic acid offers multiple health benefits: improvements to cholesterol levels, blood pressure and inflammation, along with decreased heart disease risk and potential to improve mood and cognition.	Test for improved cognition by administering a cognitive test in human subjects before and after naked clam consumption.	Tutunchi et al., 2020[126]
Tambelo extract (*Bactronophorus thoracites*) contains anti-inflammatory properties.	Inflammatory marker tests such as C-Reactive protein test can verify whether inflammation is present.	Leiwakabessy et al., 2023[127]
Kamoro tribe, Mimika Regency, believes that tambelo (*B. thoracites*) can potentially be one of the herbal supplements that can stimulate physical fitness in men. Wairara et al. tested this hypothesis and found that tambelo extract increased the body weight of mice by about 15%.	Test for an increase in muscle mass in humans after naked clam consumption.	Wairara et al., 2019[128]
B. thoracites and other species of naked clams harvested from the mangroves of the Philippines were harvested as	Clinical trials to test for the medicinal properties of naked clams.	Tsuji, 2021[26]

a food source and valued as folk medicine. A traditional healer (*babaylan*) of Negros Island revealed that he mixes naked clams in the folk medicine he prescribes.		
Naked clams provide important nutrition to young mothers, improving the quality of breast milk after childbirth.	Clinical trial where pregnant women are fed naked clams, and test if their breast milk quality improved by analysing their nutritional content.	Tsuji, 2021[26]
Naked clams act as a tonic for diarrhoea, sickness and body aches.	Clinical trial to test for its effectiveness in pain and diarrhoea relief.	Tsuji, 2021[26] ; Shipway et al., 2024[22]
Bitterness in some naked clams may be due to their high tannin content.	Test for tannin content [129]	Tsuji, 2021[26] ; Shipway et al., 2024[22]
Naked clams have been used as a male aphrodisiac.	Test for increased serum sex hormone concentration in men [130]	Shipway et al., 2024[22]
Naked clams have been referred to as a sickness tonic – possibly due to the natural products produced by naked clam symbionts.	Screen naked clams for natural products related to their symbionts.	Shipway et al., 2024[17]
They are used as a cure to treat hangovers.	Conduct a clinical trial testing effectiveness for hangovers, measuring key symptoms such as nausea, headache, fatigue, and cognitive impairment, alongside biomarkers like blood alcohol levels, inflammatory markers, and liver enzyme activity.	Shipway et al., 2024[22]
Naked clams taste like oysters.	Formal blind taste trial with oysters as the control sample.	Insider Food, 2017[62]
Filipino kinilaw, a naked clam dish, is similar to ceviche.	Random survey presenting human subjects with both ceviche and kinilaw and asking them to rate the similarity of the dishes.	Seal, 2021[63], Cerini, 2019[131]

Figure legends

Figure 1: Global distribution of naked clams with associated relative growth rates

Locality and relative growth rates of 17 species of naked clams by country or region (specified below) [132]. Only species with at least one record of growth rate with corresponding location data are shown. There are four regions where observations in any part of the region would classify as one data point: countries bounded by Mexico, the United States of America, Cuba, Colombia and Venezuela, countries and the open waters of the Indian Ocean, countries and the open waters of the Pacific Ocean, and lastly, the Atlantic Ocean. Each coloured square refers to the observation, and hence presence, of a specific species (as indicated by the legend) in that country or region. Each coloured circle represents the observation of a specific species in that country or region, with the size of the circle representing the mean growth rate of that species of naked clams relative to other growth rate measurements displayed.

Figure 2: Reported sizes of naked clams

Box plots showing the reported sizes of naked clams by species arranged from highest to lowest median size. The species with the greatest median size is *Nototeredo norvagica* (860mm)(2.s.f.), while the species with the lowest median size is *Teredo clappi* (9mm). Box plots represent the first quartile (lower hinge), median, and third quartile (upper hinge). Whiskers represent 1.5× the interquartile range from the hinges. Dots represent individual data points. Icons represent the morphology of each species of naked clams. Naked clam species without reference pictures found on Google Images were represented by a graphic of a generic naked clam.

Figure 3: Growth rates and predicted lengths of naked clams

A: Box plots showing the growth rates of naked clams by species arranged from highest to lowest median growth rate. Box plots represent the first quartile (lower hinge), median, and third quartile (upper hinge). Whiskers represent 1.5× the interquartile range from the hinges. Dots represent individual data points. Naked clam species without reference pictures found on Google Images were represented by a graphic of a generic naked clam.

B: Box plots showing the predicted lengths of naked clams after 6 months by species arranged from highest to lowest median length. Box plots represent the first quartile (lower hinge), median, and third quartile (upper hinge). Whiskers represent 1.5× the interquartile range from the hinges. Dots represent individual data points. Icons represent the morphology of each species of naked clam. Species without reference pictures found on Google Images were represented by a graphic of a generic naked clam.

Figure 4: Growth rate and predicted weight comparison of naked clams and blue mussels

A: Box plots showing the wet meat weight gain rates of naked clams and blue mussels (*Mytilus edulis*) by species, with naked clam box plots arranged from highest to lowest median wet meat weight gain rate. Box plots represent the first quartile (lower hinge), median, and third quartile (upper hinge). Whiskers represent 1.5× the interquartile range from the hinges. Dots represent individual data points. Icons represent the morphology of each species of naked clams. Species without reference pictures found on Google Images were represented by a graphic of a generic naked clam.

B: Box plots showing the predicted wet meat weights of naked clams and blue mussels after 6 months by species, with naked clam box plots arranged from highest to lowest median length. Box plots represent the first quartile (lower hinge), median, and third quartile (upper hinge). Whiskers represent 1.5x the interquartile range from the hinges. Dots represent individual data points. Species without reference pictures found on Google Images were represented by a cartoon of a generic naked clam.

Figure 5: Pathway towards a new naked clam aquaculture system

Flowchart showing five key steps for optimising naked clam aquaculture growth systems. The steps are shown on the left column in chronological order from top to bottom, with images depicting each step [133–141]. The right column shows examples of factors to consider at every step.