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Foto portada: AZTI. Ejemplares de zamburiña *Mimachlamys varia* en el laboratorio, durante las mediciones biométricas. © AZTI

First attempt to cultivate black scallop *Mimachlamys varia* (L., 1758) under suspended conditions in waters of the Basque coast (SE Bay of Biscay): a note.

Izaskun Zorita[1*], José Germán Rodríguez[1], Joxe Mikel Garmendia[1]

Resumen

En el presente estudio se ha evaluado la viabilidad del cultivo de zamburiña *Mimachlamys varia* (Linnaeus, 1758) utilizando diferentes sistemas de cultivo en suspensión en la costa vasca (SE del golfo de Vizcaya). Los juveniles obtenidos de un criadero, con una longitud media de 23,6 ± 4,1 mm y un peso medio de 2,06 ± 1,09 g, se colocaron en cestas ostrícolas y nasas en dos sitios experimentales: una batea situada en aguas abrigadas en un puerto (Mutriku) y un *longline* o cultivo suspendido ubicado en mar abierto, a unas dos millas de la costa (Mendexa). El experimento se desarrolló desde junio de 2019 hasta agosto de 2020. Las zamburiñas alcanzaron la talla comercial (40 mm) en 8 meses en aguas de alta mar y en 10 meses en aguas abrigadas del puerto, alcanzando un peso medio final de 10,23 g, independientemente del sistema de cultivo utilizado. La supervivencia fue baja tras los primeros meses de inmersión en ambos sitios (1,9-56,9 %), aunque los valores de supervivencia más elevados se detectaron en las zamburiñas criadas en nasas en alta mar. Esta elevada mortalidad debe reducirse para que el cultivo de esta especie pueda ser viable desde el punto de vista de rentabilidad económica. Este trabajo aporta datos relevantes para la diversificación de la producción de moluscos bivalvos en la costa vasca.

Palabras clave: Crecimiento, Supervivencia, Golfo de Vizcaya, *Mimachlamys varia*, Acuicultura en alta mar, Diversificación.

Abstract

In the present study the feasibility of black scallop *Mimachlamys varia* (Linnaeus, 1758) culture was evaluated using different growing systems under suspended conditions on the Basque coast (SE Bay of Biscay). Juveniles obtained from a hatchery, with a mean shell height of 23.6 ± 4.1 mm and a mean weight of 2.06 ± 1.09 g, were deployed in oyster cages and pots at two experimental sites: a raft installed in the sheltered waters in a harbour (Mutriku) and a longline located at offshore waters, at 2 nm from the coast (Mendexa). The experiment was run from June 2019 to August 2020. Black scallops attained commercial size (40 mm) in 8 months in offshore waters and in 10 months in the sheltered harbour waters, reaching a mean final weight of 10.23 g, regardless of the culture system used. Survival was low after the first months of immersion at both sites (1.9-56.9 %), but the highest survival values were detected in black scallops reared in pots in offshore waters. This high mortality must be reduced so that the culture of this species can be viable from the point of view of economic profitability. This work provides relevant data for the diversification of bivalve mollusc production on the Basque coast.

Keywords: Growth, Survival, Bay of Biscay, *Mimachlamys varia*, Offshore aquaculture, Diversification.

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Introduction

Offshore mollusc production is an emerging activity in the Basque coast (SE Bay of Biscay). Mussel (*Mytilus galloprovincialis*) culture feasibility has been demonstrated in open waters (Azpeitia et al., 2016) but there is also interest in diversifying the bivalve mollusc production by cultivating new species with higher commercial value (Zorita et al., 2021). Pectinids and especially the black scallop *Mimachlamys varia* (L., 1758) (Figure 1) could be a complement to mussel production.

Figure 1. Black scallops *Mimachlamys varia* (L., 1758).

In fact, the interest for black scallop cultivation is growing in Europe (Cano et al., 2006; Rathman et al., 2017; Prato et al., 2020) due to the scarce natural beds, limitation of fisheries (Iglesias, 2012) and its economic value and market demand (Fleury, 2009; Basuyaux et al., 2014; Parrondo et al., 2021). Spanish production of black scallops comes mainly from the exploitation of natural populations. At present, *M. varia* populations in Galicia are very scarce and there is no commercial black scallop fishery developed at the national level. However, data on black scallop fisheries are available since 2009. Initially, from 2009 to 2015 catches were low, showing values below 5000 kg per year, but catches have been progressively increasing. Black scallop fishery between 2019 and 2022 in Galicia is around 25,000 kg per year, although in 2021 it reached its maximum with more than 40,000 kg (https://www.pescadegalicia.gal/estadisticas/). Tentatively, black scallops reach commercial size in less than two years (Iglesias, 2012) a relatively short time, making this species a very attractive commercial candidate. However, information on the survival and growth of black scallop culture is scarce. Most studies have been conducted in sheltered areas in Mediterranean countries (e.g., Cano et al., 2006; Rathman et al., 2017; Prato et al., 2020), as France (e.g., Robert et al., 1994) and northwestern Spain (e.g., Iglesias, 2012). So far, to our knowledge, no studies have been carried out with this species (or other scallops) in the Cantabrian Sea. Thus, the aim of the present study was to assess the survival and growth of black scallop, starting from medium-sized organisms, up to commercial size, in suspended aquaculture facilities on the Basque coast using different growing systems.

Material and methods

The study was conducted at two experimental sites for aquaculture studies on the Basque coast: a raft installed in sheltered waters in the harbour of Mutriku, and a longline located in offshore conditions in Mendexa, two miles off the coast (Figure **2**).

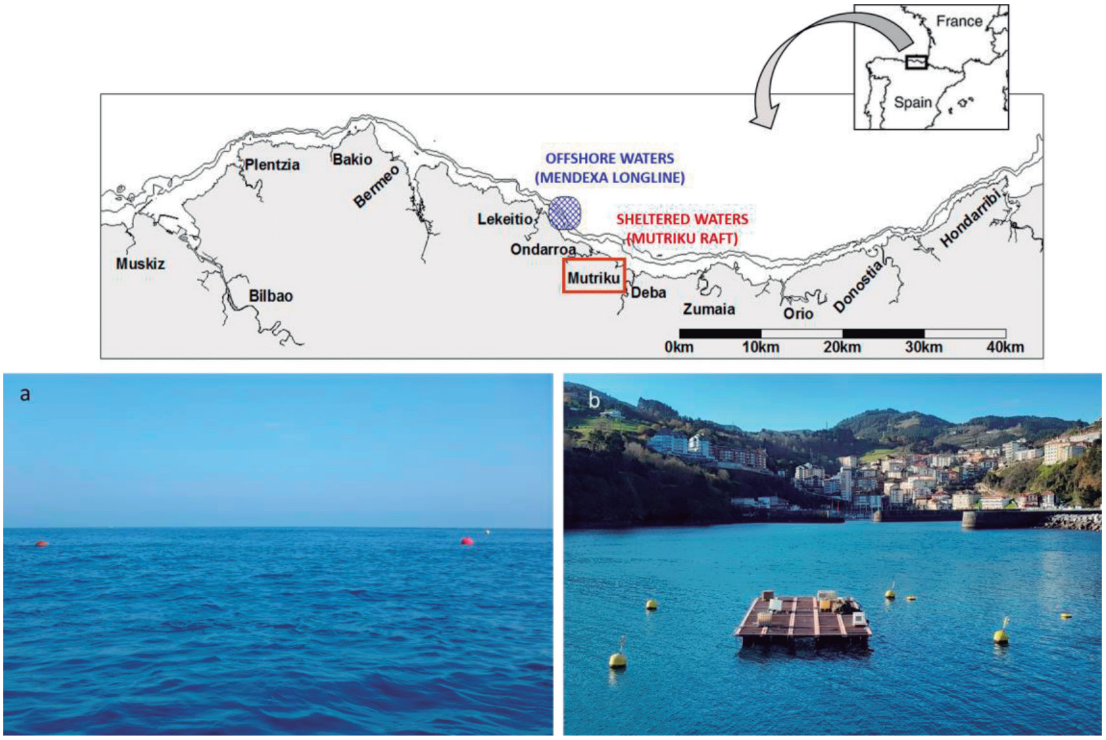

Figure 2. Map of the Basque coast showing the location of the two aquaculture experimental sites, a) a longline in offshore waters of Mendexa and b) a raft in sheltered waters in the harbour of Mutriku.

Figure 3. Obtention of black scallop spat from Brittany (France). a) Black scallop spat from the hatchery were obtained with a vessel from the Bay of Brest where they were placed for a nursery phase prior to the fattening experiment in the Basque Country, b) selection of black scallop spat of a mean size of 23.6 ± 4.1 mm, c) transport of black scallops to the Basque Country by van, and d) black scallops covered with towels moistened with seawater and constant temperature (18°C) to keep samples alive.

Black scallop spat, with an initial mean shell height of 23.60 ± 4.12 mm and an initial mean wet weight of 2.06 ± 1.09 g was obtained from a hatchery in Plougastel-Daoulas (France). Approximately 25,000 black scallops were transported by van using towels that were moistened with seawater every 2 h during 12 h journey (Figure 3). After arrival to AZTI´s facilities in Pasaia (Gipuzkoa, Spain), the specimens were deployed in the sea.

At each experimental site, live black scallops were distributed in cages (415 mm diameter, 80 mm height, 8 mm mesh size) and pots (636 x 245 x 140 mm, 6 mm mesh size) (Figure 4). 160 individuals were introduced in each cage, while 350 individuals were placed in pots, which is the equivalent to 1185 individuals m^{-2} in cages and 2246 individuals m^{-2} in pots, respectively. It is worth noting that in cages black scallops were divided into two bags of 5 mm mesh size, whereas in pots black scallops had more space to swim and the entire surface of the pot to hold onto (Figure 4). In the longline, 10 cages and 10 pots were deployed at a depth of 3 m, while in the raft, 11 cages and 11 pots were installed at 1 m depth.

The experiment was run from June 2019 to August 2020. Samplings were carried out approximately every one to two months, although the frequency was not exactly the same at both sites during the first months of the experiment. At each sampling time, a cage and a pot were retrieved from each site (Figure **5** and Figure 6) and survival was calculated by counting live organisms. A subsample of 100 live black scallops was used to determine the individual shell height using a digital caliper (Insize IP67 1118, Spain) and the wet weight with a balance (Fisher Scientific, Spain). When live individuals were less than 100 all individuals were measured (Figure **7**). Besides, environmental variables (temperature, salinity, oxygen saturation and chlorophyll “a”) were monthly measured using a CTD profiler in the experimental offshore longline.

Results and discussion

Environmental variables were in the range of those previously reported in the Basque coast (Azpeitia et al., 2016; Bilbao et al., 2021), showing seasonal temperature fluctuations (13.0–23.4 °C), relatively constant water salinity (33.1–35.3), high values of oxygen saturation (91.7–122.2 %), and low chlorophyll “a” concentration (0.04–0.84 µg L^{-1}) (Figure 8).

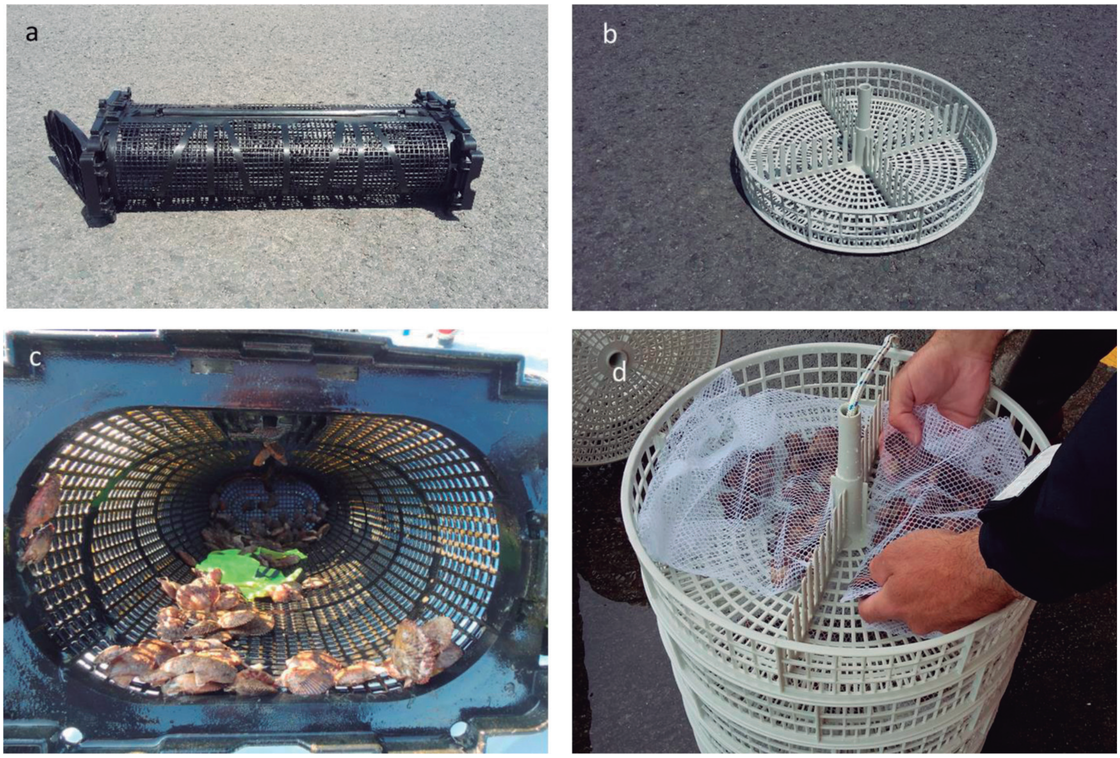

Figure 4. Growing systems used in the study. a) A plastic pot and b) an oyster cage; and distribution of black scallops c) in pots (n = 350) and d) in oyster cages (n = 160).

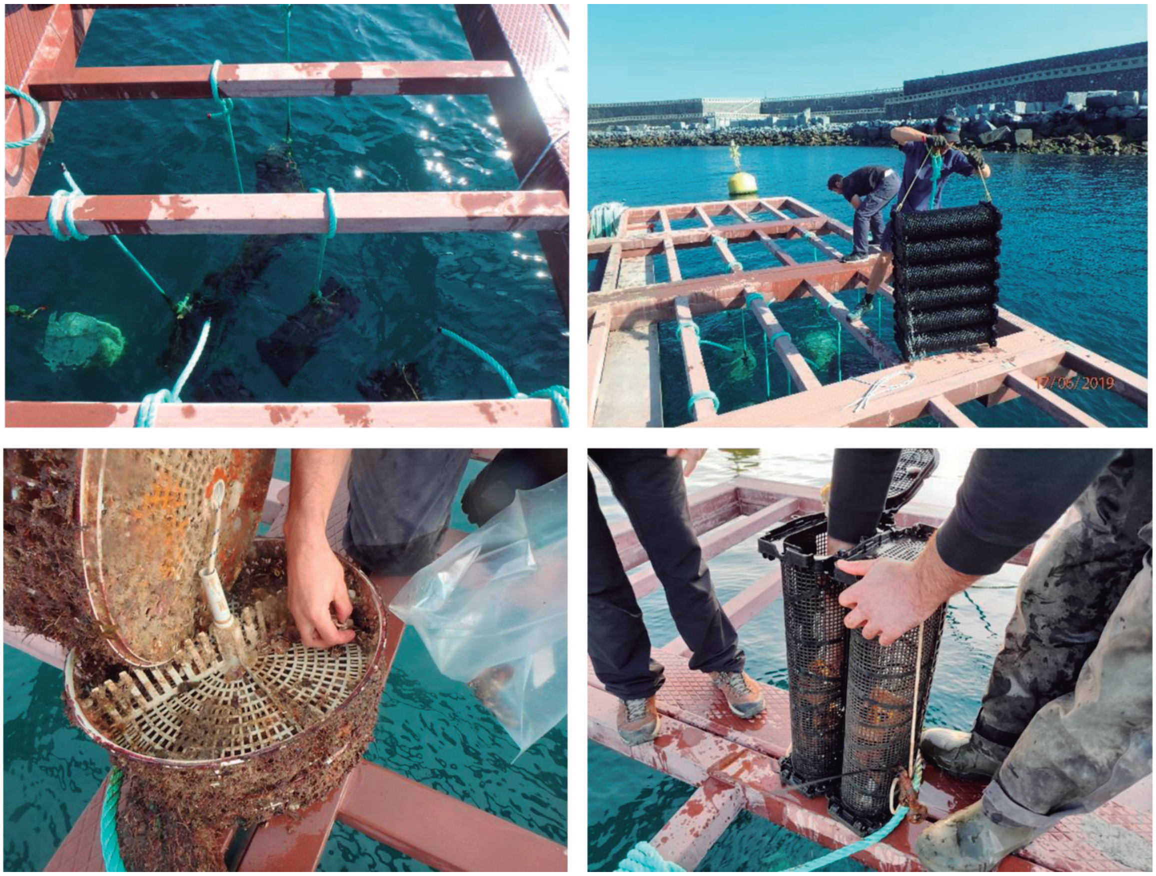

Figure 5. Sampling of black scallops in the raft located in the harbour of Mutriku.

Figure 6. Sampling of black scallops in the longline located in offshore waters of Mendexa.

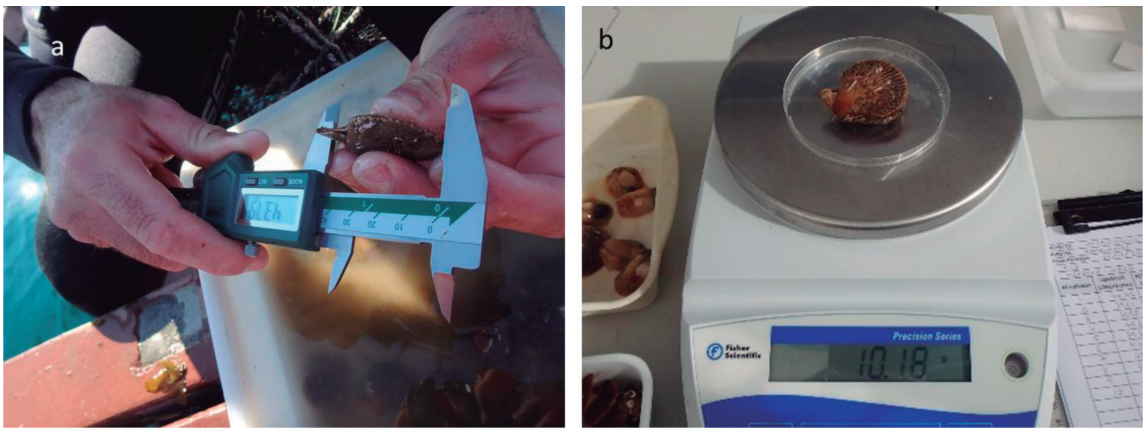

Figure 7. Determination of biometric parameters, a) shell height using a digital caliper and b) wet weight using a digital balance.

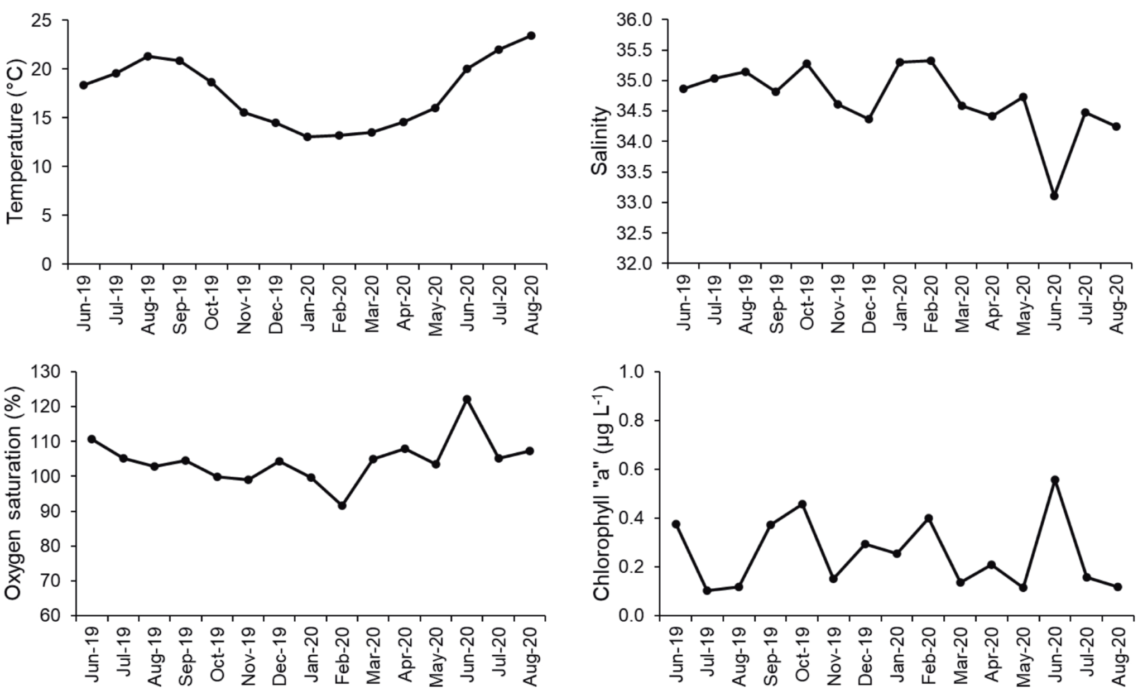

Figure 8. Environmental variables measured monthly with the CTD profiler at 3 m depth in the offshore longline.

The survival of black scallops decreased throughout the study, but especially during the first months of immersion at both sites (Figure 9). This drastic decline could be partly related to stress during the transport or handling in the experimental set-up, as this species is very sensitive to air exposure (Trut et al., 1994; Dao et al., 1999). In the longline, black scallop survival decreased from June to September 2019, showing values of 46 % in pots and 19.4 % in cages. Survival remained relatively constant until March 2020 but afterwards it decreased again with mean values of 29.1 % in pots and 15.3 % in cages until the end of the experiment. Black scallop survival in the pots was almost always clearly higher than in the cages. Accordingly, in the raft, the survival of black scallops was drastically reduced from 100 % to 11.1 % in pots and to 6.9 % in cages at the end of the experiment. Overall, survival values were higher at the longline than at the raft. These survival values were lower than those recorded in black scallops reared in Croatia at different depths, 75 % (1 m), 83.4 % (3 m) and 28.6 % (5 m) (Rathman et al., 2017) or in the Krka river (43–75 %) (Marguš et al., 2005) and in Spain using bags (91 %) or cages (88 %) as growing systems (Cano et al., 2006). An additional explanation for the high mortality could be overstocking and lack of cleaning and maintenance works, as these factors are known to affect the growth and survival of pectinids (Román et al., 1999). Furthermore, the stocking densities used in the present study (1185 individuals m^{-2} in cages and 2246 individuals m^{-2} in pots) were similar or higher than those used by Cano et al. (2006) (740 individual m^{-2} in cages and 1700 individual m^{-2} in bags) and Rathman et al. (2017) (1688 individuals m^{-2} in cages), which may have contributed to lower survival.

Black scallops, with an initial mean size of 23.6 ± 4.12 mm, attained commercial size (40 mm) in 8 months at the longline in offshore waters and in 10 months at the raft in sheltered waters, regardless of the culture system used (Figure 10). However, in the longline the maximum mean values of shell height and weight were reached in March 2020 using pots (49.89 ± 4.30 mm and 18.54 ± 4.55 g, respectively) and in May 2020 using cages (48.83 ± 3.94 mm and 16.61 ± 4.66 g, respectively), highlighting a marked spring growth, as previously found in other areas (Cancelo et al., 1992; Trut et al., 1994). Afterwards, irrespective of the culture system used, mean shell height and weight values remained relatively constant until the end of the study (ca. 46.71 mm and ca. 14.32 g). Once black scallops reached commercial size, growth slowed down and mortality increased considerably, which is consistent with previous studies (Cano et al., 2006; Saavedra et al., 2009; Rathman et al., 2017). In the raft, a progressive increase in the shell height of black scallops was found, but after reaching commercial size in March 2020, a slowdown was observed showing mean values of 46.62 mm in pots and 42.79 mm in cages at the end of the study (Figure 4). As for the weight, black scallops reared in pots presented a progressive increase showing the highest values at the end of the study (13.86 g). On the other hand, black scallops grown in cages registered the highest weight increase from March to April 2020 (almost 0.1 g per day) and then stabilized showing mean values between 12.06 g and 12.93 g (Figure 10).

The growth performance in the longline was faster than in the raft, probably due to the hydrodynamics of the area, as temperature and food availability are similar at both sites (Azpeitia et al., 2016; Bilbao et al., 2021; Zorita et al., 2021).

Comparisons between studies are complicated due to differences in starting sizes, stocking densities, gear, site, depth, time of year and environmental conditions (Duncan et al., 2006; Rathman et al., 2017; Prato et al., 2020). However, the growth of black scallops reported in this study was comparable to previously recorded values (Table 1).

On the other hand, it is known that different growing systems can influence the growth and survival of scallops (Mendoza et al., 2003; Cano et al., 2006). Although in this study a comparison between the two growing systems cannot be made due to the difference in stocking densities and the absence of replicates, pots presented a logistical superiority for handling than cages.

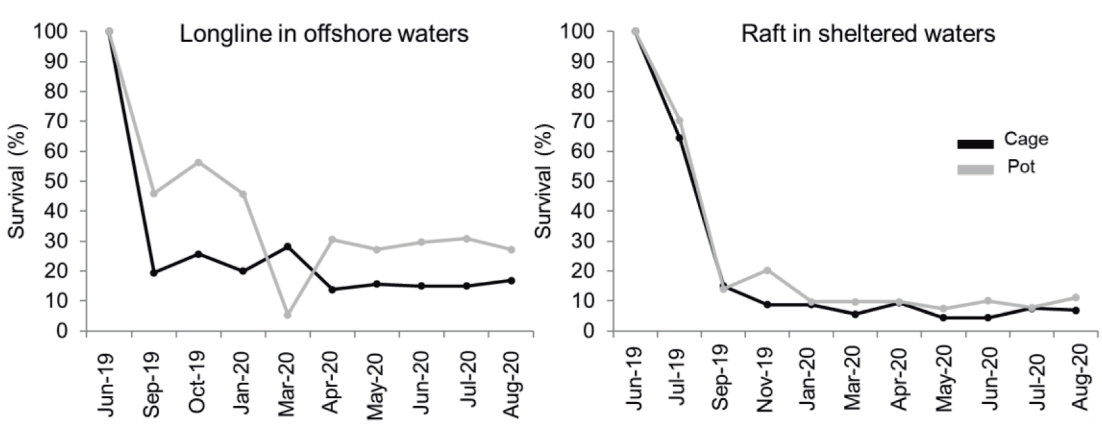

Figure 9. Survival (%) of black scallops reared on the longline in offshore waters and on the raft in sheltered waters from June 2019 to August 2020. The raw data obtained from the study are available in Zorita et al. (2022).

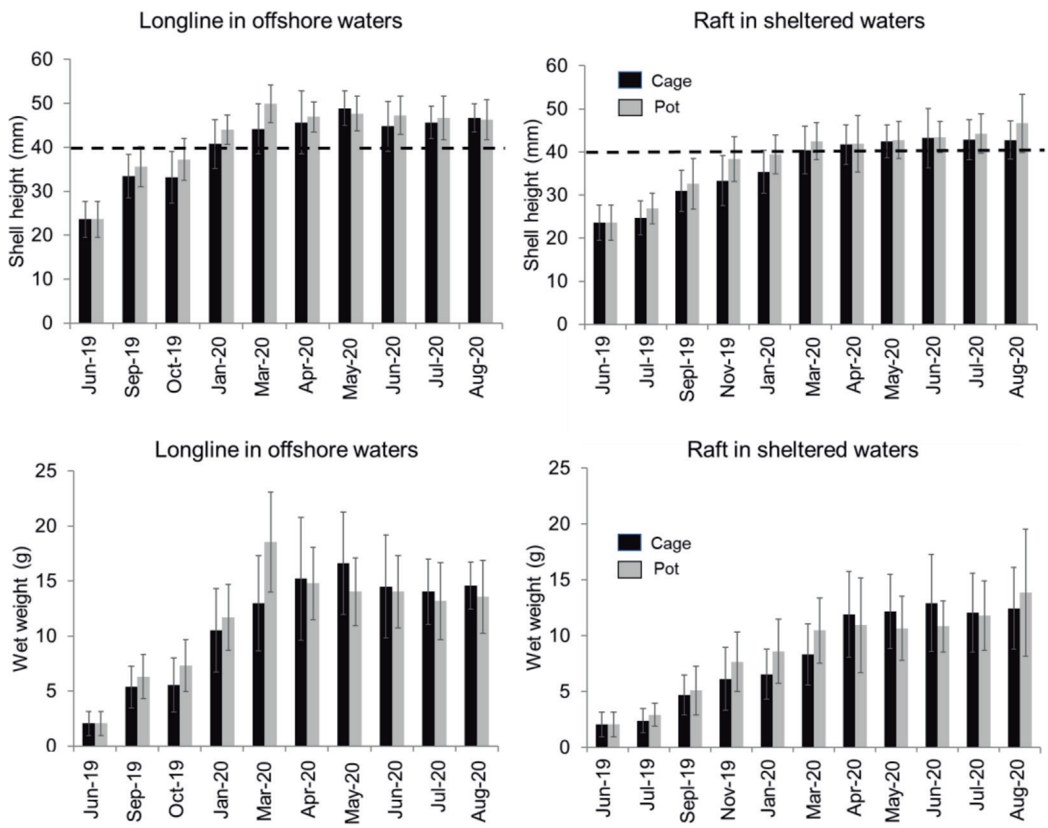

Figure 10. Evolution of mean ± standard deviation of shell height and wet weight of black scallops reared at the longline in offshore waters and at the raft in sheltered waters. The horizontal dotted line indicates commercial size. The raw data obtained from the study are available in Zorita et al. (2022).

Table 1. Comparison of growth data of *Mimachlamys varia* from different studies, including this one. Data refers to mean ± standard deviation when available.

Locality	Spat origin	Growing system	Stocking density (individuals m^{-2})	Depth (m)	Immersion period	Initial shell height (mm)	Final shell height (mm)	Initial wet weight (g)	Final wet weight (g)	Reference
Raft in sheltered waters of the Basque coast, Spain	Hatchery	Cage	1185	1	5 June 2019- 25 August 2020	23.6 ± 4.1	42.8 ± 4.4	2.1 ± 1.1	18.7 ± 1.9	This study
Raft in sheltered waters of the Basque coast, Spain		Pot	2246		5 June 2019- 25 August 2020	23.6 ± 4.1	46.6 ± 6.7	2.1 ± 1.1	13.8 ± 5.6	
Longline in offshore waters of the Basque coast, Spain		Cage	1185	3	5 June 2019- 25 August 2020	23.6 ± 4.1	46.6 ± 3.2	2.1 ± 1.1	14.6 ± 3.2	
Longline in offshore waters of the Basque coast, Spain		Pot	2246		5 june 2019- 25 August 2020	23.6 ± 4.1	46.3 ± 4.5	2.1 ± 1.1	14.3 ± 2.5	
Lorbé, Ría de Ares-Betanzos, Galicia, Spain	Natural seed	Cage	Changed during growth performance	2.5	17 April 2008- 2 December 2008	26.4 ± 6.7	38.9 ± 3.1	-	-	Iglesias, 2012
				7.5		26.4 ± 6.7	42.2 ± 4.2	-	-	
				12.5		26.4 ± 6.7	41.6 ± 3.3	-	-	
Mali Ston Bay, Adriatic Sea, Croacia	Natural seed	Cage	1688	1	September 2008- July 2010	13.4 ± 2.2	45.3 ± 4.1	-	-	Rathman et al., 2017
				3		12.7 ± 2.8	42.4 ± 2.4	-	-	
				5		10.9 ± 2.1	41.9 ± 4.2			
San Ciprian, Galicia, Spain	Hatchery	Cage	Changed during growth performance	1	June 1989- September 1990	6.4 ± 0.7	34.4 ± 0.6	-	-	Cancelo et al., 1992
				7		6.4 ± 0.7	36.4 ± 0.5	-	-	
				1		6.4 ± 0.7	40.7 ± 0.5	-	-	
				7		6.4 ± 0.7	38.6 ± 0.6	-	-	

Šarina draga Bay, Krka river, Adriatic Sea, Croatia	Natural seed	Cage	409	2.5	One-year period October-October	16.4 ± 2.1	45.6 ± 3.5	1.0	15.7	Marguš et al., 2005
				7.5		17.6 ± 2.2	47.5 ± 3.3	1.4	17.5	
				12.5		17.0 ± 2.2	45.5 ± 3.9	1.3	16.8	
				17.3		17.3 ± 3.3	42.7 ± 3.2	1.4	12.1	
Fuengirola, Málaga, Spain	Natural seed	Cage	740	-	August 2003-January 2004	18.3 ± 4.9	>40	-	-	Cano et al., 2006
		Bag	1700		August 2003-March 2004	0.9 ± 0.7	>40	-	-	
Gulf of Taranto, Ionian Sea, Italy	Natural seed	Cage	600	6-7	1 April 2014-21 January 2015	17.0 ± 2.0	48.5 ± 3.1	0.6 ± 0.3	13.9 ± 3.0	Prato et al., 2020
					1 April 2014-17 December 2014	12.7 ± 1.8	41.4 ± 3.3	0.3 ± 0.1	9.5 ± 1.9	
					13 May 2014-21 January 2015	26.8 ± 2.3	44.4 ± 3.0	2.5 ± 0.8	10.6 ± 1.8	
					13 June 2014-21 January 2015	24.2 ± 2.4	46.5 ± 2.8	2.0 ± 0.6	12.2 ± 2.4	
					5 August 2014-22 June 2015	20.0 ± 2.4	44.0 ± 2.1	1.0 ± 0.3	9.2 ± 1.2	
					19 August 2014-21 January 2015	13.7 ± 2.1	31.9 ± 3.3	0.3 ± 0.1	4.1 ± 1.1	
					17 October 2014-30 June 2015	14.1 ± 1.2	40.2 ± 3.0	0.4 ± 0.2	7.4 ± 1.5	
					7 October 2014-21 January 2015	17.7 ± 1.3	33.1 ± 2.7	0.7 ± 0.3	4.7 ± 1.0	
					21 November 2014- 29 May 2015	22.3 ± 0.2	36.7 ± 3.3	1.4 ± 0.4	5.7 ± 1.3	
Bassin d'Arcachon, France	Hatchery	Cage	Changed during growth performance	-	October 1989-November 1990	17.6 ± 0.8	43.7 ± 1.1	0.9 ± 0.1	13.7 ± 0.8	Robert et al., 1994
					November 1990-July 1992	6.5 ± 0.1	40.8 ± 0.3	0.04	13.5 ± 0.2	

Conclusion

The culture of *M. varia* is biologically feasible in waters of the Basque coast, but there is high mortality. Regardless of the culture system used, black scallops reached commercial size in 8-10 months beginning from 23.6 mm in height, which is a short time period, but survival values should be improved for the profitability of the culture. Since the mortality of black scallops may be due to stress caused during the transport, conditioning during transport should be optimised and/or other alternatives for seed supply could be explored, such as the development of a local hatchery or the use of seed collectors. On the other hand, since no increase in growth was observed during the last months of the study in any of the culture systems used, further research should be conducted with other culture technology to achieve larger sizes. Finally, this work provided relevant data for the diversification of bivalve mollusc production on the Basque coast.

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