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Comparison of growth of mussel, *Mytilus edulis*, on longline, pole and bottom culture sites in the Pertuis Breton, France

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Abstract: Growth of the mussel, *Mytilus edulis*, was compared for the first time under three culture regimes, longline located in open sea, pole and on-bottom both situated on an intertidal flat, in the Pertuis Breton, on the Atlantic coastline of France. Mussel sampling was performed on a monthly basis over 1 year while monitoring of hydrobiological parameters was conducted on a biweekly basis. Fluctuation of environmental parameters showed a similar pattern on both sea and shore locations with generally higher concentration levels for the intertidal area compared with the open sea, i.e. 4.07 and 3.17 mg l^{-1} for particulate organic matter, 3.16 and 2 µg l^{-1} for chlorophyll-*a*, 58.43 and 38.72 mg l^{-1} for inorganic-N, respectively. A clear seasonal growth pattern was observed, being similar for all three cultural conditions. A gradient of length and weight growth appeared as a function of the culture type. Longline mussels exhibited the highest performance while Bottom-type culture showed the lowest. An emersion time of approximately 26% was estimated from the temperature record of the Pole station during the period of maximal growth. This could partly explain the reduced growth in length on Pole compared to Longline. While growth was faster in Longline culture and condition index were better for Pole culture, further data on the carrying capacity of the area are needed for the establishment of a mussel culture extension policy.

Keywords: Author Keywords: *Mytilus edulis*; Growth; Water quality; Food resource; Emersion; Condition index

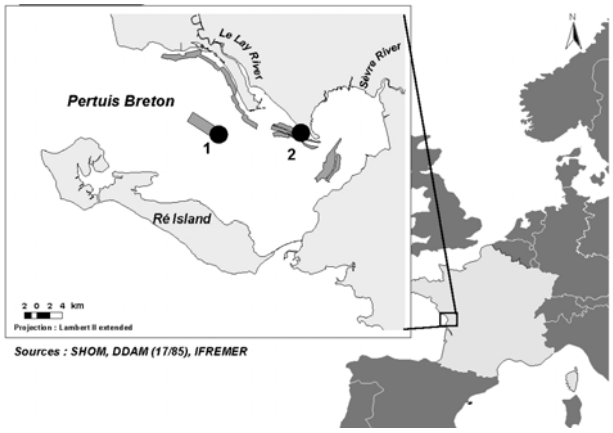
1. Introduction

The Pertuis Breton is a macrotidal estuary of 350 km² located on the French Atlantic coast (Fig.1). It is widely open to the Northwest on the Bay of Biscay and leads Southward into the Pertuis d'Antioche. Freshwater inputs, lower than $100 m^3.s^{-1}$ in winter, mainly stem from the discharges of both Lay and Sèvre rivers. With an average depth of less than 10 m, hydrodynamics of this water body are ruled by tidal cycles and possibly strengthened by west winds, which may induce higher turbidity. Its eastern part is covered by large mudflats accounting for one fifth of its total area (Hily, 1976) and composed of very fine clay material that can be easily resuspended in water (Gouleau, 1975).

Blue mussels (*Mytilus edulis* L.) have been cultivated since the 13th century in the Pertuis Breton area (Dardignac-Corbeil, 1979), which is one of the main French production centres accounting for 7 to 10 000 $tons.y^{-1}$ (Goulletquer and Héral, 1997; Goulletquer and Le Moine, 2001). Mussels are traditionally grown on bouchot, which are rows of wooden poles placed perpendicularly to the shore, stuck in the sandy mud ground within the gently sloping intertidal strip. Mussels are transferred either as seed attached on collecting ropes or as juveniles placed in net sockings and then wound up around the 2 m poles where they will fatten and grow to the marketable size in less than 2 years. Presently, 337 km of stakes are in culture along the Pertuis Breton shoreline. Some suspended culture on sub-surface long lines was deployed in 1991 to enhance the area mussel productivity and facilitate mussel spatfall. Two hundred forty lines of 100 m each carrying a 4 m mussel rope every 1.2 m are set up in a 400 hectares zone and account now for about 10% of the Pertuis Breton production. Most of the long line production concerns spat recruitment, seed being marketed to all French rearing areas. The growth of mussels collected on ropes is favoured by frequent selective harvesting. Bottom type culture is barely developed along the French Atlantic coast and is not used and

has never been used at all in the Pertuis Breton, while it is very important for mussel culture in northern Europe (Smaal, 2002).

Figure 1 Geographic location of the Pertuis Breton and the experimental culture stations: (1) Longline and (2) Pole and Bottom. Dark grey indicates suspended and bouchot commercial culture areas.



New national and EU directives for water quality of cultured areas and for nature conservation are being implemented while culture mechanisation leads to a necessary higher productivity in a slowly expanding mussel market (Smaal, 2002). Therefore, there is strong concern among farmers about the optimisation of the mussel culture in the Pertuis Breton. Particle sedimentation which raises the substrate level is favoured by the bouchot culture (Dardignac-Corbeil, 1996). This process progressively causes productivity loss from poles in the higher intertidal and has prompted the farmers to move whole rows towards lower tidal levels. Moreover, the available intertidal area is fully exploited and the extension of suspended culture capacity has been considered as a possible alternative for development.

It is useful to characterise the growth performance of mussels cultured at different areas within the Pertuis Breton. Mussels, as filter feeders, are fully dependent for their growth on the nutritive resources of their environment. The quality and the quantity of food produced

in the ecosystem and the availability of that food for the consumers are strongly variable depending upon the season and the site (Héral, 1991). Several studies have reported on mussel growth in bottom and/or suspended cultures in other countries (Seed, 1973; Kautsky, 1982; Loo and Rosenberg, 1983; Rodhouse et al., 1984; Hilbish, 1986). Growth of bouchot mussels has already been studied in the Pertuis Breton (Dardignac-Corbeil, 1996) and in Marennes-Oléron Bay (Boromthanarat, 1986) as well as growth of suspended culture mussels in the Pertuis Breton (Barillé, 1996). However, no comparative study has been performed between bouchots and suspended mussels.

The present work aims to compare the growth of mussels deployed on bouchot, suspended culture and on-bottom culture locations in the Pertuis Breton, in relation to their hydrobiological environment and over a one year period (1999-2000). The effect of emersion time on growth is also examined through the seawater temperature monitoring.

2. Materials and methods

Mussel growth was studied at three culture stations located in two sites of the Pertuis Breton (Fig. 1). A Longline station was located in the area of suspended culture (1), with mussels being set up on hanging ropes. Pole and Bottom stations were located in bouchot area (2), where mussels were set up on poles at their top and onto the ground respectively.

Seawater temperature was recorded every 15 min, from March 10, 1999 for Longline and Pole and from March 31 for Bottom to February 15, 2000, using Optic StowAway® temperature probes. It should be noted that probes at Pole and Bottom were emersed during low tide and recorded air temperatures.

Twice a month between March 1999 and March 2000, water samples were collected at high tide and 50 cm depth from Longline and Pole stations. The total particulate matter (TPM) was determined after filtration of 500 to 750 ml through preburnt and preweighed Whatman GF/C filters and drying for 24 h at 60°C. The particulate inorganic matter (PIM) was then determined after filters were burnt for 1 h at 450°C, and the particulate organic matter (POM) was calculated from difference between TPM and PIM. Chemical analyses were carried out from water filtered through GF/C filters. A Skalar analyser was used to assess concentrations in nitrates + nitrites as (NO_3^-+ NO_2^-)-N after UV irradiation (Wood et al., 1967), in ammonia as (NH_4^+ + NH_3)-N (Koroleff, 1983), and in phosphate as PO_4-P (Murphy and Riley, 1962). The inorganic-N concentration was calculated as the sum of (NO_3^- + NO_2^-)-N and (NH_4^+ + NH_3)-N. Chlorophyll-*a* was extracted with acetone after filtration through a GF/C Whatman filter according to the method of Holm-Hansen and Riemann (1978) and its concentration was determined with a Turner fluorimeter at 665 nm.

Mussels were collected from suspended culture in the Pertuis Breton on 18 February 1999 and hand sorted to ensure that initial populations were of homogeneous size from the same cohort which had settled during autumn 1998. They were randomly separated into 12 sets of 120 mussels for each station, i.e. a total of 36 sets. All sets were placed separately in cylindrical bags made of a rigid plastic net (12 mm mesh), of 40 cm diameter and 20 cm height. For Longline, bags were attached in pairs on two ropes of six bags each. For Pole, six contiguous poles were used, each carrying one pair of bags attached to its top at a height of 2 m. For Bottom, six pairs of bags were attached to the bases of the same poles, directly on the sediment surface. Ropes and poles used for the study were placed among cultured mussels in established suspended and bouchot cultures respectively. Every month, mussels were systematically removed from their plastic bag in all experimental conditions and replaced in a clean bag to avoid biofouling accumulation. Mussel growth was followed for one year by

performing size measurements once a month. For each culture condition a random sample of 50 mussels was collected monthly from one different randomly selected bag, until 23 February 2000 for the last sample. Mussels were transported to the laboratory held in humid air, brush cleaned of their epibionts and measured. Shell length (*Ls*) was measured (± 0.1 mm) with callipers according to Seed (1973). Total weight of individual live mussels and tissue weight after opening and draining on filter paper were measured to obtain the condition index: Ci = 100 * tissue weight / total weight. Shell dry weight (*Sdw*) and tissue dry weight (*Tdw*) were measured after placing the shell for 24 h at 60°C and after flesh freeze-drying, respectively. Mussels of the initial common set were also measured before being sorted and placed under experimental conditions.

Growth rates within determined periods of time were calculated and statistically compared using linear regressions with Statgraphics Plus® Version 5.1 software. Means given throughout the text were computed with their confidence intervals expressed as standard error.

To estimate the emersion time for Pole and Bottom stations, temperature data were analysed as follows. Water temperature were supposed to have similar daily variations at Longline and Pole. It was then assessed that a sudden change in recorded Pole or Bottom temperature indicated that probe and mussels have just been immersed or emersed. As temperature was recorded every 15 min, a mean temperature was calculated over 4 h for every high tide at Pole. For a station, Pole or Bottom, when the difference between recorded temperature and mean temperature was larger than 1°C, an emersion period of 15 min was identified. All 15 min emersion periods were then summed for each tideand the sum time value plotted against the corresponding tide coefficient, with the aim to describe their relationship by a linear regression. Estimated values of emersion times were then obtained

from a tide schedule using this linear regression and summed over a growth period. To estimate effect on growth monthly measurements of *Ls* and *Tdw* during phase II were plotted against the calculated emersion time for Pole. Linear regressions were assessed and their slopes compared with the slopes of corresponding regressions formerly obtained for Longline.

3. Results

Seawater temperature, recorded on probe at Longline, ranged between 4.6 and 22.5°C. While extrema recorded at Pole and Bottom were measured in air, the seasonal variation pattern was similar for all three stations. Daily variations supported by mussels were less than 3.2°C for Longline and higher than 16.7°C and 14.8°C for Pole and Bottom respectively.

Variations over one year of some of the main water parameters (concentrations of PIM, POM, Chlorophyll-a, N-inorganic and P-PO4) are shown in Fig. 2. Patterns for all parameters were similar at all stations but higher values were generally found in Pole rather than Longline culture. Annual PIM mean values were 19.1 ± 27.7 and 9.7 ± 5.5 $mg.l^{-1}$ in Pole and Longline, respectively, and annual POM mean values were 4.1 ± 2.8 and 3.2 ± 1.4 $mg.l^{-1}$ respectively. Two peaks of particulate matter appeared in spring and in early summer in both stations as well as a sharp one in fall in Pole only. Chlorophyll-a concentrations increased during spring and early summer up to the maximal values of 11.08 and 9.59 $\mu g.l^{-1}$ in Pole and Longline, respectively. Summer and fall were characterised by distinct successive lower peaks and winter by poor concentrations around 1 $\mu g.l^{-1}$ in Pole and even less in Longline. Mean annual concentrations were 3.16 ± 3.12 in Pole and 2.00 ± 1.97 $\mu g.l^{-1}$ in Longline. The chlorophyll-a to POM ratio fluctuated accordingly reaching for the three main peaks higher

values in Pole (3.51, 3.00, 1.98 µg.mg^{-1}) than in Longline (1.09, 1.50, 1.62 µg.mg^{-1}) and similar low values from November to March (0.17 to 0.60 µg.mg^{-1}).

The inorganic-N concentrations decreased strongly from March to June keeping until September low values between 1 and 3 µmole.l^{-1} , and then increased again to the mean values of 84.4 ± 53.8 and 54.3 ± 20.8 µmole.l^{-1} during fall and in Pole and Longline, respectively. Inorganic-N was constituted by Nitrate-N at 80% and 77% for Pole and Longline respectively. Similarly phosphate concentrations seemed to decrease slowly from October to May, with more fluctuations in Pole (between 5.51 and 0.53 µmole.l^{-1}) than in Longline (between 1.83 and 0.54 µmole.l^{-1}). Concentrations reached a minimum on May 31 (0.08 and 0.07 µmole.l^{-1} in Pole and Longline, respectively), but recovered later on.

Variation in *Ls*, *Sdw* and *Tdw* showed a consistent faster growth rate for Longline mussels than for Pole and Bottom mussels (Fig. 3).

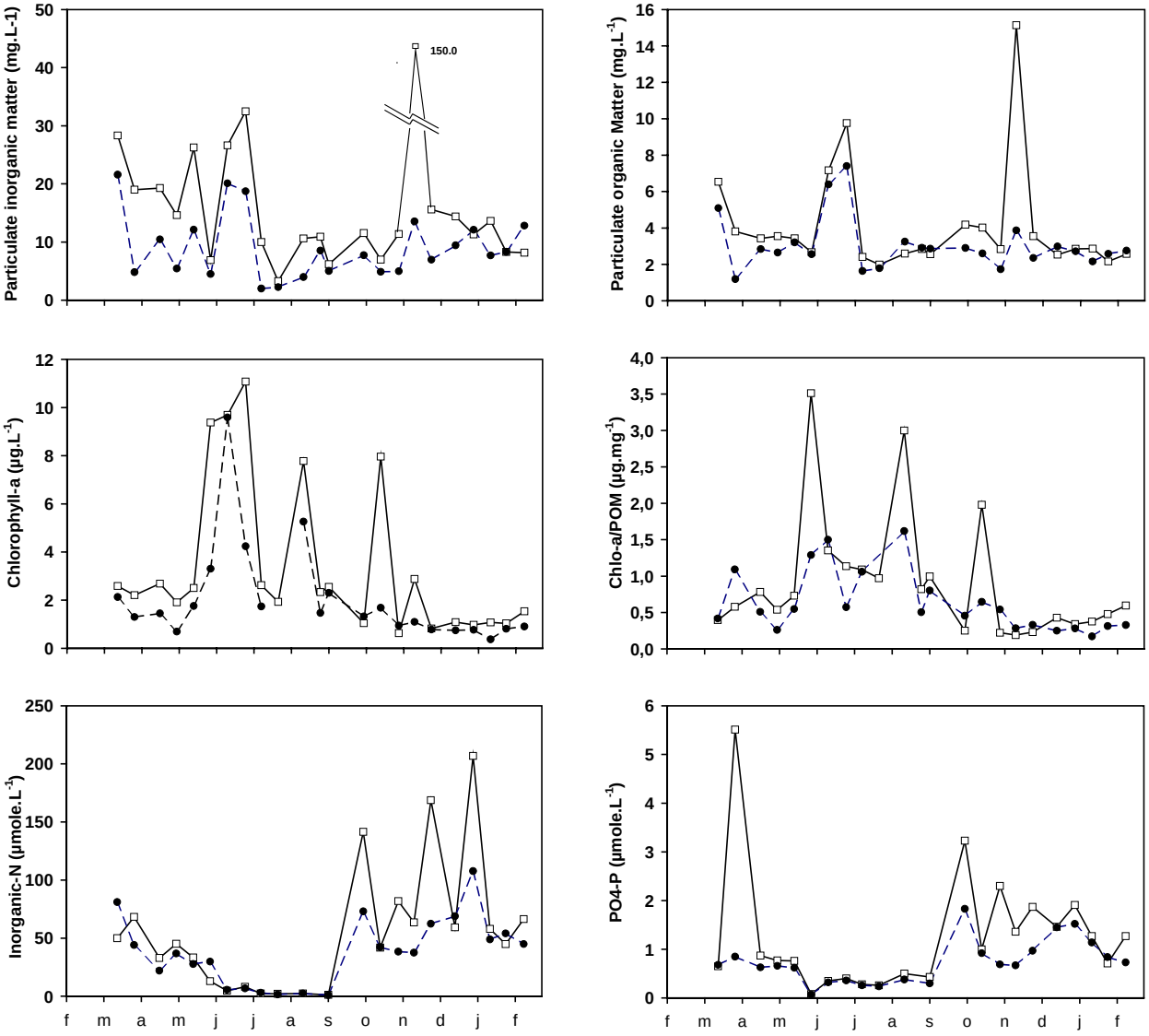
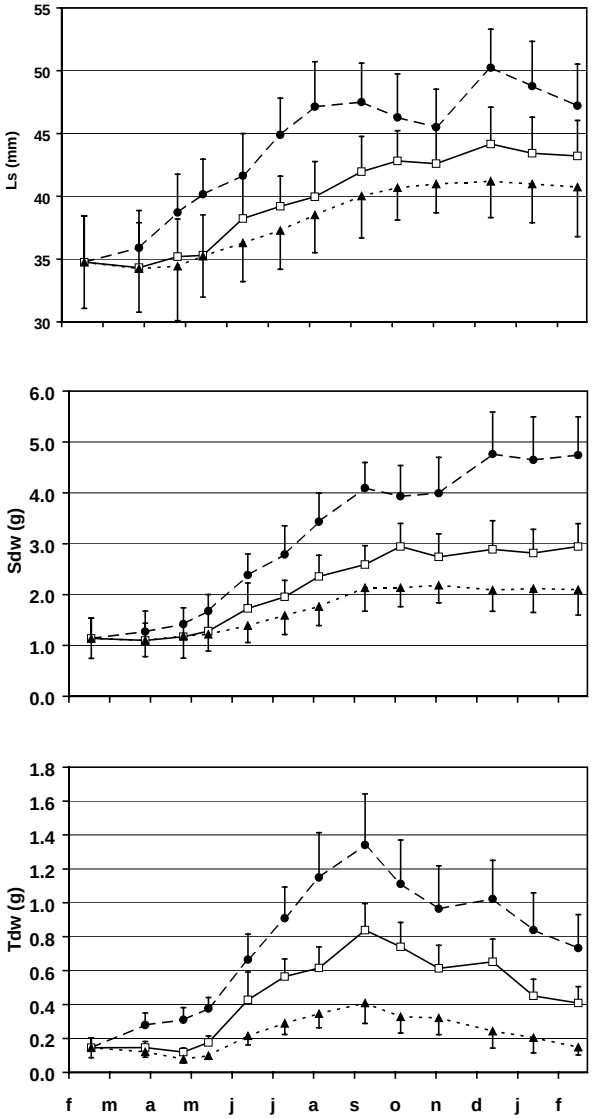


Figure 2. Temporal variations of water parameters measured at Longline (●, dashed line) and Pole (!, plain line) over the one year experimental period.

Figure 3. Monthly evolution of shell length, shell dry weight and tissue dry weight of mussels from the three stations, Longline (●, dashed line), Pole (!, plain line) and Bottom (σ, dotted line). Data plotted as mean ± SE.



Growth in shell length was steady from February to September in Longline mussels and May – November in both other stations. An unexpected shell length decrease appeared in Longline from September to November followed by a growth rebound and another decrease from December to February. There was no observed growth between December and February in Pole and Bottom. Mean *Ls* increased in one year from 34.8 ± 3.7 mm to 47.2 ± 3.3 mm in Longline, 43.2 ± 2.8 mm in Pole and 40.7 ± 3.9 mm in Bottom, respectively. *Sdw* increased in

Longline from May to September, did not vary for the following two months, increased again in December and remained constant until February. In Pole and Bottom it increased from June to October and remained then stable. *Sdw* increased from 1.14 ± 0.39 g to 4.74 ± 0.76, 2.94 ± 0.45, and 2.10 ± 0.50 g in Longline, Pole and Bottom, respectively. *Tdw* increased from 0.16 ± 0.02 g in February 1999 to 1.34 ± 0.08 g in September in Longline, 0.84 ± 0.04 g in Pole and 0.41 ± 0.03 g in Bottom. There was a subsequent weight decrease to February 2000 mean weight values of 0.73 ± 0.06 , 0.41 ± 0.03 and 0.15 ± 0.02 g in Longline, Pole and Bottom, respectively.

The annual *Tdw* growth variation could be divided into three phases, for all stations. (I) (from February to late April) was characterised by a slow or negative growth, during (II) (from May to the end of September) growth was exponential and (III) (from October to February) was characterised by emaciation. Comparisons were done between the regressions on *Ls* and *Tdw* growth using the same phases. The estimated slopes of *Ls* and *Tdw* growth were all statistically different among the three stations for each phase (Table 1).

Table 1. Comparison of growth regressions during different seasonal phases in Longline, Pole and Bottom mussels.

Seasonal phase	Station	Slopes of the linear regressions	Comparison		
			n		P
Shell length		mm. day^{-1}			
I	Longline	$5.46\ 10^{-2}$ (± $0.93\ 10^{-2}$ SE)	446	***	< 0.001
	Pole	$0.52\ 10^{-2}$ (± $0.96\ 10^{-2}$ SE)			
	Bottom	$0.51\ 10^{-2}$ (± $1.00\ 10^{-2}$ SE)			
II	Longline	$6.83\ 10^{-2}$ (± $0.50\ 10^{-2}$ SE)	749	***	< 0.001
	Pole	$5.17\ 10^{-2}$ (± $0.45\ 10^{-2}$ SE)			
	Bottom	$4.04\ 10^{-2}$ (± $0.48\ 10^{-2}$ SE)			
III	Longline	$1.61\ 10^{-2}$ (± $0.47\ 10^{-2}$ SE)	745	*	0.022
	Pole	$0.51\ 10^{-2}$ (± $0.37\ 10^{-2}$ SE)			
	Bottom	$0.03\ 10^{-2}$ (± $0.42\ 10^{-2}$ SE)			
Tissue dry weight		$g.day^{-1}$			
I	Longline	$2.41\ 10^{-3}$ (± $0.198\ 10^{-3}$ SE)	446	***	< 0.001
	Pole	$-0.35\ 10^{-3}$ (± $0.121\ 10^{-3}$ SE)			
	Bottom	$-0.94\ 10^{-3}$ (± $0.150\ 10^{-3}$ SE)			
II	Longline	$8.24\ 10^{-3}$ (± $0.324\ 10^{-3}$ SE)	749	***	< 0.001
	Pole	$5.20\ 10^{-3}$ (± $0.202\ 10^{-3}$ SE)			
	Bottom	$2.56\ 10^{-3}$ (± $0.231\ 10^{-3}$ SE)			
III	Longline	$-2.53\ 10^{-3}$ (± $0.311\ 10^{-3}$ SE)	745	***	< 0.001
	Pole	$-2.37\ 10^{-3}$ (± $0.173\ 10^{-3}$ SE)			
	Bottom	$-1.40\ 10^{-3}$ (± $0.217\ 10^{-3}$ SE)			

Emersion time (E) was assessed in days during phase II, while growth was steadier and faster than in phases I and III, from the tide coefficient by the following relationships.

$E = 1/1440 \times [100.78\ (\pm\ 8.51\ SE) + 1.34\ (\pm\ 0.11\ SE) \times Tide\text{-}coefficient]$ for Pole

($n=163$, $R^2=0.47$, $P<0.001$),

$E = 1/1440 \times [-111.68\ (\pm\ 12.13\ SE) + 2.21\ (\pm\ 0.16\ SE) \times Tide\text{-}coefficient]$ for Bottom

(n=119, R^2=0.61, P<0.001).

Cumulative emersion times during phase II were 31.5 and 7.7 days for Pole and Bottom stations, respectively, and represented 26.5% and 6.5% of the total duration of this phase. Mussels in these stations were therefore immersed in seawater during the equivalent of 87.5 and 111.3 days for Pole and Bottom respectively compared with 119 days for Longline (length of phase II).

Slopes of growth regressions for Longline and Pole corrected by emersion are given in Table 2. As growth was very poor on Bottom, an assessment of the emersion corrected growth was not made for this station. Regression slopes for shell length were not statistically different (P=0.795) indicating the same *Ls* growth rates at Longline and emersion corrected-Pole. Regarding tissue dry weight, the regression slopes were statistically different (P=0.016) between Longline and emersion corrected-Pole. The ratio of *Tdw* growth between Pole and Longline conditions changed from 63% before correction to 88% after correction by time of emersion.

While an annual cycle of condition index (Ci) was evident in Longline and Pole (Fig. 4) with similar values in February 1999 (25.9 ± 2.1) and 2000 (28.5 ± 1.5 and 25.8 ± 1.4, respectively), Ci decreased over one year in Bottom (to 14.8 ± 0.9). Ci increased in Longline from February to September to the maximal value of 39.5 ± 1.4 and then decreased until the following February. Meanwhile, after a decrease in Ci at Pole between February and April, Ci rapidly increased to reach a July value similar to the Longline value and remain comparable to it until February. Bottom Ci values were always lower, reaching an August value of 27.2 ± 1.2, close to the common starting point.

Figure 4. Monthly evolution of condition index of mussels from the three stations, Longline (●, dashed line), Pole (!, plain line) and Bottom (σ, dotted line). Data plotted as mean ± SE.

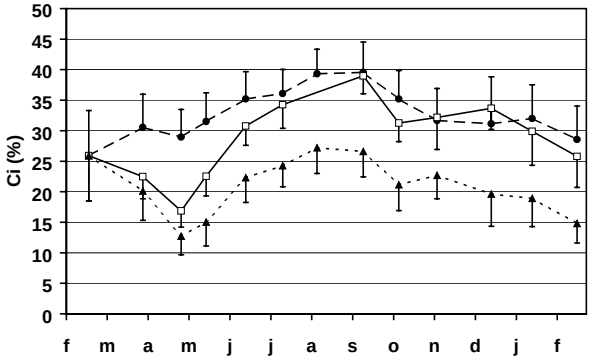


Table 2. Comparison of growth during phase II after correction by emersion time for Pole.

Station	Slopes of the linear regressions	Comparison		
			n	p
Shell length	10^{-2} mm. day^{-1}			
Longline	6.83 (± 0.67 SE)	n.s.	500	0.795
Corrected Pole	7.04 (± 0.64 SE)			
Tissue dry weight	10^{-3} g.day^{-1}			
Longline	8.24 (± 0.33 SE)	*	500	0.016
Corrected Pole	7.17 (± 0.36 SE)			

4. Discussion

The importance of daily variability of water parameters compared to their seasonal variability has been reported by Héral et al. (1987). Hydrobiological parameters measured in this study were compared with data obtained in previous studies in the Pertuis Breton from 1987 to 1993 (Dardignac-Corbeil, 1996) and over 1991-92 (Barillé, 1996) and showed similar fluctuation patterns over a year. Variation in seston and dissolved seawater parameters

indicated a typical spring phytoplankton bloom followed by irregular blooms of lower importance in summer and autumn. Those blooms took place after the progressive uptake of inorganic-N and PO_4-P, as described by Soletchnik et al. (1998) in the nearby Marennes-Oléron bay. Chlorophyll-a concentrations measured in this study (1-10 $\mu g.l^{-1}$) compared with the 1987-93 average on Pole (1-16 $\mu g.l^{-1}$). Except during bloom events the low chlorophyll-a:POM ratio indicated a poor quality of organic seston and a high detritus fraction in winter. It also confirmed the mostly detrital composition of the November peak of particulate matter which entered the system in relation to rains and water discharge (Malet, unpublished data). Moreover, the present work showed that seston parameters, and especially a potential food indicator like the chlorophyll-a:POM ratio, fluctuated at higher levels in Pole than in Longline, as had already been observed by the earlier studies carried out in the Pertuis Breton.

Thompson (1984) stated that the most important factor explaining mussel growth is the food supply. An increase in dry tissue weight is generally considered to be a function of amount of food available to individuals (Héral et al., 1987; Goulletquer and Bacher, 1988). For all stations in our study the overall growth pattern observed was compatible with the food sources identified in the Pertuis Breton. The period of faster growth from June to September, occurred when chlorophyll-a levels were the highest. Héral et al. (1989), working in the Marennes-Oléron Bay and other authors (Page, 1986; Rivonkar et al., 1993) also described a strong positive relationship between growth and chlorophyll-a concentration. Growth slowed down after mid September, when phytoplankton levels were lower. Koehn et al. (1980, in Hilbish, 1986) also observed a loss of soft tissue in the autumn. Mussels feed mainly on unicellular algae (Bayne and Hawkins, 1992) and to a lesser extent on detrital material (Coe and Fox, 1944 in Seed, 1976; Rodhouse et al., 1984; Langdon and Newell, 1990) even though the latter is reported to be a poor quality food (Williams, 1981). Richard (2000) reports that mussel food sources in the Pertuis Breton include neritic phytoplankton, microphytobenthos

and terrestrial organic matter which could contribute to 15-30% of the mussel resources in winter. The consumption of incoming detrital material could partially explain the growth resumption in November, when seawater temperature (above 8°C) should not be a limiting factor for growth (Widdows and Bayne, 1971). The decrease in shell length and the shell dry weight plateau described in the autumn for Longline mussels occurred during phytoplankton bloom and could be therefore related to a mechanically induced loss of newly grown thin shell under the effect of a series of storm. The offshore swell reached 3 to 6 m during these storms on 20 September, 22 to 25 October, 6 November and later 27 and 29 December 1999 (Centre Départemental de Météo France, 1999-2000).

All mussels had the same origin, thus variation in growth was attributed to environmental factors as reported by Kiørboe et al. (1981), Mallet et al. (1987) and Fuentes et al. (2000). Growth was slower in Pole than Longline cultures although chlorophyll-a concentrations and chlorophyll-a:POM ratio were better in Pole; however PIM was generally higher in Pole than in Longline and the organic content of seston lower, which Bayne and Worral (1980) suggested as an important factor for reducing growth. Moreover, mussels experienced quite different thermal conditions with higher daily fluctuations in Pole compared to Longline. Thompson (1984) indicated that physiological stresses experienced by intertidal mussels could be partly responsible for their lower growth. High temperature fluctuations are due to the night-day differences during emersion. The influence of emersion time on the growth of wild and cultured mussels has been documented by several authors (Coulthard, 1929; Baird, 1966 in Seed, 1976; Seed, 1969; Gillmor, 1982; Rodhouse et al., 1984; Skidmore et al., 1985; Van Erkhom Shurink and Griffiths, 1993; Buschbaum and Saier, 2001). Mussels located at higher tidal levels have therefore a shorter period of access to food, which could result in a lower growth rate (Seed, 1976), despite a longer gut residence time of food (Bayne et al., 1988). This effect of the tidal level could interfere with food availability

and with other environmental factors as shown by the wide range of growth reduction occurring with increase of aerial exposure estimated by various authors (Table 3). Our study showed no significant difference between *Ls* growth in Pole corrected for emersion time and in Longline during phase II. Emersion time could therefore explain the whole variation in Length growth among both conditions. In contrast, *Tdw* growth, after correction for emersion time, remained lower in Pole than in Longline and the emersion effect could only explain a part of the tissue growth difference between both stations. It is likely that the remaining growth difference originated in other factors like a different food quality or a different physiological behaviour (Demers and Guderley, 1994). The short emersion time of Bottom mussels cannot explain their lowest growth among the three stations. Even in the absence of environmental data at this station (other than temperature), we speculate that it may be attributed to a very high silt content inducing a lower food consumption (Kiørboe et al., 1981) and physiological stress. The Bottom mussel bags were partly buried in the sediment at most of the sampling dates (pers. obs.). Similarly, Fréchette and Grant (1991) showed as well that mussels in the beds grew less than mussels suspended 1 m above the sediment.

Table 3. Estimates of growth reduction in mussels exposed to air with regard to subtidal mussels

Species	Area	Status	% aerial exposure	Parameter	Growth [a]	References
M. edulis	New Brunswick (Canada)	wild	50%	L	6% - n.s.	Coulthard, 1929
M. edulis		wild	56%	n.a.	0%	Baird, 1966 in Seed, 1976
	Waden Sea (Germany)	wild	mid intertidal	L	55 to 58%	calculated from Buschbaum and Saier, 2001
M. edulis		wild	75%	L	>0%	Seed, 1969
M. edulis			80%	Tdw	0%	Gillmor, 1982
M. edulis	Killary H. (Ireland)	wild	13% 33%	Sdw	72 to 76% 14 to 29%	calculated from Rodhouse, 1984
M. edulis	Perthuis Breton (France)	cultured	26.5% - Pole 0% - Corrected	L	76% 103% - n.s.	this study (phase II)
			26.5% - Pole 0% - Corrected	Tdw	63% 87%	this study (phase II)
P. perna	Saldanha Bay (South Africa)	cultured	50%	L	80%	van Erkom Schurink and Griffiths, 1993
M. galloprovincialis	Saldanha Bay (South Africa)	cultured	50%	L	80%	van Erkom Schurink and Griffiths, 1993
C. meridionalis	Saldanha Bay (South Africa)	cultured	50%	L	66%	van Erkom Schurink and Griffiths, 1993

Rise of the condition index was faster in Pole between April and September compared to both other stations and Ci reached values close to those of Longline, suggesting a higher increase in meat content. It is a characteristic of bouchot mussels which are sold at their best quality from June to October.

Bottom mussels presented the worst growth performance. This observation is confirmed by the absence of this kind of culture in the mudflats of the Pertuis Breton. The higher growth of Longline mussels could favour an extension of suspended culture in the area, even to the detriment of Pole cultures. Indeed, the carrying capacity of the area is limited and studies on modelling mussel growth on long line as a function of environmental conditions and rearing density (Bacher, personal communication) would require further data on this matter (Goulletquer and Le Moine, 2001). However, the good condition index observed in Pole mussels from June to October and its well appreciated specific taste identify the production in the market and are an advantage for the bouchot method. Bouchot mussels are protected by a label established in 1999 by th Shellfish National Comitee (CNC) including cultivation aspects, product characterisation and tracibility (Prou and Goulletquer, 2002). There is also locally a registered label “La Charron” for the Pertuis Breton bouchot mussel. Consequent regulations do not allow to sell line mussels under the same commercial label. Thus the mussel farmers of the area are moving towards a culture technique which combines seed collection and pregrowth in suspended culture with final growth on bouchot to allow a shorter production cycle of a mussel for this specific market. So both line and bouchot mussels are different products and a production increase of line mussel could satisfy the French market demand whithout damage for the bouchot mussel market.

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