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GROWTH PERFORMANCE OF OYSTERS (*CRASSOSTREA GIGAS*) FARMED IN TWO AREAS WITH DIFFERENT HYDRODYNAMICS: A CASE STUDY IN THE VARANO LAGOON (ITALY)

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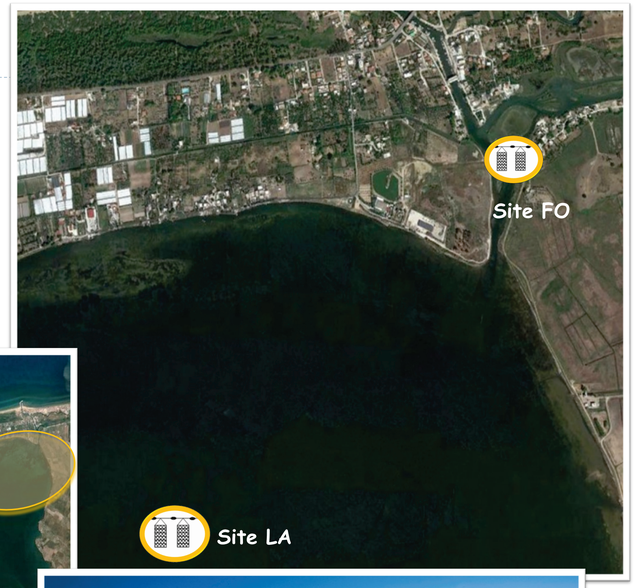
Aquaculture production has increased worldwide over the last few years and it is expected to fill the shortfall in aquatic food products resulting from static or declining capture fisheries and population increase (De Silva, 2001). Based on ecological and market considerations, the most areas for Mediterranean aquaculture include bivalve molluscs that will continue to be a driving force for socioeconomic and ecological change in complex coastal systems as lagoons. Indeed, an increase of shellfish culture (oyster and mussel) is important for the expansion of environmentally sustainable aquaculture but also for food security, employment, and trade balance. providing a number of additional services, including eutrophication management. In order to diversify the fish production, the pacific oyster *Crassostrea gigas* was cultured at commercial farms in the Varano lagoon (SE Italy). The assessment of the growth performance of *C. gigas* was performed from November 2014 to September 2015 through growth rates, condition and mortality in two different sites of the lagoon, characterized by different hydrodynamics conditions. Specific sites were located in the North-East area of Varano Lagoon where concessions for shellfish culture (mussels and clams) of the Consortium of Fishermen Ischitella are concentrated. Site LA is located in a more central area characterized by highest hydrodinamic condition, because wind exposed, and by higher depth (>4 m); Site FO is located within a channel sheltered, close to a sandbanks system, and subject to weak hydrodynamics influenced by tidal ranges and at lower depths (2m).



Environmental and Trophic variables

	Site LA				Site FO			2-way ANOVA sites	2-way ANOVA months
	mean ±DS	min	max		mean ±DS	min	max	p	p
T°C	18,3±7,01	9 (Jan)	30,1 (Jul)	=	18,3±6,99	9,8 (Jan)	29,5 (Jul)	n.s.	**
S psu	20,6±2,12	19 (Apr)	25 (Sep)	<	24,2±5,98	15 (Apr)	31 (Sep)	*	n.s
O%	77,4±11,21	50,73 (Apr)	92,45 (Jul)	>	70±10,47	56,11 (Jun)	91,49 (Jan)	n.s.	n.s.
TSM mg/l	18,98±5,7	7,2 (Jan)	30,1 (Jul)	<	31,24±31,1	15,5 (Jan)	127,2 (Nov)	n.s.	n.s.
ISM mg/l	15,1±4,9	6 (Jan)	2,29 (Jul)	<	24,7±0,273	1,1 (Jan)	10,84 (Nov)	n.s.	n.s.
OSM mg/l	3,9±1,9	3 (Nov)	7,7(Jul)	<	6,5±7,8	1,1 (May)	38,8 (Jan)	n.s.	n.s.
Chl-a $mg \cdot m^{-3}$	4,31±6,52	0,13 (Sep)	24,93 (Jul)	>	2,61±2,06	0,24 (May)	8,85 (Sep)	n.s.	n.s.
NOx µM	18,42±11,92	0,31(Jul)	39,26 (Dec)	>	17,20±10,89	0,42 (Jul)	32,26 (Dec)	n.s	***
$NH4^+$ µM	1,655±1,88	0,1416(Jul)	6,8 (Sep)	<	2,91±1,90	0,37(Mar)	6,92 (May)	**	*

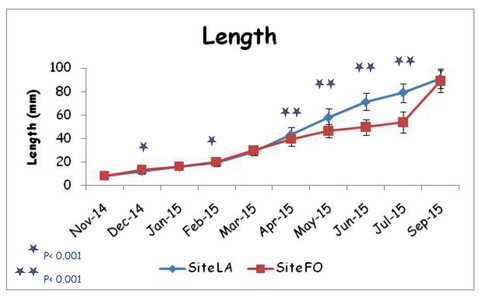
n.s. Non significant differences
* p<0.05 ** p<0.01 *** p<0.001

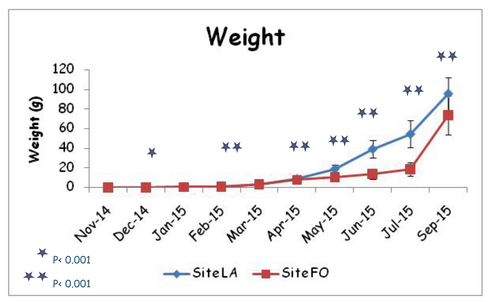
Surface water temperature, nitrate and nitrite (NOx) showed a significant temporal variations, whereas salinity exhibited a significant difference between sites. Ammonium instead showed a significant spatial-temporal variation.

Growth parameters

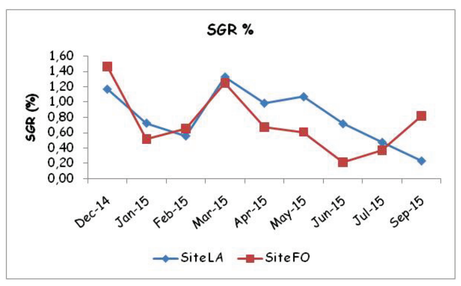
Biometric analysis (length, width, height) were carried out on 80 individuals collected at each site and in each sampling month, while dry mass (lyophilized) was measured on a sub sample of 6 individuals for the calculation of the Condition Index (CI=dry mass meat ·100/dry mass shell).

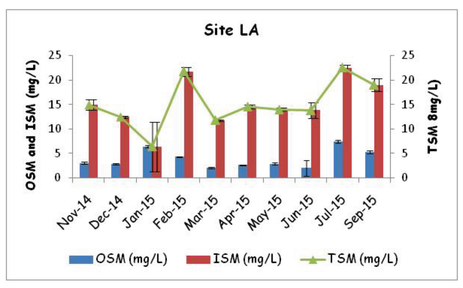
Shell length and wet weight of oysters increased during cultivation time at all sites, with values significantly higher in LA site than in FO site (Kruskall-Wallis test, p< 0.05). At the end of experiment (September 2015), no significant difference in the shell length was observed between sites (91.4 mm ± 8.4 and 89.2cm ± 9.2 LA and FO sites respectively) (Kruskall-Wallis test, p> 0.05). On the other hand a significant difference in weigth was observed between sites (95.9 g ± 16.6 and 73.8 g ± 20.9 LA and FO sites respectively) (Kruskall-Wallis test , p< 0.01). Moreover, a total mortality of 18% was recorded only in site FO.

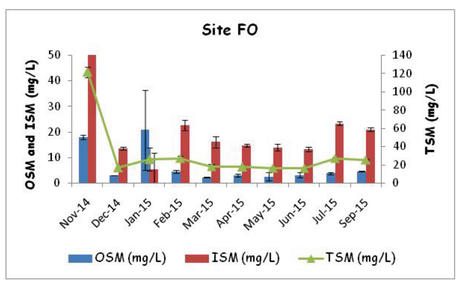




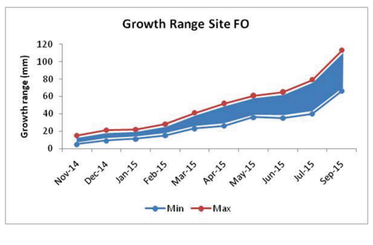
Growth performance was analysed by calculating growth specific rate (SGR%). Mean montly SGR ranged from 1.33% (March) to 0.23% (September) with a mean of 0.73±0.42% in LA site. In FO site, mean montly SGR showed a maximum in December (1.46%) and a minimum in June (0.04%) with a mean of 0.57±0.48%. No relationship was found between SGR and environmental variables in site FO (p>0.05). A negative relationship was found between SGR and Salinity, TSM and ISM in LA site (p< 0.05). SGR was positively correlated with nutrients, and negatively with Salinity, TSM and ISM in the site LA (p<0.05). In addition, TSM and ISM were strongly positively correlated (R=1, p<0.001).

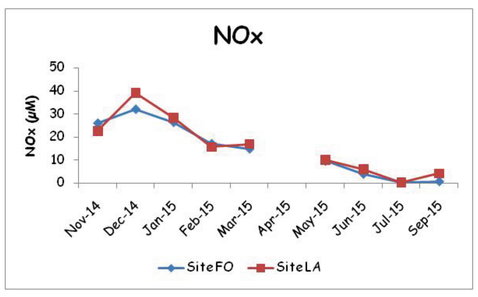


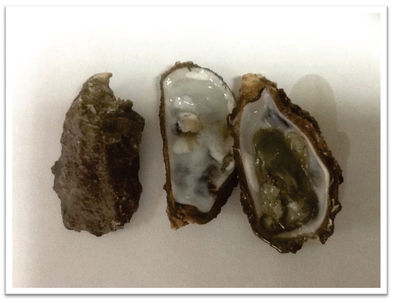




Growth range (minimum and maximum growth of shell length) showed a strong intraspecific variability at both sites throughout the growing period, more accentuated in the FO site.







To determine the dry mass of meat (DMW) and valves (DSW) and condition index (IC, according to Walne and Mann, 1975), soft tissue and shell of six animals for each site and sampling time were freeze-dried and weighed. The preliminary results were shown in the table on the right. Significant differences for all parameters were found between the two sites , except for DMW in September (Kruskall-Wallis, p<0.05).

	July		September	
	Site LA	Site FO	Site LA	Site FO
DMW	0,96±0,41	0,22±0,08	1,8±0,29	1,53±0,61
DSW	25,9±5,24	8,45±0,08	51,68±6,66	31,23±8,76
CI	3,59±0,91	2,66±0,28	3,55±0,82	4,79±0,74

DISCUSSION

The results of this study show that environmental conditions are suitable for oyster culture in Varano lagoon, reaching the commercial size (60 mm) in short time (6-8 months). Indeed, the oysters reared in the two sites exhibit a better growth than other sites in Mediterranean Sea (eg. Mersin Bay, Turkey) (Acarli et al. 2011) and in offshore environments (eg. North Sea, Germany) (Pogoda et al. 2011).

Despite length and weight of oysters showed higher values in site LA during the study, sizes of the animals reared in the two sites were comparable at the end of experiment in terms of shell length and dry mass. In the site LA, the commercial size of oysters was reached in shorter time (six months) than in site FO (eight months). Although both sites may be consider suitable for the oyster culture in Varano lagoon, the site LA demonstrated better conditions.

In this study, specific growth rate (SGR) of *C. gigas* showed a comparable trend in the two different sites in the first part of the experiment period. From April, the growth performance of oysters decreased appreciably less in the site LA than site FO. In the last two months, SGR increased in the site FO, reaching higher values than site LA, while SGR decreased in site LA.

In spring, the high concentration of nutrients in the lagoon water positively affect the feeding response of suspension feeders, so the oysters showed higher growth performances. The decrease in growth was obtained in winter and in summer as a result of the simultaneous decrease of nutrients and increase of salinity, TSM and ISM. Indeed, an increase in suspended inorganic sediment decreased the filtration rate in bivalves (Resgalla et al., 2007), so the oysters showed slower growth rate.

In conclusion, these data demonstrate the suitability of transitional environments for oyster cultivation and encourage aquaculture activities into Varano lagoon.

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