Aquacultural Engineering 45 (2011) 137–145

Contents lists available at SciVerse ScienceDirect

Aquacultural Engineering

journal homepage: www.elsevier.com/locate/aqua-online

Effect of different longline farming designs over the growth of *Mytilus chilensis* (Hupé, 1854) at Llico Bay, VIII Región of Bio-Bio, Chile

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ARTICLE INFO

Article history:
Received 8 June 2011
Accepted 19 September 2011

Keywords:
Mussel
Mytilus chilensis
Growth
Longline
HDPE tubes

ABSTRACT

This study evaluates the effect of three culture design factors over the growth of the *Mylitus chilensis*, farmed through suspended systems known as longline with buoys, and longline with High Density Polyethylene (HDPE) tubes. The study was carried out at the Llico Bay, VIII Region of Bio-Bio, Chile. The three factors studied are: sleeve spacing, sleeve type and depth. The results show that in the longline with buoy system, the sleeve spacing presented a significant effect over the shell length and the wet meat weight ($p < 0.001$, for both growth variables). On the longline of HDPE tubes system, the sleeve spacing had a significant effect over the meat yield ($p < 0.001$). The depth factor had the most important effect over the growth on the longline with HDPE tubes system ($p < 0.001$). The sleeve type presented an effect on all growth variables ($p < 0.001$), but only in the longline of HDPE tubes. The conclusion is that on the longline with buoys, for *M. chilensis* farming, the best growth results and operational advantages are obtained under the following design configuration: continuous sleeve with spacing between sleeves of 40 cm, and a length/depth of 6 m. For the longline with HDPE tubes, the best configuration is a net sleeve, with gaps of 40 cm and a length of 6 m. When comparing results by both types of longline in a semi exposed zone, at the end of the study period, the longline of HDPE tubes shows superior results in shell length and meat yield over the longline of buoys with an 8.13% increase in the shell length and a 7.22% in meat yield.

1. Introduction

Mytilus chilensis (Hupé, 1854) is a bivalve mollusc that is distributed between the 18°29′24.36″ S and the 54°56′49.42″ S of the Chilean coast. It is found in the inferior intertidal zone and up to 25 m in depth (Navarro and Winter, 1982). *M. chilensis* feeds of phytoplankton and detritus through filtration from the water column, it has separate sexes and it reproduces by external fertilization (Navarro and Gutiérrez, 1990) and is farmed through suspension systems in southern Chile (Winter et al., 1984; Navarro and Gutiérrez, 1990; Alcapán et al., 2007). SERNAPESCA (2009) reported a growth in production of a thousand percent (1000%) between 1998 and 2008, and ninety nine percent (99%) of this production was harvested from farming centers, the rest was extracted from natural beds. Currently, the main farming centers produce 98% of the national output. These farms are located in protected bays in the X Region of southern Chile (40°44′ S; 79°35′ W) covering a total of 15,484 ha. This farming concentration, or farming density, has resulted in a yield reduction and a reduction in the observed growth rates, due to a reduction in food particles available in the environment (Ogilvie et al., 2000; Toro et al., 2004; Grant et al., 2007). This is why the shellfish farming industry has been searching for new locations at lower latitudes such as the Llico Bay, located in the VIII Region of Bio-Bio in the central zone of Chile, which is an open and unprotected zone. The Llico Bay is a zone of interest because it presents concentrations of chlorophyll-a (Chl-a) of up to 52.6 mg m^{-3} (Ahumada, 2002), which would suggest a higher level of productivity. An experimental farm was implemented in this new potential zone, in order to identify the longline design that would report the highest mussel growth and yield, before implementing projects at a commercial scale.

It is known that mussel growth depends on variables such as temperature and salinity (Bayne and Worral, 1980; Fuentes et al., 2000; Karayücel and Karayücel, 2000; Nair and Appukuttan, 2003; Ogilvie et al., 2004; Yigin and Tuncer, 2004; Waite et al., 2005), concentration of food particles (Perez et al., 1995; Ogilvie et al., 2000; Dowd, 2005; Waite et al., 2005; Grant et al., 2007; Lök et al., 2007; Filgueira et al., 2008; Celik et al., 2009), seeding density, and farming system design (Raman-Nair and Colbourne, 2003; Lauzon-Guay et al., 2005; Plew et al., 2005; Drapeau et al., 2006; Aure et al., 2007; Stevens et al., 2007; Ramsay et al., 2008; Strohmeier et al., 2008). However, there is a lack of studies to determine the effects of

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doi:10.1016/j.aquaeng.2011.09.002

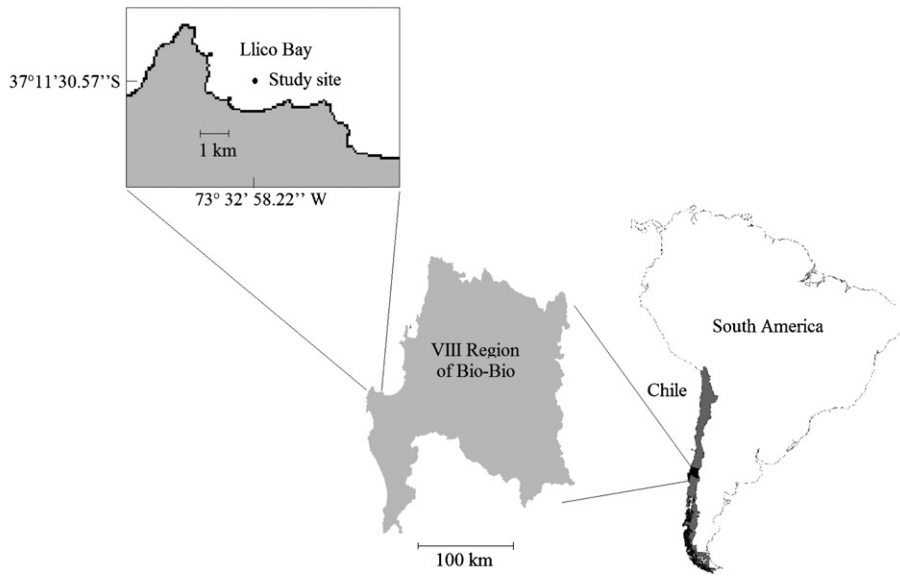

Fig. 1. Study site in the VIII Region of Bio-Bio, Chile.

the different culture design over the growth of the *M. chilensis*. The objective of this study, it is to evaluate at the end of a period of 10 months, the effects of longline culture design factors over mussel growth and meat yield, in a lower latitude zone than the one used today for commercial production.

2. Materials and methods

2.1. Study site

This farming experiment was implemented between April 2009 and February 2010, before the earthquake and tsunami of February 27th of 2010. The location was the Llico Bay (37°11′30.57″ S; 73°32′58.22″ W), in the VIII Region of Bio-Bio, Arauco Gulf, Chile (Fig. 1). This zone is a Benthic Resource Management and Exploitation Area (BRMA), where only legally constituted artisanal fishing associations are assigned exclusive rights to use and exploit benthic resources in geographic sectors within five miles of the coast, only for artisanal fishing, or in inland and interior waters (Sobenes and Chávez, 2009). This BRMA is managed by the Artisanal Fishermen Union of Llico, which holds the authorization to implement aquaculture activities.

Llico Bay has depths between 5 and 15 m and a total area of 101.2 ha whose 1.5 ha was used for the experiment. The marine bottom is mainly composed of sand and rock. The Gulf of Arauco is one of the upwelling area off central Chile (Parada et al., 2001; Valle-Levinson et al., 2003; Castro et al., 2007), and the wind are the main driving agent of the nontidal circulation in the Gulf of Arauco, prompted a continuous circulation at gulf.

2.2. Culture system design

A total of four superficial longlines of 100 m long each one separate 50 m were implemented with two different types of flotation systems: two longlines with buoys (Fig. 2A and B), and two longlines with HDPE tubes (Fig. 2C and D). For each system (buoy or tube), two types of 6 m sleeve, made with crop rope material, were installed. One sleeve system is known as continuous sleeve (Fig. 2A), which consists in a continuous line laid in a sinusoidal manner and tied to the flotation system, and the other is known as independent sleeve (Fig. 2B). Each sleeve type was set with spacing of 30, 40 and 50 cm. A third sleeve type was installed only in the HDPE tubes system (Fig. 2C and D). It consists of a mesh type net with gaps of 40 and 50 cm. The net allows a 1.91 times higher productivity per flotation line meter in relation to the continuous sleeve, because at each union point in the net, there are two sleeves coming out, increasing its total sleeve length by 0.5 m each. The culture lines were installed in the Llico Bay in a direction that minimizes the hydrodynamic resistance from the NW-SE direction in accordance to the Bompais (1991), Plew et al. (2005), Stevens et al. (2007), and Strohmeier et al. (2008) criteria.

Mussel seed from a natural population from Bahia Cochamó X Region, were transplanted to the study site, and sieved previously to reduce length variability (19.49 ± 0.24 mm, mean ± S.E.). Ropes were seeded at a density of 600 (seeds m^{-1}) with an automatic machine.

2.3. Sample design

Every 15 days a mussel sample was taken, when the meteorological conditions allowed it. The samples consisted of 20 individuals per sleeve type, per sleeve spacing, and at 2 and 6 m in depth, in each of the four longlines (Fuentes et al., 2000; Lauzon-Guay et al., 2005; Drapeau et al., 2006). The samples were extracted manually with the help of a diver. The selection of the specific sleeves was determined at simple random with no reposition. The sleeves used for sampling were marked and labeled in order not to select them again. The number of individuals collected in the sample each date was of 560 = [(20 individuals × 2 depths × 3 sleeve spacing) × 4 designs + (20 individuals × 2 depths × 2 sleeve spacing in the net sleeve)]. The total sample examined was of 10,080 individuals (560 × 18 sample extraction dates) over the 10 months of the study. To evaluate the effects of longline design, we compare only the data at the end of the experiment.

The following measures were taken: shell length (SL) as the distance in the longitudinal axis of the shell, using a precision caliper of 0.01 mm. Total weight (TW) or meat plus shell weight was obtained using an electronic balance after cleaning the shell exterior from incrustations and fouling. Wet meat weight (WMW) was obtained after cutting the adductor muscles, extracting the valve and draining the excess water using filter paper. The meat yield in percentage (MY) was calculated for each individual using the formula: MY = (WMW/TW) × 100 (Okumus and Stirling, 1998).