Aquaculture 281 (2008) 56–62

Contents lists available at ScienceDirect

Aquaculture

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

Development of longline mussel farming and the influence of sleeve spacing in Prince Edward Island, Canada

L.A. Comeau [a,*], A. Drapeau [b], T. Landry [a], J. Davidson [b]

[a] Department of Fisheries and Oceans, Gulf Fisheries Center, P. O. Box 5030, Science Branch, Moncton, New Brunswick, Canada E1C 9B6
[b] Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown, Prince Edward Island, Canada C1A 4P3

ARTICLE INFO

Article history:
Received 23 October 2007
Received in revised form 23 May 2008
Accepted 26 May 2008

Keywords:
Mytilus edulis
Mussel
Farming
Husbandry
Longline
Carrying capacity

ABSTRACT

This paper describes the historical development of blue mussel (*Mytilus edulis*) farming in Tracadie Bay (Prince Edward Island, Canada) and relates the spacing of suspended sleeves (S_S) on longlines to seston uptake. From 1990 to 2001, mussel biomass in Tracadie Bay increased by a factor of four (from 1137 to 4743 t). By 2001, seston uptake rates were approximately three-fold water renewal rates, and harvest yields (kg sleeve^{-1}) were significantly lower than in the early 1990s. A one-year field experiment was carried out to determine whether a change in S_S could restore harvest yields. We found that S_S (10, 20, 40, 60, 80 cm) had no significant effect on the condition index of mussels. However, high S_S positively affected shell growth and abundance for small seeds that were densely packed within sleeves. A complete husbandry shift toward high S_S and high seeding densities (within sleeves) may enhance farm productivity (production per unit of effort) and curtail seston uptake at the bay scale.

1. Introduction

Bivalves are filter-feeding organisms that extract suspended food particles from the water column with an extraordinary filtration capacity. Dense bivalve beds can deplete available food resources faster than the ecosystem can replace them through primary production and tidal currents (Wildish and Kristmanson, 1979; Fréchette and Bourget, 1985a,b; Newell, 1990; Dolmer, 2000; Petersen, 2004). The determination of optimal rearing densities for bivalve aquaculture has become an important—and increasingly studied—issue. A predictable impact of overstocking bivalves is a reduction in farm productivity due to curtailed growth and delayed harvests (e.g., Aoyama, 1989; Héral et al., 1986; Boromthanarat and Deslous-Paoli, 1988). Therefore, there is a need to identify the stocking density at which the demand for food particles is well matched to the supply. This optimal density level is often referred to as the production carrying capacity (PCC) of a system (McKindsey et al., 2006).

Using mathematical models optimal density was estimated to be approximately 0.26 oysters m^{-3} in the Carlingford Lough in Ireland (Ferreira et al., 1998) and 50 scallops m^{-3} in Sungo Bay in China (Bacher et al., 2003). The most sensitive model input parameters are normally bivalve biomass, phytoplankton turnover rates and hydrographic data. However, one key element that is currently not well parameterized is the influence of gear configuration on the PCC. Current models assume that individual bivalves are homogeneously distributed within an embayment (or sub-system), a simplification that discounts any effect of gear configuration on bivalve feeding behavior. In a recent review of carrying capacity models, McKindsey et al. (2006) highlighted this shortcoming and recommended the inclusion of rearing techniques (e.g. gear configuration) to improve veracity in model simulations and predictions.

For now, modeling the influence of gear configuration is hindered by a scarcity of documented information on the subject. The effect of gear configuration on seston depletion rates is still poorly defined both in quantitative and predictive terms. To date, the limited research on this topic has been directed almost exclusively toward a better understanding of the mussel raft culture (e.g. Cabanas et al., 1979; Navarro et al., 1991; Boyd and Heasman, 1998; Heasman et al., 1998; Fuentes et al., 2000). There is an emerging consensus that the close spacing of mussel ropes (1 rope m^{-2}) results in localized food reduction, such that mussels at the downstream end of the raft are left with fewer food particles to consume than upstream mussels. However, such generalizations are not straightforward for submerged longline systems. Reports of food reductions associated with longline culture show variable results (Rosenberg and Loo, 1983; Fréchette et al., 1991; Ogilvie et al., 2000; Pilditch et al., 2001; Strohmeier et al., 2005), perhaps because of major differences in stocking density and longline configuration between study sites. Sleeve spacing (S_s) along individual longlines may be an important regulator of food uptake. S_S is reportedly set at 120 cm in France's Pertuis Breton region (Garen et al.,

* Corresponding author. Tel.: +1 506 851 2723; fax: +1 506 851 2079.
E-mail address: comeaul@dfo-mpo.gc.ca (L.A. Comeau).

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doi:10.1016/j.aquaculture.2008.05.031

2004), 60 cm in Scottish sea lochs (Okumu and Stirling, 1998), and 44 cm in Canada's Prince Edward Island (PEI) region (Drapeau et al., 2006). To date, there have been few attempts to study relationships between S_S and food uptake. Drapeau et al. (2006) reported a positive field correlation between S_S and mussel yield; however, the correlation was tenuous, appearing only for a single year (in a three-year study).

The principal objective of this investigation was to evaluate the relationship between S_S, mussel yield, and seston uptake in Tracadie Bay, PEI, Canada (Fig. 1). An extensive grower interview process was used to gather detailed historical information on longline configuration in Tracadie Bay. The influence of S_S was then investigated as part of a field experiment. Mussel yield at different S_S was monitored at specific intervals over one year at four experimental sites. Yield was converted into seston uptake rates, and the potential impact of S_S on bay-wide seston utilization was modeled.

2. Materials and methods

2.1. Study embayment

Blue mussel (*Mytilus edulis*) farming in PEI (Fig. 1a) is carried out using a longline system of suspended polyethylene sleeves (Scarratt, 2000). Mussels are cultivated on the northern and the eastern sides of the island (Fig. 1b), where a total of 4351 ha of estuarine waters have been leased out to individuals and companies. Presently, there is a societal consensus that the PEI mussel industry is completing its developmental phase and entering into a management phase. This view is evidenced by a moratorium on the granting of new leases since 1999. Tracadie Bay is situated on the north shore of PEI (Fig. 1c) and represents an important mussel producing bay, contributing 20% of the island's total production.

2.2. Grower interviews

Tracadie Bay has 34 mussel leases exploited by 24 leaseholders. In the winter of 2001, the majority (23/24) of these leaseholders agreed to share historic production and husbandry information, with the understanding that the data would not be divulged in a way that could be traced back to individual growers. Data from 1990 to 2000 was captured on a standardized questionnaire during the interview process. In general, the data originated from personal logbooks and sales records that leaseholders brought with them to the interviews. Similar interviews were repeated in the winter of 2002 to capture data for 2001 and extend the time series by an additional year.

The interview dataset was used to calculate standardized indices of stocking density. We first examined seed abundance within individual sleeves. Sleeving is normally carried out in autumn when seed on collector ropes ranges in size between 4 and 30 mm. Leaseholders provided the initial (at deployment) seed abundance within polyethylene sleeves (SDI_{sleeve}) and we reported SDI_{sleeve} as the number of seed contained in a one meter section of sleeve. Leaseholders also provided detailed information that was used to calculate seeding density on an area basis within individual leases. Average seeding density within leases (SDI_{lease}) was calculated as the number of seed m^{-2}. SDI_{lease} was computed for each year of the dataset using the following equation:

$$SDI_{lease} = \left(\frac{\sum_{lease=1}^{n} \left[\left(\frac{1}{S_s \times L_s} \right) \times S_l \times SDI_{sleeve} \right]}{n} \right) \quad (1)$$

where S_s and L_s are the reported spacing between sleeves and longlines, respectively, and S_l is the sleeve length. Note that SDI_{lease} does not take

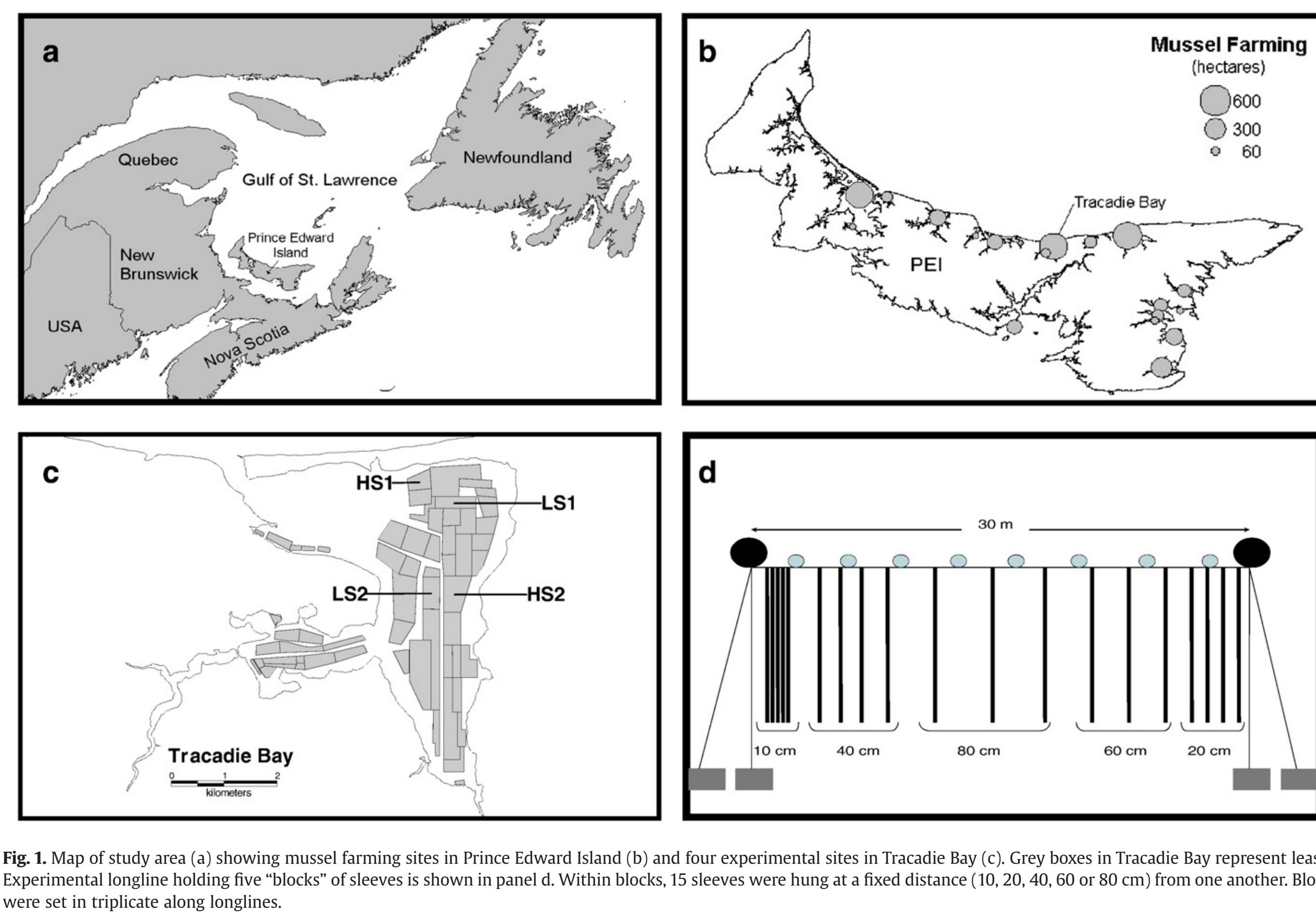

Fig. 1. Map of study area (a) showing mussel farming sites in Prince Edward Island (b) and four experimental sites in Tracadie Bay (c). Grey boxes in Tracadie Bay represent leases. Experimental longline holding five "blocks" of sleeves is shown in panel d. Within blocks, 15 sleeves were hung at a fixed distance (10, 20, 40, 60 or 80 cm) from one another. Blocks were set in triplicate along longlines.