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Effects of mussel culture husbandry practices on various benthic characteristics

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Abstract

Sediments and macroinvertebrate diversity underneath suspended mussel lines were examined in a shallow water system in Prince Edward Island, Canada. The objectives of the study were to describe the benthic environment in a typical mussel farm from eastern Canada and to underline various relationships between benthic parameters and husbandry practices. Benthic parameters included granulometry of the sediments, organic matter and sulfide contents as well as redox potential and common macroinvertebrate diversity indices. Husbandry operation parameters investigated were the number of years of operation and mussel culture density for a given lease. The results did not show any particular spatial patterns. The sediments' mud content varied between 96 and 100%. Redox potential varied between −150 and 250 mV while sulfide concentration ranged between 100 and 9500 μM. Organic matter content varied between 1 and 16%. A total of 31 species were identified. Diversity indices were small throughout the study site. The number of years of operation for a given site varied between 0 (control sites) and 16 years while mussel culture densities ranged between 0 (control sites) and 0.70 kg/m^2. Overall, no strong relationship was underlined between benthic parameters and studied husbandry practices. BIOENV analyses showed that culture density explained a small proportion of the benthic assemblages variability underneath mussel lines when using the macroinvertebrate abundance data set ($r=0.137$). Similar analyses showed that water depth better explained the variability observed under mussel lines when using the macroinvertebrate presence/absence data set ($r=0.263$). The absence of a strong relationship between husbandry practices and the studied benthic parameters might be related to the oceanographic characteristics and land-based activities associated with the water system rather than direct and cumulative effects of mussel culture.

Keywords: Mussel culture; Blue mussel; *Mytilus edulis*; Biodeposition; Benthic impact; Sediment characteristics; Diversity; Benthic assemblages

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1. Introduction

The eastern seacoast of Canada is known to foster many aquaculture activities. The Atlantic salmon (*Salmo solar*) and the blue mussel (*Mytilus edulis*) represent the two most important species for the aquaculture industry in Atlantic Canada (Boghen, 1995). In Prince Edward Island (PEI), 86% of the province aquaculture production for the year 2002 came from blue mussel suspension culture on long lines (Department of Fisheries and Oceans, 2004). This represented 79.5% of the province aquaculture revenue for that year. The availability of new sites for mussel culture activities in PEI is, however, limited (LeBlanc et al., 2003). Farmers have to rely on increased productivity in present operating sites and optimize husbandry practices in order to keep up with the growing demand and insure profitability. Culture densities observed on lines (i.e. number of socks per line) have been on the rise during the last decade in PEI.

Though less important than finfish farming (Findlay et al., 1995; Christensen et al., 2003; Crawford et al., 2003), bivalve culture activities are known to cause seabed disturbances (see review below). Through their feeding activities, mussels may alter the nutritive value, stability and textural composition of the sediments by removing large amounts of suspended material and altering sedimentation rate through biodeposits directly under the aquaculture operation (e.g. Tenore et al., 1982; Hargrave, 1994; Kaiser et al., 1998; Christensen et al., 2003). PEI mussel farmers use the longline system to support mussels. The strategy presently used in PEI (i.e. increase in culture density) should lead to a larger production of faecal material that will accumulate underneath mussel lines over the years. This, in turn, should lead to an organic enrichment.

Studies carried out on the impact of shellfish farming on the benthic environment present various data sets that suggest a large spectre of effects ranging from small (e.g. Baudinet et al., 1990; Buschmann et al., 1996; Crawford et al., 2003) to important (e.g. Dahlbäck and Gunnarson, 1981; Kröncke, 1996; Tenore et al., 1982; 1985; Mattson and Lindén, 1983; Kaspar et al., 1985; Grant et al., 1995; Sorokin et al., 1999; Stenton-Dozey et al., 1999; Mirto et al., 2000; Chamberlain et al., 2001; Christensen et al., 2003; Smith and Shackley, 2004). This wide range of impacts observed in the literature is largely related to various local effects such as the heterogeneity of the coastline (e.g. open versus protected areas), various oceanographic (e.g. currents, tides, flushing time) and biological parameters (e.g. overall productivity of the ecosystem, algal and animal communities) as well as husbandry practices. In eastern Canada, Shaw (1998) conducted an extensive benthic survey of 20 estuaries throughout PEI. The survey included several culture free estuaries as well as estuaries bearing mussel culture operations for 2 to 15 years. Although his survey revealed differences in benthic characteristics between culture free estuaries and estuaries with mussel culture, the overall conclusion was that the sediment quality of the surveyed estuaries could not be attributed to mussel culture alone.

The aim of this study is (1) to document the benthic characteristics of a well known mussel culture site in PEI and (2) to use this data set to look at various correlations between commonly used ecological indices (Shannon–Wiener diversity index, Pielou's evenness, Berger–Parker dominance index) and environmental conditions underneath mussel lines (mud and organic matter contents, redox potential, sulfide concentration). Correlations between these indices and lease information (years of culture operation, culture density) were also performed. Non-metric multidimensional scaling (nMDS) was also used to strengthen the interpretation of our results. Overall, we expect that the benthic environment will show high mud, organic matter and sulfide contents under (1) high density culture lines and (2) old operating sites within the same water system. Ecological indices are expected to change under the same set of parameters (Shannon–Wiener diversity index is expected to decrease but two others are expected to increase, Pielou's eveness and Berger–Parker dominance index). This broad overview should allow a better understanding of shellfish farming disturbances and provide an objective assessment to evaluate their effects on the benthic environment.

2. Materials and methods

2.1. Study site

The study was carried out in November 2000 in Prince Edward Island (PEI), Canada. The study site is