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Benthic Macrofaunal Changes Resulting from Finfish Mariculture

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Abstract We present a review of the benthic macrofaunal changes that are circumstantially linked to intensive marine finfish aquaculture, or mariculture. The community structural and functional changes of macrofauna identified are mostly near-field effects, limited to the farm cage footprint. In common with other organic enrichment events in sediments, the mechanism in mariculture-related macrofaunal change is primarily caused by death due to hypoxia in sediments, followed by re-colonization with specialized organic enrichment tolerant macrofauna. Despite recent attention to the field of mariculture ecology, much still remains to be done to fully understand and manage the ecosystem effects of this activity.

In the second part of this chapter we present a case history study from a marine tidal inlet (L'Etang) in the Bay of Fundy, Canada during a period of rapid industrialization, dominated first by pulp mill effluents in the 1970s, and then by salmon mariculture development beginning in the 1980s and continuing today. Circumstantial evidence links the temporal benthic macrofaunal changes found in L'Etang Inlet to far field organic enrichment effects, primarily resulting from pulp mill pollution in the most landward area

and salmon mariculture in the seaward end. It is shown that the temporal macrofaunal changes at the seaward end are not due to hypoxia in sediments or to natural seasonal and interannual changes. A new alternative hypothesis in aquaculture ecology is proposed: that the macrofaunal changes are far field effects resulting from the increased sedimentation (quality and amount) associated with intensive mariculture.

Keywords Benthic macrofauna · Finfish mariculture · Near- and far-field effects · Organic enrichment · Temporal change

1 Introduction

The intensive grow-out of fish, such as salmon, in floating marine net pens or cages (mariculture) has, within the last 25 years, become an industrial activity that is common worldwide [1]. Because of the potential for the production of large amounts of organic wastes from mariculture operations [2], which contribute to organic enrichment in the receiving environment, there is already considerable literature dealing with the effects of organic enrichment from mariculture [3, 4].

Ecologically, organic enrichment is a complex process, involving pelagic-benthic coupling and responses in both the water column and sediments. The effects are due to both natural and anthropogenic sources of organic matter. Thus, it is hardly surprising that some species of benthic macrofauna have become specialized to live where high inputs of organic matter occur. Natural examples of organic enrichment include a whale carcass decomposing on the seabed [5], or the annual spring die-off of phytoplankton blooms decomposing in sediments [6]. Common anthropogenic sources of organic enrichment include: municipal sewage, pulp mill effluents, other industrial sources and, more recently, from intensive aquaculture [7].

At present, intensive salmon mariculture is the pre-eminent finfish farming activity in temperate seas [1]. Here the organic matter inputs are from uneaten food and fecal particles which reach the seabed at rates $> 1\ \mathrm{g\,C\,m^{-2}\,d^{-1}}$ [2] within the farm footprint. The latter is defined as a generally elliptical area of the seabed, with the major tidal flow being on the long axis of the ellipse where water movements deliver most of the food and fecal particles [8]. The nature of the sedimentary response will depend on the realized amount of sedimentation that is proportional to the farm footprint area, and hence depth and water movements. Sediment particle transport, deposition, and erosion are determined by sediment particle sizes and the ambient velocity patterns of a particular site [9], although the relationship is a complex one. For example, medium particle size sands are the most susceptible to erosion at low velocities, whereas finer silt/clay particles require a higher velocity to erode from a sediment deposit. Deposition, on the other