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Salmon Aquaculture, Nutrient Fluxes and Ecosystem Processes in Southwestern New Brunswick

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Abstract Salmon aquaculture discharges organic wastes into the marine environment. Salmon metabolism and the waste discharges add nutrients and organic matter to and remove oxygen from both the water column and sediments. The salmon industry in Southwestern New Brunswick (SWNB) is used to illustrate how waste discharges can be estimated in the absence of detailed information on farm operations. A fish growth model and mass balance calculations are used to estimate carbon, nitrogen and phosphorus wastes at the farm scale. Feed nutrition data and environmental measurements are used to partition wastes into fractions, and to estimate the oxygen demand. The predicted demand at the time of maximum discharge is 200 times greater than the oxygen uptake measured in surface sediments at cages, suggesting that most farm wastes are dispersed over wide areas and do not accumulate directly under cages. The number of farmed fish in an inlet is then used to predict total discharges to that inlet. In SWNB, salmon aquaculture is the largest anthropogenic source of organic input to the coastal zone. The significance of the wastes on inlet scales (2–25 km) is evaluated by comparing element fluxes through salmon farms with fluxes due to natural processes: primary production, nutrient regeneration, and community respiration. In intensively farmed bays, fluxes due to salmon farms reach values of 20, 330 and 160% of those due to natu-

ral processes for oxygen, nitrogen and carbon, respectively: significant changes to the ecosystem have occurred in these bays. Spatial scales are critical in describing such impacts: effects will be greater close to the farms, and smaller when averaged over larger areas.

Keywords Aquaculture · Salmon wastes · Ecosystem processes · Marine

1 Introduction

Sea-cage salmon aquaculture discharges a number of waste types into the marine environment, including nutrients (nitrogen and phosphorus) and organic matter. The organic wastes from excess feed and salmon faeces are partially decomposed by bacteria. This process consumes oxygen, adds nutrients and lowers the oxygen content in both the water column and surface sediments. The respiration of the farmed fish further reduces the oxygen levels. In areas of intensive aquaculture, these waste streams can have significant impacts on the ecosystem: organic wastes may add to suspended particulate matter (SPM) or enrich or smother the benthic habitat; nutrients can stimulate growth of phytoplankton and/or macroalgae; and reduced levels of dissolved oxygen can stress native organisms as well as the farmed fish. The increased SPM and resulting reduced water transparency, build-up of nutrients, reduction of dissolved oxygen levels and stimulation of algal growth are all aspects of eutrophication.

Growth of sea-cage salmon aquaculture in Southwestern New Brunswick (SWNB) has been quite rapid since its inception in 1978. In 2002, there were 93 operating farms (Fig. 1), with an estimated total of almost 20 million fish in sea cages based on the province of New Brunswick Department of Agriculture, Fisheries and Aquaculture (DAFA) Approved Production Limits (APLs). Production in 2002 was 39 450 tons worth $ 201 million (Can $).

This paper examines the environmental significance of the particulate and dissolved wastes discharged from salmon aquaculture in a coastal ecosystem, using the industry in SWNB in 2002 as an example, by comparing the discharges to natural levels and processing rates for carbon, oxygen and nutrients. Because our focus is on the environmental impacts in SWNB, we use data that we believe to be most representative of the industry there in 2002. The first step in this process is to estimate the magnitude of the discharges from the fish cages. The next step is to evaluate the impacts of the fluxes of organic matter, carbon, nutrients and oxygen demand from the farms by estimating how they might influence ambient conditions in the receiving waters and how they compare with other anthropogenic sources and the natural cycling of these elements elsewhere in the ecosystem, including both the water column and the sediments. Such comparisons measure the extent to which