Hdb Env Chem Vol. 5, Part M (2005): 59–82
DOI 10.1007/b136004

Published online: 15 July 2005

Ecosystem Indicators of Water Quality Part I. Plankton Biomass, Primary Production and Nutrient Demand

W. Glen Harrison (✉) · Tim Perry · William K. W. Li

Biological Oceanography Section, Ocean Sciences Division, Fisheries and Oceans Canada, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, B2Y 4A2, Canada
HarrisonG@mar.dfo-mpo.gc.ca, PerryT@mar.dfo-mpo-gc.ca, LiB@mar.dfo-mpo.gc.ca

Abstract Seasonal measurements of plankton (phytoplankton and bacteria) biomass and abundance, primary production, and nutrient demand were conducted in the coastal waters of southwestern New Brunswick (SWNB) in 2000–2002 to investigate the far-field effects of finfish (salmon) aquaculture on the pelagic ecosystem. Plankton biomass and production varied seasonally with peak concentrations and activity in summer–fall and lows in winter. Nutrient demand followed a similar pattern with nitrogen (nitrate and ammonium) turnover times ranging from greater than a week in winter to less than a few days in summer. Ammonium concentrations were elevated at the aquaculture sites relative to control sites, however, effects on other nutrients, phytoplankton biomass, bacterial abundance, and primary production were not discernible despite the significant flux of nutrients into the system from finfish farming. Several lines of evidence point to the conclusion that primary production in SWNB is under light rather than nutrient control and that phytoplankton there have limited capacity to process additional nutrients produced as aquaculture in the region expands. The ratio of bacterial abundance to phytoplankton biomass (B/P ratio) is proposed as an easily measured water-quality indicator for assess-

ing the trophic balance (autotrophy vs. heterotrophy) of the pelagic ecosystem in coastal waters.

Keywords Aquaculture · Phytoplankton · Bacteria · Primary production · Nitrate · Ammonium · Nutrient demand · Light-limitation · Water quality

1 Introduction

Finfish aquaculture is a fast growing industry worldwide. In southwestern New Brunswick (SWNB), Canada, the farming of Atlantic salmon has grown dramatically in the last 30 years with the number of active farms doubling and the harvest increasing fourfold over the last 10 years [1]. The growth of this industry has been accompanied by mounting concern about its environmental impacts on coastal ecosystems. There exists now an extensive literature and several comprehensive reviews on the documented and potential environmental effects of aquaculture in the coastal zone (e.g. [2]).

In reviewing existing knowledge and research needs on environmental effects of finfish aquaculture, Hargrave [3] noted that surprisingly little is known about far-field effects (ecosystem-scale), particularly on the pelagic ecosystem, when compared with knowledge of near-field effects (within or adjacent to fish farms), especially on the benthos. Aquaculture impacts on the water-column are mainly concerned with farm effluents/wastes, i.e. inorganic and organic nutrient enrichment and their effects on plankton growth dynamics and community structure, i.e. eutrophication (e.g. [4]). Eutrophication is the consequence of nutrient enrichment [5, 6] and manifests itself in the pelagic zone as increases in plankton (phytoplankton and bacteria) biomass and production (including increased frequency and intensity of benign and Harmful Algal Blooms, HABs [7]) and changes in community structure and trophic state [8]. Among the latter are concerns about the effects of aquaculture on the balance between autotrophic and heterotrophic biomass/production that determine the pelagic oxygen balance of coastal ecosystems [9]. A fundamental question, therefore, is, "Can ecosystems maintain their natural state under the influence of aquaculture activity and for how long?". More specifically for the pelagic zone, "What is the capacity of plankton to process the effluents of aquaculture?"

This question was at the core of a recently completed multidisciplinary project, Environmental Studies for Sustainable Aquaculture (ESSA), aimed at

1. Evaluating current far-field environmental effects of salmon aquaculture on three contrasting Canadian coastal ecosystems;
2. Constructing models to predict future ecosystem changes and;
3. Developing standard methodologies for effective management of the Canadian finfish aquaculture industry for sustainability [10, 11].