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Modelling The Input Of Organic Materials From A Marine Fish Farm In Western Turkey

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Abstract

Throughout the world, the development of marine aquaculture along the coastal areas raises concerns about the sustainability of natural environment in a balanced state. While primarily an environmental issue, the rapid development of the fish farms has also resulted in conflicts between other users of the coastal zone, particularly tourism. Therefore, studies on the impact of coastal fish farms have been an area of common interest. The input of organic waste to the surrounding ecosystem entering in the form of fish feed is particularly important as it effects not only the overall water quality but also the richness of macrobenthic communities in the vicinity of fish farms. Once in the water column, the organic particulates undergo the effects of currents and overtime accumulates on the bottom.

The present study reports the results of an extensive study aimed to determine the effects of marine net pens on the natural environment. An important part of this study concerns simulating the accumulation of organic material by a modeling software using field data collected during 2 years. Model simulations indicated that the "foot print" expressing the impacted areas of fish cage farms with the accumulation of organic material located in deeper sites is dispersed over a larger area compared to the shallower sites and indicated a higher assimilative potential of the benthos. In addition, the shape of the foot print was roughly a uniform circle indicating the lack of strong, dominant currents in this particular site.

Results of this study may be used to determine coastal areas that are suitable and unsuitable for net cage fish farms. However, in order to determine the effect of a single farm accurately, all other fluxes from a given coastal area should be accounted for, including nearby farms and other terrestrial discharges and runoffs.

Keywords: Aquaculture, Net-pens, Pollution, Particulate organic material, coastal areas

Introduction

Advances in the field of aquaculture has resulted in increased production during the last two decades and today aquaculture produces 50% of the world's seafood. A considerable portion of this production comes from cage farms (net pens) in coastal areas (FAO 2006). Early net-pen designs and materials were small and simple but materials and designs evolved rapidly after the World War II. Modern net-pens consist of components such as a net bag

suspended from a floating collar and an anchoring system designed to hold the system at a fixed location on the bottom (Pillay, 2004). Culture of fish in cages in open water bodies has a number of advantages over land-based aquaculture systems such as lower capital investment, no requirement for water pumping, filtration and heating. However, despite its potential in meeting the increasing demand for fish protein and therefore, considered as "Blue Revolution" by many, the rapid expansion of aquaculture in coastal areas induced a public interest and an increasingly heated debate as a potential polluter of the environment throughout the world. Similar to any form of industrial production, net pen aquaculture has environmental impacts and the majority of the monitoring studies report negative impact of cage farms. In general, net-pen operations in coastal regions cause nutrient enrichment and eutrophication of the receiving water bodies as well as discharges of therapeutants. In addition, the rapid development of net-pen aquaculture has created socioeconomic problems due to conflicts with other users of the coastal areas.

In Turkey, as in many parts of the world, the majority of potential environmental concerns is of a speculative nature and in many cases is not supported by scientific evidence. On the other hand, the extent to which cage aquaculture results in degradation of the ecosystem is a difficult question to answer due to the diversity of farm sites with regard to physical, chemical and biological parameters as well as the magnitude of operations. Furthermore, most of these parameters are more or less linked to each other and implies that it may be difficult or even impossible to establish correlations and determine globally-accepted standards. Such complexity also requires a team work of expertise and a multi-disciplinary approach so that any limitations in developing environmental consequence analysis for a given aquatic ecosystem are minimized. In addition, data obtained from field surveys may be problematic with the potential of considerable differences in the analytical reliability of different parameters. Such inherent difficulties require that many samples must be analyzed and analytical techniques must be perfected before site-specific values within a given statistical reliability is obtained and is, therefore, considered reliable. Considering all these factors, it is not surprising that there is limited information on the impact of cage farming all over the world (Sarà et al., 2004). In Turkey, in presence of limited scientific data, increasing environmental concerns and awareness coupled with conflicts with other users of the coastal regions have motivated displacement of fish cages from coastal areas to designated off-shore sites before any conclusive evidence of the effects of coastal cage farms on the surrounding environment have accumulated. Off-shore sites with stronger currents have greater potential to distribute the organic load to larger areas and facilitate conditions that will maintain assimilative capacity of the ecosystem.

All these factors require the need to acquire basic information to make appropriate environmental assessments of fish farms and develop sustainable management strategies. The current project aims to determine the effects of marine cage farms located in coastal regions in Western Turkey with a view to suggesting procedures for better management in the planning and impact assessments and to assisting in the evaluation of future projects. In addition to providing extensive on-site data that have major role in environmental impact assessment for predetermined representative farms, it is an important aspect of this project to predict the environmental impact of existing farms through computer simulations. However, it is also necessary to understand the scale of the environmental impact using simple parameters of assessment that will help to establish and implement regulations.

An important parameter that has been used to determine the level of impact from cage aquaculture is the accumulation of organic matter. Intensive fish farming generates organic

waste which is a function of biomass, type of fish and feeding. Unlike land-based systems, waste from marine cage systems is directly discharged into the environment in the form of dissolved and particulate organic material. The most evident effect of fish cages on sediments is the accumulation of organic matter over the sediment in the vicinity of cages which in turn, results in anoxic conditions that adversely affect benthic organisms. Therefore, a thorough understanding of the relationship between the organic load and its effects will allow development of strategies for a sustainable management of fish farms without serious environmental implications.

Modeling has been developed to determine the impacts of cage aquaculture with the purpose of minimizing the accumulation of organic load (Gowen et al., 1989; Gillibrand and Turrell, 1997; Panchang et al., 1997; Dudley et al., 2000; Henderson et al., 2001; Cromey et al., 2002). Modeling the dispersion of organic particulates provides information to predict the potential quantitative impact of fish farms before establishment or an increase in production of an existing farm which, in turn, may be used for regulatory purposes, i.e. to determine future locations for cage farms, to predict the carrying capacity of a designated area or to optimize the production target of an existing farm for sustainable production in a given area. Such decision making processes will help to improve the management of cage farms and reduce the effects of organic load.

Methodology

In the present study the effects of cage farming in western Turkey has been studied through a 3 year period. For this purpose, periodic samples of chemical, biological and physical parameters were collected from 3 different typical cage farms rearing European seabass, *Dicantarchus labrax*, and gilthead sea bream, *Sparus aurata*. The representative fish farms were located in İzmir: while two of the farms were located in the Gulf of Gerence, Çeşme, İzmir, an area characterized by intensive fish farming during the last two decades, the third farm was in the Gulf of Sığacık, İzmir an area recently designated as a potential off-shore site for cage aquaculture. Sampling of seawater and sediments from fish farms and reference areas were collected for a period of 2 years from predetermined stations. Chemical, biological and physical parameters were collected monthly. Benthic surveys were carried out seasonally. Sedimentation rates of organic waste input from cages were determined using sediment traps placed in predetermined stations under the cages for a period of 3 weeks. A computer software (Meramod) was used to predict the amount and distribution of organic material accumulation (footprint).

Results and Discussion

Water quality parameters, such as ammonia, nitrite and nitrate did not indicate significant changes in the vicinity of cages. Other parameters such as chlorophyll-*a* and Secchi disk readings did not reveal any significant pattern of eutrophication. The physical characteristics including depth, current speed, prevailing winds and the short life of the fish farm may have contributed to this finding: such parameters have short-term memories and are subject to natural dilution in a short period of time. The organic enrichment of the seabed directly beneath the cages was the most prominent result of the sedimentation of particulate waste due to feeding and fecal wastes. Our simulations using data collected during field surveys indicated that the model can be used to determine the footprint of organic material

accumulation under the cages. However, there is a need to validate the simulations against data collected by sediment traps.

The coastal zone is an area of conflicts with many different uses such as recreation, fishing, shipping, navigation and tourism all of which place different regulatory demands to control their expansion. Therefore, sustainable use of the environment with scientifically warranted programs is required. From the view point of effective and rational use of the coastal areas in Turkey, universities should play a central role in obtaining objective, scientific data through interdisciplinary research supported by major research projects and developing new perspectives for sustainable management by taking into account the socio-cultural concerns of the public. However, in order to develop sound management strategies for cage aquaculture, the findings should be supported by legislations and regulations. Although other human activities are clearly more responsible for the fate of coastal areas than fish farming, it is in the interest of cage farms to integrate methods for sustainable development along with impact assessment with all phases of production cycle.

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