ENVIRONMENTAL EFFECTS OF FISH FARMING IN THE MEDITERRANEAN

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Abstract.
A research project addressing the problem of environmental impacts of cage farming was carried out from 1995-1998 in Greek coastal waters, involving sampling of biogeochemical variables in the water column and the sediments at different spatio-temporal scales. The impacts found in the water column were low and the impacts on benthos were more easily detectable at silty sediments than at coarse sand sites. In all cases benthic effects did not exceed a distance of 25 m from the edge of the cages.

Keywords : aquaculture, geochemistry, plankton, zoobenthos, pollution

Introduction

The Mediterranean has experienced an exponential increase in fish farming production during the last 15 years, but only recently there have been some studies on the impact of fish farming on water quality and parasites (1), the effects on nutrients and plankton (2), the effects on seagrass (3), the dynamics of sediment accumulation beneath fish farm cages (4), the recovery process of the benthos after cessation of fish farming (5) and the effects on sediment geochemistry and benthic organisms (6, 7, 8).

Materials and methods

Sediment sampling for total organic C and N, redox, ATP content, Chl *a*, pheopigments, and macrofauna (>0.5 mm) was carried out during 3 seasonal cruises (July, November 1995, April 1996) aboard the RV *Philia*. Two fish-farms were visited in the Ionian and one in the Aegean Sea (Cephalonia, Ithaki and Sounion, respectively). Samples taken at 0, 5, 10, 25, 50 and 100 m from the edge of the cages were analysed as reported in (6). Water column was also sampled at different depth layers at the cages and at a control site. Samples were analysed for POC, PON, Chl *a*, nutrients and microplankton species diversity and community structure as described (2) .

Results

Benthic effects. A summary of the information (6) on impacts on the seabed beneath and close to the cages is given in Table 1. The Cephalonia fish farm showed typical signs of disturbance due to organic enrichment with low macrofaunal abundance dominated by the *Capitella* complex. The coarse sediment sites showed high macrofaunal abundance (10 times more than in the control sites) dominated by *Capitella* spp. in Ithaki and by *Protodorvillea kefersteini* and *Cirrophorus lyra* in Sounion. The associated geochemical variables, and particularly redox potential and total organic carbon (TOC) showed higher enrichment and low Eh in Cephalonia, almost negligible effects in Sounion and intermediate ones in Ithaki.

Table 1. Effects up to 10m from the cages in comparison to the control sites

Area	Cephalonia	Ithaki	Sounion
macrofaunal diversity	<	<<	<
macrofaunal abundance	<	>	>
macrofaunal biomass	<	>10	>10
Capitella spp.	dominant	dominant	present
P. kefersteini - C. lyra	abundant	present	dominant
Tharyx heterochaeta	absent	absent	absent
Redox potential	<<	≈<	≈
ATP	x10	x10	x2
TOC	x2	x2	=
TON	x2	x2	=
Sediment type	muddy sand	coarse sand	coarse sand

Water column. In two of the farms, no significant difference was found in any of the measured variables between the control sites and the water column in the cages. A significant increase in concentrations of phosphate and ammonium was detected within the cages over the control site in the third farm but without any significant effect on chlorophyll concentration. Plankton abundance for the major taxa (diatoms, flagellates, dinoflagellates, ciliates) and microplankton community structure were determined by the effects of season and location rather than by the presence of fish farming.

Discussion

At all three farms, the benthic assemblages in the immediate vicinity showed symptoms of disturbance. In Cephalonia there was only a change in faunal composition but in the coarse-sediment areas there were also pronounced changes in abundance and biomass. The coarse substratum in Ithaki and Sounion apparently allows for oxic sediment conditions and therefore the microbial processes related to the decomposition of sedimenting material do not result in severe chemical stress for the macrofauna. The identical patterns of spatial change found in the three areas (6) indicate that the benthic community approaches its normal characteristics at 25 m distance. The ecotone point may lie in this region because diversity was at maximum and the assemblage included species from both the polluted region and from the original community. Seasonal variability in geochemical and macrofaunal variables was always more pronounced at stations close to the farm (0 to 10 m) than at the control site or the stations at 25 m. This may be attributed to large differences in food supply to the farmed fish between warm and cold seasons, to increased oxygen supply to the sediments during winter or to H_2S toxicity, which is also affected by seasonal processes.

Water quality is an issue extensively used in the arguments regarding the impacts of fish farming on the usability of the coastal zone by other users. However, the scientific basis of these arguments is rather weak since there is little information relating aquaculture to water quality degradation. The inconsistency between nutrient enrichment and lack of a significant increase in chlorophyll *a* may be attributed to limited utilisation of the excretory wastes due to rapid flushing time, so that phytoplankton are not present long enough to capitalise on the high production of nutrients. Since site-selection for fish farming aims at excluding sites with low water renewal, it is unlikely that signs of eutrophication would be detected in the vicinity of fish farms. However, it is possible that under certain hydrographic conditions aquaculture effluents might affect adjacent coastal bays during certain periods of time.

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