Environmental Impact Assessment of Suspended Bivalve culture

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Bivalves are sedentary organisms that require substrate for spat settlement and subsequent growth during which time they filter feed on phytoplankton, detritus, protozoans and bacteria. It is well known that large scale aquaculture can pose complex ecological socio-economic and management problems. As commented by Hastings and Helnte in the introduction to the dedicated issue on "Effects of Aquaculture in the Estuarine Environment (Estuaries Vol. 18 (1)-1995)- *the potential for increased farming of coastal marine waters is considerable but the potential for significant environmental degradation associated with such activities is also large*". Considerable work has been done on the variations in the hydrological, sediment and benthic faunal composition due to mussel and oyster farming by off bottom methods. The main impacts of suspended bivalve farming are given below.

Effect on primary productivity: Commercial large scale bivalves farming will consume substantial quantities of phytoplankton particularly when there is a high density of culture units over a large area, resulting in reduction in primary productivity of the area. In Japan, the culture of 50,000 to 60,000 oysters reduced the amount of seston (predominantly phytoplankton) by 76.95%. Suspended culture of green mussels in New Zealand has been found to remove upto 60% of the available food as the water flows through the farm. A mussel raft in Spain has been found to remove 35-40% of plankton and detritus, whereby 30% of the carbon,42% of the nitrogen and 60% of the chlorophyll *a* of the particulate organic matter is retained. However it has also been suggested that primary productivity may be stimulated by an increase in nutrient cycling although field evidence of increased primary production in the farm vicinity is still lacking. Bivalve culture competes with other planktonic herbivores which has been shown for the Spanish Ria de Arousa where suspended mussel culture replaced copepods as the main pelagic grazing organism.

Effects on current velocity and water movements: Bivalve farm structures modify current velocity and direction of water movements. In turn, these movements may alter patterns of erosion and sedimentation of particulate matter. Reduced water flow may result in decrease in natural

erosion by wave action, which in turn is followed by siltation and accumulation of suspended matter in cultured areas.

Effects on sedimentation: Bivalves produce pseudofaeces (mucous-bound particles expelled without passing through the gut) in addition to the normal faeces (biodeposition) which constitutes organic –rich particulate waste. For example in Hiroshima Bay a raft holding 420 000 oysters generate 16 m tons of faeces and pseudo faeces in about a 9 month period and several such farms have been found to have a major impact on the sediment deposition in the bay. Studies have shown that for a farm covering an area of 1500 m^2 the sedimentation of dry matter would amount to about 10 t, and sediment under the raft would accumulate to 10 cm per farming season.

Table 1.Faecal waste production and from bivalve farming

Species	System	Faecal production
Mytilus galloprovincialis		***14.3–149.3 mgDW/individual/24h***
Mytilus edulis	Natural shore population	1.76gDW/gDW/mussel/yr0.13gC/gDW/mussel/yr0.0017 g N/ gDW mussel/yr0.00026 g P/ gDW mussel/yr
Mytilus edulis	Rafts	9.5 kg carbon /sqm/yr1.1 kgnitrogen/sqm/yr

Sediment accumulation below bivalve farms				
Species	**System**	**Depth**	**Current velocity**	**Sediment accumulation**
M.edulis	longline	8-13 m	App 3cm/sec	10-15 cm
M.edulis		11-13 m	Very weak	7-30 cm
M.edulis	Rafts	>15m	Upto 200cm/sec	No sig biodeposition, shells present

Effect on benthic productivity: The deposition of particulate organic wastes can result in physico-chemical changes of the substrate, particularly in the immediate vicinity of the culture site. The enrichment of sediment with organic material stimulates microbial activity resulting in deoxygenation of the substrate and bottom waters due to reduced interstitial oxygen concentration and increased oxygen consumption, increased sulphate reduction, increased denitrification and increased release of inorganic nutrients such as nitrate, nitrite, ammonium, silicate and phosphate from mussel beds. The regeneration of potentially limiting nutrients may increase primary productivity.

Effect on benthic community structures : Benthic communities beneath suspended farms may be affected. Macro fauna may be lacking entirely in the area directly under the culture site.

Species richness is reduced and opportunistic enrichment tolerant species become predominant. A relatively large number of detailed studies of fine sediment deposition have been carried out. A range of responses of the sea-floor biota have been identified, from little or no community modification after low levels of nutrient enrichment, through to major alterations and the dominance of small polychaetes and absence of larger animals such as molluscs and urchins after high levels .

Introduction of predaters: Introductions of bivalves have negative ecological effects, particularly when parasites and diseases are also introduced. A typical example is the introduction of the Japanese oyster drill and flatworm to North America from Japan

Impact on birds : The structures could have several impacts on birds. The rope system could impede diving and the pursuit of prey and possibly cause injury to birds. However, there is no evidence that this is a problem, the ropes being coarse and very visible, and birds have been observed feeding within farms on occasions.

Creation of new habitat The mussel lines can be considered to be new temporary habitats created in the water column for a range of animals in addition to mussels. The epifaunal community on mussels has been recorded to consist of over 100 different species. There is also deposition of live shells, mussel shell litter, and the remains of other associated biota below a farm. 'Shell drop', the deposition of shells, live mussels and associated biota, largely affects the area directly below the farm, typically to 20 m from its boundaries. The value of shell drop in creating a reef-like substrate seems very variable; under some farms the litter is barren, whereas under others there can be a rich biota, including sponges, ascidians, anemones, tube worms together with starfish, sea cucumbers and crabs.

Effects on water column: The column is frequently stratified due to the separation of water layers with different densities associated with changes in salinity or temperature. The impacts of a farm can be considered in terms of nitrogen alone, which can at times be at such low levels as to limit plankton growth. The harvesting of mussels will periodically remove nitrogen from the aquatic system. It has been calculated that, based on an average turnover of mussels of two years, denitrification was 68% higher at the farm study site compared to a nearby reference site. Further research is in progress on the role of nitrogen in limiting phytoplankton growth and thus in turn mussel growth. A positive response was seen from adding nitrogen to the water in summer. 'Fertilising' the sea in this way could become a management practice and flow-on effects on zooplankton and fish.

Increase in pelagic resources :Farms exclude trawlers from areas, and this has resulted in enhanced numbers of scallops and horse mussels at sites. There is debate about the extent to which the mussel lines and their attached.

Though the impacts are not as large as shrimp and cage culture, the intensity of negative impact cannot be neglected. Bivalve farming practices are simple and are known to provide employment opportunities and promote development of ancillary industries in coastal areas. Hence it is essential that proper management practices be stipulated for sustainable development of bivalve farming industry.