XIII

ENVIRONMENTAL MONITORING IN SEA CAGE CULTURE

Jayasree Loka, S.M. Sonali,
L.S. Korabu and K.K. Philipose

Cage culture is a fast growing industry all over the world and demands good environmental practices to assure sustainability. The sustained development of coastal aquaculture has reached a good understanding with the environment, respecting it and undertaking actions that tend to diminish the possible impacts that may arise from this activity. In order to do so, measures are to be taken in production to avoid degrading the environment, whilst still being appropriate, economically viable and socially acceptable. In this sense, it has been considered necessary to develop some basic environmental strategies to assure the best site for the aquaculture purposes, avoiding possible confrontations with other coastal uses. Basic protocols required to have a sustainable cage culture are to identify the appropriate sites for the installation of open sea fish cages, and to identify the environmental management of such industries. Monitoring is an important part in environmental management of mariculture, and is integral part of an Environmental Impact Assessment (EIA), and should be included in any mariculture regulation programme or coastal zone management plans. A well conceived and designed monitoring programme is needed for measuring environmental change and relating these changes to inputs from fish cages; in effect, investigating impacts from these inputs. However, there are no set ways for monitoring and interpretation of the data obtained. These are dependent on the purposes and aims of the study, the size, characteristics, etc.

In monitoring environmental effects of cage culture, data is collected at various time points and compared with original pre-development data and with contemporary reference data. This will show changes not only with time due to impacts but also allow natural environmental change to be taken into consideration.

Survey techniques vary but generally require a design that collects data before development – a baseline survey – and collection of post-development data – a monitoring survey:

(i) Baseline survey. This provides essential background ecosystem data for subsequent comparison. The survey may be both spatial and temporal, giving pre-development data on the natural environment and its changes throughout the proposed development area. This data can aid in the design of an appropriate monitoring study, i.e. focusing on the areas which are most relevant for investigating change in any particular environment. There are several types of experimental design, incorporating the baseline survey. One of the most commonly used is the BACI or BACUP systems (Underwood, 1991).

(ii) Monitoring study: This provides data on the actual impacts, in relation to the contemporary reference and baseline data. Once interpreted the results may be used directly for management decisions by both fish farmer and environ mental regulator by ensuring adherence to EQSs and acceptable zones of effect (AZEs).

The environmental impact of a sea farm depends to a great extent on the species, the farming method, the stocking rate, feed type and hydrographic conditions. Both organic and non-organic waste from the fish farms can cause nutrient enrichment and even eutrophication where farming sites are in semi-enclosed zones with little exchange of water. Almost 85% of the phosphorus, 80-88% of carbon and 52-95% of nitrogen introduced into the cages can enter the environment through feed waste, fish excreta, faeces production and respiration. In order to interpret the data effectively standard measures, including direct measures, i.e. ionised and un-ionised ammonia, nitrate, nitrite and dissolved reactive phosphorus, and indirect measures of productivity, i.e. dissolved oxygen, chlorophyll 'a' content, turbidity, in addition to temperature and pH, salinity, should be taken.

Long term measurement and monitoring of effects of soluble wastes are difficult due to the high mixing and dilution afforded by the marine environment. This ensures that impacts in all but the most sheltered and enclosed conditions are transient. Particulate wastes tend to settle to the sediments usually distributed in the direction of the main current flow. The wastes usually form a gradient of effect away from the discharge point which causes a variety of changes on the seabed. These changes in sediment composition decrease in dissolved oxygen or sulphur reduction due to increase in microbial production and changes in benthic biota.

A variety of measures are used as indicators - physical and chemi cal changes in sediments can be investigated using: particle size analysis, determination of concentration of organic carbon and nitrogen, redox potential (Pearson and Stanley, 1979), and measurement of sulphide content. Biological changes can be seen by looking at many factors, the presence of the sulphur reducing bacteria *Beggiatoa*, abundance of species which are indicative of nutrient enrichment and investigation of community structure (infauna and associated fauna).

Monitoring methodology

There are several considerations to be taken into account when deciding on monitoring methodology. These include:

(i) frequency of sampling;

(ii) position of sampling stations;

(iii) method of sampling water or sediments; and

(iv) method of analysis of the samples taken to measure the determinants.

These factors will be different with type of culture and method of waste discharge. Again, there is no fixed method of deciding on these factors as this is dependent on the purpose of the monitoring study. Sample strategies usually attempt to maximise data collection per expended effort, which normally entails the use of transects aligned with the direction of principle current flow rather than a less efficient but more statistically rigorous random sample or grid approach. Samples along these transects may be taken using water samplers such as the Van Dorn and sediment samplers like remotely operated grabs, dredges, trawls or corers or diver operated techniques such as photography, video, corers or REMOT systems. Grabs and coring techniques can be used to take quantitative samples which give accurate and easily comparable temporal and spatial data for physical, chemical and biological analysis (Fig.5). Photography and video methods are qualitative or semi-quantitative but are good visual record of change.

Recently, with the advent of advanced computer based electronic methods, surveys can be undertaken using sophisticated ship based technology. Such a method is side scan sonar which has been used, with varying success, to characterise sediment types throughout bays containing fish farms (MacDougall and Black, 1999) and for mapping biotopes in coastal regions. Initial findings show that these techniques need further work but they offer promise for the future where surveys will be able to study large areas of seabed quickly and accurately.

Protocol for the environmental management of aquaculture cage farms:

Data on the following should be provided:

i) Designing of the basic sampling data: on location, occupation, markers, features of the installation works, characteristics of production (species, quantities to be produced, etc.), characteristics of management (feeding, medication, waste treatment, production cycles, etc.).

Sampling : Regarding the sampling design, in each case this should be decided on the basis of previous knowledge existing on the zone. If no previous knowledge is available, the required minimum could be:

(a) Two samplings in extreme seasons: winter and summer.

(b) Five sampling points, whose design should be based on the main dispersal of the waste from the cages. Of these points, at least one should be below the point where the cages are to be installed and another should serve as a reference point for the future in an area unlikely to be affected.

(c) The sampling depths are left to the discretion of specialist carrying out the work, in accordance with the culture system.

(ii) Water column: temperature, salinity, dissolved oxygen, optical properties (turbidity, suspended solids, Secchi disk transparency), nutrients (phosphorus, ammonium and nitrogen), chlorophyll. In this case pollutants such as metals or pesticides could be studied (if so, it would be better to analyse this in filter animals such as mussels or oysters). The data must be used in order to establish the "zero state" so as to compare with that during the environmental monitoring (once the culture is functioning), the real impacts correspond to the predicted ones, in order to act in consequence if this is not the case.

(iii) Sediments: distribution of the soft substrate in the area (linked to bathymetry) with data on granulometry, organic matter and redox potential (Fig.1). In this case pollutants could be studied.

(iv) Bottom communities: with special influence on the presence of communities with a high ecological value (marine phanerograms, coralligen etc.) or with special interest (algae meadow, etc.). Besides identification, data on richness of species, abundance, biomass and diversity should be available.

Fig 1. Sediment grab

(v) Protected areas: establishment of their existence and types of protection.

(vi) Presence of other aquaculture firms: study possible synergies or accumulative effects (maximum stocking rate), from simulation data of the previous Protocol.

(vii) Interference with other uses: concentrate principally on fishing, navigation and tourism

(viii) The impacts should be determined as objectively as possible, and in order to do so, baseline contamination data should be used, as well as legislation data and data from previous environmental studies, etc. The study will be focused on the outstanding impacts.

(ix) Proposal of a monitoring programme: it should include a monitoring proposal

An integral part of monitoring is interpretation of results and relating physical and chemical results to the biological effects. For water samples this is often a compromise due to the transient nature of this environment. Most often water quality monitoring requirements are fulfilled by collection of empirical data which can be directly compared to EQSs. For sediments a similar comparative method may be used but, due to the more stable nature of this habitat, more sophisticated techniques can be employed to investigate both gross and subtle changes, such as those that may be due to discharged chemotherapeutants. These techniques use species abundance data to investigate spatial and temporal changes in sediment dwelling communities and relate these to physico-chemical parameters and waste inputs in order to achieve environmentally sustainable cage culture of marine finfish. ■

Source:

FAO 2009 Environmental Impact Assessment and Monitoring in Aquaculture.

MAFRI Report No. 46. (2002) Gavine,F. M. and Mc Kinnon, L. J. 2002. Environmental Monitoring of Marine Aquaculture in Victorian Coastal Waters: A Review of Appropriate Methods. Technical Report No.46. Marine and Freshwater Resources Institute, Victoria