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A protocol for the establishment and environmental monitoring of sea farming cages in Spain[1]

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SUMMARY – Aquaculture in Spain is a fast growing business and demands of good environmental practices to assure sustainability. 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. The aim of the protocols proposed is to help coastal managers in making decisions about the potential of a given coastal region for such activities. Two basic protocols have been developed, to identify the appropriate sites for the installation of open sea fish cages, and to identify the environmental management of such industries. The first one identifies the factors influencing the quality of the prepared products and the sustainability of the activity, the safety of the cages and their content and competition of uses. The second one defines the basic and minimum Environmental Impact Studies (EIS) and the Environmental Monitoring Programme that has to be followed in the terms indicated in the EIS.

Key words: Aquaculture, sustained development, environmental management, siting, monitoring, EIS.

RESUME – *"Un protocole pour l'établissement et la surveillance environnementale des systèmes d'élevage en cages marines en Espagne". L'aquaculture en Espagne est une activité à expansion rapide qui nécessite de bonnes pratiques environnementales pour assurer sa durabilité. Dans ce sens il paraît nécessaire de développer certaines stratégies environnementales fondamentales pour sélectionner les meilleurs sites aux fins d'aquaculture, en évitant de possibles confrontations avec d'autres usages du littoral. Les protocoles proposés visent à assister les gestionnaires du littoral dans la prise de décisions concernant la capacité pour une région côtière donnée d'accueillir ces activités. Deux protocoles de base ont été mis au point, l'un visant à identifier les sites appropriés pour l'installation des cages piscicoles en mer ouverte, et l'autre, à identifier la gestion environnementale de ces industries. Le premier identifie les facteurs qui influencent la qualité des produits préparés et la durabilité de l'activité, la sécurité des cages et leur contenu et la concurrence entre usages. Le deuxième définit les Etudes d'Impact Environnemental (EIE) de base et minimales et le Programme de Surveillance Environnementale qui doit être suivi selon les termes indiqués dans l'EIE.*

Mots-clés : *Aquaculture, développement durable, gestion environnementale, sélection du site, surveillance, étude d'impact environnemental.*

Background

Aquaculture in Spain is a business sector that is clearly growing. Its future, in terms of sustainability, lies in the optimisation of the present production units, in the diversification of its products, in the development of new culture techniques and of course in the respect and conservation of the marine environment.

The average growth of the sector, according to data from the National Advisory Council for Sea Farms (JACUMAR), has been an annual 12% in recent years. Regarding cultivated species, the most predominant is the mussel, representing 90% of the total aquaculture production, however the group showing the most significant and constant growth is the finfish: their production has multiplied by 27 in the period between 1988 and 1999 (source JACUMAR), especially species such as sea bass, sea bream and tuna.

In 1998, the number of businesses devoted to sea farming was 66 (draft of the white paper for aquaculture in Spain, 1999). The number of workers employed directly by the sector rose to nearly 1000.

[1] Paper not included in the seminar programme, kindly contributed by authors.

The previsions for growth of this economic sector are determined by the decrease in captures of the traditional fishing grounds of the Spanish fleet. However, this situation is similar internationally, since previsions indicate that the world production of fishery products should increase 26% for the year 2010 and for this it is expected that the contribution of the fish farming production will double.

The quality of the waters in the fish farm sites directly affects the farm's yield and the final quality of the product. It is for this reason that the sustainable development of coastal aquaculture is in optimum harmony with the environment and makes a consistent and respectful exploitation that tends to minimise possible impacts derived from this activity.

In this sense, and given the perspectives of the sector, it was deemed necessary to prepare a protocol that defines the scope of the impact of aquaculture farms as well as environmentally monitoring these industries. The document prepared aims to gather together the most relevant basic studies that should be carried out in order to ensure good environmental practices of this industry. This protocol was accepted at the 49th meeting of JACUMAR on 6 November 2000.

Introduction

The concept of sustained development is a widely accepted social objective for the economic development of natural resources, according to the BRUNTLAND commission report.

The conflicts arising from the use of coastal resources by developing aquaculture, as well as the adverse effects that this type of industry could have on the environment, have given rise to certain doubts on the appropriateness and continuity of aquaculture activity in the marine environment.

As with most of the traditional coastal industries, the aquaculture industry finds itself in increasing conflict with other coastal activities (navigation, fishing, recreation, industrial development, wildlife, etc.).

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.

Before the development of the sea cage farming technology in the sixties, most of the fish farming production was carried out in hatcheries and ponds. From the seventies, the farming of fish species took a giant step forward thanks to the farming of certain species such as salmon, sea bream, sea bass, amberjack, etc., in floating cages in bays, coastal lagoons, fjords, estuaries, inland seawater lakes and protected straits. Today farm cage technology has become so developed that it is possible to conduct successful experiments offshore, even though they are exposed to considerable waves. This technological development should mean less impact on the environment, as farms can be set up further away from the coast but still obtain better yields since there are no problems of poor water circulation or low renewal rates.

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.

Studies carried out on various fish farms have shown that on certain occasions a significant impact can be detected in a radius of one kilometre around the sea cages. Greater impact has been observed on the bottom from a higher oxygen demand, anoxic sediments, toxic gas production, changes in the communities, decrease in benthos diversity and development of contamination-resistant species that can be harmful to the farmed species and phytoplankton bloom, among others.

Another problem that arises in certain regions is the introduction of allochthonous species for farming, which means an impoverishment of the biodiversity of the marine ecosystem due to competition and hybridisation.

On some occasions the indiscriminate use of drugs, particularly antibiotics, for controlling or preventing fish diseases in coastal farms has led to the development of microbial communities resistant to antibiotics.

A series of environmental changes has been described, associated to the use of drugs in aquaculture: qualitative and quantitative changes in microbial flora, toxic effects on wild organisms, development of antibacterial defences in fish pathogens and transfer of antibacterial resistance to human pathogens.

Another type of chemicals, such as pesticides or anti-foulants also contaminate the marine environment and can seriously alter the ecosystem as they are toxic for wild sealife and farmed species, which, through their consumption, can become a danger for human health. Besides, the organic load due to the periodical cleaning of organic incrustations on the cages should be added.

These effects may not all happen in the same place, but the possibility that some of these undesirable effects can develop means that a clear and efficient methodology should be established in order to minimise such impacts. AZTI, Fishing and Food Technological Institute, has a wide experience in the preliminary study of potential zones for cage farming in the Mediterranean and Panama, as well as monitoring and carrying out impact studies. The need to bring together activity in the marine environment as well as its preservation is always prevalent. Not only is protection of the environment an obligation but it is also essential for the future of the activity. For all these reasons, in July 1999 a methodology applicable to sea farm cages was proposed.

From this initial proposal, and taking into account the suggestions received through JACUMAR of Autonomous Communities such as the Canary Islands and Andalusia, it is considered necessary to divide the Protocol of action into two differentiated parts: (i) Protocol for the identification of appropriate zones for installing sea farm cages; and (ii) Protocol for the environmental management of the aquaculture cage systems.

Protocol for the identification of appropriate sites for installing sea farm cages

The marine areas where aquaculture in cages can be successfully undertaken should fulfil a series of requirements to a greater or lesser degree. The factors can be divided into various groups, but not necessarily systematically:

(i) Factors influencing the quality of the prepared products and the sustainability of the activity.

- Good quality of waters: understood as good enough for the activity to be carried out, avoiding contaminated places. There should normally be a high concentration of dissolved oxygen (i.e. >4 ml/l or 80% saturation). The following parameters should be controlled: temperature, salinity, dissolved oxygen, turbidity, suspended solids and pollutants (in this case not systematically, but only where their possible presence is suspected). Some of these variables (temperature, salinity, turbidity) can also be measured by the current meter installed (see following point). At this point, it should be noted that certain events may have great importance on a local scale: for instance, runoff or floods from neighbour rivers.
- A good renewal of water: the current in the zone should be strong enough to prevent the accumulation of waste products (faeces and feed waste) from deoxygenating the water. The current should favour dispersal, diffusion and mixture of the waste, avoiding very enclosed areas with little water renewal. The parameters to be controlled are: the speed and direction of the current for at least 30 days, taking data every 10 minutes (a current meter should be placed in the mid bottom of the cage, and, if possible at several depths in the area), tides (where applicable), meteorology (mainly wind speed and direction throughout the year) and nearby supply (flow from rivers or water courses and suspended matter). Of all these, wherever possible it is preferable to have historical data.

(ii) Factors influencing on the safety of the cages and their content.

- Waves: this is related to the resistance of cages, besides the stress to which the fish are submitted and therefore with the survival of the business. It must be ensured that the frequency and height of the maximum and most important wave do not exceed the resistance standards fixed for that model of cage. The data can be obtained from the wave measurement buoy network of the Department of Maritime Climate belonging to the state-owned public port body. The parameters to be controlled are: the prevailing wave direction (frequency of each quadrant; the period of the wave, the most significant and greatest heights (according to the extreme scale regimes); the threshold waves for storms in the area, with the days that this value is exceeded per year; the fetch (length of the area of wave exposure, that is, passage of the wind over the sea without obstacles); the wave type (sea or swell).
- Depth: in tidal zones depth should be taken into account for safety reasons. It should also be considered with regard to the dispersal of residues regardless of whether it is a tidal zone or not. Sites should be avoided where the depth under the cages is less than twice the depth of the nets of the cages. As a rough guide, cages should never be installed in sites where the sea bottom is less than 15 m deep.
- Wind: although this has been mentioned in the previous section, it should be taken into consideration as a wave generator. Therefore it is necessary to have data available from the nearest site, of at least 10 years.

(iii) Factors that influence competition of uses.

- Uses that are little or not at all compatible with aquaculture should be avoided, such as effluents, protected areas, tourism (partially), beaches, bathing or navigation, among others. It is necessary to have an idea of the present and future uses through an exchange of information between Administrations and attempting to catalogue uses.
- In this sense, it would be necessary to have a preliminary idea of the biodiversity of the zone (through mapping data and population assessments, among others), so as to avoid setting up projects that could alter communities of interest or protected species. However, a deeper study of these aspects should be undertaken when making the Environmental Impact Study (EIS), if it were compulsory.

Through the data obtained above and from a contrasted hydrodynamic model (validated, tested and used by expert staff), various simulations should be made with the most common winds in the area, validating the results with the current data obtained and then proceeding to study the dispersal, diffusion and mixture of residues. In order to do this the bathymetry data from the area will also be used, as well as density data, tides (if necessary), flows (if necessary) and waves. Sedimentation rates should be used (as a function of decline), and they should be appropriate for the size of the food particles and faeces.

In this way the range of the waste generated by the farm will be delimited, which will provide useful data for carrying out the EIS (if it were compulsory), such as possible areas affected, pollutant load, etc. From this preliminary protocol, the possible incidence on other uses will be established in the later EIS, as well as the distance between cages or farms to avoid synergetic effects between them (that is, safety corridors between farms), and the stocking rate of the site.

Protocol for the environmental management of aquaculture cage farms

In this Protocol it is attempted to include the minimum content required for an EIS as well as the subsequent Environmental Monitoring that is to be carried out if the farm is installed.

EISs

The studies should consider the European, Spanish and Autonomous legislations and their requirements. The Autonomous Community of Murcia has some recommendations on the EIS of cages that can be considered for the whole coast.

We estimate that the EIS should never be simply a formula. The studies should be conducted by experts in marine environment and aquaculture. In general, and as has been stated previously, these studies should be linked to the results obtained from the modelling carried out in the first Protocol. The studies should be adapted to each site, and not be exhaustive lists, but should concentrate on the aspects that have greater influence on the environmental factors and only where they may be affected. As a guide, data on the following should be provided:

(i) Description of the project and alternatives: including 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.).

(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). These data must be used in order to establish the "zero state" so as to be able to compare that, during the environmental monitoring (once the business 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. 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. Proximity to these zones should be avoided, establishing an area of safety that should be provided by the modelling obtained in the previous Protocol.

(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, 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.

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

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

(ii) 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.

(iii) The sampling depths are left to the criterion of the specialist carrying out the work, in accordance with the project that is presented.

Environmental Monitoring Programme

Emphasis is to be placed *only* on those aspects that the environmental impact study has determined as *outstandingly* affected. It should be clear, pointing out which environmental factors should be controlled (only those that will be notably affected) and which parameters should be measured. Do not address secondary factors but only those that are fundamental to correct unwanted impacts in the future. For example, if it has been determined that the problem lies in a phanerogram meadow, the Monitoring Programme will focus on it, and avoid making expensive and non-operational studies on contaminants in molluscs or other compartments that are not notably affected. In this sense, each Programme should be unique, there are no formulas for general application. The most appropriate procedure would be for an expert to design the Programme.

The sampling frequency should be determined by the EIS, although as a rule, each compartment of the system may have a different frequency. Compartments of a great natural variability such as the water column should have shorter frequencies and the impact integrators such as sediments or benthic communities should be longer.