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Preliminary studies on environmental impact of cage aquaculture in Canary Islands

J.M. Vergara Martín[1], N. González Henríquez[2], R. Haroun Trabaue[1], L. Molina Dominguez[2] & M.I. García Rodríguez[2]
[1] *Departamento de Biología. Universidad de Las Palmas de Gran Canaria, España*
[2] *Instituto Canario de Ciencias Marinas, España*

Abstract

More than 50% of the present marine finfish aquaculture production in the Canary Islands (800 Mt for 1999) is carried out in off-shore cage farms, being the predominant technology involved in all new commercial projects in the Archipelago. This economical sector has experienced a significant growth in recent years at a Regional level, with excellent prospects for expansion due to different geographic and climatic advantages. However, this is giving rise to an increasing social concern about environmental implications, being frequently used as an argument to restrain this activity. The present work aimed to develop a protocol for environmental impact assessment of these farms, by identifying those physical, chemical, and biological parameters more sensitive to the operation of this type of facilities. A comprehensive sampling program was carried out since 1994 at a cage farm producing 500 metric tons per year of gilthead seabream (*Sparus aurata*) and seabass *(Dicentrarchus labrax*), located at the East Coast of Gran Canaria Island. The studies included water quality, retention and discharge of nitrogen and phosphorus by cultured fish, sediments, hydrology, fouling, and biological assessment of benthic ecosystems.

As a whole, none of the studied parameters showed negative effects on the surrounding ecosystems, the results suggesting that both local currents regime and carrying capacity of this particular Bay seem enough to disperse solid organic waste deposits and to transform ammonia excreted by cultured fish. The presence of fouling organisms resulted in appositive biofilter effect.

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1 Introduction

The culture of the marine fish gilthead seabream (*S. aurata*) and European seabass (*D. labrax*), predominant in the Mediterranean area has experienced a dramatic growth in recent years, from production figures amounting a few thousands in 1984, until around 100 000 metric tons estimated for 2000, totally commercialised in European markets.

These two species are also produced in the Canary islands, the main advantages being a large coastline (1291 km), and a warm range of surface water temperature, shortening the ongrowing period of these fish species when compared with Mediterranean farms. Thus, the required ongrowing times for seabream and seabass in the Mediterranean are 16 and 20 months, respectively, while in the Canaries these periods are reduced to 13 and 16 months. This fact also allows to economically produce bigger (one kg) fish with no competence in the Mediterranean. However, other factors derived from the long distance to markets represent negative counterweights in the total profitability of local farms, despite their positive whole balance. Another advantage lays in the absence of heavy water polluting industries, giving to coastal waters the high quality required for the culture of the above marine species.

Funded by the EU program STRIDE, our research group installed a pilot farm in May 1994, consisting of six polystyrene, floating cages of 900 m^3 each (Figure 1), which were moored in the bay of Melenara, at the Southwest coast of Gran Canaria island. Simultaneously, an Consortium Agreement was signed with the private company ADSA, in order to allow the firm to operate the facilities and to fund a variety of research work to be done, including environmental impact assessment. Fish were firstly stocked in the cages on June 1994, and the environmental studies were iniciated a month earlier. In addition, our research group was recently granted with funds from a national and European program (CICYT-FEDER) that will allow us to improve and continue these studies at least until 2001.

2 Environmental impact studies

The environmental impact study was designed to identify those parameters more sensitive to the operation of this type of farms, thus allowing to produce an environmental management program which could be useful both to farmers and to public institutions implied in the regulation of aquaculture at the Canary islands. The work included three categories of studies: 2.1) nutritional – mass balance of nutrients; 2.2) water quality; and 2.3) ecological – sediments, fouling, and benthic ecosystems. Simultaneously 2.4), the hydrology of the zone was also studied using an automatic currentmeter.

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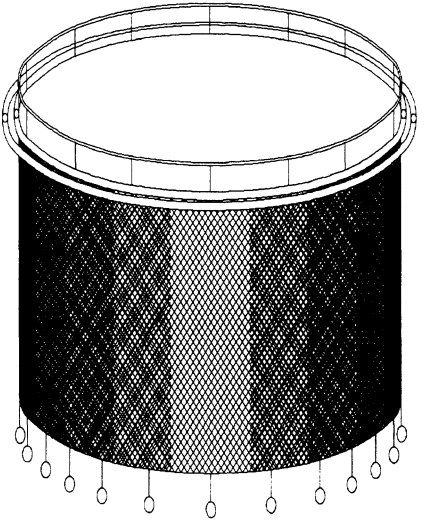

Figure 1: Polystyrene floating cage

2.1 Nutritional studies

The nutrient budget or mass balance model (Gowen et al., 1987) was studied by a series of biochemical analyses carried out on a significant fish population and the fishfeeds used during the growout period of both fish species, then the nitrogen and phosphorus retained by cultured fish was determined, as well as the nitrogen and phosphorus fractions released to the environment. Results showed that yearly total nitrogen and phosphorus inputs to the farm via feeds amounted for 39.5 and 5.5 Mt, respectively, resulting in a release of 32.1 and 3.8 Mt, respectively, in both dissolved and particulate forms (Figure 2).

2.2 Water quality

Water quality was studied by means of sampling and subsequent analyses of the water column at different influence zones, including one control and three different points, and two different depths for each point. On site data on water temperature and dissolved oxygen were obtained at each point with a portable electrode probe, while water samples were filtered (0.45 μm) and frozen at –20°C for further analysis.

Water temperature ranged between 17.5°C -January-March- and 24.1°C -September-November-, and dissolved oxygen values ranged between 6.3 and 11.7 mg/l. Phosphate values ranged between 0.0 and 1.1 $\mu mol.l^{-1}$, with an average value below the average value, 0.45 $\mu mol.l^{-1}$, reported for this bay (García, 1999). Silicate values ranged between 0.4 and 2.6 μmol^{l-1}, with an average value of 1.1 $\mu mol.l^{-1}$. Nitrate+Nitrite values ranged between 0.0 and 1.2 $\mu mol.l^{-1}$, always below the

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average value, 3.52 μmol.l^{-1}, reported for this bay (García, 1999). Ammonia values ranged between 8.77 and 21.7 μmol.l^{-1}, with an average value, 14.9 μmol.l^{-1}, above the average value, 6.96 μmol.l^{-1}, reported for this bay (García, 1999, Table 1).

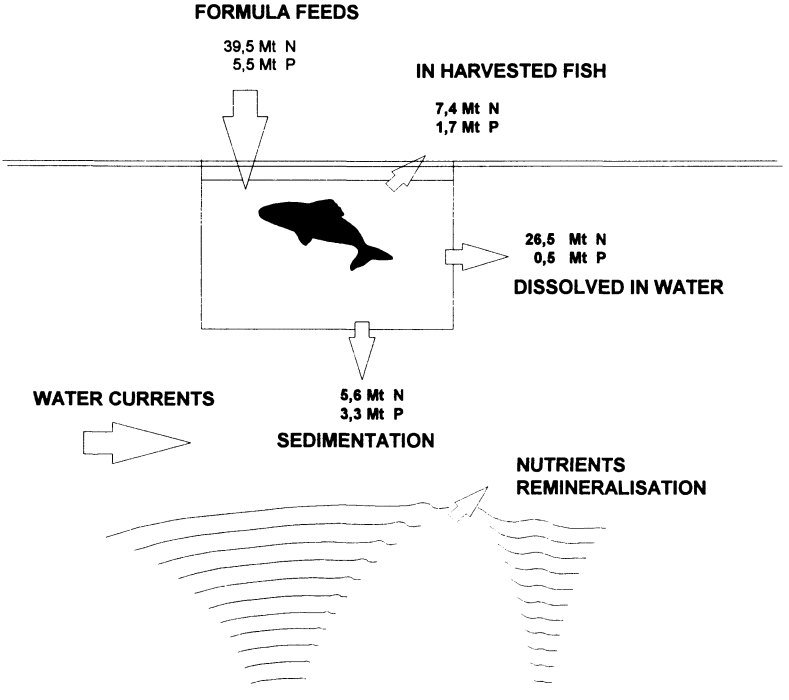

Figure 2: Yearly nitrogen (N) and phosphorus (P) mass balance in the studied farm, with calculated dissolved and solid fractions.

Table 1. Range of values of water quality in the studied cage farm.

	T [a] (°C)	O_2 (mg.l^{-1})	PO_4^{3-} (μM)	SiO_3^{2-} (μM)	$NO_3^- + NO_2^-$ (μM)	NH_4^+ (μM)
Cage Installations Values Ranged	17.5-24.1	6.3-11.7	0.0-1.1	0.4-2.6	0.0-1.2	8.77-21.7
Bay of Melenara Average Values			0.45		3.52	6.96

Nitrate+nitrite, and ammonia values were the parameters showing highest differences between points inside the cages and those outside the facilities, particularly during the autumn season. This can be explained as a consequence of highest water temperature values occurring during this season, leading to an increased food consumption by fish and corresponding ammonia excretion. As a consequence of nitrifying bacterial processes, nitrate+nitrite values were also highest

inside the cages in this season. However, these values were always well below those values considered as normal for this area, suggesting that the carrying capacity of this bay was enough to transform the ammonia excreted by all fish stocked at the cages, and to keep normal nitrate+nitrite values.

2.3 Ecological studies

Sediment samples were collected with cores in three different influence zones: underneath the cages (two sampling points), 60 meters from the cages (four sampling points), and 200 meters from the cages (four sampling points). Analyses included particle size, organic matter, and total nitrogen and phosphorus contents. No significant differences were found for all parameters between points located within each sampling zone. When different zones were compared, no significant differences were found for particle size, organic matter and phosphorus content. However, the average nitrogen content of sediments underneath the cages was significantly higher than those of the other sampled zones. A marked seasonal trend was observed for values in both nutrients and organic matter, similar in all zones and characterised by periodical recovering of initial values in the three zones. These results suggest that the water currents regime of the area was enough to whash away organic sediments.

Studies on the fouling occurring on cage installations (floats, frames, ropes, moorings, nets, etc.), in terms of biomass, species diversity, and biochemistry analyses, together with results from chemical water analyses, suggest that these organisms act as filters of dissolved organic and inorganic products resulting from fish loads, diminishing the amount of nutrients finally released to the environment.

Two 150 meters length transepts (NE and SW), croosing over the vertical of the cages, were marked on the sediments, and used to perform periodical visual counts by divers, in order to assess the benthic ecosystems. By the end of the third year of the cage operation, a significant decrease in populations of the seagrass *Cymodocea nodosa* was apparent in the zone underneath the cages, as well as an increase in the population of the polychaete *Diopatra neopolitana*. An increase in benthic fishes was also observed in this area, with average values of 150 individuals per 20 meters length.

In general terms, some negative effects could be appreciated in the benthic ecosystems directly underneath the cages, although such effects were less apparent as showed by the sediments analyses and by the increase in species diversity observed in the fouling studies.

2.4 Hydrology

With respect to water current velocities, maximum registered values (60 cm/sec, with average values of 25-30 cm/sec) coincided with storm episodes, and were below maximum values recommended by the cages manufacturer (100 cm/sec). Minimum average velocities (10 cm/sec) are generally considered as enough to allow for a good water and oxygen renewal in cages, as well as for whashing away organic sediments.

Predominant directions of currents arriving the cages were NE and SW, this pattern being determined by the general Canarian Current (North-South direction), above which the locally predominant tidal currents are superimposed. Its direction NE or SW will vary depending on high or low tides.

3. Results of the studies

As a whole, results obtained up to present suggest that the currents regime is the main factor affecting the interaction between this type of farms and the surrounding ecosystems, and that in this particular case, both released organic matter in solid form to the sediments and dissolved nutrients have produced no significant negative effect on the surrounding environment. These results have been submitted every year to the Local Government of the Canary Islands, as a requisite of the permission granted in 1994. The firm, which operates the farm also, receives these results with similar periodicity.

4. Socio-economical effects

At the present, the production of these two finfish species in the Canary islands amounts 1000 Mt per year. If a reasonable number of those new commercial farm projects (all off-shore cages based) which nowadays are waiting for permission start to operate and consolidate in the next three to five years, it can be estimated that total local production could then reach 5000 Mt per year. This would imply an overall 4000 million peseta a year business, directly employing between 100 and 150 people and near 1000 indirectly. These production figures would also allow, by scale economies, local feed manufacturing and hatchery industries to open, which would contribute to dramatically reduce production costs, and hence, to improve competitiveness of local farms. In the long term, a conservative estimation of the potential for this sector could be near 15 000 Mt per year, three times as big as the previous estimates.

On the other hand, reports opposing to this and other similar farms have been regularly published in the local press, including a variety of arguments on their negative effects, among which can be summarised:

- Attraction of dangerous species (sharks, etc.) by cages.
- Negative visual impact.
- Negative environmental impact, including water and sediment pollution, damages to benthic seaweed species, fish scapes, the use of dangerous anti fouling products and medicated feeds, or the presence of oil films in the surface of surrounding waters.

The origin of this opposition is also varied, including local town councillors, community associations, and green groups. Regularly, and when these opposition campaigns were more continuous, local R & D institutions have released reports to the press with the above results of environmental impact studies, where different

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arguments against these farms were invariably contradicted.

All the above indicates:

a) That this new industry generates a series of conflicts with different local users of coastal resources, as with local fishermen.
b) That these conflicts become apparent in the form of opposition to settling of this industry within the local community, generally expressed in the form of environmental arguments.
c) That an evident difficulty to transfer the results of environmental impact studies to the community where these farms intend to operate exists.

5 Discussion and conclusions

One of the possible reasons for the above described situation could be the fast growth of this industry in the Canary islands, interfering in the short and medium term with their integration within local economies. This fact can be also the cause of an image problem, which become apparent in a variety of conflicts with the local communities.

If we assume this hypothesis, maybe this industry should consider an approach of corporative image improvement targeted towards local communities where they intend to settle, including the public divulgation of environmental management programs carried out at present in every, as part of this strategy.

In addition, local authorities implied in the regulation of this sector must make a substantial effort in promoting this industry as strategic for the economy of the Islands, as well as supporting the wide use of environmentally sound practices by farmers.

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