Offshore Aquaculture Development in Ecuador

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Abstract: Ecuador has a long tradition in aquaculture, mainly related to the cultivation of shrimp and tilapia in earthen ponds. Land-based production methods have a large environmental, economic and social impact due to the extensive use of land and its effects on the ecosystems. In order to increase the production of fish without further land use and with a lower environmental impact, a good alternative is the culture of fish in floating cages, adopting technologies used successfully in many other countries. This article analyses the current situation of offshore aquaculture (the production of fish and other aquatic organisms in the open sea) in Ecuador, and the prospects for the future of this sector in the country.

Keywords: mariculture, fish, cage aquaculture, offshore aquaculture, sustainable aquaculture, Ecuador

1. Introduction

Aquaculture started in Ecuador in a quite casual way at the end of the 1960´s, when some local farmers from El Oro province, in the south of the country, noticed that there were shrimp growing in coastal ponds. The juvenile shrimp had entered the ponds accidentally, probably with a high tide. In the 1970´s the culture of shrimp started its expansion in El Oro province, and by 1974 there were 600 hectares in production (FAO, 2005a). The activity grew a lot in the 1980´s, and Ecuador became the world´s main shrimp exporter (Hirono, 1983). At the end of the 1980´s and beginning of the 1990´s the industry was affected by the syndromes of the seagull and Taura, causing great mortalities; Ecuador was displaced by the Asian producers as the main world shrimp producer (Brock, 1997). Aquaculture production eventually recovered during the second half of the decade of 1990´s, reaching new record production levels. From 1999, with the appearance of the white spot syndrome, production fell drastically, more than 60 %. It was during this period that many shrimp producers stopped their activities, and some other farmers assessed the possibility to produce tilapia in order to gain some utility from the underused infrastructure: ponds and feed mills. Shrimp production recovered during the second half of the decade (2000´s) being currently at record high production levels (2015).

At present there are approximately 213.000 hectares of shrimp/tilapia farms (Lombeida, pers. comm.) producing each year more than 300.000 tons of shrimp and fish, with a market value of over 1.500 million USD (FAO, 2015). Shrimp has become the second non-oil export product, only after the bananas, although there are recent reports that indicate that at the end of 2014 shrimp almost equaled bananas in export value (Banco Central del Ecuador, 2015).

However, aquatic production as it has developed in Ecuador, has generated a high ecological cost. For its development, ponds were built in low areas near the coast, first in salt evaporation ponds and saltpetre areas. But as the activity expanded, and it proved to be profitable, mangrove trees were fell to build new shrimp farms. Mangroves are marine swamp forests that form coastal ecosystems with an important social, cultural, economic, biological and ecological impact. Mangroves develop in coastal tropical areas, and they form a transition zone between dry land and the open sea. These ecosystems are nurseries for many marine organisms and birds, playing a very important role in the reproductive cycle of many species of commercial interest. These areas are also very productive, working as traps for nutrients coming from the rivers, and later recycling these nutrients. Mangroves also play a role in avoiding coastal erosion processes, and it gives a way of life to many families who are gatherers of aquatic resources.

The great expansion of the aquaculture activity has caused an impact on the mangrove ecosystems. If the country wants to have a sustainable development, it is very important to establish alternative production methods that are gentler to the environment, especially with sensible ecosystems such as the mangroves.

With the aim of diversifying aquaculture production in Ecuador, several projects have been carried out for the production of shrimp, *Litopenaeus stylirostris* (Cun, 1982), red drum, *Sciaenops ocelatus* (Guartatanga *et al.,* 2003), yellowtail, *Seriola rivoliana* (Blacio *et al.,* 2003) and lobsters *Cherax quadricarinatus* and *Procambarus clarki* (Naranjo-Páramo *et al.,* 2004). However, these projects did not achieve large scale development due to technical and biological limitations.
In 2002, as a consequence of the white spot syndrome, alternative production methods for shrimp were developed, such as culture in covered ponds that allowed the reduction in water exchange and a more constant temperature level, and the system called "onshore", that consisted in culturing the shrimp at very low salinities using water from boreholes and rivers, in agricultural zones of Manabí and Guayas provinces.

There were also some low scale trials for culturing oyster and scallop in the central coastal region, and some preliminary trials for the production of macroalgae in shrimp ponds, but without reaching intensive levels of production.

2. Offshore aquaculture

In order for aquaculture to become sustainable, not depending on pumping for water exchanges, and to eliminate or reduce to a minimum its impact on the coastal ecosystems, offshore aquaculture is being looked at as an alternative to land based production. This system of production relies on the management and harvest of marine organisms on its natural environment, enclosed in specially built structures (cages, rafts).

Cage aquaculture is a relatively new production technology. Even though there are references of pond aquaculture in China more than 4.000 years ago, the first references of cages used to transport live fish are just 200 years old. Traditional wooden cages have been used in Asia for some time. However, the origin of modern cage aquaculture is found in the pioneering work carried out in Scotland and Norway in the 1970´s. Nowadays this technology has become very important in the world aquaculture production. Main species produced are high value species (salmon, rainbow trout, yellowtail, red seabream, gilthead seabream, sebass, cobia) as well as an increasing number of omnivorous species (carps, tilapias, catfish). Currently there is a wide variety of culture systems used, from artisanal systems used in some Asian countries, to the high tech systems used in Europe and the Americas (Tacon and Halwart, 2007). Based on the available information, the main countries producing fish in cages are Norway (652.000 tons), Chile (588.000 tons), Japan (273.000 tons), United Kingdom (136.000 tons), Vietnam (126.000 tons), Canada (98.000 tons), Turkey (79.000 tons), Greece (76.000 tons), Indonesia (67.000 tons) and The Philippines (66.000 tons).

In Latin America and the Caribbean, the aquaculture sector has become an important economic activity, present in 31 of the 44 countries in the region, and employing directly more than 200.000 people. With regard to cage aquaculture, the great majority of all cages in Latin America are located in Chile for the production of salmonids. The other group of fishes widely cultured in the region are the tilapias, that include several species and hybrids. According to some recent reports, only 10 % of the tilapia produced in Latin America has been produced in cages (Rojas and Wadsworth, 2007), although it is expected to increase to over 30%. Tilapia is currently cage-cultured in Mexico, Brasil, Colombia, Honduras, Costa Rica, Nicaragua and Cuba. Besides tilapia, there are commercial cage operations of tuna in Mexico, and cobia in Panama, Colombia, Belize and Brazil.

3. Current status of the offshore aquaculture in Ecuador

Legal and regulatory aspects

In spite of the good natural conditions, long aquaculture tradition in the country, and the development of cage aquaculture projects in other countries of the region, offshore aquaculture has not developed much in Ecuador. This lack of development may be due to the poor knowledge of the advantages of offshore aquaculture, and the tradition of the aquaculture sector to operate in land-based ponds in a relatively cheap way. However, it is known that these ways of land-based production are not environmentally sustainable, because of the detrimental effects on the mangrove ecosystems and on the traditional gathering communities.

Aware of these limitations, the Ecuadorian Government has developed a number of laws to regulate this sector. In 2012 a Ministerial Agreement was published (AM 458) for the regulation and control of aquaculture leases. It declared that aquaculture leases could be awarded in all areas of the sea and rocky or sandy bottoms where the cultivation of marine organisms is technically feasible, taking care not to affect

other fishing activities, tourism, navigation and other uses of this public good, using the available technology to minimize the environmental impact of the surrounding areas. Consequently, the following areas were explicitly excluded for the development of offshore aquaculture: protected areas that form part of the National System of Protected Areas (SNAP), areas of national security, navigation channels, and areas of marine reserves. However, this ministerial agreement does not make any reference to minimum distances to the shore or depth required for the offshore operations. A previous ministerial agreement (AM 134, 2007) established the first nautical mile from shore as a reserve zone for the reproduction of aquatic organisms. In the first 8 nautical miles from shore only artisanal fisheries are allowed, and industrial fishing is explicitly forbidden. This agreement does not make any specific mention to aquaculture. A later law (Ministerial Agreement 42, 2013) states that aquaculture research projects in the first 8 miles can be awarded to artisanal fisheries organizations, and to pilot research projects. This law does not mention any limitation to commercial projects, but it seems to infer that commercial aquaculture should not take place in the 8 mile zone.

The first 8 nautical miles from shore had been reserved by the Ecuadorian law as an exclusive fishing zone for the artisanal fishermen (Ministerial Agreement 80, 1990). This agreement was prepared on request from the artisanal fishermen, who felt endangered by the activities of large trawlers.

Even though there is no mention of the 8 mile limit in the aquaculture laws, the first leases awarded in the country were given in the zone beyond the 8 mile zone. The first offshore farm is already in operation, in an area with water depths of over 65 meters (Fig. 1).

Fig. 1. Open ocean cage farm 9 nautical miles out of Jaramijo, Manta, Ecuador.

The installation and management of aquaculture sites at these depths needs more investment and logistics than in shallower waters and smaller distances to shore. Considering these limitations, the Ecuadorian Government is currently developing a series of zone maps with the sites that are suitable for mariculture along the coast of the country, with the objective of regulating the activity and favoring the establishment of new enterprises. The main criteria used for this zone development has been water depth, distance to shore, currents, waves, protected areas, navigation, artisanal fishing grounds, areas of oil exploration, and the proximity of fishing harbors that will be used as base ports. Optimal depths for the installation of aquaculture moorings are between 20 and 50 meters. In the Ecuadorian coast all marine areas with depths of under 50 meters are within the 8 mile zone. With this information, the government is considering the possibility to award leases to non-artisanal entrepreneurs within the 8 mile zone, excluding areas of artisanal fishing grounds or any other activity that may conflict with aquaculture.

Research and development in offshore aquaculture

There are at present a number of public institutions dedicated to research and development of aquaculture in Ecuador. Among them, the National Fisheries Institute (INP), the Nacional Centre for Aquaculture and Marine Research (CENAIM), and the State University of Santa Elena (UPSE). The National Fisheries Institute, through its mariculture program, has carried out the first trials of shrimp culture in experimental floating cages with promising results. Currently the INP is conducting trials to determine the optimal culture conditions of several species in floating cages. In addition, the Institute is preparing a zone map of the coastal areas to facilitate aquaculture development.

Other limitations

Besides legal and technological aspects, there are some other aspects that need to be strengthened so that offshore mariculture may achieve its full potential in Ecuador. The main aspects are: the supply of seed (larvae or juveniles of the cultured species), a better knowledge of the nutritional requirements of the species to be cultured, training of the personnel for working in offshore farms, port infrastructure, sources of funding, and new species (native or introduced).

- Supply of seed: this is the main bottleneck for the development of the aquaculture sector. There is no point in developing culture technologies and offshore farm designs if we do not have enough seed to fill up the farms. This is the same limitation that

has been present in other countries where aquaculture has developed, with only one or two species with known biology and production technology, dominating the production in each country. For example, in the Mediterranean aquaculture, sea bass and sea bream are the main cultured species, just because there is large scale availability of seed for these two species. A similar situation occurs in Japan with the yellowtail and the red sea bream, and in Chile, Scotland, Norway and Canada with salmonids. In Ecuador one company is already producing cobia juveniles (Fig. 2).

Fig. 2. Hatchery production of cobia in Ecuador.

- Nutritional requirements of the cultured species: feed is the main cost item in the total production cost of cage cultured fish. A cultured species will usually grow well when all its nutritional requirements are above a minimum. However, these minimum requirements are different for each species and life stage (López-Alvarado, 1995, López-Alvarado and Kanazawa, 1997). Considering the high impact of feeds on the production cost, it is crucial to investigate the nutritional requirements for each species and life stage in order to optimize costs.
- Training of personnel to work in offshore farms: since this is a completely new activity in Ecuador, it will be necessary to train a number of professionals at all levels for the daily work and management of the offshore operations. It is important to make emphasis on the training of workers and middle management who will be responsible for the daily operations. The main abilities needed for the day to day operations are boat skipping, professional scuba diving, and knowledge of feeding and feed management. It will be necessary to organize theoretical and practical training at several levels, to prepare technicians for working in the offshore farms. In addition, it would be convenient the hiring for a limited time of experienced workers and technicians that could transfer their practical knowledge to local workers. Regarding the management, there are already university level programs that prepare for the management of aquaculture business, that could be modified for the management of floating fish farms. In the long term it would be convenient to establish specific courses and degrees for the management of offshore farms.
- Port infrastructures: for the development of mariculture at an industrial scale, it will be necessary the use of medium size boats (12-16 meters long) that require harbors for its operations. It is also important that the farming companies have some store in the port facilities or its proximities, to store nets, feeds, and other machinery, and office space. At present there are only a few harbors in Ecuador with these characteristics: Anconcito, Jaramijo, San Mateo and Esmeraldas (Fig. 3)

Fig. 3. Fishing harbor in Esmeraldas, Ecuador.

- Sources of funding: the development of a mariculture enterprise requires an initial investment that, although smaller than a land-based farm, may reach a considerable amount. In addition to the initial investment, finance must be available for the daily operations and regular purchases of feed and seed. Credit lines from financial institutions will be needed to facilitate the investments needed for the development of mariculture in the country.
- New species: the introduction of new species for aquaculture purposes is not necessarily a toxic subject if the introduction is carried out under close supervision during the culture phases. Many countries support their aquaculture production with non-native species. This is the case of salmon in Chile, and tilapia in Asia and Latin America.

SWOT analysis of the aquaculture sector in Ecuador

Table 1 summarises the SWOT analysis of the aquaculture sector in Ecuador:

Table 1. SWOT analysis of the aquaculture sector in Ecuador.

STRENGTHS	OPPORTUNITIES
- Adequate climatic conditions for a wide range of species - Technological potential for the diversification of species and products - Perception of aquacultured products as healthy foods - Product availability with constant quality year-round - High international know-how - Dominant position at international level for some species - Price of product is competitive - Well developed distribution channels - Increasing effort in R&D - Activity generates employment in rural areas	- Fisheries stagnant or in decrease - Establishment of quality seals - Development of new value-added products and services - Market for processed products growing world wide - Access to R&D - High potential for diversification of new species - Link of sector with tourism activities - Government declaration of aquaculture as a strategic sector - New potential markets for organic products and other certifications
WEAKNESSES	**THREATS**
- Low product diversification - Lack of a communication and image strategy - Unclear laws regarding aquaculture - Poor coordination between R&D and companies - Many small companies - Small number of hatcheries for species other than shrimp - High cash-flow needs	- Competing uses for the coastal zone - Low integrated coastal management - Increasing environmental, health, and animal welfare requirements - Health risks: new pathologies - Environmental risks due to alterations of the environment - Poor knowledge of the effects of climate change on the sector - Market of aquatic products very attractive to third countries - Poor knowledge of the media, reduced number of positive news - Risk of burglary

4. Future perspectives

Offshore aquaculture is a new activity in Ecuador, and as any other new venture, there is a lot of uncertainty about its future development. In theory, Ecuador has all the climatic conditions needed for an adequate development of mariculture: warm waters all year round, good oceanic conditions, and a general absence of adverse oceanic conditions. These factors, together with other strengths such as the high technical level of the human resources and the presence of well developed distribution channels indicate that there is a good chance for the development of the mariculture sector. With a gradual and cautious development, mariculture could become an important source of work and wealth for the country. Some examples of mariculture development in other countries could serve as a guide. In Spain, mariculture production expanded from a production of just 100-200 tons of sea bream in the 1980´s to 6.000 tons by the end of the 1990´s, and over 20.000 tons by 2010 (Apromar 2014). In other countries such as Turkey, the growth was even faster, overtaking the Spanish production in a few years.

The production capacity of the Ecuadorian mariculture is still to be quantified. Ecuador has *ca.* 640 km of coastline with a wide continental shelf that is suitable for mariculture. The average productive capacity of a mariculture operation for large leases is roughly 100 tons of fish per hectare of sea bottom used. That is, to produce 2.000 tons of fish we need a lease area of approximately 20 hectares. This is only a rectangle of 400 x 500 meters of sea bottom. If we assume that this will be the average size of the new marine farms in Ecuador, with just some 50 operational farms the country could produce 100.000 tons of fish per year. This is by no means the maximum production capacity of the country, just a conservative estimation of where the sector could be in a few years. The success of this new sector will to a large extent depend on the initial success of the first ventures, and on the incentives from the public sector. Following the first experiences, no doubt many other companies will follow. Ecuador could be in a few years among the 10 largest world producers of cage aquacultured products. If salmonids are excluded, Ecuador could become the second largest producer of marine fish in cages (only after Japan) helping to diversify the Ecuadorian economy, increase the foreign exchange reserves through exports, and increase the level of economic and social inclusion through employment in rural and coastal areas of the country.

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