



The European Association
of Fisheries Economists

E.A.F.E.

VI Annual Conference.

28/30 mars 1994 - Heraklion (Grèce)

**Management of shrimp farming versus the
environmental challenge in Thailand.**

by J.Y. WEIGEL¹

Introduction

The space encroached upon for coastal aquaculture may be land, formerly salt flats, rice paddy or perennial crops, or it may be in between land and sea, i.e. mangrove swamps, as in the case of shrimp (penaeid) culture which takes up 98% of the coastal aquaculture space, or 53,000 hectares. Pond shrimp culture, as it is called, is in full expansion as is demonstrated by the 15,000 production units which were commissioned in 1990, i.e. more than twice the figure of five years ago. Besides the fact that shrimp culture takes up and modifies a large amount of space (most often, mangrove land converted into ponds), it also consumes inputs in bulk, and thus actively contaminates water and pollutes the soil. The impact of this dual phenomenon on the environment is unparalleled by fishfarming or declining oyster culture or even by some other less significant forms of aquaculture (shellfish, crab, seaweed, etc.). The last two take up only 2% of the coastal aquaculture acreage, and are usually practised in large open bodies of water (in cages or pens in the sea or in an estuary), and generally require far less input. The focus on the predominant form of aquaculture is thus warranted.

Turning now to the main phases of shrimp culture development and its impact on the environment, it should be noted that there are three phases : the first, which might also be considered the foundation phase, stretches from the significant beginnings of coastal aquaculture in the early sixties up to the late seventies. The second phase covers the next ten years, corresponding to the expansion of shrimp culture and the setting up of the production and marketing chain. The third phase starts in 1988 and is that of the shrimp farming boom, which put Thailand on the world market of this product, and, with a shrimp culture output of

¹ Chairman of the Commission Development. O.R.S.T.O.M. 72, Route d'Aulnay. Bondy 93143 cedex. France. Fax : (33)-1-48473088

Fonds Documentaire IRD



010025453

1

Fonds Documentaire IRD
Cote : B* 25453 Ex : weig

120,000 tons valued at approximately Baht 13 billion, made the country one of the market's top producers in 1991.

1. Shrimp culture development and environmental degradation

1.1 The foundation phase : initiation through the development of an extensive system

All countries in Southeast Asia have a tradition of extensive shrimp culture, and Thailand is no exception, as is borne out by the fact that extensive shrimp farming existed as early as sixty years ago. This type of aquaculture, which is still practised today, has not undergone any major changes; most production units and coastal aquaculture areas were farmed in this way until 1987². Extensive shrimp culture, which represents the first Thai stage in this context, is practised in ponds, sometimes natural, but most often artificial, watered by the tide, with a sluice gate to retain the water and the trapped fry until the next tide. This is therefore a system which requires hardly any inputs³, but at the same time, the output is very low. Nevertheless, this extensive production system has practically no impact on water pollution, since very few extraneous residues are discharged into the natural environment, into the surrounding canals, although the effluent is more saline than water from the natural environment - a phenomenon which is explained by evaporation. However, this method of shrimp culture leads to increased acidity and salinity of the submerged soil, which was previously rice paddy or perennial crops, and is now unsuited, at least for a certain time period, to this form of agriculture.

The most notable environmental impact of this extensive system, per se a major space consumer, is the past and present destruction of mangrove : from the early sixties to the late seventies, i.e. when it was the principal shrimp farming system, it is thought to have been the cause of the clearing of 27,000 hectares of mangroves. According to Aksornkao (1986), during this period, 84,000 hectares of mangroves or 4,200 hectares per year were destroyed ; Klankamsorn and Charupatt (1982) state that 32% of the land reclaimed from the mangrove was converted into shrimp culture ponds mainly in the provinces along the Inner Gulf of Thailand (from Petchburi to Chachoengsao) until the end of the seventies; this is confirmed by the regional distribution of the shrimp culture tracts, the largest concentrations of which are in Samut Sakorn, Samut Songkhram and Samut Prakarn.

The construction of ponds on converted mangrove areas has a direct impact in that it leads to cutting down the forest cover. But it can also have indirect effects. One of these may be the deterioration of the remaining mangroves in two conflicting ways, depending on the land and water flow configuration : first, the accelerated water circulation caused by clearing part of the mangrove stand provokes leaching, and thus erosion and an increase in salinity and acidity; secondly, preventing the free circulation of water by constructing numerous dykes, channels and canals also induces the degradation of the mangroves. These changes in water circulation may have repercussions on the catch or even on the other forms of aquaculture practised in the surrounding area. Another impact, the drop in the area's productivity, stems from the fact that the ecological fish and crustacean niches have become rare and are no longer of the same quality : the destruction of the mangrove, which is the nursery area for numerous aquatic species, including shrimp, also affects neighbouring fisheries (marine, estuarine and even riverine catches). All these factors are emphasised if there is also pollution

² Here some technical information may be necessary to enable the reader to grasp the characteristics of this production system and its effects on the environment. However, every time that such an approach has proved necessary, the author has tried to be as brief as concise as possible.

³ No electricity or diesel oil as there is usually no pumping system, no supplying of postlarvae or industrial feed, chemicals or veterinarian products. "Natural" densities are around 500 to 1,000 shrimps per hectare.

from the dumping of organic waste of aquacultural origin. Finally, pond shrimp culture competes with other destructive activities, such as charcoal production, logging for building materials, (tin) mining, forest clearing for agricultural production or for the construction of fishing piers, etc.

Thus, at the end of 1977, there were 1,400 shrimp farms, most of which had adopted the extensive system of production covering a total area of 13,000 hectares, and producing 1,600 tons of shrimp, i.e. 1.5% of the current yield, but already at the heavy cost of the disappearance of several thousands of hectares of mangroves.

1.2 The expansion phase : interaction between the establishment of the production-marketing chain and mangrove destruction

It was during this phase that the different segments of the production and marketing chain were gradually established, following the assimilation of the transfer of technology, mainly from Taiwan and Japan, and thanks to the incentive provided by foreign investment. The entire period, from 1978 to 1987, had benefitted from the favourable economic situation, characterised by sustained demand from importing countries. The setting up of the different segments of the production and marketing chain took some fifteen years, but it was during this period that the main pieces of the puzzle were matched. This set-up was initiated, as is often the case in Thailand, by actions imposed by the State for extension and R&D activities, by facilities granted to foreign investment, and finally, by the opening up of credit lines, which were particularly favourable for shrimp farmers.

The approach adopted for the dissemination of shrimp culture techniques was very production oriented, with no concern for environmental protection, and with the assistance of international agencies like the South East Asian Fisheries Development Center (S.E.A.F.D.E.C.) and the Food and Agriculture Organisation (F.A.O.). Research and development was first undertaken by the responsible government departments, such as the Department of Fisheries (D.O.F.), which, in turn were relayed by private companies (the Charoen Prokphand group currently allocates 2% of its annual budget to research). The thrust of R&D was on the processing and packaging of fishery and aquaculture products, on feed quality and on the development of veterinary products or aquaculture machinery. Previously, during the initial stage of managing the entire shrimp farming chain of production and marketing, the main focus was on shrimp hatcheries and nurseries. As early as 1973, technicians trained in Japan succeeded at a Department of Fisheries' station in mastering the hatching and nursing of the *penaeus monodon* and the *penaeus merguensis* from spawners taken from the natural environment : at the end of the eighties, almost 2,000 hatcheries and nurseries were producing 120 million postlarvae. This result can be partially explained by the success of an extension programme undertaken by the same Department, but is mainly due to the transfer of technology made possible by the creation of joint ventures. This last element does indeed seem to be the principal reason for this success in production and return on investment : the results of our survey show that these joint ventures⁴ were, on the whole, successful particularly as they benefitted from the most sophisticated technological input of the production and marketing chain, whereas most of the other companies recorded inferior results, and some even had to stop certain activities. Some of these joint ventures obtained Board of Investment (B.O.I.) fiscal privileges as well as facilities for the repatriation of profits - which should not have applied to this segment of the production and marketing chain.

More downstream segments such as the production of industrial feed, and particularly, processing (mainly freezing) were developed later. The activities also benefitted from the facilities granted by the B.O.I. Large investments in industrial feed were started in 1986 with

⁴ These joint ventures were established mainly on the basis of ethnic affinity, with Taiwanese companies seeking to relocate for various reasons including environmental.

the creation of a 19,000 ton capacity plant by Ta Tung Co, which increased to 100,000 tons in 1990. The other major groups rapidly followed suit in so far as they wished to be present on all the segments of the production and marketing chain: Aquastar Co thus entered with an investment of Baht 67 million, and the Charoen Prokphand group with the construction of two plants in Hat Yai and Samut Sakhon with a total capacity of 220,000 tons per year.

The processing, and particularly, the freezing facilities, after a harmful delay for the sale of the products in 1989 and 1990, now have a slight overcapacity, which is explained by the massive investment made by Aquastar Co. through its subsidiary, Aquastar Food Co (Baht 200 million) and those made by Charoen Prokphand (Seafood Enterprise Mahachai Co, with an annual capacity of 12,000 tons and C.P. Intertrade Co. in Rayong with a capacity of 15,000 tons per year).

A proper financing plan was developed from 1985, enabling shrimp farmers to take advantage of soft loans of up to Baht 12 million at annual interest rates of between 10% and 14%, which were considerably lower than those of commercial banks. This policy was implemented through the nationalised Bank of Agriculture and Cooperatives (B.A.A.C.). As in the case of research and development, the initial thrust was given by the public sector before being taken over on a wider scale by the private sector.

The production and marketing chain was established with the supply to potential shrimp farmers of postlarvae, industrial feed, adequate equipment and processing facilities, which enabled them to start the intensification process, which resulted in the four fold increase of yield per hectare from 120 kg in 1977 to 500 kg in 1987. The extensive system only accounted for half the 6,000 shrimp production units in operation in 1987, still covering 29,700 hectares, but only representing 47% of the 2,400 tons produced. These ten years laid the foundation for the intensive system, but more particularly, served to disseminate the semi-intensive system already practiced by 30% of the shrimp culture farms.

The semi-intensive system is, by definition, heterogeneous, because it combines both the extensive and intensive systems depending on the farmer; the fry and the feed come from both the natural environment and are injected into the pond by the supplementary addition of postlarvae and industrial feed. This combined practice explains the very high variability of annual yield, depending on the degree of intensification of the artificial pond⁵ : from 0.5 to 3 tons per hectare during the two or three annual cycles of three to four months each, a supplementary addition of industrial feed, varying from one to seven, and especially, a daily water renewal rate of 5% to 20%.

During the period under consideration, the process of intensification was relatively limited by the fact that it concerned virtually only the newcomers, i.e. those who had reclaimed the mangrove stands, practicing the semi-intensive rather than the intensive system. Although there was less water pollution and soil degradation from coastal aquaculture than during the following period, the destruction of the mangrove continued relentlessly : of the 95,000 hectares destroyed between 1980 and 1986, more than 90%, according to Chantadisai and Apinan (1986), or 88,000 hectares, were destroyed for aquaculture. In fact, whereas for the entire period between 1975 and 1979, the annual rate of mangrove destruction was 5,300 hectares (i.e. 32% of the total destruction) during the next seven years, this rate more than doubled to reach 13,500 hectares. Finally, this period was different from the previous one for the following reasons : aquaculture was henceforth the main cause of mangrove destruction, which was to affect all the provinces in the country, following the gradual shifting of coastal aquaculture towards the east and the south. Although the most massive destruction was taking place in the Inner Gulf of Thailand area, with the disappearance of 35,000 hectares or 92% of its heritage, from 1980 to 1986, the entire coastline was affected :

⁵ These are usually earthen ponds, which are more regular in shape than in the extensive system, with an area of 1 to 6 hectares and a depth of 1.5 to 2 meters; most often, they are watered by pumps, sometimes complemented by a set of aerators. The densities are in the order of 2,000 to 5,000 shrimps per hectare.

13,000 hectares in the eastern part of the Gulf, 5,000 hectares in the central part, and 9,000 in the south and even along the Andaman coast. This destruction was moving even faster than aquaculture development : in 1987, the Inner Gulf only represented two thirds of the coastal shrimp farming area.

This massive destruction was permitted by the vagueness and contradictions in the legislation on mangrove forests, which potential users and some administrative authorities interpreted in their own favour. From 1978 to 1987, no less than six decrees were issued by the Council of Ministers, showing concern, but also indecision, and highlighting the successive governments' difficulties in drawing up a national policy. Thus a decree in June 1982 annulled part of another decree of August 1980, and one in July 1984 covered only the province of Phuket; again, a bill proposed in the Council of Ministers in May 1984 on mangrove zoning was not adopted until December 1987. Still, the will to conserve mangroves can be seen, and is demonstrated in the planting of 8,600 mangrove trees during the period in question : for example, the August 1980 decree banned the declassification of mangrove zones and denied administrative authorities the right to issue land deeds to potential users, and another decree in May 1984 proposed the creation of a research centre in collaboration with the National Research Council of Thailand (N.R.C.T.) and the D.O.F. More lobbying led to the 1987 decree which classified and regulated the status of the mangrove : now, even though all the ambiguities had not been ironed out, extensive and uncontrolled abuse was made more difficult. When technological control of the entire production and marketing chain is added to this new situation, it is easy to see that the way had now been paved for the intensification of the production system, which took concrete shape in the shrimp culture boom.

1.3 The shrimp culture boom : intensification and pollution

From 1987 to 1990, enormous intensification increased output sixfold in three years to attain 118,000 tons, whereas the number of production units only doubled from 6,000 to 15,000 and the cultured area in hectares was only one and a half times that of 1987. The fourfold increase in the average yield per hectare, i.e. almost two tons in 1990, illustrates this increase in productivity. This intensification was not evenly distributed : some was helped along by the semi-intensive shrimp farmers, whose yield per hectare rose from 400 to 600 kg, but most of the increase resulted from the adoption of the intensive system, where the one ton yield of 1987 was multiplied four times. The success of the intensive system is illustrated by its preponderant share in the number of production units, cultured acreage, and, of course, the production figures. The extensive system was still predominant in 1987, when it was practiced by 4,000 holdings, covering 30,000 hectares and producing 10,000 tons, but in 1990, there were only 3,300 operators on 21,000 hectares, producing no more than 7,000 tons. In the semi-intensive system, the number of operators and acreage doubled between 1987 and 1988, then underwent a stagnation and stabilised at 21,000 hectares in 1990 with 4,300 units producing 13,000 tons. It was the intensive system which grew most spectacularly, where the number of units increased sixfold in three years, giving 10,900 in 1990, and where the total acreage quadrupled to reach 24,000 hectares and a total production of 98,000 tons, or 14 times that of 1987 !

The intensive system in Thailand was based on the Taiwanese model, and is characterised by high densities, requiring inputs in the hatcheries or nurseries, and therefore, the addition of industrial feed, fertiliser and various chemicals to maintain an adequate level of water quality, veterinarian products to prevent disease and the use of aquaculture equipment to provide oxygen and renew the water daily (the rate of renewal varies between 10% and 30%). However, even more markedly than in the semi-intensive system, the intensive system covers a wide variety of different situations, depending on the level of investment or operating costs, and thus records a wide range of annual yields, which can be anything between three and thirty tons per hectare. Thus, within the same system, different practices have varying effects on the environment : this is because the level of pollution depends on the

degree of aquaculture intensity, unless preventive measures are taken. High densities per hectare require the addition of a proportionate amount of industrial feed, of veterinarian products to control pathogens or accelerate growth (antibiotics, anabolics), the addition of chemicals to control acidity (liming of calcium or magnesium based soil), or fertiliser (nitrate, phosphate or potassium based fertiliser). In particular, these different additions may lead not only to eutrophication, a cause of anoxia, and fish and crustacean mortality, but also to the assimilation at the bottom of ponds of hydrogen sulfate produced by the deoxygenation of organic matter e.g. from industrial feed, whether ingested or not, and which is released by the movement of the water as the ponds are emptied. And since one of the features of this form of aquaculture is the daily renewal of water, the pond has to be discharged into the immediate surroundings, and therefore pollution spreads through secretion. Thus, the spreading of polluted water not only has repercussions on other uses, such as the consumption of drinking water, and rice, fruit or vegetable cultivation, but also on coastal aquaculture itself : a boomerang effect, so to speak. In an area where intensification is badly controlled by the large number of shrimp farmers practicing excessive densities without a water treatment system, intensive culture pollutes the holding itself because of the necessary water renewal (other extra-aquaculture factors may also contribute). This pollution may, in turn, be the cause of epizootic diseases which the farmer will try to combat by administering anarchic or desperate medication, which, in turn, will give rise to the shrimps' resistance to antibiotics, ending up with significant mortalities. The outcome of this infernal cycle may well be the formation of a moon landscape of abandoned ponds.

While water pollution and soil degradation increased considerably, the rate of mangrove destruction was halved: by 1989, there were only 5,500 hectares left to regain the level of the second half of the seventies, despite the existence of a still large mangrove "reserve" in 1987, estimated at 20,500 hectares by the Forestry Department, almost 50% of which was on the shores of the Andaman Sea. The shift progressed further, and after exhausting the Inner Gulf's potential, new shrimp culture land was tapped mainly in the eastern part of the Gulf, (from Rayong to the Cambodian border), where, between 1987 and 1989, seven thousand hectares were cleared, as well as on the Andaman coast, where six thousand hectares were cut down. Thus, in 1990, the spatial distribution of coastal aquaculture had clearly changed compared with 1987 : henceforth, the Inner Gulf no longer harboured two thirds but less than half of the total aquaculture acreage, the remainder having been taken over by the southern coastline (35% from Prechuap Khiri Khan to Pattani), the eastern part (19%) and even the shores of the Andaman Sea (2%).

2. Management of the production and marketing chain versus the environmental challenge.

2.1. The players : the small operators and the big shrimp farming companies

Coastal aquaculture is mainly practiced by a myriad of small or medium-sized enterprises, be they hatcheries or nurseries, farms which do the rearing themselves or those that take care of collecting the finished product. Thus, in 1991, the big companies, or "giants" accounted for merely 10% of the total acreage under intensive shrimp culture and produced only 20% of the total number of market-sized shrimps, which did not give them a high position on the market. On the other hand, on other segments of the production and marketing chain, such as the manufacture of industrial feed, veterinarian products and handling, some companies played a major role to the point of finding themselves in the position of a feed oligopoly, for example.

Small and medium-sized shrimp farming companies developed in two waves - from the first half of the seventies to 1987, and after 1987. The first wave was dominated by farmers and fishermen who had switched to extensive aquaculture : this often partial reconversion, which was possible because they owned the title deeds, did not require any substantial investment. While continuing to produce a small yield for sale, extensive shrimp culture, and

sometimes, for the more enterprising ones, semi-intensive shrimp farming, allowed them to supplement their incomes significantly. The second wave was mainly brought about by entrepreneurs from the secondary and, sometimes, tertiary sectors, businessmen or civil servants, with more training and qualifications, but often with no inkling of agriculture or fisheries, or if they had, it was in a technically developed form of agriculture. The latter, who often had local contacts, which facilitated their obtaining a title deed or a land lease, had a much higher investment capacity; their interest in shrimp farming was stimulated by the hope of higher and quicker profits than in other sectors.

The best known big group in the production and marketing chain is the Thai conglomerate, Charoen Prokphand (C.P.) which became involved through its direct subsidiaries or through joint ventures. There were also the American groups, Aquastar and Unicord, or the joint ventures created by the Taiwanese group, President Feed, or by Mitsubishi. At the beginning of their involvement in the production and marketing chain, these groups selected their area of involvement according to their technological and managerial know-how in similar sectors, such as pig and poultry feed for Charoen Pokphand, and packaging and processing of fishery products for Unicord. Only Aquastar had an uncontested advantage in shrimp culture in the Philippines and Taiwan. Using their area of specialisation as a springboard, some of these groups tried to occupy the entire chain of production and marketing : the best known examples are those of C.P. and Aquastar. The latter invested equity worth Baht 450 million in five subsidiaries, each of which was specialised in a particular area : research and technical services, feed, handling, hiring and training of shrimp farmers, infrastructure and equipment. Thus, Charoen Pokphand invested in handling by creating Seafood Enterprise Mahachai Co. and C.P. Intertrade Co., and joined the Canadian group, Aqua Health Co., as a partner in producing vaccines.

2.2. Managing the production and marketing chain : a dynamic and multivarious strategy

The "giants" strategy to ensure a dominant position in this sector, and thus to install the dependency of small and medium scale enterprises, was multiform and dynamic.

When there is an oligopoly on one segment of the production and marketing chain, in feed production, for example, where nine companies share 80% of the market, price fixing enables them to amass substantial profits and to offer debtor shrimp farmers financial assistance in return for an exclusivity contract on feed supplies, and, sometimes, even on the sale of future crops. In 1990, these oligopoly arrangements required the intervention of the government departments concerned resulting up in a commitment on the part of the feed producers to respect a given price range.

Intervening on the production volume, particularly between 1987 and 1990, was the "giants" favourite method of intervention : while Unicord had paved the way in 1986 with the creation of an 80 hectare holding in Prechuap Khiri Khan province, in 1991, C.P. was the top producer, with a total acreage of 1,400 hectares. High yields and the advantages of economies of scale for all or part of the production and marketing chain put pressure on price levels in general, and thus on the profitability and productivity of small and medium-scale enterprises.

But growing difficulties in obtaining suitable land caused the large companies to change their method of intervention, by increasing their range and not just focusing on investment in production. The issuing of decrees on mangrove protection, the increase in the number of conflicts related to mangrove destruction, and lobbying by non-governmental organisations and the press complicated the acquiring of new land. As for purchasing already constructed ponds, there was a dual problem here : on the one hand, the high cost of land following intense land speculation, which none of the coastal provinces were spared, and on the otherhand, the tenuousness of some of the land deeds issued by the local authorities for reclaimed mangroves.

Henceforth, the "giants" preferred means of intervention was controlling the shrimp farmers, either by setting up a cooperative, which would conclude a contract with a company

controlled by the "giant", or by creating, at the initiative of one of the "giants", a company in which the shrimp farmers would be shareholders. The common feature in these methods of intervention was that the big companies' land involvement was reduced to a minimum, which, firstly, avoided them having heavy land investments, and, secondly, reduced their capital assets and increased their possibilities of divestiture. In both cases, the shrimp farmers were not only bound by explicit or implicit exclusivity contracts, but more particularly, were obliged to strictly obey production standards which included postlarvae densities and feed frequencies, water renewal and treatment, marketable sizes and rigorous harvesting and handling precepts. Thus, in 1990, through Bangkok Shrimp Culture Co., a joint venture with Mitsubishi, Charoen Phokphand set up a cooperative in Nakhorn Si Thammarat which leases 80 hectares for a ten-year period at Baht 120,000 per hectare, an investment which is twenty times cheaper for the company than purchasing the land. The members of the cooperative are obliged to follow a system of production, whose standards are imposed by Mitsubishi and C.P.; and the feed supplier is stipulated in the exclusivity contract with C.P.; finally, indirect control is exercised over the sale of the crop, since the identity of the purchaser is determined by the cooperative's extension center ... monitored by C.P. agents.

These new methods of intervention are considered to be the most appropriate, since, for example, the Bangkok Shrimp Culture Company does prospecting in the provinces of Surat Thani, Phang-Nga, Krabi, Trang and Songkhla to look for new acreage and volunteers who wish to be part of the scheme. Thus, despite major problems, the functioning of these new structures increases profits, while adapting to the growing constraints of the international market on quality and standardisation of the "finished product".

2.3. The environment : the last element of this strategy

Nevertheless, these structures are undergoing some operational changes, as could be seen in Ranot, in Nakhorn Si Thammarat province, in June 1991 : backed by their title deeds, and therefore difficult to evict, the shrimp farmers started questioning certain clauses of the contract binding them to Aquastar, and, in particular, sought higher densities for short term, random profits. In the conflict between the company and the small producers, the environmental protection banner was brandished by the "giant" to justify its aquaculture policy.

Comparatively lower densities and sufficient water renewal, declarations to ensure better managed production systems and to provide decanting and water treatment ponds, and a promise to use better quality veterinarian or cleaning products were the arguments put forward by the big companies to show that with the same acreage, those suspected of doing the most polluting are not really the culprits. These companies, after being accused during the initial stages of their aquaculture investment of pillaging the environment, paradoxically reversed the argument in a risky but notable way by claiming that for the same acreage, their intensive system was less harmful than the system practised by the small "uncontrolled" producers. Thus, the environmental conservation argument was recovered by the big companies and used to justify their extension of the production system : it became part of the big groups' strategy to acquire a hold over the shrimp culture production and marketing chain.

After the last environmental regulation which entered into force on 1st January 1992, and especially in view of future regulations, which will be more constraining, the big holdings are better prepared than the smaller ones. The latest regulation bans the release of water into drainage canals with a biological oxygen demand (B.O.D.) of more than 10 milligrams per liter; moreover, residual sludge may not be discharged into public areas, including rivers and canals. But the cost of water treatment, storage, or even sludge solidification is prohibitive for small undertakings, whereas it represents a marginal cost for the large companies, benefitting from economies of scale and having acquired the necessary technology. At the same time, large companies and smallholders will not be on an equal footing when they have

to obtain the mandatory authorisation from the competent authority (D.O.F.) before undertaking any aquacultural activity.

Conclusion.

At the outset, the vigilance of the "environmentalists", which, whether for ideological or more down to earth reasons (conflicts of interest), resulted in making mangrove deforestation more difficult, has been one of the causes of the intensification of the relative regression of the extensive system: it has become more and more difficult to acquire sufficient acreage. Subsequently, the emphasis put by the same militants on water pollution and soil degradation, resulting from the semi-intensive and intensive systems, explains the sudden interest of shrimp farmers in adopting less polluting technologies. Gradually, a set of regulations is being drafted to limit the negative effects of aquaculture speculation on the environment. But, in the Thai context, where there is a large number of small operators, if these regulations are applied, the very structure of production may be modified by penalising small holders and favouring the big companies, who will have less difficulty in complying. To avoid impoverishing the smallholders, the State should undertake some authoritarian action in the transfer of less polluting technology, by disseminating information and opening up credit lines with the same resounding success achieved during the shrimp culture boom. Even if it is more difficult for the smaller operators than it is for the large companies to introduce these techniques, there are other solutions such as mobile sludge hardening and solidification units, and cooperative action for waste water treatment.

This is what it will cost to safeguard an activity which directly employs about 80,000 people, especially since turning back from the intensive system is difficult to envisage. Thai shrimp farmers are now between a rock and a hard place : they need to maintain competitiveness on a very internationalised market, while conserving an already very damaged environment to avoid the very high social and eventually economic costs. On the one hand, the ever more constraining health and configuration standards of the "finished product" imposed by the purchasing countries (Japan, United States, Europe, Singapore) call for better managed production systems, which would include protection of the environment. On the other hand, the countries of the region, whether new to intensive shrimp culture (Vietnam, Burma,), or seeking to develop it through incentives (Indonesia, Malaysia), are subject to less pressure and are currently offering investors better conditions, until coastal aquaculture has inflicted as much damage in these countries as it has in Thailand. There is still plenty of suitable acreage left for shrimp culture to plunder!

Bibliography.

Thailand Development Research Institute : Thailand Natural Resources Profile. January 1987.

Manager : The trouble with prawns. July 1991.

F.A.O - N.A.C.A : Environmental assessment and management of aquaculture development TCP/RAS/2253. Summary report of the planning workshop. 15-18 september 1992. Bangkok.

Kapetsky J.M. : Mangroves, fisheries and aquaculture in Selected working papers submitted to the eleventh session of the Advisory Committee of Experts on Marine Resources Research. F.A.O. Rome. 21- 25 May 1985.

Kapetsky J.M. : Some potential environmental effects of coastal aquaculture with implications for site selection and aquaculture engineering. South China Seas Fisheries Development and Coordinating Programme.SCS/GEN/82/42/76-82.

Shang Y.C. : Aquaculture economics : basic concepts and methods of analysis. Westview Press. Boulder (Colorado). 152 pages.

Department of Fisheries : Statistics of shrimp culture 1992,1991,1990, 1989,1988,1987.

Charrupatt A and Klamkamsorn C : Using landsat imagery to investigate the change of forest land use. Department of Forestry. Bangkok. 21 pages. 1981.

Sanit Aksornkaeo : Mangroves. Ecology and management.Bangkok. 1989. 251 pages.

Klamkamsorn C : Report on the land use zonation in mangrove areas.Department of Forestry. Bangkok. 77 pages. 1987