



United Nations
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UNEP/WG.15/INF.3
15 January 1978
ENGLISH
Original FRENCH

Expert Consultation on Aquaculture Development
in the Mediterranean Region convened by the
Government of Greece in cooperation with
FAO/GFCM and UNEP

Athens, 14 - 18 March 1978

AQUACULTURE AND THE ENVIRONMENT IN
THE MEDITERRANEAN REGION

Note prepared by the Atelier Méditerranéen de Prospective (AMP)
and published in October 1976 as document UNEP/IG.5/INF.5



United Nations Environment Programme



Distribution:
RESTRICTED

UNEP/IG.5/INF.5
21 October 1976

ENGLISH
Original: FRENCH

Intergovernmental Meeting
of Mediterranean Coastal States
on the "Blue Plan", Split, Yugoslavia
31 January - 4 February 1977

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GE.76-10614

ANNEX III

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I. GENERAL DATA: TYPES, SCIENTIFIC AND TECHNICAL RESEARCH, ECONOMIC DEVELOPMENTS

A. Types of aquaculture: definitions

1. Aquaculture is a generic term covering a variety of activities. As far as the medium involved is concerned, this study deals with mariculture and "valliculture". As for the groups "bred", none is excluded a priori, although primary attention is given to fishculture in sea-water and in brackish water. The breeding of aquatic creatures, such as carp in China or, to a lesser extent, oysters and mussels in western countries, is a very ancient activity. But only the past ten years have seen a real awareness of the convergence of the problems and techniques peculiar to the aquatic environment; plans have been formulated, in particular in Japan, the United States, the United Kingdom and France and at the international level at the instigation of FAO, to co-ordinate scientific and technical efforts which had hitherto been dispersed.

2. At the present stage of development of fish culture in sea water or brackish water, it is essential to draw a distinction, which has important economic and social implications, between natural production aquaculture and controlled-process aquaculture. These two concepts to some extent correspond to those of extensive and semi-intensive aquaculture.

3. Extensive culture is carried out without fertilization or a food input; it simply makes use of a natural ecological balance for the benefit of man. Many sea fish and crustaceans "come to the coast" to spawn; the young, being attracted by a certain decrease in salinity, settle in coastal and lagoon zones. For a long time now, in many parts of the world, nurseries based on this habit have been established in growing ponds (in the Mediterranean region, this is done in particular in the Italian valli).

4. Semi-intensive culture is assisted either by means of manuring, to promote the plant growth favoured by the herbivorous species, or by direct feeding. Rudimentary but strict "fertilization" (periodic draining, plant balance), which is advantageous for herbivorous species such as the tilapia, would appear less suitable in the Mediterranean. "Supplementary feeding", on the other hand, gives high yields in the production of carnivorous species, but the difficulty lies in the need to supply protein-rich food (35-40 per cent of protein for bream and bass).

5. These two forms of breeding conform to the same environmental principle: the breeder is concerned to maintain a natural balance so that waste, excreta, surplus food and dead animals are totally mineralized, their biodegradation occurring through biological self-purification mechanisms.

6. On the other hand, the purpose of intensive culture, in which all food is supplied artificially, is simply to achieve maximum metabolic yield, without consideration for ecological balance, water circulation being relied on to remove waste products and to supply oxygen.

7. Whereas controlled-process aquaculture, in its intensive form, requires a high degree of scientific and technical expertise, particularly for ensuring a level of output, oxygenation and optimum temperature, and hence substantial investment, the extensive and semi-extensive forms of natural aquaculture offer more accessible development possibilities.

8. What then in practice, are the principal characteristics of current projects in Mediterranean basin countries and the trends in the scientific and technical research behind those projects?

1. Trends in scientific and technical research

i) Basic data

Because of the difficulties involved in research on the marine environment, much less is, in most cases, known about the general biology of the species which it is hoped to breed than about that of land species. Two essential problems must successively be solved:

- artificial breeding in a controlled environment, in other words, the development of techniques which provide sufficient numbers of captive young produced by captive parents;
- growth of the young to commercial size, irrespective of their origin.

0. The difficulties to be overcome are not the same; the two processes are affected differently by the various forms of pollution.

a) Artificial breeding

1. The purpose of artificial breeding is to control reproduction and the development of the larvae and young until they have attained growing-on size.

2. In order to take advantage of the extraordinary fertility of most marine species (an oyster, for example, releases between 1 and 3 million larvae), a solution must be found for the problem of keeping the parents under such conditions of captivity that they are capable of reproduction.

3. In addition, the most favourable conditions for embryonic development (incubation of the eggs) must be ascertained and created. By the time the eggs are hatched, the problems of feeding the larvae and subsequently the postlarvae must have been solved. During this period, the timing, nature and quantity of the diet varies. Thus the anaeid shrimp is at first vegetarian, subsequently becomes carnivorous, eating live prey, and finally becomes and remains necrophagous.

4. Initially, the usual practice is to recreate a live metabolic chain under artificial conditions; as knowledge increases, this chain may be replaced by food compounds which are easier to handle.

5. Although the sea water necessary for breeding must be of excellent quality, since densities are high, the quantities of water necessary are relatively small (expensive fish hatcheries jeopardize profitability).

b) Growth

6. This process requires more space and more water than reproduction; the fish or crustaceans must be allowed to breathe, waste products and excreta must be removed, and sufficient living space must be made available. Systematic prior treatment of the water is economically excluded at this stage, especially since the techniques used (enclosures, beds, floating cages and ponds) involve direct contact between the fish and the environment, and hence the pollution resulting from human activities (see below).

7. During these two stages, the risk of disease or contagion is particularly great since densities are high.

(ii) Present limits of research

18. In order to overcome these difficulties, scientific and technical research has, from the outset, been oriented in a number of very significant directions, at the initiative and instigation of FAO.

19. The availability of young (mollusc spats, crustacean postlarvae and fish fry) constitutes the starting-point for any fish-culture activity. The capture of young at sea and their direct delivery for growing-on is excessively unreliable, uneconomical (losses at time of capture and during transport) and above all incompatible with programmed fish-farming. Successful "egg-to-egg" breeding is therefore essential for economic farming: thus on the coasts of the Languedoc region the young bass and bream obtained by induced spawning attain by the month of May a size which will not be attained until August by the same species in the wild. A hatchery makes it possible to programme a commercial yield in one season, without wintering, which would be impossible with wild fry.

20. The considerable scientific and technical efforts being made at present are therefore concentrated on the development of artificial hatcheries. The hatcheries will have three purposes: to ensure the maturation of the brood stock, to obtain food suitable for young larvae, and to produce young.

21. In most cases, mature brood stock are simply caught wild and spawning is stimulated experimentally: spawning under laboratory conditions is still uncommon and egg-to-egg breeding remains a goal to be attained before genetic selection studies can be undertaken.

22. The feeding of larvae is a complex process: research is frequently carried out on the production of artificial feed, but accurate estimates of the cost of such feeds are rare. This is also the case with the actual production of young, a process which requires substantial human and material investments. Most hatcheries are therefore dependent on public financing, but although their contribution to the supply of young to breeders is already significant in the case of crustaceans and is likely to become equally significant in the case of fish, because of the very nature of the financing, cost problems are underestimated.

C. The economics - largely unknown

23. Unlike the preceding stage, growing-on is or should be primarily a matter for experts. More information is needed on:

- existing farms, their nature and their production, a general idea of which cannot be deduced from the information collected at present;
- potential sites, on which a very interesting but unfortunately uncompleted survey was carried out by FAO.

i) Existing farms

4. Since existing farms are undoubtedly very few in number, to compile an inventory of them would appear to be an easy task. However, this is not the case - a situation which is revealing in itself. Little would appear to be known about the various economic aspects, such as investments, costs and markets. There are no recent statistics concerning the number, type, production or financing of farms.

5. On the basis of what is known about the situation, however, it may be stated without great risk of error that farms operating without specific financial facilities granted by the public authorities are very rare outside the sphere of shellfish breeding.

ii) The FAO/GFCM survey

6. The survey conducted by FAO and the General Fisheries Council for the Mediterranean (GFCM) on usable sites in the Mediterranean basin yielded some very interesting information. ^{1/} It is worth noting that:

- very little use is at present being made of the considerable potential, although not all the countries replied and the survey did not cover the whole of the Mediterranean region; FAO estimates this potential at 640,000 hectares, of which only 29,000 hectares (less than 5 per cent) are at present developed;
- most of this potential area consists of lagoon sites;
- of the total area, approximately 300,000 hectares appear to have a good or very good potential yield;
- the average yields of farms vary widely (from 10 to 2,250 kg per hectare);
- other data collected related to salinity, temperature of surface water, average depth and the areas affected by domestic and industrial waste.

7. Regardless of the limitations of the survey and the obsolescent nature of the data, there is no doubt that there are still significant possibilities for large-scale aquaculture in many Mediterranean countries.

II. REMARKS ON THE DEVELOPMENT OF AQUACULTURE IN THE MEDITERRANEAN REGION; WEAK POINTS AND STRONG POINTS

A. The weak points

8. In a country like France, for example, the days of the pioneering enthusiasm of the "blue revolution" and of the conquest of the oceans are long past. But behind the apparent disenchantment, there is undoubtedly a more realistic appreciation of the numerous obstacles, both scientific and economic.

^{1/} The FAO/GFCM survey was planned and carried out between 1972 and 1974. Algeria, Cyprus, Egypt, Malta, Spain, Tunisia and Yugoslavia replied to the questions asked in the survey. Unfortunately, no official report on the survey has yet been published.

(i) The scientific obstacles

29. Although spectacular results are being achieved through research in such fields as induced spawning and feeding, fundamental difficulties are being encountered in research on the transition from "fishing-gathering" to breeding. The "breedable" species do not have the same resistance to significant environmental changes as domestic animals; this is a pathological problem and constitutes a serious obstacle. The space devoted to it in the quarterly FAO Aquaculture Bulletin is in this respect revealing. The second difficulty is the problem of genetic selection, which has hardly been tackled: we are still at the stage where very little is known about the genetic possibilities of developing special varieties.

(ii) The inadequacy of economic analysis

30. These uncertainties have a particularly serious effect on the possibilities of economic farming since the purely economic aspects are neglected or are approached far less methodically than the scientific problems. This is one of the areas in which possibilities of progress exist (see below). The potential for the immediate development of aquaculture should not therefore be exaggerated. Yet aquaculture exists, as many have found in Japan. However, the Japanese example in particular should be evaluated with discernment: 20 years elapsed between the time when the first shrimp were obtained from eggs laid in the laboratory by mature females caught at sea and the time when the first commercial farms began operating in 1962. But because of the importance of fish in the Japanese diet, the ingenuity of fishermen and the means devoted to fish-farming, aquaculture is a national issue in Japan. In no Mediterranean country would the present situation seem comparable with that in Japan. Aquaculture, a growing form of economic development and an essential means, in the foreseeable future, of meeting a proportion of over-all food requirements will not in the immediate future be a leading competitor for the use of marine and coastal areas. Although it may appear to be losing the race against pollution, it does have some strong features.

B. The strong points

Aquaculture has two strong points:

(i) The natural and scientific potential

31. The advantages of aquaculture for the Mediterranean coastal countries include the natural potential (lagoon sites, advantages of a tideless sea, the very intensive scientific and technical research effort of countries such as Spain, Italy and France, the start made by other countries such as Tunisia, the existence of demand and markets, and the value of Mediterranean products (6 per cent of the world catch, 10 per cent by value).

i) The diversity of the objectives and forms of aquaculture

2. The other strong point lies in the very diversity of the potential economic objectives of agriculture and the relationships of aquaculture, as an activity, with the occupation of marine and coastal areas and the environment.

a) The economic objectives may be of various kinds and may include:

- Integration within the modern forms of agricultural and food production and distribution, enabling programming and regularity of supplies, which cannot be said to characterize the fish trade at present;
- A consequential increase in export resources through sales of products having a high commercial value (e.g. shrimp and eels) which require rapid and modern transport;
- Regional development aimed at providing for fishing communities threatened by the new techniques and subject to numerous hazards the possibility of change: certain small-scale fishermen in the Languedoc region have quite easily made the change to fish-farming;
- A more capitalistic form of aquaculture giving rise to upstream activities (compound feeds) or downstream activities (refrigeration systems, distribution) may also have repercussions on development;
- A significant contribution to the food supplies of the inhabitants of the Mediterranean region. It should not, however, be forgotten that most shellfish and a substantial proportion of eels are already derived from aquaculture.

33. Practically speaking, two types of development possibilities exist for a few fish species (mullet, bream, bass):

- First, as a kind of "eco-development" based on the needs and initiatives of traditional fishing communities, use would be made of all kinds of extensive or semi-intensive farming possibilities;
- Second, financial and technical intervention of the industrial type would be necessary, with the objective of profitability and/or currency earnings.

34. Several countries would appear to be capable of simultaneous developments of this type, in which certain elements might be combined. As regards management and regional development, three possible types of action suggest themselves.

(b) The types of action: restocking, improvement and intensive production

- Restocking consists either in introducing into depleted environments species capable of reconstituting natural stocks, or in creating sanctuaries for the young and thereby increasing considerably the local fauna. The dumping of various objects, especially car bodies, in 10 metres of water off Palavas was found to cause considerable numbers of noble species, fish, crustaceans, and molluscs, to congregate where fishing was previously very poor. There have been two other beneficial effects: flat oyster spats have collected and coastal nurseries have been protected against abusive and devastating trawling.

- Improvement aquaculture consists in making use, by extensive methods, of regions characterized by high natural productivity, such as estuaries, lagoons and coastal shallows, whose spontaneous ecological balances give rise to lateral losses and the formation of biomasses, especially algae, which are unusable by man. It has become apparent that yields could, in coastal ponds, be about 8 to 10 times higher than those of sea fishing - hence the tendency to extend shellfish culture in Roussillon (France) and Corsica, and hence the very good results achieved with bass-culture in certain ponds.
- Intensive aquaculture is pursued to obtain marketable products from aquatic farms and in conditions favourable to the farmer. In these industrial-type activities, aimed at achieving optimum returns on capital invested, there is a trend towards products having a high commercial value, such as bass, bream and eels, and towards the miniaturization of installations, one of the main reasons being the increasing cost of land.

There are therefore various possibilities for action - a fact which undoubtedly constitutes one of the strong points of aquaculture.

III. RELATIONSHIPS WITH THE ENVIRONMENT

A. An economic development activity for which environmental protection is essential

35. Aquaculture is moving less rapidly into the economic stage than some had hoped. There is indeed a danger that it will remain a simple "hypothetical alternative" in the face of other, much stronger pressures which are at present being exerted on the coastline and the marine environment (tourism, exploitation of submarine resources). By its very nature, it is a development activity fully compatible with environmental protection: it avoids overexploitation of natural resources and cannot tolerate any form of pollution, whether chemical or bacterial. In this respect, the signs are numerous and alarming: in Spain a hatchery is being transferred from one site to another; in Italy, a fish-farm owner says that a sanitation improvement plan for the neighbouring town must be put into effect if the farm is to survive; in France, the shellfish in Thau lagoon are systematically cleaned. The situation is therefore clear: aquaculture is a form of economic development which can be carried out only if pollution is curtailed and if space is reserved for it sufficiently early.

36. A number of experiments now in progress, particularly in France (Martigues and Grau du Roi), go one step further: their purpose is to make use of thermal effluents or lagoonal effluents for the benefit of aquaculture, thus placing it in a very special position in relation to the problems of environmental protection and efforts to combat waste. The results, however, are not yet known. The forms of pollution caused by aquaculture in its intensive form would, in fact, appear to be completely controllable.

B. The need for more efficient measurement of the degradation of the potential due to pollution

37. At what precise point are these relationships between this nascent form of development and pollution of the marine environment? This could be determined only by continuing and bringing up to date the FAO inventory of sites and by obtaining detailed information concerning the intensity and nature of pollution and the detection of irreversible situations. It means resuming and supporting action already initiated.

IV. PROPOSALS FOR ACTION

38. From what has been said above it may be concluded that aquaculture is consistent with a global environmental policy in three respects:

- (i) From the standpoint of economy of natural resources, its contribution is obvious. Moreover, in one of its forms, it may even help to replenish such resources.
- (ii) From the standpoint of land development, it has the enormous advantage of not constituting an irreversible use: reserving sites for aquaculture may be a means of safeguarding the future by keeping open the possibility of a different use in the future. This is not the case with other activities, such as industry.
- (iii) Lastly, from the standpoint of the preservation of the natural environment, its incompatibility with any form of pollution marks it as an economic activity which will ensure that the fundamental balances of the natural environment are maintained.

39. Care should, however, be taken not to place too much reliance on aquaculture precisely at a time when it is competing for the occupation of coastal or marine areas with a number of activities which are more profitable in the short term and when its commercial development seems likely to be less rapid than expected. This has given rise to the idea of a programme of action for the promotion of aquaculture in the Mediterranean based on two principles and four types of action aimed at giving it fresh, pragmatic impetus.

40. Two principles for action

- (i) The first principle is that a very realistic assessment should be made of economic data on the current situation: yield and financing of farms, cost of anti-pollution measures, food inputs, etc.;
- (ii) The second is that transfers of technology should be promoted from the more advanced countries to their less advanced Mediterranean partners in order to develop active co-operation in the future.

41. Four types of action

(i) The first step would be to continue, bring up to date and supplement the inventory of suitable sites for aquaculture compiled by FAO/GFCM since 1972.

Special attention would be devoted to the need to list not only sites, but organizations (research institutions, development organizations and, in particular, farms) operating in the coastal countries, and to classify precisely the various types of farm. As regards sites, by re-examining the data obtained, which are incomplete since some countries have not replied, it would be possible accurately to evaluate the criteria used, to revise them if necessary and to measure changes related to the increase in pollution. Such action is an example of one type of contribution the "Blue Plan" could make to the activities already being undertaken within the United Nations system: by giving fresh impetus, with the explicit support of Governments, to a beneficial initiative which would be sustained by new resources (for example, a specialist made available to FAO/GFCM for the duration of the mission) it would trigger a whole chain of activities and a new process of co-operation.

(ii) Once more information had been obtained concerning the economic aspects of the current situation, it would be possible to launch a new training programme, aimed at "training trainers" to give instruction in their own countries in the techniques involved in the planning, organization, management and evaluation of projects. The promotion of well-planned and well-managed projects is undoubtedly essential during the current phase of the development of aquaculture. The definition of a training programme based in particular on the evaluation of a number of actual cases might thus be entrusted to the specialist referred to above.

(iii) Once this operation had been undertaken, the trainees might assist in the organization of three pilot-projects in three developing countries, with the support of a maximum number of partner countries and competent international organizations.

As has already been noted (section II, B above), one of the strong points of aquaculture is that it lends itself to very different types of planning, financial structure and economic implications.

Action in each of the following three fields would be particularly useful:

- Restocking: in recalling the example of the creation of submerged reefs off Palavas, we would point out that such an operation should be regarded as a sort of "public service" in the communal interest;
- Development, which would make use of the considerable lagoon potential of the Mediterranean, as well as the expertise of the local inhabitants (eco-development);
- Intensive exploitation, which, through the scientific and technical expertise which it requires, might demonstrate that the developed countries should engage in unrestricted co-operation involving the intensive transfer of technology.
- Once these projects were under way, their results would be monitored continuously under the "Blue Plan".

iv) Accompanying this process, the supply of equipment and expertise would be intensified, in order to give the developing countries of the Mediterranean basin genuine possibilities of obtaining scientific information about pollution and its effects on fishery resources and about aquaculture problems, in the light of the actual projects under preparation.

A joint UNEP/FAO/GFCM programme mobilizing all the Mediterranean institutions concerned might provide the necessary framework. If adopted, this programme, pragmatic but ambitious and comprising both research and action, would be a practical illustration of what the "Blue Plan" enterprise means.