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INTERACTIONS BETWEEN AQUACULTURE AND CAPTURE FISHERIES: A METHODOLOGICAL PERSPECTIVE

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INTERACTIONS BETWEEN AQUACULTURE AND CAPTURE FISHERIES: A METHODOLOGICAL PERSPECTIVE

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PREPARATION OF THIS DOCUMENT

This document is the final version of the report of the AdriaMed Expert Consultation "Interactions between Aquaculture and Capture Fisheries" organized by the FAO AdriaMed Regional Project (*Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea*) in Rome, Italy, from 5 to 7 November 2003.

The outcomes of the Consultation were presented at the fourth session of the Committee on Aquaculture (CAQ) held in Alessandria, Egypt, in June 2004. CAQ highlighted that a similar approach should be considered in other areas of the Mediterranean taking into account the impact on biodiversity, restocking, space competition, marketing and the role of local fishing communities. CAQ further agreed that priority should be given to these issues and that the experience should be extended with due consideration to the peculiarity of the two sub-sectors at national and regional levels. Moreover the outcomes of the Consultation were presented at the seventh session of the Scientific Advisory Committee (SAC), held in Rome, Italy, in October 2004.

An abridged version of this document will be also published as an AdriaMed Technical Document.

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ABSTRACT

The FAO AdriaMed Expert Consultation on the Interactions between Aquaculture and Capture Fisheries was held in Rome (Italy), from 5 to 7 November 2003. The principal objective of the Expert Consultation was to explore the main issues dealing with interactions between aquaculture and capture fisheries by using the existing knowledge available at the Adriatic basin level. This initiative would represent a contribution at subregional level towards the establishment and implementation of the principles of the FAO Code of Conduct for Responsible Fisheries (CCRF) concerning aquaculture activities. A preliminary matrix for the identification of indicators emerged and was drafted from comments made by the experts from the Adriatic present at the meeting. This matrix represents a first step towards the definition of a set of indicators, in order to monitor the relationship between aquaculture and capture fisheries in the Adriatic region following the criteria for sustainability. Moreover the Expert Consultation adopted a series of recommendations that could be directed to the Adriatic countries in which it is underlined that positive and negative interactions between aquaculture and capture fisheries must be considered in the context of integrated Coastal Zone Management (CZM) from which they could benefit correct assessment and better interactions between these two sub-sectors, national programmes and international cooperation for research activities dealing with the interactions between aquaculture and capture fisheries both in marine and freshwater environments. Reports on the situation of the aquaculture sector for each participating country (Albania, Croatia, Italy, Montenegro and Slovenia) were discussed and these are included in the document. They include general information (history, tradition, evolution); the characteristics of the sector (historical statistics, species reared, methodologies and technologies applied, production data and seed availability); national policy (national plans, legislative framework, environmental impact assessment, economical feasibility) and production market (general economic indicators, export/import; national policy concerning quality control and labelling policy). Interactions with the national capture fisheries are also detailed. Thematic lectures with specific reference to the Adriatic Sea regarding the market of fish products, their quality and certification systems in both cultured and captured products were illustrated and discussed. Three case studies on the interactions between aquaculture and capture fisheries were also presented on blue fin tuna, eel and shellfish culture.

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FAO-AdriaMed
Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea
GCP/RER/010/ITA

Report of the AdriaMed Expert Consultation "Interactions between Aquaculture and Capture Fisheries" [1]
Rome (Italy) 5-7 November 2003

Introduction and background information

The FAO AdriaMed Expert Consultation on the Interactions between Capture Fisheries and Aquaculture was held in Rome (Italy) from 5 to 7 November 2003 and hosted by the Italian Ministry of Agriculture and Forestry Policies (MiPAF), Directorate General for Fisheries and Aquaculture. The Consultation was attended by experts from the AdriaMed participating countries (Albania, Croatia, Italy, Serbia Montenegro and Slovenia), by the President of the Scientific Advisory Commission (SAC) of the General Fisheries Commission for the Mediterranean (GFCM) and by the staff of the FAO Regional Project and by the staff of the Inland Water Resources and Aquaculture Service (FIRI) of FAO (Annex A).

The Italian Director-General for Fisheries and Aquaculture (MiPAF), Mr Attilio Tripodi kindly welcomed the participants and underlined how the Italian Government gives particular relevance to the FAO multilateral initiatives, which are also considered a means for dialogue with the Mediterranean countries, as in the case of AdriaMed and MedSudMed Projects. Furthermore the fact that Italian Government intends to give support to a new FAO Regional Project in the Eastern Mediterranean underlines the belief that greater cooperation at all levels, even in fisheries, can assist in the resolution of regional issues. An addressing message was sent to the participants from the State Undersecretary (MiPAF) for agricultural policies with responsibility for fisheries, On. Paolo Scarpa Bonazza Buora (Annex B).

The rationale for this Consultation goes back to the first Coordination Committee Meeting of the Project[2] in the year 2000 in which the representatives from the AdriaMed Countries recognised the important issue of responsible aquaculture and suggested the organization of an expert consultation on the interactions between aquaculture and capture fisheries (Annex B). The representatives underlined the aspect that aquaculture could determine market and environment effects on fisheries activities and particularly on the prime species market. This initiative could represent a contribution at sub-regional level to the implementation of the principles of the FAO Code of Conduct for Responsible Fisheries (CCRF) concerning responsible aquaculture activities. During the third GFCM Committee on Aquaculture (CAQ) the interactions between aquaculture and capture fisheries were confirmed as priority issues. Furthermore during the Twenty-eighth Session of the GFCM held in Morocco (October

[1] The outcome of the AdriaMed Expert Consultation on Interaction between capture fisheries and aquaculture including the author's contribution indicated in this report, will be published as *GFCM Studies and Reviews* and *AdriaMed Technical Documents series*.
[2] AdriaMed. 2000. Report of the First Meeting of the AdriaMed Coordination Committee. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea. GCP/RER/010/ITA/TD-01: 64 pp.

2003), the Consultation was also recalled and was included in the programme of activities in support of the SAC and the CAQ.
The aims of the Consultation were to achieve a comprehensive description and analysis of the aquaculture sector in the countries which border the Adriatic Sea[3], and acquire the tools to improve the knowledge on the relationships between aquaculture and capture fisheries and in the area[4] (Annex D).

The principal objective of the Consultation was to explore the main issues dealing with the interactions between aquaculture and capture fisheries using the existing knowledge at Adriatic basin level. The national contributions provided background information on the aquaculture sector in the Adriatic countries.
The summary of the contents, results and recommendations of the Consultation are given hereunder.

General issues relative to the interaction between aquaculture and capture fisheries

The general principles and the methodological framework of the Consultation were based on the factor that both aquaculture and capture fisheries have the objective of producing aquatic products for human consumption. The separation between the two sectors has been reinforced in a scientific context and the discussion concerning the interactions between aquaculture and capture fisheries has only recently begun. The FAO CCRF defines the global framework in which aquaculture and capture fisheries are to be considered as parts of the same system. The importance of having correct assessment of such interactions represents one of the crucial issues for the implementation of the Code especially in areas where the use of the coastal zone increase rapidly and conflicts may arise from many resource user (not only fishers and fishfarmers) all competing for space and resources. The presence of a specific article in the Code which deals with aquaculture is of particular significance and marks an important step forward in the systemic treatment of fisheries. Aquaculture is clearly placed in the fisheries system and if responsibly developed, could contribute to trace the pathways towards responsible fisheries. The Consultation provided specific recommendations within a systemic

[3] During the Expert Consultation a general preparatory documents presented the state of fisheries and aquaculture in the Adriatic sea: these include the Aquaculture Country Profile of the Adriatic countries (Croatia, Slovenia, Albania, Montenegro and Italy) and the presentation of the Adriatic capture fisheries profiles at sub regional level. In these background documents the more relevant topics on the relationships between capture fisheries and aquaculture were also considered.
[4] Discussion was held on four thematic areas considered relevant for the expert consultation. A first discussion theme concerned general issues relative to the interaction between capture fisheries and aquaculture; a further two themes dealt with interactions between capture fisheries and aquaculture in the market and concerning product quality; the fourth theme concerned a case study: tuna farming. The Consultation suggested that local targets for conservation and management should be established, with particular reference to the species or group of species, for which the interaction between capture fisheries and aquaculture is strong (blue fin tuna*;* Northern bluefin tuna, *Thunnus thynnus* L., fishing and farming in the Adriatic Sea, I. Katavic, V. Ticina, paper presented to the Consultation; European eel and shell fish). With respect to eels, the Consultation made reference to the existing Action Plan "Development of a Community Action Plan for the management of European Eel" COM(2003) 573 final). The contributions on eels (Interactions between capture fisheries and aquaculture: the case of the eel, *Anguilla anguilla*. E. Ciccotti, paper contribution*)* and the shellfish (Interactions between capture fisheries and aquaculture: the case of shellfish, G. Prioli, paper contribution) were submitted to the Project as technical papers after the Consultation.

approach in which the different dimensions of fisheries (governance, ecological, economic and social) are taken into consideration[5].

Short overviews of the status of aquaculture and capture fisheries in the Adriatic Sea

Adriatic marine capture fisheries have developed since historical time. Due to the semi-enclosed nature of the Adriatic Sea basin, one of the principle features of Adriatic fisheries is that of taking place in one of the largest and best-defined area of occurrence of shared stocks in the Mediterranean. The shared character of Adriatic fishery resources makes it necessary to take in full consideration the indications provided by the CCRF with respect to the issue of shared stocks which emphasizes the cooperation among states as essential and unavoidable requirement to pursue responsible exploitation of such resources. A review of the recent history of some traits of Adriatic fisheries provides an insight on their complexity where several different factors, which may interact simultaneously, can play an important role. Performance dynamics of some fisheries besides being based on resources availability are also strongly driven by market demand and prices. Such multifaceted fishery systems should ideally be addressed and managed through multidisciplinary analysis[6].

The description of the aquaculture sector for each Adriatic country (Albania, Croatia, Italy, Montenegro and Slovenia)[7] provide general information on its history, tradition, and evolution and describe the main characteristics of the sector (historical statistics, species reared, methodologies and technologies applied, production data and seed availability); the national policy (national plans, legislative framework, environmental impact assessment, economical feasibility), and the production market (macro economic indicators, export/import; national policy concerning quality control and labelling policy).

Aquaculture in the Adriatic is characterised by a high differentiation in both cultured species and applied technologies, determined by various historical, environmental and socio-economic conditions, and by the different morphology of the eastern and western coasts. The diversity of aquaculture activities and their development emerge from the national reports (local fishing communities, environmental impact on fishing grounds, market competition). However, in some cases aquaculture and capture fisheries are already highly interconnected and this is also reflected in some countries at local (local plans and Coastal Zone Management) and national level (National Commission on Fisheries, Strategy and Development Plans).

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[5] Interactions between capture fisheries and aquaculture. S. Cataudella, F. Massa, D. Crosetti (paper presented to the Consultation)

[6] Adriatic Sea Fisheries: outline of some main facts. P. Mannini, F. Massa, N. Milone (paper presented to the Consultation).

[7] Short overview of the status of aquaculture in the Adriatic countries: Albania, by A. Flloko; Croatia, by V. Franicevic; Italy by G. Marino, E. Ingle, S. Cataudella; Montenegro by V. Macic; Slovenia by M. Kadoic (papers presented to the Consultation).

Overview of the interactions between aquaculture and capture fisheries

Market and quality were considered as key arguments within the relationships between aquaculture and capture fisheries in the Adriatic area.

The market of fish products with specific reference to the Adriatic Sea stressed the influence of different distribution channels for farmed products and by-catches and their link to the trend of the market price, as well as the cost of imported products. The importance of the demand for cultured species is also determined by the pattern of added value in terms of labelling, brand certification, traceability and other information that qualifies the product[8].

Fish quality and certification systems are continuously important in both capture and cultured products. A closer interaction between aquaculture and capture fisheries is relevant as the product reaches the same market place. Wild and cultured fish products can be considered substantially equivalent to meet the human nutritional requirements. As far as quality is concerned (commercial size, organoleptic and chemical nutritional attributes) differences exist for the same fish species due to the seasonal reproductive phase and to the quality of the aquatic environment. Quality changes from farm/boat to table, and new techniques for improvement and quality certification are required for both captured and fish-farmed products[9].

One market strategy for the fisheries sector is to increase the quality and certification of the product. On the question of quality and market, especially of tuna, seabass and seabream, the improvement of the quality of the product generally represents additional costs (up to 20-30%) for farmers. The consumer in some cases is willing to pay a little more for a product where quality is guaranteed, but this is not always so in some parts of the Adriatic area where the minimal consumer spending power constitutes a limiting factor. Labelling of fish products represents an important tool to guarantee food safety and quality to the consumer. However, the danger of too many labels can generate misrepresentation and/or confusion to consumers. A specific strategy is required to guarantee a correct labelling system for the area, as it is important that fishery products do not lose credibility and therefore their value. National or indeed sub-regional coordination is a useful step to be competitive on the market. In spite of the recognised importance of eco-labelling, in areas where quality certification strategies are less well developed, producers can fear that an excess of internationally fixed standard could create a barrier to the development of their activity. Certification must not become a limiting factor.

The case study on blue fin tuna farming provided a good example of different interactions between aquaculture and capture fisheries, and how the two sectors could be synergic or not.

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8 Market interactions between fishery and aquaculture in Italy, M. Cozzolino (paper presented to the Consultation).

9 Quality and certification of fishery products from both capture and farming in the same market place, B.M. Poli (paper presented to the Consultation).

Blue fin tuna farming in the Adriatic area and in particular in Croatia[10] is a typical example of relationships with capture fisheries, as it involves issues common to both aquaculture (i.e., cage technology) and capture fisheries (i.e., gear technology and stock assessment). The principal fishing grounds for Croatian blue fin tuna purse-seiners are offshore waters of the central part of the Adriatic Sea. After capture, tuna are transferred into a floating towing cage. The use of space in the sea for cage allocation and also the use of small pelagic fish as feed are elements of interaction with capture fisheries.

Tuna farming shows positive interactions with capture fisheries (fleet reconversion, restocking, market, etc.), but can also have a negative impact on tourism, navigation during the transport of live fish and conflicts with longline fishing. However, tuna farming does not only aim at producing biomass but at improving the quality of the final product for the target market, which is for the most part Japanese. Currently market demand changes according to the season and quality. If farmers manage to maintain a constant high level the market will react accordingly, thus increasing product value and improving benefit.

A further relationship between aquaculture and capture fisheries is the use of small pelagic species, especially sardine, as fish feed in tuna farming. This is an important area for the future development of interactions, which could require further study.

Identification of a set of indicators

A comprehensive framework of aquaculture and capture fisheries in the Adriatic countries was defined as a result of the presentations on specific themes provided by the regional experts and the discussion that followed the Consultation’s methodological approach.

In the Adriatic Sea the interactions between aquaculture and capture fisheries is determined through a series of inputs according to the nature of the decisions made by aquaculture or fisheries activities. At different levels these interactions could determine a positive or negative impact for each different fisheries dimension: governance, ecological, economic and social. The importance of the correct assessment of such interactions and the establishment of local and regional targets for conservation and management, represent the basic steps towards the sustainable development of the two sectors in the Adriatic area. The use of an appropriate set of indicators could help in monitoring the different levels of these interactions and support the decision-makers in the process of identifying or implementing a specific action at local and national level[11].

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[10] Northern bluefin tuna, *Thunnus thynnus* L., fishing and farming in the Adriatic Sea, I. Katavic, V. Ticina (paper presented to the Consultation).

[11] On the basis of the information available, a preliminary commented inventory of the main (or potential) relationships between aquaculture and capture fisheries were presented and discussed, including: local fishing communities (i.e. competition for coastal area use), the impact of aquaculture on local aquatic resources (i.e. genetic pollution, exotic species introduction, pathology spreads), market competition, product quality, mechanisms to control and prevent competition, existing agreements.

In order to monitor the relationships between aquaculture and capture fisheries in the Adriatic Region, a table (Table 1) was prepared by the experts present at the meeting, as a first step towards the definition of a set of indicators[12].

In the table, for each Dimension (governance, ecological, economic and social) a number of issues were identified (Table 1, Column 1). These issues represent a series of conditions for which some interactions between aquaculture and capture fisheries exist or might be produced.

The necessary criteria to identify reliable indicators (Table 1, Column 2) associated with the Dimensions are indicated.

A series of specific technical recommendations (Action Tools) are identified. These tools in many cases represent an instrument that aims to develop local, national or regional strategies or a monitoring system which might be considered by the participating countries.

The Consultation considered the Table proposed as methodological contribution to the identification of the list of reliable indicators to be monitored, but also represents a basic element to addresses research and monitoring programmes towards the study of relationships between aquaculture and capture fisheries. The structural approach and the content of the Table proposed was not considered exhaustive but it was intended to provide a useful checklist for further explanation and development[13].

The use of these indicators allow support to be given to the decision-makers in management strategy and in assessing progress towards sustainable development of the sector.

Recommendations of the Consultation

The AdriaMed Expert Consultation on the Interactions between Aquaculture and Capture Fisheries concluded that positive and negative relationships must be considered in the context of integrated CZM. Aquaculture and capture fisheries could benefit from the appropriate assessment of the interactions between these two sub-sectors.

The Consultation adopted a series of recommendations addressed to the Adriatic countries, which could be summarized as follows:

- The establishment of national programmes and international cooperation for research activities dealing with the interaction between aquaculture and capture fisheries would be useful in both marine and freshwater environments

- The implementation and the monitoring of the principles of the CCRF in many cases needs appropriate assessment on the interactions between aquaculture and capture fisheries, leading to benefits to both sub-sectors (increased product value, optimal use of discards and

[12] The indicators selected followed a methodological approach consistent with the FAO Technical Guidelines for Responsible Fisheries No.8 “Indicators for Sustainable Development of Marine Capture Fisheries”, for which the same terminology was also partially adopted.

[13] In order to provide additional and useful information for the finalization of the Table of indicators, experts from the Adriatic countries sent additional information. In particular information on the state of the existence of specific Action Tools (i.e National Programme, Fisheries Regulations, CZM plans) were provided to the AdriaMed Project for further development of the Table.

by-products from capture fisheries, safeguarding of income for small scale fishermen through reconversion policies from capture to farming).

- The possibility of developing pilot projects at sub-regional level (Adriatic Sea) based on the enhancement of interactions between aquaculture and capture fisheries should be considered.

- Fishermen and farmers should consider the competitive opportunities that the positive interactions between aquaculture and capture fisheries can offer (total quality certification systems applied to specific local conditions, identification of new services such as tourism).

- In the coastal zone management planning approaches to allocate resources (space, grants, loans) to aquaculture and capture fisheries especially, in the case in which the relationships between capture fisheries and aquaculture contribute to the sustainable use of environmental resources, must be followed.

- Specific cases of interactions between aquaculture and capture fisheries, such as tuna farming, wild fry collection and coastal lagoons management, require a sound knowledge base and a decision making process based on the participation of the different stakeholders to be correctly considered.

The results of the Expert Consultation, including the Table with the indicators and the recommendations, were considered by the experts a useful support for the Adriatic countries in promoting guidance, which may be used in the development of national fisheries strategic policy and to advance relevant issues at sub regional level.

Table 1

Interactions between capture fisheries / aquaculture	Criteria to identify reliable indicators	Action tools
I. Dimension: Governance		
I. a Legislation and Policy		
Integrated development policy of the fisheries sector Competition in allocation of public financial resources to aquaculture and capture fisheries Planning in integrated coastal zone management	Number of positive and negative interactions between capture fisheries and aquaculture Consideration of aquaculture as a specific identity within fisheries Numbers of specific legislations, plans and rules in which both aquaculture and capture fisheries are considered	Developing plans at sub-regional / national / local for the integrated development of capture fisheries and aquaculture Consideration of aquaculture as a specific identity within fisheries Improvement of positive interactions between capture fisheries and aquaculture at local level by applying local regulations Promotion of sub-regional fisheries management for shared transboundary resources (including freshwater) Consideration of both capture fisheries and aquaculture in development of integrated coastal zone management Development of concern on interactions between capture fisheries and aquaculture in the framework of sustainable fisheries Development of appropriate legislation for food safety Development of regulations for organic waste management and rules for disposal Improvement of fisheries statistics data collection in order to be comparable at sub-regional level
II. Dimension: Ecological		
II. a Introduction of non native species / strains		
Spread from natural spawning Competition for space Impact on biodiversity Disease spreads (cf "Disease outbreaks" below) Loss of genetic diversity Introduction of allochtonous species associated with bivalves # Natural spread of cultured species from rearing sites	State of biological community (Biotic Indices) Genetic introgression or species displacement in natural populations Occurrence of new pathologies	Development of regulations for non native species/strains introduction and culture Establishment of periodical control of culture facilities in order to prevent escapees Selection of native broodstocks for the production of eggs and juveniles for grow-out (genetic profile of broodstocks - census of broodstock) Increased control on adult and seed market (origin, transport pathways) Promotion of risk assessment on genetically modified organisms Introduction of quarantine for non-native seed

Table 1

Interactions between capture fisheries / aquaculture	Criteria to identify reliable indicators	Action tools
II.b Restocking of natural water bodies		
Genetic impact on natural stocks Restocking programmes with wild or wild-like seed Restocking programmes with hatchery seed Disease spreads (cf "Disease outbreaks" below)	Number of specialised hatcheries devoted to restocking programmes (native broodstocks and wild-like seed) Occurrence of new pathologies	Promotion of risk assessment and monitoring of restocking programmes Creation of data base for cultured stocks origin and genetic diversity Assessment of genetic diversity of cultured stocks Development of restocking programmes throughout: - seed certification for restocking programmes - seed production from native broodstock for restocking Development of local hatcheries devoted to restocking programmes (native broodstocks and wild-like seed) Development of a sea ranching programme * Selection of native broodstocks for the production of eggs and juveniles for restocking: (genetic profile of broodstocks ; census of broodstocks)
II.c Use of natural resources for aquaculture production		
Use of wild seed/juvenile/sub-adult and adult collection for farming	Number of farms in a specific area Number of cultured species of native wild origin	Definition of quotas and licences for wild seed/juvenile/sub-adult and adult collection Development of research on artificial propagation techniques for "new" aquaculture species
Fleet reconversion towards support activities to aquaculture *	Number of boats involved in aquaculture activities	Improvement of fishery socio-economic survey
Exploitation of feed fish stocks *	Stock assessments based on methods for abundance estimations * Spawning stock biomass, recruitment index, exploitation rate of feed fish stocks *	Monitoring and management of fisheries for feed fish * Monitoring feed fish quality *
Reduction of available seed for stock enhancement due to the increasing fishing effort on glass eels for aquaculture §	Stock biomass estimation	Monitoring of fishing pressure on glass eels§, Monitoring to ensure recruitment/settlement targets at local scale (promotion to guarantee quotas for stocking)§

Table 1

Interactions between capture fisheries / aquaculture	Criteria to identify reliable indicators	Action tools
II.d Organic and inorganic waste		
Eutrophication Fish gathering around cages Spread of technical material wastes (nets, ropes, etc..) # Accumulation of pseudo-faeces # Shell accumulation #	State of biological community (Biotic Indices)	Development of environmental impact assessment and monitoring system Improvement of site selection strategy Promotion of research for high quality feed Improvement of research and monitoring of waste management Development of monitoring of Fish Aggregating Devices (FADs) effect
Fishing activities around and nearest shell fish and fish culture facilities and cages	State of fisheries activities near rearing sites	Monitoring of fishing activities
II.e Disease outbreaks		
Disease spreads from shellfish culture facilities in the wild Disease spreads from cage-culture and waste waters from land-based fish farms to the environment and fishery resources	Number of disease outbreaks in wild organisms Occurrence of new pathologies in the wild	Increase control on seed market (origin, transport pathways) Food safety enhancement Introduction of quarantine for non- native seed
II. f Use of dangerous chemicals, therapeutants and hormones		
Environmental pollution Contamination at benthic level and throughout the water column	Presence of pollutants in the water column, at benthic level, and throughout the food web	Wide application of vaccines to reduce use of therapeutants Improvement of animal welfare measures (lower densities, high quality feed, etc)
II.g Coastal lagoon management		
Preservation of wet lands Conservation of nursery areas Lagoon biodiversity conservation Conservation of traditional management practices as potential instrument for fisheries resources conservation §	Number of hectares managed for aquaculture State of biological community (Biotic Indices)	Guarantee the management of coastal lagoons (public interventions where the private sector is not present) Guarantee escape quotas § Guarantee the application of traditional models of "enhanced fisheries", based on the rational use of fisheries resources

Table 1

Interactions between capture fisheries / aquaculture	Criteria to identify reliable indicators	Action tools
III. Dimension: Economic		
III.a Market		
Same market for capture fisheries and aquaculture products Exploitation of feed fish stocks (i.e small pelagic fisheries resources) New markets opportunities for tuna capture fisheries caused by tuna farming#	Presence of specific rules for labelling at public and private level Prices of captured/cultured products Presence of intersector marketing strategies Market shared quotas of the same species for capture fisheries and aquaculture	Development of specific legislation to inform the consumer on the traceability of fish products Development of intersector marketing strategies Development of information campaigns on aquaculture products Development of training of fisheries operators on the quality of fishery products Improvement of fisheries statistical data and market prices
III.b Quality		
Same final users for capture fisheries and aquaculture products	Availability of quality systems that specify the product origin, the production process, and food safety	Definition of culture standards Development of “farm/vessel to table” certification Development of ecolabelling Development of quality certification labels for cultured products (origin; production process; food safety; ecolabelling) Promotion of training for fisheries operators on food safety Development of information campaigns on fishery products with particular reference to food safety
Different attitude from consumers towards capture fisheries or aquaculture products	Quantities sold of the different capture fisheries/aquaculture products	
IV. Dimension: Social		
VI.a Employment/income opportunity		
Integration between capture fisheries and aquaculture New employment opportunities (i.e tuna farming *	Number of fishers involved in capture fisheries and aquaculture	Development of opportunities of reconversion / income integration of fishers to aquaculture activities
VI. b Use of coastal areas		
Water surfaces dedicated to aquaculture activities not available for small scale fisheries	Number of hectares dedicated to aquaculture and to fisheries, in the coastal zone	Development of integrated coastal zone management plan

Fisheries products: aquatic products from capture fisheries and aquaculture living aquatic resources
#: shellfish, *: tuna, §: eels

A short overview of the status of aquaculture in Albania

Aleksander Flloko*

1. General background

Albania is a small country in Europe which covers an area of 28 748 m² and is situated in the Western part of the Balkan Peninsula, between 39° 38’ and 42° 39’ of north latitude and 19° 16’ to 21° 40’ longitude It is bordered by Greece on the South and Southeast, by Macedonia on the East and by Kosovo and Montenegro on the North, and on the West there are the Adriatic and Ionian Seas. Albania’s boundary is 1 094 km long with a coastline of about 470 km. Its national waters and fishing areas are confined to territorial waters of 12 mi in width. The continental shelf lies entirely within the 15 mi Exclusive Economic Zone. The shelf is wider in the North (Adriatic Sea), up to 25 mi across, and narrower in the South (Ionian Sea), from 2 to 3 mi in width. In the international channel the sea depth exceeds 1 000 m for more than 25 mi. The sea bottom varies from north to south. In the north, the shelf is larger and the slope less steep to the 200 m isobath making trawling easier, while in the south, where the water depth rapidly reaches 200 m, it is uneven and covered with rocks.

Being compressed by the sea on the West and mountains on the East, Albania resides between two climatic areas: the Mediterranean and Continental zones of Central Europe. Consequently, its climatic conditions vary greatly according to the location: coastal plains, and hilly and mountainous zones.

Albania has a population of 3.4 million inhabitants and has one of the highest population growth rates in Europe. The Republic of Albania is divided into 12 prefectures, 36 districts, 312 communes and 65 municipalities.

Table 1. General data.

1. Total land	28 748 km^2
2. Coastline (length)	470 km
3. Lagoon area	100 km^2
4. Natural lakes and reservoirs	500 km^2
5. GVP (2001)	US$ 10 550 000
6.Value of fish imports (2001)	€ 5 355 408.333
7. Value of fish exports (2001)	€ 8 917 993.896

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2. Characteristics of the sector

2.1. Historical data

In Albania, because of economical reasons, aquaculture activities dealing mainly with the rearing of water species (fish, molluscs, crustaceans, etc.) has recently changed becoming an important business. The development of modern aquaculture rearing techniques during the last three decades has created a new vision. Therefore, its main concern is the growth of aquaculture production, in particular that of freshwater species (carp and trout); marine species (seabass and seabream); bivalves (mussels) and crustaceans (Japanese shrimp).

Experience in semi-intensive and intensive aquaculture in Albania commenced in the early 1960s. During that period the first carp hatcheries were constructed and later the Koran hatchery in Pogradec was built. These hatcheries were used for restocking carp fingerlings in natural and artificial lakes and reservoirs, while in the Koran hatchery fingerlings were stocked in Ohrid Lake. For the first time in 1960, new fingerling species such as silver, bighead and grass carp were imported from China. In 1972 a group of qualified Chinese specialists in grass and plankton fish feed, arrived in Albania. The first reproduction of grass and plankton fish feed (silver, bighead and grass carp) was carried out in 1972 in the Laknas hatchery near Tirana. From 1972 to 1973 Albanian specialists become acquainted with up-to-date technology. This experience gained served not only for the extension of the activity throughout the country, but also for the reproduction of other fish species.

In 1978, rainbow trout was imported from Italy for the first time. In the early 1980s a 7 ha trout hatchery was constructed in Saranda. This hatchery reached an average production of over 200 tonnes and 1 million fingerlings per annum. During the same period in the Port of Shengjini, successful experiments were achieved in the artificial reproduction of seabass, which later extended into an industrial range. Many more hatcheries (over 25) were built then mainly in Central Albania and in the lower coastal zone for fish species of the carp family for a total surface area of 800 ha (Kavaja 200 ha, Durresi 200 ha, Vlora 150 ha, Shkodra 100 ha, etc.). In the 1980s about 80 mussel farms were constructed in the Butrinti Lagoon (Saranda). These farms gave an average annual production of 2 000 tonnes, and its peak was reached in 1989 with 5 000 tonnes. With the ban on the export of live molluscs, this activity decreased continuously until it ceased completely. After the nineties the State hatcheries were privatized and today only a part of these are still operational. By the end of 2002 and during 2003 important investments were carried out for the construction of a modern hatchery for Koran in Ohrid Lake. These investments were realized through the contribution of the Albanian Pilot Fishery Development Project, financed by the World Bank. Before the mid-1990s to the present day, trout hatcheries have been constructed and extended in many areas of Albania (Saranda, Tepelena, Pogradec and Dibra, etc.).

The first intensive aquaculture of marine species started in the mid-1990s in the Kavaja hatchery, for the growing out of shrimps. The Italian-Albanian joint venture KAP Kavaja had operated for a decade changing the Kavaja hatchery from a freshwater species hatchery to one for marine species. This was done through important investments for the acquisition of the most up-to-date technology in this field. Recently, along the Ionian coast from Vlora Bay to the South border with Greece, the first farms for the cultivation of marine species in floating cages were constructed. The results obtained during the early years are very promising and have raised the interest of other Albanian businessmen in the extension of this activity in other coastal areas.

Commercial freshwater aquaculture of warmwater species (originally based on common carp, to which Chinese carp at the beginning of the seventies were introduced) represents the major aquaculture production in the country. Coldwater salmonids, mainly *Oncorhynchus mykiss* and *Salmo letnica* are another important group of species. Due to the economical and political transition period, the production decreased sharply but in the last two years has showed a positive upward trend. The culture of bivalves (especially *Mytilus gallo-provincialis)* began more recently and the average production was about 2 000 t/year with a maximum of about 5 000 tonnes in the year 1990. Shrimp culture is still a new activity, and there is only one farm in Albania. As regards to marine aquaculture there are seabream and seabass fish farms using about 10 small floating cages in Saranda and the Vlora Region. As there are many possibilities for the development of marine aquaculture in Albania, and judging by the country's water resources, climate, biologic potentials and socio-political factors it could become an important sector for its economy.

2.2 Aquaculture systems

2.2.1 Extensive aquaculture production systems

Natural lakes and coastal lagoons can be considered as extensive aquaculture production systems. All the major natural lakes of Albania are international. They border with Montenegro (Shkodra Lake), Macedonia (Ohrid Lake) and Macedonia and Greece (Prespa Lake).

Shkodra Lake is situated on the Northwest part of Albania and is fed by the Moraca River (97 km) of Montenegro and tributary to the Adriatic Sea through the Buna River. At a total area of 391 km^2 38 percent of the lake (147.9 km^2) lies in Albania, and 62 percent in Montenegro. Shkodra Lake is the largest of the balkan lakes and its water surface varies from 360 km^2 in summer to 690 km^2 in winter/spring. At an area of 372 km^2 it has a mean depth of 4.4 m. Fishing is considered a traditional activity in Shkodra Lake. There are 37 species which belong to 15 families and the most important are cyprinids with about 90 percent of the fish biomass. The most valuable fish food of the lake are common carp (*Cyprinus carpio*), bleak (*Alburnus albidus*), crucian carp (*Carassius carassius*) and ‘scrap’ fish such as *Rutilus rutilus.* Migratory fish from the Adriatic Sea through the Buna River include eel *(Anguilla anguilla*), grey mullets (Mugilidae), shad (*Alosa fallax*), seabass (*Dicentrarchus labrax*), some specimen of sturgeons such as (*Acipenser sturio*) and (*Acipenser naccari*). At the end of the 1980s fish catch production in Shkodra Lake varied from 650 to 815 t/year, today its no more than 300 t/year.

Ohrid Lake is situated on the Eastern part of Albania at an altitude of 695 m. Its total area consists of 348.8 km^2, one-third or 118.9 km^2 lies in Albania and the rest belongs to Macedonia. Being the deepest of the balkan lakes, it has a maximum and mean depth of 286 and 145 m respectively, it is also the largest biological reserve in Europe. There are 17 species of fish (10 of which are endemic), and the commercial catch is composed of koran (*Salmo letnica*), belushka (*Salmothymus ohridanus*), bleak (*Alburnus alburnus*), and common carp (*Cyprinus carpio*), etc. The fish catch varies from 90 to 150 t/year. From 1965 to 1966, artificial reproduction was carried out for *Salmo letnica***,** and millions of fry and fingerlings are stocked every year.

Prespa Lake, at an altitude of 853 m (above sea level), flows into Ohrid Lake by an underground stream and is shared by Albania, FYROM (Former Yugoslavian Republic of Macedonia) and Greece. This oligo eutrophic lake has a total area of 274 km^2, of which 49.4 km^2 (18 percent) lies in Albania. It has an average and maximum depth of 20 and 54.2 m respectively. The fish catch is mainly of cyprinids, moreover bleak (*Alburnus albidus*) and common carp, and the average production varies from 300 to 500 t/year.

There are eight rivers in Albania but fishery activities are practised only in the Buna and Vjosa Rivers. The species caught in the Buna River are the same as those of other lakes, while in the Vjosa River an annual production of about 10 t is based mostly on *Chondrostoma nasus.*

Due to lack of funds, during the economical and political transition, only the restocking of natural lakes was undertaken using limited public funds, while single or groups of organized fishermen stocked the reservoirs. The natural lakes are restocked annually with millions of fry and fingerlings and the Albanian Government has taken into consideration the time it takes to (conserve) preserve the genetic diversity. Therefore, breeders taken from each lake produce common carp fingerlings which are stocked every year in the Shkodra, Ohrid, and Prespa Lakes. For the past four decades, to protect the endemic species, annual stocking of millions of fry and small quantities of fingerlings of koran *(Salmo letnica)*, an old species were introduced in the Ohrid Lake. Also in the same lake, until 1980, there were good conditions from the hydrological point of view for natural reproduction of *Chondrostoma nasus ohridanus*. However, since then, with the changes of the stream hydrological system the conditions necessary for the natural reproduction of this species no longer exist.

Fishing activities in the above-mentioned ecosystem were exercised by the State fishery enterprises. The fishermen, organized in teams, were paid on the basis of quantity and fish species catch with a fixed price per kilogram which was decided beforehand by the State. It was the State fishery enterprises who provided the different nets, mechanical spare parts, small boats, and fuel for the commercialisation of the products. During the last decade a sharp decrease has characterized the fisheries sector in Albania. In this exercise many people carry out fishing activities without a licence. This is a serious social problem that needs to be considered carefully. Estimates show that there are 4 000 employees in this sector for whom fishing is the only source of income. Fishing in inland waters, especially lakes, without having a licence makes this activity rather complex. This difficult situation is related to the socio-economic conditions of the population around the lakes, who consider fishing as the sole opportunity to earn a living. The Shkodra and Ohrid Lakes give the most problems. The Directorate of Fisheries has taken action to improve the situation by adopting the law not only as an authority, but also by obtaining assistance from the local Government in the hope of minimizing this serious problem.

Extensive aquaculture inside coastal lagoons has been traditionally developed in Albania. The total surface area of the lagoons is about 10 000 ha and is divided as follows: Velipoja 180 ha, Merxhan 300 ha, Ceka 800 ha, Patoku 300 ha, Karavasta 3 900 ha, Narta 2 800 ha, Orikum 120 ha, and Butrinti 1 600 ha. With the exception of the Butrinti Lagoon, which is situated along the Ionian Sea, the others are on the Adriatic Sea with depths from 0.3 to 1.5 m, salinities of 15-40‰, oxygen 2.8-8 mg/l, and temperatures ranging from 5-32 °C. The past average yields have varied from 40-80 kg/ha. The main species found in the lagoons are mullets, *Mugil cephalus, Liza* spp., *Chelon labrosus;* seabass, *Dicentrarchus labrax;* eel *Anguilla anguilla*; seabream, *Sparus aurata* and sand smelt, *Atherina hepsetus*. The lagoons have similar geomorphologic characteristics with soft bottom sediments over compact clay and organic material. Butrinti Lagoon has a different geomorphologic and hydrological characteristic: with a depth of up to 25 m, salinity from 18 to 30‰ and a temperature range of 10 to 27 °C.

Coastal lagoons are very sensitive ecosystems; the main problem faced by the lagoons is their communication with the sea, deterioration of the fresh water quality as well as old fish-weirs with a low selection capacity. Fishing in the lagoons has been stabilized and is performed by certain groups of fishermen. Harvesting yields range between 50 and 150 kg/ha and consist mainly in quality fish like seabass, wrasse, eel, and mullet, etc. The Butrinti Lagoon is important for the cultivation of mussels. In the past, 75 units for mussel cultivation were established in this lagoon with a production that reached 5 000 tonnes by the end of the 1980s. This production was mainly for export to community markets but a small amount was kept for domestic markets and processing industries.

A difficult situation created in the Albanian fishery in the coastal lagoons caused by illegal fishing (related to the socio-economic situation of the surrounding areas) is in the process of being stabilized. In this direction, parallel with the fishing inspectorate work, other government structure support is also closely collaborating with the district Government. The situation on the biggest part of the lagoons has now improved. The lagoons are in different States, and depend on the stability of their respective hydraulic equilibrium for the dynamics of fresh and sea water. These environments, once productively organized according to the plans of the former regime, will be reorganized. In the framework of the PHARE Programme an intervention by the Albanian Coastal Lagoons Board (Ministry Agriculture and Food MAF, 2002) has been calculated, consisting of some engineering work in the Karavasta and Lezha Lagoons.

The legal aspects regarding the concessions of the areas, the use of 'lavoriero' (fish-weir) and the duties of the agents must be defined by clear regulations. At the moment the lagoons are managed in situations that vary from one to another while awaiting the provisions that will regulate relations with the State. For the most important lagoons, the current situation is outlined as follows:

Karavasta Lagoon is the largest of the Albanian lagoons and covers an area of 3 800 ha. It is situated in the central part of the country and was recently included in the Ramsar convention due to its particular qualities from the naturalistic point of view. At the moment 80 fishermen work in this lagoon and it is one of the few basins that may still be considered as ‘managed’ in the organizational difficulties that the whole country is experiencing. There are three canals that connect the lagoon with the sea and all have "lavoriero" (fish-weir) managed by fishermen. However, these structures are of an old-fashioned type and should be renewed not only to improve fish capture but also for the inflow and outflow of the water in the communication canals with the sea. This lagoon produced from 1986 to 1990 an average of 242 t/year of various species of which one third was made up of eels, 12.2 tonnes of seabass and 12.5 tonnes of seabream, therefore, from a production point of view it is considered particularly valuable. Later from 1996 to 1998 production had fallen sharply (130-150 t/year) due to the irregular dredging of the three communication canals with the sea.

Narta Lagoon. Forty local fishermen work in this managed lagoon of approximately 2 800 ha. They are organized in teams, and one of them is operating in the ‘lavoriero’ while the others are in the lagoon. The average production from 1986 to 1990 was about 200 t/year but from 1996 to 1998 it decreased from 50 to 70 t/year (MAF, 2000). Until two years ago the lagoon was more or less totally non-productive, as there was no communication with the sea and the salinity exceeded 70‰ during the summer period also one third of the lagoon had dried. Starting in 1998, both public and private funds were used for dredging the only communication canal between the lagoon and the sea. The approving of the new amendments in the law on “Aquaculture and Fisheries" business management of the basin must be completely re-established.

Butrinti Lagoon is the only Albanian lagoon on the Ionian coast and covers an area of about 1 600 ha. It communicates with the sea through a large navigable canal and it has a "lavoriero". The whole area is of incomparable natural beauty to which should be added the important archaeological ruins of the Hellenistic influence on Ancient times. The lagoon has controlled inflows of fresh water. It is one of the deepest salty lakes in the Mediterranean with an average and maximum depth of 10 and 25 m respectively. There are 20 licensed fishermen with a fish production which now varies from 50 to 70 t/year.

2.2.2 Integrated aquaculture production systems

The presence of the mountain barriers before the rivers break through them into gorges en route to the lowlands, as well as the impervious bedrock for dam sites, provide good conditions for reservoirs in Albania's upland basins. There are hydroelectric power stations and the total surface of the artificial lakes is about 7 000 ha. The most important fish species in these lakes are cyprinids like bleak (*Alburnus albidus*), and Chinese carps. In only one of them, Fierza Lake (5 000 ha) shared with the former Yugoslavia, two other species: pike perch *Stizostedion lucioperca* and perch *Perca fluviatilis* had been introduced since 1980. The pike perch has found very good conditions for both natural reproduction and feeding. The fish catch (mostly bleak) has reduced from 200 to 50 t/year (mostly pike perch) but the commercial value of fish is higher.

There are about 6 000 small reservoirs covering a total surface area of 2 700 ha. In many of these extensive aquaculture is practised and the fish production of the Chinese carp family (especially silver and bighead carp) varies from 500 to 800 t/year. Currently, the estimated production is about 200 t/year. Until 1990 the Government owned all the fish farming centres, with a total surface of 215 ha, carrying out the restocking of the reservoirs, and natural and artificial lakes. The most important species stocked are Chinese carps (*Hyphophtalmichthys molitrix, Aristichthys nobilis, Ctenopharyngodon idella, Megalobrama amblycephala*), common carp (*Cyprinus carpio*) and "koran" *Salmo letnica*. Wild caught fingerlings of grey mullets (*Mugil cephalus* and *Liza ramada*) are used to restock some reservoirs in the Southern part of Albania.

2.2.3 Intensive and semi-intensive aquaculture systems

Table 2. Main species and production systems currently in practice.

Common name	**Species**	**Production facilities**	**Market focus (export /domestic)**
Trout	*Onchorhyncus mykiss*	Raceways, tanks	Domestic
Seabass	*Dicentrarchus labrax*	Cages	Domestic
Seabream	*Sparus aurata*	Cages	Domestic
Common carp	*Cyprinus carpio*	Ponds	Domestic
Silver carp	*Hypophthalmichtys molitrix*	Ponds	Domestic
Bighead carp	*Arystichthys nobilis*	Ponds	Domestic
Grass carp	*Ctenopharyngodon idella*	Ponds	Domestic
Shrimp	*Penaeus japonicus*	Ponds	Domestic/export
Mussel	*Mytilus galloprovincialis*	Trays	Domestic/export
Koran	*Salmo letnica*	Tanks	Domestic

Carp farming, which is based on the rearing of Chinese and common carp, is traditionally developed in Albania and it is the most widespread aquaculture practice. Perhaps Albania was the first Eastern European country to introduce Chinese carp, first in 1959 and later in 1969. In 1972 artificial reproduction and mass production of fingerlings was performed**.** Since then and until 1990 new fish farming centres were constructed all over the country, covering a total surface area of about 800 h. More than 32 million fingerlings of approximately 8 to 10 g were produced for restocking purposes. A part of these fingerlings were used as stocking material in the fattening ponds of the semi-intensive fish farms. About 200 ha were used (as fattening ponds) with an average yield of 2 to 2.5 t/ha and a maximum of 5 t/ha.

Trout farming. Before 1997 there was only one trout farm (*Oncorhynchus mykiss*) in Albania (MAF, 1999), which covered an area of 4.2 ha of raceways near Saranda, with an annual production of about 250 tonnes. The fingerlings for this farm were produced locally in another fish farm of one hectar and the pellets were imported from France and Italy. There was an excellent abundance of freshwater but the trout farm suffered from a poor feed conversion rate, low international market prices and of the high cost of imported feed.
In 2003 there were about 20 trout farms (generally private family activities) in Saranda, Tepelena, Pogradec Diber and other regions, but unfortunately today trout farming is non-existant.

Shrimp farming. The farming of marine species is still at the pilot stage of development. There is only one extensive shrimp culture farm at Kavaja with a total surface area of 215 ha. It was built 30 years ago and the main production until 1992 were the fingerlings and finfish of Chinese carps. In 1994 a joint-venture the Kavaja Aquaculture Production (KAP) was founded with Italian partners. They undertook the reconstruction of the farm and are currently working on a surface area of 120 ha for extensive shrimp culture of *Peneaus japonicus*. Recently, they have ensured that half of the farm will continue with shrimp culture and the other half will begin stocking species like seabass and seabream. There have been attempts by fish farm owners in Narta (200 ha) to also found a joint-venture with Italian partners. Being near to the sea this fish farm has shown some advantages for foreign investors.

Bivalves farming. Since the beginning of the 1960s bivalve culture has been developed in the Butrinti Lagoon. Fixed structures for the production of mussels (*Mytilus galloprovincialis*) are used. Due to very good environmental conditions, about 80 fixed concrete units had been constructed during the late 1970s. Since then the annual production of mussels has increased, reaching a maximum of 5 000 t/year in the late 1980s. During the past years mussel production practically ceased, both for internal organizational reasons, but mainly because of the ban on exports imposed in October 1994 by the EC for sanitary reasons, moreover for all living products of the fishery sector. Some attempts have been made by private groups to put into operation approximately half of the fixed structures, mainly for the local markets in the hope that, in the near future this will open up the exportation to the EC countries.

Marine fish farming in floating cages is in its third year of production in Albania. During the past years about ten private entrepreneurs obtained a licence to start marine finfish farming in floating cages (seabream - *S. aurata* and seabass - *D. labrax*) in a 16 units (for a total of about 8 000m^2 of sea water, MAF, 2002) and the first production in 2001 was of approximately 20 tonnes. Good positions for this aim along the littoral zone of the Ionian Sea have been identified and there are no constraints with the other users. The lack of funds seems to be for the moment the most important constraint to overcome in close collaboration with foreign investors and other international donors.

Table 3. Aquaculture production systems.

Groups and environnent	Species combination		Intensity of production			Production facilities	Ecosystem
	Mono-culture	Poly-culture	E	S-I	I		
Fish Freshwater culture of common carp	x	x	x	x		earthen ponds	Fish farm, reservoir, lake
Freshwater culture of Chinese carp		x	x	x		earthen ponds	Fish farm, reservoir, lake
Freshwater culture of trout	x				x	cement ponds	Fish farm
Freshwater fingerling production of common carp and Chinese carp	x	x			x	earthen ponds	Fish farm
Freshwater culture of Koran *Salmo letnica*					x	raceways, tanks	Fish farm
Marine water culture of seabass and seabream	x				x	cages	Nearshore waters
Crustaceans Marine water culture of shrimp *Penaeus japonicus*	x		x	x		earthen ponds	coastal area
Molluscs Mussel culture in brackishwater	x		x			trays	coastal lagoon

3. National policy

In Albania a specific aquaculture policy document does not exist and aquaculture is included in the Fishery Sector Development Strategy, part of the Green Strategy, approved by the Government in 1998. In the absence of a specific policy, aquaculture development is mainly based on development plans elaborated by the authorities in charge of administering the fishery sector (Directorate of Fisheries, Ministry of Agriculture and Food). Under the Albanian Law No.7809, 05/04/1995 on “Fisheries and Aquaculture" it is also foreseen the establishment of a Consultative Committee. It is a consultative body to the minister in the aquaculture and fisheries sector, composed mainly by representatives of producers and experts.

In Albania the administration of the aquaculture and fishery sector is centralized and Article 9 of the Albanian law on “Fisheries and Aquaculture” (Laws No. 7908/1995 and No. 8870/2002) states that the Aquaculture and Fisheries Development Plan is a specific object of the State budget. The Ministry of Agriculture and Food develops the policy for fisheries and aquaculture. At the same time this Ministry administers agriculture, animal husbandry, veterinary services, forestry and fisheries.

The undertaking of aquaculture activities is permitted by a relevant licence issued by the Ministry of Agriculture and Food. The licence is issued subject to projects not causing harm to the environment and to their support in the development of the Albanian economy. The Board for issuing aquaculture licences is constituted by representatives of the Committee on Environmental Protection and other ministries concerned.

Planning in the field of aquaculture is carried out on the basis of an integrated management of economical and environmental interests with other sectors concerned being the subject for procedures for evaluating environmental effects. The right to use private land for undertaking aquaculture activities is given through special procedures, in conformity with the legislation in force. The right to use State controlled lands for undertaking aquaculture activities is permitted by the same licence, taking into consideration recommendations and the consent of local competent authorities for the proposed area. The right to use the waters of the Republic of Albania for undertaking aquaculture is determined through the same aquaculture licence. State controlled land for aquaculture purposes is classified as agricultural land according to the legislation in force. Based on the Law No. 8318, foreign investors lease the land for 99 years. In Albania there is no separate law for aquaculture, but it is included in Law No. 7908 on “Aquaculture and Fisheries". This law is the same for both the central and local Government, and it is clear that aquaculture has no advantages or privileges. In a few words, aquaculture is not seen as an agriculture activity. Based on the Law Nos. 7638 and 7764 the attitude to foreign investment in any field of the economy, aquaculture included, has no limit and could arrive at 100 percent of the original share capital.

There is no specific legislation which regulates the environmental impact on aquaculture. The international conventions are applied to introduce the non-indigenous species and based on the Laws No. 7908 on "Fisheries and Aquaculture " and No. 7674 on "Inspection and Veterinary Service" both Directorates in the Ministry of Agriculture and Food issue a specific authorization.

Until a few years ago there were government agreements between Albania and the former Yugoslavia, but due to the specific situation and the war these agreements do not exist today. On the other hand there are some technical agreements between Albania and the former Macedonia regarding Ohrid Lake. Both countries have continued to restock the lake with the advanced fry and fingerlings. As regards Shkodra Lake the collaboration has been scarce, but due to the new situation in the Republic of Montenegro it is hoped that in the near future collaboration will take place, and a similar collaboration/agreement will be made with Greece for the Prespa Lake.

The Albanian law on “Aquaculture and Fisheries” was prepared and formulated during 1994 in close collaboration with FAO’s technical assistance. This law was approved on 5 April 1995. All the principles of the Code of conduct for responsible fisheries are included in this law, but the actual putting into practice of this law is not so easy, moreover for social reasons and lack of funds. Albania does not have a specific legislation for aquaculture products.

The marketing of fisheries products is regulated by the Law No. 7674 dated 23 February 1993 on the “Veterinary Service and Inspectorate”, the Law No. 7941 dated 31 May 1995, Regulation No. 2 dated 20 July 1999 on the “Sanitary Veterinary Rules that Regulate Production and Marketing of Bivalve Molluscs”, Regulation No.3 dated 26 July 1999 on the “Conditions of Marketing of Livestock and Aquaculture Products”, as well as the EU regulations and directives that have been accepted through the decision of the Council of Ministers No. 646 dated 20 November 1995 on the “Veterinary Conditions of Marine Products”.

Trying to overcome the restrictions compelled by the EC in connection with the hygiene and sanitary problems, new regulations and directives are now being prepared.

In Albania incentives are provided to aquaculture producers. Credit does not exist and there are no incentives for the price of water and use of land for aquaculture activities. Taking into consideration the problems that aquaculture producers are faced with, the reduction of import tax from 20 percent to 0 percent is very little. Penalties are included in the Albanian law on “Aquaculture and Fisheries" and based on this law, a Fishery Inspectorate has been established with 12 inspectors within the country for both marine and inland water fisheries. However, in practice this Inspectorate does not function as well as it should. It seems to be the social problem such as the high level of unemployment that influences this fact.

In defining the role of aquaculture in Integrated Coastal Area Management (ICAM) there is a need to point out that this industry is relatively new and that its development has coincided with a large increase in environmental awareness. Unlike other industries located in the coastal zone, aquaculture relies heavily on natural aquatic resources, and requires a very high environmental quality. Aquaculture in most cases represents a new activity, and as such has to establish rights of access to coastal areas and resources in the context of the existing Albanian legislative system which acts to protect the established activities. On the whole, legislation and regulations in Albania are inadequate and non-specific to aquaculture and may not be particularly beneficial for integration of aquaculture and other activities in the coastal zone management plans. Since aquaculture uses both terrestrial and aquatic environments, it has experienced much duplication, confusion and uncertainty. This has resulted in conflicts with other coastal users and managers as, for example, problems with tourism. Each of these users has different requirements and aspirations. Of most relevance to integrating aquaculture into ICAM is the interaction between scientists, ICAM policy planners, economists, general public and neighboring coastal communities. Each group requires information in a very explicit format. The lack of effective transfer of information between these groups is considered a major obstacle in the integration of aquaculture into ICAM policies and resource allocation strategies. The role of aquaculture in ICAM is to develop the industry with a full appreciation of environment/production interdependencies and allow it to become an integral part of the overall ecosystem. ICAM will take advantage of a full integration of aquaculture if techniques, planning and management are harmonized with the natural ecosystem and are compatible with other coastal users so that any negative impact is minimized.

In the framework of lagoon management, Albanian administration is based on the principles of the Code of Conduct for Responsible Fisheries (CCRF), published by FAO in 1995 and approved by consensus. The CCRF, which was unanimously adopted on 31 October 1995 by the FAO Conference, provides the necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. Income could increase for producers through the application of labels. This use could be also considered as an important institutional result. In fact, an increasing sustainability of the fishery activities, including aquaculture, could be expected, while more security for consumers will be assured. Apart from the direct application to aquaculture and capture fisheries the adoption of the principles of the CCRF could also facilitate the integration of these activities within the coastal zone planning if the sustainable use of natural resources were to be considered an important issue. Every year grants are received from the State budget to manage the coastal lagoons mouth.

4. Production and market

Fish production according to water categories has changed during the past few years. The following table provides information on the production from inland waters (lakes, dams, rivers, reservoirs) and coastal lagoons (including mussel production from the Butrinti Lagoon) during the period from 1990 to 2001.

Table 4. Production according water categories (in tonnes)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Coastal Lagoons	816.5	221	123	116	34	116.4	79	80	225.6	240	174	240
Inland Waters	2 322.4	1627	107.9	373	93	257.3	50.2	60	370.5	627	1 198	1 558
Butrinti lagoon (mussels)	444.2	662	300	445	300	300	200	104.4	0	200	200	150
Total	**3 583.1**	**2 510**	**530.9**	**934**	**427**	**673.7**	**329.2**	**244.4**	**596.1**	**1 067**	**1 572**	**1 948**

At the beginning of the 1990s, Albania inherited about 35 aquaculture farms and hatcheries. These farms and hatcheries were oriented towards the production of carp fingerlings and fish for general consumption, and one of the farms was used to cultivate trout in Saranda. After privatisation and the economic transition, some of these farms and hatcheries ceased to operate. However, during recent years investments have been undertaken to set up new farms with more suitable species for the market and new approaches for aquaculture farming including sea farms with cage culture.

With the inception of the privatisation process all the fish farm centres and hatcheries both for carp and trout cultivation became privatised, but only a few are still in operation. To date only eight hatcheries with a total surface area of about 40 ha and a annual production of about 3 million fingerlings are in operation. This sharp decline in the fingerling production occured due to the political and economical transition period (absence of legal framework and financial support, land ownership problem, water price liberalization, etc.). This lack in fingerling production was influenced by the poor stocking rate of the reservoirs, natural and artificial lakes, and, therefore, in the fish catch. There are four public property aquaculture farms under the Fisheries Research Institute, which are involved in the inland waters restocking programme.

Agricultural reservoirs have a broad distribution all over the country and can serve as an important source of income. In the context of the policies designed by the Ministry of Agriculture and Food and its Directorate of Fisheries to reduce poverty, a specific programme on their reactivation for fishing was begun. As a second step, a collaboration programme was established with the local government under which these reservoirs are located. Following specific policies further steps will be oriented towards increasing the degree of organization to support the production of fingerlings. The following table provides information on the licensed companies that deal with fishing in the agricultural reservoirs. This sector has a lot of development opportunities. Once the agricultural reservoirs start restocking, hatcheries will begin operating again, as the need for fingerlings will increase considerably.

In order to protect fishery reserves of inland waters as well as reduce poverty, a special restocking programme for natural and artificial lakes is being implemented. Every year, the Fisheries Research Institute receives funds for the production and purchase of fingerlings in order to restock the Ohrid, Prespa, Fierza and Uleza Lakes. The institute has five hatcheries for the production of fingerlings: Tapize (Tirana), Lin, Tushemisht and Zagorçan (Pogradec) and Zvezde. The hatcheries in Zagorçan and Zvezde produce carp fingerlings in order to restock Prespa and Ohrid Lakes. Meanwhile, hatcheries in Lin and Tushemisht produce Koran fingerlings (*Salmo letnika*). In all of these hatcheries, local parents from respective lakes are used in order to ensure preservation of biodiversity. For the Koran (*Salmo letnika*), spawn is collected from the species harvested from the lake. Spawns are then kept in incubators until they reach the correct weight for repopulation. The hatchery in Tapize is used to keep genetically improved fish of the carp family such as the common carp, *Ctenopharyngodon idella* and *Hypopothalmichthys* spp. A certain quantity of fingerlings is purchased from private fishermen in order to restock the large artificial lakes of Fierza and Uleza.

The following table (Table 5) provides information on the production of fingerlings by the Fisheries Research Institute and the amounts purchased from private hatcheries and their distribution.

Table 5. Quantity of larvae and fingerlings produced by the FRI (in thousands).

YEAR	CARPS		KORAN		TOTAL
	Fingerlings Average weight 4 g	**Fingerlings** Average weight 8 g	**Larvae**	**Fingerlings** Average weight 2 g	
1994	250	605	320	-	**1 175**
1995	-	300	480	-	**780**
1996	-	400	480	100	**980**
1997	245	478	1 000	200	**1 923**
1998	190	535	800	200	**1 725**
1999	200	540	800	350	**1 890**
2000	470	560	750	370	**2 150**
2001	245	680	750	370	**2 045**
TOTAL	**1 600**	**4 098**	**5 380**	**1 590**	**12 668**

Source: The Fisheries Research Institute – Durres

Table 6. Amount purchased from private hatcheries (in thousands)

YEAR	Fingerlings	Stocked inland waters
1995	400	Uleza, Belsh, Seferaj
1996	700	Shkodra, Uleza, V. Dejes, Fierza.
1997	431	Shkodra, Uleza.
1998	726	Fierza, Uleza, Shkoder.
1999	1 030	Fierza, Uleza, Thane.
2000	551.5	Fierza, Uleza, Thane.
2001	919.87	Fierza, Uleza, Shkoder, Tirana

Source: The Fisheries Research Institute - Durres

The earlier years shown in the above table correspond to the time when these hatcheries were moved to come under the responsibility of the Fisheries Research Institute. For the past three years aquaculture development was directed in such a way that the fish market received more requests. Albania imports marine aquaculture products from Greece, mainly seabass and seabream. The request for these products made it necessary to increase investment in cage and trout culture. Marine aquaculture is developed in the southern part of the country, which offers much more possibilities to expand this activity. On the whole part of imports get the aquaculture products, mainly seabass and seabream from Greece and trout.

Table 7. Fish farm production from 2000 to 2002 (in tonnes)

Year	Trout	Seabream and seabass	Mussels	Shrimps
2000	25	10	200	10
2001	60	40	150	12
2002	120	113	350	15

Nevertheless, the development of this sector is faced with difficulties in providing fingerlings and fish feed. The lack of hatcheries for the production of marine fingerlings obliges the Albanian farmers to import, mainly from Greece. To this aim, parallel with the support politics for fingerling production, initiatives are decreasing the custom tasks of the fingerling imports. In trout aquaculture, together with the import of fingerlings, some farms produce these rather for necessity and not for providing third parties.

According to the Decision 95/98/CE dated 17 March 1995, that amends the Decision 94/621/CE the export of live bivalve molluscs to the community market, is prohibited. The opening of the exports for live bivalve molluscs to the EU is a common priority of the Albanian Veterinary Service and the Directorate of Fisheries. As a first phase in this context, the EU legal framework has been adopted in the field of live molluscs collection and marketing. Structures for the control of the products have been set up and also redesigned. The necessary budget has been obtained for the monitoring of the production areas and this activity has begun. This fund will be constant in guaranteeing consistent monitoring in the future. Under the PHARE Programme, the Fisheries Research Institute has received important equipment that will allow it to perform analyses of the phytoplankton (i.e., inverted microscope as well as other equipment for physical – chemical analyses). The cost of this equipment is € 215 000.

5. Relationship with capture fisheries

Over the past years marine aquaculture has shown a large expansion in production in a number of Mediterranean countries including Albania. It provides an important source of high quality food and could be considered an important management tool to limit pressure on wild fish stocks which are heavily stressed due to over fishing and pollution in coastal areas. The degree of interaction between aquaculture and the environment depends on the sensitivity of the ecosystem where it is implemented, on the culture system, and on the species. As a result of these interactions and of the growing public concern for the environmental problems, the choice of adequate sites for aquaculture activities is becoming more important.

In Albania, the impact of aquaculture on social conditions has not been studied sufficiently. In rural areas, in particular, its importance has been neglected. In addition, most of the rural coastal communities rely heavily on one activity (e.g., agriculture or traditional fisheries) that may be vulnerable to external financial inputs.

Site selection for aquaculture is probably one of the main factors that determines the feasibility and sustainability of aquaculture projects. However, the coastal zone in Albania is under pressure from many different competing activities, which may affect existing and future aquaculture operations. Competition for space is one of the most critical factors of the relationships between aquaculture and other activities. Fishing zones, spawning areas, nurseries, artificial reefs, access to harbours, military zones, land reclaiming, protected or reserved zones, dredging, recreative activities such as bathing, sailing or fishing may be submitted to regulations which limit the possibilities for selecting suitable areas for sea-based aquaculture. Land-based aquaculture systems interact naturally with all other developed activities on the seashore and especially with urbanization, industry, tourism and agriculture activities.

Economical facilities for aquaculture development are positively influenced by the attraction of investments and infrastructure (roads, electricity supply) connected with industry, urbanization and tourism. For example, in Saranda and Pogradec (Ohrid Lake) Regions, tourism could help the development of local markets for aquaculture products. Fishery activity in the vicinity of aquaculture also has a positive effect by providing feed for aquaculture and enhancing demand for aquaculture products.

Aquaculture development refers also to social constraints. Urbanization may involve new ways of living where fresh fish and shellfish consumption could be replaced by new standards of human nutrition (frozen and cooked products of high quality). The existing fishery education system in coastal areas (Durres, Vlora, Shengjin and Saranda) could have a positive effect for new aquaculturists. However, competition between aquaculturists and fishermen could arise, especially in low settlement areas, where transfers of employment from fishery to aquaculture occur and lead to social disturbance. Development of wildlife and seascape preservation may lead to major constraints on aquaculture development and social conflicts with local inhabitants and tourists. On the other hand, ecotourism provides mutual benefits between tourism activity, discovery of wildlife and aquaculture practices.

Currently, in Albania there are no identified conflicts between aquaculture and fisheries, either through the competition in the coastal area, or in the fish marketing and trade. This probably is because marine aquaculture is a new activity and it is concentrated in limited areas, particularly in the southern coast in Saranda. The greatest problem for aquaculture is fish (seabass and seabream) imported mainly from Greece, who compete with relatively low prices. In freshwater aquaculture, its development harmonizes and coordinates with artisanal fisheries, particularly due to the fact that fingerlings are used for restocking these waters. The fingerlings consist of carps, grass and plankton feeding species (for lakes and reservoirs) and Koran for Ohrid Lake.

In coastal zones, the pre-existing activities are protected by regulations at multinational level, through national plans at the municipality level. All these regulations present main constraints for the development of new activities such as aquaculture. The consumption of marine products was limited to some restricted areas (Durres, Tirana, Vlora, Saranda, etc.) and fewmarine fish species). Development of aquaculture (finfish or shellfish) enhanced the consumption of new products and correlatively is contributing to the implementation of new ways of marketing and creation of networks for the commercialization of marine products in Tirana and neighbouring ports. New aquaculture techniques need qualified skills, provided by special training courses. This education system could benefit the marine workers (fishermen, traditional aquaculturists) which is currently absent in Albania. However, in places where manpower is lacking, competition between different activities could occur by transfer of employment from one to the other.

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Annex 1. List of aquaculture licensed farms (active)

No.	Name	Region/ district	Property	Culture system	Surface	Production facilities
1	Shoq."Petraq Koçi"	Sarande/Ksamil	Private	Seabream and seabass	1000m^2	6 cages
2	"Derveni" shpk	Sarande/Ksamil	Private	Seabream and seabass	300m^2	8 cages
3	"Bati-Sa" shpk	Sarande/GjiuBati	Private	Seabream and seabass	1000m^2	12 cages
4	"Marikom" shpk	Sarande/GjiuBati	Private	Seabream and seabass	400m^2	8 cages
5	"Bregdeti-Hi" shpk	Vlore/Qeparo	Private	Seabream and seabass	2800m^2	4 cages
6	" Xhino" shpk	Vlore/Karaburun	Private	Seabream and seabass	2000m^2	8 cages
7	"Vangjeli" shpk	Vlore/Raguza 2	Private	Seabream and seabass	500m^2	5 cages
8	Mihallaq Andrea	Vlore/Limopua	Private	Seabream and seabass	na	earthen ponds
9	Andon Lesaj	Lezhe/Beltoje	Private	Seabream and seabass	2 ha	earthen ponds
10	Ek.pesh.fshati Tatzat-Del.	Delvine/Tatzat	Private	Rainbow trout	1000m^2	earthen ponds
11	"Trofta-Bi" shpk	Delvine/Bistrice	Private	Rainbow trout	450m^2	earthen onds
12	Ek. Pesh."Luca" shpk	Delvine/Tatzat	Private	Rainbow trout	500m^2	earthen ponds
13	"Gjeto Pepaj" shpk	M.Madhe/Tamare-Kelmend	Private	Rainbow trout	200m^2	earthen ponds
14	"Dash-peshk" shpk	Gjirokaster/Kardhiq	Private	Rainbow trout	1500m^2	4 earthen ponds
15	Ek.pesh."Trofta Lura Alb"shpk	Peshkop/Arras	Private	Rainbow trout	900m^2	earthen ponds
16	Sokol Shtrezi	Bulqize/Kavashice-Shupenze	Private	Rainbow trout	730m^2	7 earthen ponds

17	" GO and Caj" shpk	Shkodra lake /Shiroke	Private	C. carp	na	2 cages
18	Ek.pesh Thane,Fier Shegan	Lushnje/Thane	Private	C. carp	1,4 ha	earthen ponds
19	"Klosi" shpk	Elbasan/Mollas	Private	Carps fingerlings	11,3 ha	earthen ponds
20	"Hydra" shpk	Tirane/Laknas	Private	Carps fingerlings	6.2 ha	earthen ponds
21	"7.P." shpk	Fier/Vidhisht	Private	Carps fingerlings	7 ha	earthen ponds
22	Ek.pesh.Tushemisht	Pogradec/Tushemisht	Private	Koran	0,2ha	earthen ponds
23	Liqeni i Butrintit	Sarande/ Butrinti lagoon	17private units	Mussels	na	18 trays
24	"KAP Kavaja" shpk	Kavaje/Karpen	Ital-Alb J/Venture	Shrimps	180 ha	earthen ponds
25	Ndue Vokrri	Lezhe/Shengjin	Private	Mussels	na	1 tray
26	"Pelikani" shpk	Lushnje/Divjake	Private	Marine fish	na	ponds
27	Tapize	Kruje / Tapize	Public (FRI.Durres)	Carps fingerlings	3.1 ha	earthen ponds
28	Lin (Ohrid lake)	Pogradec/Lin	Public (FRI.Durres)	Koran fingerlings	0.7 ha	tanks
29	Zvezde (Prespa lake)	Korce / Zvezde	Public (FRI.Durres)	C. carp fingerlings	3.6 ha	earthen ponds
30	Zagorcan	Pogradec / Gurras	Public (FRI.Durres)	C. carp fingerlings	2.5 ha	earthen ponds

List of aquaculture farms (non-active)

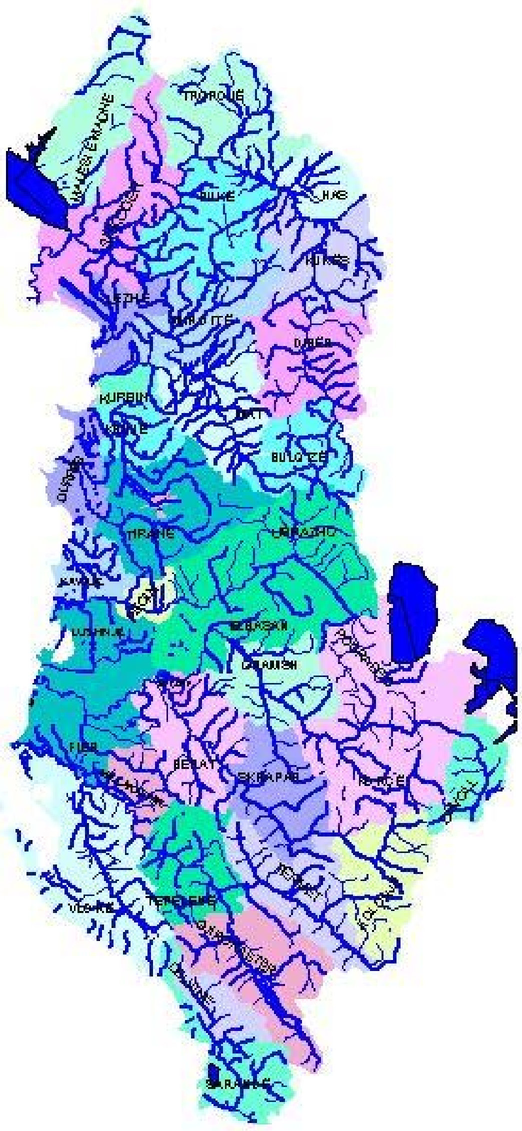
No.	Name	Region/district	Property	Culture system	Surface	Production facilities
1	Grizha	M. Madhe / Demiraj	Private	Carps	5.2 ha	earthen ponds
2	Vraka	Shkoder / Shtoji R.	Private	Carps	4.8 ha	earthen ponds
3	Shtodri	Shkoder / Mes	Under Privatization	Carps	6.5 ha	earthen ponds
4	VauiDejes	Shkoder / Vau i Dejes	Private	Carps	3.8 ha	Earthen ponds
5	Rec-Pulaj	Shkoder / Rec	Private	Carps	110 ha	earthen ponds
6	Shtiqen	Kukes / Shtiqen	Under Privatization	Carps	12.ha	earthen ponds
7	Urake	Mat / Urake	Under Privatization	Carps	15.ha	earthen ponds
8	Balldren	Lezhe/ Balldren	Under Privatization	Carps	10.ha	earthen ponds
9	Durres	Durres / Rrashbull	Under Privatization	Carps	115.ha	earthen ponds
10	Gurras	Pogradec / Gurras	Under Privatization	Carps	8.ha	earthen ponds
11	Toshkez	Lushnje / Toshkez	Private	Carps	20.ha	earthen ponds
12	Izvor	Vlore / Orikum	Private	Carps	5.ha	earthen ponds
13	Boboshtica	Korce / Boboshtica	Under Privatization	Carps	20.ha	earthen ponds
14	Gorican	Berat / Gorican	Private	Carps	3.5 ha	earthen ponds
15	Mavropull	Sarande / Xarrë	Under Privatization	Carps	15.ha	earthen ponds
16	Doftie	Gjirokaster / Libohove	Private	Carps	10.ha	earthen ponds
17	Narta	Vlore / Panaja	Private	Shrimps	200.ha	earthen ponds
18	Muzine	Delvine / Muzine	Private	Concrete	0.2 ha	concrete ponds
19	Syri Kalter	Delvine / Kronjgj	Private	Concrete	1.ha	concrete ponds
20	Vrion	Sarande / Vrion	Private	---	4.ha	raceways

Annex 2. Institutions involved in research activities on aquaculture

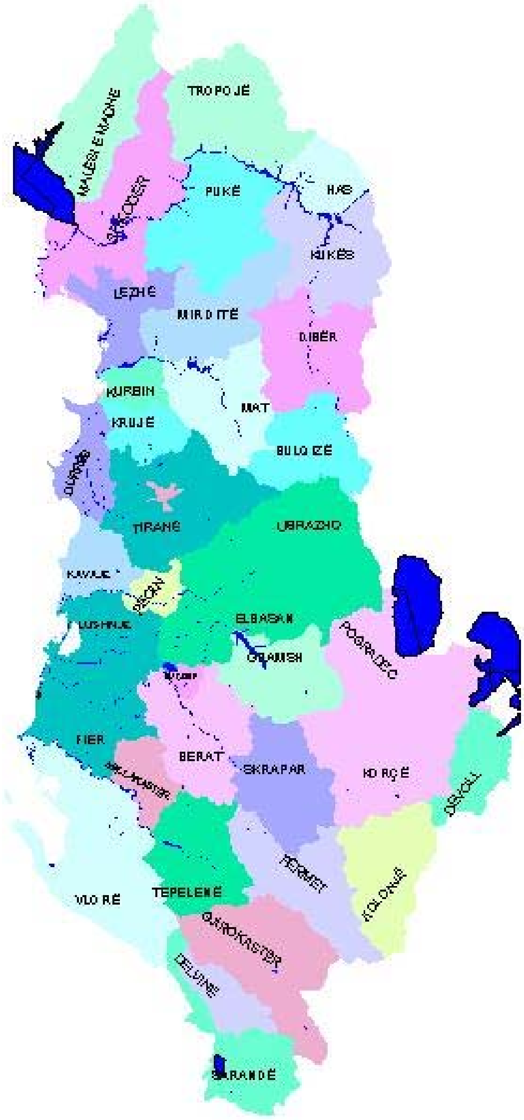
1. Fisheries Research Institute	Durres
2. Hydrometeorology Institute	Tirane
3. Veterinary Research Institute	Tirane
4. Agriculture University of Tirana	Tirane
5. Institute of Statistics (INSTAT)	Tirane

Annex 3.

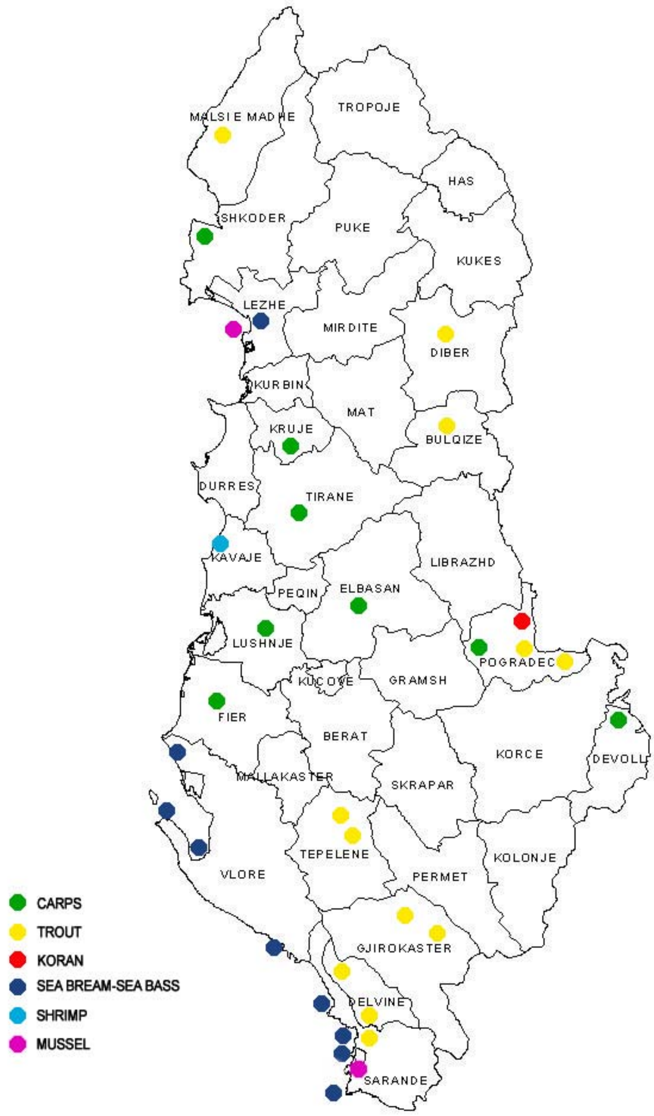
Map 1. The hydrological map of Albania



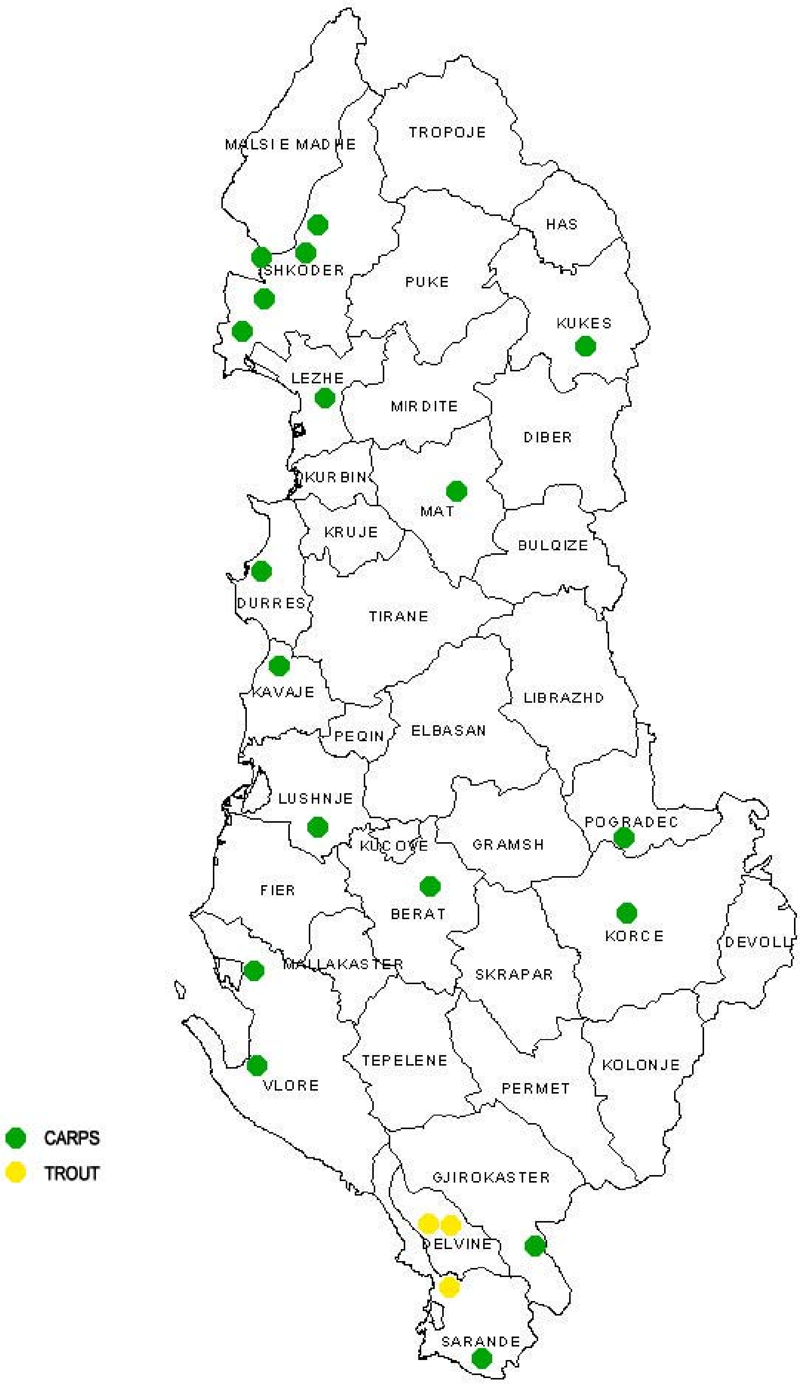
Map 2. Inland waters: lakes, dams, and reservoirs



Map 3. Aquaculture licensed farms (active)



Map 4. Aquaculture farms (non-active)



A short overview of the status of aquaculture in Croatia

Vlasta Franicevic*

1. General background

The Croatian coastline is 5 835 km long and has 1 185 islands making numerous protected sheltered bays and channels (Table 1). Its favourable climatic conditions and unpolluted environment provide great possibilities for mariculture activities.

Croatian mariculture predominantly includes the production of seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*) in floating cages and bluefin tuna (*Thunnus thynnus*) in offshore floating systems. Shellfish production is largely composed of black mussels (*Mytilus galloprovincialis*) and European flat oysters (*Ostrea edulis*) on long lines.

There is an ancient shellfish culture tradition in this area. The first records of shellfish culture in the Bay of Mali Ston (Republic of Dubrovnik) and the River Krka estuary go back to as far as the fifteen and seventeen centuries (Lorini, 1903). From the beginning of last century there have been more than one hundred sites on the East Adriatic coast where fish and shellfish have been cultured. Shellfish production has been stable during the past few decades, but was interrupted as most production sites were directly affected by the recent war activities. Limiting factors for a more rapid revitalization after the war are the lower domestic market demand, and European Union (EU) import restrictions. As shell fish production has always been considered as a family business, transitional changes had no significant effects. Today there are more than one hundred small family farms that have now started to organize themselves in the various associations.

Today all shellfish production is concentrated in the Bay of Mali Ston, the River Krka estuary, and Istria.

About 25 years ago the first important experimental trials on marine fish farming commenced whit several fish species giving very promising results. In the early eighties commercial fish culture of seabass and seabream began in Croatia, making it one of the first countries in the Mediterranean to start aquaculture production. The first hatchery was built in Zadar, and at that time it was considered one of the largest in the Mediterranean. The first farm with floating cages was also constructed during the early eighties forming part of a government project. There was an significant annual increase on fish production, and that encouraged the construction of small family farms. During the nineties mariculture activities expanded rapidly and many small family farms have started based on private investments. This rapid expansion was soon interrupted by the war activities. After the war production suffered from high production costs, expensive loans and credits, privatisation problems, and a weak domestic market. Although still resulting in a very good quality, the product was expensive

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when reaching the EU markets. In 1998, the Ministry of Agriculture and Forestry saved fish production from a total collapse by introduction of new incentives. The big producers are now finishing the process of privatisation, but the small ones still do not recognize all the advantages of the associations.

Today production is organized mainly on the middle coastal islands.

Table 1. General background information on Croatia (2002) (Croatian National Bank, Croatian Bureau of Statistics).

Political boundaries:	Slovenia, Hungary, Serbia and Montenegro, Bosnia and Herzegovina
Internal administrative regions:	20 counties
Climate:	Continental, Mediterranean
Population:	4 494 000
Distribution:	56% urban
Total land area:	56 610 km2
Total sea area:	32 200 km2
Coastline length:	5 835 km
Agricultural GDP:	9%
GDP *per caput*:	US$ 4 640

Tuna production is a new activity created about six years ago in the Zadar area, by a few local people who had brought a basic technology from Australia. This activity is developing rapidly, and showed the first signs of stability during 2002.

2. Characteristics of the sector

Croatian mariculture includes the production of:

1. seabass (*Dicentrarchus labrax)* and seabream (*Sparus aurata)*,
2. tuna (*Thunus thynnus)*,
3. mussel (*Mytilus galloprovincialis)* and oyster (*Ostrea edulis)*.

Seabass and seabream are reared intensively in floating cages, in shore, or semi-offshore. There are five big fish farms with a production of 200 to 800 t/year, and 40 small ones with a production of 10 to 100 t/year. There are four hatcheries producing five million fish fry per year, which is about 30 percent of the amount needed, and the remaining 70 percent is imported mainly from Italy and France.

Tuna is growing in semi-offshore floating cages. There are six farms, three of them producing more than 1 000 tonnes of tuna per year. Due to the small-size of fish caught in the Adriatic Sea technology is changing. Today fish is no longer kept in cages just for a few months, but sometimes even for a period from 18 to 24 months. As fish for growing purposes is caught from a wild, about 40 percent of the catch comes from national waters and the rest is mainly imported from Italy, Spain and Tunisia.

Mussels and oysters are produced on long lines. Producers started to face the first problems with regard to seed availability, due to the uncontrolled harvesting during the war period.

Production data are given in Table 2.

Table 2. Production data for the last six years (t) (Ministry of Agriculture and Forestry, unpublished data).

	1997	**1998**	**1999**	**2000**	**2001**	**2002**
Tuna	390	400	690	1 167	3 045	3 971
Bass and bream	1 500	1 747	1 750	2 100	2 500	2 500
Mussels and oysters	790	900	1 100	1 111	3 000	2 500
Total	**2 680**	**3 047**	**3 540**	**4 378**	**8 545**	**8 971**

3. National policy

Within the Development Strategy for Agriculture and Fisheries of the Republic of Croatia, (National Gazette 89/02) it was planned to increase mariculture production to 10 000 t of fish (tuna not included) and 20 000 tonnes of molluscs by the end of this decade. The requirements needed to reach planned production are approximately 25 000 tonnes of fish feed, 40 million peaces of sea bass and sea bream fingerlings (2-5 g) and several hundred million of shellfish spat per year.

The major priorities to achieve this goal are:

- A clear national policy for mariculture needs to be developed, consisting of regulations and administrative procedures. This process has already been started, and a few new regulations have recently been established.

- Zones for mariculture activities have to be defined by land-use planning followed by ecological studies and continuous monitoring to make the project compatible to the existing and planned activities in the coastal areas. The Directorate of Fisheries, in collaboration with other ministries, has commenced a project “Coastal Zone Management Plan” (CZMP) with particular focus on mariculture.

- Financial institutions should be encouraged by an official long-term strategy to support mariculture activities by establishing acceptable loans. The Directorate of Fisheries has urged the banks to offer such loans to the farmers, based on clear and sustainable programmes.

- National reproduction centres should be established to produce a sufficient quantity of autochthon fish fry, which is fundamental for the recognition of “Croatian quality products”. The legislation came into force recently and it is to be expected that the incentives to encourage farmers to keep broodstock animals will be introduced in a very short time. A national programme is under construction.

- Mariculture has to be integrated into rural development, especially on the islands, to contribute to the social policy and to encourage family businesses in fish and shellfish production.

- Technology has to be improved and education and training is needed. Cooperation between researchers, administrators and producers also need to be improved.

- A promotional and marketing strategy for mariculture products has to be undertaken to reduce trade barriers and give these products the adequate added value.

There is no unique legislation that regulates all the rights and obligations for mariculture producers. Several ministries and government agencies come under this legislation. Officials in national governmental agencies cover the largest part of the administrative supervision over mariculture, while only a smaller part comes under county management.

In order to possess a licence a concession has to be obtained. The use of maritime resources requires a marine resource concession which is issued by the County for a period of up to 12 years, by the Government for period of up to 30 years, and by the Parliament for a period of over 30 years (Maritime Code). There are several parameters that have to be fulfilled to obtain a location licence (Regulation on criteria for suitability of a section of a maritime estate for the activities of rearing of fish and other marine organisms).

Fish farms that produce more than 50 tonnes per year are under obligation to have an Environmental Impact Assessment Study (EIAS) prepared by the authorized institution which is capable of undertaking a continuous monitoring programme of mariculture (Nature Protection Act).

Producers are also obliged to receive confirmation regarding the level of education, issued by the Ministry of Agriculture and Forestry (Regulation on examination programmes for rearing activities).

All facilities producing goods for the market are obliged to have the HACCAP Programme incorporated in order to obtain quality control and protection (Regulation on veterinary-sanitary terms to be met by installations for rearing, production and marketing of fish and fisheries products, and for crustaceans and their products).

There are also special veterinary requirements for the production, collection and marketing of shellfish (Regulation on veterinary-sanitary terms for fishing, culturing, purification and trading of live shellfish).

A mariculture producer requires a special licence for final registration, which is issued by the Ministry of Agriculture and Forestry (Regulation on licence for rearing of fish and other marine organisms).

4. Production and market

Fish markets in Croatia are not well organized, therefore there are no special collecting and distributing centers for mariculture products. Fish and shellfish are often sold directly to consumers (restaurants, hotels), which makes the record of actual national fish production statistics very difficult. There are no promotional marketing activities, which could make these products more popular between the local population.

The main market for mariculture products is in Italy. Due to the constant increase of the total Mediterranean production, the price has decreased to less than a third to what it was 15 years ago. Seabass and seabream have the EU quota for imports of 550 and 35 t / year respectively.

Due to the EU import barriers, the complete shellfish production is sold on the domestic market. As the necessary monitoring has recently been completed, the EU Commission was expected to finalize all procedures by the end of 2003 and to start export to the EU markets by the beginning of 2004.

Thanks to the revitalization of tourism and the increasing demand for sea products, the domestic markets have become very attractive providing the possibility to obtain much higher prices than on the European market.

Per caput consumption of seafood in Croatia is only 8 kg per year. Due to disorganized trading, the final price is usually unreasonably high. The best quality fish is sold directly to hotels and restaurants, which results in a poor offer to the market. Aquaculture products are very often the best quality fish offered on the market. These products are still not properly recognized and accepted by domestic customers.

The export of seabass and seabream is restricted by the EU quota. More than 90 percent of the exported products are sent to Italy, the remaining 10 percent to Slovenia, Austria, Germany, SR Yugoslavia, Bosnia and Herzegovina, France and Spain. Fingerlings are not exported. There is an insignificant import of market size seabass and seabream, coming exclusively from Italy. Import of bass and bream fry is almost twice that of the national production. About 80 percent is imported from Italy, and the rest from France and Greece (Croatian Chamber of Economy, unpublished data).

Due to EU restrictions the total shellfish production is sold on the domestic market. There is an insignificant import, 80 percent from Spain, and the rest from Italy and Chile (Croatian Chamber of Economy, unpublished data).

The total tuna production is exported to Japan. Due to the restricted national quota for tuna fishing, and also to the fact that there are no giant tunas in the Adriatic Sea, about 50 percent of tuna for farming purposes is imported from Italy, Spain and Tunisia (Ministry of Agriculture and Forestry, unpublished data).

The total fisheries export and import data for 2002 are shown in Table 3.

Table 3. Total fisheries export and import data for 2002 (Croatian Chamber of Economy, unpublished data).

	Import (tonnes)	Import ($US)	Export (tonnes)	Export ($US)
Total agriculture and food products	1 398 468	999 777 417	2 073 319	557 951 907
Fisheries*	51 936	65 668 621	11 630	61 587 853

*Includes catch, processing and culture in fresh and sea waters

Fisheries (includes catch, processing and culture in fresh and sea waters) import makes 3.71 percent of the total agriculture and food import in quantity, and 6.65 percent in value. With respect to export, however, it makes only 0.56 percent in quantity, but 11.03 percent in value. The biggest part of this high value comes from export of farmed tuna (Croatian Chamber of Economy, unpublished data).

At present, there are no existing eco-labelling certifications for seafood products. A new legislation has come into force and some producers have started registration procedures. Due to the high ecological quality of seawater in almost total Croatian mariculture area, it is expected that many producers will obtain eco-labelling certification with no significant changes in the technology applied. New incentives have been introduced by the Ministry of Agriculture and Forestry to stimulate ecological production of seafood. The responsible agencies are the Non-governmental Organizations (NGOs) officially recognized by the government.

5. Relationship with capture fisheries

As mariculture activities have rapidly expanded during the last five years, mainly due to tuna farming, competition with other coastal area users has increased. The main competitor is tourism, followed by the local fishing communities. The Directorate of Fisheries has recognized this problem and its strategic determination is to integrate mariculture into the physical planning activities in Croatian coastal countries. To obtain this goal the project CZMP (Coastal Zone Management Plan) commenced in 2002. This project should develop the guidelines for the sustainable development of aquaculture in coastal zones in harmony with other coastal area users.

The Croatian National Monitoring Programme “Jadran” which covers research and monitoring of the aquaculture areas regarding its ecological effects, did not show any serious or irreversible changes in the ecosystem, or in the cultured fish health status (unpublished data).

There is no market competition between cultured seafood and capture fisheries. Capture fisheries products obtain higher prices, sometimes even if the quality is poorer due to bad handling of the product. Mariculture products coming to the market are regularly of high quality, due to the technology applied and proper handling of the product. Very often mariculture products are sold in hotels and restaurants as captured fish.

6. References and web addresses

Lorini, P. (1903) Fishing and Fishing Gears on the East Adriatic Coast. Vienna.

www.hgk.hr : Croatian Chamber of Economy

www.dzs.hr : Croatian Bureau of Statistics

www.mps.hr : Ministry of Agriculture and Forestry

www.izor.hr : Institute of Oceanography and Fisheries

www.hnb.hr : Croatian National Bank

www.hr : Croatia in general

Annex 1. Aquaculture Farms (registered by the Directorate of Fisheries*)

Name	Address	Location	Species
1. Medi and Co d.o.o.	Ston	Uvala Žuronja	oysters
2. Ljiljana Bebek	Ston	Stupica	oysters
3. Mato Ledinić	Dubrovnik	Uvala Sutvid	oysters
4. Ante Mekišić	Luka-Ston	Bjejavica	oysters
		Punta Nedjelja	
5. Niko Maškarić	Doli, Zamaslina	Za puntzu	mussels, oysters
6. Mirko Dassena, "Marcanela"	Vabriga, I.Kontrade 34	Rt Saline-Rt Busula	mussels
7. Milovan Labinac	Vabriga, Ribarska 5	Rt Soline	mussels, oysters
8. Ivan Zupičić	Trget, Brgod 61	Zaljev Budava	mussels, oysters
		Raški zaljev	
9. Dragan Pejić	Labin	Raško zaljev	mussels, oysters
		Raški zaljev	
10. Mario Lovrinov "Daniel-L"	Pula, Ušići dvori 189b	Uvala Valmižeja	mussels
		Zaljev Valun	mussels
		Školjić pomerski	mussels
11. Vesna Alviž, "Angul"	Raslina	JZ od rta Sv.Josip u Prokljanskom tjesnacu	mussels
12. Roman Lokas	Raslina, Zaton	Uvala Ljuta	mussels
13. Šime Gulan, "Maestral"	Pirovac	Uvala Vrilo	mussels
14. Duško Gulin, "Manga"	Šibenik	JI od rta Arasovo	mussels
15. Mytilus d.o.o.	Šibenik	Rt Nova Pošta	mussels
		Uvala Strmica	
16. Iglun komerc d.o.o.	Posedarje	Uvala Prdelj, N. more	mussels
17. Marituna d.d.	Gaženica b.b., Zadar		tuna
18. Adriatic tuna d.o.o.	Zadar, Gaženica bb	Mali i Srednji otok, otok Iž	tuna
19. Brač tuna d.o.o.	Milna, otok Brač	Uvala Smrka	tuna
20. Drvenik tuna d.o.o.	Marina,A.Rudana47	Uvala Mala luka – Drvenik veliki	tuna
21. Jadran tuna d.o.o.	Biograd na moru, P.Svačića 29	SZ od otoka Borovnik	tuna
		J od otoka Vrgada	tuna
22. Kali tuna d.o.o.	Kali	otok Fulija	tuna
		otok Kudica	
23. Tome Erak, "Marikultura"	Murter	JI od uvale Prosika	bass, bream mussels, oysters
24. Marimirna d.d.	Rovinj, G.Paliage 4	Limski kanal	bass, bream, mussels, oysters

25. Anita Mudronja, “Lubin”	Šibenik, Kaprije	Uvala Luka	bass, bream
26. Malo more d.o.o.	Split	Zap. od otoka Tajan	bass, brem
27. Adria octopus d.o.o.	Biograd na moru, A.Šenoe 9	N od otočića Žižanj	bass, bream
28. Blitvenica d.o.o.	Filip-Jakov, Turanj	Prokljanski tjesnac	bass, bream
29. Badioli i Maksan d.o.o.	Pakoštane, Ob.K.P.Krešimira 64	V. i M.Školjić, o.Vrgada	bass, bream
30. Convento albamaris d.o.o.	Biograd na moru, A.Šenoe 9	N od otočića Žižanj	bass, bream,
31. Bisage-nit d.o.o.	Kali	Otočić Bisage	bass, bream
32. Cenmar d.d.	Zadar, Trg tri bunara 5	Uvala Zaglavić	bass, bream
		Otočić Golac	
		Otočić Košara	
		Veliki Školj	
33. Dumboka-mar d.o.o.	Sali	Uvala Dumboka	bass, bream
34. Esso grande d.o.o.	Veli Iž	Uvala Vela Sveža	bass, bream
35. Limbora d.o.o.	Tkon	otok Žižanj	bass, bream mussels, oysters
36. Martinović-fish d.o.o.	Zadar, Poljanska 4	Uvala Kablin	bass, bream
37. Per-mar	Zadar	Uvala Vičija bok, Rava	bass, bream
38. Skrajno, d.o.o.	P.P.6, Veli Iž	Otočić Glurović	bass, bream
39. Solana Pag d.d.,	Pag	Uvala Dinjiška	bass, bream
40. Salmo-trota d.o.o.	Rijeka, Vinogradska 30	Uvala Žrnovnica	salmon, trout mussels, oysters
41. Ante Dragoslavić, “More”	Veli Lošinj	Uvala Kaldonta	bass, bream mussels
42. Sardina d.d.	Postira, otok Brač	Uvala Maslinova	bass, bream
43. Agrimar d.o.o.	Kaštel Stari, Žrtava rata 27	Uvala Stipanska	bass, bream mussels,oysters
44. Sajtija d.o.o.	Šolta	Uvala Vela luka	bass, bream mussels
45. Uvala Vlaška, d.o.o.	Split, B.Jelačića 1	Uvala Vlaška	bass, bream
46. Miani-Giovanelli-Vuljan d.o.o.	Metković, Z. i Frankopana 89	Uvala Mritnovik	bass, bream mussels
47. Ratko Klisović, “Klismar” d.o.o.	Split	Uvala Peleš	bass, bream
48. Rudan and Co d.o.o.	Lovište, Lovište 57	Uvala Vela Bezdija	bass, bream mussels, oysters
49. PZ Korijen	Mljet, Zabrežje bb	Uvala Sobra	bass, bream mussels

* As the regulations regarding licences came into force in 2002, there are some farms (mostly shellfish farms) which until 31 March 2003 had still not applied for a licence.

Annex 2. Institutions Involved in Aquaculture Research Activities

Institute of Oceanography and Fisheries, Split
Institute of Oceanography and Fisheries, Dubrovnik
Ruđer Bošković Institute, Zagreb
Ruđer Bošković Institute, Rovinj

A short overview of the status of aquaculture in Italy

Giovanna Marino*, Enrico Ingle*, Stefano Cataudella#

1. General Background

1.1 Geography, climate and population

Italy is a peninsula situated in Southern Europe which projects into the central Mediterranean Sea. Its territory has considerable southward extension (47°-35°N, 6°-18°E) and covers an area of 1 932.2 km. The bordering countries are: France 488 km, Switzerland 740 km, Austria 430 km, and Slovenia 232 km. This peninsula is surrounded by the Ligurian, Tyrrhenian, Ionian and Adriatic Seas and has two main islands, Sardegna and Sicilia, which form part of the national territory (Figure 1). In total, Italy has an area of 301 337 km^2 and a length of 1 932.2 km, which is subdivided into 20 administrative regions. It currently comprises 103 provinces and over 8 000 municipalities.

Geography: The Italian territory is varied and fragmentary in nature. Much of the land is covered by mountains (35.2 percent): the Alps extending across Italy and the Apennine run down the centre from north to south. The territory consists plainland (23.2 percent), while 41.6 percent is made up of hilly areas. Its coastline is approximately 7 500 km long, with the western coasts differing considerably from those in the east. The west coast is rugged and interspersed with bays, gulfs and other inlets, while the Upper and Middle Adriatic coast is low and sandy.

Climate: The climate varies considerably according to the type of terrain and its latitude (Alpine, Po Valley, Adriatic, Apennine, Ligurian-Tyrrhenian, Mediterranean). On average, the hottest month is July (when temperatures can reach more than 30°C); the coldest month is January; the wettest month is November, with an average rainfall of 129 mm; while the most dry month is July, with an average rainfall of 15 mm. During the winter high pressure conditions favour the north winds (*tramontana*, *maestrale* and *bora*) while the south winds (*libeccio* on the Tyrrhenian coast and *scirocco* on the Adriatic) are favoured in the summer. These climatic changes intensify extreme events, with two simultaneous effects: on the one hand, an increased frequency of extreme events; and on the other, an increase in the intensity of individual events. The damage caused by these natural processes can have an effect on any coastal structure and superstructure built without taking into account extreme environmental conditions in the area.

Population: According to the last census carried out by ISTAT in 2001, Italy has a resident population of 56 305 568 inhabitants, of which 51.6 percent are women. It has a zero

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demographic growth rate, with a birth and death rate both standing at 9.4‰. The mean population density is 186.9 inhabitants/km^2, one of the highest in Europe, and is distributed unevenly over the territory due to the variable environmental conditions. The urban and rural population account for 67 and 33 percent respectively, with 53 percent, i.e., over 20 000 inhabitants, living in centres.

About 17 million people live along the Italian coast, and to these a further 16 million tourists must be added, thus creating an overall demographic load of about 32-33 million persons. Taking into considering the local population alone, the coastal municipalities account for 14percent of the country's total area and 29 percent of the resident population, with a mean density twice that of the national population, which exceeds 500 inhabitants/km^2 in the Rome, Naples and Genoa areas.

Figure 1. Italian seas.

1.2 Land and water resources

Water Resources

The hydrographic system is based on numerous rivers that, on the whole, are nevertheless characterized by a low flow rate. The watercourse flow conditions are closely linked to rainfall. The main river is the Po, about 652 km in length, which with its numerous tributaries creates approximately 965 km of navigable internal waterways. It forms a large delta on the Adriatic Sea coast and makes the largest contribution of fresh water to the Mediterranean. There are relatively few large Italian lakes, excluding the 3 000 Alpine lakes of different origin and small in size. Of particular importance for aquaculture purposes are the lakes and coastal lagoons, most of which are situated in the Northern (Friuli, Veneto, Emilia Romagna) and Southern Adriatic coast (Puglia), in the Central Tyrrhenian coast (Toscana and Lazio), and along the West coast of Sardegna and Sicilia.

Coastal land resources

In Italy, 58 percent of the coastal territory is exposed to intensive anthropic pression, 13 percent to extensive occupation and only 29 percent is free from settlement and infrastructures (WWF, 1996), although the distribution is uneven. Contributing to this figure is the 73 percent of Sardegna and 40 percent of Veneto, while along the Central and Southern Adriatic coast the free areas represent a negligible amount. A 500 km long strip runs along the Tyrrhenian and Ligurian coasts and other coastal conurbations are in the Southern Tyrrhenian, gravitating around the bays of Naples and Salerno, and in the central Adriatic, around the Marche and Emilia-Romagna. Anthropic pressure on the Italian coastal zone is mainly due to the resident and tourist population, as well as the increasing and more intense use of resources. More than twenty use categories (ENEA, 2001) are identified on the Italian coasts. Some of these involve only the coastal land while an ever-growing number, including aquaculture and fisheries, involve also or only coastal waters**.**

Table 1. Land and water resources.

Item	**Area (km^2)**	**Length (km)**
1. Total land	301 337	1 932.2
2. Coastline	7 210	7 456.4
3. Lagoon area	1 500	
4. Main lakes and reservoirs (23)	1 371.9	
5. Main rivers and streams (27)		4 316.0

1.3 Selected economic and human indicators

Italy has a diversified industrial economy with roughly the same total and *per caput* output as France and the UK (Table 2). This capitalistic economy is still divided into a developed industrial north, dominated by private companies, and a less developed agricultural south, with a 20 percent unemployment rate. Most of the raw materials needed by the industries and more than 75 percent of energy requirements are imported.

Table 2. Selected economic and human indicators (CIA, 2003).

GDP (US $)	$1.438 trillion (2002 est.)
Agricultural GDP (US $)	2.4%
PCE[1] or GDP per caput income (US $/caput)	Purchasing power parity: $25 000 (2002 est.)
Human Development Index	Labour force: 23.6 million (2001 est.); Labour force by occupation: Services 63%, industry 32%, agriculture 5% Unemployment rate: 9.1% (2002 est.)

[1] *Per caput* earnings.

2. Characteristics of the sector

2.1. General information on Italian aquaculture: tradition, evolution of main practices and location

Italian aquaculture is characterized by the farming of a wide range of different species and applied technologies owing to the diversity of available sites (Table 3). Some production areas are the result of traditions of ancient origin, while others became important with the introduction of modern intensive farming techniques. The geographical distribution of the aquaculture areas is characterized by valliculture in the north/east regions, pond farming in Central Italy and the Islands and by shellfish farming in the coastal areas.

Table 3. Main species and production systems currently in practice.

Common name	Species	Production facilities	Market focus (export/domestic)
European seabass	*Dicentrarchus labrax*	Monoculture in land-based and sea cage (SW)	Domestic
Gilthead seabream	*Sparus aurata*	Mono and polyculture in land-based and sea cage (SW)	Domestic
Sea breams	*Diplodus spp.* *Puntazzo puntazzo*	Polyculture in land-based and sea cage (SW)	Domestic
Mullets	*Mugil spp.*	Extensive and semi-intensive polyculture (BW/SW)	Domestic
European eel	*Anguilla anguilla*	Intensive monoculture in land based (FW)	Domestic
Rainbow trout	*Onchorynchus mykiss*	Intensive monoculture in land based (FW)	Domestic
Catfish	*Ictalurus spp.* *Ameiurus spp.*	Semi-intensive monoculture in land based (FW)	Domestic
Common carp	*Cyprinus carpio*	Extensive/semi-intensive monoculture in land based (FW)	Domestic
Sturgeon	*Acipenser spp.*	Intensive monoculture in land based (FW)	Domestic
Other fish	*Pagrus spp., Umbrina cirrosa,* *Argyrosomus regius,* *Dentex dentex , etc*	Monoculture in land-based	Domestic
Mussels	*Mytilus galloprovincialis*	Monoculture fixed (<10%), single ventia long-line (75%), multi-ventia (Trieste long-line)	Domestic (95%)
Clams	*Tapes philippinarum* *Tapes decussatus*	Monoculture, management of natural resources and hatchery-restocked juveniles.	National domestic (76%) Regional domestic (74%)

2.1.1 Aquaculture in coastal areas

Extensive fish farming

Aquaculture production inside coastal lagoons currently occupies a total area of approximately 100 000 ha, of which about 60 000 ha are covered by water and 43 000 ha are regularly utilized by 112 units (2001) for fish-farming activities.

Valliculture covers an area of 16 000 ha in Veneto, 11 000 ha in Emilia Romagna and 600 ha in Friuli Venezia Giulia (Table 4). The "valli da pesca" are located in confined coastal lagoon environments with an area from 10 to 10 000 ha; the smallest are located in Friuli Venezia Giulia and the largest in Veneto and Emilia Romagna.

Table 4. Regional distribution of extensive and semi-intensive production units and relative surface (ha) in 2001 (ICRAM-API, modified from Ingle *et al.,* 2002).

Region	Extensive Production Units (n)	Extensive Production Surface (ha)
Veneto	50	16 000
Friuli Venezia Giulia	36	600
Emilia Romagna	12	11 000
Puglia	5	5 000
Toscana	1	5 000
Lazio	1	1 500
Sardegna	6	9 000
Sicilia	6	1 000
Adriatic Basin (subtotal)	98	32 600
TOTAL	***112***	***49 100***

Valliculture in the Northern Adriatic accounts for 66 percent of the confined wet lands used for fish farming, and 87 percent of the extensive units in Italy supplying about 70 percent of the aquaculture production from coastal lagoons. The remainder is produced by extensive farming carried out in coastal areas and brackish waters located in Toscana, Puglia and Sardegna. Pond farming used in these coastal areas is technologically more simple than that used in valliculture; even if productivity is generally higher (between 30 and 300 kg/ha, respectively).

Extensive and semi-intensive aquaculture carried out inside coastal lagoons consists of the farming of euryhaline species, such as seabass *Dicentrarchus labrax*, seabream *Sparus aurata*, mullets *Mugil* spp., *Chelon* spp., *Liza* spp. and eel *Anguilla anguilla*, which are capable of withstanding a high degree of salinity variation both within the span of the same day (tides) and during seasonal changes (influx of freshwater from rivers). Currently production trends in these species has changed and there has been a strong reduction in eel culture in favour of seabream and partly of seabass, while grey mullets remain the reference species for this type of production.

Aquaculture undertaken inside coastal lagoons represents a unique ecological, landscape and cultural heritage and contributes to the conservation of the sensitive wet lands, under constant threat of negative impacts from the various anthropic activities. Environmental degradation of coastal areas, the impact of ichthyophagous birds and the delay in taking management action to improve such environments, has recently caused a major decline in production and has diminished the peculiarity of Italian aquaculture.

Intensive fish farming

The intensification of fish production in coastal areas began in the early 1980s in the same areas used traditionally for lagoon farming and in geographic areas where climatic conditions were favourable. Today land-based aquaculture farms are scattered along the entire coastal area and are mainly constituted by seabass and seabream farming. Due to technological improvements the number of land-based units increased from 60 in 1993 to 74 in 2001, accompanied by a constant growth in production. At present further expansion of land-based aquaculture units is constrained by the competition for the space use in coastal areas. This leads to a continuous trend towards in-shore mariculture protected areas and off-shore mariculture in the open sea. The number of cage installations increased from 4 units in 1993 to 48 in 2001, but this number has doubled in the last three years alone (Table 5).

Table 5. Number of intensive farms and hatcheries for marine species for the period 1993–2001 (ICRAM-API, modified from Ingle et al. 2002).

Marine species	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Land-based farms (n)	60	62	67	66	65	63	60	67	74
Cage farms (n)	4	5	7	9	10	19	22	36	48
Hatcheries (n)	22	22	20	20	20	17	17	17	21

The regional distribution of marine species production units shows a greater concentration of land-based farms in the Northern Adriatic (Veneto, Puglia and Friuli Venezia Giulia), while over 60 percent of the cage-based mariculture installations are concentrated in the Southern Adriatic and account for only 35 percent of the total.

Commencing in the 1980s, a strong impulse to set up intensive farms for marine and/or euryhaline species came from the development of controlled reproduction techniques applied to seabass and seabream. The construction of a large number of hatcheries between the 1980s and 1990s ensured self-sufficient seed production from 1991 onwards. Since 1993 the number of hatcheries has remained constant at around 20 (21 in 2001), although the installations have undergone a continuous and substantial technological improvement. Marine hatcheries are concentrated in five regions: Toscana (6), Veneto (4), Puglia, Sicilia and Lazio (3). In the Adriatic there are 11 hatcheries which account for 50percent of the total production units (Table 6).

New hatchery technologies, using large volume tanks, have been recently developed for the production of high-quality seabass and seabream fry, suitable for extensive farming supply and restocking procedures. The "large volume techniques", have been adopted by the majority of new units brought into production since 1998.

Since 1995, reproduction techniques have been developed for the production of new species and in 2001 ten hatcheries produced fingerlings at a commercial level of the sharpsnout seabream *Diplodus puntazzo*, the shi drum *Umbrina cirrosa*, the striped seabream *Lithognathus mormyrus*, the pandora *Pagellus erythrinus*, the common dentex *Dentex dentex*, the common seabream *Pagrus pagrus* and the dusky grouper *Epinephelus marginatus*.

Table 6. Regional distribution of intensive land-based and cage farms and hatcheries for marine species in 2001 (ICRAM-API, modified from Ingle *et al.,* 2002).

Region	**Intensive Land-Based Farms for Marine Species (n°)**	**Intensive Cage Farms for Marine Species (n°)**	**Hatchery for Marine Species (n°)**
ADRIATIC			
Veneto	11	1	4
Friuli Venezia Giulia	7	3	1
Emilia Romagna	3	0	0
Lazio	3	2	3
Abruzzo	1	1	0
Molise	2	0	0
Puglia	12	10	3
SUB TOTAL	***39***	***17***	***11***
OTHERS			
Liguria	0	2	0
Toscana	8	4	6
Campania	4	4	0
Basilicata	2	1	0
Calabria	0	1	0
Sicilia	9	10	3
Sardegna	12	9	1
SUB TOTAL	35	31	10
Adriatic/Others (%)	***47.3***	***35.4***	***52.3***
TOTAL	**74**	**48**	**21**

Shellfish farming

A process of conversion to modern mollusc farming practices occurred in the late 1980s with the introduction of a new species, the Manila clam (*Tapes philippinarum*) into the Upper Adriatic lagoon farms, and the development of a new culture technique. The ready adaptation of Manila clam to the local environment ensured its spontaneous diffusion, effectively revolutionizing the productive structure in costal areas and providing important social implications. During the same period, the introduction of off-shore technologies in mussel farming allowed the open sea areas to be cultured. To the traditional production areas, most of which were in strictly coastal or lagoon zones, were added numerous off-shore productive areas which were less subject to environmental, health and hygiene problems which traditionally affect mussel culture.

Currently shellfish culture is mainly based on mussels (*Mytilus galloprovincialis*) and Manila clams (*Tapes philippinarum*), to which a small quantity of grooved carpet shells (*Tapes decussatus*) and oysters (*Crassostrea gigas* and *Ostrea edulis*) must be added.

A recent survey carried out by the “UNIMAR” Consortium in 2001 identified 269 active mollusc farms (Table 7) with a total of 4 000 employees that used different methods often with multi-species production.

Mussel farming is widespread along much of the Italian coastline (Table 7). The traditional mussel-culture coastal or lagoon regions include the Gulf of Taranto (Puglia), La Spezia (Liguria), the Venetian Lagoon, the Flegrean Coast (Campania), to which more recently has been added the Trieste coastal area (Friuli-Venezia Giulia), the Gulf of Olbia (Sardegna), Emilia-Romagna and the Adriatic part of Puglia. Only three coastal regions - Calabria, Basilicata and Toscana - are totally lacking in mussel farming facilities.

In the year 2000 there were 204 mussel farms in Italy which essentially used three farming systems (Table 8): the fixed; the 'monoventia' long line; and the 'multiventia' or Trieste long line systems. Mussel culture is monospecific, except for that located in lagoon areas, where clam production is often associated with mussel production. Oyster production is generally associated with offshore mussel production.

Clam farms in Italy are concentrated in the principal lagoon areas. A total of 54 farms have been recorded, distributed mainly in the Po area (Emilia-Romagna and Veneto) and in Sardinia. In the Upper Adriatic lagoons farming is based mainly on Manila clam production to which must be added small quantities of grooved carpet shells, *Tapes decussatus,* in the Ravenna area (Emilia Romagna) and in Sardinian ponds.

Table 7. Number of farms and employees in mollusc culture (modified from Prioli, 2001).

Region	**Farm (n)**	**Employees (n)**	
		Regular	Temporary
Abruzzo	4	8	2
Campania	19	76	0
Emilia-Romagna	29	928	251
Friuli-Venezia Giulia	31	53	0
Lazio	5	22	4
Liguria	68	98	9
Marche	7	13	19
Molise	2	8	0
Puglia	35	355	20
Sardegna	18	346	28
Sicilia	1	10	4
Toscana	1	0	5
Veneto	49	1 801	4
Total	***269***	***3 718***	***346***

Table 8. Number of mussel farms and size of productive structures (modified from Prioli, 2001).

Region	**Total**	**Total metres**	**m (average)**	**min.**	**max.**
Abruzzo	1	18 000	18 000	18 000	18 000
Campania	12	41 288	3 441	300	10 000
Emilia-Romagna	19	631 150	33 218	6 000	200 050
Friuli-Venezia Giulia	24	186 440	7 768	400	35 800
Lazio	4	21 295	5 324	1 500	6 000
Liguria	68	49 042	721	275	12 648
Marche	6	55 500	9 250	2 500	25 000
Molise	2	46 000	23 000	22 000	24 000
Puglia	31	550 270	17 751	700	210 000
Sardegna	16	143 660	8 979	1 050	36 200
Sicilia	1	600	600	600	600
Veneto	20	303 240	15 162	110	82 500
Total	***204***	***2 046 485***	***10 032***	***275***	***210 000***

Table 9. Mussel farms and their size (modified from Prioli, 2001).

Culture System	Region	total metres	min.	max.
Fixed	Emilia-Romagna	81 600	81 600	81 600
Fixed	Liguria	15 270	40	532
Fixed	Puglia	96 750	180	30 000
Fixed	Sardegna	1 200	600	600
Fixed	Veneto	9 340	100	7 500
Total fixed		***204.160***	***40***	***81.600***
Single ventia	Abruzzo	18 000	18 000	18 000
Single ventia	Campania	41 288	300	10 000
Single ventia	Emilia-Romagna	549 550	6 000	118 450
Single ventia	Friuli-Venezia Giulia	400	400	400
Single ventia	Lazio	21 295	1 500	6 000
Single ventia	Marche	55 500	2 500	25 000
Single ventia	Molise	46 000	22 000	24 000
Single ventia	Puglia	376 670	3 000	180 000
Single ventia	Sardegna	107 340	1 140	24 000
Single ventia	Sicilia	600	600	600
Single ventia	Veneto	293 900	2 400	75 000
Total single ventia		***1.510.543***	***300***	***180 000***
Trieste system	Friuli-Venezia Giulia	186 040	400	16 000
Trieste system	Liguria	33 772	96	500
Trieste system	Puglia	76 850	300	16 800
Trieste system	Sardegna	30 830	2 4 0	20 800
Trieste system total		***327.492***	***96***	***20.800***
Rafts	Sardegna	4.290	1.050	3.240
Total rafts		***4.290***	***1.050***	***3.240***
Total		***2.046.485***	***40***	***180.000***

2.1.2 Inland aquaculture

Intensive fish farming

*I*nland aquaculture is traditionally characterized by the intensive farming of trout (*Oncorhynchus mykiss),* eel (*Anguilla anguilla*) and only recently of sturgeon (*Acipenser sturio*). Trout culture represents the earliest intensive farming practice in the aquaculture sector, but the number of farms decreased considerably in the last decade (Table 10), from 589 production units in 1993 to the present 383 (-35 percent). Production remained high due to the recent technological modernization of many plants and national financing plus cuts in production costs. More than 50 percent of the trout production is located in Veneto and in Friuli Venezia Giulia (Table 11).

Table 10. Trends in the number of intensive farms for salmonids and eel and weaning units for eel for the period 1993–2001. (Source ICRAM-API, modified from Ingle *et al.,* 2002).

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Salmonids Intensive farms (n)	n.r.	n.r.	n.r.	n.r.	n.r.	589	520	454	383
Anguilla Intensive farms (n)	125	125	125	120	120	74	62	52	47
Anguilla Weaning units (n)	6	6	6	7	7	5	5	4	3

Eel production was traditionally accomplished by both intensive and extensive aquaculture but until the early 1990s extensive farming made a significant contribution. Currently eel production is carried out almost exclusively in intensive facilities operating at high temperatures (24-26 °C) using water of geothermal origin or recirculating systems in which the water is heated. Over the past five years the growing competition from Central and Northern European countries has led to a considerable decline in the number of production units, now standing at 47, that is, practically only one third of those in operation in 1993 (Table 10). The reduced availability of fry has also led to a reduction in the number of weaning units "cecherie", and only 3 are still in existence (Table 10). A large production of fry is concentrated in a small number of big farms (10-15 units) located in Northern Italy (Table 12).

Catfish farming has a long tradition. It developed in the Po Valley and, moreover, in Emilia Romagna there are 163 production units out of the 193 counted in Italy. The farms use very weak intensive techniques and are mostly small in size and often family owned. In Italy the autochthonous species (*Icthalurus melas*) or common catfish was traditionally farmed. Later, however, the American species (*Icthalurus punctatus*) was introduced and, starting from the mid-1990s, a strong reduction in the local catfish production s was observed as a result of the strong incidence of viral pathologies. The American catfish, which proved much more resistant to pathogens, gradually replaced the autochthonous species in culture farms. The local catfish species is still more appreciated for sport fishing.

Table 11. Regional distribution of trout farms and production (t) in 2001. (ICRAM-API, modified from Ingle *et al.*, 2002).

Region	Trout farms (n)	Trout production (t)
Valle D'Aosta	2	70
Piemonte	23	3 000
Lombardia	66	5 100
Trentino Alto Adige	54	2 200
Veneto	86	12 100
Friuli Venezia Giulia	70	12 300
Emilia Romagna	5	100
Toscana	29	1 200
Umbria	9	1 500
Marche	8	2 600
Lazio	8	650
Abruzzi	10	2 900
Molise	1	10
Campania	5	70
Basilicata	1	10
Calabria	3	50
Sicilia	1	20
Sardegna	2	120
TOTAL	***383***	***44 000***

Table 12. Regional distribution of eel farms and weaning units in 2001 (ICRAM-API, modified from Ingle *et al.*, 2002).

Region	Eel intensive farms (n)	Weaning units (n)
Piemonte	2	0
Lombardia	7	1
Veneto	16	2
Friuli Venezia Giulia	1	0
Emilia Romagna	2	0
Toscana	1	0
Marche	1	0
Lazio	3	0
Campania	3	0
Puglia	3	0
Calabria	1	0
Sicilia	1	0
Sardegna	6	0
TOTAL	***47***	***3***

3. National policy

In Italy the aquaculture and fishery sectors are coordinated under the responsibility of the Directorate General of Aquaculture and Fisheries of the Italian Ministry of Agriculture and Forestry Policies (MiPAF). Since 1997 the administrative functions concerning agriculture and fisheries (DL 143/97; DL 112/98) have been assigned to the various regions, while the Ministry retains the power of setting policy, coordination, planning and the management of marine fish resources of national interest.

The logic underlying this law is the coordination between the central government and regional administrations through an economic and territorial programme for the sector and the overall decentralization of management and responsibility. This redistribution has required a strong interaction between the central government and regional administrations in order to avoid duplicating responsibilities and expenditure, and to avoid behaviour that may not be convergent among the regions (for instance, as in the case of the criteria used to assign concessions for mariculture activities).

3.1 National Plan

The topics to be addressed in the consolidation and development of Italian aquaculture for the from 2000 to 2002 have been identified in the sixth Three-year Plan for Aquaculture and fisheries (Ministry of Agriculture), and a new plan (2003/2005) is actually in the final drafting stages. The National Plan provides a detailed and appropriate reference framework for the aquaculture sector and an accurate analysis of major constraints limiting the expansion of the sector. Institutes, cooperatives and production associations are deeply involved in its design. Objectives, priorities and financial instruments are identified according to European and national policies and since 1996 the Directorate General of Aquaculture and Fisheries has promoted the relevance of sustainable aquaculture and disseminated the principles of the Code of Conduct for Responsible Fisheries (CCRF) (FAO, 1995) throughout the aquaculture and fisheries industry. The following strategies have been included as priorities:

3.1.1 Increasing domestic production in a context of environmental sustainability

Priority has been given to investments for increasing the environmental compatibility of aquaculture farms and to support responsible aquaculture models, through:

- improvement in the development of priority criteria to assign financial grants to non-polluting forms of aquaculture;
- certification policies regarding fish production, encouraging the spreading of ISO standards and eco-labelling, such as EMAS**;**
- development of organic aquaculture;
- development of vaccines, implementation of vaccination campaigns and new prophylactic and therapeutic drugs that have a lower impact on local ecosystems than those currently in use.

Priority has also been given to the adoption of measures to increase the volume and the quality of fish production. In particular these consist of:

- improve farming technologies and structural updating of plants to reduce production costs;
- development of effective innovative intensive farming technologies, e.g., for off-shore mariculture;
- development of controlled breeding techniques for new species in order to enhance the diversification of production;
- application of labels for quality improvement, enhancing the image of aquaculture imported products and quality control;
- evaluation of market perspectives and productive trends by means of an accurate analysis of Mediterranean aquaculture products, market flow, foreign demand, consumption habits and regulations.

In the case of molluscs:

- environmental rehabilitation of lagoon environments, including vivification action in the areas at greater risk of eutrophication;
- action to control unauthorized harvesting, in particular in the Venice Lagoon, which may also have negative effects in terms of hygiene and quality product qualification;
- encourage mollusc farming practices rather than simple resources management by means of seeding , cleanliness and management during harvesting;
- supporting farmers with technical structures and by setting up Management Consortia.

3.1.2 Safeguarding employment levels

Safeguarding employment levels, which have been placed at risk by the intense action aimed at reducing fishery efforts in general and the growing pressure regarding the restrictions of certain fishing systems, by means of:

- integrating aquaculture with fisheries through the initiatives by operators in the sector in favour of reconversion and income integration. Priority will be given to shellfish farming initiatives, in particular mussels and clams, that offer opportunities for reconversion and allow fisheries to be combined with fish farming;
- reconversion involving mariculture, sport fishing activities and tourism;
- reconversion involving quality control and innovative marketing systems.

3.1.3 The involvement of research in the aquaculture sector

The scientific research carried out as part of the Aquaculture and Fisheries Plan represents an important support for the sector. The action of coordinating the efforts of the various scientific workers in the field and with producers means that research is increasingly being focused on priority topics that will have spin-off applications in this sector.

3.2 Relevant legislation on aquaculture

The regulation status of aquaculture is rather fragmentary, and does not encourage the realization of the potential of this sector nor does it ensure its full environmental compatibility. The over-abundance of laws and regulations has led to considerable problems of application in the past, due to constant conflicts of competence among the authorities. The recent devolution of power in administrative matters to the Regions (DL 112/98) should at least partially resolve the problem of excessive red tape in the sector.

The DPR 12/4/1996 entitled "Guidelines and Coordination for the Implementation of Article 40, comma 1, of Law No. 146 dated 22 February 1994, concerning provisions regarding the "Environmental Impact Assessment (EIA)" also devolved to the Regions the task of implementing Directive No. 337/85/EC as amended and supplemented by Directive No. 11/97/EC. According to the provisions of DPR 12/4/96 fish farming facilities with a total area exceeding 5 ha situated in protected natural areas are subject to EIA procedures. Conversely, if the facility does not lie within a protected area the competent authority shall determine by means of a "verification procedure" (Article 10) whether the project characteristics (Annex D) require the EIA procedure to be carried out. The competent authority is the actual Region, except in the case of concessions granted in national parks, marine reserves and sensitive areas (e.g., SIC Directive No. 92/43/CEE) for which the adoption of safeguarding and management measures is a task determined by the State.

The regulations governing the management and treatment of waste in aquaculture, do not clearly define whether fish farming plant waste is to be considered effluent or waste. In practice, effluent disposed of through pipes is considered as discharge, which must be disposed of in accordance with the provision of Legislative Decree No.152 of 11 May 1999. Conversely, if disposal takes place in another manner, the waste must be considered as special waste in accordance with the Ronchi Decree (No. 22/97). Excluded from this classification is refuse of animal origin (e.g., fish carcasses), which is sub-divided into low and high risk material in accordance with Legislative Decree No. 508 of 14 December 1992. In this case aquaculture producers must perform a number of tasks designed to allow traceability of the path followed by the waste from the time of its production until its final disposal. In practice, this consists of self-disposal of waste by the producer after prior consent or notification (Article 10), otherwise the transport and treatment of carcasses is delegated to an authorized third party (transformation plants).

The responsibility for the issuance of concessions regarding the use of public water by aquaculture facilities and quality of the effluents from the farms has been devolved to the Regions and is regulated by the recent Legislative Decree No. 152/99 governing the concession and protection of water resources. The approach introduced by 152/99 concerning the protection of water resources is radically innovative as it subordinates the emission limits of each individual effluent to the general quality objective of the receiving body as a whole, and introduces the criterion for the quantitative protection of the resource. The new regulations make provision for a period of transition of a maximum of four years after the coming into effect of Legislative Decree No. 152/98, during which it is necessary for aquaculture farms to follow the parameters set out in Table 3 of Annex 5 and to take the necessary steps to avoid even a temporary increase in pollution. At the end of the four-year period, which actually ended in 2002, the same Decree in Article 37 called for the definition of “criteria referring to the containment of environmental impact due to aquaculture and fish farming” by the Ministry of the Environment, acting in conjunction with other administrations. In particular as far as trout farms are concerned, another important aspect, is the use of water resources. Concessions concerning the use of water utilized for human consumption may be granted only in cases, such as abundance availability and the administrative authority may impose flow rate restrictions on previously granted withdrawal concessions in order to guarantee a minimum viable watercourse flow and the general protection of the source.

Italy subscribed to the 1992 Rio Convention, which was ratified by Law No. 124 dated 14 February 1994, which did not allow *alien species* to be introduced. On 24 November 1996 Italy signed the Protocol for Protected Areas and Biological Diversity in the Mediterranean to the revised version of the Barcelona Convention for the Protection of the Marine Environment and of the Mediterranean Coast (former Convention for the Mediterranean Sea against pollution) amended in Barcelona in June 1995. The protocol, ratified by Italy in May 1999, entered into force on 12 December 1999. The Protocol considered (Article 13) the adoption of measures to prevent the voluntary or accidental introduction of non-indigenous species and the eradication of introduced species that can cause problems. National legislation delegates the authorization and control over the transfer and introduction of non-indigenous species to the Regions. Any intended introduction of marine fish must receive the prior authorization of the competent authorities of the Region, and is subject to sanitary inspection measures and veterinary controls, also in accordance with Decree Nos. 454/1988, and 555/1992 with Directive 91/67/EEC on “Veterinary Police for Aquaculture Products”, Decree no. 263/1997 with EU Directive No. 93/53 on “Fish Diseases”. The sanitary control measures include a certificate for the introduction and control by the competent Customs Offices; the establishment of an appropriate quarantine site for species preservation; the use of recirculated seawater systems and/or sterilization of all the effluents from the facility; sampling and sanitary controls to be carried out by the competent authority (Ministry of Health, Istituti Zooprofilattici Sperimentali) to monitor the health of the introduced species and the first generation of individuals.

Italy has also signed other important international Conventions closely related to aquaculture and coastal zone management, such as the Ramsar Convention on Wetlands of International Importance.

Italy has a specific legislation for aquaculture products, as well as having general regulations applicable also to other products of animal origin. There are two general laws: Legislative Decree 26/5/97, No. 155 implementing Directives 93/43/EEC and 96/3/EC which lays down rules governing the hygiene of food products, including aquaculture products, updated in 1998 by Circular No. 227 of 26 January 1998 of the Ministry of Health regarding provisions concerning the publication of handbooks giving correct hygiene practices. The second law is the recent EU Directive on traceability of food products (178/2002), due to be incorporated into Italian legislation by 2005.

The EC Regulation No. 2065/2001 providing information to consumers on aquaculture and fisheries products was DM 27 March 2002, which deals with the organization of common markets and establishes that products must be provided to the consumer with basic information of their main characteristics.

Specific regulations covering fishery products include sanitary aspects during production and marketing and are contained in Legislative Decree No. 531 30/12/1992, implementing Directive 91/493/EEC and in the recent updates concerning health monitoring in aquaculture production facilities (Circular of 13/6/2000 No. 12/38 – Ministry of Health).

In the case of shellfish, Legislative Decree 30/12/1992, No. 530 implementing Directive 91/492/EEC and Ministerial Decree 14/10/98 – the Ministry of Health sets down health regulations applying to the production and marketing of bivalve mollusc. According to Legislative Decree No. 530/92, mussel production areas are divided into A, B and C. Only mussels originating from A can be used directly for human consumption, whereas B products need to be processed in cleansing or in approved marine growing centres to comply with hygiene and health regulations. Circular No. 1166 of 31/5/00 – Ministry of Health updates No. 530/92 as far as the packaging and transportation of live bivalve molluscs are concerned.

Two recent regulations on animal feed, in particular the Ministry of Health Decree 23/3/2001 concerning modes and conditions of low risk material and products for the production of animal feed, now need to be amended in the light of Directive 2002/32EC on undesirable substances in animal feeds; Legislative Decree 4/8/1999, No. 336 implemented Directives 96/22/EC and 96/23/CE prohibiting the use of certain substances exerting a hormonal or thyreostatic action, as well as of β-agonist substances in animal product and control measurements of certain substances and their residues in live animals and their products. Policies on health regulations regarding aquaculture products are contained in Legislative Decree 30/12/92, No. 555 implementing Directive 91/67/EEC, which is aimed at creating disease-free zones and farms for the purpose of commercial exchanges among such farms having the same health status. Subsequently modified by Presidential Decree 16/12/99, No. 543 it contains the regulations enabling Directive 98/45/EC, modifying Directive 91/67/EC. Presidential Decree 3/7/1997, No. 263 implemented Directive 93/53/EEC containing minimal community measures to combat certain fish diseases. For shellfish, Presidential Decree 20/10/98 No. 395 implemented Directive 95/70/EC concerning minimum measures to combat certain diseases affecting live bivalve molluscs.

4. Production and market

4.1 Current and historical statistics of aquaculture production and seed availability

The Italian aquaculture output in 2001 amounted to 257 600 tonnes with a total value of over 500 million Euro (Table 13). Mollusc production accounts for over 73 percent of the total, made up of 135 000 tonnes of mussels (about 30 000 t from fishing) and 55 000 tonnes of Manila clams. Freshwater fish species production amounts to nearly 50 000 tonnes (mostly trout). The output of sea and brackish water species exceeded 23 000 tonnes in 2001, thus becoming the sector showing the greatest increase in production. More than 17 900 tonnes are represented by seabass and seabream, most of which are reared in sea water, to which 2 700 tonnes of eels and 700 tonnes of sturgeon must be added. Extensive output accounts for 22 percent of the total (Table 13).

Table. 13. Italian aquaculture output in tons and corresponding economic value in millions of Euro for the year 2001. (ICRAM-API, modified from Ingle *et al.*, 2002)

Species	**Intensive production (t)**	**Extensive production (t)**	**Total (t)**	**Value (millions €)**
Seabass	8 900	700	9 600	59.50
Seabream	6 800	1 100	7 900	42,.87
Sharpnout	400	0	400	2.27
Eel	2 400	100	2 500	15.49
Mullets		3 000	3 000	10.07
Trout (*)	44 000	0	44 000	129.53
Cat fish	650	0	650	2.48
Carps	700	0	700	2.17
Sturgeons	700	0	700	4.34
Other fish (**)	2 200	0	2 200	11.36
TOTAL FISH	66 750	4 900	71 650	280.07
Mussel (***)			135 000	80.21
Manila clams			55 000	142.03
TOTAL MOLLUSC PRODUCTION			190 000	222.24
TOTAL ACQUACULTURE PRODUCTION			257 600	502.31

(*) Taking into account also the added value of fresh products processed on site.
(**) Pike, perch, striped bass, shi drum, dentex, red seabream, etc.
(***) Total output includes about 30 000 t gathered from natural beds.

In terms of production value, the relative contribution made by shellfish decreased to 44 percent (about € 222 million), while the remaining 56 percent is represented by € 160 million accounted for by freshwater species (32 percent of the total) and € 120 million for sea and brackish water species (24 percent of the total).

4.1.1 Marine fish production

Seabass production rose from 250 tonnes in 1983 to the present 9 500 tonnes, which represents 94 percent of the entire seabass output (Table 14); extensive production also increased until after the mid- 1990s, and then decreased to about 600 t/year. A similar situation was also found for seabream (Table 14), where intensive production increased from 310 tonnes in 1983 to the current 7 800 tonnes. Intensive farming accounts for 87 percent of the total, although extensive productions, which exceeded the intensive output until the early 1990s, are still increasing. In regions where production of marine species is greater, the ratio between land-based units and sea-cage facilities is very close to 1, whereas in regions where aquaculture has a longer tradition (Veneto, Friuli Venezia Giulia, Toscana), production is achieved mainly on land-based farms. There are some sea-cage facilities that have still not achieved full production. The highest output (nearly 70 percent of the total) was obtained in Sicilia, Puglia, Sardegna and Toscana. As regards the Adriatic basin, the output for Veneto is 1 000 tonnes in land-based units and only 50 in sea cages; Friuli Venezia Giulia produces 350 tonnes in land-based units and 500 in sea cages which in total account for about 22 percent of the output.

Mullet culture involves five species (*Mugil cephalus*, *Chelon labrosus*, *Liza aurata*, *Liza saliens*, *Liza ramada*), which are mainly farmed in brackish waters using extensive techniques in lagoons and costal areas. Fry is obtained still captured in the wild, although recently successful reproduction trials have been carried out using semi-intensive large volume techniques. For more than 15 years the output has remained practically stable at around 3 000 t/year (Table 14). From the other marine species only sharpsnout bream, *Diplodus puntazzo*, production has been sufficiently consolidated while shi drum, *Dentex*, common seabream and dusky grouper farming is still only little more than at pilot stage. Sharpsnout seabream production began only in the late 1980s, with controlled reproduction experiments being performed on the common two-banded seabream (*Diplodus vulgaris*). Production was essentially intensive (both land-based and in sea cages) and after a substantial initial increment it practically doubled between 1996 and 2001, rising from 200 to 400 t/year, thus satisfying the limited market demand.

4.1.2 Freshwater fish production

Rainbow trout (*Oncorhyncus mykiss*) represents the most important intensively farmed fish in Italy. As early as 1983 Italian production had already exceeded 20 000 tonnes and a constant growth (over 10 percent per year) in output was observed until 1997. From 1998 onwards the output decreased to approximately 45 000 tonnes (Table 14). Other freshwater fish, such as carp and catfish are linked to the productive tradition of several geographic zones. Sturgeon represents an innovation on the national scene. Other autochthonous salmonid species such as *Salmo trutta*, *Salmo trutta marmoratus*, the northern pike *Esox lucius*, and the white fish *Coregonus lavaretus*, are important for restocking.

Eel production stands at 2 500 tonnes and is accomplished through intensive rearing techniques in recirculated systems, which reduce the duration of the production cycle and optimize survival at the early stages. The production trend (Table 14) shows how the contribution made by extensive farming gradually decreased to 100 tonnes in 2001. Over the same period intensive production grew, reaching its peak in 1999 (3 000 tonnes). The strong reduction in production over the past two years, down to 2 400 tonnes in 2001, is due to the strong competition from Central and Northern European countries rather than to the reduced seed availability. Originally, these countries were traditional importers of Italian products, but now their new closed-circuit hyperintensive facilities allowed them to be highly competitive.

Tab. 14. Trend of intensive and extensive aquaculture production (t) of marine and freshwater fish species from 1986 to 2001 in Italy (ICRAM-API, modified from Ingle *et al.*, 2002

Fish	**Culture system**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Seabass	Int.	450	530	600	600	1.055	1.378	1.836	2.150	2.900	3.150	4.000	5.200	6.600	7.500	8.900
	Ext	300	400	500	450	483	448	630	700	700	650	600	650	600	600	600
	Tot	**750**	**930**	**1.100**	**1.050**	**1.538**	**1.826**	**2.466**	**2.850**	**3.600**	**3.800**	**4.600**	**5.850**	**7.200**	**8.100**	**9.500**
Seabream	Int.	200	300	350	350	360	460	882	1.100	2.350	2.800	3.100	4.600	4.800	5.000	6.800
	Ext	350	450	500	500	605	610	645	750	850	850	800	900	900	1.000	1.000
	Tot	**550**	**750**	**850**	**850**	**965**	**1.070**	**1.527**	**1.850**	**3.200**	**3.650**	**3.900**	**5.500**	**5.700**	**6.000**	**7.800**
Breams	Int.										150	200	300	350	400	400
	Tot										**150**	**200**	**300**	**350**	**400**	**400**
Eel	Int.	2.700	2.550	2.500	2.200	2.095	2.010	2.020	2.100	2.300	2.650	2.700	2.900	3.000	2.600	2.400
	Ext	1.900	1.700	2.000	1.500	1.490	1.300	1.060	900	700	350	400	250	200	100	100
	Tot	**4.600**	**4.250**	**4.500**	**3.700**	**3.585**	**3.310**	**3.080**	**3.000**	**3.000**	**3.000**	**3.100**	**3.150**	**3.200**	**2.700**	**2.500**
Mullets	Ext/semin	2.900	2.685	2.500	3.000	2.880	2.942	2.892	2.900	3.000	3.100	2.900	3.000	3.000	3.000	3.000
	Tot	**2.900**	**2.685**	**2.500**	**3.000**	**2.880**	**2.942**	**2.892**	**2.900**	**3.000**	**3.100**	**2.900**	**3.000**	**3.000**	**3.000**	**3.000**
Trout	Int.	27.000	30.000	31.000	35.000	38.000	40.000	42.000	45.000	50.000	48.000	51.000	48.000	44.000	44.500	44.000
	Tot	**27.000**	**30.000**	**31.000**	**35.000**	**38.000**	**40.000**	**42.000**	**45.000**	**50.000**	**48.000**	**51.000**	**48.000**	**44.000**	**44.500**	**44.000**
Catfish	Int.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	1.800	800	400	800	700	750	550	650
	Tot	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**1.800**	**800**	**400**	**800**	**700**	**750**	**550**	**650**
Carp	Int.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	600	600	600	700	700	700	700	700
	Tot	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**600**	**600**	**600**	**700**	**700**	**700**	**700**	**700**
Sturgeon	Int.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	500	500	500	500	400	450	550	700
	Tot	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	**N.R.**	500	500	500	500	400	450	550	700
Other fish Other sparids, shy drum)		N.R.	N.R.	N.R.	N.R.	N.R.	**2.000**	**2.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**2.000**	**2.100**	**2.200**
Total marine fish		N.R.	N.R.	N.R.	N.R.	N.R.	**7.138**	**7.945**	**8.500**	**10.500**	**11.050**	**12.000**	**14.900**	**16.450**	**17.600**	**20.800**
Total freshwater fish		N.R.	N.R.	N.R.	N.R.	N.R.	**42.010**	**44.020**	**50.000**	**54.200**	**52.150**	**55.700**	**52.700**	**48.900**	**48.900**	**48.450**
Total fish		N.R.	N.R.	N.R.	N.R.	N.R.	**51.148**	**53.965**	**59.500**	**65.700**	**64.200**	**68.700**	**68.600**	**67.350**	**68.600**	**71.450**

4.1.3 Fingerling production

In the case of marine species, controlled reproduction systems have now attained a high level of reliability and production is focused mainly on seabass and seabream, allowing the national demand to be easily satisfied and a large number of fish to be exported. Seabass and seabream fry production has risen from just over 3 million juveniles in 1987 to over 90 million in 2001 (Table 15). In the 1990s seabass hatchery production satisfied the national demand and in 1995 that for seabream.

Table 15. Seabass and seabream juvenile production and the need over the period from 1987 to 2001. (ICRAM-API, modified from Ingle *et al.*, 2002)

Years	SEABASS			SEABREAM		
	Hatcheries production ($n \times 10^3$)	**Juveniles Need ($n \times 10^3$)**	**Gap ($n \times 10^3$)**	**Hatcheries production ($n \times 10^3$)**	**Juveniles Need ($n \times 10^3$)**	**Gap ($n \times 10^3$)**
1987	3 000	6 500	-3.500	400	5 400	-5 000
1988	4 000	6 300	-2.300	600	5 000	-4 400
1989	6 350	7 500	-1 150	1 850	5 000	-3 150
1990	6 450	7 600	-1 150	2 500	5 500	-3 000
1991	6 900	8 900	-2 000	4 050	7 000	-2 950
1992	9 000	9 000	0	6 450	7 000	-550
1993	20 400	14 000	6 400	15 037	14 000	1 037
1994	19 000	20 000	-1 000	11 200	15 000	-3 800
1995	21 500	22 000	-500	14 000	19 000	-5 000
1996	25 000	22 000	3 000	24 000	20 000	4 000
1997	33 000	22 000	11 000	28 000	21 000	7 000
1998	60 000	20 000	40 000	40 000	22 000	18 000
1999	62 000	20 000	42 000	46 000	22 000	24 000
2000	50 000	25 000	25 000	40 000	30 000	10 000
2001	50 500	26 500	24 000	40 200	31 200	9 000

Reproduction and larval rearing techniques have been set up for several new species such as dentex (*Dentex dentex*), common seabream (*Pagrus pagrus*), red pandora (*Pagellus erythrinus*), shi drum (*Umbrina cirrosa*) and dusky grouper (*Epinephelus marginatus*).

4.1.4 Mussel production

For more than a decade the output for Italian mussel has been the largest component of national aquaculture (Table 16). In spite of the gradual technological updating and modernization of the farms (long lines), during which most production units were shifted offshore, production has undergone slight variations, rising from 84 200 tonnes recorded in 1990 to 100 000 tonnes in 1994, and to the current 107 000 tonnes (Table 16). The productions based on an extensive exploitation of artificial barriers and the management of bottom mussel beds make only a modest contribution. However, output statistics take into account global production, adding to the farming output the quantity also gathered on natural beds. Observation of the data in Table 14 shows that the greatest fluctuations in global production are linked to the different fishery trends over the period (from a minimum of 11 000 to a maximum of 31 500 tonnes).

4.1.5 Clam production

For more than a decade, clam farming has represented the second-ranking Italian production and places Italy first in Europe with 55 000 tonnes. Production comprises almost exclusively the imported Manila clam (*Tapes philippinarum*), which has replaced the local clam (*Tapes decussatus*). Clam production which began around 1980, underwent a rapid increase starting in the mid-1980s until the early 1990s. Subsequently growth slowed down, although always remaining significant (the peak output of 60 000 tonnes was reached in 1996) and flattened out at around 50 to 55,00 tonnes in the last three years (Table 16).

Table 16. Trends in mussel and manila clam production during the period from 1990 to 2001, taking into account both farming and natural beds production. (modified from Prioli, 2001)

MOLLUSC		**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Mussel	Culture	90.000	84.500	90.000	100.000	105.000	105.000	103.000	105.000	106.000	110.000	107.000
	Banks	11.000	31.500	30.000	26.000	27.000	25.000	27.000	25.000	24.000	26.000	28.000
	Total	*101.000*	*116.000*	*120.000*	*126.000*	*132.000*	*130.000*	*130.000*	*130.000*	*130.000*	*136.000*	*135.000*
Manila clam	Culture	27.116	26.740	24.000	40.000	60.000	40.300	40.000	48.000	50.000	53.000	55.000
	Total	*27.116*	*26.740*	*24.000*	*40.000*	*60.000*	*40.300*	*40.000*	*48.000*	*50.000*	*53.000*	*55.000*
Total molluscs		***128.116***	***142.740***	***144.000***	***166.000***	***192.000***	***170.300***	***170.000***	***178.000***	***180.000***	***189.000***	***190.000***

4.2 Market

In 2001 the Italian aquaculture output increased by 1.5 percent, which is slightly under the European average of 3.5 percent, attaining about 260 000 tonnes (API/ICRAM estimates). Italy is a net importer of fish products. Italian aquaculture contributes to satisfying the domestic demand for fish products, accounting in 2001 for 42.9 percent of the fishery sector by volume, and for 25 percent in terms of value.

Italy is the reference market for fresh products for the entire Mediterranean basin. In recent years, the traditional exporting countries such as Spain, Portugal, France, Scandinavia and Argentina have been joined by Greece, Morocco, Egypt, Tunisia, and Malta. Significant reduction in market prices has occurred with increased market competition (Table 17).

For farmed marine species, in particular, the Italian market is also the largest at the European level. In 2001 the Italian Fish farmers Association (API) estimated a demand of about 80 000 tonnes, of which only 22 percent was covered by internal production. The figures in Table 17 show that the price of seabass has decreased by 24 percent, that of seabream by more than 33 percent and that of sharpsnout seabream by about 15 percent in six years. Italian farmers have reacted by diversifying the supply (e.g., by offering transformed products on the market) and by increasing the market size (400-800 g). With regard to commercial aggressiveness, in particular by Greece, protests have been lodged by producers' associations in France, Portugal, Spain and Italy. Trout production showed a long positive supply trend with a consequent difficulty in marketing the fresh product. Farmers responded to this difficulty by gradually reducing the global production and increasing product diversification with processed and semi-processed products having a higher added value. The unit price of trout in the past eight years has increased by over 60 percent, rising from € 1.81 in 1994 to the current € 2.94, although in 2001 it fell by 6 percent compared to 2000. Italy traditionally exported most of the eel production. Recently, however, competition from the Northern European countries and from Asian producers has led to a sizeable decrease in the value of the Italian output. The unit selling price, which reached a peak value of € 9.55 in 1997, has dropped by 35 percent. As far as other freshwater species (carp, catfish and sturgeon) are concerned there exists a niche for production on local markets. However, selling prices, which have displayed positive trends in recent years, could decrease rapidly if the quantities offered for sale were to increase. The same applies for new marine fish species (shi drum, common dentex, sole, Mediterranean amberjack, dusky grouper), for which there is as yet no consolidated production.

Table 17. Trends in production and prices of Italian aquaculture products from 1994 to 2001. (ICRAM-API, modified from Ingle *et al.*, 2002).

		1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Seabass	Prod (ton)	2.850	3.600	3.800	4.600	5.850	7.200	8.100	9.500
	Price (€/kg)	**8,26**	**7,23**	**7,23**	**7,23**	**7,95**	**7,24**	**6,71**	**6,26**
Sea bream	Prod (ton)	1.850	3.200	3.650	3.900	5.500	5.700	6.000	7.800
	Price (€/kg)	**8,26**	**6,71**	**6,71**	**6,71**	**6,95**	**6,71**	**6,46**	**5,50**
Sharpsnout seabream	Prod (ton)	-	-	150	200	300	350	400	400
	Price (€/kg)	-	-	**6,71**	**7,23**	**6,67**	**6,79**	**6,20**	**5,68**
Anguilla	Prod (ton)	3.000	3.000	3.000	3.100	3.150	3.200	2.700	2.500
	Price (€/kg)	**8,26**	**8,78**	**8,80**	**9,55**	**7,87**	**6,78**	**6,20**	**6,20**
Mullets	Prod (ton)	2.900	3.000	3.100	2.900	3.000	3.000	3.000	3.000
	Price (€/kg)	**3,10**	**3,10**	**3,10**	**3,62**	**3,62**	**3,44**	**3,36**	**3,36**
Trout	Prod (ton)	45.000	50.000	48.000	51.000	48.000	44.000	44.500	44.000
	Price (€/kg)	**1,81**	**1,81**	**1,81**	**2,07**	**2,80**	**3,04**	**3,13**	**2,94**
Catfish	Prod (ton)	1.800	800	400	800	700	750	550	650
	Price (€/kg)	**2,60**	**3,00**	**3,10**	**3,62**	**3,62**	**3,79**	**3,76**	**3,81**
Carps	Prod (ton)	600	600	600	700	700	700	700	700
	Price (€/kg)	**2,40**	**2,50**	**2,58**	**3,10**	**3,10**	**3,10**	**3,10**	**3,10**
Sturgeon	Prod (ton)	500	500	500	500	400	450	550	700
	Price (€/kg)	**5,00**	**5,00**	**5,16**	**6,20**	**6,20**	**6,20**	**6,20**	**6,20**
Mussel	Prod (ton x 10^3)	126.	132.	130	130	130	130	136	135
	Price (€/kg)	**0,52**	**0,52**	**0,52**	**0,52**	**0,57**	**0,57**	**0,59**	**0,59**
Manila Clams	Prod (ton x 10^3)	40	60	40	40	48	50	53	55
	Price (€/kg)	**2,07**	**1,72**	**2,07**	**2,07**	**2,07**	**2,07**	**2,58**	**2,58**

Euryhaline species are mostly marketed domestically and are usually consumed within Italy. A UNIMAR survey carried out in 2000 shows that 70 percent of farms prefer to sell through wholesalers, and 10 percent by the fish market, with peaks of 25 percent in the case of extensive farms which offer a high quality product that is probably highly appreciated. Only 28 farms out of 188 address foreign markets and only 6 of these exclusively. Organized large-scale distribution is used on average by 9 percent of the enterprises and never in the case of extensive productions. Direct consumer or restaurant sales are made by 5 percent of the enterprises. Transformation and added value is still used relatively rarely in the fish market.

Mussel production has been at a very high and stable level for over a decade. Production stability is reflected in the wholesale price which has increased only slightly (about 13 percent). The trend is different for the unit price of Manila clams which, after a long stationary period at around € 2.00/kilogramme has increased by nearly 30 percent over the past two years. The recent increase in clam prices is due to a renewed market appreciation of this mollusc in restaurants but also for home consumption, which increasingly turns to the large-scale distribution. Also a decisive influence is the growing role of Consortia in regulating the market supply. A small percentage of these enterprises do their own product packaging and marketing as they are equipped with cleansing centres. Over 90 percent of the remaining enterprises carry on exclusively the role of production and rely on external operators for their marketing needs.

The marketing of mussels deserves a separate treatment as, unlike other shellfish, they display comparatively high seasonal peaks. This is essentially the result of the often simultaneous and synergistic effect of several different factors (Rossi and Prioli, 2001): the farming technique used, the natural recruiting of fry, reproductive cycle progress and the product's organoleptic quality which varies as a function of the reproductive cycle. Consequently the majority of farms market their mussels in the period between May and September, while between November and February fewer farms market their products. Only in Veneto does the marketing season extend from March to September, while the regions with the shortest period are Campania and Emilia-Romagna, with the latter concentrating solely on the spring period. The primary outlet market is 56 percent domestic, while only farms located in Abruzzo, Emilia-Romagna, Friuli-Venezia Giulia and Marche address foreign markets directly.

According to EASTFISH statistics (2001), mussel importation in 1999 amounted to 34 478 tonnes. Consequently, Italy ranks second among the importing European countries following France and followed by Belgium and Germany (Rossi and Prioli, 2001). More than 34 percent of mussels are imported from Spain. Although there is no official data, the remaining 66 percent should be imported from Greece (40 percent), and from Ireland and Denmark (26 percent) (Rossi and Prioli, 2001).

According to the EASTFISH data, Italy exported 4 988 tonnes in 2001. A survey carried out by UNIMAR on a sample of a significant number of production enterprises estimated the exported quantity to about 11 000 tonnes, mainly to the French and Spanish markets (Rossi and Prioli, 2001).

4.3 Certification

A targeted marketing policy has been devised to provide the specific qualitative characteristics of the national product. A recent initiative was taken by the API through the adoption of a voluntary “Code of good practice of aquaculture farming” to guarantee to the consumer the national origin of the product and the adoption of responsible practices by the farmers, as far as the use of drugs, animal meal, product traceability and animal welfare are concerned.

Processes of product qualification to guarantee food safety and quality to distinguish it on the market have been undertaken, in particular by trout and marine species producers. Quality assurance systems that certify the organizational and management efficiency of the enterprise have been adopted by several intensive marine fish production plants (ISO 9001:2000).
EMAS aquaculture guidelines have recently been developed by ICRAM in collaboration with the National Environmental Protection Agency (ANPA) and provide farms with the necessary elements to understand the contents of the EMAS Regulations, thus facilitating their consistent application to the operating conditions of each individual farm. In this project three Italian farms were involved, and different production systems were certified**.** The EMAS objective is to promote the best management practices and to improve the transparency of productive processes that have an impact on the environment and the resource management. Obvious advantages derive both from the increased market competitiveness of the certified product and, in the case of any responsibility attributed to the enterprise, for harming the environment.

Pilot culture trials of seabass and seabream with organic methods were carried out in 2001/2002 as part of a national programme. An important contribution was thus made to establish specific EU regulations regarding aquaculture productions which should be introduced in the future.

5. Relationship with capture fisheries

The Three-year Aquaculture and Fisheries Plan has defined aquaculture in the broadest possible reference planning framework of the Italian fishery. Indeed, even if the intensive farming of aquatic species has many points in common with land animal raising, strong links still remain with the world of fisheries and the national planning of aquaculture and fisheries are thus considered jointly. The interactions between aquaculture and fisheries are more obvious for the activities taking place in coastal areas where they both share environment and resources. They have been considered at the administrative level when negative effects and local emergencies arise, but an integrated evaluation of the interactions between aquaculture and fisheries in which these elements can be considered as a whole is still lacking. Concrete initiatives regarding plans for the integrated coastal zone management, which include aquaculture and fisheries activities, have only recently been taken at the regional level, for example in the case of Emilia Romagna.
With reference to five arbitrary categories of aquaculture and fisheries interactions and to the conditions prevailing at the national level, the following examples are listed.

5.1 Environmental interactions

- Aquaculture activity as a tool for the conservation of biological resources for fishing activities;

An important example is extensive aquaculture in the Adriatic area, such as "valliculture" and productive lagoon management, and its strategic role in the conservation of sensitive coastal lagoon areas, ecosystems and thus biological resources for fishing activities.

- Aquaculture activity as a source of environmental pollution;

The intensification of production in the land-based units has led to conflicts, particularly in sensitive areas. An evident example is fish farming in the Orbetello Lagoon, where large-scale aquaculture activities are carried out together with lagoon fishing and tourism. Although it has been shown that aquaculture production units operate within the limits set by Law 152/99 regarding discharge into the environment, a finger has been pointed at aquaculture enterprises as being responsible for eutrophication of the lagoon and for the strong decrease in fish catch.
In the case of cage farms in protected areas, the release of nutrients from aquaculture production are considered responsible for eutrophization and pollution, which may have effects on the environment, ecosystems and fishery resources. In actual fact, the research implemented as part of the Fifth National Plan has shown that rearing cages are point-sized sources of environmental impact and that the ecological effects due to nutrient release are limited in the area under the cages

- Shared space with other coastal users;

Intensive fish farming of marine species in sea cages requires space in coastal areas that are also sought for other activities, including fishing and tourism.

5.2 Ecological interactions

- Spreading of pathogens and parasites to wild species by farmed species;

The farming of marine species may be a cause for the introduction and spreading of pathogens, which also affect the fishery resources. Examples are the *Nodavirus* and the *Pasteurella* spp., which were imported with aquaculture products in the Northern Adriatic and have spread to wild fish populations, especially seabass, seabream, sole and flathead. There is also some evidence that ecto- and endo-parasites of marine fish reared in cages are transferred to associated fauna.

- Risk of ecological and genetic impact on the natural populations as a result of farmed fish escapees

The escape of farmed fish from the sea-based facilities is hard to quantify. However it is not a rare occurrence judging by the requests made by the national Fishery Solidarity Fund to the MiPA (Law 72/92) regarding cages damaged by adverse weather conditions. Fish escapees may represent an ecological potential danger to fishery resources. However, these effects still have to be demonstrated, in particular those of a genetic type tending to reduce biodiversity, at least as far as the aquaculture species cultured in Italy are concerned.

5.3 Social interactions

- Aquaculture as an opportunity for the reconversion of fishermen

Aquaculture in lagoon areas has provided good opportunities for reconversion. One example is the introduction of the Manila clam (*Tapes philippinarum*), in the Upper Adriatic coastal environments, which has adapted to the local conditions and has become a resource which has revolutionized the productive configuration of the Northern Adriatic lagoon areas, with important social implications.

Tune farming will also ultimately become an important opportunity for the reconversion of fishermen. The involvement of fishermen in this type of aquaculture is essential in order to begin a process of domesticity which can offer opportunities for reconversion. It is possible that in the case of the tuna there are now more concrete opportunities for reconversion than there were several years ago in mariculture activities, which never materialized.

5.4 Productive interactions

- Active restocking and sea ranching;

The acquisition of controlled reproduction techniques for several farmed species, including threatened species such as the shi drum and the dusky grouper, provides an opportunity for active repopulation. By combining together fish farming and traditional fishery experiences, restocking can lead to interesting returns, when the conditions are suitable and a responsible approach is adopted. The experience acquired in MiPA-funded research has revealed the productive potential of restocking intervention in protected areas by artificial barriers and a positive effect on recruitment of important commercial species.

- Use of natural resources for aquaculture production;

As in the case of extensive aquaculture, which currently uses wild fry for restocking, at least as in the case of grey mullet, eels, tuna and shellfish.

5.5 Market interactions

The increase in aquaculture production in Italy (which now accounts for more than 40 percent of the output in the sector) determines the nature of fish supply offered to the market as well as prices for marine species. The relatively recent EU directive in labelling fish products (1 January 2002) allows a distinction to be made between the farmed and the fishery product, which generally enjoys a better market price. However, domestic consumption of fish products is increasingly focused on hyper- and supermarkets, which has an effect on fish product prices (ISMEA, 2003).

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A short overview of the status of aquaculture in Montenegro

Vesna Macic*

1. General background

The Republic of Montenegro is situated on the Western part of the Balkan Peninsula and covers an area of 13 812 km^2. Montenegro is bordered by the Republic of Serbia (135 km) on the North, by Croatia (14 km), Bosnia and Herzegovina (225 km) on the West and by Albania (172 km) on the East. The length of its coastline is 293.5 km and comprises numerous beaches (73 km in length), approximately ten islands, two lagoons and the large Boka Kotorska Bay. Montenegro is divided into 21 communes, 1 256 localities and has a population of about 700 000 inhabitants. General data regarding the country are reported in in Table 1.

Table 1. General data on Montenegro.

Total land	13 812 km^2
Coastline	293.5 km
Lakes and reservoirs	355.16 km^2
Rivers (more than 40 km in length)	636 km
River basin area	12 127 km^2
Population	about 700 000
GDP Serbia and Montenegro (without Kosovo) 2000	$US 8 670
GDP Serbia and Montenegro (without Kosovo) 2000 *per caput*	$US 1 035

Historical documentation confirms that fish and some representatives of the mollusc family and crustaceans have been used as food for many years, especially in the coastal area of Montenegro. However, these were primarily organisms caught or collected in their natural habitat, although there are indications that there was also some kind of primitive husbandry of oysters and mussels. Due to the specific conditions of abiotic and biotic factors in the area of Boka Kotorska Bay, this coastline differs from that in the open part of the Adriatic, and due to its richness and diversity of wildlife, it has been so far the one most studied. Although edible shellfish represented a very interesting object for study, because of their economic value, intensive studies have been undertaken. In 1966 mussels started to be industrially farmed in Boka Kotorska, Kukuljina and Tivatski Bays (Stjepčević, 1974). Although oysters were also popular as food, they were not accepted as a suitable farmed product as there was not enough fry in Boka Kotorska Bay, and it was too difficult and expensive to repeatedly import the product from other areas (such as Malostonski Bay in Croatia) (Stjepčević, 1967).

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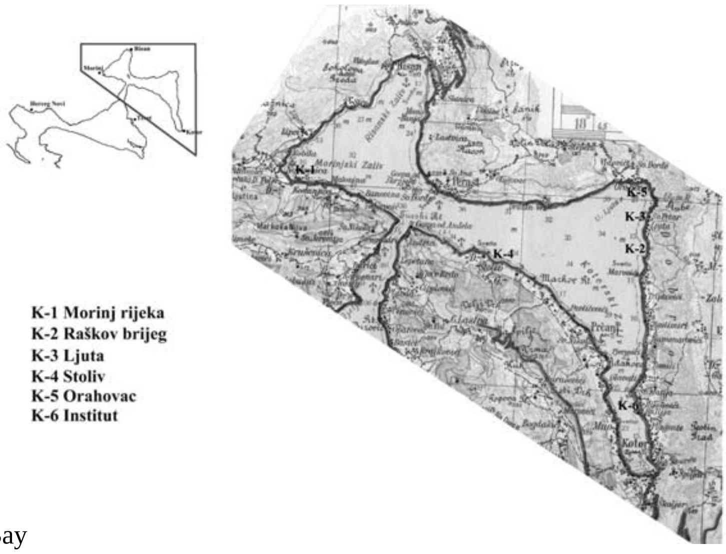
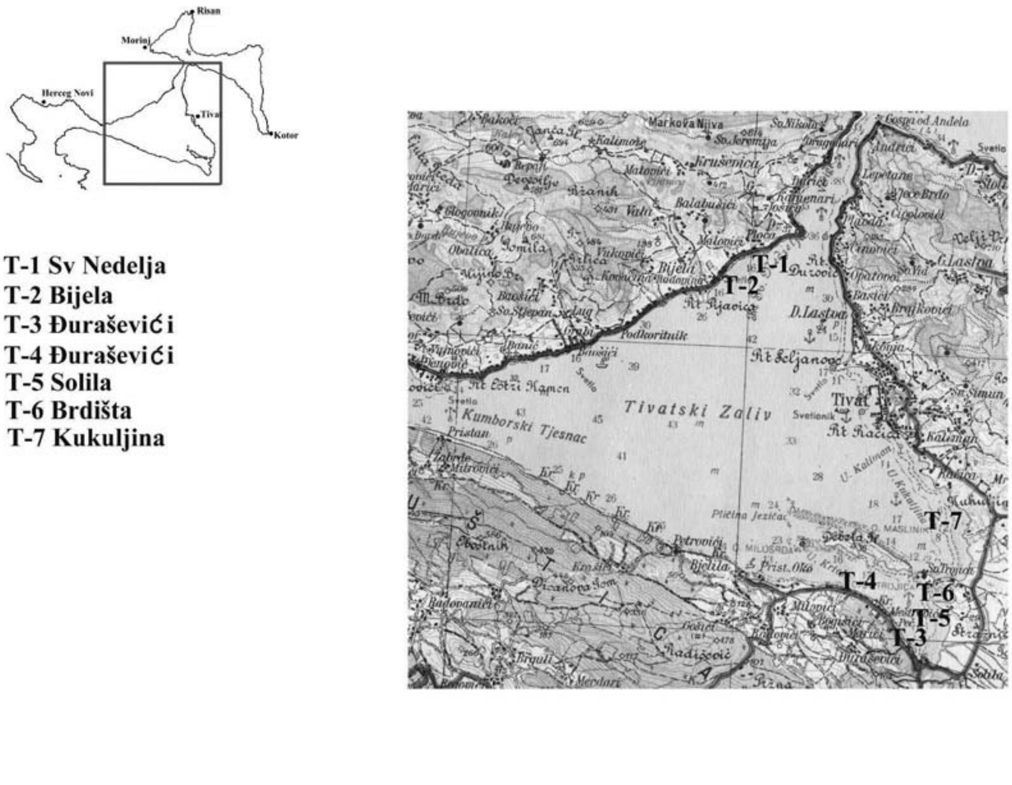
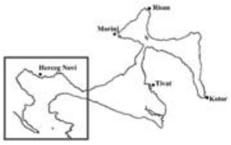
Currently there are 12 mussel farms in Montenegro and these are all situated in Boka Kotorska Bay. Their distribution and size are reported in Figure 1 and Table 2.



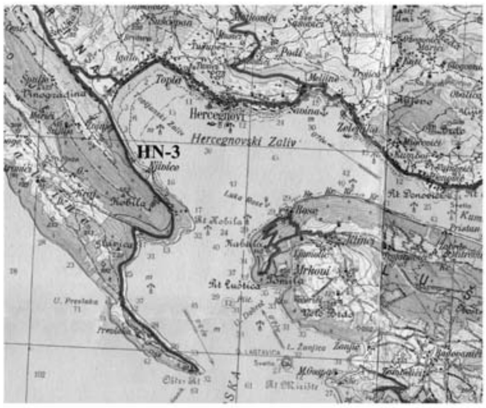
A) Kotor-Risan Bay



B) Tivat Bay



HN-3 Njivice



C) Herceg Novi Bay
Figure 1. Mussel farms in Boka Kotorska Bay.

Table 2. Mussel farms in Boka Kotorska Bay.

	Zone	**Name of locality**	**Surface of aqua-zone**	**Purpose**	**Beneficiary**
HN1	II	cape Sv. Nedelja	8000m^2 I faze 1500 m^2 IIfaze	Farming of mussels	Perović Predrag
HN2	II	cape Sv. Nedelja	20000 m^2	Farming of mussels	Svilanović Slavo
HN3	I	Njivice	20000 m^2	Farming of mussels	Pop Miroslav
KO1	II	Kostanjica	11700 m^2 I faze 29900 m^{2}II faze	Farming of mussels	DOO Larry and Brothers Company
KO2	II	Ljuta, Raškov brijeg	13200 m^2	Farming of fish and mussels	Company Cogi doo
KO3	II	Stoliv	600 m^2	Farming of mussels	Company Una doo
KO4	I	Orahovac	8000 m^2	Farming of mussels	Krivokapić Sreten
TV1	I	Solila	55510 m2 faze A 7840 m^{2}faze B	Farming of mussels	Dubravčević Danijel
TV2	I	Solila	1250 m^2	Farming of mussels	Peričić Dragan
TV3	I	Solila	10000 m^2	Farming of mussels	Dubravčević Zorica
TV4	I II	Solila Brdište	30000 m^2 12500 m^2	Farming of mussels	Company Enex
TV5	II	Kukuljina	21000 m^2 faze A 20000 m^2 faze B	Farming of mussels	Company Putača

It must be noted that there are also several farms that do not possess a licence to carry out this activity, but these are only very small private farms. In the plan of locations where mariculture may be undertaken, there are approximately ten localities in Boka Kotorska Bay and several others in the open sea. As suggested by the Institute of Marine Biology in Kotor the planned locations for mariculture of mollusc should be within the Bay, while fish farming should be in the open sea. This is suggested because Boka Kotorska Bay is a naturally rich area, partially eutrophied, with weak water circulation, so fish farming in such a zone could additionally threaten the survival of existing ecosystems.

On the Montenegrin coast there is only one fish farm within the Boka Kotorska Bay in the locality of Ljuta. In this farm since 1998 seabream *(Sparus aurata)* and seabass *(Dicentrachus labrax)* have been reared, with an annual production of 20 tonnes. There are also 20 freshwater fish ponds which rear trout, mostly located in the regions of Podgorica, Bijelo Polje and Nikšić. Some fish ponds are about 25 to 30 years old, 18 of them are in the private sector and 2 are mixed owning (public and private property). Herewith below is a map of Montenegro (Figure 2) showing the localization of fish farms.

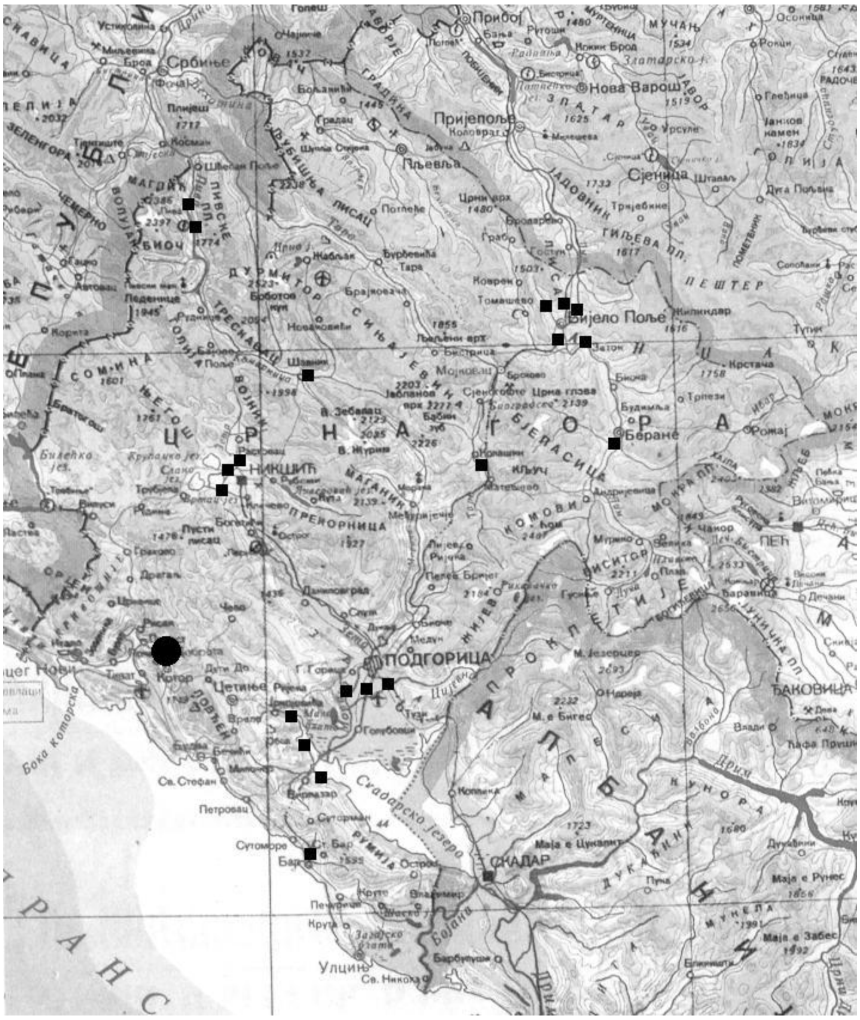


Figure 2. Map of Montenegro showing the localization of fish farms (• sea water ■ fresh water).

2. Characteristics of the sector

The first experimental parks led by the Institute for Marine Biology in Kotor were made in Boka Kotorska Bay (1966) in three localities: Orahovac, Morinj and Kukuljina, composed of overhanging wreaths (for oysters) and a series of stage sifters (for mussels) (Stjepčević, 1974). Pillars and horizontal holders in the parks were made of railroad rails F 18 kg l/m. In each of the three localities there were two experimental parks (a=5x20m) for farming of oysters and mussels, respectively. Each experimental park had four beds (Figure 3). In these parks, mussels were successively introduced in a series of stage sifters made of plastic and equipped with lids. The dimensions of a single sifter were 50x50x15 cm. Mussels were introduced in three-monthly intervals (from May 1966 to March 1967) and during each interval six series of stage sifters were planted (a single series contains three sifters on different depth levels of 0.5, 1.5 and 2.5 m respectively**.** In each locality, in all four beds within the experiment**,** a total of 21 600 individual mussels were placed. The mussels used for experiment were collected in the Bay, within autochthonous populations. One hundred mussels of an average age between 18 to 20 months and length of 30-40 mm were introduced in each sifter (Stjepčević, 1973). Due to the specific conditions in the area mussel farming and the overall process of production was carried out in two phases: Phase 1 included capturing and farming of the spat; and Phase 2 was placing the spat in wreaths and farming it to market size. Some of the results of this experiment are shown in Tables 3, 4, 5 and 6.

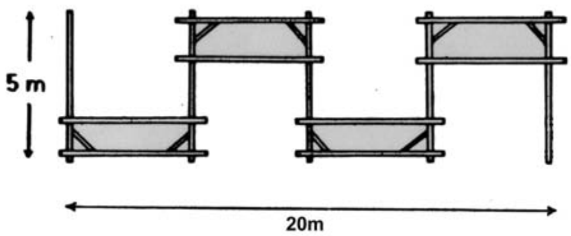


Figure 3. Schematical representation of a park for mussel and oyster farming (viewed from above).

Table 3. The results of breeding mussels in Orahovac.

ORAHOVAC	No. Pieces/100g	Mean weight of biomass (g)
I seedling	8.7	11 378
II seedling	10.8	9 218
III seedling	12.8	7 772
IV seedling	11.3	8 820

Table 4. The results of breeding mussels in Morinj.

MORINJ	No. Pieces/100g	Mean weight of biomass (g)
I seedling	10	9 919
II seedling	11.5	8 659
III seedling	10.8	9 231
IV seedling	15.6	6 404

Table 5. The results of breeding mussels in Kukuljina.

KUKULJINA	No. pieces/ 100g	Mean weight of biomass (g)
I seedling	26.5	3 766
II seedling	25.6	3 900
III seedling	23.5	4 242
IV seedling	27.9	3 573

Table 6. Some nutritive values for mussels in Boka Kotorska Bay.

Mussels	H_2O	Dry weight	Glycogen	Lipid	Protein
ORAHOVAC	77.84%	22.15%	4.53%	4.51%	11.2%
KUKULJINA	80.68%	19.31%	2.90%	3.05%	11.18%

The area chosen for experiment presented good conditions for industrial farming of mussels. Areas within Boka Kotorska Bay such as: Kukuljina and Krtole (within Tivat municipality) and northwestern part of Risan (within Kotor municipality) are favoured for this purpose as well. Kukuljina zone spreads on 428.2 ha, and at least 70 ha are suitable for stationary type of oyster and mussel breeding. Krtole zone spreads on 231 ha and for this type of oyster and mussel breeding at least 60 ha of sea surface is required. The paper by Stjepčević (1974): Ecology of Mussel *(Mytilus galloprovincialis* Lamk.) and Oyster *(Ostrea edulis* L.) in Cultures of Boka Kotorska Bay, points out that the capacities of the Bay are such that it could become one of the biggest mussel production centres in the Adriatic.

It is estimated that the possible quantity of farmed mussels in Boka Kotorska Bay is about 100 t. However, there is no control of the quantity of farmed mussels even in the official farms**.** The reason for this is that there is neither a depurification centre nor any other collecting point, and the products are therefore either sold directly in the farming localities and local markets or sent to markets in Serbia. Besides the lack of evidence regarding mussel production, there is also no adequate sanitary control. Microbiological controls of the seawater in farming localities are usually carried out by the Institute for Marine Biology whilst those relating to the presence of parasites or harmful material are most irregular.

From the experiments made in each of the three above-mentioned localities in Boka Kotorska Bay in 1966, one park was reserved for oysters which were introduced and cemented on wreaths made of coconut fibre. Phase 1 included catching the fry on bunches of stalks; Phase 2 was the processing of bunches and forming wreaths with separated branches; and Phase 3 was the removal from the branches, cementing and weaving into definitive wreaths. On wreaths with separated branches (Phase 2), 14400 specimens of autumn fry (40 mm in length) and 7200 specimens of spring fry were selected for cementing. During the whole experiment 21600 specimens were introduced. From this group, 180 wreaths with cemented oysters were formed for analyses in monthly and bimonthly intervals for all three localities (Phase 3). Each inhabited wreath was 2.5 m long with 120 specimens of cemented oysters. Some of the results of this experiment are shown in Tables 7 and 8.

Table 7. The results of breeding oysters in Boka Kotorska Bay.

Oysters (30 month old)	No. Pieces /100g	Mean weight (g)	Mean weight of biomass (g)
ORAHOVAC	14.2	46 871	7.025
MORINJ	15	44 692	6.730
KUKULJINA	20.4	37 047	4.904

Table 8. Some nutritive values for oysters in Boka Kotorska Bay.

Oysters	H_2O	Dry weight	Glycogen	Lipid	Protein
ORAHOVAC	79.2%	20.7%	6.1%	1.7%	10.2%
KUKULJINA	80.5%	19.45%	5.5%	1.5%	9.3%

From this experimental farming (1966), it was ascertained that the greatest vermin were the sea stars (Asteroidea) (Stjepčević, 1974). They grouped together on the sea bottom near to the sea beds, in greater quantity than in other places. This can easily be explained by the fact that during farming a small number of mussels and oysters fall off the stage sifters and wreaths. During the work in the parks in Orahovac and Morinj, the wreaths with cemented oysters were sometimes overgrown with mussels and therefore became rather heavy (more than 65 kg), detaching themselves from the holders and falling down to the sea bottom. After only 3 to 4 days one of these wreaths was retrieved and about 80 percent of the mussels had been eaten, mostly by the sea stars. Apart from this, sea stars were often found even in stage sifters where mussels had been farmed. It is assumed that it was actually plankton larvae of the sea stars that got into the sifters and developed there, as some of them were smaller than those found on the sea bottom under the parks. Fortunately, there were only 11 similar cases in all three localities. However, within the farming system based on wreaths, sea stars cannot make a greater damage than that already mentioned, except in cases when they are very numerous and can destroy oyster fry on the stems as well as on the natural beds of these organisms. It is estimated that one medium-size sea star can destroy at least 5 one-year old oyster daily. Therefore, if it is active for 7 to 8 months a year, each sea star destroys at least about 1 200 oysters.

In the experimental farming it was recorded that certain representatives of Gastropoda (*Murex trunculus* L., *M. brandaris* L., *Ocenebra erinacea* L.*)* may also provide damage. However, more damage is observed if the sifters are placed on the sea bottom, while in industrial farming of mussels and oysters they almost present no danger. Other destructive species worth mentioning are several species of fish (*Trygon pastinaca, Chrysophrys aurata, Pagrus vulgaris, Charax puntazzo* and *Sargus rondeletii*), but the damage which may occur is much less. Also small indirect damage may be caused by sea urchins (the edge of cemented oyster's shell can be eaten away by urchins) (Stjepčević, 1973).

Another serious problem encountered in experimental farming in 1966 and 1967 was epibionts that mostly grow on mussel and oyster shells, depriving them of food. These epibionts also can eat significant quantities of mussel's and oyster's larvae and in that way disturb the full capacity of their development (Stjepčević, 1974). It was a regular occurrence that a mass growth on oysters leads to a high mortality rate. For example, on wreaths with cemented oysters that remain in parks for more than 12 months, the mortality rate was up to 85 percent (especially in the localities of Orahovac and Pririnj). On the experimental areas, mussel was primarily a main competitor of food for oysters, although both have many common competitors such as some Ascidians, various Bivalvia, certain Porifera and numerous Polychaeta worms, Cirripedia and Algae (Stjepčević, 1974).

During the three years of study (from 1968 to 1970) there were three recorded representatives of parasitic fauna for the studied mollusc species on the experimental farms in Boka Kotorska Bay (Stjepčević *et al*., 1978). With respect to mussels, there was a greater quantity of hydroid polyp *Mytilhidra (Eugymnathea) polimanti* Cerruti, recorded for the first time in the Adriatic**.** According to the research, this parasite was introduced in 1967 when the owner of a mussel farm in Kukuljina imported 900 kg of mussel fry from Tarant Bay in Italy in order to determine their quality. The individuals were introduced immediately after import, without prior controls, and grew to market size (12-18 months). It is assumed that during this process, a parasite *Mytilhidra polimanti* was introduced together with the mussel fry, and later spread throughout Boka Kotorska Bay, where it became very dangerous for the natural survival of mussels. On oysters in all three localities there was a parasitic annelid *Polydora hoplura* Claparede, which was also the first record for this part of the Adriatic. It should be noted that at the beginning of the oyster farming experiment, fry was imported from Malostonski Bay (Croatia) in large quantities (e.g., 100 stems – with 1 500 to 2 500 individuals on each stem). The reason for this is due to the fact that the natural oyster beds in Boka Kotorska Bay were very degraded and the quantity of fry was insufficient; so several hundred sexually mature specimens were imported. It may be assumed that even before the introduction of the fry and sexually mature specimens from Malostonski Bay, the parasitic polichaete P*oydora hoplura* was already present in the natural beds in Boka Kotorska Bay, but the introduction of the new specimens also contributed to its further spreading.

In 1998, with the agreement of the Ministry for Agriculture and Water Industry,the private fish farm in Boka Kotorska Bay imported from Italy 30 000 specimens of seabream and seabass fry. It was also agreed that a further 600 kg or 200 000 specimens of fry would be imported but that quota has not yet been fulfilled. The annual import of fish fry until 2003 is shown in Table 9.

It should be noted that in Montenegro there are no proper conditions for a complete control of imported goods. However, veterinary experts take samples and control specimens in order to determine the possible presence of parasites and vermin, but there are no conditions for quarantine keeping of imported fry for a period of 21 days. Therefore, an agreement by the the Ministry in 1999 to import fish fry included the obligation for the owner to hold the fry for 21 days in his own isolated basins on land. If within that period there was no disease signs or outbreaks, fry could be transported in cages located at sea.

Table 9. Import of fish fry per year.

Year	Imported quantity (Number of specimens)
1999	10 000
2000	25 000
2001	21 000
2002	21 000
2003	35 000
Total	112 000

This fry had been farmed with the help of imported fish food that had passed a regular custom control. The specimens that reached the commercial size were taken either to Montenegrin markets or exported, mostly to Serbia. Control of these products, both in import and export, is carried out by the National Institute for Health and the CETES Centre for Ecotoxicological Research. There is no information available on import and export data principally because they are not classified.

Regarding freshwater fish farming, there are 20 ponds in Montenegro (Figure 2), 18 of them in the private sector and 2 are mixed owning (public and private owning). The projected capacities of these ponds are about 700 t of trout per year, however so far only 450 t/year has been achieved. The reasons for such a small production when compared with the planned capacities are primarily due to lack of funds and also to the fact that some of the ponds are 25 to 30 years old and have old facilities which can cause the loss of product due to poor water management. Also, the limited size of freshwater fish markets and strict export regulations, make investing in freshwater fish farming risky.

3. National policy

Fisheries and mariculture come under the auspices of the Fisheries Department of the Ministry for Agriculture and Water Industry of Montenegro. A specific national mariculture development plan has yet to be developed. Some basic principles for sustainable and responsible mariculture have been established in the new law on marine fisheries. Until October 2003 there was a legislative framework from the year 1992, but now a new law on marine fisheries has been accepted (Služ. List, 2003). Some of its characteristics that influence mariculture will be presented. Mariculture, following the new law, primarily includes controlled reproduction and farming of fish and other marine organisms. This activity is allowed to industrial companies and businesses that have registered for that activity, and who have qualified personnel at expert level for this type of farming, or are qualified at expert level themselves, and must fulfil the technological conditions of farming. The Ministry for Agriculture and Water Industry determines the locations and conditions for the establishment of fish farms and other marine organisms, with the application of an adequate technology of farming, after suggesting appropriate scientific institutions and agreement by the Ministry of Marine Transport, Ministry of Health and Ministry of Environmental Protection and Spatial Planning. If for the use of some locations it is necessary to use the sea coast, there should be an agreement from a public firm "Morsko Dobro", and for the use of the location for mariculture activities a concession fee must be paid. Also, in order to get contracts for fish farming, environmental impact assessment should be performed (the improvement of legislative framework currently is in process.) Farming of marine organisms may be carried out only in locations where a specific contract has been stipulated for the farming of fish or other marine organisms that are cited in that contract. Locations of farming must be properly marked, and fishing is forbidden within the zone of 100 m from the marked position of the farm. Also approach to the farm from the sea, within the zone less than 50 m from the marked area, without permission, is forbidden.

4. Production and market

In Montenegro neither fishing nor mariculture is much developed, and statistical data are not well organized**.** One of the reasons for this is the inefficiency of the old fisheries law**,** mainly due to inappropriate penalty regulations.

Appropriate data for employees, and marine crafts in marine fishing, are accessible but for the mariculture sector there are no data available. According to the Statistical office, catches and production of marine fish, crustaceans, shells (bivalves) and other molluscs from 1992 to 2001 are shown in Table 10. Accordingly, the same office in the year 2000 showed a gross domestic (material) product by establishment principle for FR Yugoslavia were 348 887.5 million dinars and for Montenegro 33 498.7 million dinars. From that amount fishing in FR Yugoslavia contributes with 119.0 million dinars and in Montenegro with only 15.0 million dinar (Statistical Yearbook of Yugoslavia, 2002).

Table 10. Catches and production of marine fish, crustaceans, shells and other molluscs from 1992 to 2001 (in kg).

Year	**Total**	**Pelagic fish**		**Other fish**	**Crustaceans**	**Shells**	**Other molluscs**
		Total	of which sardine				
1992	**225 547**	113355	74 460	96042	1 840	5 625	8 685
1993	**286 494**	130396	67 850	114280	10 925	8 555	22 338
1994	**263 536**	112324	57 970	123965	6 325	3 585	17 337
1995	**374 180**	151095	56 680	173560	14 649	7 520	27 356
1996	**383 175**	131135	41 760	207335	10 730	1 990	31 985
1997	**373 152**	128430	45 190	199270	10 182	2 375	32 895
1998	**416 569**	149980	48 960	215117	12 652	2 890	35 930
1999	**431 347**	164882	49 430	215540	9 880	3 735	37 310
2000	**431 358**	146313	35 935	229835	13 145	3 200	38 865
2001	**445 310**	150685	27 625	236475	15 665	2 285	40 200

Fish import and export data in Montenegro are presented in Table 11. It is evident that EU import barriers cause very weak export which means that the total fish production is sold on the domestic market. Due to an increase in tourism there has been a bigger request for sea products, but the present market in Montenegro is unable to supply this heavy demand for mussels. Regarding other fish products, the evaluation of seabass and seabream farming are 20 t/year (one part is exported to Serbia). Since 2003, 18 tonnes of trout were exported to Serbia, 9 to Kosovo and 11.5 to Bosnia and Herzegovina.

Table 11. Fish import/export data in Montenegro for 2001 (thousands. $US).

	Export	Import
Total	177 960	529 409
Fish	4	1 862

At present there is only one factory for the partial processing of freshwater fish products, but as its capacity is insufficient and the fish are still not popular on the market, this adds another difficulty in fish farming. Disorganized processing and trading, are usually the main reasons for high prices. Also, this is one of the reasons for a low *per caput* fish consumption (non-official estimate is less than 2 kg/year).

Labelling and eco-labelling certifications of aquaculture products are non-existant, but the responsibilies for the control of these products lies with the Ministry of Health and the CETES Centre for Ecotoxicological Research.

5. Relationship with capture fisheries

There is little knowledge available on interactions between aquaculture and capture fisheries. Probably this is because of the concentrated aquaculture areas in the limited zones of Boka Kotorska Bay. Marine aquaculture has shown a great expansion over the past few years and because of the environmental friendly policy the choice of sites for mariculture is becoming more important and probably the main interactions between these activities will be in competition for space. However, not just interactions between mariculture and capture fisheries but also between tourism, urbanization and other activities are playing an important role in occupying the coastal zone. Because of this the integrated coastal zone management is necessary for the sustainable development of aquaculture.

As mariculture is a new activity in Montenegro, some of the research carried out by the Institute for Marine Biology in Kotor, is directly connected with the possibilities of capture fisheries development.

The first is (together with the Federazione Italiana Maricoltori-Trieste (Italy)) the monitoring of mussel growth in the experimental park near the Institute (Kotor Bay). For the past two years, this park has been modernized with new floating devices that now support two rows of longitudinally placed ropes, which in turn hold the dangling stems. Therefore, it is possible to compare these results with those from former years when another way of farming was used.

However, during the period from 1999 to 2002 there was an intensive study on fish fry for some economically important fish species like: *Mugil cephalus, Chelon labrosus, Liza ramada, Liza aurata, Liza saliens* (Mićković, 2000, Mandić *et al.*, 2003, Mandić *et al.*, 2004.). Regarding that in Montenegro there is no artificial production of fry, possibilities for commercial farming also includes the determination of areas suitable for the capture of certain species of fry. But this is just possibility for now, and for eventual future sustainable utilization more investigations are required.

The characteristics of the life cycle of eel (*Anguilla anguilla* L.*)* were also studied in order to enable a proper estimate of the resources and to sustain and enhance its culture (Hegediš, *et al.*, 1996, Hegediš *et al*., 2001).

“Development of new technologies in marine industry of food and pharmacy products” is a part of the strategic developmental program of Institute of Marine Biology in Kotor, with a goal to accelerate development of aquaculture in Montenegro. For that purpose an experimental floating cage was set up in order to determine possibilities of farming rainbow trout in brackish waters of Boka Kotorska Bay. Results and measurements during the six-month period 2001/02 showed that the growth of rainbow trout is much greater in the sea conditions than in freshwater fish farms or in floating cages on Skadarsko Lake (Kljajić, *et al.*, 2002).

To conclude, nowadays in Montenegro freshwater fish farming is developed on average level, while farming of sea fish is almost non-existent so there is no conflict between aquaculture and fishery.

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Annex 1: List of Institutions involved in Aquaculture Research Activities

1. Ministry for Agriculture and Water Industry (Podgorica)
2. Ministry of Environmental Protection and Spatial Planning (Podgorica)
3. Institute for Marine Biology (Kotor)
4. Republic Institute of Health (Podgorica)
5. CETES Center for Ecotoxicological Research (Podgorica)
6. Public Firm "Morsko Dobro" (Budva)
7. Center for Environmental Protection (Podgorica)
8. Office for the Consultation of Mariculture Activities (at Institute of marine biology Kotor as result of Cooperation between the Italian Region (Friuli-Venezia Giulia), Federation of Italian Mariculturists (Trieste) and the Institute of Marine Biology (Kotor)).

A short overview of the status of aquaculture in Slovenia

Mitja Kadoič*

1. General background

1.1 Geography, climate and population

Geography
Slovenia became independent in 1991 and from 1 May 2004 will be a member of the Europen Union (EU). The country is divided into 193 municipalities, but in the near future between 5 and 13 administrative regions will also be established.

Slovenia is situated at the crosspoint between Central Europe and the Balkan Peninsula (Figure 1). Its surface area is 20 273 km², from which 63.3 percent is covered by forests, 30.5 percent by agricultural areas and 0.7 percent represent inland waters. The remaining area comprises roads, railways and barren land. Slovenia borders on the North with Austria (330 km in length of which 79 km border on rivers); on the East with Hungary (102 km in length of which 13 km border on rivers); on the West with Italy (280 km in length of which 31 km border on rivers and 48 km border the sea) while the South has the longest border of 670 km with Croatia (290 km border on rivers but the sea border has not yet been defined).

Slovenia has quite an heterogeneus topography covering a relatively small surface area. On the east side where the land is flat intensive agriculture takes place. The north/east, central and southern part has hilly areas and the north/west covers mountainous areas (the Alps) while the south/west with the Karst has a short coastline (46.6 km).

Climate
Being placed between the Adriatic Sea on the south/west, the Alps on the north/west, the Dinaric hills on the south and the Pannonian land on the east, Slovenia has a heterogeneous climate. The climate experienced is continental in the eastern and central boundary; alpine in the north/west; and submediterranean in the south/west. Data are presented in Table 1. All data can vary significantly as there are differences in microclimate also within regions.

In the last decade, weather conditions changed rapidly. There were several years when a dry, hot and long summer was experienced. Dry and hot summers can also have a big influence on freshwater aquaculture. Salmonid rivers become too warm (in extreme conditions the water temperature can also reach 24 °C) and the water flow can decrease drastically. These unforeseen circumstances can cause serious problems in salmonid breeding. Farmers have big losses due to lack of growth and mortality because of the high water temperature. Difficult

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weather conditions can have a negative influence even on the breeding of carp and other cyprinids.

Figure 1. Map of Slovenia

Table 1. Average temperature, precipitation and humidity in different Slovenian Regions.

Region	Temperature (^0C)	Precipitation (mm/m^2)	Humidity (%)
East	11.2	750	78
Central	11.5	1 300	77
West/West	8.5	1 500	80
South/West	13.5	1 200	73

Source: Ministry of Environment, Spatial Planning and Energy – Environmental Agency of the Republic of Slovenia

Extreme high water temperatures in ponds can lead to lack of oxygen. On the other hand marine aquaculture is more affected by cold winters. Winters on the Slovenian coastline can be relatively harsh, and the water temperature can drop to –8°C and at worst for 2 months to even –10°C. In such low water temperatures the breeding of seabream can become problematic.

Population

According to the final data of the Census undertaken in 2002, the population in Slovenia was of 1 964 036 inhabitants. However, since the 1991 Census the population increased by 2.6 percent. The increase by 50 681 persons is the result of immigration from abroad (28 000 persons since 1991) and the legalization of residence of former Yugoslav citizens who already lived in Slovenia during the 1991 Census. This increase between the last two census had a negative result by 3 500 inhabitants.

Data regarding the population in Slovenia is shown in Table 2.

Table 2. Distribution of population by gender, urban, rural, coastal and inland and population density (inhab/km^2).

	1991	**%**	**2002**	**%**
Total Population	1 913 355	100	1 964 036	100
Man	923 643	48.3	958 576	48.8
Woman	989 712	51.7	1 005 460	51.2
Urban	971 502	50.8	997 772	50.8
Rural	941 853	49.2	966 264	49.2
Coastal	na	-	78 846	4.0
Inland	na	-	1 885 190	96.0
Density	94.5		96.9	

Source: Statistical Office of the Republic of Slovenia (SORS).

1.2 Land and water resources

Slovenia has many inland waters although these are not equally distributed around the country. Land and water resources are presented in Table 3.

From this data it is clear that in Slovenia inland freshwater aquaculture resources are more important than the short coastline.

Table 3. Land and water resources.

Item	**Area (km^2)**	**Length (km)**	**Capacity (km^3)**
Total land	20 256		
Coastline		46.6	
Lagoon area	-		
Lakes and reservoirs	53.43		0.35
Rivers and streams		26 989	

Source: Ministry of Environment, Spatial Planning and Energy – Environmental Agency of the Republic of Slovenia.

1.3 Selected economic and human indicators

After its independence in 1991 the Gross Domestic Products (GDP) drastically decreased, since its economy lost important markets in the former Yugoslav Republics. However, soon after the Slovenian economy started to improve and it began to focus more on the EU countries. During the past years, a loss was again felt in the southern markets on the Balkan Peninsula. From 1994 to 2000 the yearly GDP growth varied from 3.5 to 5.2 percent and in fact fell to 2.9 percent in the last two years. Table 4 reports some economic and human indicators.

Table 4. Selected economic and human indicators in 2002.

GDP ($US)	21 960 000 000 [a]
Agricultural GDP ($US)	590 168 000 [a]
GDP *per caput* income ($US/*caput*)	11 004 [a]
Human Development Index (year 2001)	0.881 [b]

[a] Source: Statistical Yearbook 2003
[b] Source: Human Development Report 2000-2003

1.4 Fish food consumption

Table 5 clearly shows that fish consumption in Slovenia is not high. Pork, beef and poultry meat are still preferred to fish. During the past few years there has been a slight increase in fish consumption and the trend for healthier food in general, is leading to an expected increase of aquaculture products.

Table 5. Apparent fish consumption and contribution of aquaculture.

	Production ('000 t)	**Total production ('000 t)**	**Exports ('000 t)**	**Import ('000 t)**	**Total supply ('000)**	**Per caput supply (kg)**
Capture fisheries (food fish)	1 774	3 035	0.604	7 792	10 223	5.21
Aquaculture	1 261					

Source: SORS

From the total fish consumption only 12.3 percent is produced by domestic aquaculture and the remainder is imported for the markets (Table 5). There are plenty of oppurtunities for aquaculture growth but there are also some limitations (e.g., short coastline, limited inland water resources, etc.) (Table 6).

Table 6. Main species and production systems currently in practice.

Common name	**Species**	**Production facilities**	**Market focus (export/domestic)**
Rainbow trout	*Oncorhynchus mykiss*	concrete raceways, earth ponds	domestic
Common carp	*Cyprinus carpio*	warm water ponds, accumulations	domestic
Seabass	*Dicentrarchus labrax*	Cages	domestic
Seabream	*Sparus auratus*	Cages	domestic
Mussel	*Mytilus galloprovincialis*	Trays	domestic

2. Characteristics of the sector

2.1. Historical data

Historical data regarding aquaculture in Slovenia dates back to the Middle Ages. Since then several documents have been published regarding freshwater aquaculture. Only ponds were used for extensive carp breeding (and other cyprinids) and fish was eaten by the affluent society and clergy mainly at special religious feasts.

Towards the end of the nineteenth century, more intensive aquaculture systems were introduced. In 1881, Professor Ivan Franke made his first artificial insemination of brown trout (*Salmo trutta fario*), which is considered the birth date of Slovenian aquaculture. A few years later he also started to work with rainbow trout (*Oncorhynchus mykiss*). Following this in the twentieth century aquaculture development slowed down, and although some large "cooperatives", owned freshwater farms (3 coldwater salmonid farms for rainbow trout breeding; and 2 warmwater cyprinid farms), a few small private farms were also created. After 1990 development increased, and in 1991 the Slovenian Government decided to actively invest in aquaculture products – mainly salmonid. A new advisory service for aquaculture was established, and financial support for farmers was obtained. The production of salmonids (95 percent of rainbow trout) doubled in only five years. On the other hand, because of unsatisfactory legislation, production of carp and other warmwater species began to stagnate. At the end of the 1980s and beginning of the 1990s marine aquaculture began on the Slovenian coast. In the mid-1980s a few small production units for molluscs (only *Mytilus galloprovincialis*) were established. Later in 1990 two commercial farms for seabream and seabass also started production, but unfortunately due to the strong international competition, production decreased rapidly.

Development of the different types of aquaculture farms in Slovenia had to be terminated by region, due to the difficulties encountered. In the north/east region called Prekmurje, the conditions for salmonid breeding are unfavourable and the same applies for warmwater breeding in the north/west and northern regions called Primorska and Gorenjska. In other regions such as Štajerska, Dolenjska and Notranjska salmonid and warmwater fish breeding are practised. Traditionally, people from different regions have different nutritional habits connected to natural sources – in Prekmurje and Štajerska carp and other cyprinids can be found, while in Primorska and Gorenjska mainly trout is reared.

Currently only four types of production can be found in Slovenia:

- coldwater freshwater species – rainbow trout and arctic charr
- warmwater freshwater species – carp, tench, pike perch, pike, catfish, etc.
- warmwater marine species – seabass and seabream
- marine molluscs.

As mentioned previously, dating back to the Middle Ages extensive carp breeding was first developed in ponds. Much later at the end of the nineteenth century carp production in semi–intensive ponds was developed. Warmwater fish breeding in the twentieth century was mainly undertaken in the Štajerska region and on a much smaller scale in the Dolenjska and Notranjska regions. At the end of the 1980s and beginning of the 1990s it seemed as though warmwater fish farming would achieve a higher intensive level of production. As mentioned before, unsatisfactory legislation created an atmosphere where farmers either did not want, or were not able to invest in new technologies and new farms. Therefore, the present day production of warmwater species has begun to stagnate.

However, production of salmonids has a much shorter history. It started at the end of the nineteenth century with semi-intensive production in earth ponds and continued until the 1970s, when a new technology in concrete ponds and the use of complete dry feed for salmonids was slowly introduced. Later in the 1980s and more specifically in the 1990s better facilities were based on concrete raceways and several other ponds were also converted from earth to concrete. Because of the limited number of water resources suitable for the production of salmonid, small- and medium private farms were built (small farms with a capacity of 3 to 15 t/year whilst medium farms with a capacity of 15 to 50 t/year). Only a few farms were constructed with an annual capacity of more than 50 tonnes.

The latest production is marine aquaculture, which never reached great importance at the commercial level. Because of limited natural resources (short coastal area) marine aquaculture has never had a real basis for fast growth. Farms for molluscs and fish are located in the same basin (Piran Basin), where molluscs are produced in a standard manner and fish are cultured in cage systems.

2.2 Aquaculture systems

Aquaculture statistics are recorded by the Statistical Office of the Republic of Slovenia (SORS). In these official statistics freshwater aquaculture is always divided into fish farming for human consumption and for re-stocking and angling. Present day market production for human consumption is mainly carried out by private farms, since production for re-stocking and angling is further divided between the private farms and farms run by local fishing associations and the Fisheries Research Institute of Slovenia.

Slovenia aquaculture can be divided into:

1) freshwater aquaculture, which is further divided into:
    a) warmwater fish farming
    b) coldwater fish farming
2) marine aquaculture is also further divided into:
    a) fin fish
    b) shellfish

1) <u>*Freshwater aquaculture*</u>

a) Warmwater fish farming

Several species are reared in warmwater fish farming. Most important for human consumption and for angling purposes, is the production in polyculture of the following species:

- Carp (*Cyprinus carpio*)
- Grass carp (*Ctenopharyngodon idella*)
- Silver carp (*Hypophthalmichthys molitrix*)
- Bighead carp (*Aristichthys nobilis*)
- Pike (*Esox lucius*)
- Catfish (*Silurus glanis*)
- Pike perch (*Stizostedion lucioperca*)
- Tench (*Tinca tinca*).

However on a smaller scale the following species are present as polyculture by-products:

- Prussian carp (*Carassius auratus gibelio*)
- White eye bream (*Abramis sapa sapa*)
- Bleak (*Leuciscus cephalus cephalus*)
- Babusca (*Rutilus rutilus carpathorossicus*)
- American catfish (*Ictalurus nebulosus*)
- and others.

For re-stocking purposes there are only small-scale cultures of:

- Frauenfish (*Rutilus pigus virgo*)
- Barbel (*Barbus barbus barbus*)
- Nase (*Chondrostoma nasus nasus*).

The main production of warmwater species is in semi-intensive polyculture farms, and a smaller part is in extensive polyculture ponds. Warmwater fish farms were developed according to the availability of the water reservoir. Ponds were mainly built for the accumulation of water in order to irrigate agricultural fields, and also for fish farming purposes. There are only a few ponds built exclusively for warmwater fish farming in Slovenia. Production areas for freshwater aquaculture in warmwater from 1995 to 2001 are presented in Table 7.

Table 7. Number of production facilities for freshwater aquaculture in warmwater fish farms in Slovenia from 1995 to 2001 and the utilized areas.

	Ponds for production of			Polyculture	Winter	Utilized area
Year	Fry, fingerlings	Market size	Broodstock	ponds	quarter	(ha)
1995	50	21		3	19	315
1996	43	27	3	3	21	348
1997	34	13	3	23	19	353
1998	50	35	3	10	13	361
1999	52	32	3	12	24	540
2000	64	29	3	13	14	508
2001	76	59	4	16	9	399

Source: SORS

Table 7 also shows a peak of the utilized surface area in 1999 dedicated to warmwater fish production. In 2001 there was a drastic decrease of the surface area used and the main reasons were:

- incomplete legislation (in the field of water concessions), and
- conflict of interest between fish farming and bird protection.

On the contrary statistics in Table 7 show an increase of fry and fingerling ponds, and ponds for market size fish. Reason for increasing number of ponds is in better reporting. The last few years more small-scale farmers are sending their data to SORS.

According to the estimation from the Advisory Service for Aquaculture, methodologies in warmwater fish farming are as follows:

- 75 percent of production units have semi-intensive polyculture systems
- 20 percent of production units have extensive polyculture systems
- 5 percent of production units have intensive monoculture (only fry, fingerling production)

An estimate is also made regarding warmwater fish farming technologies. Warmwater species are reared only in earth ponds.

b) Coldwater fish farming

Freshwater aquaculture in coldwater fish farming is exclusively for the rearing of salmonids. Both warmwater and coldwater fish farming is for human consumption and it is also important for re-stocking and angling.

The species reared for human consumption are:

- rainbow trout (*Oncorhynchus mykiss*), and
- artic charr (*Salvelinus fontinalis*).

The following autochthonous salmonid species are reared for re-stocking and angling:

- marble trout (*Salmo marmoratus)*
- brown trout (*Salmo trutta m. fario*)
- lake trout (*Salmo trutta m. lacustris*)
- Danube salmon (*Hucho hucho*)
- grayling (*Thymallus thymallus*).

Table 8 shows production facilities in coldwater fish farming from 1995 to 2001.

Since 1995 there has been a decrease of ponds for fry, fingerling and broodstock but the number can also vary annually according to disease problems. When a hatchery becomes infected by virus, it should be disinfected under veterinary control. Because some owners are undecided regarding the sanitation programme, they lose the possibility of obtaining a licence for broodstock and fry production. They can also lose one to two years of production by having to go through a controlled sanitation programme. Ponds for market size fish are continuously increasing since 1995. This data also complies with the production data presented in Table 3. The capacity of the ponds decreased in volume after 1998 due to the reconstruction of several fish farms.

Table 8. Number of production facilities for freshwater aquaculture in cold water fish farms in Slovenia from 1995 to 2001 and the utilized areas.

Year	**Number of ponds for**			**Utilized area (m^2, m^3)**
	Fry, fingerlings	**Market size**	**broodstock**	
1995	371	193	33	118949[a]
1996	325	224	36	110684[a]
1997	328	238	34	117243[a]
1998	261	327	32	76740[b]
1999	292	260	37	71140[b]
2000	328	365	41	56972[b]
2001	308	406	29	64895[b]

Source: *SORS*
a: Data till year 1997 are in m^2
b: Data from year 1998 are in m^3

Farms were reconstructed with concrete raceways in order to improve water flow in comparison with the older constructed earth ponds – which usually had higher volumes but an unsatisfactory water flow.

Statistical data for methodologies and technologies for coldwater fish farming are not available. Approximate estimates are as follows:

- 100 percent are intensive (for human consumption)
- 25 percent have earth ponds
- 75 percent have concrete ponds
- 50 percent have concrete raceways.

2) <u>*Marine aquaculture*</u>

a) Fin fish

There are limited resources for marine fish farming in Slovenia. Only in one basin (Piran Basin) concessions for marine aquaculture are granted by the authorities. However, from 1990 fish farming was started by two companies and the species reared are:

- seabass (*Dicentrarchus labrax*),
- seabream (*Sparus auratus*).

Statistical data are not available as only two companies are involved in fish farming and SORS are not willing to provide any information, due to personal data protection. Farms are located in the Piran Basin and each one has several floating cages. From the unofficial data available, it is obvious that marine fish farming is now facing serious problems. According to the farm owners production during 2001 was much lower than the previous years and later was even lower than in 2002. The reason for the decrease in production was due to small-scale farms not being able to compete with Italian, Croatian and Greek producers. On the other hand, in 2003 both farms were taken over by new owners, who planned to increase production approximately from 200 to 250 tonnes in the year 2004 and 2005.

b) Shellfish

Fish and mollusc farming have the same conditions, and there are only 3 farms which rear only one species:

- blue mussel (*Mytilus galloprovincialis*)

For the same reason as in fish farming, statistical data from SORS were not available. Market conditions are also very strong in this segment, but it seems that mollusc production has slightly increased. On the other hand the number of units is the same but perhaps even smaller than a few years ago.

2.3 Production data

Statistical data since 1991 are included in this report and are divided into freshwater and marine aquaculture. Aquaculture production of the main species in Slovenia from 1991 to 2001 is presented in Table 9, and the development during the last decade can be clearly identified. Freshwater production has increased by 51 percent. Although development of mariculture activities was showing a promising increase until 1998, it is now facing serious problems. Unfortunately, for various reasons, production of marine fish species decreased significantly but the volume for 2001 has increased because of a higher mollusc production.

Table 9. Aquaculture production in Slovenia from 1991 to 2001 ('000 kg).

Species/year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Rainbow trout	469	573	469	541	446	511	516	601	800	840	820
Other coldwater	5	5	18	10	26	21	19	22	37	38	50
Total coldwater	474	578	487	552	471	532	535	623	837	879	869
Carp	64	102	143	118	213	155	172	126	255	172	181
Other warmwater	5	1	23	15	42	57	82	6	13	34	58
Total warmwater	69	103	166	133	255	212	255	132	267	205	238
Total freshwater	543	681	653	685	726	744	790	755	1104	1084	1108
Seabream, bass											
Molluscs											
Total marine	65	150	59	101	62	124	127	154	102	116	154
Total aquaculture	**608**	**831**	**712**	**786**	**788**	**868**	**916**	**909**	**1207**	**1200**	**1261**

Source: SORS

Table 9 shows official data regarding aquaculture production in Slovenia, whereas data from the Chamber of Agriculture are slightly different. On the basis of available data from the Agricultural Advisory Service production of freshwater species is much higher. An estimate for 2001 was approximately 1 300 tonnes for the production of rainbow trout and 300 t for warmwater species for a total of 1 600 tonnes. Estimates for 2002 are approximately the same. The reasons for these differences are that some small farmers fail to send their production figures to the SORS.

3. National policy

After Slovenia declared independence in 1991, Slovenia was taking over all legislation concerning aquaculture from "Socialistic Federative Republic of Yugoslavia". Since 1991 several legislations were changed, a lot of new legislations were accepted. Aquaculture is today regulated by the following laws:

- Marine Fisheries Act (ZMR – 1)
- Freshwater Fisheries Act – (new one in preparation)
- Animal Husbandry Act (ZŽiv)
- Veterinary Service Act (Zvet) and their regulations, ordinance, etc.

The protection of fish species and other water organisms have to be considered by aquaculture production. They are regulated by the following laws and acts:

- Environment Protection Act (ZVO)
- Nature Conservation Act (ZON)
- Waters Act (ZV)
- National Environmental Action Programme.

A national plan for aquaculture is today part of the National Development Plan (NDP) 2001-2006. Presented in this document are several national objectives and indicators. These objectives are at different levels: strategic, specific and operational. Aquaculture and fisheries are treated together as one single “Fisheries Sector”.

Strategic or general objectives:

Agriculture and fisheries policies in Slovenia are in principal similar to the existing EU legislative regulations. Strategic objectives come from the field of food security, preservation of rural population density, preservation of sufficient production potential, increase of competitiveness in the agriculture sector, and assuring equity of income to farmers.

The most important objectives in fisheries are:

- to ensure permanency of fish resources
- to create competitiveness of the fisheries sector
- to increase the education level for employees in the fisheries sector
- to increase the number of participants in permanent education in the field of fisheries,
- putting research and scientific achievements into practice.

Specific objectives in fisheries:

- Sustainable management with natural resources – especially fish resources.
- Development of the fisheries information system.
- Increase of production capacities for freshwater aquaculture in connection with natural water resources.
- Further development of public services and institutions from the fisheries sector.
- Improvement of conditions for fisheries.
- Organization of the market for aquaculture and fishery products.
- Development of the market information system.

Operational objectives in fisheries are defined in the NDP as follows:

- Annual catch of 4 000 tonnes of marine organisms.
- Up-to-date data collection for aquaculture and fisheries.
- Annual production of 2 000 tonnes of freshwater fish.
- Strengthening and qualifying of the State administration (Ministry of Agriculture, Forestry and Food).
- Strengthening of public services and institutions in the fisheries sector.
- Establishment of 2 producer organizations – one in marine and another in freshwater fishery.
- Modernization of the fishing fleet.
- Modernization of the fish processing industry.
- Organization of markets with fish and fishery products.
- Development of market data collection for information systems.
- Assurance of an important scientific and research base for the implementation of fishery policies.
- Development of information and education systems.

Financial support to achieve the main objectives are presented in Table 10.

Table 10. Planned financial support in aquaculture and fisheries from 2001 to 2006 (in '000' SIT).

Budget item/year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1) Mariculture development support	0	0	0	0	0	0
2) Support for freshwater fish farming and freshwater fish processing	46.641	70.000	75.000	80.000	90.000	110.000
3) Modernisation of marine fishing and marine fish processing	61.242	80.000	10.000	107.000	115.000	130.000
4) Research in fishery, monitoring and fisheries register	43.216	72.000	100.000	110.000	120.000	150.000
5) Structural adjustment and social assistance	0	30.000	30.000	30.000	30.000	50.000
Total	**151.099**	**252.000**	**215.000**	**327.000**	**355.000**	**440.000**

Source: NDP – Ministry of Agriculture, Forestry and Food

Evidence is shown from the above table that little effort will be placed on mariculture activities since natural sources are rather limited. Nevertheless, there are some financial resources planned for the modernization of marine fishing and marine fish processing. It appears from the NDP that more efforts will be placed on freshwater aquaculture over the next four years.

A specific national plan and sub-plan for aquaculture and fisheries are currently being prepared and will come within the existing national and EU legislative framework.

In Slovenia there are no specific principles for responsible aquaculture. A legislation should be prepared in the year 2003 or at least before it becomes a new member of the EU. The national methodology for environmental impact assessment has not yet been established. Also, each new farm with a capacity of more than 20 t has to prepare an environmental impact assessment for their own farm.

Standards for organic production of freshwater cyprinids have been established in accordance with those valid in Germany. In the near future standards for organic production of salmonids will also be prepared.

4. Production and markets

Production data for the last decade are reported in Table 9. It is clear that from these data and from the NDP that the Ministry of Agriculture, Forestry and Food in Slovenia intends to financially support in the future freshwater fish farming and marine fisheries. Perhaps this is not in accordance with the general guidelines of the European fisheries sector. However, marine aquaculture has very limited resources. Financial support for freshwater aquaculture will bring a higher production capacity and larger units. One of the future problems of freshwater fish farming will be the relatively small production units. These small units will have difficulty in competing with the EU common market. According to the data available and the fact that Slovenia intends to join the EU, the future of the aquaculture sector is unpredictable.

However the following points should be noted:

- ♦ freshwater aquaculture will be further developed, because of government support;
- ♦ freshwater aquaculture will have to be restructured (average farm capacity will have to be increased);
- ♦ together with higher production also the processing industry should be developed;
- ♦ without government support marine aquaculture will not survive.

Some data for marine aquaculture are unavailable. The reason being that marine aquaculture and capture fisheries data have been combined and also because of the already mentioned provision for privacy. Table 11 reports the number of employees and the average wages received for freshwater aquaculture.

Table 11. Number of employees and average wages (in SIT) in freshwater aquaculture in Slovenia from 1995 to 2001.

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001***
Employees	114	118	116	120	144	159	192
Avg.wages	106.223	110.404	138.458	155.587	158.587	181.004	191.643

Source: SORS
* For year 2001 data are fully in compliance with Eurostat, ILO and FAO

The increase in number of employees during the past few years is in accordance with the production data. For 2001 the statistical methodology used is in full compliance with Eurostat, ILO and FAO standards. Nominal wages for the sector have increased since 1995; but actual wages increase is, of course, much lower, since annual inflation in Slovenia was between 7 and 10 percent in the period from 1995 to 2001.

Fish import data are presented in Table 12. Data shows an increase in the import of live and fresh fish since 1994. In 1993 import of marine fish was high. Later, due to the increase in aquaculture and capture fisheries, the import of live and fresh fish was stable. However, after 1999, for several reasons import was again high (smaller marine capture, smaller marine aquaculture production, higher demand for fresh fish, etc.).

Import of live fish during the last decade has never been at a particularly high level. Until the year 2000, there was high import of carp and other warmwater species and the figures for live fish also contain the volume of imported fry. The import of carp, seabass and seabream was in the past the main source of fry for Slovenian aquaculture. Since 2001 domestic production of carp fry has increased and because of this import has decreased. Marine species fry is 100 percent obtained from import. Domestic trout fry production is sufficient to cover the needs, but there is also quite an important import of trout eggs.

Main supplies of carp come from Hungary, Croatia and the Czech Republic while seabream and seabass are imported from France, Spain or Italy. Ornamental fish are imported from Austria, Germany and Singapore and 80 percent of trout eggs from the US. During the last few years trout eggs were also imported from South Africa and Denmark. The main import of eggs takes place during the summer, since the farmers do not have their own production.

Table 12. Import of live, fresh and processed fish in Slovenia from 1994 to 2002.

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Alive									
Ornamental	7	7	8	10	14	14	13	15	12
Carp	50	39	32	18	75	51	46	10	1
Other freshwater	1		3	3	3	4	7	3	6
Marine	1	52	1	23	1	8	1	1	1
Fresh, cooled									
Trout		4	14	6	4	3	3	1	48
Other freshwater		0	0	0	1	2	3	9	14
Salmon	6	11	37	50	60	71	80	86	97
Plaice, sole	46	34	14	13	14	23	27	19	23
Anchovy, sardine sprat	137	48	39	29	58	70	54	20	162
Mackerel	13	5	3	4	1	11	11	10	22
Hake			20	22	18	19	19	38	29
Sea bass			54	66	46	71	91	103	139
Sea bream			48	40	36	62	91	130	140
Other marine	331	300	339	350	397	181	391	343	344
Frozen and processed									
Trout			0	2	2	2	2	1	1
Other freshwater	33	1		4	10	28	0	1	
Salmon	1	36	18	23	21	12	30	32	42
Plaice, sole	2	40	50	48	67	44	33	38	32
Anchovy, sardine sprat	379	6	118		0		29	103	94
Mackerel	1.875	1.419	1.462	1.322	1.434	1.539	1.408	1.661	1.830
Hake	8	535	2.050	1.776	1.938	1.771	1.240	1.736	1.779
Other marine	2.160	2.222	754	873	528	432	963	767	414
Fish together	5.050	4.760	5.064	4.682	4.728	4.4417	4.542	5.126	5.232
Crustaceans	360	309	362	367	351	573	366	330	340
Mussels	79	47	155	60	76	102	93	123	99
Squid, octopus	1.732	1.828	1.920	1.677	1.621	1.979	1.851	2.213	2.163
Total	**7.221**	**6.944**	**7.5000**	**6.786**	**6.776**	**7.071**	**6.853**	**7.792**	**7.834**

Source: SORS

Table 12 shows that the import of fresh farmed species is also increasing rapidly. The import of seabream, seabass, and salmon is constant from year to year but that of sole and plaice has been higher since 1996. The 1994 figures show a higher volume of these two species, but only because the volume for some other sea species has been included in the different year classification. Import of carp and other warmwater species was never considered important. In 2002 volume of rainbow trout increased drastically and the reason for this could be the difference in price for fresh fish products between Italy and Slovenia (88 percent of trout is imported from Italy). Salmon is mainly imported from Norway, Denmark, Ireland and Italy; sole and plaice from the Netherlands and France; and seabream and seabass from Greece, Croatia and Italy. Other species come from capture fisheries mainly from Croatia, Morocco and Spain. Approximately 75 percent of the fish products are either frozen, dried or processed and mainly come from the EU countries. Although hake and squid comes from Argentina and

other South American countries they are also imported from South Africa. More than 90 percent of the species are from captured fisheries, therefore only 10 percent come from aquaculture.
Export of fish and fish products in Slovenia are presented in Table 13.

Table 13. Export of live, fresh and frozen fish and fish products in Slovenia from 1994 to 2002.

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Alive									
Ornamental						0			1
Trout	73	1	3	6	17	3	37	1	9
Other freshwater	3	3	2	0			0		
Marine				2	3	3	4	16	2
Fresh, cooled									
Trout	1	4							
Other freshwater									
Anchovy, sardine, sprat	73	158	457	423	95	95	54	118	5
Sea bass			19	2	2	0	6		
Sea bream			1	16	8	0	2	1	
Other marine	24	4	16	12	32	81	88	83	40
Frozen and processed									
Freshwater species		6	0		12	2		4	2
Anchovy, sardine, sprat	379	80	353	7	4	1	3	4	4
Other marine	57	133	88	90	119	95	161	160	133
Fish together	610	389	938	559	293	280	356	387	196
Crustaceans	5	2	3	4	5	6	10	8	3
Mussels	7	8	19	2	3	0	0	1	0
Squid, octopus	250	90	110	106	173	137	199	208	58
Total	872	489	1.070	670	473	424	564	604	258

Source: SORS

The above table shows a decrease in the export of fish and fish products in Slovenia due to the following reasons:

1. Smaller catch of marine fish.
2. Higher demand of fish on domestic markets.
3. Smaller marine farm production during the last few years.

The main markets for the export of Slovenian products are Croatia, Italy, Bosnia and Herzegovina. Export to Croatia, Bosnia and Herzegovina was also composed of re-export. Slovenian companies bought fish and fish products on the world markets and then resold to Croatia and Bosnia. Such resale has greatly diminished during the past years bringing an overall decrease in export. Figures also show how the decrease of catch can influence export volume. Currently the export of aquaculture species is non-existant.

As shown in Tables 12 and 13 Slovenia is a net importer of fish and fish products, and the overall consumption from 1993 to 2001 was between 10 000 and 11 000 t/year. This means that the average *per caput* consumption was between 5.0 and 5.5 kg/year. From this the consumption of freshwater species was approximately 0.5 to 0.8 kg/year. Only approximately 12 percent of the consumption is covered by domestic aquaculture production. Since the fish consumption figures are lower than average in the EU, it is evident that there are still good possibilities for further aquaculture development.
The main domestic consumption centre is in the city of Ljubljana while the main market centre for marine organisms is in the coastal areas, and that for freshwater species is again in Ljubljana. However, Slovenia being a small country it is very difficult to define its main centres. Generally, fish consumption in rural areas is slightly higher.

Great efforts are being undertaken by the Ministry of Health which is in favour of a higher consumption of aquaculture products. Better balanced and healthier food also means better food control. The HAACP system is compulsory for all kind of food production and processing. Food safety has been reassured by the new Slovenian regulations. Also in the Marine Fisheries Act and its regulations and ordinance, product quality for aquaculture species is prescribed. The Veterinary Administration of the Republic of Slovenia (VARS) is responsible for aquaculture products quality. At present there is no other private or government institution for the quality control of aquaculture products. However, it is ensured that as in some other areas where food production takes place (cattle, dairy, vegetables, etc.), labelling and eco-labelling will be developed. At the moment standards for organic production of carp and other warmwater species are in force, but an institution to control this has not yet been established. Standards for organic production of salmonids have already been planned and will be the basis for further development. Unfortunately, in the NDP from 2001 to 2006 there are no specific targets regarding the development of organic fish farming.

5. Relationship with capture fisheries

There is little relationship between aquaculture and capture fisheries in Slovenia, although both are in the same sector and covered by the same ministry they still have to face many problems, whereas in the past they were both quite profitable. Problems occurred in capture fisheries when Slovenia gained independence. Since then, the Slovenian fleet was no longer considered a "domestic" fleet in the Croatian Sea, and the fish catch decreased. However, aquaculture production increased also due to the new government policies.

Over the past few years problems have also occurred in aquaculture but this was not related to capture fisheries. Slovenia is a net importer of fish and fish products, so there is no competitiveness between domestic aquaculture producers and fishermen. Moreover, in the future they will have to work more closely with each other in order to secure their place on the market. Without cooperation they will have even less chance to survive under competitive conditions within the EU. At the moment fishermen and fish farmers do not have any registered association. In some respect their interests are represented by the Chamber of Agriculture and Forestry.

There have been no problems between fish farmers and fishermen in the coastal areas, the reason being that with only two farms (limited production) aquaculture cannot have any serious influence on the market. Also, the environmental impact on fishing grounds seems rather limited. Therefore, a drastic increase in marine aquaculture production is not foreseen to seriously impair the environment.

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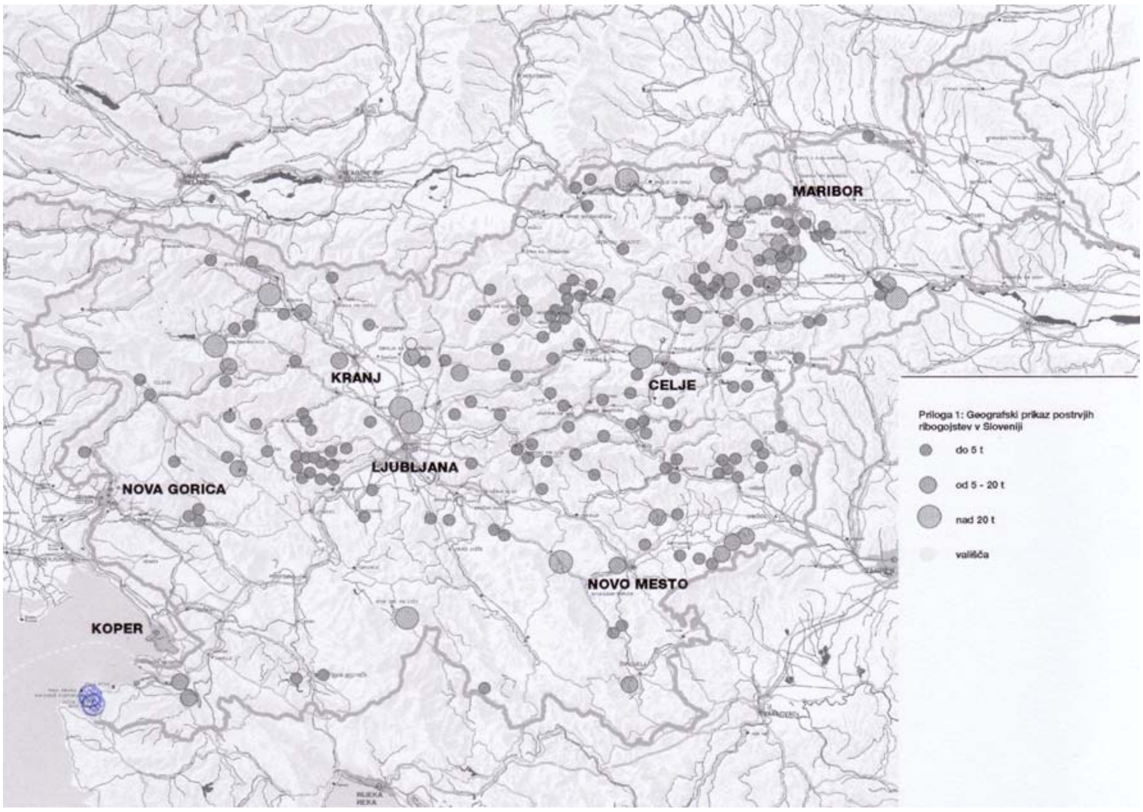
Human Development Report – http://www.sigov.si/zmar/aprojekt/hdr/02-03/
Environmental Agency - http://www.arso.gov.si/
Ministry of the Environment, Spatial Planning and Energy - http://www.sigov.si/mop/
Ministry of Agriculture, Forestry and Food - http://www.sigov.si/mkgp/

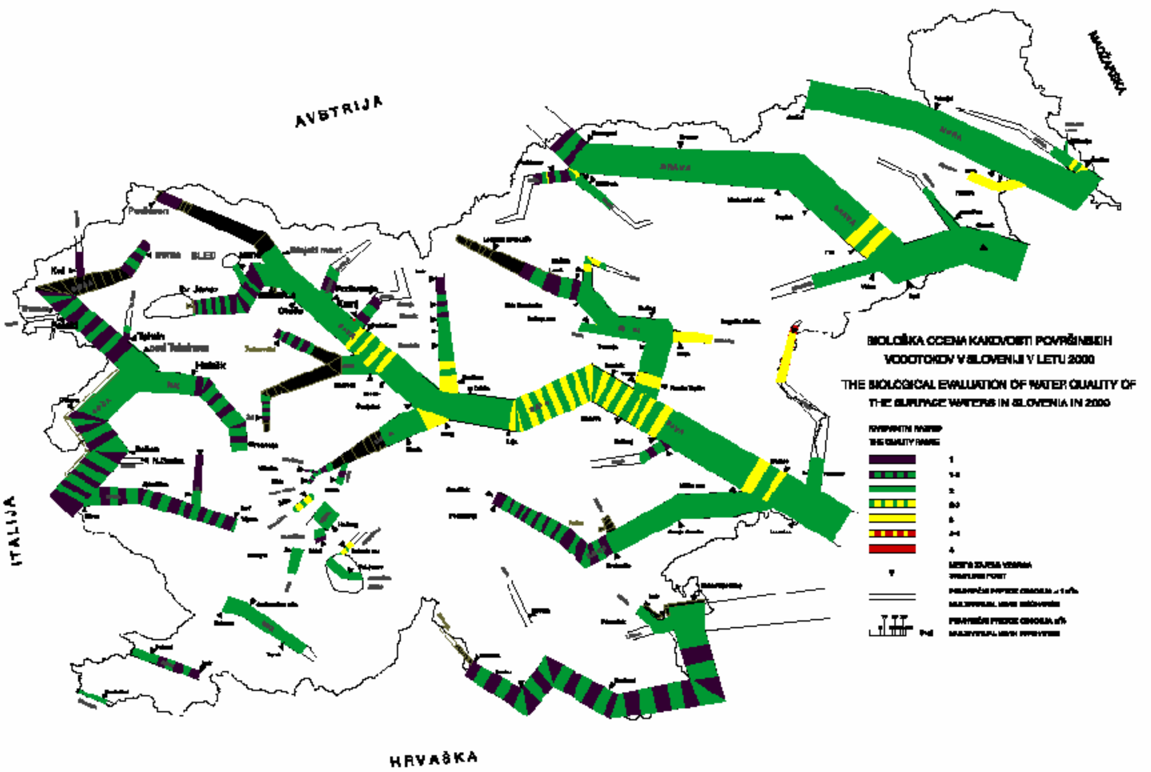
Annex 1. Geographical Presentation of Slovenian Fish Farms



Annex 2. List of Institutions Involved in Research Aquaculture Activities

1. Biotechnical Faculty – Zootechnical Department, Groblje 3, SI-1230 Domžale
2. Veterinary Faculty – Institute for Breeding and Health Care of Game, Fish and Bees, Gerbičeva 60, SI-1115 Ljubljana
3. Fisheries Research Institute of Slovenia, Župančičeva 9, SI-1000 Ljubljana
4. Ebra d.o.o., Cesta 5. Maja 3, SI-1370 Logatec

Annex 3. The Ecological Evaluation of Surface Water Quality in Slovenia in 2000



Interactions between capture fisheries and aquaculture

Stefano Cataudella[*], Fabio Massa[#], Donatella Crosetti°

Abstract
Interactions between aquaculture and capture fisheries are analysed in this document. The increasing relevance of aquaculture at institutional level is underlined with reference mainly to the FAO Code of Conduct for Responsible Fisheries. A series of issues are addressed for further discussion and emphasis was put on the sustainable development. The interactions generating conflicts and mutual benefits should be taken into consideration for a sustainable development. In the light of the Code of Conduct, it is suggested that interactions should be reviewed using a systemic approach, including ecological, economic, legal and governance dimensions. Finally the positive interactions (mutual benefits) between capture fisheries and aquaculture could be used within the group of indicators to evaluate the sustainability in the framework of aquatic organisms production.

1. Introduction

This paper analyses some interactions between capture fisheries and aquaculture. The contents of the topics discussed here are not original as the aim of this presentation was to enrich a general discussion in this AdriaMed Expert Consultation[1]. Emphasis are taken on some selected points (Codes of Conduct of Responsible Fisheries (CCRF, FAO, 1995), scientific and production context, sustainable development) rather than presenting an exhaustive overall report. Different interactions are briefly commented on, without going into the methodology in any great detail, by discussing a series of still open questions on several neglected subjects.

Aquatic products for direct and indirect human consumption have two origins: capture fisheries and aquaculture. In general terms, these two activities are different forms of man interventions in the life cycle and the harvest of living aquatic organisms, similar to the hunting and husbandry of terrestrial animals and plants. Many people assume that fishing and farming are equal partners in the same food-producing system: however, there are many specific interactions between the two sectors, which in some case have become serious issues.

Before identifying the interactions between capture fisheries and aquaculture, it is important to consider space and time dimension related to these activities. First, water covers more of the earth surface than land does, and contiguity is one of the most evident properties of

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aquatic ecosystems. This implies close integration of different uses and users, both locally and globally. Second, both capture fishery and aquaculture have evolved in a very short time: it took only 60 years for the modern fishing sector and only 30 years for modern aquaculture to develop into a mature sector.

Discussions on interactions between capture fisheries and aquaculture have only recently begun. At present, most of these interactions occur within marine and coastal ecosystems. On the contrary, there are many examples in continental ecosystems where most potential interactions have already been settled by close integration of capture fisheries and aquaculture (De Silva *et al*., 2003). However most of the successful productions obtained, especially due to species introduction in inland waters, should be reviewed within the recent developments of the Convention on Biodiversity contents (Watson *et al*, 1995).

The Code of Conduct for Responsible Fisheries (FAO, 1995) defined the global framework in which capture fisheries and aquaculture were to be considered parts of the same productive system. The presence of these two different activities in the same "container" should be considered as the beginning of a new vision.

Interactions between capture fisheries and aquaculture should therefore be studied and discussed as soon as possible, before they become conflicts which may reduce competitiveness within either industry, or prevent new economic sustainable growth. Aquaculture has been defined as: "*the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated… …aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without licence, are the harvest of fisheries.*" (FAO, 1992). However, some grey areas remain, and the definition between fishing and aquaculture will be sharpened as knowledge improves.

Geography and history support the hypothesis that aquaculture originated in these "grey areas". The physical confinement of portions of aquatic environments, due to natural events or human interventions, led to the development of aquaculture in primitive societies, also after the development of water bodies ownership, as for land for agriculture.

The evolution process of aquaculture may have been regulated by three major elements: confinement of aquatic areas, resistance of some fish species to natural environmental stress (extreme ecological conditions, handling, etc.), human interest for fish. The challenge of controlling fish production certainly assumed both a practical and a symbolic value. The origin of aquaculture, apart from its cultural significance, is of particular importance when its relationship with capture fisheries is considered.

An exhaustive classification of various fishery practices divided into capture fisheries and aquaculture is proposed by Welcomme (1997), (Figure 1).

PRODUCTION FROM	AQUACULTURE	FISHERIES
Hatcheries	*	
Ponds	*	
Tanks	*	
Raceways	*	
Cages	*	
Pens	*	**
Barrages	*	
Stocked lakes and reservoir --with other enhancement (predator, control and/or fertilization, habitat modifications) --no other invention	* 	 **
Unstocked lakes an reservoirs --with enhancement (fertilization and/or predator control, habitat modifications) --no enhancement	* 	 **
Ranching of anadromous fish		**
Fish and crustaceans caught in open waters		**
Privately owned recreational fisheries		**
Fish and other animal harvested from brush parks --managed over time and with other enhancement --harvested on an install and harvest basis	* 	 **
Fish and other animals harvested from --fish aggregating devices --artificial reef		** **
Molluscs --subject to open fishery --from owned and managed grow-out site	 *	**
Enhanced marine fisheries		**
Harvest of natural seaweed beds		**
Harvest of planted and suspended seaweed	*	
Rice-field culture --from stocked rice-paddy --from unstocked rice-paddy	* 	 **
Lagoon (including vallicoltura) production	*	
Private, tidal ponds (tambaks)	*	

Figure 1. The classification of various fishery practices divided into capture fisheries and aquaculture as proposed by Welcomme (1997).

2. The Code of Conduct for Responsible Fisheries and the increasing institutional relevance of aquaculture

Annex 1 of the CCRF provides clear information on the origin, elaboration and negotiation of the Code, which recognised the nutritional, economic, social, environmental, and cultural importance of both capture fisheries and aquaculture.

The CCRF does not represent the point of view of a group of FAO experts, but of the countries'. After its approval, it became a common and useful tool for all States, for both Governmental or Non-Governmental International Organisations, and for all those involved in fisheries at world-wide level.

On October, 31st, 1995, the twenty-eighth session of the FAO Conference adopted by consensus the CCRF with the respective resolution reported in Annex 2. In its introduction, the Code includes aquaculture in the Fisheries system. It recognises the role of these activities in providing "*…a vital source of food, employment, recreation, trade and economic of well being for people, employment throughout the world, both for present and future generations*". Aquaculture development is considered in Article 9, including culture based fisheries.

Particular emphasis is placed on the risk of impact on biodiversity at different levels, particularly within transboundary aquatic ecosystems. The impact of farm escapees on wild stocks is one of the most evident interactions that imply a direct effect of aquaculture on capture fisheries.

The presence of a specific article in the CCRF which deals with aquaculture is of particular significance and marks an important step forward in the systemic treatment of fisheries. In the past, aquaculture has always been considered a marginal area of fisheries, as it is similar in environment or market point of view. At present the exponential growth of aquaculture, with an increase of 9.2 %/year from 1970 (FAO, 2002), has led to a review of the role of aquaculture as animal production. Aquaculture fast development and the effects of the contents of Article 9 gave to this activity a renewed role within the global fisheries system.

In 2001, the Committee on Fisheries (COFI) established a sub-committee on aquaculture, that held its two first sessions in Beijing (China, 2002) and Trodheim (Norway, 2003).

The 24th session of COFI recognised *"the increasingly important role that aquaculture was playing in global fish production, and food security by providing opportunities for economic development in Member States"* (FAO, 2001), and raised the issues of integrations between aquaculture and capture fisheries, caused by aquaculture development.

The Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (2001) addressed the issue of introducing more ecosystem considerations into conventional fisheries management and recognises "*the complex interrelationship and the other components of the marine ecosystems*". In particular the Declaration calls for, *inter alia*, the monitoring of interactions between fisheries and aquaculture.

3. The scientific context

As early as 1864, the Norwegian government asked Georg Ossian Sars to establish why cod catches from Lofoten Islands fluctuated so greatly. Within twenty years, Norway had established a scientific agency to study fluctuations in its fisheries and many other nations soon joined Norway. Throughout the 1880s and the 1890s, many conferences were held, aimed at promoting co-operation between European countries.

The opening meeting of the International Council for the Exploration of the Sea, held in Copenhagen in July 1902, paved the way to future co-operative programmes on fish migration and overfishing. At the beginning of the twentieth century, overfishing was already recognised as a management problem in living aquatic resources. Under the terms “fishery science”, “fishery biology” and “fish population dynamics” a series of both biological methods and mathematical models were set up. Fishery scientists first developed an autonomous body, creating opportunities for constructive collaboration between biology and mathematics. The focus of these studies has continually shifted between the immediate need to predict catches, and the longer term need to understand the population and ecological mechanisms that limit them. Thanks to an applied interdisciplinary approach, fishery science and related theories have largely contributed to the development of important ecological theories. Relationships between policy and fishery science have been frequent and sometimes contradictory: the decision making process needed, and still needs, strong scientific support, especially in problems identification, whereas in the problems solving phase, final decisions require a compromise between science and policy. Fishermen have not always been satisfied with scientists’answers or points of view on fisheries management.

Aquaculture as an autonomous discipline developed more recently, with several fundamental and applied sciences playing an important part. As in agricultural sciences, development depends on knowledge from different fields, ranging from biology to engineering. Most of the practical results obtained came from a mix of scientific and “trial-and-error” approach. Research scientists in aquaculture work closely with farmers, and sometime take the same stand against public decisions. However, during the last two decades, the consciousness of environmental impacts from aquaculture created a generation of research scientists in conflict with fish farmers.

Fisheries research originated from a public need to generate appropriate tools for managing common goods. Aquaculture research grew to support producers, using science as accelerator, especially in the last three decades. For many years, fishery science and aquaculture development did not interact: for instance, often fishery scientists did not include the development of a responsible aquaculture in the measures required to rehabilitate degraded areas which had been overharvested.

The fundaments of the Sustainable Development theory produced a much more open vision (UNCED, 1992). An interactive effort was needed, with all the different subjects from different backgrounds involved, avoiding preconceptions of disciplinary origin that could delay the resolving of new questions.

The Rome Consensus on World Fisheries signed in FAO (1995) by the Ministers responsible for Fisheries of most countries of the world recognised that action was urgently required to:
a) eliminate overfishing and prevent further resource decline;
b) reduce overcapacity;
c) rehabilitate productive habitats;
d) minimise wasteful practices and post-harvest losses;
e) develop sustainable aquaculture and stock enhancement;
f) develop alternative sustainable source of supply compatible with ecosystem conservation.

Within these recommendations, the interactions between fisheries and aquaculture at scientific level are still not considered adequately. The development of systemic sciences, such as ecology and economics, increased the possibility of a constructive relationship between marine fisheries and aquaculture scientists. The need to solve problems in the same environment, and the presence of fished and farmed goods in the same market, led to the merging of activities and scientific interests which had been traditionally separated. For instance, research programmes on inland fisheries or on coastal lagoon management are fields in which aquaculture and fishery science have a long tradition of collaboration. This division was frequently due to personal academic preconceptions which often hampered progress in research institutes, international agencies and public administrations, causing a delay in the realisation of a common programme of fishery science and sciences involved in aquaculture. Research scientists in the past have sometimes sustained negative policies which have slowed down responsible aquaculture development, or were considered as prophets-of-doom when declaring that fishing is in an irreversible and rapid decline. What is really important is the identification of common grounds where several sciences can work together in an attempt to discover how the entire system works.

4. The production context

The main interaction between capture fisheries and aquaculture is to join efforts in providing high quality food for mankind in a sustainable way. Reading The State of World Fisheries and Aquaculture 2002 and updating the figures with the available statistics 2001, it is possible to have an immediate look of the diversified annual growth rate that justifies the importance assumed by aquaculture. In 2001 global capture fisheries amounted to 91,3 million tonnes and world aquaculture production reached 37,5 million tonnes (Figure 2-3, FAO, 2002).

The increasing role of aquaculture in world fisheries has been recognised worldwide (NACA/FAO, 2000; Flos and Cresswell, 2000; Subasinghe, 2003; Tacon, 2003) proving general considerations based on FAO statistics on quantities and values.

The possibility for aquaculture to meet the world demand of fisheries products is conditioned by many factors (Pedini, 1999): population growth by region, potential production increase from capture fisheries and from aquaculture, access and use of natural resources (land and water) for aquaculture production, government development policies and technological development impact.

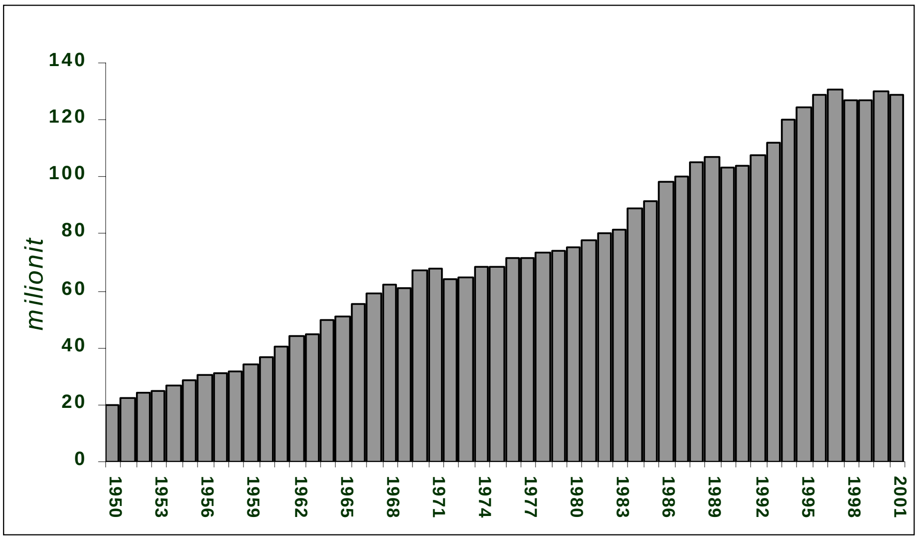

Figure 2. World capture fisheries and aquaculture production: 1950-2001 (Source FAO- 2002).

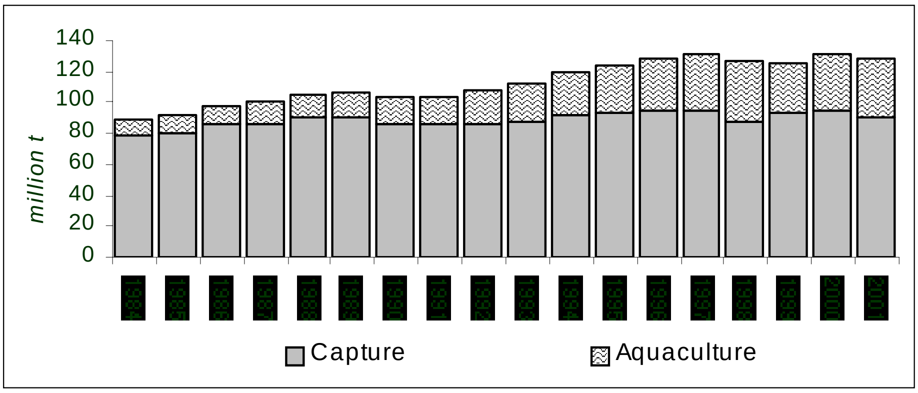

Figure 3. World capture fisheries and aquaculture production: 1984-2001 (Source FAO- 2002).

Interactions between different stakeholders of common resources must be expected as a part of any industrial growth and modernisation. New generations are faced with problems of population growth and the prospects of diminishing food safety and life quality. New models for sustainable fisheries, including aquaculture, are trying to anticipate the problems of over-population by taking into account the different needs for the so-called developing and developed countries at both local and global level, fisheries resources overexploitation, and to implement the Code of Conduct of Responsible Fisheries in new fisheries policies at both national and international level.

In the present paper all interactions have been divided into two main families defined as old and new. Old interactions are issues generated by: the introduction of exotic species; the need for stocking programmes; the ownership of resources and of confined environments; the use of wild seed to supply aquaculture and the use of fishery products to supply the fish feed farming industry. New interactions are issues concerning: stocking and restocking models; the genetic origin of cultured organisms; biodiversity conservation and value; genetic improvement through breeding programmes and genetic engineering; aquaculture development in sensitive environments; direct impact of farmed products on markets and prices; the growing role assumed by aquaculture in meeting the additional demand for fishery products; product quality and labelling; capture fisheries and aquaculture within a sustainable system approach.

The recently originated new interactions are due to the growth of environmental concerns at both public and NGO level, the private sector has only recently become an active component in the interaction system. Fishermen and aquaculturists have been traditionally involved in conflicts regarding space use, but today conflicts on market issues are becoming more frequent. These have been generated by the increased production of some aquaculture species, which are still also captured in the wild. In this respect is the case of farm salmon product increase that has impacted the fishing industry and "outcompeted" fishery salmon (Eagle *et al*., 2004). The market generated by farmed species could also impact on other wild species in addition to cultured ones, as in the case of shrimp culture (Benè *et al*., 2000).

New interactions involve new specific principles, including ethical, cultural, social, economical, biological and environmental aspects. Among the former is an unexpected impact of aquaculture on biodiversity. One of the characteristics of aquaculture is the use of many different species, whereas terrestrial animal husbandry domesticated and selected a number of races from only a few species. The number of aquaculture species has increased annually: more then 210 different animal and plant species were reported in 2000 (FAO, 2002). The development of fish genetics and fish ecology highlighted the negative impact of many interventions carried out to produce, which were positively considered in the past.

Pullin, Bartley and Kooiman (1999) provided a revision of the major issues to be addressed for the formulation and implementation of more effective policies in this area, considering that the policies for the conservation and sustainable use of aquatic genetic resources are poorly developed.

Welcomme and Bartley (1998) described the current approaches to fisheries enhancement, comparing the contrasting strategies for inland fisheries management in developing and developed countries.

In developing countries, provision of food, income, labour-intensive, etc. are the most important issues for fisheries enhancement, whereas in developed country conservation, habitat restoration, sound environmental restocking seems to be the priorities. These differences opened a series of complex political issues, already known in other sectors, such as forest conservation for instance. We have to face the real differences that could modify different perspectives of aquaculture role in world fisheries, otherwise the gaps between advanced and in-transition economies will increase. The distance that separates temperate and tropical areas of the world could delay future debates on who will be responsible for biodiversity decline in future development strategies. This problem already exists today in areas where States with different economic conditions share the same water bodies (Art 9.2 of the CCRF referred to the "Responsible development of aquaculture including culture based fisheries within transboundary aquatic ecosystems"). In this scenario, the adaptation of the CCRF without reducing its principle values should be an imperative issue.

One major aspect of aquaculture which concerns fishery managers is the effect escapees from fish farms might have on native stocks. Much of the research has involved salmonid fish, especially Atlantic salmon and brown trout in Europe (Gross, 1998; Vandeputte and Prunet, 2002; Wang *et al*., 2001; Youngson, *et al*., 2003).

The forecast of future aquaculture in a different perspective could use the genetic impacts of fish produced in hatcheries as a milestone. In this framework, new challenges for scientists and producers should be faced. If the genetic effects and the spread of disease and parasites caused by farmed fish introduction must be controlled, restocking programmes will consequently need wild-like seed, i.e. hatchery produced fry with biological characteristics similar to wild fish. This could also represent a new commercial competitive opportunity for hatchery productions, where the effort of science and technology in creating innovative procedures for producing wild-like fish will be economically convenient within sustainable aquaculture practices.

In the Mediterranean, differences between cultured and wild gilthead sea bream and sea bass juveniles have been detected in the last ten years (Loy *et al*., 1999; Boglione *et al*., 2001). The use of extensive larval rearing techniques that simulate the conditions of wild nurseries enabled the production of juveniles with a morphology and a behaviour which are similar to wild specimens. This is particularly important today, when the demand of seed for restocking coastal lagoons has increased, but the availability of wild fry has drastically decreased.

Within the production of 450 million marine fin-fish fry (mostly sea bass and sea bream) in the Mediterranean, there is a specific demand for wild-like fry for the Vallicultura practice. A “wild-like” fry label is in preparation, using different kinds of descriptors within research programmes aimed at producing marine fish larval quality systems for restocking. The application of large marine enclosures for early life history studies revealed important information for rearing methods. Traditional induced spawning practices developed during the 70s and 80s to rear Atlantic cod, turbot, Atlantic halibut, gilthead sea bream and sea bass, should be reconsidered to help adapting aquaculture to specific fisheries enhancement and intensification supports.

The use of wild-like fry for restocking purposes does not solve the problems related to unintentional or accidental release of cultured organisms in the wild caused by escape events from culture farms. These problems are enhanced by several factors such as the continuity of aquatic ecosystems, the number of operating farms, and the high mobility of many farmed aquatic species.

Hindar and Jonsson (1992) summarised a list of recommendations aimed at reducing the effects of cultured fish on wild fish. The need to produce selected aquaculture strains and GMOs leads to another crucial issue. On the one hand, stands the awareness of the crucial importance of producing aquatic organisms for human consumption, using the best available technology, selecting genomes, manipulating genes, following the same pathway paved by other agriculture activities in the modernisation process. On the other hand, ethical problems, such as equity and solidarity, must be conceptually faced.

In considerations of all the aspects highlighted above, something should be reinvented in the productive context when looking for the new economic opportunities that sustainability brings. The following actions are therefore suggested:

- Producers and their Associations should take an active part in aquaculture planning, with more involvements in the decision making process and development strategy. Voluntary codes of practice, which have low costs compared to expected benefits, should be widely encouraged. This effort could be considered as a public investment toward sustainability.
- The commitment to prevent fish escapes should be very hard: at present from the fish farmer point of view, it merely represents a loss of income, with little concern of environmental impact.
- Quality aspects of fisheries products is another interaction that could generate competition between wild and farmed products, especially when they supply the same market. The quality concept has rapidly developed and can influence the consumer's preference. Debates on food genuineness or origin could be solved through a clear certification of origin.
- Consumers should be correctly informed. Real quality will depend on several factors: for instance, capture fishery products deriving from polluted areas are not better simply because they are wild. On the other hand, aquaculture products reared in safe and pure water, using high quality feed, or extensively produced in a clean environment, could offer top quality. Safety still represents a priority, but also nutritional and organoleptic properties should be considered.

5. Interactions and sustainable development

The concept of sustainable development and its application to fisheries is well discussed in the FAO Technical Guidelines for Responsible Fisheries n.8 (1999) (Figure 4). Sustainable development is "simply" development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. The same Technical Guidelines report that: "…*Sustainable development of fisheries will require improved governance and changes in the perspective of the main stakeholders to focus to more on long- term outcomes. This would require:*

- *increased awareness of factors beyond the conventional realm of fisheries management;*
- *better integration of fisheries management into coastal zone management;*
- *control of land- based activities that degrade the marine environment;*
- *stronger control of access to co-resources;*
- *stronger Institutions and legal frame work;*
- *greater participation by all stakeholders in the fisheries management process;*
- *improved understanding of socio-economic characteristics of fisheries;*
- *stronger systems of monitoring control and enforcement;*
- *measures to deal with uncertainty and variability in natural resource and ecosystem dynamics and*
- *strengthening community commitment to responsible use of natural resources."*

In this framework, aquaculture could be considered in many ways. First, as one of the many activities which must to be integrated with fisheries as a part of coastal zone management. Second, as one of the land-based activities to be controlled in order to prevent the degradation of marine environment. Third, as an opportunity to reduce the effect of overfishing of many stocks through the alternative supply of fish products. Fourth, as an activity whose Sustainable Development requires strong integration among the different components of the fisheries system.

Finally, more attention should be given to the role of aquaculture within the sustainable development of fisheries, especially if aquaculture meets the additional demand for fishery products (in 2001 aquaculture provided 29,1 percent of the world fish supply).

DIMENSIONS	CRITERIA
Economic	Harvest
	Harvest value
	Fisheries contribution to GDP
	Fisheries exports value (compared with total value of exports)
	Investment in fishing fleets and processing facilities
	Taxes and subsidies
	Employment
	Income
	Fishery net revenues
Social	Employment/participation
	Demography
	Literacy/education
	Protein/ consumption
	Income
	Fishing tradition/culture
	Indebtedness
	Gender distribution in decision-making
Ecological	Catch structure
	Relative abundance of target species
	Exploitation rate
	Direct effects of fishing gear on non-target species
	Indirect effects of fishing: trophic structure
	Direct effects of gear on habitats
	Biodiversity (species)
	Change in area and quality of important or critical habitats
	Fishing pressure – fished vs. unfished area
Governance	Compliance regime
	Property rights
	Transparency and participation
	Capacity to manage

Figure 4. Examples of criteria for the main dimensions of sustainable development (FAO, 1999).

Rao (2000) discussed marine fisheries in his comprehensive book on Sustainable Development economics and policy, in the chapter dealing with resources and environment. He sustained that fish remains among the most desirable food items for nutritional and health value, and that the critical situation of many fish stocks could worsen malnutrition in several poor countries. A series of possible interventions aimed at reaching harvesting sustainability are listed, but aquaculture is never considered as an opportunity to be integrated in a global vision toward sustainable fisheries.

The philosophy behind sustainable development models should consider the different interactions that generate conflicts and mutual benefits. Good interactions with a "responsible aquaculture" could alleviate the fishery crisis. FAO (1999) proposed the development and the use of indicators for the sustainable development of marine capture fisheries: "*The purpose of indicators is to enhance communication, transparency, effectiveness and accountability in natural resource management.*"

The FAO Guidelines are the first synthesis which highlight this matter. In this framework, considerations on the interactions between capture fisheries and aquaculture should be made. The following considerations are limited to the interactions that should be considered from both fishing and farming. The examples of criteria for the main dimensions of Sustainable Development, selected in the framework of SDRS (Sustainable Development Reference System) for fisheries, are reported in Figure 4: with indications of all those which directly or indirectly interact with aquaculture. The scaling of indicators and value judgements should consider the nature of the interactions that occur between farming and fishing, especially for coastal fisheries.

Eco-labelling will be another important issue that sustainable fisheries should face: "…*Eco-labelling schemes are increasingly perceived as a way simultaneously to maintain the productivity and economic value of fisheries while providing incentives for improved fisheries management and the conservation of marine biodiversity*." Mandatory eco-labels could generate barriers causing trade restriction and conflicts between fishery and aquaculture products, whereas voluntary eco-labels may be a new tool for increasing the role of producers Associations.

6. Issues to be discussed

1. For adoption and application of the FAO Code of Conduct for Responsible Fisheries, including aquaculture, interactions causing conflicts between capture fisheries and aquaculture must be investigated and resolved.
2. Any investigation and analysis should take into consideration the traditional (old) interactions which, for the most part, encouraged fishery enhancement practices.
3. In the light of the CCRF, interactions should be considered and reviewed from all sides, using a systemic approach. This would include both environmental and marketing consequences, which frequently provide more fertile ground for realistic discussion in the disputes between capture fisheries and aquaculture.
4. Scientists and technologists from the range of disciplines relevant to both capture fisheries and aquaculture must be prepared to present facts to enable the process for risks evaluation, a process in which both fishermen and fish farmers will give an active contribution.
5. Interactions (mutual benefits) between capture fisheries and aquaculture should be considered as indicators of sustainable production of aquatic organisms. However, indicators are not a target, but tools to help any decision-making process, and are useful in that they can be adapted to local conditions and continuously updated through the active participation of all stakeholders.

6. The importance of aquaculture in global fish supplies cannot be evaluated simply by comparing its growth with the decline of many exploited stocks in the principal fishing areas of the world. To respect the principles of the CCRF, the different roles of capture fisheries and aquaculture should be expressed fairly, with emphasis placed on their potential for co-operative development, and the application of their appropriate tools to improve the different markets, economies, and cultures.
7. Policies to meet the demand on coastal areas for multiple use should consider the different economic and environmental benefits which capture fisheries and aquaculture can provide together, especially in the increasing demands for high quality seafood and open space for tourism. The integration level between capture fisheries and aquaculture is a reliable indicator of the political and institutional impact on sustainable fisheries within coastal zone management.
8. All stakeholders in aquatic ecosystems, whether public or private, should do more to discuss and solve real and potential conflicts between capture fisheries and aquaculture, and to actively participate in the building of a common future.
9. Fisheries and aquaculture scientists should work together to avoid any irreversible damage to the marine environment. The presence of fishermen and fish farmers in all aquatic environments of the world, particularly in small-scale coastal communities, could be exploited in new environment conservation projects.

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Adriatic Sea fisheries: outline of some main facts

Piero Mannini*, Fabio Massa and Nicoletta Milone

Abstract
Following a brief introduction to some principal characteristics of the Adriatic Sea, the paper focuses on two main aspects of Adriatic Sea fisheries: fishery production and the fishing fleet. The evolution of capture fisheries landings over thirty years (1970-2000) is outlined: demersal and pelagic fishery production is compared and the quantities landed of some key shared stocks are described. The evolution of the Adriatic fishing fleet is reported in terms of number of fishing units, length category and fishing technique. The importance of basic reliable, comparable and easily integrated statistics is underlined; in the case of Adriatic shared fisheries the need for international cooperation is fundamental together with increased multidisciplinary analysis for the management of shared fishery stocks for the achievement of effective sub-regional fishery management.

1. Brief introduction to the Adriatic Sea

The Adriatic Sea is a semi-enclosed[1] basin within the larger semi-enclosed sea constituted by the Mediterranean, it extends over 138000 km^2 (Buljan and Zore-Armanda, 1976) it may be seen as characterised by Northern, Central and Southern sub-basins with decreasing depth from the south toward the north. Along the longitudinal axis of the Adriatic geomorphological and ecological changes can be observed, resulting in the remarkable differences of the northern and southern ends. Six countries, whose coastline development differs greatly, border the Adriatic. Some key-features of Adriatic coastal states for which marine fisheries are relevant are given in Table 1.
The Adriatic is characterised by the largest shelf area of the Mediterranean, which extends over the Northern and Central parts where the bottom depth is no more than about 75 and 100 m respectively, with the exception of the Pomo/Jabuka Pit (200-260 m) in the Central Adriatic. The Southern Adriatic has a relatively narrow continental shelf and a marked, steep slope; it reaches the maximum depth of 1223 m (Figure 1).
In the Adriatic Sea all types of bottom sediments are found, muddy bottoms are mostly below a depth of 100 m, while in the Central and Northern Adriatic the shallower sea bed is characterised by relict sand (Alfirević, 1981). The Eastern and Western coasts are very different; the former is high, rocky and articulated with many islands, the Western coast is flat and alluvional with raised terraces in some areas (Bombace, 1990).
The hydrography of the region is characterised by water inflow from the Eastern Mediterranean (entering from the Otranto channel along the Eastern Adriatic coast) and fresh water runoff from Italian rivers. These features seasonally produce both latitudinal and longitudinal gradients in hydrographic characteristics along the basin (Buljan and Zore-Armanda, 1979; Artegiani *et al.*, 1981).

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[1] Semi-enclosed and enclosed seas are here defined according to Art. 122 of the United Nations Convention on the Law of the Sea (1982) as follows: "… a gulf, maritime basin or sea surrounded by two or more States and linked to another sea or to the ocean via narrow straits of exit, or entirely or mostly made up of territorial seas and exclusive economic zones of two or more coastal States".

Table 1. Some data on Adriatic coastal states participating in AdriaMed.

	Notes	Albania	Croatia	Italy	Serbia-Montenegro	Slovenia
Coastline*(km)	The total length of the boundary between the land area (including islands) and the sea.	362	5835 (mainland 1777 km, islands 4058 km)	7600 (inclusive of Ionian and Tyrrhenian coastline)	199	47
Population* (July 2002 est.)		3 544 841	4 390 751	57 715 625	10 656 929	1 930 132
Population growth rate*	Annual population growth rate.	1.06% (2002 est.)	1.12% (2002 est.)	0.05% (2002 est.)	-0.12% (2002 est.)	0.14% (2001 est.)
Gross Domestic Product (GDP - real growth rate)*	Measure of the economy of a country; the total market values of goods and services produced and capital within the country borders during a given period.	7.3% (2001 est.)	4% (2001 est.)	1.8% (2001 est.)	3.5% (2002 est.)	4.5% (2000 est.)
Education index, 1999 **	Based on the adult literacy rate and the combined primary, secondary and tertiary gross enrolment ratio.	0.80	0.88	0.94	n.a.	0.94
Human development index (HDI) value, 1999 **	A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, education and knowledge and an acceptable standard of living.	0.72	0.80	0.90	n.a.	0.87
Urban population (as % of total) 1999 **	The mid-year population of areas defined as urban in each country, as reported to the United Nations.	41	57.3	66.9	n.a.	50.3
Infant mortality rate (per 1,000 live births) 1999 **	The probability of dying between birth and exactly one year of age expressed per 1,000 live births.	29	8	6	17*	5
Diffusion of recent innovations: Internet hosts (per 1,000 people) **	A computer system connected to the Internet	0.1	6.7	30.4	n.a.	20.3
Personal computers (per 1,000 people) ***		8 (2001 est.)	86 (2001 est.)	195 (2001 est.)	23 (2000 est.)	276 (2001 est.)
Agriculture, value added (% of GDP) ***	Agriculture corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes forestry, hunting and fishing, as well as cultivation of crops and livestock production. The net output of the agriculture sector after adding up all outputs and subtracting intermediate inputs.	31 (2001 est.)	10 (2001 est.)	3 (2001 est.)	15 (2000 est.)	3 (2001 est.)
Industry, value added (% of GDP) ***	Industry corresponds to ISIC divisions 10-45. It comprises value added in mining, construction, electricity, water, and gas.	23 (2001 est.)	34 (2001 est.)	29 (2001 est.)	32 (2000 est.)	38 (2001 est.)
Services, etc., value added (% of GDP) ***	Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport and government, financial, professional and personal services such as education, health care and real estate services.	42 (2001 est.)	56 (2001 est.)	68 (2001 est.)	52 (2002 est.)	59 (2001 est.)
Per caput fish supply (Kg/year, 1997-99) ****	Data should be regarded as giving only an order of magnitude indication of consumption levels.	2.0	4.3	21.9	2.7	6.7

***The CIA World Fact-book: Web 2002 Edition (public domain)** --- http://www.countryreports.org/ --- http://www.atlapedia.com/
****UNDP. Human Development Report** --- http://www.undp.org/hdr2001/indicator/
*****The World Bank** --- http://devdata.worldbank.org/data-query/
****** FAO Yearbook of Fishery Statistics - 2001** --- ftp://ftp.fao.org/fi/stat/summ_01/appIybc2001.pdf

Geo-morphological characteristics of the Adriatic basin, geo-political changes along the Eastern coast, existing national statistical divisions and fishery resource distribution have led to the identification of the two Geographical Sub-Areas (GSA) as shown in Figure 2. Croatia, Bosnia-Herzegovina, Italy and Slovenia border the GSA 17 (North and Central Adriatic), Albania, Italy (South-Eastern coast) and Serbia and Montenegro are included in the GSA 18 (AdriaMed, 2001; GFCM, 2001).

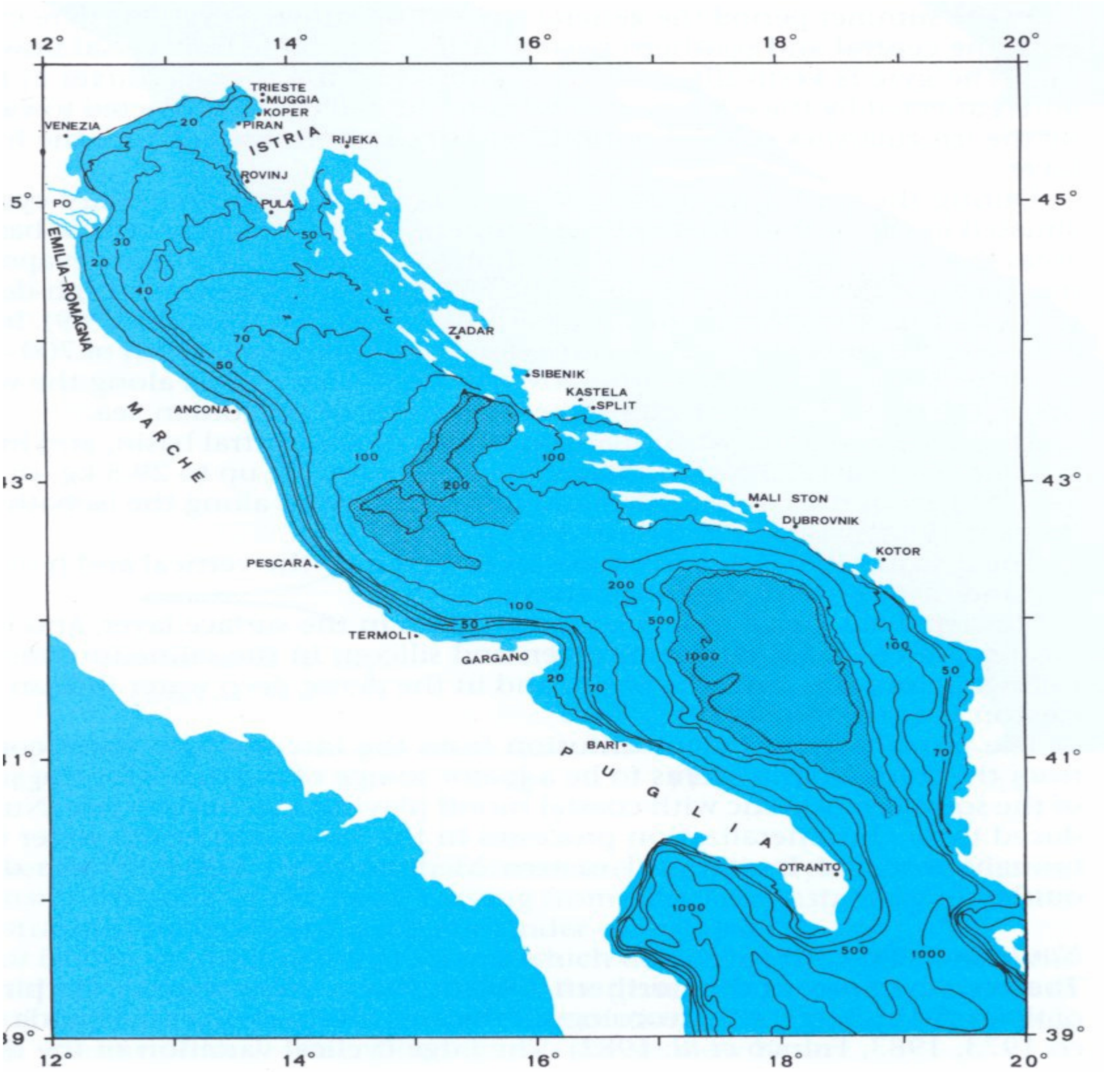


Figure 1. Adriatic Sea bathymetry (from Fonda Umani *et al.*, 1990).

The presence of the characteristics of a semi-enclosed sea as defined in Article 122 of the 1982 UNCLOS (United Nations Convention on the Law of the Sea) make the Adriatic a particularly suitable case to meet the provisions contained in Part IX (Article 23) of UNCLOS on cooperation of coastal states in enclosed or semi-enclosed seas (Sersic, 1992).

Finally, the Code of Conduct for Responsible Fisheries (as formulated by FAO in 1995) in coherence with UNCLOS and accounting for the Declaration of Cancun (1992), the Rio Declaration (1992), the provisions of the Agenda 21 of UNCED, the 1992 FAO Technical Consultation on High Sea Fishing, the 1984 FAO World Conference on Fisheries Management and Development and other relevant international fisheries instruments (FAO and UN, 1998), further emphasizes the necessity, when in presence of shared stocks, for coastal states to cooperate for fisheries research and management.

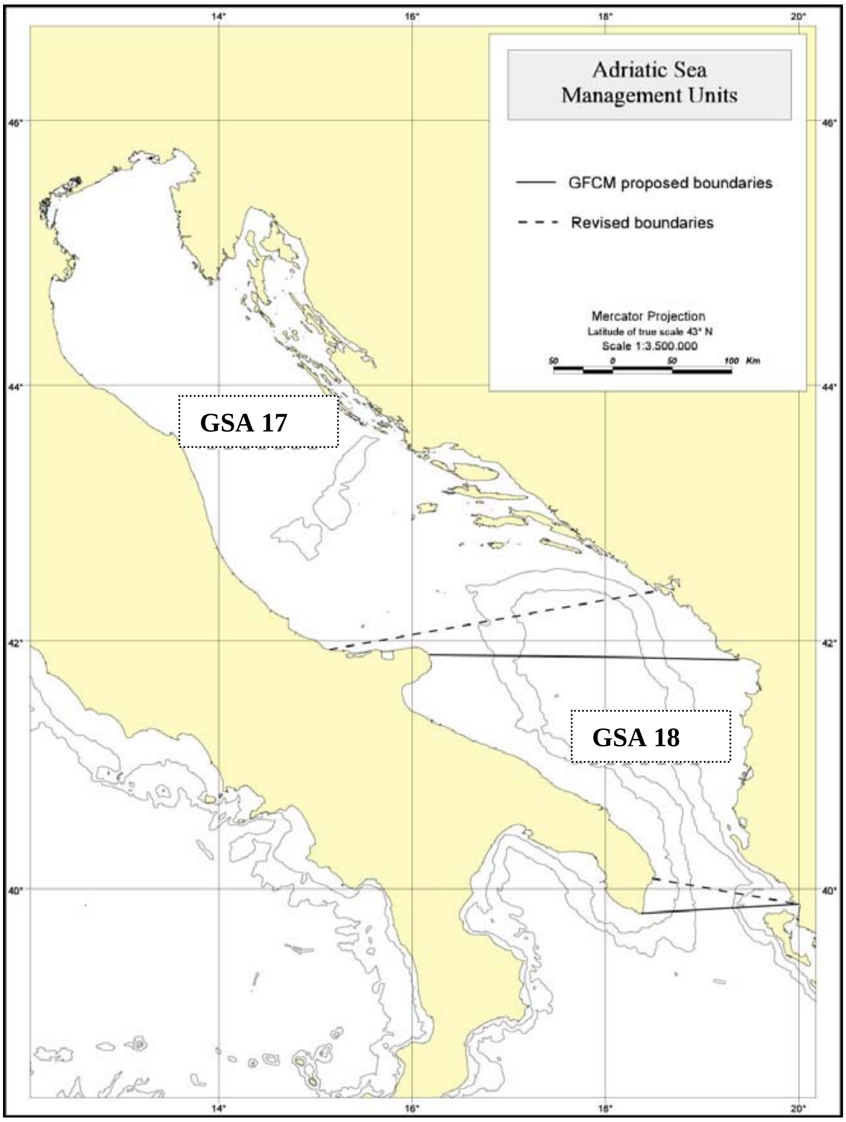


Figure 2. Map showing the boundaries of the Adriatic Sea Geographical Sub-areas 17 and 18 (formerly Geographical Management Units 37.2.1.a and 37.2.2.b) as originally indicated by the GFCM (solid line) and with the proposed (and currently adopted) revision (modified by AdriaMed, 2001).

2. Fishery production over time (1970-2000)

Recently the issue of shared fishery stocks in the Mediterranean has gained particular attention within international bodies such as the General Fisheries Commission for the Mediterranean (GFCM), its Scientific Advisory Committee (SAC) and the European Commission (EC). For instance, areas in the Mediterranean where shared stocks are reported or believed to occur are indicated in the EC Communication COM 535 (2002). It may be noted that with the exception of highly migratory stocks that are shared over the most of the Mediterranean, the Adriatic Sea is one of the largest areas of occurrence of demersal and small pelagic shared stocks in the Mediterranean.

Evidence of the transboundary and straddling nature of some important stocks may be drawn from the geographical occurrence pattern in late spring and early summer of the European hake (*Merluccius merluccius*) and Norway lobster (*Nephrops norvegicus*) which are high-value stocks targeted by the Adriatic demersal fishery (Figure 3a, 3b).

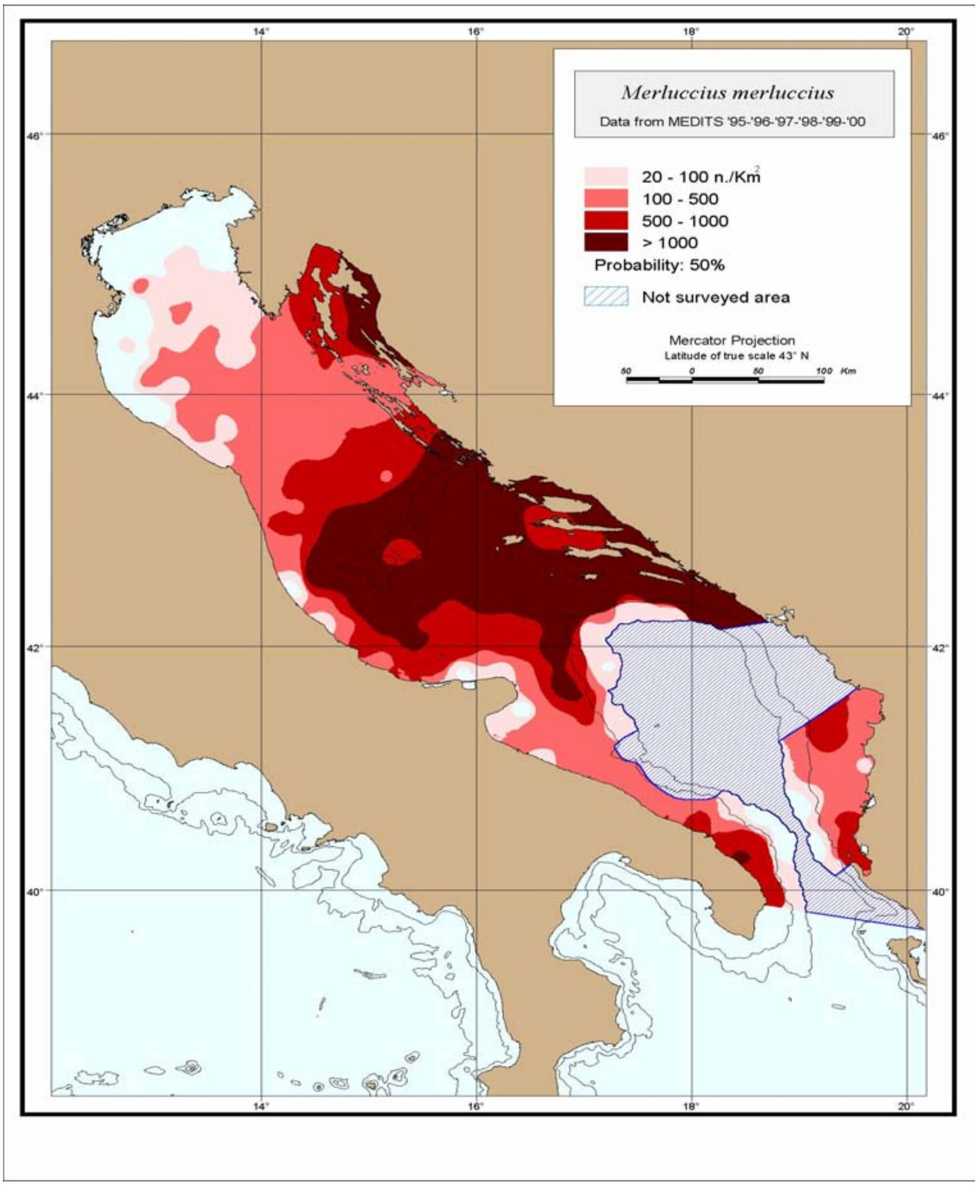
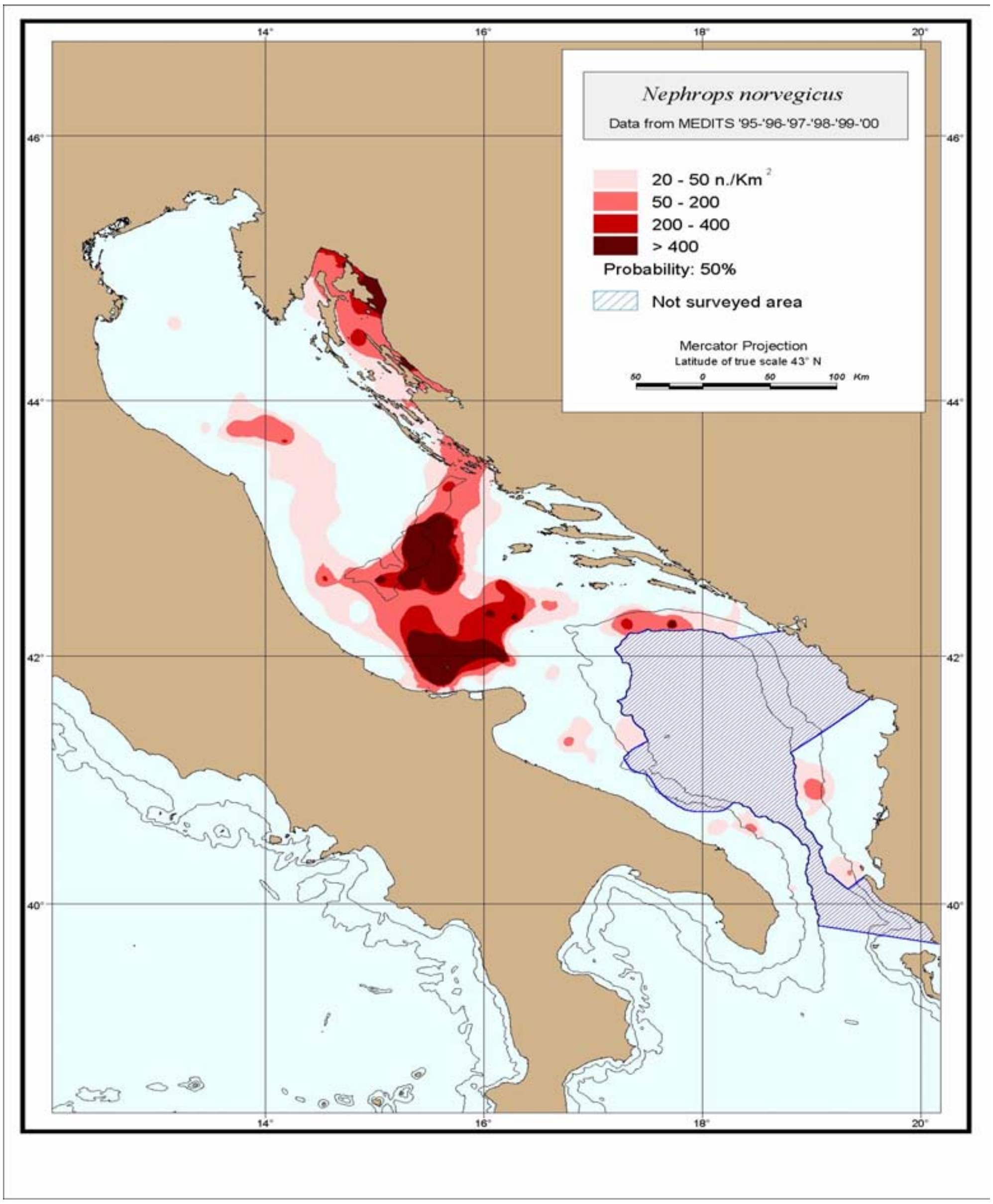


Figure 3a. Distribution of *M. merluccius* in the Adriatic Sea: indicator kriging representation (Gramolini *et al.*, in press). Data: Medits Programme.



Figures 3b. Distribution of *N. norvegicus* in the Adriatic Sea: indicator kriging representation (Gramolini *et al.,* in press). Data: Medits Programme.

The most important demersal and small pelagic commercial species whose stocks are shared in the Adriatic were identified and agreed upon by regional experts convened by AdriaMed (AdriaMed, 2000; Mannini *et al*., 2001). The recognition of the shared-stock status of the priority species (Table 2) was subsequently proposed to the national management authorities of the AdriaMed member countries (Albania, Croatia, Italy and Slovenia), and then endorsed at the 28th Session of the GFCM (GFCM, 2003).

The overview of capture fisheries landing trends from the Adriatic over thirty years (1970-2000) roughly outlines the fisheries production performance of the region. Data are from the open-access FAO statistics as compiled in the Fishstat Plus version 2.3 (FAO 2001). Nominal

landing figures are provided to FAO by member states and their reliability, which can differ greatly between countries and regions, cannot be easily assessed.
Therefore, caution needs to be exercised when considering trends in fisheries landing. It is important to note that the following main factors may be behind apparent landing trends: changes in the level of accuracy of fishery statistics reporting, trends in fishing intensity on the species in question, environmental trends in the productivity of the system, socio-economic factors affecting relative demand or accessibility of the species concerned.

Table 2. Relevant common species whose stocks are shared by at least two Adriatic countries (from AdriaMed Technical Documents N. 2 and 3).

Species	**Area of Occurrence**		
Adriatic Sea basins	Northern Adriatic	Central Adriatic	Southern Adriatic
Geographical Sub-area	**17**		**18**
Eledone cirrhosa		●	●
Eledone moschata	●	●	○
Loligo vulgaris	●	●	●
Lophius budegassa	○	●	●
Lophius piscatorius		○	●
Merlangus merlangus	●	●	
Merluccius merluccius	●	●	●
Mullus barbatus	●	●	●
Nephrops norvegicus	●	●	●
Pagellus erythrinus	●	●	●
Parapeneus longirostris		○	●
Sepia officinalis	●	●	●
Solea vulgaris	●	●	○
Engraulis encrasicolus	●	●	●
Sardina pilchardus	●	●	●
Sprattus sprattus	●	○	
Scomber scomber	●	●	●

●: common occurrence; ○: scarce; blank: negligible.

Underestimation of quantities landed is a common problem affecting the available statistics to an often unknown extent. For instance, and as an extreme case, according to a field interview survey conducted in Montenegro, it would appear that this country's landing statistics in recent years were underestimated by a factor of six (Regner, 2002). Nevertheless, although landing figures are likely to be (sometimes largely) underestimated in many cases, it can be reasonably assumed that overall, major trend patterns in fisheries landings are reflected in the time series. During the thirty-year period under consideration (1970-2000) the total landings of the Adriatic commercial capture fisheries of Albania[2], Croatia, Italy, Slovenia, Federal Republic of Yugoslavia (FRY) and the ex-Yugoslavia Republic reached its maximum in 1981 with about 220000 tonnes of declared landed catch, to subsequently decline to the minimum

[2] According to GFCM definition of statistical sub-areas the Adriatic Sea falls within the area 2.1, thus including only the Northern and Central basins, while the Southern Adriatic basin and consequently the coast of South-eastern Italy and of Albania are included in the Ionian Sea (area 2.2). In order to have as comprehensive a picture as possible of all Adriatic Sea fishery production, Albanian data originally classified as from the Ionian Sea have been included in the Adriatic data set used. Unfortunately, this was not feasible for South-western Italy (Apulia Region).

of 100000 tonnes in 1999 (Figure 4). Nominal total landing of Adriatic fisheries amounted to about 110000 tonnes in the last available year (2000).

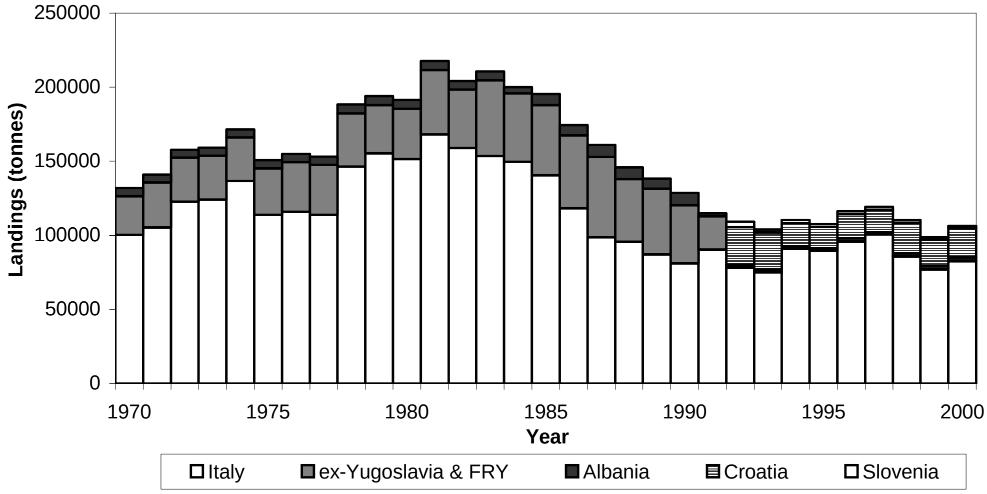


Figure 4. Adriatic Sea capture fishery production (excluding bivalve molluscs and aquaculture, see also text footnote 2). Data: FAO.

Recent demersal[3] and pelagic[4] fishery landings were compared to peak landings by area (Table 3). The comparison indicated that overall landing of the selected demersal species assemblage has currently declined to about 60-70 percent when compared to peak landing which in both western and eastern Adriatic demersal fisheries[5] was reached during the second half of the 1980s. In 1999 small pelagic fishery yields amounted to 53 percent (western fishery) and 35 percent (eastern fishery) of the maximum pelagic landing achieved in the early and mid 1980s.

[3] Demersal species are here defined as those belonging to ISSCAAP (International Standard Statistical Classification of Aquatic Animals and Plants) groups 31, 32, 33, 34, 38, 43, 45, 47 and 57 which included, in this paper, mainly: soles, turbots, gurnards, hakes, sparids, surmullets, sharks and rays, cephalopods, spottail squillid mantis, deepwater rose shrimp and Norway lobster.

[4] Pelagic fish are here defined as those belonging to ISSCAAP groups 33, 35 and 37, which include, in this paper, clupeoids, mackerels, mullets and garfish.

[5] The terms Western fisheries and Eastern fisheries are used to mean the landings of the Italian fishery and those, pooled, of ex-Yugoslavia and Albania (1972-91) and of Croatia, Slovenia, Federal Republic of Yugoslavia (Republic of Serbia and Montenegro) and Albania (from 1992 onward) respectively.

Table 3. Comparison by area of recent landings to peak landings of selected species from Adriatic Sea demersal and pelagic fishery, based on three-year running means (see footnote 3 and 4). Year 1999 is the last data point available in the running mean series. Data source: FAO

Demersal fishery				
Area	**Recent landing (t)**	**Max landing (t)**	**Year of max landing**	**Recent/max landing**
West Adriatic	25951	42442	1986	0.61
*East Adriatic	5414	8124	1989	0.67
Pelagic fishery				
Area	**Recent landing (t)**	**Max landing (t)**	**Year of max landing**	**Recent/max landing**
West Adriatic	51825	97624	1980	0.53
*East Adriatic	16770	47772	1986	0.35

* Pooled data: 1972-1991 from Albania and ex-Yugoslavia, 1992-2000 from Albania, Croatia, Slovenia and FRY.

Pelagic catch dominated the marine fish landing, particularly in the East Coast fishery (Mannini and Massa, 2000), even though from the mid 1980s the contribution of pelagics to total fish landings decreased remarkably as a consequence of the successive downsizing of the anchovy and sardine stocks and, more recently, of the economic changes which took place in the eastern coastal countries.

Demersal and pelagic landing patterns, expressed as a percentage variation relative to the mean, highlights the regression of small pelagic fisheries production in both the anchovy-based western fishery and the sardine-based eastern fisheries (Figures 5a and 5b).

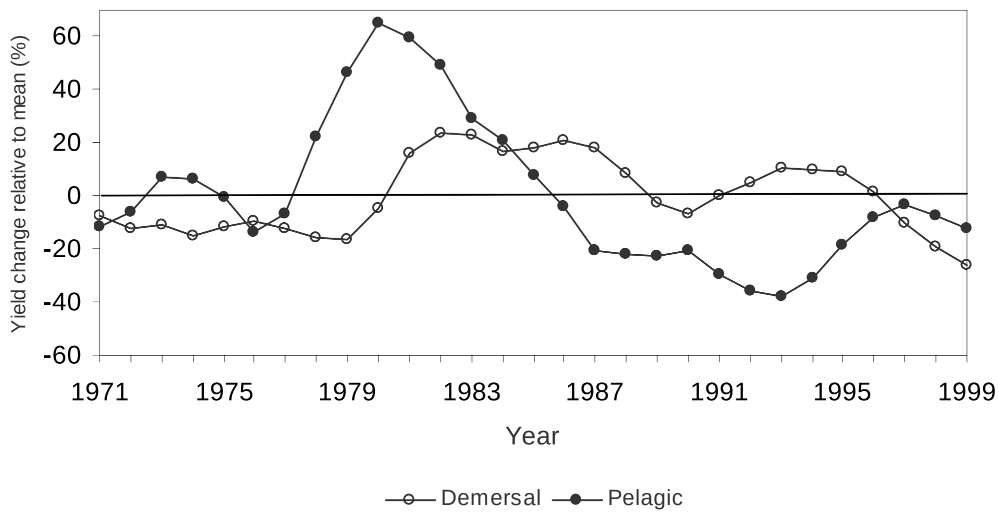


Figure 5a. Percentage landing change relative to mean value of Western Adriatic fisheries. Data source: FAO.

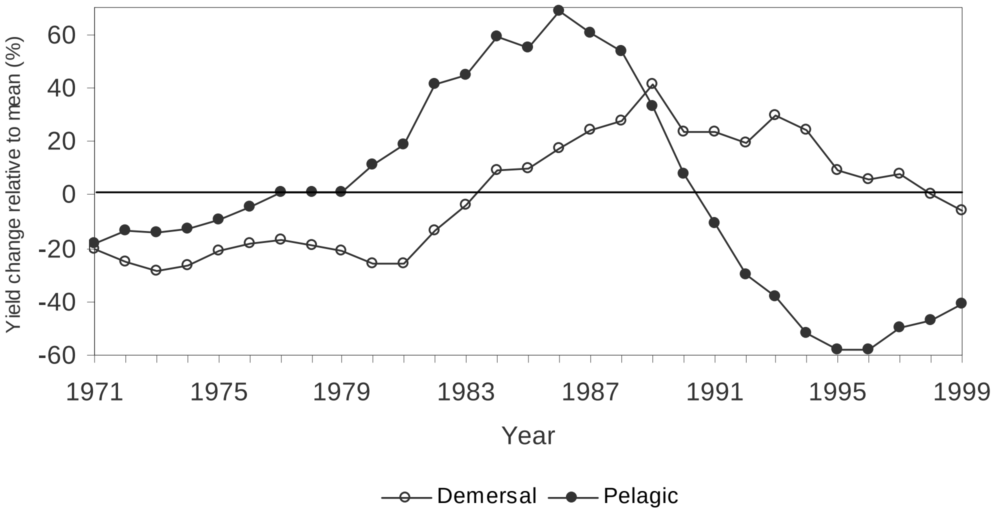


Figure 5b. Percentage landing change relative to mean value of Eastern Adriatic fisheries. Data source: FAO.

Both fisheries were strongly affected by factors of different origin producing a significant impact on the small pelagic fishery performance, such as subsidised production during part of the 1970s and 1980s (Bombace, 1993; Cingolani *et al*., 1998, 2000; Jukić-Peladić, 2001), anchovy recruitment failures (Bombace, 2001; Cingolani *et al*, 1996), and socio-economic changes affecting the sardine fishing industry in the Eastern Adriatic (Kapedani, 2001; Jukić-Peladić, 2001; Marčeta, 2001). Unlike the small pelagic fishery, demersal landing has developed and persisted above the average since the 1980s to begin declining in the second half of the 1990s. Out of the 15 species which currently contribute to total Adriatic landings with at least 1 percent, the quantities landed over time of some key-shared stocks are described hereunder.

Merluccius merluccius (2.6 percent average contribution to total landing; 10.7 percent average contribution to demersal landing as defined in footnote 3): The nominal landing of the European hake for the whole Adriatic Sea has been increasing since 1984 reaching the maximum of about 7000 tonnes in 1994. Since then, this growing landing trend has reversed sharply declining to less than 4000 tonnes according to the last available statistics (Figure 6). The average hake landing from 1970 to 2000 was about 4000 tonnes.

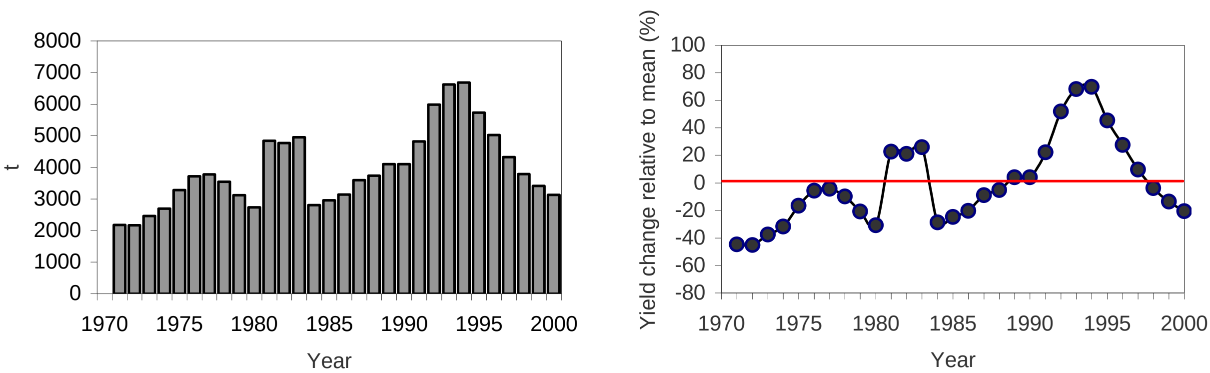


Figure 6. Landing (right) and percentage landing change relative to mean value (left) of *M. merluccius* from the Adriatic Sea (GFCM Geographical sub-area 17 and 18, three-year running average). Italian landings from area 18 are not included (see footnote 2).

Mullus spp. (1.3 percent average contribution to total landing; 5.5 percent average contribution to demersal landing as defined in footnote 3): The surmullets (*Mullus* spp.) landing has been increasing almost regularly with modest fluctuations since the second half of the 1980s, to reach multiple maxima each of about 3000 tonnes throughout the second half of the 1990s somehow levelling the yield increase of the previous decade (Figure 7). Over the period from 1970 to 2000 the average landing of red mullet according to official statistics was about 2000 tonnes.

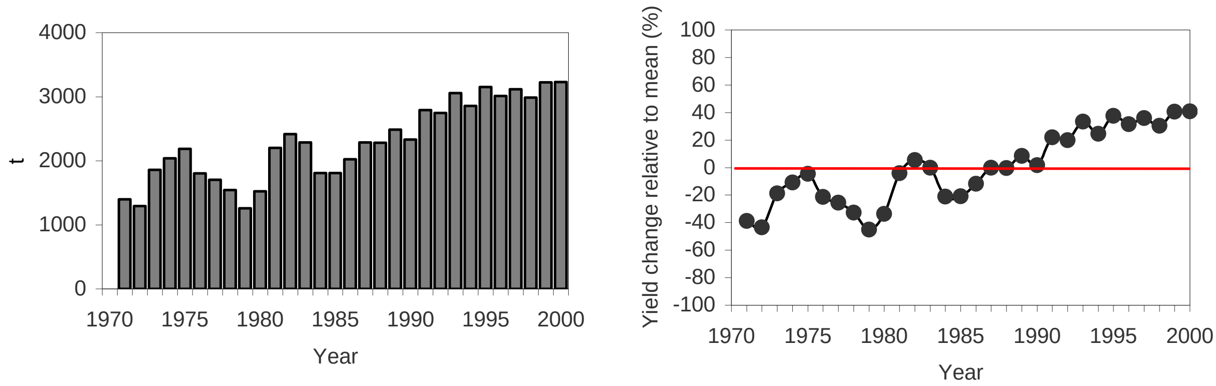


Figure 7. Landing (right) and percentage landing change relative to mean value (left) of *Mullus* spp. from the Adriatic Sea (GFCM Geographical sub-areas 17 and 18, three-year running average). Italian landings from area 18 are not included (see footnote 2).

Nephrops norvegicus (1 percent average contribution to total landing; 4.3 percent average contribution to demersal landing as defined in footnote 3): The nominal landing of Norway lobster reached the highest level of about 2500 tonnes in 1993, when the increasing pattern started during the early 1980s strongly reversed to less than 1000 tonnes in the year 2000. The average landing over the 1970-2000 period could be estimated at about 1500 tonnes (Figure 8).

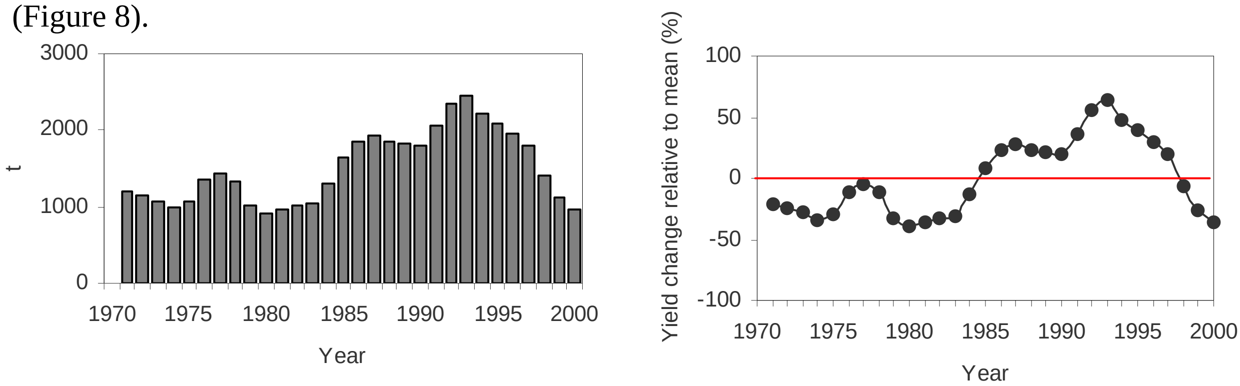


Figure 8. Landing (right) and percentage landing change relative to mean value (left) of *N. norvegicus* from the Adriatic Sea (GFCM Geographical sub-areas 17 and 18, three-year running average). Italian landings from area 18 are not included (see footnote 2).

Engraulis encrasicolus (19.1 percent average contribution to total landing; 32.3 percent average contribution to pelagic landing as defined in footnote 4): Anchovy landings during the last thirty years are characterised by two major factors: the landing peak of more than 50000 tonnes in 1981 and the subsequent decline to the minimum of 10000 tonnes in 1987, which lasted till the early 1990s.

Since then yield has been increasing to the current level of more than 30000 tonnes (Figure 9). Average landings over this period can be estimated at about 27000 tonnes.

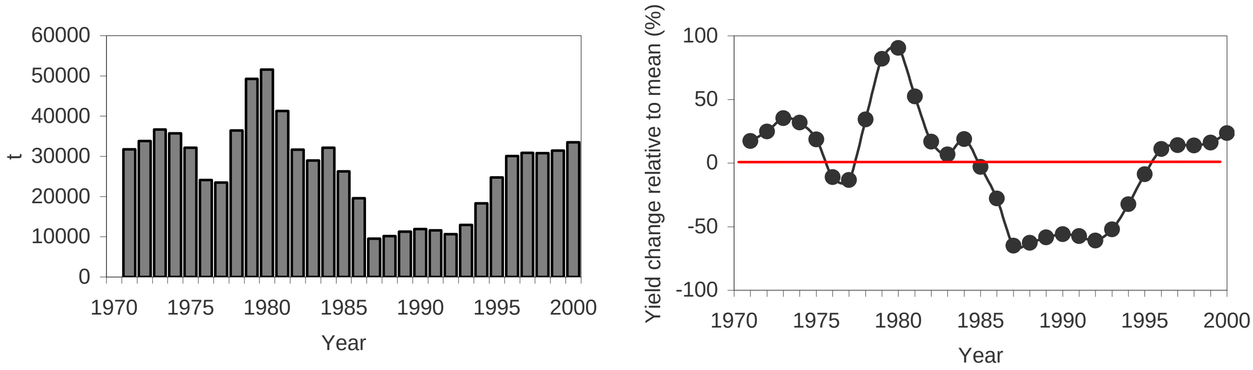


Figure 9. Landing (right) and percentage landing change relative to mean value (left) of *E. encrasicolus* from the Adriatic Sea (GFCM Geographical sub-areas 17 and 18, three-year running average). Italian landings from area 18 are not included (see footnote 2).

Sardina pilchardus (31.9 percent average contribution to total landing; 54 percent average contribution to pelagic landing as defined in footnote 4): the Sardine yield pattern shows a rising trend since the beginning of the available time series to peak at more than 80000 tonnes in 1982 and to regress to the minimum of 28000 tonnes from 1994 onwards. Over the whole period, Adriatic sardine landings averaged at about 48000 tonnes (Figure 10).

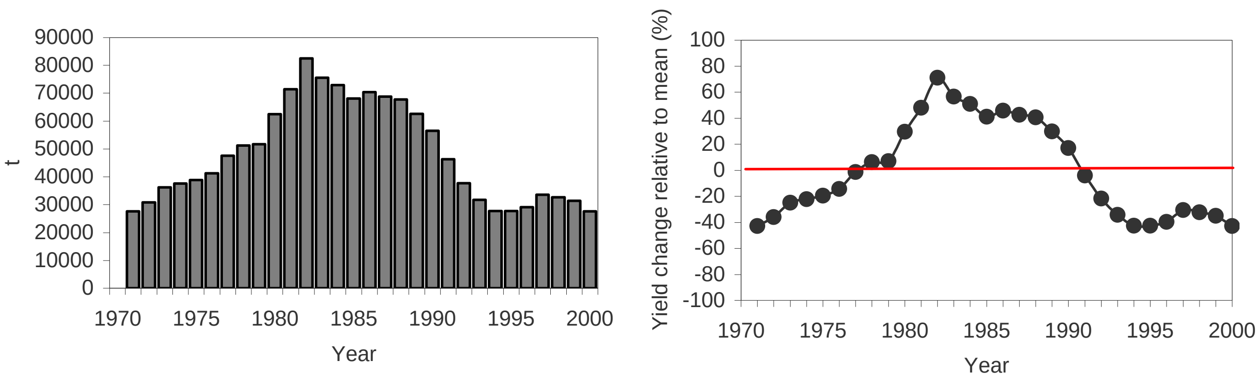


Figure 10. Landing (right) and percentage landing change relative to mean value (left) of *S. pilchardus* from the Adriatic Sea (GFCM Geographical sub-areas 17 and 18, three-year running average). Italian landings from area 18 are not included (see footnote 2).

The high number of species exploited by the demersal fishery characterizes the Adriatic fisheries (as well as Mediterranean fisheries in general) as remarkably multi-specific. The occurrence of many species in the demersal fishery landings would appear to confer a relatively moderate temporal variability to total landing. For instance, in Adriatic GSA 17 the temporal variability of the nominal total landed biomass (CV_t = 13.6) is lower that that of single species or species group landed biomass whose CV_i ranged from 17.7 to 78.9 (Table 4). Total demersal landed biomass variability between periods would be more conservative than single species or species group landings. This aspect of exploited demersal fishery communities has been recently investigated and discussed in detail by Blanchard and

Boucher (2001) comparing different areas of the Eastern Atlantic and Mediterranean using both fishery dependent and independent data. Apart from the possible reasons behind this fact, its role with respect to Adriatic demersal fishery production should be taken into consideration. Within the overall exploitation of Adriatic demersal communities the relatively high variability of landed quantities of individual species (or groups of species) determines, within the observed trends, the relative stability of the temporal variation of total landing. This may cause the total landing of the valuable multispecies assemblages to rely on a relatively constant supply even if within decreasing total quantity. This fact, coupled with the rise in prices which maintains the profitability of fisheries, can contribute to promote fishing activity (i.e. effort) thus generating further exploitation (see Irepa, 2003, for detailed analysis of the performance of Italian fisheries).

Table 4. Individual and total coefficient of variation in the landed biomass of demersal resources of the Geographical Sub Area 17 in the Adriatic Sea.

Species	**Geographical Sub-Area 17**	**Species**	**Geographical Sub-Area 17**
Pagellus spp.	78.93	Rajiformes	38.76
Todarodes sagittatus	78.75	Pleuronectiformes	37.29
Parapenaeus longirostris	69.40	*Dicentrarchus labrax*	36.59
Conger conger	64.53	*Nephrops norvegicus*	35.03
Triglidae	60.56	*Micromesistius poutassou*	34.12
Dentex dentex	57.80	Scophthalmidae	34.01
Mustelus spp.	54.36	*Mullus* spp.	31.41
Gobiidae	52.70	*Loligo* spp.	31.22
Sparus aurata	51.04	*Sepia officinalis*	31.00
Boops boops	48.58	*Octopus vulgaris*	29.71
Eledone spp.	44.46	*Oblada melanura*	28.28
Merluccius merluccius	43.56	Scorpaenidae	27.18
Squalidae	40.60	*Solea solea*	26.70
Lophius piscatorius	40.00	Crustacea	22.19
Spicara spp.	39.41	*Squilla mantis*	17.68
		CV total	**13.64**

3. Fishing fleet

Tentatively, the evolution of Adriatic fishing fleet size, in terms of total number of fishing units as available from various sources, is given in Figure 11. It is possible that in some cases the records concerning small-scale artisanal fishery vessels were inaccurate or incomplete.

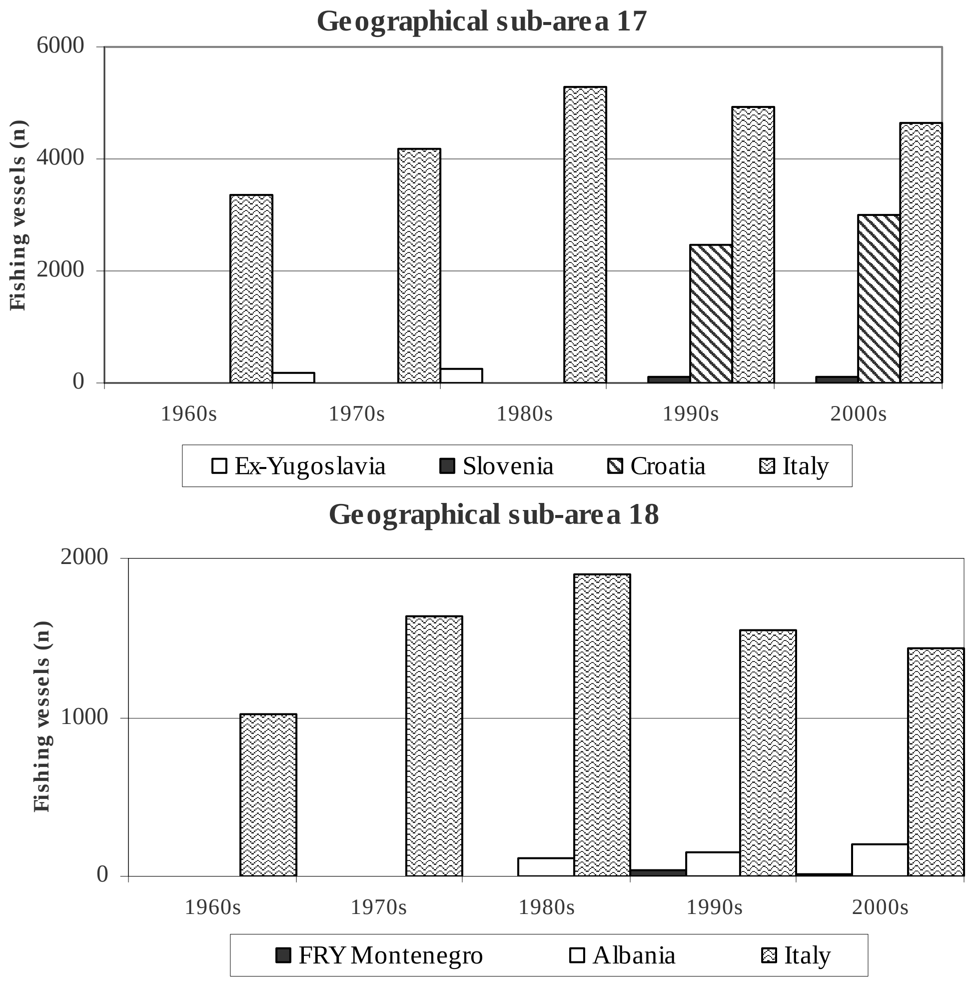


Figure 11. Tentative estimate of the Adriatic fishing fleet evolution in terms of number of units from the 1960s taken from available literature and the AdriaMed database (year 2001). In some cases, data on small-scale fishing fleets are approximate or incomplete. Source: AdriaMed (unpubl.), Breuil (1997), Caddy and Oliver (1996), Dujmušić (2000), Ferretti and Arata (1987), Katavić (2002), Regner (2002), Irepa.

The regional fleet including all fleet segments, i.e. from small-scale fishery vessels to large trawlers reached its maximum numerical size between the 1990s and the year 2000. However, since the 1980s two trends appear to have taken place: the number of fishing vessels has been decreasing along the Italian coast and in Montenegro (in this latter case small-scale fishing vessels were not included) while the opposite can be observed in the cases of Croatia and Albania.

The size of the Adriatic fishing fleet (Albania, Croatia, Italy and Slovenia) in 2001, on the basis of official and semi-official sources, was about 10000 registered/licensed fishing vessels, although the actual number of small artisanal units was certainly under-reported[6]. This is due to the fact that in some countries artisanal fishery is partially recorded or an

[6] At the time of the preparation of this paper, national fleet size estimates were being reviewed and updated by the Countries concerned.

official census is not taken. Average vessel age of national fleets ranged from about 25 (Italy) to 38 years (Croatia).

At present (as of 2001), the numerical composition of the Adriatic Sea fishing fleet by vessel/gear consists of three main categories made up of fishing units equipped, or permitted to operate, with multiple gears (i.e. polyvalents), passive fixed gears (mostly belonging to small scale fishery) and bottom trawl gear (Figure 12). To some extent the unspecified polyvalent category might be overestimated and consequently others underestimated, as vessels within this group could carry out a specific fishery (e.g. passive gear fishing or small coastal trawling) for a consistent part of the year.

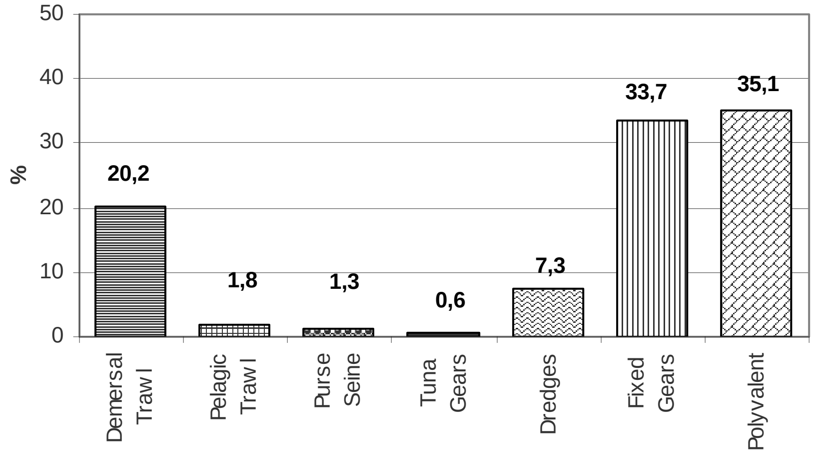


Figure 12. Adriatic Sea fishing fleet composition in 2001 (Albania, Croatia, Italy and Slovenia) expressed as the numerical percentage of vessels by fishing technique category. Source: AdriaMed database compiled in cooperation with the Fisheries Directorates of Albania, Croatia, Italy (through Irepa assistance), and Slovenia.

In terms of fishing capacity, a more indicative insight into the Adriatic fleet is obtained using vessel tonnage (Figure 13). Overall fleet tonnage for the most part resulted as allocated within the demersal trawl category followed by the polyvalent category. Fishing units performing pelagic fishery (mostly small pelagic fishery) ranked third (including both pelagic trawlers and purse seiners).

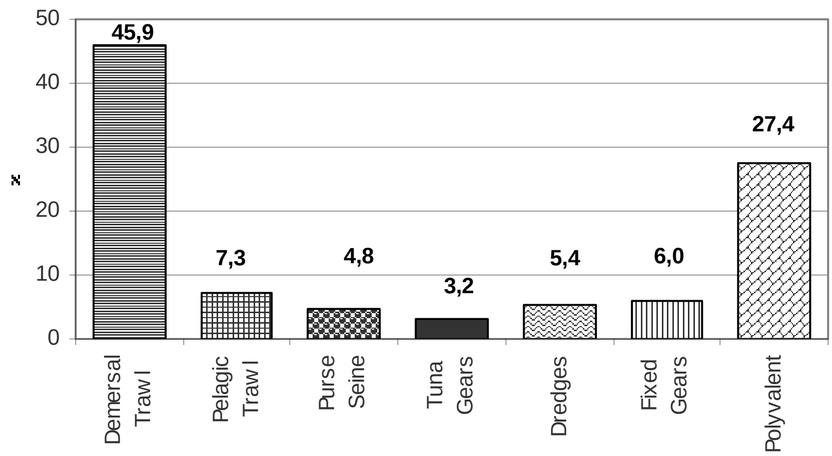


Figure 13. Adriatic Sea fishing fleet composition in 2001 (Albania, Croatia, and Italy) as percentage tonnage (GT) allocation by fishing technique category. Source: AdriaMed database compiled in cooperation with the Fisheries Directorates of Albania, Croatia, and Italy (through assistance from Irepa).

Fishing fleet composition in number by vessel size (length overall, LOA) and fishing gear showed (Figure 14) that most of the small scale fixed gear fishery is performed by small units of less than 12 m (LOA), most polyvalent vessels fall within the small vessel class with only about 20 percent being within the medium-size vessel category.

Most demersal and pelagic trawlers, purse seiners and tuna vessels belong to the medium-size category (12-24 m LOA) even though they are also present with various percentages in the small vessels segment. Lastly, consistent percentages of pelagic trawlers, tuna vessels, purse seiners and demersal trawlers in decreasing order of occurrence within each vessel/gear group, belong to the large vessels category (length above 24 m).

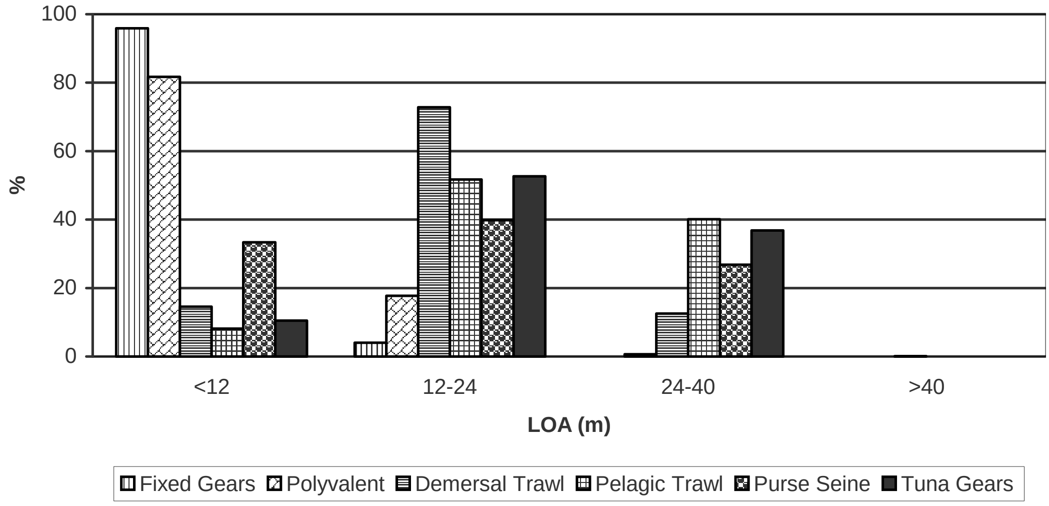


Figure 14. Adriatic fishing vessels numeric distribution in 2001 (Albania, Croatia, Italy and Slovenia) by length class (LOA) and fishing technique category. Source: AdriaMed database compiled in cooperation with the Fisheries Directorates of Albania, Croatia, Italy (through assistance from Irepa), and Slovenia.

4. Some remarks

The Adriatic Sea is probably the largest and the best-defined area of occurrence of shared stocks in the Mediterranean. The main issues related to shared stocks and to the management of their fisheries have been known for a long time. In 1980 Gulland observed with reference to scientific cooperation in research on shared stocks that “The main benefit from international cooperation in research is that it becomes possible to consider all the information concerning a stock of fish wherever it occurs. In the absence of such information it is very easy for a country to misinterpret what is happening to the stock in its EEZ, even when it has good information on everything that is happening in that zone” (Gulland, 1980, p. 8). With reference to the Adriatic Sea fisheries some facts can be pointed out and taken into account for the needs of fishery management planning.

Maximum total landing of both demersal and small pelagic resources was reached in the 1980s. Small pelagic fishery production has been affected by both environmentally induced stock size fluctuations (emphasised to some extent by fishery exploitation) as in the case of the western anchovy fishery and socio-economic factors (most likely combined with low stock size) as in the case of the eastern sardine fishery. Western demersal fishery in terms of landed production fully developed during the 1980s while the eastern demersal fishery has been developing since the 1980s. The western fishing fleet size reached a maximum in terms of number of vessels during the 1980s to start decreasing from the 1990s. The eastern fishing fleets started to increase considerably in the 1980s. Owing to several reasons (e.g. vessel age, available technology, crew skills, land-based services and infrastructures) vessel fishing power and fleet capacity can be assumed to vary widely between national fleets.

The development of Adriatic fisheries, as may be observed from the available landing data time series, seems to some extent to resemble the generalized fishery development model (Grainger and Garcia, 1996) which is composed of four phases: underdeveloped, developing, mature and senescent. This could be particularly the case for demersal fisheries, which are in general less prone to environmentally induced stock size fluctuations. Following Grainger and Garcia's definition of "meta-fishery" to mean a fishery targeting a species assemblage through an interacting multi-gear fleet in a given area (Grainger and Garcia, 1996), Adriatic demersal meta-fishery would appear to have developed through the 1980s reaching the mature phase in the late 1980s and 1990s to subsequently go through a senescent phase. The impact and sustainability of the overall growth of the demersal trawl fleet (as number of fishing units) in recent times should be closely monitored as it may have led to excessively high exploitation rates particularly affecting some key-species (Ungaro *et al*., 2003).

The state of heavy exploitation of Adriatic fishery resources is evident and for some stocks is critical. It can be noted that several different factors, often interacting simultaneously, have affected Adriatic fisheries. Fishery production dynamics are based not only on resource availability but are also strongly driven by market demand and prices. Socio-economic forces have been observed to be determinant in shaping fishery exploitation patterns. The understanding of any fishery system, and the Adriatic makes no exception, increasingly calls for multidisciplinary analysis; basic reliable fisheries statistics are fundamental and, in the case of Adriatic shared fisheries, should necessarily be comparable and easily integrated.
Recently, management of shared stocks has been the topic of the Government of Norway-FAO Expert Consultation on the Management of Shared Fish Stocks where beyond the biological aspects, the economics of the management of shared stocks was also given relevance (Munro, 2003). The Consultation, while noting that the management of shared fishery resources is one of the great challenges in the pursuit of sustainable fisheries, highlighted the fact that non-cooperative management easily leads to overexploitation. It has to be recognised that management and enforcement of rules are rather obviously more complex for shared fisheries than for non-shared fisheries.

The Code of Conduct for Responsible Fisheries (FAO, 1995; *Article 7.1.3; 7.3.1; 7.3.2; 7.4.6; 12.7*) clearly and unequivocally addresses issues concerning shared stocks, emphasis is given to cooperation among States as an essential and unavoidable requirement for the responsible exploitation of such resources. Nevertheless, cooperative fishery research and, above all, management can be really effective when each part foresees benefits equal or superior to those it would expect in a scenario with no cooperation (FAO, 2002).

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Quality and certification of fishery products from both capture and farming in the same market place

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Abstract

Increasing interest on fishery products' safety/quality has emerged in all parts of the fishery chain, related to consumer concern and the variability in supply and quality. Differences in species, age/size, reproductive phase, quality of aquatic environment, feeding availability, water temperature, production method and season of harvest and variability in handling, processing and packaging methods contribute to variability in safety and quality of the final product. The cold chain maintenance before the final product distribution is essential for the safety and for the single most important attribute of quality such as the freshness of the product. Much work has been done on developing scientific methods for accurate, rapid, and inexpensive measurement of the fish freshness. For the time being, the sensory assessment remains the favoured option. The limited fishery products' supply suggests a closer integration between cultured and captured fish trade, an improvement of raw product quality and a reduction to a minimum of any waste along the processing line and distribution chain. Superior fresh aroma, iridescence of skin, body and flesh leanness and higher n-3 highly polyunsaturated fatty acids content are frequently found in wild fish in comparison to cultured fish of the same species and size. On the other hand, cultured fish can be fully controlled along the whole productive chain, constantly available in Extra freshness class. Moreover, its size and other qualitative traits, including the high n-3 HUFA, can be modulated towards the preferred ones mostly by changes in feed quantity and quality and feeding strategy. Both captured and cultured fishery products can be healthy and nutritional food, able to exert beneficial effects on the human body functioning, if produced and maintained safe, free from contaminants and fresh to the consumer. For this reason a "farm/sea-to table" policy is important, scientifically based and responsive to the seafood production chain changes. This policy should be articulated around the use of the farm/vessels Good Manufacturing Practices, the HACCP systems full implementation and should include the risk analysis to develop seafood safety objectives and standards. Sustainability, management responsibility, traceability, consumer information, quality label and certification can ensure safety for the consumer and help businesses to prosper. Initiatives of quality labels and certification for fishery product are not yet being used to a greater extent but it will be necessary to distinguish the more suitable among different types of quality certification standards and inform the consumers about them, without bewilderment due to the label proliferation.

1. Introduction

Quality seafood products with extended product shelf-life are a valid meat alternative for meeting the health-conscious consumer demands. Due to the limited seafood supply, a closer

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integration of cultured and captured fish trade shall become more important. For both capture fisheries and fish culturing sector another important issue is the improvement of raw product quality and the reduction to a minimum of any waste along the processing line and distribution chain. Seafood is particularly perishable and varies in composition because of differences in species, age, size and season of harvest. Moreover, variability in handling, processing and packaging methods further contribute to variability in quality (Huss, 1995). Maximising quality by selecting only the best specimens for harvest can be done for cultured animals but not in fisheries. Seafood processing industry needs new technologies to enhance quality, detect decomposition and extend product shelf-life while adding minimal costs.

In this time of sweeping changes in seafood industry, the increasing trend in consumption and trade, half of which coming from non-European countries, has evidenced a need of information at each transaction point of the market chain. More than 300 species, in every possible size and shape, some of them coming from aquaculture, each of them with specific handling, processing and packaging requirements, are traded at the market. European consumer demands credible information and assurance on product safety and quality parameters, such as fish freshness, origin, nutritional traits, variety and innovation. Moreover social/ethical issue - such as religion/beliefs, business ethics, animal welfare - and environmental issues - such as farming methods, pollution, genetic modification - are gaining interest. Increasing interest in fish safety/quality has also emerged in all parts of the fishery chain, in relation to consumer concern and to the variability in supply and quality of this delicate and highly perishable commodity (Pérez-Villarreal and Aboitiz, 2003).

Fish product credibility is important for purchaser/consumer and this is particularly true for cultured seafood, about which there is little, and often negative, knowledge. The Code of Conduct for Responsible Fisheries (FAO -1995), the Code of Conduct for the European Aquaculture (FEAP - 2000) and numerous EEC Regulations that followed, have introduced into the seafood sector concepts common to other animal food industry such as safety, sustainability, management responsibility, process line, traceability, consumer information, quality label and certification. Certification is the way to give information on products and to guarantee it is true and verifiable, therefore representing a competitive advantage and a market strategy. However, to make it work it is necessary to distinguish the different types of quality certification standards and inform the consumers about them (Poli and Scappini, 2002).

The objective of this paper was to contribute in drawing an outline of quality, quality changes from farm/boat to table, new techniques for quality improvement and certification issues of both capture and farming fish products found in the same national marketplace.

2. Fish products safety and quality

Fish is by European consumers perceived as a healthy and nutritional food and its freshness and price as the most important reasons to buy it (Luten, 2003). This perception is supported by the recent inclusion of fish in the "functional food" list, which was particularly due to the high content of natural n-3 highly unsaturated fatty acids (HUFA) C20:5 (EPA) and C20:6 (DHA) in fish lipids. At least twice-a week consumption of fish has been recommended by the Dietary Guidelines of International Committee, to prevent cardiovascular diseases, colon cancer and inflammatory bowel diseases. However, to exert all the potential beneficial effects without any risk for human health, it has to be produced and maintained safe, free from contaminants and fresh up to the consumer. In fact, no food quality can exist without assuring a reasonable food safety.

For this reason *seafood safety is a quality pre-requisite*, assured by law with the aim of the consumers' health protection, throughout both horizontal (Dir. 43/93/EEC, Reg. CE 466/2001, 2375/2001, 178/2002) and vertical (Reg. CE 2377/90, Dir. 91/67/EEC, 492/91/EEC, 493/91/EEC) regulations, able alone to give *a minimum food standard from the hygienic point of view.*

With the exclusion of pre-harvesting and harvesting on farm/vessels, food services and retail operations - for which the Code of Conduct for Responsible Fisheries (FAO -1995), the Codex Alimentarius (vol.9 Codex Standard for Fish and fishery products, 1999), the Code of Conduct for the European Aquaculture (FEAP - 2000) and other GMP guidelines could be implemented - all safety controls are made on the entire production process according to the general Directive 93/43 EEC concerning the “Hygiene of food products” that obliged a methodology based on the process line control: the HACCP (Hazard Analysis of the Critical Control Points). Such a system provides for the identification of the potential risks (microbiological, chemical, physical) connected with the production of food in different production phases, allowing the realisation of specific interventions to prevent any identified risk.

International standards to reduce the risks of illness from consumption of fish and fishery products are set up by the Codex Alimentarius Commission - an intergovernmental body with the purpose of implementation of the joint FAO/WHO Food Standards Program. Draft Code of Practice for Fish and Fishery products is currently under review by the Codex (Austin and Smith, 2003).

Further safety tools aiming at higher transparency in the fishery chain are partial seafood traceability, represented by the label for consumer information on common name of the species, harvesting area and production method (Reg. 104/2000; 2065/2001) compulsory from January 2002 and the future *whole supply chain traceability*, which is going to become compulsory as from 2005 and wholly implemented by 2006 (Reg. 178/2002/CEE). The whole supply chain traceability should increase food safety, provide better protections against food scandals and improve overall consumer confidence.

Seafood safety is generally based on the conformity to the foreseen levels/absences of a mix of attributes, such as food/borne pathogens, heavy metals and toxins, pesticide or drug residues, soil and water contaminants, food additives, preservatives, physical hazards, spoilage and botulism (Dir. 91/67/EEC, 492/92/EEC, 493/92/EEC, 43/93/EEC, Reg. CEE 466/2001, 2375/2001, 178/2002). Veterinary inspection generally includes the identification of the species which could potentially cause the seafood poisoning (*Tetraodontidae, Molidae, Diodontidae, Canthigasteridae*) or the presence of biotoxins (PSP, DSP, NSP, ASP) and the research of visible parasites (*Anisakis* spp). Microbiological, chemical and toxicological laboratory tests could also be requested and the following are the more frequent ones: total volatile basic nitrogen (TVB-N), trimethylamine (TMA) and dimethylamine (DMA), *Salmonella* spp., *Shigella* spp, *Staphylococcus aureus*, *Coli bacteria*, *Escherichia Coli*, *Vibrio cholerae*, *Vibrio Parahaemolitycus* and *Vibrio vulnificus*, *Listeria monocytogenes*, TVC, *Clostridium botulinum*, biogenic amines such as histamine, antibiotics, sulphamidic, Hg, Cd, Pb, and the PCBs.

At present, one of the most debated environmental issues causing considerable safety concern are the contaminants generally found in the environment as complex mixtures - Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), polychlorinated biphenyl (PCBs) and organochlorine pesticides (OCPs). All are very persistent in soil, water and seabed with a strong potential for bioaccumulation along the food chain. These lipophylic substances gradually accumulate in wild and cultured seafood lipids, causing long-term damages to animals and their consumers. Several regulatory proposals have been elaborated to reduce directly or indirectly the emission of these substances into the environment and to safeguard human health. A limit of 1-4 pg WHO-TEQ/kg body weight was considered tolerable as daily intake value (TDI) by WHO in 1998 (van Leeuwen *et al*., 2000). In general, even if at trace levels, a constant presence of organochlorine pesticide and polychlorinated biphenyl, both in seafood and in commercial diets used in aquaculture, was confirmed recently, although no indication of important health risk associated with consumption of marine species’ products from the Mediterranean and the Adriatic Sea emerged (Bayarri *et al*., 2001; Focardi *et al*., 2001; Orban *et al*., 2000; 2002).

The rapid alarm system is another important safety tool. The system includes the notification of a direct and indirect risks for human health due to food or animal feed. All EU-member states, Commission and the European Authority for Food Safety participate in the rapid alarm system by 1) an *alert notification* and 2) an *information notification*. The *alert notification* implies an immediate action and consumers are assured that the product is eliminated from the market (i.e. only in the period May/June 2003 *alert notifications* were given by the Netherlands due to the presence of chloramphenicol in shrimp from Malesia and of nitrofuran in shrimp from Equador; Italy due to *Listeria monocytogenes* found in Norwegian salmon and Hg in blue shark from Spain; UK due to the presence of nitrofuran in shrimp from Bangladesh). The *information notification* regards products found in other Countries and consumers are guaranteed that those products won't be present on their national market.

Quality is related to particular attributes that seafood possesses, which are meeting the consumer demands *in addition to safety.*
Some quality attributes, endogenous and typical of the species, the result of the interaction of the endogenous factors and the environmental/nutritional/rearing condition exerted *infra vitam* on the animal, are fixed at death such as:

- commercial size, merchantable traits, body fat deposits quantity and distribution;
- organoleptic attributes, such as general appearance and colour of skin/muscle/eye/ gills, texture and odour of raw product and texture, taste, odour, flavour and juiciness of the cooked product;
- chemical-nutritional attributes of the edible portion, such as water, proteins, non protein nitrogenous compounds, lipids, saturated/ monounsaturated/ n-6 and n-3

polyunsaturated fatty acids, cholesterol, minerals and vitamins content, net energy-calories.

Differences exist for the same fish species due to age/size, season, the reproductive phase, the quality of aquatic environment, particularly as regards the possible presence of chemical and microbiological contaminants, feeding availability and water temperature.

Aquatic/environmental/feeding conditions may be differently favourable both in the wild and in captivity. Conditions which effect the favourability of a rearing site and practice include the position and technology applied (off-shore, in-shore, tanks, ponds, diet…). Among the pre-harvesting parameters for cultured fish the quality of hatcheries that supply the fry, the zooplankton and phytoplankton production for *larvae* and *post larvae* feeding has also to be considered and controlled.

Even if both *wild* and *cultured* fish products can be considered substantially equivalent in their ability to meet the human nutritional requirements, some difference generally emerge between them in specific organoleptic, chemical and nutritional aspects, mostly related to the different nutritional and environmental conditions where the animals were living. To be correct, comparison among cultured and wild fish should be done at the same season, water conditions and size. In general it can be underlined that for cultured fish the main factors of influence on the chemical and organoleptic traits are linked to feed quantity/quality and fish density during rearing. On the other hand, aquaculture products safety/quality can be controlled along the whole productive chain and modulated in part by the rearing/dietary factors in order to constantly meet the complex set of traits that consumer demands.
In comparison to wild fish, cultured fish of the same species generally show different odour and aroma, less evident colour and iridescence of the skin, higher lipid deposits, both at visceral level and, even if at lower extent, at muscular level. For examples cultured and wild sea bream of the same average weight (410 g) had respectively: 18 and 20% CP; 9.8 and 1.2% fat; 71 and 78% moisture and 1.4 and 1.5% ash. Significantly higher fat and lower moisture in muscles of cultured fish may be due to the high dietary fat in the commercial feed (20%) and the reduced activity (Alasalvar *et al.*, 2002). Analogous lipid/moisture composition was reported by Orban *et al*. (2003) for cultured (514 g) and wild (653 g) sea bass (9.36 vs 2.15% and 69.56 vs 76.67%); less evident were the differences found in lipid/moisture composition of cultured (360 g) and wild (389 g) gilthead sea bream (11.13 vs 7.37% and 67.13 vs 70.68%).

Higher levels of n-3 PUFA in wild fish in comparison to intensively reared one were reported by Krajnovic-Ozretic *et al*. (1994) for sea bass and by Serot *et al.* (1998) for turbot. Orban *et al.* (2003) found a) no differences in n-3 and n-6 PUFA percent levels between the wild (from lagoon) and farmed sea bass fillets (23.66 vs 22.70%; 7.84 vs 8.19%) and b) significant differences with the lower levels of n-3 and n-6 PUFA percent in wild gilthead sea bream in respect to the farmed ones (12.06 vs 24.07%; 4.42 vs 6.64%). In any case, farmed fish species closely reflected diet characteristics (sea bass diet: 22.05% n-3 PUFA and 7.48% n-6 PUFA; gilthead sea bream diet: 21.46% n-3 PUFA and 6.64% n-6 PUFA). Therefore the lower n-3 and n-6 PUFA, together with the higher saturated and monounsaturated fatty acids, found in wild gilthead sea bream, possibly reflected different quality of food available in the lagoon from where they were caught. The fish age and the season of sampling (not well specified by the authors) can also have influenced lipid deposition both in quantity and quality.

Fatty acid composition of flesh of cultured marine fish could in the future reflect even more the fatty acid profile of vegetable components, due to their increasing presence in commercial feeds (higher incidence of PUFA such as C18:2 n-2 and C18:3 n-3 and the lower incidence of HUFA such as C20:5 n-3 and C22:6 n-3). On the other hand, because fish lipids closely reflect the lipid composition of the diet, cultured fish can be characterised by similar, or even higher, levels of intramuscular n-3 HUFA (C20:5 n-3 and C22:6 n-3), in comparison to the wild fish of the same species, when fed on a good fish meal or on diets with a low vegetable source added with the right fish oil quantity. A promising feeding strategy to reduce the use of fish oil without compromising the fatty acid pattern of fish flesh is the return to a fish oil diet some weeks prior to harvesting (Bell *et al*., 2003; Régost *et al*., 2003).

A higher proportion of highly unsaturated fatty acids in the wild fish might cause faster deterioration of its desirable flavour, despite a lower fat content (Alasalvar *et al.,* 2002). Some other factors, such as higher capture stress and/or higher numbers of initial microbial flora in the wild fish may also possibly result in a more rapid spoilage. Other differences can be observed in cholesterol content per lipid gram and mercury level, generally lower in cultured fish products (Orban *et al*., 1996; 2000; 2003).

3. Quality changes: freshness concept/measure and importance of cold chain maintenance from farm/boat to table.

Some chemical fish parameters, such as the high levels of non protein nitrogenous compounds and of n-3 HUFA, highly susceptible to oxidation, together with the low carbohydrate content and the consequent high final pH in muscle not as efficient in microbial proliferation inhibition, contribute to its trait of high perishable food in respect to other meats.

Moreover, all conditions affecting fish biochemical processes taking place during *post mortem* period can heavily influence the expression of its flesh quality and the subsequent changes during storage, including freshness loss and shelf-life, all of them well indicated by the changes of the sensory/organoleptic attributes such as *rigor* status, general appearance and colour of skin/muscle/eye/gills, texture and odour of the raw products.

Seafood safety and quality can change as the product moves through the distribution chain, mostly due to the lack of attention paid to seafood correct harvesting and handling in sorting, icing, packaging, grading, transport and distribution of product in refrigerated and hygienic condition.

There is a general agreement among the EU member countries and along the transaction points of the whole distribution chain, that the Good Manufacturing Practices on board, in aquaculture plants, during storage and processing are essential for maintaining well defined safety and quality levels in this delicate and highly perishable commodity (Pérez-Villarreal and Aboitiz, 2003). Code of Conduct for Responsible Fisheries (FAO, 1995), Codex Standard for Fish and fishery products (Codex Alimentarius, 1999) gave indications and a Draft Code of practice for Fish and Fishery products is currently under revision (Austin and Smith, 2003).

Indeed, it is necessary to get it right at the start, because the initial quality and refrigeration level of the catch are essential for the best maintenance of the original fish product safety and quality, and the times, the temperature and the technology utilised are critical. The HACCP system, compulsory after harvesting and landing, but not always fully implemented, needs to be applied from origin of food to consumption. Mainly the *hygienic handling and packaging and the uninterrupted cold chain* during product storage, packaging, transport and distribution must be assured. The cold chain is considered one of the most important critical points to be strictly monitored and the time/temperature condition before the final product distribution can be a risk factor for the safety and for the single most important attribute of the quality such as *the freshness* of the seafood delivered to the consumer.

Freshness is more a concept than an entity. *"Fish freshness means that fish (with some restrictions the following applies also for molluscs or crustacean shellfish) is in its entire properties not far away from those properties it had in the living state or that only of short period of time has past since the fish has been caught or harvested… it is more a complex idea of an ideal state of wholesomeness, soundness and perfection of a newly harvested fish"* (Oehlenschäger and Sörensen, 1997). The same authors affirm that *"it is advisable to speak about* ***freshnesses****, where freshness* $_{t=0}$ *is the freshness at time of catch and/or harvest and freshness* $_{t>0}$ *has to be differentiated from the initial one…. So it can be concluded that freshness is an attribute which changes continuously but comprises a certain time period".*

Apart from the definition difficulty, seafood freshness is basic for its safety and quality. Differences in freshness changes, resulting from the different *post mortem* biochemical and microbial processes rate in different storage conditions, affect the shelf-life (the time seafood is fit for human consumption) and the eating quality of the products. Much work has been done on developing scientific methods for accurate, rapid, inexpensive fish freshness measure. Sensory evaluation, the use of sensors (volatile compounds, electrical properties, ATP metabolites) and spectroscopic methods (NIR) can be considered potential instruments for a rapid and non-destructive freshness evaluation of fish products (Olafsdóttir *et al.*, 1997). Multisensor technique for monitoring the quality of fish was also proposed (Nesvadba, 2003) combining the outputs of colour, electronic noses and texture measures, calibrating with sensory scores for appearance, smell and texture and giving an Artificial Quality Index that can be accurate as the sensorial method of reference. For the time, sensory assessment, with all its disadvantages, remains the favoured option.

The *sensory evaluation* is used *"to evoke, measure, analyse and interpret reactions to characteristics of food as perceived through the senses of sight, smell, taste touch and hearing"* (Huss, 1995). There are several methods at industry level and in the inspection service for evaluating fish quality and freshness but at the present the EU scheme (Council Regulation 2406/96) and the most modern Quality Index Method are the most commonly used.

The fresh fish evaluation by sensorial analysis according to the *EU Scheme* requires a seafood freshness/quality grading system at the point of the first sale according to the grading scales included in the regulation. Seafood evaluation for trade is usually carried out in auctions or other authorised plants by trained personnel and on the basis of schemes for different groups of species (white fish, fatty fish, selachians, cephalopods, shrimps, prawns) which grade fish freshness in three categories: E (Extra) - very fresh fish, A class - fresh fish and B class - bad quality but still edible fish. Below B is the level (Unfit) where fish is discarded for human consumption. Whole and gutted animals are assessed for appearance, odour of skin, outer slime, eyes, gills and belly cavity. Refrigeration slows down the rate of *post mortem* biochemical changes, slows the rate of change from a freshness class to the following one and increases shelf-life. For example: at 4 °C sea bass shelf-life is 6 days distributed in 2 days extra class, 2 days A class and 2 days B class; at 4 °C with ice covering sea bass shelf-life is 9 days distributed in 3 days extra class, 3 days A class and 3 days B class; at 1 °C with ice covering sea bass shelf-life is 10 days distributed in 3 days extra class, 3 days A class and 4 days B class (Poli *et al*., 1997).

Quality Index Method (QIM) has been suggested as an alternative to the EU schemes. This is a promising method in assessing the freshness of fish in a rapid and reliable way, based upon a scheme originally developed by the Tasmanian Food Research Unit (Bremner, 1985). QIM is based on well-defined characteristic changes of raw fish that occur in outer appearance of eyes, skin and gills, and odour and texture and a score system from 0 to 3 demerit (index) points. The description of each score for each parameter is listed in the QIM scheme. The scores for all the characteristics are summarised to give an overall sensory score, the so-called Quality Index. The aim when developing QIM for various species is to have the Quality Index increase linearly related with storage time in ice. As the Quality Index increases linearly with storage time in ice, the information may be used in production management. QIM schemes are developed for the following species: brill (*Rhombus laevis*), cod (*Gadus morhua*), Atlantic mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), European sardine (*Sardina pilchardus*), dab (*Limanda limanda*) deep water shrimp (*Pandalus borealis*), farmed salmon (*Salmo salar*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), peeled shrimp (Pandalus borealis), plaice (*Pleuronectes platessa*), pollock (*Pollachius virens*), redfish (*Sebastes mentella/marinus*), sole (*Solea vulgaris*) and turbot (*Scophtalmus maximus*), gilthead seabream (*Sparus aurata*) (Martinsdottir *et al*., 2003). QIM is in the future expected to become a reference method for the assessment of fresh fish within the European community. The internet selling, quality assurance systems implementation, information need of retailers and consumers and traceability are important issues which will stimulate the use and implementation of QIM.

The flesh of newly caught fish is free of bacteria. However considerable amounts of bacteria may be in viscera, gills and on skin. By reducing temperature to about 0°C the growth of spoilage and pathogenic micro-organisms is reduced, thus reducing the spoilage rate and reducing or even eliminating some safety risk. When the fish is stored whole in ice, the deterioration caused by bacteria is minimal for the first days of storage. *Post mortem* bacterial contamination of fish generally comes from extraneous sources. The number of bacteria increases thanks to the use of various compounds, which results in increasingly bad-smelling sulphur and nitrogenous volatile compounds, until fish become unfit for human consumption.

The activity of micro organisms is the main factor limiting the shelf-life of refrigerated fish, even if there are important non microbiological factors of fish deterioration. Total Viable Count (TVC) is the total number of bacteria capable of forming visible colonies on culture media at a given temperature. TVC of 10^2-10^6 cfu/g are usual on whole fish and cut fillets. Only a small fraction of the micro organisms present on seafood is actually of importance for product spoilage. Therefore TVC in seafood correlates poorly with the degree of freshness or remaining shelf-life. There is no correlation between the TVC and presence of any bacteria of public health significance. The aquatic environment may contribute to the microbial contamination of fish and affect its shelf-life. The temperature of the water from which fish are harvested may also determine its susceptibility to spoilage: the bacterial flora of cold-water fish species are not inhibited by refrigeration as effectively as are the bacterial flora of fish harvested from temperate to tropical waters (Herbert *et al.* 1976). However, the total number of bacteria on fish rarely closely indicates sensorial quality or storage characteristics. At the point of sensory rejection, the TVC of fish products generally can be around 10^7-10^8 cfu/g even if from a study by European consumers fish was assumed not to be in a good enough condition to be stored for long when TVC were around 10^6 cfu/g.

To have a safe seafood of good quality, it's necessary to get it right from the harvesting stage**.** Management of harvesting/killing procedures, if carried out without care to avoid severe stress to the animal, can heavily influence the expression of quality and the subsequent safety and quality changes during storage of the final product. This relationship has been amply demonstrated in all terrestrial animals. The killing method may be very stressful, particularly if it provokes prolonged agony in fish (Robb, 2001; Sigholt *et al*., 1997; Poli *et al*., 2003).

The length of the fishing process, intense handling, struggling and crowding during most capture protocols are very traumatic times for fish. To show an example, the bottom trawl fishery, according to its duration and depth, may damage and compromise fish quality, shelf-life and suitability to the industrial processing. The small pelagic fish anchovies (*Engraulis enchrasiculus*), harvested by trawling, generally have a market value inferior to that of fish of the same species caught by purse seine.

Nevertheless, the wild fishery capture stress is almost unavoidable or hard to control, while aquaculture presents a better opportunity to manage pre-harvest and harvest practices thereby minimising stress. Aquaculture operators have to consider that taking care of animal welfare is not only important from an ethical point of view, but means a better preservation of potential quality of the products that can be obtained for human consumption and thus preservation of their potential value. Increased muscular activity during stress condition and relative endocrine response can greatly influence fish *post-mortem* biochemical processes, mostly the anaerobic muscular degradation rate of glucose and cellular energy compounds. This in turn can markedly influence the onset and release of *rigor mortis* rate, which largely determines the involution rate of fish freshness, in this way leading to undesirable changes in the marketable, physical, organoleptic and freshness quality parameters. For example, killing methods influenced the *rigor* onset and release and shelf-life of sea bass was one day longer in less stressed animals (knocked, spiked and live chilled fish) in comparison to the more stressed ones (killed by Asfixia, CO_2 narcosis and electro narcosis) (Poli *et al.,* 2003).

It is possible to try to minimise some fish stress and this may improve the keeping quality of the final commercial product. High stocking density in particular often interacts in a complex manner with other factors such as quality of water, mostly hypoxia due to crowding prior to slaughter (Parisi *et al.*, 2001). Managing the pre-harvest and harvest practices with the aim of minimising stress has an ethic aspect that positively influences the quality of the final product.

Icing the fish at sea and keeping it properly iced throughout distribution and handling is the way to obtain the potential shelf-life (time span from the day of catch during which fresh fish can safely be placed on the market). The optimal refrigeration temperature along the whole supply and distribution chain would be 0°C but it is difficult to be maintained. Generally the 1°/2°C with ice covering can assure the best maintenance. There is a critical role of temperature control in atmospheric storage: keeping the temperature low affects both the microbiological and the biochemical aspect of the changes in quality. According to the law, ice microbiological and chemical safety (sea water or fresh water ice) has to be checked periodically. The right quantity and alternate layers of microbiologically and chemically safe ice and fish has to be used in clean containers. The latent heat of fusion of ice is about 80 kcal/kg. This means that a comparatively small amount of ice will be needed to cool 1 kg of fish (2,25 kg to cool down from 20°C to 0°C 10 kg fish). The reason why, in practice, more ice is needed is mainly because ice melting should compensate for thermal losses. This is the main reason for the introduction of insulated fish containers in fish handling, particularly in tropical climates: ice keeps fish and the insulated container keeps ice. Ice melting around the fish occurs at constant temperature so to be a self-contained temperature control system and to have this property on all contact points (Huss, 1995). In practice, the correct fish/ice ratio could be 70-60% fish: 30-40% ice.

Refrigerator or ice machine may be needed on the fishing vessel depending on duration of fishing operations. Times, temperature and technology utilized on board are critical and the total respect of hygienic rules as regards the environment, the personnel and the tools used has to be assured. In particular the fishing vessel deck and tools used for handling of the catch must be cleaned, mud and sediments washed out from fish before the following sorting and grading procedures. Fish, sorted according to the species, has to be covered with ice or dipped in ice and water to reduce body temperature to about 0 °C, so to decrease pathogens growth and spoilage rate. When large catches are to be handled, or if catch handling cannot start immediately, it is necessary to pre-chill the catch during holding in deck by using ice or in tanks using refrigerated sea water or a mixture of ice and seawater.

As already underlined, a fall in temperature reduces the autolytic *post mortem* processes rate, and delays the *rigor mortis* onset/release, so the more gradual autoliytic processes and microbial activity better preserve product freshness and its organoleptic and nutritional properties, even if with differences according to the species and size: larger fish spoil more slowly than the small ones, bony fish species keep longer than the cartilaginous and lean fish species better than fatty ones under aerobic storage. The faster spoilage rate of fatty small pelagic fish can also be due to their very thin skin, more susceptible to easier physical injuries and quick bacteria penetration. In Italy small pelagic fish are dipped immediately after fishing in baskets containing water and ice in order to delay the onset of *rigor mortis* and to slow down the modifications it implies (Huss, 1995).

Quality and storage life of many fish decrease if they are not gutted. This is due to digestive system bacteria and enzymes which can cause a violent autolysis *post-mortem*, giving rise to belly off-flavour. Gutting of lean fish such as cod is compulsory in northern countries. Gutting of hake (*Merluccius merluccius*) is practised in Italy by fishermen of the Adriatic Sea but not by those of the Tyrrhenian Sea. However, great care must be paid to such a procedure to avoid that bacteria and parasites (*Anisakis*), inhabiting the gut of this species, reach the muscle.

In case of clear signals of bad management of the catch, indicated by temperature, odour, *rigor mortis*, physical damage, the equipment of fishing boat should be checked to see what went wrong and to remedy the situation for a better quality of the following catch. Catches should be landed under optimal refrigeration conditions and docks should be suitable to receive the product allowing a quick unloading of boxes, avoiding the exposition of fish to the sun. Markets and auctions facilities have to be hygienically suitable and equipped with refrigerated rooms supplied with a temperature recorder.

A better sanitation and equipment design can prevent potential, unwanted microbiological problems. Structural and management conditions, cleaning and sanitation of tools and environments, control of the unwanted animals' presence, quality of water used, good manufacturing practices, careful temperature registration, self-control practices (decision 356/94/CEE), sanitary documentation and labelling correctness, packaging kind and transport (motor vehicle traits, load modality and temperatures) (327/80) are important factors to evaluate safety and quality maintenance. In auctions and other authorised plants, veterinary inspectors at first control identify the presence of the species which might cause the seafood poisoning as well as visible parasites, and carry out microbiological, chemical and toxicological lab tests.

The compulsory HACCP system needs to be applied from origin of food (from harvesting) to consumption and requires constant checking of fish quality on arrival to the factory to avoid the risk of substandard quality entering the processing line. During seafood chilling and freezing a continuous temperature checking (automatic recording) in chill room (< 5°C) and frequent check of icing is necessary to prevent early deterioration. Critical limits are +1°C for chilled fish and –18°C for frozen fish. In case of temperatures out of control, all products must be re-inspected, sorted and low quality material rejected (Huss, 1995).

In most primary markets the fish is sold whole, or gutted and gilled or headed and gutted. At the moment of gutting/beheading/defining/washing of fish there is a potential risk of contamination of the working tools, equipment and environment that can condition hygienic quality of catch. There is the need of suitable structures on the boat to avoid contamination during gutting and to allow a careful waste elimination. For all processing steps the hazards are bacteria growth and gross contamination by enteric pathogens. Control measure for bacteria growth is the establishment of *short processing time* which must be checked on daily basis by the line manager. For contamination control, the personal hygiene must be supervised continuously by the production manager, and prescribed procedures must be followed (medical certificate, report on illness, dress). Microbiological control of water quality must be carried out on a regular basis (daily, weakly, monthly- depending on the source of water). Critical limits for water quality are standards for drinking water (Huss, 1995).

The catching/harvesting method (severity of the pre-slaughter and slaughter stresses) and conditions at death and during storage (handling and storage temperatures), processing and transport that can cause quality changes are indicated by:
a) fish and fillet appearance (physical injuries, flesh gaping and colour);
b) technological properties of the fish and fillet (*rigor mortis* evolution, texture including firmness, cohesiveness and elasticity, water holding capacity and fillet shrinkage, *rigor mortis* onset;
c) freshness indicators, such as dielectric properties or impedance, K value, and/or spoilage indicators such as biogenic amines and lipids' oxidation products such as malonaldehyde;
d) sensory qualities of raw fish (skin appearance, *rigor* status, eye, gills colour, smell, mucus, flesh condition), the shelf-life and, even if less frequent, the differences in some sensory traits of cooked fillets as texture, taste, flavour, odour.

4. Culture standards

The Code of Conduct for Responsible Fisheries (FAO -1995) and the Code of Conduct for the European Aquaculture (FEAP - 2000) focus on production process quality rather than food safety, labelling or traceability. In particular this last Code stated as focal points for a responsible production in aquaculture the farm hygiene and healthiness, the culture eco-compatibility, the diet and feed safety and traceability.
Parameters potentially conditioning quality and safety of aquaculture products can be summarized as follows: genetic factors, management practices (farming techniques, use of chemicals…), environmental factors (water quality), dietary factors (quality and composition of diets), harvesting method, storage method, transport, handling and transformation, convenience (ready-to-use meals). The Code could be the basis for the development of individual national Codes of Practice, in order to interpret and apply existing standards and also to develop, refine or improve standards, as required; i.e. the Italian Fish Farmers Association (API) proposed The Code of Best Practice, where fish welfare is one of the key points they wish to assure.

European legislation principles (Dir. 91/67/EEC, Reg. 2377/90/EEC, 492/91/EEC, 493/91/EEC, Dir. 43/93/EEC, Reg. 2406/96/EEC; Reg. 104/2000/EEC; Reg. 2065/2001/EEC; Reg.466/2001/EEC, 2375/2001/EEC, 178/2002/EEC) state that a safe and high-quality product may be achieved through an increasing responsibility of fishery operators in the management and conservation of the natural resources involved in the process line. The adoption of protocols of fishery and hygienic catch handling is strongly recommended. A valid instrument to this purpose may be the "Good Manufacturing Practice" drawn up by different category associations, by persons and/or normative organisations. Starting from a risk analysis drafted for each specific process chain, such manuals allow a clear proposal of the technical instruments and monitoring elements necessary/sufficient to carry out the process in accordance with the norms. Naturally each manual should be adapted to any specific situation to design an adequate management responsibility strategy, in this way each operator works to the achievement of a safe and good quality product. In Italy, at present, there are initiatives aimed at achieving a better safety and quality standard by voluntary norms: National Agreement for Food Safety and Quality (CNEL); Guidelines and Technical Specifications on Product Certification for Sea Bream, Sea bass and Trout from Aquaculture (API, Associazione Piscicoltori Italiani); Guidelines for the Application of HACCP to Fishery Enterprises Marketing Seafood Directly (drawn up by Cooperativa Mare, Consorzio Mediterraneo); Protocol for the freshwater fish process line (AGEI/INRAN).

Because there is still concern about possible pharmaceuticals residues and/or environmental contaminants from feed in cultured fish, organic aquatic foods now appear to be more accepted as consumers extend their concern with non-organic terrestrial production systems to fish farming systems. Organic certification was developed for aquaculture farms in the ‘90s by the International Federation of Organic Aquaculture Movements (IFOAM), and was received in the European countries by different certification bodies that have developed their own standards, many still in draft form. Norms for marine species are those of the French Ministère de l’Agriculture et de la Pèche (2000 - in reference to Reg. CEE 2092/91) for sea bass, sea bream and turbot. Standards draft for aquaculture in Italy comprises specific norms for organic rearing, with reference to trout, salmon, sea bream, sea bass, carp and catfish (AIAB 2001). An organic standards draft for Italian marine aquaculture by adapting the Reg. 1804/99/ECC for organic terrestrial animal production to aquatic animal production was proposed by the Consorzio Uniprom. The Uniprom project output (Cataudella and Bronzi, 2001), even if still standards in draft to be completed and improved, represents an important starting point from which a proposal for an E.U. organic marine aquaculture regulation could be performed.

It is still a challenge for aquaculture to follow the same general principles as terrestrial organic agriculture (Reg. 1804/99/EEC) as far as it is still contentious what constitutes an organic product, because it involves specifications for all aspects of the supply chain. This includes stocking density (i.e. 15 kg/m^3 for tanks and 10 kg/m^3 for floating cages), feeds and their source, use of chemicals and pharmaceuticals in the treatment of diseases, environmental impact, slaughtering and the welfare rights of fish, without mentioning the post harvest question in the energy intensive distribution chain around the world, when alternative substitutes may be available locally. However it is worth to remind that both conventionally and organically grown food products must be safe. Thus an organic label only conveys information about production practices, not safety.

5. Quality improvements in both cultured and captured fish

The growth of the fishery industry is strictly related to quality-control techniques. Government mandates to continually monitor both the safety and the quality of seafood products from water to table are on the horizon. The key areas where to act to contribute to the seafood sector progress can be summarised as:

1) ensuring safety and quality of seafood,
2) improving seafood processing technology,

3) adding value to seafood products,
4) expanding supplies and markets.

These topics are closely interconnected and focused on ensuring safety for the consumer and helping businesses to prosper. Technology will be a primary vehicle for improving food safety and quality, lowering production costs and adapting processing plants aimed to reduce energy consumption/waste and to increase productivity.

Improvement of seafood safety implies the development of appropriate regulations such as the food safety control system HACCP and its operations, under which the pathogen control during seafood processing is one of the major food-safety issues. Processors will need considerable technical assistance to evaluate and validate procedures that will assure product safety and marketability. The way to proceed is to validate HACCAP and sanitation models under commercial conditions to determine their effectiveness, reliability, and the cost and benefits of investments in equipment and instrumentation versus manual control and monitoring. The surveillance of imported seafood would be enhanced through evaluations of product-testing methods. Faster international agreements on methods for validating technologies can facilitate the training opportunities.

The sectors of the seafood supply chain which are exempt from HACCP regulations, such as harvesting vessels, food services and retail operations, need to develop better on-board handling methods to improve food safety assurance and consistent raw-product quality.

Other issues for safety and quality improvement are the correct implementation of innovative technology procedures, including high pressure, pulsed electric field, e-beam radiation, x-ray treatments, etc.

Improvements are also needed in many conventional technologies, such as depuration, hot water pasteurisation, anti-microbial additives and treatments, traditional thermal processes and reduced-oxygen packaging.

Preventing product degradation by protecting seafood proteins during processing by adjustments in pH can be useful as far as to extend product shelf-life by developing active packaging and edible films.

Innovative uses for modified-atmosphere packaging and anti-microbial treatments for seafood products and rapid-testing methods for hazards, including toxins and pathogens, have to be developed to enhance safety and quality. This also implies improving product-tracking systems and time-temperature monitors and validating pathogen growth models in commercially produced seafood. This implies ensuring that significant seafood hazards are controlled from harvest to consumption by creating and coordinating educational and training programs and national courses. Computerised systems for tracking and monitoring the status of sensitive products throughout the distribution stream are becoming commercially feasible. New software will be needed to collect and manage data to allow a reliable prediction of remaining quality shelf-life under controlled conditions.

Many fish species are still not widely consumed because they degrade rapidly. Improved storage and processing techniques are needed, but because fish and shellfish are highly variable in their physiology, there is a need to study their properties by species. Ready-to cook and ready-to-eat seafood products require processing and storage, which may reduce product quality. A better understanding of the chemical and physical properties of seafood muscle components could minimise these effects.

6. Certification of Mediterranean fish products

Product credibility is important for purchasers/consumers and this is particularly true for cultured seafood, about which there is little, and often negative, knowledge. Mandatory label for consumer information on common name of species, harvesting area and production method (Reg. 104/2000; 2065/2001) is compulsory from January 2002. Other labelling is voluntary when the government judges that buyers have a "want to know" before making purchase and have a "need for fraud protection".

Certification is the way both to give information on products and to guarantee they are true and verifiable, thanks to regular checks made by an independent third party organisation. Certification is therefore a competitive advantage and a market strategy. However, to make it work it is necessary to distinguish and choose the more suitable among the different types of quality certification standards and inform the consumers about them. All types of food certification are voluntary, based on a norm or on public specifications and regulated and controlled by national standard bodies or accredited independent organisations.

Certification may relate to both the process - such as those of Quality Management (ISO9000), Environmental System (ISO14000, EMAS) and Good Manufacturing Practices (GMP) - and the product - such as European Standards (PDO, PGI, CSC), Certified Products (Voluntary Product Certification), National Labels, Collective Trademarks (CT), Quality Awards, Organic Certification, Eco-label and the whole supply chain traceability. Initiatives of quality labels and certification for seafood have been set in Europe but, until now, they are not yet used for fish products to any great extent (Poli and Scappini, 2002).

Obtaining ISO 9000 or ISO 14000 or EMAS certification is beneficial for a firm, because it can tighten production and management practices, thereby reducing cost and inefficiency, and, in addition, it communicates to external parties that a firm has a documented quality/environmental management system in place. These certifications are scarcely represented in the fish sector and are used mainly by processors, by some auctions and by a small proportion of farms and vessels, particularly in the Nordic Countries, and controlled by third part independent organisation. There are a few aquaculture farms certified (ISO 9002) in Italy, Greece and Norway, and some aquaculture farms and EMAS in Norway. On the whole in Italy there are: 10 aquaculture farms, 2 feed industries, 1 auction, 9 wholesalers, 52 processors certified ISO9001, 9002, 9001:2000 and 7 processors of fish products certified ISO 14000; 1 pilot project which aims to apply EMAS to 3 different aquaculture farms (the ISO Survey of ISO 9000 and ISO 14000 Certificates. http://www.iso.ch).

Good Manufacturing Practices (GMP) are handling and manufacturing standards applied specifically for the fish sector, voluntary based and established and operated by the industry itself or by independent organisations. Usually they are applied to specific links of the commercialisation chain (wholesalers, processors and retailers) and are used as guide models or as a business certification scheme or awards. Technical, organisational or business procedures can be certified. There are GMPs in UK, Portugal, France (specification for bivalves producers and wholesalers), Norway and nowadays they are being developed in every European Country, including Italy with the Code of Best Practice proposed by the Italian Fish Farmers Association (API). The most famous GMP standards used are: Code of Conduct for Responsible Fisheries (FAO 1995); Codex Alimentarius (vol.9 Codex Standard for Fish and fishery products, 1999); Code of Conduct for the European Aquaculture (FEAP - 2000); Norwegian Industries Standards, launched in Norway in 1998.

Important standards of product quality are the *European standards* (Reg. 2081/92/CEE and 2082/92/CEE) *Protected Designation of Origin, Protected Geographical Indication* and *Certificate of Specific Character products (PDO, PGI, CSC).* The schemes contain European compulsory technical rules developed to assure the origin of the product and are able to assure high level of both safety and quality. *PDO* is open to products produced, processed and prepared within a particular geographical area, and with features and characteristics which must be due to the geographical area; *PGI* is open to products which must be produced or processed or prepared within a geographical area and have a reputation, features or certain qualities attributable to that area. Really, out of 600 certified products, only 6 fish products have been certified by these schemes until now: n. 1 *PDO*: *Avgotaraco Messolonghioui Botargo* (spawn of Mesolongi) from Greece, and n. 5 *PGI*: *Coquille St. Jacques de Cotés-D'Armour* (scallops of Cotes d'Armor) from France; *Schwarzwaldforelle* (rainbow trout of Schwarzwald) and *Oberpfälzer Karpfen* (carp from Oberpfälzer) from Germany; *Whitstable Oysters* from UK*; Clare Island Salmon* from Ireland (the European Union On-Line: http://europa.eu.int).

Other initiatives are in preparation for *PGI*, mainly for cultured and processed fish products, at least: 3 in France (for oysters for example); 3 in Spain (processed fish, southern mackerel, tuna and aquaculture product); 3 in Portugal; 3 in Italy (*Acciughe sotto sale del Mar Ligure* - salted Anchovies; *Mitili del Golfo di La Spezia* – Mussels; *Vongola Verace delle Lagune di Calera e della Marinetta* - Clams).

The *Voluntary Product Certification* schemes are developed by industry to assure particular characteristics or special professional practices. They are voluntary, single-link involved, normally the producer, or the whole fish trade involved from producer to distributor. They are established and controlled by industry or independent official body. In France the well known mark NF Agro-Alimentaire guarantees that the product follows a norm of the French National Organism AFNOR. Actually, there are 9 AFNOR norms concerning fish products: fish farmed trout «*la truite charte qualité*», processed fish - frozen fillet portion, oysters – denomination and classification, cephalopods size classification, carp - classification, pike - classification, salmon - classification, processed fish - salted anchovy. The Scottish «*Tartan Quality Mark*» is the mark owned by some fish products (Scottish Quality Farmed Salmon Scheme; Smoked Scottish Quality Salmon Scheme; Salmon Smolts; Organically Produced

Farmed Salmon) produced in accordance with the standards set out in the Quality Manuals by Food Certification Scotland Ltd., an independent third party certification body; another Scottish certified product is the «*Scottish Quality Trout*» by the Scottish Food Quality Certification Ltd.

A certified product is also the «*Irish Salmon*», with an independently assessed assurance system, covering quality and safety, and is administered in trust for BIM (An Bord Iascaigh Mhara) by Irish Food Quality Certification Ltd.

Italian examples are *Pesce a marchio Coop, Salmone Norvegese, Rintracciabilità del Salmone Norvegese,* according to the specification drafted by the CSQA official certification body, *Tonno Round Pinne Gialle*, according to the specification drafted by DNV, *Rintracciabilità della Filiera Trote iridee – Spigole e Orate del Golfo di Patt*", according to the specification drafted by Certiquality.

Other products are Greek Mariculture Product certified by Agrocert (a national certifying organisation), following the standards AGRO 4-1 (qualitative control of fish) and AGRO 4-2 (packaging of fish).

National Labels are the official quality signs of a nation, and they are under the jurisdiction of a public organisation. In France the most famous National Labels are controlled by the Commission Nationale des Labels et de Certification des produits agricoles et alimentaires (CNLC):
Label Rouge (established in 1960) guarantees the superior quality of a product: at every product-making stage, the product must be strictly controlled and must comply with requirements pertaining to quality and taste. Out of a total of 403 Labels Rouges, only 6 regard fish products: *Conserves de sardines de Saint-Gilles-Croix-de-Vie, Bar d'aquaculture, Huîtres vertes «fines de claires» de Marennes-Oléron; Huîtres spéciales «pousses en claires» de Marennes-Oléron; Saumon fumé tranché à la main; Saumon écossais frais entier et découpé.*
Certificat de Conformité Produit (CCP), attesting that a foodstuff has special properties and complies with strictly controlled production rules: it guarantees consistent, distinct quality making it different from an ordinary product. Out of a total of 294 CCPs there are 8 fish products that fulfil these requirements: *Coquilles Saint-Jacques des Côtes d'Armor, Huître creuse* (oysters), *Anchois de Collioure* (salted anchovy), *Poissons pélagiques frais, Saumon Fumé*, *Saumon Fumé Atlantique* (smoked atlantic salmon), *Saumon Frais* (fresh salmon) from Norway, *Crevettes*.
Regional Label, only 1 label related to fish products: Nord Pas-de-Calais, applied to rollmops du Nord Pas-de-Calais, *filets de harengs fumés doux or marinés, soupes de poisson du Nord*. (Signe de qualité et origine des produits. http://www.agriculture.gouv.fr).

In Denmark there's another national label: The Blue Magnifying Glass Label or The Food Ministry Quality Label, given to Danish and foreign producers that follow the criteria fixed by the national legislation. Created in 1996, at first it was just for pork and veal, but in the year 2000 it was extended to fish (rainbow trout, eels from aquaculture) and vegetables (potatoes, carrots).

Collective Trademarks (CT) are non-company specific symbols certifying that products have certain characteristics; usually they distinguish the goods of the members of the association which owns the mark from others in the market; they are controlled by the holder of the mark or, in some cases, by third party independent organisations as external auditors. They are widely used especially in Southern Europe, such as in:
- France n. 7 (Bretagne Qualité Mer for fish and shellfish, Poitou-Charentes for troll sea bass bar de Ligne, Golfe du Lion – qualité producteurs for captured fish, Normandie Fraîcheur Mer for scallops, Pays Basque Sea Bass and Trout, Filiere Opale Boulogne Sur Mer, Bar de Ligne de Saint Jean de Luz);
- Italy n. 6 (Prodotto Ittico Italiano owned by Federcoopesca; Gabbiano Blu owned by AGCI pesca, Pesce Fresco di Qualità owned by Consorzio Pesca Ancona, Pesce Fresco della Versilia, Itticus pesce Veneto; Produzione Ittica Naturale).
- Spain n. 3 (Qualitat Alimentaria for Anchovy de l'Escala and Paix Blau de Tarragona, Kalitatea for tuna fish, Galicia Calidade for canned fish and fresh hake),
- England n. 2 (Superior Quality Shetland Salmon; Scottish Salmon Smokers Quality Assurance);
- Finland n. 2 (Salmon Trout / Superior, standard, process; Silverside);
- Holland n. 1 (Silver Sealed , a quality mark for some auctions);
- Norway n. 1 (Seafood from Norway, for exported products).

Quality Awards. These kinds of certifications are found mostly in northern-European countries and consist in quality contests where the best tested products are given the award and the possibility to use the label on the product. The most important are:
- Gold, silver and bronze medals of the DLG, German Agricultural Society, from Germany (this test is based on sensory assessment, which is made by mixed panels which comprise members from industry, trade, science and authorities; the system itself is based on the detection of defects in products; it is for all type of fishery products except for fresh fish);
- RAL quality award for fish and fishery products, still in Germany (products are tested by sensory, chemical, physical and microbiological test);
- Seafish Industry Authority - Quality Awards in UK (for different parts of quality chains: industry, retailers, fryers, etc.);
- Directorate of Fisheries` Quality Award in Norway (not for product, but for producers or exporters of Norwegian seafood distinguishing themselves in product quality and production processes).

Organic Certification. This type of specifications were developed for aquaculture farms in the '90s by the International Federation of Organic Aquaculture Movements (IFOAM), and were received in the European countries by different certification bodies who have developed their own standards, many still in draft form. The famous «Standards for Organic Aquaculture» were drafted in common by Krav in Sweden and Debio in Norway, and the companies that follow such standards can put on their product a «Ø» label. In UK the same function is absolved by the «Soil Association», in Germany by «Naturland», while in France is the Ministry of French Agriculture which created a project (CC REPAB F, Cahier des Charges Française du Réglement Européen pour la Production Animale Bio) for the utilisation, also for cultured fish, of the label «Agriculture Biologique». In many countries some specifications about organic fish farming production are in progress, such as in Italy, in

Austria, and in Ireland, where there are schemes for organic salmon, trout, sea bream, sea bass, carp and catfish culture.

Eco Labels such as Marine Stewardship Council-Unilever-WWF certifies environmentally responsible fisheries management and practices using a blue product label and LLH/F∅N (The Fishermen's Ecological Network) of Danish Society for a Living Sea.

Label proliferation represents a serious risk to the use of labelling programs to promote public health, environmental quality or other goals. The primary risk is probably the consumer bewilderment - too many labels and similar/overlapping labels increase the consumer's cost of using them. Gaining consumer recognition and reputation is difficult in a crowded field.

7. Conclusions

Fish products from capture and farming when placed on the same market can differ in some merchantable, organoleptic, chemical and dietetic parameters, due to their different environmental/nutritional/rearing conditions. The differences more frequently found are related to superior fresh aroma, iridescence of skin, body and flesh leanness, higher cholesterol and n-3 highly polyunsaturated fatty acids incidences of wild fish in comparison to cultured fish of the same species and size. On the other hand, cultured fish can be fully controlled along the whole productive chain and its size and other qualitative traits, including the high n-3 HUFA, can be modulated towards the preferred ones mostly by changes in feed quantity and quality and feeding strategy. However, both of them can be a healthy and nutritional food, able to have a number of beneficial effects on the functioning of the human body, if produced and maintained safe, free from contaminants and presented fresh to the consumer.

The initial quality and refrigeration level of the caught/harvested products are essential for the best maintenance of the fish product safety and quality, and the times, the temperature and the technology utilised are critical.
The increasing trend in consumption and in trade of seafood, half of which coming from non-European countries, makes the international approach to minimise the risk posed by fisheries' products to the consumers an urgent matter. A closer link between safety and quality of capture and farming fish products is needed to meet the consumers' demands. Improvement in quality, labelling and monitoring, thus assuring safety and quality of products from point of origin to the consumer, is one of the foremost challenges confronting the European seafood industry.

A "farm/sea-to table" policy must be scientifically based and responsive to the changes in the seafood production chain, articulated around the use of farm/vessels Good Manufacturing Practices and of risk analysis to develop seafood safety objectives and standards. This policy is strongly linked with the Hazard Analysis Critical Control Point systems full implementation. Improvement of capture/farming fish products businesses can be achieved through complying with regulations, educating consumers about buying and preparing seafood, educating industry workers on handling and sanitation, and developing improved processing procedures and demonstrating how the interaction of animal physiology, harvest methods and post-harvest processing can be better managed.

Safety and quality labels offer systematic approaches to better quality and incorporate the concept of continuous improvement. As a result the label is stable to the changing marked since it evolves over time and is based on multiple attributes rather than a single one. However, competing labels could crowd the field, lowering the marked impact of the labels mostly if its credibility will be shuttered by an episode of substandard quality in either the label itself or competing labels.

On the whole, seafood sector challenges include: a) increasingly competitive global marketplaces, b) complex trade policies, c) strict regulations, d) rising energy costs and e) a limited seafood supply. Nevertheless, changes bring new opportunities for expanding markets, farming strategic alliances and advancing innovations that can lower production costs, create new products, add values to existing ones, increase safety and reduce waste.

Prosperity will be achieved by resorting to a continuous interaction between fishing and farming and science and technology, which could lead to creation of new products and processes, improved quality and expanding markets.

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Market interactions between fishery and aquaculture in Italy

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Abstract
Seafood represents an important component of the food supply for Italian population. Several factors determine developments in the fishery and aquaculture sector. The biological limitations on marine fish stocks are a major constraint on fisheries sector development, although they can be somewhat counterbalanced by increases in fishing capacity, technological developments in harvesting and transport, and the development of aquaculture. While supply in the sector is limited by biological constraints, demand for fish and fish products by consumers continues to rise. This demand is influenced by human population levels, their eating habits, available disposable income, fish prices and geographic areas. Imported species from aquaculture such as sea bass and sea bream are also being consumed in increasing amounts by Italian consumers. Data show that in Italy there are different distribution channels for farmed products and for those from capture fishery, according to different habits of Italian consumers. The difference in distribution channels is one of relevant items to orient the price of the products: the two different production form - catch and farm - are not substitutes for each other and there is no link between the price of their products. Therefore a long-run change in the price of the farmed fish species has no impact on the long-run price of the same captured species. So, there are two different and separate markets. The market for fish caught in the wild is characterised by a constant positive trend in prices; the market for farmed products is characterised by a decreasing trend in prices, linked to increasing production and low-cost imports. New consumption patterns orient the consumers to chose seafood with added value in terms of labelling, brand, certification of quality, traceability, etc, and some other information that qualifies the good in terms of safety and hygiene. This added information should be important to increase the demand for cultured species when price is not the factor on which the choice is based upon and to push the no-price oriented choice.

1. Introduction

In the last few years, the Italian national fish production has shown a steady decline and in the year 2002 it dropped below 600 thousand tonnes. A decrease in the output of farmed products over the past year can also be registered, which is to be added to the negative trend in landings over the last decade. The reduction in farmed products represents an important reversal of trend in a sector which, over the 80s and the 90s, was characterised by high growth rates. The uncertainty affecting the market and the stagnation of the demand, represented on the side of the consumer by a constant per capita consumption around 21 kg in 2001 and 2002, have urged the sector operators to diversify the offer and to improve the quality and traceability of aquaculture products rather than to increase production capacity itself.

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Within a wider, global context of declining of fisheries resources, aquaculture provides a real alternative for seafood supply to Italian markets. The aquaculture industry in Italy, mainly in the Adriatic Area, is a sector with a long tradition; however, intensive marine fish farming is a relatively new activity and remains focused on only a few species: sea bream and sea bass. In general, the aquaculture is much younger than capture fisheries sector, and that is the cause of need of an integrated policy to optimise the economic structure of the sector.
In Italy, in terms of law, aquaculture is regulated as agricultural activity, with the adoption of some laws and rules from fishery in *strictu sensu*, or from other sectors, such as environment or industry. According to the new stage of Italian fish farming sector, with high investments, highly specialised employers, the best available technologies, very innovative methodologies for feeds, for veterinarian protocols, it is ambitious to believe that the adoption of specific rules could represent an opportunity to rationalise the management system. The absence of an univocal law system represents a weaknesses for the Italian sector, e.g. in case of evaluation for licensing of new cages, there is a long administrative procedure, and in some cases it is not possible to give the public concession, because farming activity is competing with other economic activities to find a place on the seashore.

Aquaculture has to face many constraints, notably increased competition for space along the coast, absolute dependence on the quality of the environment, a lack of would-be investors and a need for recognition on the markets. Hitherto few precise figures have been available to assess the importance of aquaculture as a component of seafood supply throughout Europe. Moreover, there is a need for objective data in the emergent, and at times, controversial image of aquaculture. An interesting scenario in the Italian area is represented by the Adriatic Region, where, in the last years there has been a decrease in terms of fishery production, but the demand of seafood has constantly increased; thanks to the efforts of aquaculture, the fishery balance is no more negative.

In the Adriatic region, at present, there is the most significant presence of fish farms (e.g.: around 47 percent intensive land based, 35 percent cages and 52 percent hatcheries); in this area the aquaculture sector is characterised, on the one hand, by strong socio-economic tradition, mainly in freshwater and valliculture, and, on the other hand, by the presence of numerous areas where the building of farms is favourable.

2. Fishery and aquaculture sector: sea bass and sea bream

Over the last few years, thanks to the increasing phenomena of the internationalisation of policies and economy, the Italian fishery sector has undergone a period of profound changes. Fish catches within the Mediterranean area have markedly shrunk. This was not only due to the restrictions imposed on fishing capacity by the EU policy with its IVth POP, but also to the increasing depletion of stocks. Moreover, several environmental and war emergencies, which occurred between 1999 and 2000, considerably reduced fishing activity. Another determining factor was the progressive growth of fuel price, which led a number of operators to quit their activity by using withdrawal allowances provided for by SFOP. During the second half of the 90's the decline in the overall catches was slightly lower than 20 percent, whereas in the year 2000, according to IREPA's data, the volume of catches did not exceed 392 thousands tonnes, a figure that is definitely lower when compared to the 416 thousands tonnes of 1999 or to the 465 thousands tonnes of 1997. As regards revenues, the less negative trend of 2000 was not only determined by a considerable increase in the prices obtained by the operators, but also by a decline in the offer and a growth in the demand registered over the last months of the year, phenomena that were connected to the first cases of “mad cow” disease in France.

As regards the sea fishery, in 2002 the output of the Italian fishing fleet amounted to approximately 304 thousand tonnes of landings, corresponding to an overall turn over as high as 1.385 million Euro. A comparison with the same data relating to the year 2001 has highlighted the persisting of a situation of productive decline which has been affecting the entire fishing sector in Italy since 1996 and it is largely due to the EU permanent withdrawal policy. As a matter of fact, between 2001 and 2002 landings decreased by 10 percent while the overall revenue decreased by 6 percent. Compared to the year 2000, the shrinkage in saleable gross production revealed a reversal of trend. In the year 2000, despite the drop in the offer, sales increased because of a marked rise in the average prices of the production. Indeed, between 1999 and 2001, external issues such as the BSE effect, and internal ones, i.e. a decrease in supply, produced a sudden increase in the average production prices. On the contrary, throughout 2002, the average production value has grown at a rate that was proportionally lower than the decline of the amount produced. This caused a decrease in sales. The negative trend registered in landings is not only due to the decrease in the capacity of the fleet, but to a reduction of the fishing activity itself.

Indeed, in 2002, the national fleet totalled 161 fishing days, whereas during the previous year these were 169. In addition, in several fisheries the increase in operational costs and the unfavourable weather conditions of the past year led many operators to change fishing areas. Despite the lower productivity, the areas located close to the coast were preferred.
In terms of activity, the decline of the fishing effort involved all fishing systems. Nevertheless, for several reasons, this was particularly true for those sectors in which operators started self management systems, which involved hydraulic dredges and paired trawlers.

In comparison with the contraction registered in the previous years, the fleet did not show marked variations in 2002. The major decrease in terms of horsepower and gross tonnage was recorded between 1999 and 2001, following the measure of permanent withdrawal from fishing which underwent a rapid increase in those years. Over the last seven years, gross tonnage decreased by 21 percent and horsepower by 14 percent.

3. Fish products trading

In 2002 the external trade of fish products displayed a negative trend. Indeed, a slight increase in imports and an appreciable decrease in exports were registered. The decline of the amounts exported is due to the overall trend of the fishery sector, particularly to the shrinkage of the quantities coming from the Mediterranean. In consideration of the stability of the internal demand, this phenomenon resulted in the growth of imports and the decline of exports. It also determined a new acceleration of the growth of the deficit in fish trade balance. In 2002, imports exceeded internal production by 39 percent (807 thousand tonnes, as compared to 580 thousand tonnes) and this deficit is bound to grow up. If compared to the year 2001, the *per capita* consumption of fish products in 2002 proved to be constant, not exceeding 21.69 kg. The overall expenditure in 2002 did not exceeded 4,460 million Euro in comparison with 4,569 million Euro of the year 2001.

In the light of a growing demand for fishery products from the consumers' market, the preservation of marine resources becomes unavoidable, in order to guarantee sustainable development and at the same time satisfy market's demand. To this purpose, several laws directed at reducing the environmental impact of fishery such as, temporary withdrawal for replenishment, withdrawal for specific fishing techniques and the like, have been enforced. On the other hand, there is an increase in consumers' demand of fish for its nutritional value and of aquaculture for its healthy and controlled products. Therefore, the above-mentioned measures may prove to be the most appropriate response to consumers' requirements. To keep pace with their needs, Italian fish farming industry is developing a responsible production able to protect citizens not only as consumers (through the quality of its products), but also as human beings (by preserving the environment). Public Administrations, Fishery Associations and entrepreneurs also support this process of development of Italian marine aquaculture (with more off-shore plants). Furthermore, this kind of development provides for the availability of additional purchase information (marks of origin and other data) and, pursuant to a Community Directive, it ensures a control system on fish farming techniques directed at protecting both consumers and the environment.

Slight decrease in the outflow was undoubtedly due to the considerable growth of the average price of fish products. Particularly evident in the past three years, this phenomenon resulted in a decrease in the consumers' purchasing power. Nevertheless, it must be underlined that consumers' buying habits are slowly changing. Purchasers are indeed inclined to spend more to buy "safer" products. On the other hand, within a market that does not generally guarantee the products quality, consumers tend to reduce consumption. The choice of enhancing the value of fish products meets the requirements of a new typology of consumer who is interested in the quality of the purchased goods. For this reason, despite the increase in prices, the adoption of policies aimed at improving the traceability of fresh fish products represents a significant change which has contributed to a recovery in the consumption.

Growing increase in the Italian aquaculture is consistent with both European and world-wide trends. The increasing presence of cultured species both in traditional shops and in the retailing and distribution industry meets the requirements of the current eating habits in Italy. In this context, the consumers' demand for certain species is so high that it would be impossible for the traditional fishing sector to provide them with all the quantities required. Remarkable development of aquaculture ensures constant supply of fresh, freshwater and salt-water fishery products to our markets. On the other hand, the example of extensive fish culture in lagoons, which holds an essential role in the preservation of wet coastal areas, represents a unique landscape wealth in Italy. In the European context, Italy is one of the main producers of mussels, trout and euryhaline species (as regards sea bass and sea bream, in 2001, after Greece and France, Italy emerges as the third European producer).

In 2001, the percentage of aquaculture on the national aquatic products production reached 42.9 percent in volume compared with 38.6 percent of 2000. In terms of revenues, fish-farming industry is not as relevant as fishery. In the year 2001, the incidence of sales amounted to 25 percent, whilst the sales from the fishery sector were reduced by 5.6 percent. As regards aquaculture, trout farming holds the record and represents the most developed segment with consequently limited market fluctuations both in terms of prices and exchanged volumes. With regard to euryhaline species, we register an increasing growth in the sector. In 2001, the productive output of sea bass grew by 17.3 percent and that of sea bream by 30 percent; therefore, we may say that, from 1997 to 2001, the production has doubled. The marked productive growth is determined by the degree of specialisation achieved in the sector of fry reproduction at a low price. Thus, the sales of sea bass grew by 8.5 percent and that of sea bream by 9.2 percent. In the past year, the increasing trend of aquaculture has been partly determined by the decrease registered in the fisheries segment.

4. Italian fish farming of sea bass and sea bream

In production terms the Mediterranean fish farming industry has been a spectacular success, equal to that of salmon farming. Commercial farming of European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*) has developed rapidly in the Mediterranean region over the last 8-10 years. In the last two decades the national production of sea bass and sea bream has been increased, registering a positive trend of around 70 percent, thanks to integrated production management (intensive technologies, introduction of new feed in out-grow programmes, etc.).

At the experimental level, the aquaculture of bass and sea bream started only by the end of 80s. Historically, the first farms of euryhaline species belonged to public companies or state controlled power companies. Water from the cooling cycle of the power stations turbines regularly available at a constant average temperature supplied the aquaculture plants.
Entirely private and independent sea bass and sea bream farms were established only at the beginning of the 90s. These companies were initially orientated towards the development of land-based plants located along coastal areas, whilst the first offshore plants were established in the second half of 90s.

The rapid expansion of Italian fish farming sector has required a large amount of efforts and investments. At present there are around 130 farms, inlands and off shore, that produce different species, and more than 18 000 tonnes in 2002 only for sea bream and sea bass. Farms are scattered all around the Italian territory, mainly in Southern Regions. Farms are adopting the sea cage production system, but there are some problems to find areas where there's no interaction with other economic activities and interests. Nowadays, of the productive companies involved in the farming of sea bass and sea bream, 60.9 percent are land-based and 39 percent belong to the "intensive cage" type. As regards the output, 48.5 percent of these companies produces a maximum of 50 tonnes per year, 47.8 percent produces from 50 to 500 tonnes per year, whilst only 4 percent produces quantities that range from 500 to 1000 tonnes per year. Thus, it is evident that most Italian fish farming companies are almost always small-scale and often family-run enterprises in which few people cover different roles (i.e. plant manager, trade manager, administrative roles, even operators dealing with feeding and prophylaxis of the biomass). After 1991, increased use of mariculture, involving floating cages, submersible cages and long-lines, was undertaken in order to increase production in both fish and mussel culture. The development of this kind of culture has reduced production costs and environmental impact, but, at present, the limited availability of protected sites, the conflicts with other activities (recreational and commercial navigation) are all factors which may influence mariculture. From the other hand, mariculture can benefit from the installation of off-shore and in-shore activities, due to the easier bureaucratic process in obtaining licence respect to inland activities. For this reason the number of mariculture farms represents actually 24 percent of the total activities.

As regards the volumes of euryaline species produced, the most important companies are located in Veneto, which is the region hosting the majority of plants, followed by Friuli and Sardinia. In 2001, the three above-mentioned regions accounted for 57.4 percent of the entire volume of production of national enterprises. These regions hosted 60 percent of the active companies and 48 percent of the idle ones. With the exception of Basilicata, which hosts a single company declared inactive in 2001, the rest of the enterprises are broken down by the remaining thirteen regions. Seventeen out of twenty Italian regions of interest host sea bass and sea bream farm plants. Over the last few years, new companies have been registered in Veneto (whose productive units increased by 27 from 1995 to 2001), Apulia (with an increase of 5 percent), Campania (+ 4%), Latium (+2%) and Tuscany (+1%).

In the last two decades there was a development in the sector of fry production: until the second half of ’90 the industry was almost exclusively dependent on imported fry, with all negative implications in stock management, health control, seasonal marketing and mainly the loss foreign exchange. Nowadays a lot of hatcheries are successfully in operations, with consolidated know-how, attributing to the self sufficiency of about total fry domestic supply. The hatchery sector represents a important economic key for the Adriatic Region, where two of the most important Italian hatcheries are, satisfying more than 80 percent of national demand and exporting relevant quantities of fry, mainly in Greece and Croatia. The strength of Italian hatcheries is underlined by the high specialisation in fry production and strong technological know-how, two factors that are easily transferable to other Adriatic regions, in order to diversify the pool of species produced.

The production of sea bass fry is higher than that of sea bream because the major companies are themselves capable of producing sea bream fry, whose management during the larval and weaning phases is easier than that of sea bass fry. Generally speaking, hatcheries were historically endowed with a high productive capacity and/or were partners of big companies dealing with the fish grow-out. In this context, setting up of small or medium-sized fattening plants with their own small breeding segment appears impracticable. The above-mentioned trend associated with the highly specialized breeding techniques, if compared to the first half of the 90s, has fostered the availability of seeding material at a slightly lower price.
The disadvantage of fry farming lays in the fact that their end-products are only partially absorbed by the national market. This situation caused a reduction of volumes exchanged, to the extent that a certain quantity of fry is usually kept in the rearing basins until it can be sold as a bigger sized product and at better terms of sale. Nevertheless, the shortage of new plants and the difficulties related to the enlargement of the existing ones has drawn attention to the

lack of available basins that are suitable for the seeding of fry. The combined effects of the increased availability of seeding stuff and the lack of structures in which these could be placed have determined the decline in fry price.
The important need, for the producers, is represented from the availability of new species: the general opinion of producers is very important for the future of euryhaline farmed specie. They want diversification in terms of species, and for the mature species, as far as sea bream and sea bass, they want innovative policy for introduction of differentiation strategy of the products.

5. Sea bass and sea bream: economic items

During the period between 1998 and 2002, the significant outcome registered by the euryhaline species (sea bass and sea bream) suggests a greater ability of this segment to cope with the constant fluctuation of the national market by optimising its own productive capacity and by increasing the average size of its marketed products. Indeed, in order to cope with the competition of other Mediterranean products, this sector has gained new market segments by diversifying its offer through the placement of gutted, gilled and vacuum-packed products on the market. In addition, particularly in 2001, in face of a marked rise in the volume, the sector has registered a decrease of production prices. The growth in national and foreign offer caused a reduction of the euryhaline species prices, whose negative trend has characterised the period from 1998 to 2002 as a whole. In 2002 the price of both bass and sea bream whose average size did not exceed 330 g or ranged between 400-800 g decreased considerably. Particularly, the prices of products imported from Greece and Turkey, the main countries from which Italy imports middle-sized euryhaline species, highly influenced the price of the sizes not exceeding 330 g. Prices of products whose weight exceeds 800 g on average are not so strictly dependent on the presence of imported products. Over the last two years, a growing request for national cultured products has been registered as a general trend in the demand for fishery products. This was determined by the consumers' distrust in foreign products which were regarded as "less controlled" and therefore not as "safe". In this context, compared to others, apart from slight increases, the production prices of the output of Italian aquaculture were substantially stable, which confirms the maturity of the sector. Despite the fluctuations of the exchange rates, which, in line with the market conditions, show a tendency to remain stable, this maturity entails the effort of both producers and wholesalers to ensure the quality and the efficiency of the service (i.e., availability of qualitatively standardised products, continuity in supply, and sufficiently stable prices).

In 1998, within the fishery and aquaculture sector the demand continued to grow and it was only partially met by domestic production (capture + aquaculture). As a consequence, there was a considerable increase in imports (variation from 1997 to 1998: 6.3%). In the same year, the national production as a whole amounted to 747,000 tonnes (of these, 547 thousand resulted from capture fisheries and 216 thousand from aquaculture), whilst the apparent consumption of fishery product was 23 kg per capita: a very high value never registered before. In the same period, the increase in aquaculture products sales (+20.7%) was crucial to the expansion of the fishery sector as a whole, whilst fishery contribute (-2.3%) was significantly lower. From 1998 to 2002, the constant decrease in performances within the fishery sector was due to the reduction of the fishing effort determined by the adoption of legislative measures concerning the management of resources. Over the last few years, a constant decrease in the national fishery production has been registered. In 2002, the production has dropped below 600 thousand tonnes, whereas the sales in the sea fishery sector have decreased from 1,600 million Euro in 2000 to 1,400 million Euro in 2002. Compared with the year 2000, the shrinkage of the saleable gross production represents a reversal of trend. In fact, during that year, despite the decrease in the offer, the increase in the average production prices determined a high rise in the sales. In comparison with the year 2000, in 2001, the fishery production continued to decrease until shrinking by 8.5 percent in volume and by 4.1 percent in average value. The data show a growing trend with regard to the catches of bass and sea bream, whilst, in terms of value, their trend is less than proportional.

Consumers, who are willing to pay high prices for them, largely appreciate wild sea bass and sea bream. Specialized catering industries represent the main market for wild sea bass and sea bream. Within this sector, wholesalers do not distribute wild sea bass and sea bream, since, as a rule, these products are caught in small amounts and directly sold in small quantities to local buyers who are prepared to pay more than 12-14 Euro/kg. Products intended for this kind of distribution are usually defined as “already sold” on landing. In this context, one can easily realize that the increase in the prices is not likely to influence the demand for these products.

6. New pattern of consumption

In the course of the 90s, per capita consumption of fishery products was fluctuating, yet, if compared to the 80’s, it doubled rising from 11 kg of 1980 to over 22 kg of 1999. Generally speaking, the shrinkage of the offer within the fishing sector hardly influences the fishery balance. Even over the last 2 years, it was possible to register a strong dependence of the fishery balance on imports, which from 2000 to 2001 have increased by 7.5 percent. As for size-based production, we witnessed a considerable decrease in the offer of sea bass and sea bream whose size does not exceed 300 g. At present, the fish size which best satisfies the market demand is that which meets the consumers’ requirements for double portions (i.e., 400-500 g). In terms of prices, sea bass and sea bream of bigger sizes (that is, from 500 to 800 g) register fewer price fluctuations caused by import flows. These products are targeted to meet the needs of specific sectors, such as mass catering (canteens, restaurants, hospitals). The average-sized production seems to have the lion’s share since it meets the demand for farming of euryhaline species. Over the last three years, most of these domestic products have been intended for organised retailing and distribution industry, which requires middle-sized fish for its customers.

National statistics provide yearly data of sea bass and sea bream production. Accordingly, the monthly production of euryhaline species has been estimated. The assessment was conducted by establishing a relationship between volume, yearly quantity and the ex farm prices of imports drawn from FAO GLOBEFISH sources, and the monthly average prices drawn from ISMEA. In addition, qualitative information directly provided by interviews with national producers about monthly average amounts was taken into account in the study. The trend over the last three years shows that the productive segment, whose customers are mainly wholesalers supplying the retailing and distribution industry, tends to keep the offer substantially constant. This implies that, as for the amounts, the monthly variations of product are rather low. The incidence of the variable is closely linked to the prices of imported sea bass and sea bream: the lower the imports prices are, the more reduced national offer tends to be, and vice versa.

Generally speaking, monthly trends of both sea bass and sea bream are slightly fluctuating. The only exception is represented by the period of the year in which fish consumption is particularly important, during Christmas holidays. This trend is strictly connected to the deep-rooted historical and religious tradition of Italian people, which influences the choices of most consumers. In Italy, typical food at Christmas is indeed fish, particularly sea bass and sea bream, which are able to satisfy a large majority of people. Consumers have become accustomed to finding these two species in the market stalls being sure to follow the tradition without spending too much.

The breakdown of the national production of sea bass and sea bream into three geographical areas (the north - the centre - the south and the islands) shows that about half of the national production (47.9 percent in 2001) is located in the south and the major islands (Sardinia and Sicily).

In Italy, the strong foreign competition has pushed market prices towards the lowest levels, with a consequent decline of profits. Accordingly, farmers have reacted by diversifying the offer and by directing sizes and typologies towards filleted and gutted products preserved in modified environment. Thanks to the offer differentiation, the sector is growing and reacting by exploiting some of its positive aspects, such as sale size coat features (colour, brilliance and the like) as well as labelling and packaging. At the same time, steps towards farm modernisation, integration of both the manufacturing and the marketing segments are being taken. In this way, the path towards end users would be reduced.

The Financial Tool that grants subsidies to the aquaculture segment at special rates is the SFOP. Among its priority measures of intervention, it provides for the strengthening of the infrastructures within the existing plants and for the adoption of innovative technologies aimed at introducing an initial processing of the products. Although sea bass and sea bream production benefits from a high degree of maturity, their processing and marketing allows for further interventions aimed at boosting their image within the supply market. Besides, these two aquaculture products are also suitable to enter new market segments.

Under present conditions, in terms of price levels, fish products and their processing system can not compete with the global market. However, in line with the above statement, the segment may prove potentially competitive as regards processed products typology. This could be achieved by focusing on the processing techniques: on safety of sanitary procedures followed throughout the manufacturing and packaging processes as well as through transportation and delivery, including the high nutritional value that the products keep despite being processed.

To date, the strategy chosen by the aquaculture segment is based on the quality of its products and manufacturing processes. The quality of a fish product obtained from an aquaculture farm depends on the nutritional and biological features of the cultured organism itself and on the productive cycle quality in the farm. From this point of view, the quality under discussion is ensured by the origin of its spawns and its gametes, the farming, and by complying with the sanitary regulations of the products processing before they reach end users.

As a suitable alternative to the catch-based production, aquaculture raises some specific problems connected to the sanitation of farming and the activities performed within production farms. In order to cope with global competition, Italian companies should adopt measures that would enable them to ensure the quality and the safety of their products and to boost the development of the sector.

Some pilot experiences for differentiation of sea bream and sea bass are available in the Adriatic region, where these are tested in large-scale retail markets: cultured bream and bass in fillets, pre-cooked, “marinated” or with other fish products (mussels, crustaceans, etc.), rice or pasta are some examples. This pilot experience represents a possibility of interesting new market for sea bream and sea bass, and represents, also, a trend of Italian farms that believe in the possibility to increase production again. Innovative approach aquaculture is characterised by new perceptions about the production value: the new pattern is added indirect value to the mature farmed species, in terms of quality (ISO 9001:Vision 2000) hygiene (HACCP), environment (ISO 14001, EMAS) origin (DOP, IGP). Not only marketing Organisation, but also product diversification are factors which can help aquaculture. This means that sea bass and sea bream should not be only available as a commodity item, but also as an added value product. Through clever manipulation of both product and market, it should be possible to have parallel development of a high margin luxury array of product and a lower margin mass market product range.

However, alternative markets and development of value-added products is likely to lead to higher requirements to controlled and predictable quality. Sea bass and sea bream are loosing their luxury image and are becoming commodity items, like salmon. The existing market had become saturated, but this market represents only a small part of the overall market potential. For future growth, aquaculture industry should put a lot of emphasis on more sophisticated marketing methods. This is a must for penetrating new markets, but it is also necessary for enlarging the existing ones.

In the Adriatic region there is an interesting scenario about these economic activities. The strong tradition in aquaculture production is important in defining the market strategy of Adriatic farmers. But, traditionally small distribution channels (i.e. fishmongers, restaurants and hotels) would be used, and farmers are now orienting the majority of their production to new channels, in particular supermarkets and discount stores.

7. Interaction between fishery and aquaculture products

By comparing the prices of wild and cultured sea bass to those of sea bream, it can be easily noted that exogenous events such as the “mad cow” crisis (BSE) exert a strong influence on their trends. Accordingly, if fishermen voluntarily adopt certifications that identify products and reassure consumers, a positive influence on prices is immediately registered. On the contrary, in the field of cultured sea bass and bream, notwithstanding the number of steps taken to boost the offer, no price recovery has been observed. Indeed, over the last few years, vague and ambiguous information about the origin of products and the farming procedures (feedstuff, water quality, sanitation of primary processing, transfer and preservation, cold chain management) caused bewilderment among consumers. The price trend is also determined by new tendencies in fish consumption. Thus, consumers went from a period in which they were firmly price-oriented to the present phase where prices no longer orientate their choices. The interest of consumers has shifted towards the information that identifies the product “from farm to table” and that indirectly produces added value to goods. Aimed at qualification of the national cultured product, the policy of the sector enabled farmers to assign most of their production to new typologies of retail and distribution industry and to create new opportunities of negotiation with wholesalers. As regards the relationship between cultured and captured sea bass and bream, several studies and assessments evidence that there is no interference in the registered variations of prices between the two typologies of product since they are directed to two different target markets. Thanks to the fairly high average prices of production, fishery products meet the demand of specific niche markets. Cultured sea bass and sea bream, instead, satisfy a wider range of consumers who are orientated towards new typologies of retailing and distribution industry.

The general trend of the segment is to boost the production. However, instead of being concerned with the currently realized prices, the operators choose to adopt measures aimed at ensuring the long-term profitability of prices within the economic duration of the investment.

It is possible to register the interaction between sea bass and sea bream from capture and from the farm, in relationship with the imported products and their price ex farm. In this case the import activity of euryaline species is the most relevant item that defines the trend of national performance variation of price and monthly quantities supply. The Italian market represents a target mainly for exports of Greece and Turkey. The export activity of the Greek aquaculture industry had almost exclusive orientation towards the Italian market. Since 1994 a few exporters tried hard to penetrate new markets. The outcome of those efforts resulted in exports to new markets in U.K., Germany, France. Prospects for sea bass are better than for sea bream, as there is a stronger demand for the former. Only the Italian market regards sea bream as highly as sea bass. Greece has two major disadvantages for penetration in the two markets of France and Spain: long distance, they cannot be serviced easily by truck, but only by air (high transport costs); and the internal competition from existing production units in these countries, that have comparative advantages due to proximity.

A consistent share of fish farmed products is allocated to large-scale retail, where imported aquaculture products are offered too. Only a small share is allocated to traditional retail. This aspect gives a picture of Italian perception of farmed products: the Italian consumers, in the last five years, have switched, with regards to the purchase of farmed products, and: they now prefer to buy cultured products in the new retail channel, while they are oriented to traditional shops for locally caught products. According to Italian consumers’ perception of cultured seafood, they prefer hyper and super markets because they pay more attention to the direct and indirect hygienic safety and origin of alimentary products.

According to new pattern of consume, the Adriatic Region is characterised by different pilot and commercial projects where marketing strategies are developed to add value to farm products: it is therefore possible to find label and brand that qualify sea bream and sea bass as GMO free food. Labels sometimes contain the information on the quality of production process, or about technical agreement with large-scale retail. The large-scale retail is playing a strategically role to define a protocol which satisfies the new needs of consumers and for realising the traceability of cultured products. This aspect represents a strength of the distribution channel, where the most important quota of total national production of sea bass and sea bream is oriented. At the moment, as controls and procedures become more strict, and with many marine species imported at low ex farm price, national producers are not in a favourable market position.

The development of intensive or industrial production methods has changed the aquaculture industry dramatically. The most important factor is most likely that new production methods have allowed a substantial productivity growth. This has allowed a large increase in production, and aquaculture products have found a number of new markets. However, the introduction of aquaculture products into new markets has been far from unproblematic. As established producers have perceived aquaculture products to be competing goods a number of complaints have been raised, and where trade has crossed borders, trade conflicts have often followed.

Italian aquaculture shows serious signs of a conflicting growth and management crisis. On the one hand, Italy has a highly developed technological sector which has, in the past, undergone rapid expansion thanks to reliable reproduction procedures for sea bass and sea bream. On the other hand, the efforts made to improve production have partly been neutralised by competition from other Mediterranean countries, who thanks to better environmental factors and lower labour costs, are able to produce at lower costs than Italian farms. Another problem is represented by the careful evaluation of production and by the choice of the species to farm.

For capture fisheries a fall in dependency can mean that fewer people are employed in the sector due to either more attractive job opportunities or a loss of employment due to a decline in fish stocks and a reduction in quotas. For aquaculture, changes in dependency can result from increased job opportunities created by the expansion of aquaculture in areas where there are few alternatives for employment. In such cases, the development of aquaculture can play a major role in helping to reverse rural depopulation and in improving the quality of peoples' lives. However, this does not necessarily mean that jobs being lost in marine capture fisheries can be replaced by the expansion and diversification of marine aquaculture.

The aquaculture industry in Italy has not been able to profit from the opportunities presented by developments and this has led to an unequal growth rate in various productive sectors and recurring crises in the markets. The notable increase in farming sea bass and sea bream has not been accompanied by similar increase in the firms' entrepreneurial skills, and they have found themselves facing drops in price or increases in demand they are not able to fulfil. Another weakness is the fact that producers have not been able to keep pace with the rapid evolution in the distribution channel. They have not seized quickly enough the offers coming from of sales organisation, especially large-scale distributors who have had to look to foreign markets since domestic supply was lacking.

Within Italy, an additional pressure on the dwindling supplies of fish stocks has arisen through changes in eating habits. This has led to a trend of decreased consumption of 'red-meat', and towards greater consumption of convenience food and processed fish, which in turn have improved the market position of fish. With the shortfall in the supply of landed fish, mariculture of sea bass and sea bream has been able to capitalise on the demand for fish and fish products.

However, aquaculture is not in a position to meet the shortfall between demand for marine protein and the supply available from capture fisheries, it can merely help to alleviate the pressure. Marketing dynamics affect both the supply and the demand for aquaculture products, and these differ sharply among farmed species. The production of sea bass and sea bream, for example, has increased markedly in some Italian Regions to supply local consumers from relatively low-income households. In general, farmed and captured sea bass and sea bream have different consumers and they are supplied in different distribution channel: for sea bass and sea bream, a lot of consumption is characterised by purchase in hyper and super markets, where mainly farmed products are offered, and where there are differentiations in presentation (gutted, fillets, prepared, pre-cooked, mono-portion, etc). Capture fisheries' production of sea bass and sea bream satisfies the high demand of specialised restaurants and traditional stalls, where the typical consumer is a "traditional and expertise" person.

8. Strategic option for sea bass and sea bream

In the context of positive attitude towards seafood, with a very limited penetration of both species, the internal market offers good potential. Both individual and collective actions could be taken to stimulate sales.

- Market opportunities exist, yet they have not been clearly identified. A collective market research, that would benefit the entire industry, should be undertaken.
- The demand for value added seafood products is soaring, but supply of sea bass and sea bream based products is non existent. Some collective research and development project could be undertaken with profit to the entire industry.
- Commercial efforts are required for a better diffusion of traditional products (whole fresh). Some market segments need to be thoroughfully explored (food service industry, traiteur/delicatessen segment). This requires specific means and skills, available with a limited number of operators. Fish farmers could consider gathering their commercial forces. Cost / advantages of creating a Producers' organisation should be considered.
- By lack of precise knowledge, some buyers (trade buyers including fishmongers and consumers) are reluctant to buy farmed fish. Communication should be directed to selected target groups. Working at creating and transferring recipes to key buyers and running generic promotion would undoubtedly boost sales

9. Conclusions

Sea bass and sea bream farming is a new business. This is a very heterogeneous industry: almost no farm is like another. Many characteristics differ, including companies' size, production (10 tonnes to 8000 tonnes), technology utilised (on land, in sea cages), coastal characteristics including water temperature, etc. The limited size of most fish farmers does not give them access to economies of scale, existing in most sides of this business (production, R&D, processing, marketing, etc.) and necessary for development.

This new business has not received much attention from centralised public authorities. Being too small to be considered as an entire industry it did not motivate the introduction of specific administrative rules. Moreover, the lack of a clear and solid national aquaculture development scheme leave to local decision makers much room for taking important decision, not always favourable to this industry.

On the market side, the level of consumption is today low despite an attraction towards aquatic protein and rather good image of both products. Moreover, these two species have been sold with almost no marketing and communication efforts. The price has so-far been the only real stimulator for sales. Appropriate actions would reveal good potential for growth.

Aquaculture forms a socially and economically important component of fisheries. Growth in aquaculture production and employment can play a major role in helping to increase and diversify economic opportunities at both national and more local scales. Increasing dependency on aquaculture can be interpreted as a sign of increasing employment in remote areas where there are few alternative forms of employment.

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Fishing and farming of the northern bluefin tuna (*Thunnus thynnus L.)* in the Adriatic Sea

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Abstract
Since 1996 the farming of bluefin tuna *(Thunnus thynnus)* in Croatia has developed rapidly due to the high prices offered by the Japanese market. Bluefin tuna in the Adriatic Sea are mostly fished by purse seine for farming purposes. After capture they are kept in cages and fed for a 2 to 3-year period. This practice improves the limited fishing quota, by increasing the output tuna product biomass and its market value, without additional capture fishing mortality. This paper traces the tuna farming development in the Adriatic Sea and includes some constraints regarding the environmental impact which industry had to face.

1. Introduction

There are seven different tuna species which live in the various oceans of the world. These are: blackfin tuna (*Thunnus atlanticus*), bigeye tuna (*Thunnus obesus*), longtail tuna (*Thunnus tonggol*), yellowfin tuna (*Thunnus albacares*), albacore (*Thunnus alalunga*), southern bluefin tuna (*Thunnus maccoyii*) and northern bluefin tuna (*Thunnus thynnus*). Among them, the most important are albacore and bluefin tuna, which are both captured in the Mediterranean area. There are also some sporadic catches of bigeye tuna, while those of other species have not been reported. Capture quantities of these three species are shown in Table 1. There is a big demand for bluefin tuna due to the quality of its flesh, which is highly valued by the Japanese market. The market price for bluefin tuna can vary from a few dollars per kilogramme to more than 200 USD/kg for fat tuna meat.

Bluefin tuna can reach a length of over 300 cm and weigh more than 600 kg. This fish has a relatively long lifespan, and is believed to live up to 30 years. As it tolerates a wide range of sea temperatures, it has a very wide geographical distribution in the Pacific and Atlantic Oceans. Two main spawning grounds of the northern Atlantic bluefin tuna are located in the Gulf of Mexico and the Mediterranean Sea. During its migration, bluefin tuna can cross the Atlantic Ocean. According to recent tagging results, that suggest the existence of residency and fidelity of tuna to its spawning grounds (De Metrio *et al.*, 2003), it is believed that two sub-populations of bluefin tuna exist in the Atlantic Ocean.

2. Bluefin tuna fisheries in the Adriatic Sea

The northern bluefin tuna (BFT) fisheries in the Atlantic Ocean and in all parts of the Mediterranean area are regulated by the quota system, i.e., by Total Allowable Catch (TAC) regulated by the International Commission for Conservation of Atlantic Tunas (ICCAT). TACs are established for all stock users of bluefin tuna. Management regulations applied to BFT fisheries in the Adriatic are the same as those of the Eastern Atlantic and Mediterranean area. Consequently, there is no partial stock assessment of BFT. The quotas allocated

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annually by the ICCAT apply to the whole Mediterranean (Adriatic included), and there are no management regulations applying exclusively to the Adriatic. Spawning Stock Biomass (SSB) of the Eastern BFT in the year 2000 was estimated at a level of about 86 percent of SSB during 1970, and the ICCAT set the TAC for the Eastern Atlantic and Mediterranean BFT at 32 000 tonnes for the period from 2003 to 2006. Also, the minimum fish landing size has been increased from 3.2 to 4.8 kg (SCRS/2003/BFT Executive Summary) in order to protect juveniles.

Table 1.Capture quantities (in t) of three tuna species in the Mediterranean fishing area.

YEAR	Albacore (*Thunnus alalunga*)	Bluefin tuna (*Thunnus thynnus*)	Bigeye tun (*Thunnus obesus*)	TOTAL
1981	1.500	10.515		13996
1982	1.272	15.706		18960
1983	1.235	13.650		16868
1984	3.414	17.032		22430
1985	4.129	17.203		23317
1986	3.712	14.560	1	20259
1987	3.993	13.764		19744
1988	4.063	17.167		23.218
1989	4.060	15.628		21.677
1990	1.896	17.207		21.093
1991	2.378	19.872	2	24.243
1992	2.202	24.230		28.424
1993	2.130	24.901		29.024
1994	1.349	39.540		42.883
1995	1.587	37.640		41.222
1996	3.125	38.100		43.221
1997	2.541	33.578	1	38.117
1998	2.698	28.196	0	32.892
1999	4.851	22.825	0	29.675
2000	5.577	23.224		30.801
2001	4.743	21.662		28.406

(Data source: ICCAT Statistical Bulletin, Vol. 32)

Offshore purse-seine fishing activities concerning the bluefin tuna are a very important part of the pelagic fishery within the Adriatic Sea. In Croatia, purse seine is a principal fishing gear used for its capture. Bluefin tuna fishing activities in the Adriatic Sea are described in detail by Tičina (1997; 1999) and Tičina *et al*. (2002).

The principal fishing grounds for Croatian bluefin tuna purse-seiners are the offshore waters of the central part of the Adriatic Sea. After capture, they are transferred into floating towing cages. This is done in the open sea where the catch has occurred, by simply joining both nets under the sea surface. Once the cages are filled with the right number of tuna they are slowly towed by a tugboat towards the farming locations. The distance between the fishing ground and the farming location can vary from a few to several hundreds of miles (if the fish catch occurs outside the Adriatic Sea, Katavić *et al.,* 2003a).

Purse-seine fishery in the Adriatic has become the principal provider of fish seed for further farming purposes. The Adriatic Sea is an important feeding ground for small-size tuna (mostly up to 3 years of age, Tičina and Kačić, 1998), consequently the fish supplied to the Croatian farms are small. An unusual high amount of small tuna were recently caught in the Adriatic (88,6 percent of fish from 5 to 10 kg in 2003 - preliminary data) which is probably the result of an increase in recruitment in the last years. This could also be related to a reduced number of natural predators of small tuna (sharks, swordfish, giant tuna, etc.) due to a high fishing pressure. However, it should be pointed out that small fish are not preferred by farmers as fish seed, because of higher production risks, additional rearing efforts needed and higher overall production costs as compared with rearing the larger specimen or using them as seed.

3. Bluefin tuna farming in the Adriatic Sea

The first bluefin tuna farming started in Canada in the late 1960s, and the first tuna farming in the Mediterranean took place near Ceuta in the late 1970s. In the Adriatic Sea, the first pilot farming of bluefin tuna started in 1996, applying the technology developed during the farming activities on the southern bluefin tuna in Australia that had been practiced since the 1980s (Miyake *et al.,* 2003).

Since 1996 the farming of bluefin tuna *(Thunnus thynnus)* in Croatia has developed rapidly. Initially, they were captured by purse seiners and fattened for a period from 4 to 6 months before being harvested and exported to the Japanese market. During this period, they were fed with a variety of small pelagic species. The distribution of fish feed in floating cages is performed manually (i.e., on a wide surface area), and the quantity ranges between 3 and 8 percent according to their bodyweight. However, in the Adriatic Sea an entirely new concept of bluefin tuna farming has developed. Small- to medium-size fish are reared for a period from 2 to 3 years, before being harvested and landed. This practice is aimed at improving the limited fishing quota, by increasing the output tuna product biomass without additional capture fishing mortality (Figure 1) and at raising the value of the product, thus obtaining a better market price. ICCAT quota allocated to Croatia (about 900 tonnes) is not meeting the farmers' needs, consequently more than 50 percent of the fish seed introduced in the fattening cages are imported (Figure 2) from other countries, i.e., EU, Tunisia, etc., (Katavić *et al.,* 2003b). It should also be pointed out that tuna farming does not encourage the catch of small tuna, because there is a higher profit if bigger specimens are used as fish seed.

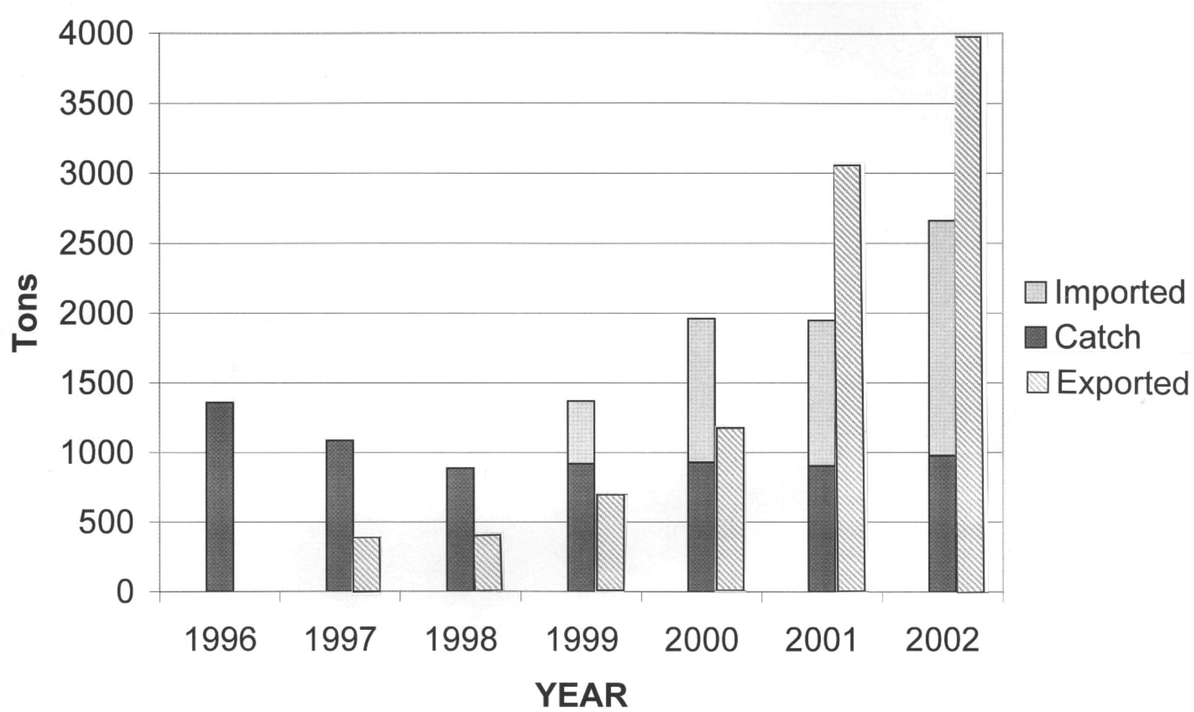

Figure 1. Comparison between Croatian BFT catch and import in relation to exported bluefin tuna from the farms in the Adriatic Sea.

In 2001, on the Eastern Adriatic Sea coast there were six medium- to large- farms with nine rearing sites which included 43 cages (Figure 3). Cages used for tuna farming are constructed as 50 m diameter floating circles with a suspending net of about 20 to 25 m in depth (Katavić *et al.,* 2003a; Miyake *et al.,* 2003).

Recently, the rapid development of tuna farming practices in the Adriatic and other parts of the Mediterranean Sea area caused great concern regarding the sustainability of this new important industry and its impacts. For this reason, an *ad hoc* GFCM/ICCAT Working Group on sustainable tuna farming/fattening practices has been formed with the aim of developing practical guidelines, in order to address the present problems, and proposing further research. According to the report of the first meeting of the GFCM/ICCAT Working Group, tuna farming currently involves the collection of wild fish, ranging from small to large specimens, and their rearing in floating cages for a period from a few months to a few years. An increase in weight and change in the fat contents of the flesh are obtained through standard fish farming practices. The confinement of the captured fish during a short period of time (2-6 months) helps increase the fat contents of the flesh which strongly influences the price of tuna meat on the Japanese sashimi market, also referred to as «tuna fattening» (SCRS/2003/020).

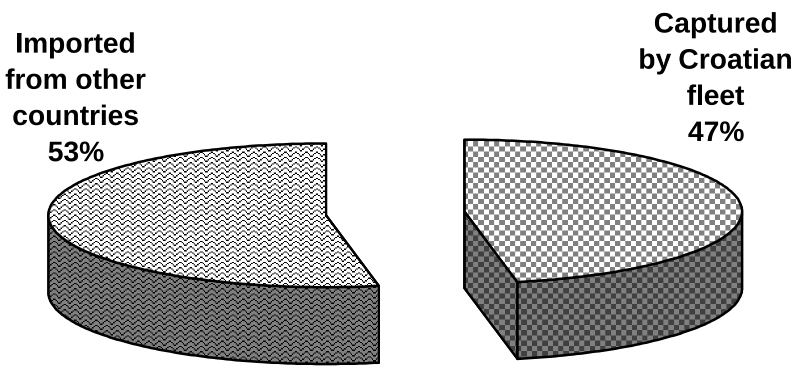

Figure 2. Origins of fish seed entered in the grow-out cages for bluefin tuna farming in the Adriatic Sea during 2000 and 2002 (Katavić *et al.,* 2003b).

Farmed tuna are mainly exported to the Japanese sashimi markets, but this constitutes only 4 percent of the total amount required. From 1998 to 2001 the tuna supply (all species) to the Japanese market ranged from 451 000 to 507 000 tonnes, but the most important is a high valued product called “toro”. “Toro” constitutes only approximately 30 percent of the wild fish catch, but almost the entire quantity of farmed tuna is considered as «toro» (Ottolenghi *et al.,* 2003). The advantages of cultured tuna are its lower prices compared to the wild tuna, and its availability at supermarkets, fresh fish shops and sushi restaurants throughout the year. However, because of the rapid increase in the quantity of farmed bluefin tuna, a serious decline in market prices was observed recently. Due to the fact that the Japanese sashimi market is close to its saturation regarding farmed bluefin tuna (BFT) consumption, it is very likely that the price of farmed products will continue to decrease, unless a new big market is found. One of the major concerns related to BFT farming practices is the negative impact this activity may have on the environment and other activities in the coastal zone (i.e. tourism). This concern stems from the past incidents caused by improper location of the cages. There are also difficulties in estimating (i.e. back calculating) the total biomass and size composition of bluefin catches assigned to fattening and farming, due to lack of information during the rearing period (e.g., accurate data on initial size, rearing period, diet, conversion rates, etc.). There is also much concern regarding the possibility of overexploitation of small pelagic fish stocks used as fish feed for tuna.

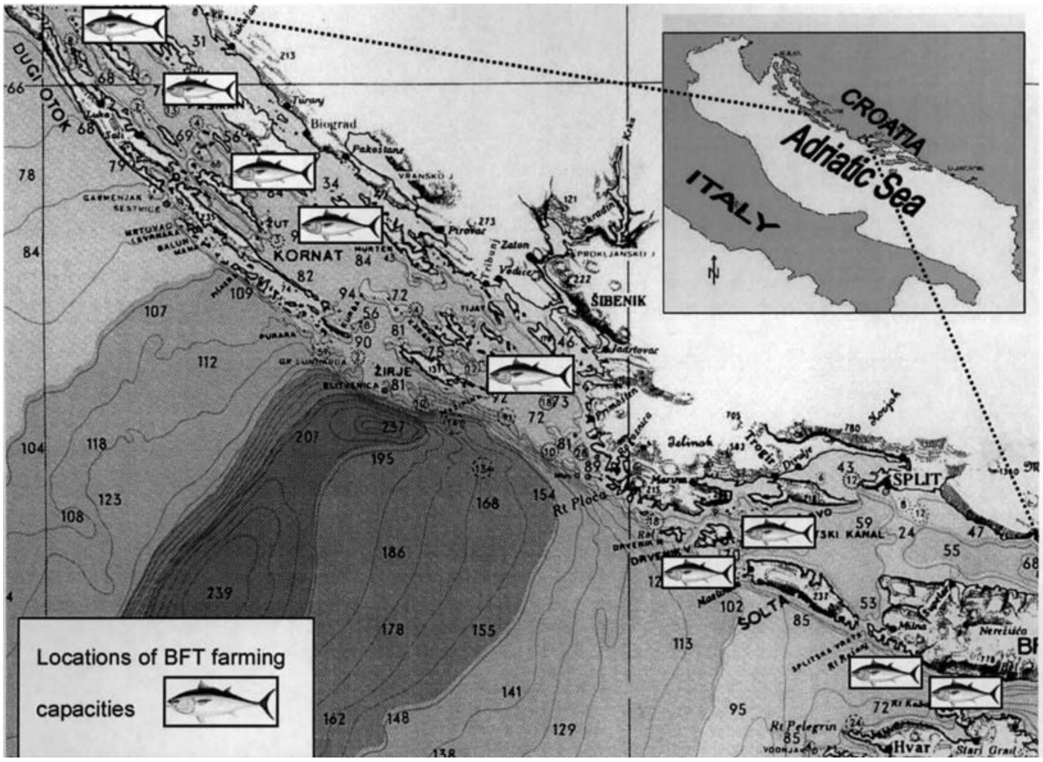

Figure 3. Locations of tuna farming sites along the Eastern Adriatic Sea coast in 2001 (Katavić *et al.*, 2003a).

As all other human activities, tuna farming has a certain local environmental impact. According to the results of some recent studies presented at the International Meeting "Tonno e dintorni" (Castellammare del Golfo, 24-26/10/2003, Italy), no significant environmental changes have been noticed in water columns and sediment at a distance of >100 m from the grow-out floating cages for tuna farming located at 45-50 m depth. In order to avoid negative interactions with other commercial activities, coastal zone management plans should be developed. Another issue of concern was the possible impact this activity could have on small pelagic fish stocks in the Adriatic, since these species are used as fish feed in tuna farming practices. In order to properly assess the availability of the resource and to prevent this problem, small pelagic fish stocks in the Adriatic Sea are monitored by annual acoustic surveys. It should also be pointed out that more than 50 percent of the tuna fish feed is imported from other fishing areas of the Atlantic.

To find out the cause and also to prevent other possible problems, various scientific research projects are currently being carried out on a national and international basis and in close collaboration with tuna farmers. Perhaps, the most important research should be performed on the spawning and breeding of bluefin tuna in captivity, thus enabling an important change from capture based aquaculture to a fully controlled and sustainable aquaculture practice. Also a permanent environmental monitoring contemporarily with studies on improving husbandry and reducing pollution should be carried out.

On the other hand, bluefin tuna farming activities have created many new jobs and currently employ about 500 people. Also, about 30 large bottom trawlers have been fully integrated into tuna farming operations, thus reducing the fishing pressure on an already over-exploited demersal fish stock. Due to its fish aggregating effect, fishing grounds around the areas with tuna cages are among the most favourable for artisanal small-scale fisherman and sport fishing.

4. Conclusions

Tuna farming has important socio-economic and environmental effects and receives considerable public attention. It is a new, rapidly growing activity aimed at increasing the tuna products biomass and also increasing its value on the market, but without increasing fishing mortality, that is already limited by fishing quotas given by ICCAT. However, one of the most important issues is the proper location of the farms so as to avoid environmental problems and negative interactions with other commercial coastal activities.

The main driving force for the development of bluefin tuna farming are high prices of tuna products on the Japanese sushi and sashimi market. Due to the recent expansion of tuna farming in the Adriatic Sea, fuelled by profits related to the Japanese market, the bluefin tuna are mostly fished by purse seine for farming purposes with the aim at obtaining fish seed, and not for canning factories or as fresh (food consumption) to local markets.

Capture-based aquaculture farming activity does not encourage the catch of small tuna, because higher profits are obtained if larger specimens are used as fish seed**.** However, due to fact that the Adriatic Sea in not a bluefin tuna spawning ground but a feeding ground, tuna catches (made by purse seine) usually does not contain large specimens of tuna (spawners). Consequently, tuna farmers in Croatia are usually unable to get a big size fish seed from local purse seine fishing fleet, but the size of fish seed used for farming usually corresponds to the fish size currently present in the Adriatic Sea.

Tuna farming activities has a positive economic impact on the heavily depopulated Croatian islands, as it helps to create many new jobs where they are mostly needed. Also, it reduces fishing pressure on demersal fish stocks by employing about 30 large bottom trawlers for farming operations. .

A number of different research studies should be carried out with the aim at preventing eventual problems that this activity could cause. However possible achieving of full control of reproduction of bluefin tuna in captivity and breeding of its early life stages, in order to manage its complete lifecycle, would guarantee a sustainable future for this sector of mariculture. To reach this objective, it is of great importance to establish interaction and cooperation between the scientific world and the industry, both at national and international levels. This is the basis for practical future development in accordance with the recent guidelines provided by Code of Conduct for Responsible Fisheries (FAO, 1995).

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Interactions between capture fisheries and aquaculture: the case of the eel (*Anguilla anguilla* L., 1758)

Eleonora Ciccotti[*]

Abstract

The European eel, *Anguilla anguilla* L., is recognised today as an international marine species and a shared resource among European and Mediterranean countries. For this species, major problems exist in relation to a continent-wide decline in recruitment observed in the course of the last decades, and to a contraction in adult eel capture fisheries. In relation to this situation, debate on the possible measures to protect the European eel stock is topical at the present moment, also in relation to a series of steps undertaken by the European Community.

1. Introduction

The European eel (*Anguilla anguilla* L., 1758) is a highly migratory amphihaline species. Its life cycle, elucidated in the 1920's by Johannes Schmidt, is considered unique due to the magnitude of the larval migration, but still cannot be considered completely resolved. Spawning takes place, according to Schmidt's findings, in the Atlantic Ocean, and precisely somewhere in the Sargasso Sea where the smallest larvae, the leptocephali, were observed (Schmidt, 1922). After hatching, leptocephali are probably driven towards Europe by the Gulf Stream: this passive migration should take over two years, although recent findings based on glass eel otholith microstructure suggest that the migration is achieved in less than a year (Lecomte-Finiger, 1992; Desaunay and Guérault, 1997). On the continental shelf, leptocephali metamorphose into glass eels, which colonize coastal and inland waters of the Atlantic and Mediterranean coasts, entry in the Mediterranean through the Gibraltar Strait being only supposed. Glass eel ascent, constituting recruitment to most systems - coastal lagoons, estuaries and rivers, streams and channels, lakes and reservoirs - takes place by a mechanism known as selective tidal transport, STT (McCleave and Wippelhauser, 1982). In the course of this phase, glass eels undergo a series of changes, physiological as well as behavioral, darkening as pigmentation develops and becoming able to swim actively, thus reaching the so-called "elver" stage The subsequent stage, the yellow eel, takes place in continental waters, with a duration ranging from 3 to 8 years for males and 5 to 15 years for females. Growth pattern in this phase shows a wide range of variation depending on habitat characteristics. Eels begin gonadal development when still in inland waters and lagoons, becoming silver eels and emigrating towards the sea. Nothing is known about adult migration, that occurs probably deep in the sea: spawning eels have never been observed, thought it is believed that spawning occurs only once, females producing 2-3 millions eggs. No homing behaviour has ever been assumed, and therefore escapement from continental water bodies is considered to contribute to the stock throughout the whole distribution area. The geographic distribution of the European eel comprises most of Europe, ranging from Northern Scandinavia to North Africa,

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and from the Eastern Mediterranean region to the Azores, the latter being the western limit of its distribution.

On the whole, the species extremely uniform genetics have been considered to confirm panmixia. Recent findings based on microsatellite DNA analyses have suggested the possibility of genetic differences within the stock (Wirth and Bernatchez, 2000) and in particular indicate that there may be population differences on a North-South basis. The genetic variation found is extremely small in comparison to other species. Investigations from different research teams are still under way, but at present the species is still to be considered, from a biological point of view, as a panmictic marine species, and from the point of view of its management as a highly migratory species.

For this species major problems exist, in relation to a continent-wide decline in recruitment observed in the course of the last decades, and to a contraction in adult eel capture fisheries (ICES, 2001; Dekker, 2002a). If compared to other shared species or to other migratory fish, the eel shows some peculiar features. Eel exploitment occurs exclusively within national boundaries, in continental waters, without any interaction between economic zones, typical eel fisheries being mainly small-scale. The spawning process takes place in international waters, and all oceanic life stages are unexploited. Finally, the population is panmictic and the species is a shared resource by practically all European and Mediterranean countries.
Spawning stock management is essential for the sustainable exploitation of the species, but no individual country has any individual responsibility nor the ability to protect it. The necessity to base the establishment of target reference points and the consequent management options on the precautionary approach is evident for this species (Moriarty and Dekker, 1997; ICES, 2001). The majority of reference points require information on several population parameters including age structure, growth, natural mortality, spawning stock size and recruitment size. The limited knowledge and particular population dynamics of the European eel are a major obstacle, in particular with regards to the existence of a relationship between spawning stock and recruitment.

The European eel represents a case for which strict interactions between aquaculture and fisheries exist. Today, a great share of eel supply to the market comes from eel culture, well established in Europe since more than 30 years, and amounting to over 10000 t in 2001. This increase in eel aquaculture production has partially filled the gap created by the wild eel contracting yields. It is well known that the main limiting factor for eel aquaculture lies in seed, i.e. glass eels or elvers to start production cycles, with particular regard to its availability, quality and price. Induced spawning of this species is to be considered out of reach for the next future, despite the basic and applied research going on at present on the reproductive biology of anguillid eels.
In relation to this situation, debate on the possible measures to protect the European eel stock is topical at present, also in relation to a series of steps undertaken by the European Community.

In the present paper, a general review of eel exploitation is given at European and Mediterranean level, with emphasis on the links between capture fisheries and aquaculture, and paying special attention to the situation in the Adriatic region. This might prove to be important in consideration of the wide geographical distribution of the eel, and in relation to the fact that management options shall have to be translated into appropriate local-system targets (ICES, 2001).

2. Eel fisheries in Europe and in the Mediterranean region

Target stages of eel fisheries throughout its entire distribution area varies from recruiting glass eel to escaping silver eel, and this applies also to eel fisheries in the Mediterranean. Fisheries for eel in single countries reflect traditions of availability and market or consumption customs. Where glass eel ascent is intense, such as in the large tidal estuaries of the Atlantic coast of France, Spain, Portugal and in the Severn estuary in England, specific glass eel fisheries have developed for direct human consumption and for restocking inland waters or to be used as seed for aquaculture. Yellow eel are fished in inland and coastal waters throughout Europe and northern Africa, fishing gears being a variety of lines, nets and traps. A third set of fisheries focuses on the emigrating silver eels which are easily caught in intercepting barriers, nets and traps on their downriver and coastal emigration routes. Silver eel fisheries are found all over Europe, but most predominantly in Scandinavia and in Mediterranean lagoons.

Large scale fisheries for eel are rare and account for less than 5 percent of the total European catch (Dekker, 2002a). The remaining fisheries can be considered small-scale, throughout Europe and the Mediterranean, and can be commercial, semi-commercial or recreational. The processing and trade industries are organised in larger size companies and operate on an international scale (Dekker, 2002a).

With reference to yellow and silver eel fisheries in the Mediterranean region, inland fisheries are found in main rivers and lakes in most countries, but no formal information is available about these rural, small scale, scattered fisheries. Egypt is the most southern place where a commercial eel fishery is known to exist, the Nile and related waters in the valley having a very large eel stock (Dekker, 2002b). Eel fisheries are concentrated in coastal lagoons and lakes, but considerable fisheries are also found in the many branches of the Nile, where fisheries target yellow eel only. The Tunisian eel fishery focuses on yellow and silver eel, the same applies to Marocco, with particular reference to the lagoon of Nador.
In the Adriatic region, eel is exploited in inland waters in Albania (Shkodra lake and Shkopte lake, an artificial basin connected with the Mat river) and in Italy. In this country, largest inland eel fisheries are from the great Alpine lakes in the northern regions, but the eel is also an important target species for professional fisheries in some volcanic lakes of Central Italy. In all those environments, eel fisheries have been sustained by restocking.

Glass eel fisheries in the Mediterranean region are small scale, if compared to the big, commercial, ship based fisheries of the Atlantic, and fishing is always carried out by handheld nets (dipnets), or by fixed fykenets of varying dimensions (with or without wings), in estuaries and low river stretches, channel mouths and lagoon openings. In Spain glass eel fisheries are present on the Mediterranean side (Ebro Delta, Albufera de Valencia, S’Albufera de Mallorca), but in this country the Atlantic regions (the Basque country and on a minor basis the Asturias) play the central role in glass eel fishing, as well as in trading and consumption.

The same applies to France, where glass eel fisheries are not present on the Mediterranean coast at all, while glass eel fisheries are known to occur in Marocco, on both the Atlantic and the Mediterranean coast (Dekker, 2002b). No consistent glass eel fisheries are known to be present in Greece, apart some small scale experiences in the western areas, despite a growing interest towards its exploitation, and glass eel stage is not exploited in Turkey nor in Tunisia and Egypt, but in both countries, glass eel entry is observed (Dekker, 2002b).

In the Adriatic area, glass eel recruitment occurs in many systems in Albania but no fishery is known to exist. In Italy, recruitment to most Adriatic lagoons is extremely reduced today, and eel production in these environments is sustained by restocking. In Italy most of the glass eel yield comes from the Central and Southern Thyrrenhian area. Fishing sites are channel mouths, estuaries and lagoon openings, frequented not only by locally-based fishermen but occasionally also by fry fishermen from other regions, who reach those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, and sea bream fry, and glass eels. Local fishermen are usually single or co-operative fishermen that are equipped with boats and facilities to store the product alive. Destination of glass eels ought to be seeding for aquaculture or restocking. Despite the fact that trading for direct human consumption is forbidden in Italy, a certain amount of glass eels for consumption reaches some traditional markets in Tuscany.

The most distinctive exploitation pattern for eel in the Mediterranean is coastal lagoon fishery. Coastal lagoon management has always been based on the intercept of seasonal migrations of these species between sea and brackish water areas: ascent of juveniles to lagoons, more suitable for growth, and return of adult fish to sea for changing environmental conditions, primarily temperature, or reproduction. To exploit these periodic movements, large areas were enclosed, and permanent capture systems were consequently developed and improved. In coastal lagoons, such as the Sardinian ponds or the French or North African lagoons, artisanal fisheries are well developed, whereas management is simple and mostly based on natural fry ascent.

Referring to the Adriatic region, in Albania, the Kanavasta lagoon and the Narta lagoon, respectively 3900 ha and 2670 ha, are known to yield eel, and on a minor basis two smaller lagoons, Orikumi and Vilun. In Italy the whole North Adriatic area, and in particular the lagoon of Venice and related *valli*, in particular Comacchio, were strongly linked to eel production up to the 1970s, and in the Southern Adriatic the lagoons of Lesina and Varano.
Fishing equipment for eel catching in lagoons includes a variety of other instruments ranging from single fyke nets to groups of fyke nets, traps, baskets and fish hooks, depending on sites, local traditions, fishermen skill etc. Systems consisting of arrangements of nets and fykenets, constituting barriers that close the lagoon from one shore to the other, are used in some lagoons, such as the “paranze” from the lagoon of Lesina in the Southern Adriatic, Italy. Those systems, large up to 100 m in length, have been exported by Italian fishermen to other Mediterranean lagoons, in Northern Africa and in Albania.

Most of silver eel captures take place at fish barriers (Italian *lavoriero*, French *bordigue*), devices based on the principle of V-shaped traps. The structure (shape, number of chambers), size and design, building materials (from reeds to concrete and metal) have greatly evolved through the centuries and differ among countries, in relation to local traditions and degree of technology attained. The basic principle of its functioning is the same, i.e. intercept the fish when moving to reach the sea: in the case of silver eel, most captures take place in winter in coincidence with seaward migration. Fishing efficiency by these devices can be considered to attain 100 percent.

Eel yields in coastal lagoons environments depend primarily on environmental quality, even more than on recruitment. Those two features both influence management operations with reference to fishing efforts and to restocking. Thus observed yields can be extremely variable, from the 6 kg/ha observed in Comacchio in the mid '1980s, to the 300 kg/ha obtained in Monaci coastal lake in 1984 by means of restocking with small yellow eels.

Italian *vallicoltura* differs from coastal lagoon management practiced in other similar environments in the Mediterranean by a more active running. This includes stocking and active hydraulic management (Ciccotti *et al*., 2000).

3. Eel culture

Eel exploitation on a "culture" basis has a long standing tradition in the whole Mediterranean area, right in relation to coastal lagoon management. The eel became an important commercial species in Italy by the 1300s, when it was first extensively reared in the lagoon of Venice and in the whole upper Adriatic region, with the *vallicoltura*. The famous Comacchio *valli* reached a peak in prosperity in 1800 thanks to the eel and its processing industry. Extensive culture played a major role in European eel production, namely in Italy, up to the 1970s, when the whole sector was struck down by a parasitic disease, "Argulosis", caused by the ectoparasite *Argulus giordanii*. This event, together with an increasing market demand, led to the first trialss towards intensive eel farming in open systems based on the on-growing in earthen or concrete ponds, on the basis of the Japanese technology already well established, and using either ground-waters or warm effluent waters. Limiting factors were seed weaning technologies and food conversion rates during the out-growing phase, together with the need of frequent grading operations. During the 1980s, advances in feed preparation technology and improvements of farming techniques (engineering and water treatment technology, disease management) enhanced the potential for successful farming, mostly in Italy but also in other southern European countries. Eel culture production shows a steady growing trend through the second half of last century (Figure 1). Up to the mid 1990s, Italy was the leading country, with 3000 t/y, about 47 percent of total European production (Ciccotti *et al*., 2000). The Netherlands are now the leader country. In this country as in Denmark the biggest investments have been made in the last decade, following the setting up of efficient heathed recyrculated systems, rising production from 500 tonnes (1988) to over 5000 tonnes (Ciccotti and Fontenelle, 2001). Hence, European eel farming has shifted towards higher productions, with improved intensive farming performances and reduced impacts on the environment.

4. Status of the stock in Europe and in the Mediterranean region

The general picture on the status of eel stocks and fisheries throughout Europe displays declining recruitment (Figures 2 and 3) and reduced yields (Figure 4), apparent both for capture fisheries and for scientific indices.

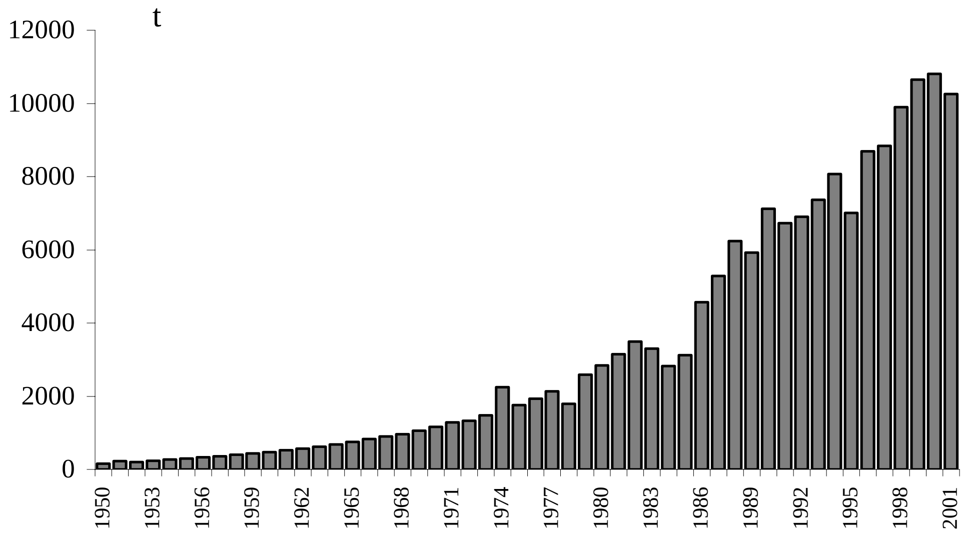

Figure 1: Cumulated eel aquaculture production in the European countries, 1950-2000 (from FAO, 2003).

The conclusion that recruitment has declined in the past decades is based on compilations of time-series data, covering varying time intervals, from 19 river catchments in 12 countries, and derived from both fishery-dependent sources (i.e. catch records) and fishery-independent surveys across much of the geographic range of the European eel. No upward trends are present in any of these European data sets: over the last two decades of all time-series,

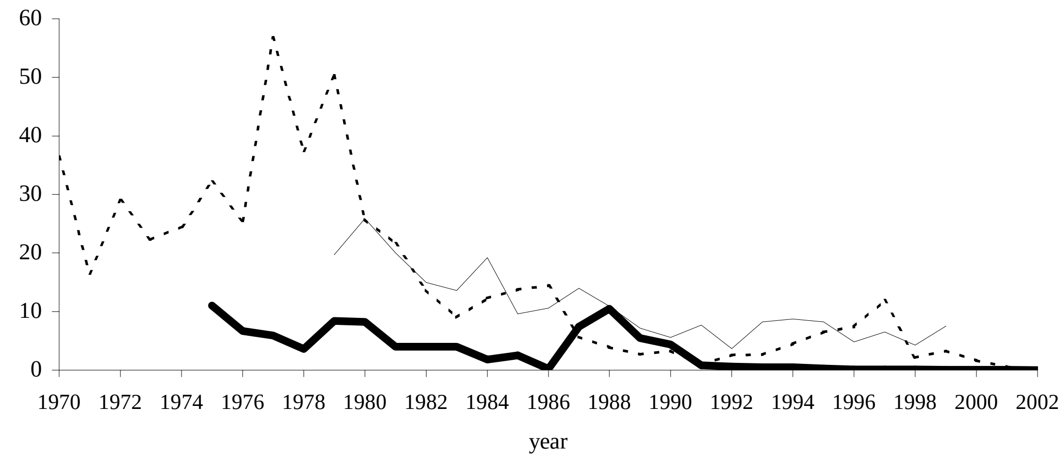

Figure 2. Recruitment trends at three sites in Europe (from ICES, 2003). – Den Oever, The Netherlands (index, dotted line); Gironde, France, NW Atlantic (CPUE, thin line); Tiber, Italy, Mediterranean (catch in tons, thick line).

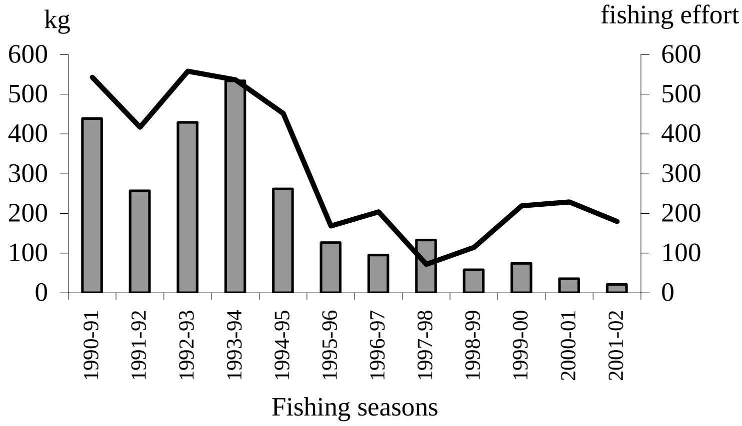

Figure 3. Recruitment monitoring at the Tiber river estuary: total catch (left axis, bars) and fishing effort (as fishing days x number of nets) (from Ciccotti, 2002).

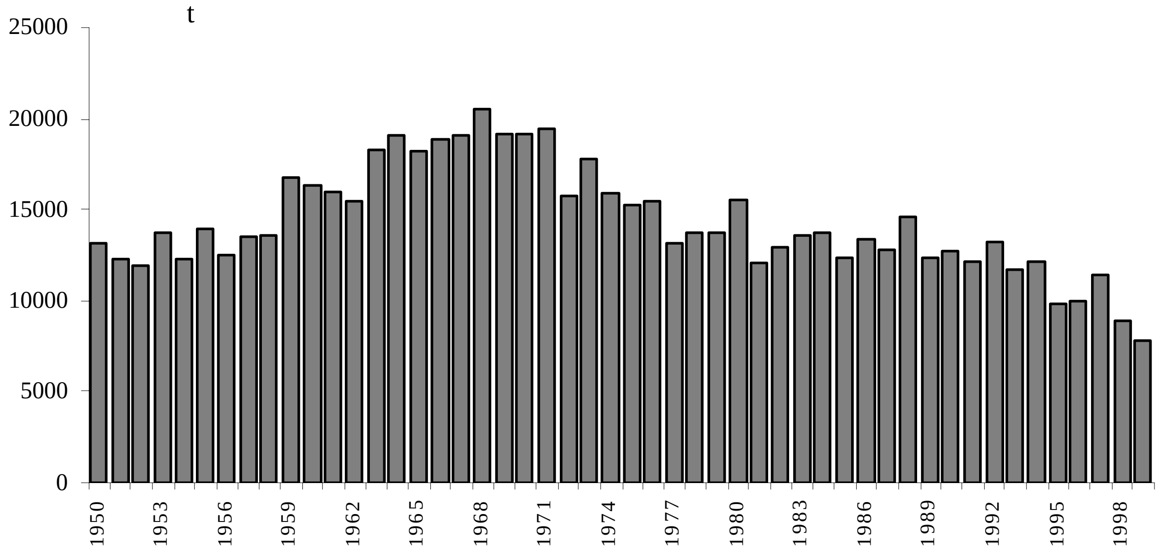

Figure 4: Total eel capture in Europe, 1950-2000 (from FAO, 2003).

downward trends were evident, reflecting the rapid decrease after the high levels of the 1970s. In the 1980s, the trend was clearly downwards; after the '90s fairly stable low levels, recent years show a continued decrease.

As a general picture, total European glass eel catch was estimated (Moriarty, 1996) to amount to about 920 tonnes, and a total commercial yield from European eel capture fisheries of 22-30 000 tonnes. Glass eel catches then only represents 2.7 percent of the total yield in weight, but accounts for more than 2.4 billions of recruits in number (Feunteun, 2002). An estimate of the whole glass eel catch for the Mediterranean does not seem feasible. Official landing statistics do not discriminate among stages, while national institutions seem lacking because of high rates of illegal fishing, not reporting or underreporting in most countries. Mediterranean glass eel yield is anyway for sure only a minor quota of the whole European catch. However, the apparent decline in recruitment reported for all Europe is confirmed for the Mediterranean area, where one of the monitoring sites is located on the Tiber river, Latium, central Italy (Ciccotti *et al*., 2000; Ciccotti, 2002).

The effects of this decline on the eel stock are not easy to document, long-term surveys in single systems being scarce and sometimes not informative, because management practices such as restocking are carried out. Contractions inyellow and silver catches in many systems from all countries, and collapse of some fisheries, have been reported (Moriarty and Dekker, 1997). Inconsistencies of national catches as quoted by official statistics have been underlined (Moriarty and Dekker, 1997; ICES, 2001), because of illegal and unreported catches, as well as lack of coverage of many areas in several countries, or variations in fishing effort. Anyway, even if catch return data do not necessarily reflect the status of the eel stock, it is felt that to some extend trends in the reported data will reflect true changes in fishing yields (ICES, 2001). Examination of reported landings (Figure 4) in Europe points to a decrease of yield in most countries during the last 20 years.

The same source has been used to outline a picture of the trend of eel yields in the Mediterranean, with minor corrections. On the whole, a decreasing trend can be evidenced for global yields, in particular for Mediterranean marine production (Figure 5) that can be considered to coincide with coastal lagoons yields because in the Mediterranean no real marine fisheries exist. In inland waters (Figure 6) the decrease is less evident, but it must be considered that in some countries inland stocks can be sustained by restockings, or data be mixed with aquaculture, or even that fishing effort statistical records have begun only recently.

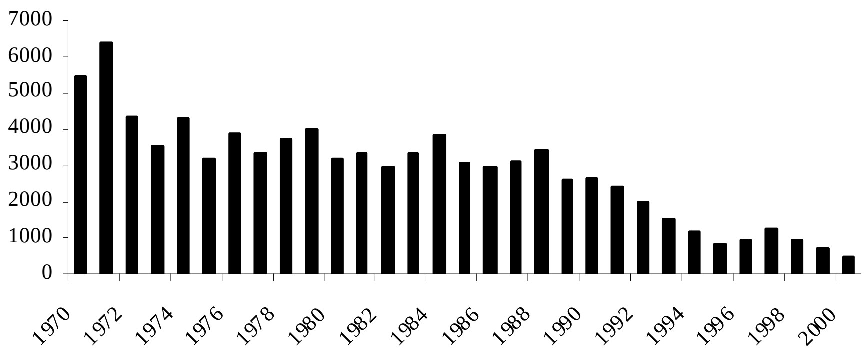

Figure 5. Eel capture from coastal areas in the Mediterranean area, 1970-2000 (from FAO, 2003).

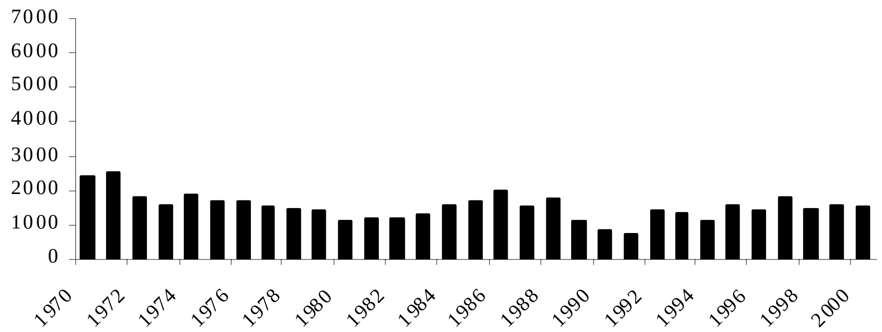

Figure 6. Eel capture from inland waters in the Mediterranean area, 1970-2000 (from FAO, 2003).

If individual countries are considered, some show market decreasing trends. For example, in Italy in coastal lagoon production a decreasing trend is evident, which took place during the ‘80s, with yields decreasing from an average of 1.500 tonnes in the ‘70s to about 500 tonnes in the ‘90s to < 300 in 2000 (Ciccotti *et al*., 2000). The main limiting factor in eel production in lagoons today, apart from the habitat changes related to coastal waters eutrophication and pollution, is seed availability for stocking. National glass eel catches are used for lagoon restocking, and the fall in recruitment and the consequent decline of glass eel fisheries cannot be compensated for by imported seed, also because of rises in prices. This, together with the fact that the eel life cycle in lagoons is long (average seven years) and hence non-competitive with the aquaculture product, means that other species are given preference when local management strategies are formulated.

In inland waters, eel populations are believed to be reduced owing to the presence of numerous dams, most of which have inadequate fishways or none at all and are therefore impassable. Recruitment to most lakes has been considerably reduced by the construction of dams along the effluent rivers. Considering that nowhere, for eel fisheries, standardised survey campaigns as compared to other marine shared species can be carried out, the most effective information can be derived from single systems followed for a consistent period of time, but this has rarely been achieved on a sound basis within the Mediterranean.

A case for which data are available refers to the North Adriatic area, i.e. the already mentioned Valli di Comacchio, renown in relation to its eel production, for which official data of fish production have been available since 1781. The trend in the course of those two centuries has always been characterised by fluctuations ranging from 6 to > 30 kg/ha, attributable to such environmental problems as hypersalinity and freezing of the valli. The average annual yield of eel per hectare was 14.3 kg, about 78 percent of the total fish production. Higher yields were obtained after 1964, coinciding with restocking and seeding practices whereas, from the late 1970s, production has been considerably lower (5–7 kg/ha), attributed to falling recruitment in the Comacchio lagoons. From 1990, owing to the above-mentioned environmental problems and to internal problems of the Consorzio Valli di Comacchio, eel production has reached its historical minimum, falling to less than 5 kg/ha, stockings having been completely abandoned. Catches consist now only of large eel, the older individuals still inside the lagoon (Ciccotti, 1997).

The hypotheses brought forward as possible explanations of the causes of the widespread decline in recruitment are diverse, from antrophogenic to natural. Among the latter, the main hypothesis is a dependence of recruitment decline by a change in the oceanic circulation. The parallel decline of the recruitment of the American eel (*Anguilla rostrata*) in some of its distribution area are thought to support this model. Spreading in Europe of the swimbladder parasite *Anguillicola crassus*, that causes swimbladder dysfunction and hence may influence the migration of mature eels, have also been called in, as well as predation by the greatly increased European populations of cormorants or other predators. With regards to anthropogenic factors, the impact of fisheries on the population cannot be adequately described. Habitat loss, wetland reclamation in coastal and estuarine environments has been considered to be considerable throughout Europe, even if the process has occurred gradually, mainly during the second half of the last century (ICES, 2001; Feunteun, 2002), and a large part of the European inland water habitat has been made inaccessible to eels by hydroelectric dams or other obstructions to upstream migration. Finally, the spread of environmental contaminants has been considered to possibly contribute to the recruitment failure. Eels accumulate organochlorines and other fat soluble substances readily, and this may impair the migration and affect the survival of the larvae. A concern expressed more recently is the spread of endocrine disruptors (ICES, 2001).

5. Interactions with aquaculture, globalisation of the market

From the late '90s, European eel aquaculture has become involved at a global scale, due to growing interactions with Asian eel aquaculture, whose production amounts to more than 180000 tonnes (Table 1) and to a globalization of processing industries and of markets. A large and rapid increase in Chinese eel culture led, as a primary consequence, to the fact that the growing Asian productive capacity increased the demand for glass eel from anywhere, and from Europe in particular, because of the current shortage of Japanese glass eels. Up to the mid 1990s, notwithstanding the decline in recruitment, the dependence of European aquaculture on glass eel or elvers from the wild was not really considered a major problem. Indeed, the demand of glass eel for European aquaculture purposes was estimated to amount to about 40 t/year. When the Far East aquaculture asked for more *Anguilla anguilla*, this upset the EU glass eel fishery scenario and markets. At a first stage (1997-1998), there was a sharp increase in seedlings prices within EU (more than 300 €/kg paid to fishermen in France). This new trend seriously alarmed producers, while a consequent increase in fishing effort on glass eels was observed by commercial fishers, the demand for glass eels being also an incentive for poaching. Then, a double impact on the wild stock should be expected: (i) by an increased fishing effort on glass eels and (ii) a reduction of available stocks for enhancement. Restocking in open waters to sustain wild eel fisheries throughout Europe is often carried out by national fishery authorities, in particular in northern countries (Sweden, Ireland, Denmark as well as France). Higher price for glass eel reduced stocking practices everywhere, thus affecting both local fisheries and local wild eel stocks. As a secondary consequence, Asian aquaculture has known an outburst of production that brought about repercussions on the European market, because exceeding supply led Europe to turn prices down.

Table 1. The world-wide production (tonnes per year) of anguillid eels in fisheries and aquaculture, averaged over the 1990s (from Dekker, 2002a, based on FAO statistics).

Area	**species**	**Fishing yield**	**Aquaculture production**
Europe and N. Africa	*A. anguilla*	15 262	18 101
America	*A. rostrata*	1 480	100
Asia, east	*A. japonica*	1 300	187 875
Asia, southeast	*Anguilla spp.*	8 385	1 579
Australia and New Zealand	*A. dieffenbachii and A. australis*	2 241	100
Total		**> 28 668**	**> 207755**

6. International framework and ongoing actions on eel management

The unique status of the eel was defined in 1976, when a joint ICES/EIFAC Working Party on Eels was established, that has met in alternate years since then. Within the WP, the above mentioned monitoring system for eel recruitment was set up, that allowed to document and follow the decline of supply following the abundance of the 1970's (Moriarty, 1990; 1996). The general concern by fishermen, fish culturists and scientists alike on the decline in recruitment and fishery yields of the eel led to the establishment of a EC Concerted Action AIR A94-1939, to pursue a project entitled *Enhancement of the European eel fishery and conservation of the species,* whose final Report (Moriarty and Dekker, 1997) contained an account of the eel fishery in Europe, a review of scientific data of significance relative to local stocks and maked recommendations for future management.

The EC in 1997 requested ICES to provide information about the status of the eel, in order to ensure a sustainable development of the eel fisheries within the European Union, and in 1998, having acknowledged that the eel stock is outside safe biological limits, has requested to provide escapement targets and other biological reference points. Since then the ICES/EIFAC Working Group on Eels (1999; 2001; 2002, 2003) has been working on the defining of reference points for European eel management use.

With specific reference to the Mediterranean, in 2002 the STECF Subgroup on Mediterranean included the eel within the species for which a scientific evaluation and critical review of the background information were performed, in consideration of the fact that this resource is shared among the majority of Mediterranean countries. Eel in fact is included among the shared stocks in the Community Action Plan for the conservation and sustainable exploitation of fisheries resources in the Mediterranean Sea under the Common Fisheries Policy (COM (2002) 535).

In conclusion, concern about the conservation of this species has been growing in the course of the last few years and the need for conservation and management measures has been clearly identified by scientists, managers, and even by the public opinion. The International Council for the Exploration of the Sea (ICES) in October 2002 pointed out the urgent need for a recovery plan for European eel, that should include measures to reduce exploitation of all life stages and restore habitats.

At present few conservation measures are being taken at national level in some Community and non-Community countries. However, given the fundamental trans-boundary migration pattern of European eel, national measures are not sufficient to ensure adequate conservation of this species in Europe. In May 2003 a Regional Workshop on Action Plans for Eels was organised by the European Commission, to provide the scientific and technical background information for the Development of a Community Action Plan for the management of European Eel, that was published October 1st, 2003 (COM (2003) 573).

This document, on the basis of the current evaluation of the eel situation, considers the legal background for management, ranging from the Community framework for action to the UNCLOS specific article (67) for catadromous species, with reference to Coastal States responsibilities and obligations to ensure ingress and egress of fish. The need to ensure that rivers do not become barriers (through pollution or public works) for the movement of the species through its natural habitat brings in also the possible role of Water Framework Directive (EC) No 2000/60. One of the key elements of the Directive is the introduction of River Basin Management on a Europe-wide scale including international co-ordination in transboundary river basins. In this respect, the WFD could joint in the objectives of the eel action programme, by using the management system and the river basin authorities when setting targets and implementing eel action programmes.

In considering the possible management measures and the rebuilding plan targets, the overall approach of the document is centred on the ICES advice. The strong need for urgent management action is acknowledged, also supported by the precautionary principle, which suggests that high-risk situations need urgent protective measures. In many areas, the quickest and most effective measure to increase the survival of eel will prove to be a reduction in fishing, whereas environmental improvements may take some years to show results. A number of actions are identified that are intended to develop a comprehensive basis for rebuilding eel stocks, based on locally-appropriate actions and targets. This rebuilding and management approach requires substantial acquisition of new scientific data before it can be fully implemented. Therefore, the Commission will urgently seek to identify a wide range of precautionary measures for rapid implementation, while the rebuilding plan is being developed.

In conservation terms, the main objective of eel management actions is identified in allowing an adequate escapement of silver eel. Possible local targets for eel conservation and management are reviewed, with regards to recruitment/settlement targets, stocking targets and particularly escapement targets. Local management actions that could contribute to the latter could include: i) managed escapement of silver eels from inland waters to the sea; ii) prohibition of certain fishing gears particularly likely to catch silver eel; iii) construction of eel passes in dams and hydroelectric plants. The need for a data collection system is pointed out, in connection to the necessity to measure outcomes of the various management instruments. The international dimension of actions and the necessity to extend to the eel the existing regional agreements is also considered, GFCM among others being indicated as an appropriate forum for such discussion.

7. Conclusions

The conservation and management of eels is a very wide-ranging issue, as it depends upon both commercial exploitation and preservation of its natural habitats. Both environmental considerations and fisheries management issues need to be taken into account. The possible effect of trade on the conservation of this species adds an additional dimension to the problem. Without doubt, a number of uncertainties, when dealing with eel, arise not only on its biology, but also on the feasibility, as well as on the chances of success of possible management strategies. A process has begun, that shall bring about a management plan, as well as emergency actions in the immediate future, to ensure eel conservation within a framework of sustainability of the related socio-economic activities.

From the information given in the present paper, some points can be drawn for the European eel in the Mediterranean. The continent-wide decline in recruitment is confirmed, and there are strong evidences of contracting stocks, emerging from both official landing statistics and from long-term observations in selected systems. The establishment of a long-term monitoring program for glass eel recruitment at the regional level seems then opportune, as well as a regional survey data monitoring program for eel fishery, that could provide elements for the identification of key index systems for eel stock assessment.

Some distinctive features of exploitation, with regards to Mediterranean coastal lagoons, and in particular to the Adriatic region, provide a key to the setting up of a relevant geographical management unit. In these environments traditional management practices were finalised to sustain local eel stocks and environmental characteristics are such that very high productions can be attained if recruitment is consistent. On the other hand, silver eel fishing at the fish barrier, typical of the Italian tradition in the North Adriatic and spread also in other Mediterranean areas, can be considered to control completely the escapement. An opportunity to resume the coastal lagoon management model seems then opportune also as a potential instrument for eel conservation: the sustaining and implementing of these traditional "enhanced fisheries", based on the rational use of glass eel fisheries and contemplating local escapement quotas, could give a contribution to overall escapement at the Regional scale.

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Interactions between capture fisheries and aquaculture: the case of shellfish

Giuseppe Prioli*

Abstract
General information (catch statistics, species cultured, culture methods) on shellfish fisheries and culture in the Mediterranean is given with particular reference to the Adriatic Sea. Details on shellfish market and legislative framework are also reported. Interactions between shellfish culture and both bivalve molluscs harvesting and capture fisheries are identified in different sectors: political-management, environmental, economical and social.

1. Introduction

Bivalve molluscs represent an important resource within Mediterranean production setting. In 2000, bivalve production amounted to 284.000 tonnes, corresponding to 15 percent of total fishery and aquaculture yield which in the same year reached 1.850.000 tonnes. Out of the total production, 1.490.000 tonnes came from capture fishery and 360.000 tonnes from aquaculture (190.000 tonnes represented by molluscs, the rest by fish and crustaceans). Within capture fisheries production, bivalve mollusc catches contributed with 93.000 tonnes, covering 6 percent of the total (Figure 1).

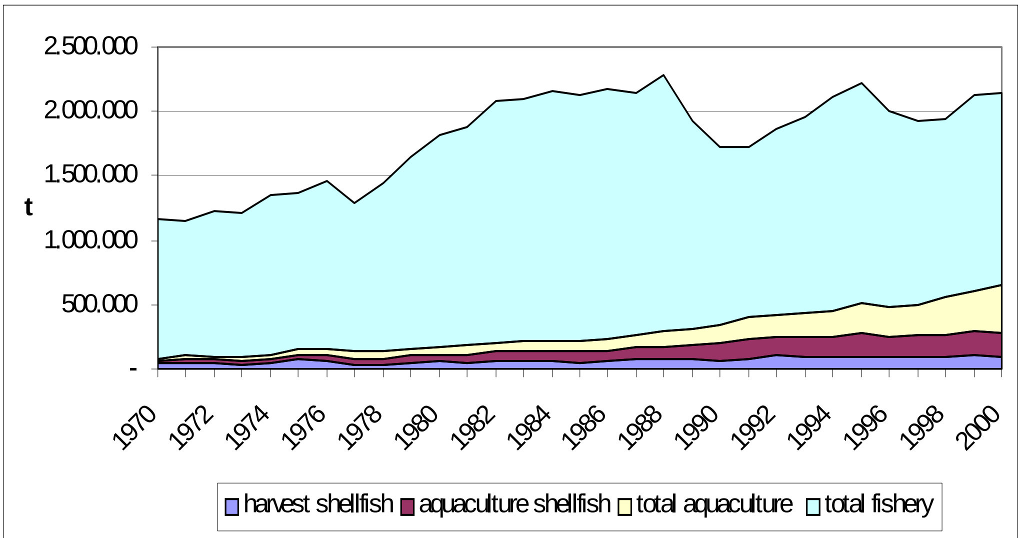

Figure 1. Total fishery and aquaculture production in Mediterranean area (FAO-Fishstat).

2. Shellfish fisheries: general information, reported catch statistics in the Mediterranean, with particular reference to the Adriatic Sea

Bivalve molluscs fisheries production amounted to 93.000 tonnes in 2000, out of which 43.000 tonnes of mussels (*Mytilus galloprovincialis*), 47.000 tonnes of clams, mainly stripped venus (*Chamelea gallina*), and 350 tonnes of oysters (Pacific cupped oyster and

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European flat oyster). Compared to 1970 figures, the production has increased by 120 percent (FAO-Fishstat) with variable fluctuations (Figure 2).

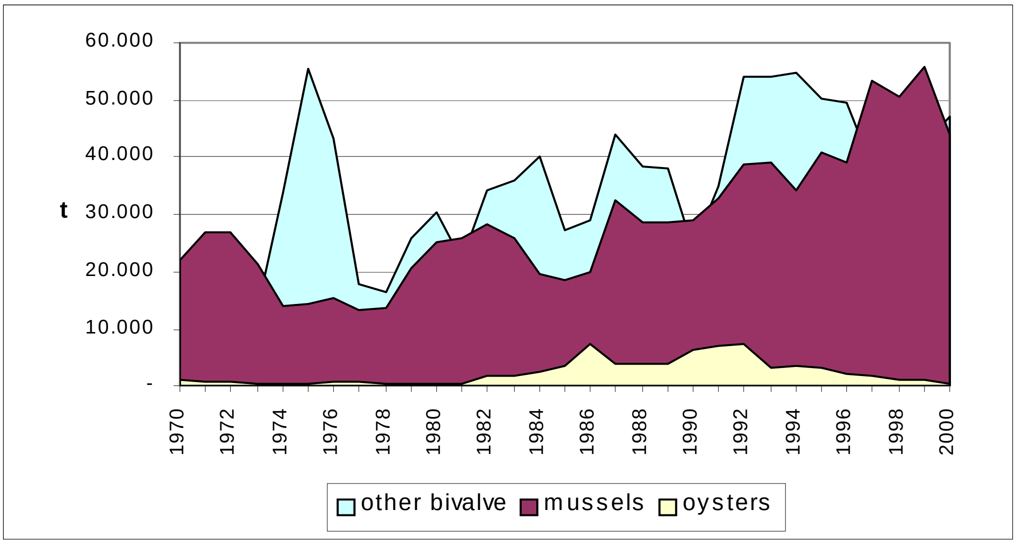

Figure 2. Bivalve molluscs fishery production in Mediterranean area by species FAO-Fishstat).

Adriatic contribution to total Mediterranean production is 59.000 tonnes, or 64 percent, out of which 27.000 tonnes are mussels, 32.000 tonnes clams (stripped venus) and 13 tonnes are oysters (European flat oyster) (Figure 3). It is difficult to quantify Japanese littleneck clams caught in the wild.

Catches of other bivalve molluscs species such as scallops (*Pecten jacobaeus*) and queen scallops (*Aequipecten opercularis* and *Proteopecten glaber*), in the past quite abundant in the northern Adriatic, are not reported in FAO sources consulted (Fishstat). While today scallops and queen scallops production appears to be quite marginal, in 1991 they were estimated to 2.500 tonnes and 100 tonnes respectively.

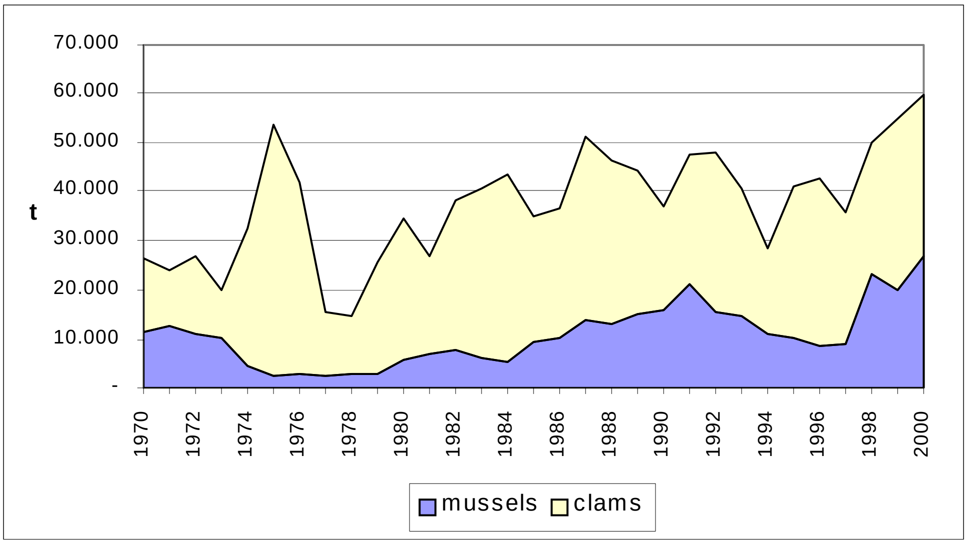

Figure 3. Molluscs fishery production in Adriatic area (FAO-Fishstat).

According to the figures reported so far, bivalve molluscs fishery seems to be quite significant in the Adriatic area, especially in the north west basin where best edaphic and trophic conditions for propagation of these species are met. Major rivers flowing into this part of the Adriatic Sea, together with extended lagoons along the coast and muddy and sandy bottoms characterized by minor slopes, are the main factors that make this area rich in biocenosis with important bivalve molluscs species. The potential of these areas is still not fully explored. It is worthwhile to cite the presence of extended *Anadara inaequivalvis* beds, an allochthonous species involuntarily introduced in Adriatic towards the end of the ‘60s, that now proliferate between 1 and 10 miles from the coast, and has yet not found a valuable market utilization.

Mussels are usually harvested (collected) by hand and less frequently, where rich mussels beds on lagoon bottoms are present, through bottom trawl fishery. The most exploited areas are the ones close to the rocky coastal parts, among which Conero promontory in the Marche region stands out. Equally important are the quantities collected on methane-producing platforms during cleaning and maintenance activities.

Clams are usually caught by vessels equipped with a hydraulic dredge. In 2000, out of 728 dredge boats registered in Italy, 685 were operative along the Adriatic coast. This fishery system operates on sandy bottoms within 1 mile from the coast. Normative applied to this capture system contains the following indications: gears dimensions, catches limit, vessels dimensions, engine power, clam size. Fishing areas are managed by compartmental management consortiums to which all fishermen are affiliated. Some of these vessels are used or other bivalve molluscs fisheries as well, such as smooth callista (*Callista chione*) and razor-clams (*Solen* spp. e *Ensis* spp.).

Western coast clams production (stripped venus) is only reported for Albania referring to the period 1987-1996. The trend shows a progressive decrease from the initial amount of 700 t (FAO Fishstat). Although reduced clam beds are present along the northern coast of this country, collection of any kind is not allowed.

Capture fisheries of Pectinidae (scallops and queen scallops) has nowadays become marginal. In the past Pectinidae species were collected in the northern Adriatic with bottom trawl gears called “rapidi”, vessels equipped with fixed dredges originally constructed for flat fish fisheries (Mattei and Pellizzato, 1997).

Although farming activities account for the largest part of clam production, natural harvesting of Japanese littleneck clams (*Tapes semidecussatus*) can be practiced according to gear regulations in specific areas, identified by hygienic and sanitary parameters

3. Shellfish culture: general information, species cultured, culture methods used, seed used in grow out, pathologies, environmental impact.

Total cultured shellfish production in the Mediterranean area and in the Black sea amounted to 196.000 tonnes in 2001 (FAO Fishstat), showing a remarkable increase compared to the 16.000 tonnes estimated in 1970 (Figure 4). Three species are dominant in this production:

mussels (*Mytilus galloprovincialis*) with 131.000 tonnes, Japanese littleneck clams (*Tapes semidecussatus*) with 55.000 tonnes, and Pacific oysters (*Crassostrea gigas*) with 9.500 tonnes.

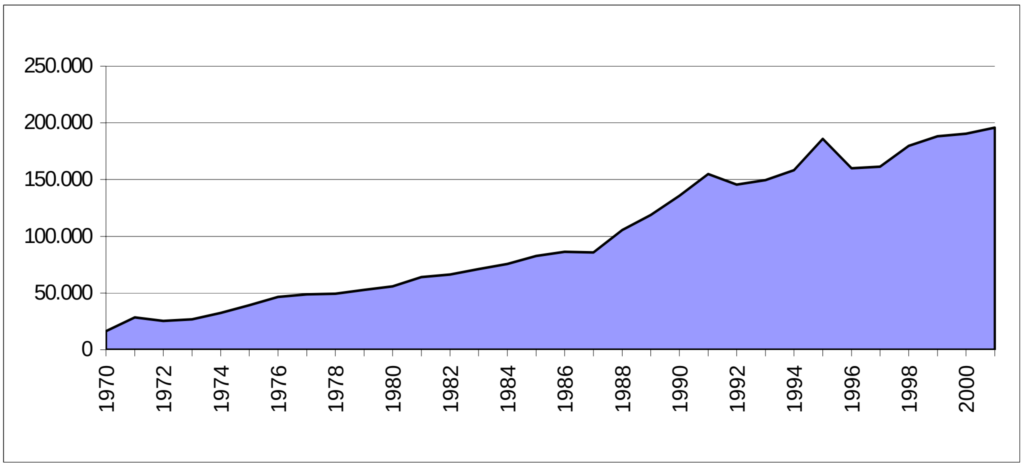

Figure 4. Bivalve molluscs culture production in Mediterranean and Black sea (FAO-Fishstat).

As far as the Adriatic area is concerned, shellfish culture has developed along both the eastern and western coasts. However, major productive sites are concentrated in the western areas, from Trieste to the Gargano promontory, where in 2000 the production has been estimated to 65.000 tonnes of mussels and 53.000 tonnes of clams, roughly equivalent to 50 percent and 96 percent of total Mediterranean production respectively (Prioli, 2001). Production contribution from other countries such as Slovenia, Croatia, Montenegro and Albania must be added to these quantities: catch of mussels and oysters (*Ostrea edulis*) reached 3.400 tonnes in 2001.

In the open sea, both mussels and oysters are farmed using the long-line systems, which sometimes differ among regions, as the *bi-tri ventia* in Friuli V. G. In lagoon basins of both coasts fixed systems prevail instead (Prioli 2001).

A total number of shellfish farms in the Adriatic is estimated to be 220, out of which 177 are located along the western, and 43 along the eastern coast. Out of the total number, 171 farms produce mussels and a minor quantity of oysters, while the other 49 produce Japanese littleneck clams (Table 1).

On the eastern coast Croatia is the country with the highest number of farms, mainly distributed between Istria, Mali Ston bay and the Krka river estuary. Three farms are situated close to Piran in Slovenia, while in Montenegro mussels culture farms can be found in Boka Kotorska bay. In Albania there is a slowdown in mussels productivity: in Butrinti lagoon, where the major mussel culture was practiced, there are 80 farms that were in use until the ’90s, and much concern is now expressed by the government to make them operative again.

In Italy most farms are situated in the northern Adriatic, but a strong development is being registered in the southern regions, especially Marche and Abruzzo. Veneto and Emilia Romagna represent the most significant productive pole of the Adriatic area, exclusive as far as clams production is concerned and nationally important for mussels production. This is well demonstrated by the number of personnel employed in this sector (Table 1).

Environmental conditions are a critical factor in shellfish culture. Aquaculture farms are situated in areas where the requirements for a high trophic level, good water quality and maintenance of farm equipment have to be met.

Nutrients supply, as well as the abundance of phytoplankton and organic particles gradually decrease from the Po delta southward. On the eastern coast nutrients are more available around estuarine and coastal lagoons. Trophic conditions are a limiting factor in shellfish culture, and this gives rise to the differentiation between Adriatic and Tyrrenic coast, as in the latter only few sites close to the shore are suitable for shellfish farming. Water quality is another important factor. Although it is not a strictly restrictive factor because contaminated molluscs can receive purification treatment after the harvest, it does weigh upon production cost. This is the reason why during the past 20 years offshore shellfish culture has much increased in many Adriatic regions. The development of new technologies, protected from mechanical stress induced by strong waves in the open sea, has extended the frontiers of shellfish culture allowing the exploitation of new areas, as well as the overcoming of restrictions connected to the oscillating environmental conditions in lagoons, both trophic and physio-chemical.

The main limit to shellfish culture development in the eastern Adriatic countries at present might be imputable to insufficient sanitary control measures and to inadequate implementation of European Community normative. This practice is precluding export to the main consumer countries and limiting productive potential. It is reasonable to foresee an increase of production in these countries once these deficiencies are overcome.

Table 1. Bivalve molluscs culture farms in Adriatic.

Regions	**Culture farms**			**Staff**
	Total	**Mussels and oysters**	**Clams**	
Friuli-Venezia Giulia	60	56	4	55
Veneto	56	29	27	1800
Emilia-Romagna	42	24	18	1200
Marches	7	7	0	32
Abruzzo	4	4	0	10
Molise	2	2	0	8
Apulia	6	6	0	220
Italy (total)	177	128	49	3.325
Slovenia	3	3		na
Croatia	28	28		na
Montenegro	12	12		na
Albania	na (80)	na (80)		na
Total in Adriatic	**220**	**171**	**49**	**3.325**

Rearing of some mollusc species such as mussel, oyster and Japanese littleneck clam, can start either from juveniles collected in the wild or from larvae captured through specific collectors. For Japanese littleneck clam and oyster, it is also possible to use spat obtained through breeding from specialised hatcheries mostly situated abroad: France, Britain, United States, and partly in Italy.

The pathologies that affect bivalve molluscs in Italy are the ones commonly known in Europe. However, serious epidemic cases in either reared or wild populations have never been recorded in Italy so far. Two sole infective cases of *Bonamia ostreae* on *Ostrea edulis* have been registered in the waters offshore Chioggia and close to Apulia coast. Other diseases so far reported are: microcytosis affecting *Crassostrea gigas* and *Ostrea edulis*; Perkinsosi, affecting *Crassostrea gigas*, *Tapes semidecussatus*, *Tapes decussatus*; MSX disease affecting *Crassostrea gigas* (Cerchia, 2003, personal communication).

The environmental impact of shellfish culture is related to the type of equipment used, to the culture method and, most importantly, to the farming site. As far as mussel farming with long line method is concerned, recent studies on culture sites offshore carried out in 2001 by ISMAR-CNR in Ancona, didn't show the presence of significant quantity of organic waste on the bottom, probably thanks to strong sea currents. Nevertheless, the same currents might damage equipment items such as buoys or ropes or cause the loss of the mesh tubing that remain floating on the bottoms after the loss of mussels.

More evident effects on the environment can be observed when farms are situated in closed areas, such as the Gulf of Trieste, or even more in lagoons. Another undesirable effect is the involuntary release of larvae in the environment related to oyster farming with suspended methods. The case of the larvaeparous species (*Ostrea edulis*), and its following settlement in the wild appears to be especially critical.

Further impact can be generated by the transport of live shellfish, both juveniles and adults. Most oysters or Philippines clams spat comes from non-Mediterranean countries, and this can determine the introduction of pathogens and undesirable phytoplankton, algal and bivalve species. In case of adult product, especially mussels in mesh tubes, the associated flora and fauna can also be transferred.

A significant impact was generated by voluntary introduction of allochthonous species such as *Crassostrea gigas* (or *C. angulata*) and *Tapes semidecussatus*. Both species have well adapted in most of the northern Adriatic lagoons and also along the coast. The spread of Japanese littleneck clam has been so considerable and fast as to influence the economy and the environment of large areas with remarkable social effects. *Crassostrea gigas* on the other hand has been less invasive although today it is present along the entire coast.

The presence of Japanese littleneck clam has led to a different lagoon environmental management that favours allocation of areas to aquaculture farmers, while harvesting in the wild decreases. In this new setting, activities aimed at improving sustainable exploitation of resources such as hydraulic interventions, bottom cleaning and seeding, are carried out.

4. Shellfish market: fresh and processed products, Mediterranean market capacity

In 2001, reported global amount of imported bivalve molluscs products was 444.343 t, 135.723 tonnes of which, or 31 percent, was of Mediterranean origin. Mediterranean countries contributed with 25 percent of fresh and frozen products and with 53 percent of processed products to the total imports (Table 2) (FAO-Fishstat).

Table 2. Global and Mediterranean imports of processed and fresh/frozen bivalve molluscs, quantity expressed in tonnes (FAO-Fishstat; 2001).

Product	Commodity	All countries	Mediterranean countries	%
Fresh/frozen	Import	354.162	87.937	25%
Processed	Import	90.181	47.786	53%
Totale	**Import**	**444.343**	**135.723**	**31%**

As shown in Figure 5 imports of fresh or frozen shellfish have gradually raised on a global scale, increasing from 135.567 tonnes in 1976 to 354.162 tonnes in 2001 (equivalent to 160 percent growth), whereas, during to the same period, the increase of 52 percent in the Mediterranean countries is much less significant.

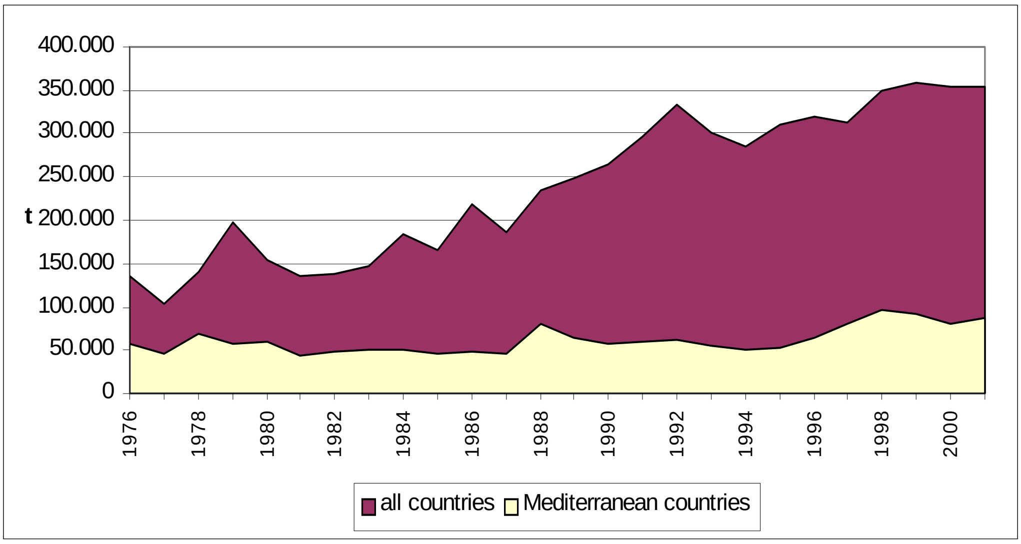

Figure 5 - Global and Mediterranean imports of fresh/frozen bivalve molluscs (FAO-Fishstat; 2001).

Different considerations can be made analysing the import trend of processed products. As it can be observed in Figure 6, the import increase registered for Mediterranean countries, from 8.037 tonnes to 47.786 tonnes, is equivalent to 495 percent, while the global trend reaches 208 percent increase, going up from 29.292 tonnes in 1976 to 90.181 tonnes in 2001.

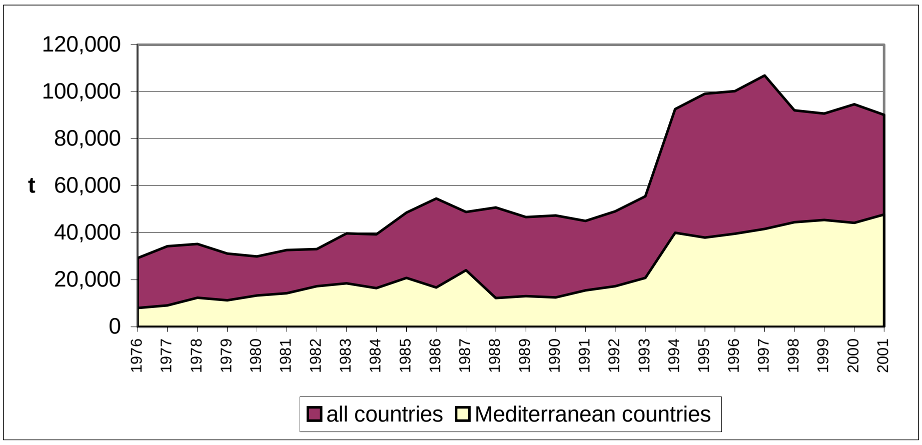

Figure 6 - Global and Mediterranean imports of processed bivalve molluscs (FAO-Fishstat; 2001).

Global quantity of fresh and processed products exported reached 483.141 tonnes in 2001, of which 15 percent, or 74.046 tonnes, were of Mediterranean origin (Table 3).

Table 3. Global and Mediterranean exports of processed and fresh/frozen bivalve molluscs, quantity expressed in tonnes (FAO-Fishstat; 2001).

Product	**Commodity**	**All countries**	**Mediterranean countries**	**%**
Fresh/frozen	Export	386.184	59.449	15%
Processed	Export	96.957	14.597	15%
Total	**Export**	**483.141**	**74.046**	**15%**

The increase of global exported fresh/frozen bivalve molluscs for the period 1976-2001 is quite significant as well, increasing from 90.447 tonnes to 386.184 tonnes, which is equivalent to 327 percent growth (Figure 7). Export of the Mediterranean countries increased by 335 percent, from 13.673 tonnes in 1976 to 59.449 tonnes in 2001

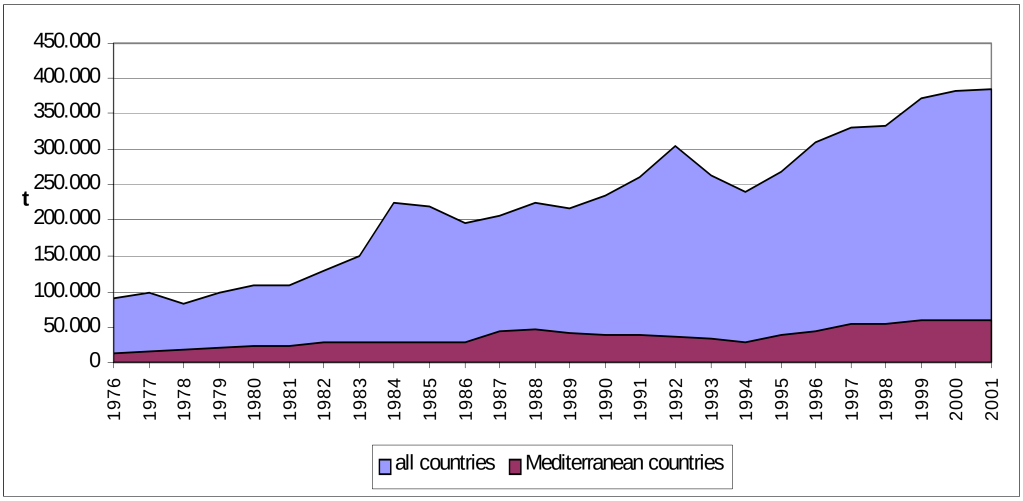

Figure 7. Global and Mediterranean exports of fresh/frozen bivalve molluscs (FAO-Fishstat; 2001).

Processed bivalve molluscs exports in Mediterranean countries rise from 5.706 t to 14.597 tonnes (Figure 8) showing an increase of 156 percent, lower than global growth, equivalent to 207 percent (from 31.597 tonnes in 1976 to 96.957 tonnes in 2001).

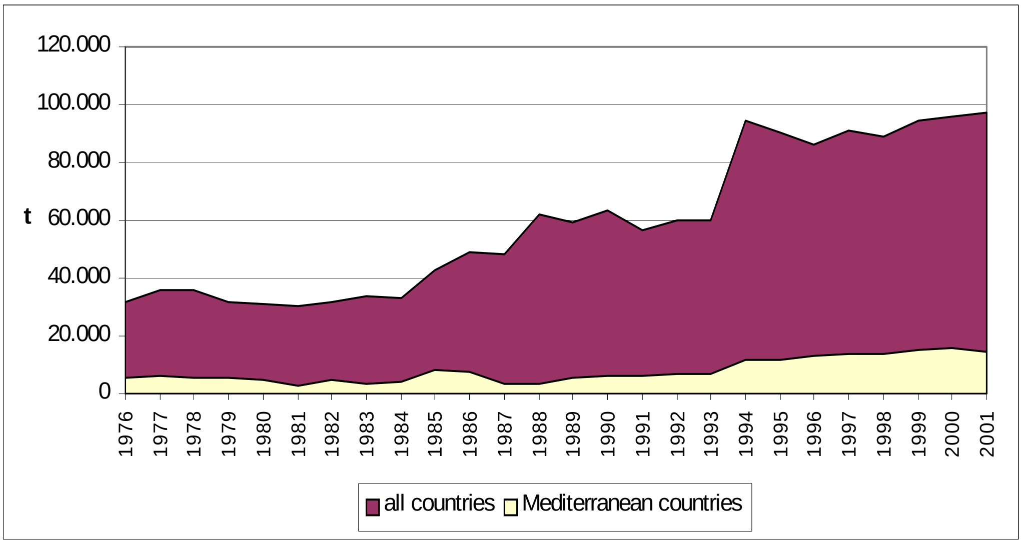

Figure 8. Global and Mediterranean exports of processed bivalve molluscs (FAO-Fishstat; 2001).

In the period 1976 - 2001 Mediterranean countries show a positive trend of fresh and frozen bivalve mollusc imports, with quantities always significantly higher than those referred to export. Furthermore, Mediterranean import trend appears significantly different from the one observed in non-Mediterranean countries (Figure 9). In 2001, reported fresh and frozen bivalve molluscs export was 59.449 tonnes, while import reached 87.937 tonnes, showing a gap of 28.488 tonnes (Table 4 and Table 6).

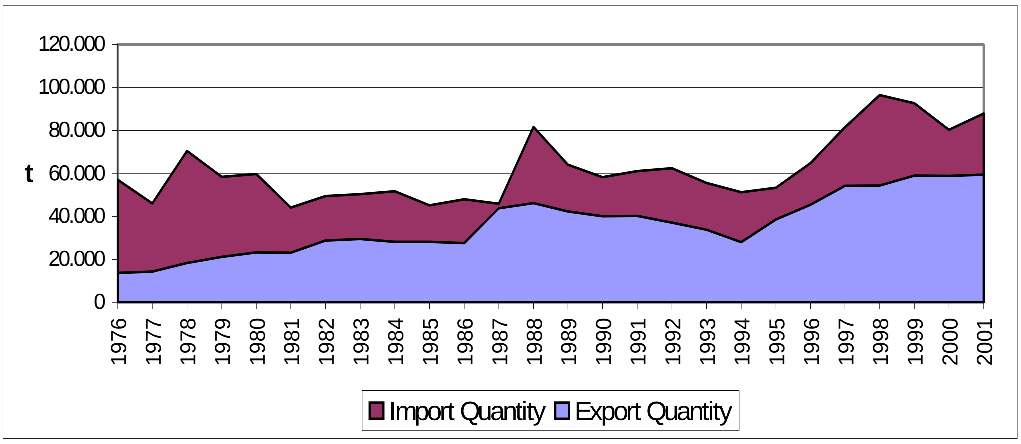

Figure 9. Import and export of fresh/frozen bivalve molluscs in Mediterranean area (FAO-Fishstat).

As shown in Table 4, in 2001 80 percent of imported fresh and frozen shellfish was represented by mussels, 11 percent by oysters and 9 percent by scallops.

Table 4. Mediterranean imports of fresh/frozen bivalve molluscs by species, quantity expressed in tonnes (FAO-Fishstat; 2001).

Commodity	Trade Flow	2001	%
European flat oyster, shucked or not, fresh or chilled	Import Quantity	4.598	5%
Mussels, fresh or chilled, nei	Import Quantity	70.648	80%
Oysters, fresh or chilled, nei	Import Quantity	5.165	6%
Scallops, shucked, fresh or chilled, nei	Import Quantity	7.526	9%
Total		**87.937**	**100%**

The countries that have largely contributed to the import of these products are three: France, 60%; Italy, 28%; and Spain, 11% (Table 5).

Table 5. Importer Mediterranean countries of fresh/frozen bivalve molluscs, quantity expressed in tonnes (FAO-Fishstat; 2001).

Country	Trade Flow	2001	%
Albania	Import Quantity	25	0%
Algeria	Import Quantity	8	0%
Croatia	Import Quantity	7	0%
Cyprus	Import Quantity	7	0%
France	Import Quantity	52.910	60%
Greece	Import Quantity	438	0%
Israel	Import Quantity	36	0%
Italy	Import Quantity	24.744	28%
Jordan	Import Quantity	1	0%
Lebanon	Import Quantity	67	0%
Malta	Import Quantity	23	0%
Morocco	Import Quantity	20	0%
Slovenia	Import Quantity	28	0%
Spain	Import Quantity	9.598	11%
Tunisia	Import Quantity	25	0%
Total		**87.937**	**100%**

Referring to total fresh/frozen shellfish exports, mussels contribute with 79 percent, scallops with 11 percent and oysters with 10 percent (Table 6).

Table 6. Mediterranean exports of fresh/frozen bivalve molluscs by species, quantity expressed in tonnes (FAO-Fishstat; 2001).

Commodity	Trade Flow	2001	%
European flat oyster, shucked or not, fresh or chilled	Export Quantity	5.831	10%
Mussels, fresh or chilled, nei	Export Quantity	46.877	79%
Oysters, fresh or chilled, nei	Export Quantity	155	0%
Scallops, shucked, fresh or chilled, nei	Export Quantity	6.586	11%
Total		**59.449**	**100%**

Among the Mediterranean countries listed in Table 7, Spain is the main exporter accounting for 35 percent of total product, followed by France and Greece 23 percent, and Italy 18 percent. The values referred to Spain and France are inclusive of both Mediterranean and Atlantic products origin.

Table 7. Exporter Mediterranean countries of fresh/frozen bivalve molluscs, quantity expressed in tonnes (FAO-Fishstat; 2001).

Country	**Trade Flow**	**2001**	**%**
Albania	Export Quantity	6	0%
Croatia	Export Quantity	1	0%
Cyprus	Export Quantity	3	0%
Egypt	Export Quantity	35	0%
France	Export Quantity	13.815	23%
Greece	Export Quantity	13.526	23%
Italy	Export Quantity	10.777	18%
Morocco	Export Quantity	75	0%
Spain	Export Quantity	21.047	35%
Tunisia	Export Quantity	10	0%
Turkey	Export Quantity	152	0%
Yugoslavia, Fed. Rep. of	Export Quantity	2	0%
Total		**59.449**	**100%**

Processed bivalve molluscs production registered a considerable increase in Mediterranean countries in the period 1976-2001, increasing from 17.627 tonnes to 55.117 tonnes, which is equivalent to 280 percent growth (Figure 10).

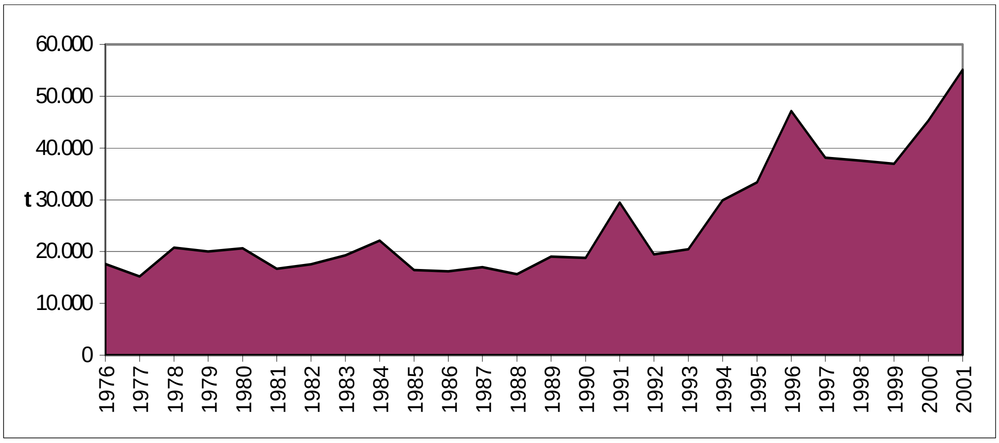

Figure 10. Processed bivalve molluscs production in Mediterranean area (FAO-Fishstat).

In 2001, 71 percent of total processed bivalve mollusc production is represented by processed mussels, 17 percent by frozen shellfish and 11 percent by clams (Table 8). 95 percent of the production, equivalent to 83.000 tonnes, is concentrated in Spain and the remaining quantity is distributed between Italy (4%) and France (1%) (Table 9).

Table 8. Mediterranean production of processed bivalve molluscs by species (FAO-Fishstat; 2001).

Commodity	Trade Flow	2001	%
Bivalves, frozen	Production	9.508	17%
Clam meat, canned	Production	5.987	11%
Mussel meat, canned	Production	38.964	71%
Scallop meat, canned	Production	658	1%
Total		**55.117**	**100%**

Table 9. Processed bivalve molluscs production in Mediterranean countries (FAO-Fishstat; 2001).

Country	Trade Flow	2001	%
France	Production	658	1%
Italy	Production	2.400	4%
Spain	Production	52.059	95%
Total		**55.117**	**100%**

Both processed bivalve molluscs import and export in the period 1976-2001 exhibit a positive trend. Import grew from 8.037 tonnes in 1976 to 47.786 tonnes in 2001, whereas export increased from 5.706 tonnes in 1976 to 14.597 tonnes in 2001. Throughout this period imports have been significantly higher than exports, reaching a gap of 33.189 tonnes in 2001, similarly to what has been observed for fresh and frozen shellfish products.

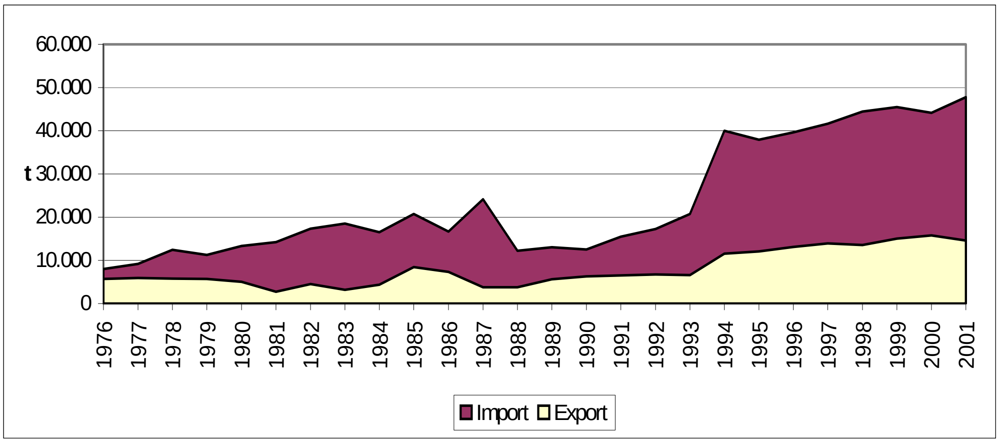

Figure 11. Import and export of processed bivalve molluscs in Mediterranean countries (FAO-Fishstat).

Processed products made of imported shellfish are reported in Table 10. Mussels are most represented as both frozen and canned products, equivalent to 54 percent of the total, followed by frozen scallops 42 percent, and processed clams 3 percent.

Table 10. Mediterranean production of processed imported product of bivalve molluscs by species, quantity expressed in tonnes (FAO-Fishstat; 2001).

Commodity	Trade Flow	2001	%
Clam meat, canned	Import Quantity	5	0%
Clam meat, frozen	Import Quantity	1.565	3%
Mussel meat, canned	Import Quantity	12.995	27%
Mussel meat, frozen	Import Quantity	12.974	27%
Mussels, dried, salted or in brine	Import Quantity	2	0%
Scallops meat, frozen	Import Quantity	20.245	42%
Total		**47.786**	**100%**

The major importer countries for these types of products in 2001 were: France, 27.789 tonnes (or 57 percent of the total), Italy, 10.583 tonnes (22%) and Spain, 8.531 tonnes (8%). Import of other Mediterranean countries was not significant, with only Greece reaching a relevant quantity of 2 percent of total import (Table 11).

Table 11. Mediterranean countries importer of processed bivalve mollusc (quantity expressed in tonnes, FAO-Fishstat; 2001).

Country	Trade Flow	2001	%
Algeria	Import Quantity	20	0%
Croatia	Import Quantity	154	0%
Cyprus	Import Quantity	144	0%
Egypt	Import Quantity	7	0%
France	Import Quantity	27.089	57%
Greece	Import Quantity	789	2%
Israel	Import Quantity	44	0%
Italy	Import Quantity	10.583	22%
Lebanon	Import Quantity	4	0%
Malta	Import Quantity	264	1%
Slovenia	Import Quantity	94	0%
Spain	Import Quantity	8.531	18%
Tunisia	Import Quantity	12	0%
Turkey	Import Quantity	36	0%
Yugoslavia, Fed. Rep. of	Import Quantity	15	0%
Total		**47.786**	**100%**

Out of the total amount of exported processed shellfish products, mussels constitute 61 percent (or 9.000 tonnes), frozen clams 26 percent (3.781 tonnes) and scallops 14 percent (2.000 tonnes) (Table 12)

Table 12. Mediterranean production of processed exported product of bivalve molluscs by species (quantity expressed in tonnes, FAO-Fishstat; 2001).

Commodity	Trade Flow	2001	%
Clam meat, frozen	Export Quantity	3.781	26%
Mussel meat, canned	Export Quantity	3.481	24%
Mussel meat, frozen	Export Quantity	5.342	37%
Scallops meat, frozen	Export Quantity	1.993	14%
Total		**14.597**	**100%**

The main exporter Mediterranean countries are shown in Table 13. As well as for imports, Spain is the country that exports the highest quantity of product, 7.026 tonnes (48 percent of the total), followed by France with 3.252 tonnes (22%) and Italy with 2.176 tonnes (15%). Amounts exhibited by Turkey, 7%, Greece, 5%, and Morocco, 2%, are also significant.

Table 13. Exporter Mediterranean countries of processed bivalve molluscs (quantity expressed in tonnes, FAO-Fishstat; 2001).

Country	Trade Flow	2001	%
Albania	Export Quantity	66	0%
Croatia	Export Quantity	3	0%
Cyprus	Export Quantity	2	0%
Egypt	Export Quantity	33	0%
France	Export Quantity	3.252	22%
Greece	Export Quantity	711	5%
Italy	Export Quantity	2.176	15%
Morocco	Export Quantity	231	2%
Slovenia	Export Quantity	1	0%
Spain	Export Quantity	7.026	48%
Tunisia	Export Quantity	46	0%
Turkey	Export Quantity	1.050	7%
Total		**14.597**	**100%**

5. Interactions between capture fisheries and shellfish culture

Bivalve molluscs production in the Adriatic is the result of both harvesting from natural beds and aquaculture. Aquaculture also includes the activities related to the management of productive areas obtained as proprieties, lease, or through authorization. The ordinary activities carried out in these areas are seedings, substrate cleaning and pruning operations.

Some shellfish species production depends on both harvesting and aquaculture. For other species only one of the two systems contributes to the final yield. Mussel (*Mytilus galloprovincialis*), Japanese littleneck clam (*Tapes semidecussatus*) and less relevantly the European flat oyster (*Ostrea edulis*) and the Pacific oyster (*Crassostrea gigas*) belong to the first category. Shellfish species that are exclusively harvested are: stripped venus (*Chamelea gallina*), scallop (*Pecten jacobaeus*), queen scallops (*Aequipecten opercularis* and

Proteopecten glaber), chequered carpet shell (*Tapes decussatus*), golden carpet shell (*Paphia aureus*), smooth callista (*Callista chione*), warty venus (*Venus verrucosa*), razor clams *(Solen* spp, *Ensis* spp).

Interactions between shellfish culture and both bivalve molluscs harvesting and capture fisheries can be identified in different sectors: political-management, environmental, economical and social.

5.1 Political-management interactions

From a political point of view it is important to pursue an integrated development of fisheries and aquaculture contrasting the effects of competitive allocation of resources to these two productive sectors. Among the planning and legislative tools that can be engaged to this purpose there is the identification of developing plans that recognise the value of territorial realities, both on a local and macro-regional scale, taking into account the necessity to consider aquaculture as a specific entity within a fishing area. The integration of fisheries and aquaculture should also be pursued through planning actions related to coastal management. The importance of clam farming, exclusively practiced in coastal lagoon areas, can be mentioned in this context. With regard to management of trans-boundary shared resources, bivalve molluscs beds (scallops and queen scallops), distributed far from the coast should be considered.

The availability of reliable statistical surveys, comparable to other countries' statistics, is necessary for the identification of a correct policy.

5.2 Ecological interactions

Ecological interactions between fishery and aquaculture are quite strong. One of the most important issues is the introduction of species or varieties of different geographical origin, either directly through voluntary introduction of allochthonous species or indirectly through the flora and fauna associated to the imported products.
The translocation of molluscs from different geographic areas can have the following side-effects:

- Diseases spread among residential populations
- Uncontrolled proliferation of introduced individuals as a consequence of environmental adaptation and natural reproduction, leading to territorial competition with indigenous species, and subsequently to negative effects on biodiversity.

In order to avoid undesirable effects it is necessary to regulate the introduction and culture of products of different geographic origin, even if the product is recognized as an autochthonous species, providing for periodical controls on culture farms and on the origin and traceability of the products. Moreover, the development of hatcheries where certificated indigenous spawners are used should be supported.
Spat imported from other geographical areas should always be certificated in order to avoid the possibility of it becoming a vector of unwanted species.

Particular attention should be given to adults' introductions, as associated flora and fauna species might be introduced with molluscs or with the culture ground. As an example, biocenosis represented by hydroids, sea-squirt, amphipods, algae etc could be carried through the mussels' mesh tubing.

Another impact that shellfish culture can have on fisheries is the enrichment of the environment with inorganic waste as a consequence of routine working operations in the farm, and the accumulation of organic waste or disperse material on the sea bottom under the farm structure. The release of tubing used for mussels' net-bags into the environment can cause problems to both gillnet and trawl fisheries, affecting the efficiency of the gear.
Accumulation of organic material in still water can cause anoxia with negative consequences on biological equilibrium in the surrounding area. On the other hand, in areas where currents favour water turnover, the increase of organic material can represent a positive factor causing an increase of the total biomass.
Several benefits for fisheries can be identified within a correct management framework of shellfish culture:

- Environmental conservation of the farm sites
- Spread of cultured molluscs in the environment, restocking effect
- Wetlands conservation
- Use of fishing vessels for shellfish culture supporting operations

Shellfish farms, situated in near the coast, might function as protected areas: as nursery areas for juveniles of several fish species; as sheltering areas for both benthonic and nektonic species thanks to the tigmotrophic effect; providing for nutrients supply, organic substances and associated biocenosis.

The presence of a high number of spawners in shellfish farms might increase the abundance of populations of cultured species in the wild, determining a valuable restocking action. Due to the molluscs' life cycle, the effect can reach long distances.

Although clam culture relies on the exploitation of an introduced species (*Tapes decussatus*), and therefore implies all the problems related to the allochthonous species, it can represent a valid solution for wetlands management when recommendations on sustainable use of resources are observed.

The running operations carried out in the culture productive sites, such as pruning spat transfer, bottom cleaning, hydraulic vivification and monitoring of environmental phenomena, contribute to maintain balanced environmental conditions.

In shellfish culture the use of wild resources can be considered. In these cases synergic actions between the fisherman who provides the product and the shellfish farmer who follows the grow-out phase can develop. This worthy behaviour can be strengthened by the restocking actions determined by shellfish farms, and it could be usefully applied to species such as flat oyster (*Ostrea edulis*) or scallop (*Pecten jacobaeus*). However, regulated management of natural mollusc beds, establishing controls on access and gears, should follow these actions

5.3 Economical and commercial interactions

The increase of shellfish culture production observed during the last 20 years has strongly influenced the molluscs fishery sector, for the reason that both products are placed on the same market. Although naturally harvested mussels represent a product which is qualitatively different from cultured mussels, marketing competition favours farm production, so that areas traditionally bound to shellfish harvesting are progressively turning into molluscs farming. One of the main reasons for this is the competitive prize of cultured molluscs. Consumers traditionally keen on harvested shellfish consider this product qualitatively superior. However, other consumers regard cultured mussels and molluscs in general as safer products as far as hygienic and sanitary aspects are concerned. A similar issue has emerged after the introduction of Japanese littleneck clam, which in some markets have totally replaced the stripped venus (*Chamelea gallina*) harvested on natural beds; although it now seems that an equilibrium has been reached due to the decline of fishery resources.

The market subject is strongly connected to the one of product quality. In order to guarantee a right coexistence to both farm and harvest products, it is essential to proceed with the application of labelled certifications where the type of production processes and traceability are documented. It is therefore wise to support trade programmes based on the application of health marks, in order to ensure the product origin, the production process and the hygienic and sanitary safety.

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5.4 Social interactions

As regards the fishery, shellfish culture activity has shown to be a social stabilizing element, representing a valuable opportunity for alternative or complementary employment. Notwithstanding the related environmental problems due to the introduction of *Tapes semidecussatus*, clam culture development has been an important employment opportunity for different social class workers devoted to small-scale fisheries in lagoons. The same can be said regarding the mussel culture, a sector which is absorbing that part of employees who are gradually being expelled from artisanal fishery due to fleet restructuring.

Although the idea of a positive influence of sustainable farming activities on fish resources is finding its way, there are still many conflicts between fishery and shellfish culture.

The large presence of culture products on the market, appreciated by many consumers for their sanitary and hygienic characteristics, might prove to be a driving force for consumption of fishery products too.

6. Legislative aspects and international regulations and actions on shellfish resources management and exploitation

6.1 Italian legislation of bivalve molluscs fisheries

Several aspects are considered by the laws that regulate resource management in both fishery and shellfish culture sectors:

- Species that can be captured

- Minimum size
- Fishing gears
- Fishing methods
- Catch limits
- Annual fishing period
- Fishing areas

Other important regulations are connected to these normatives on subjects such as hygienic and sanitary aspects of processing and trading of products, and on spat collection used for culture activities.

Clam (*Chamelea gallina*) fisheries regulation will be illustrated as one of the most represented bivalve mollusc fished along Italian and Adriatic coasts.

6.2 Regulation of bivalve mollusc *Chamelea gallina* fishery

In Italy clam (*Chamelea gallina*) fishery is practiced by authorized vessels equipped with a hydraulic dredge system. During the last years no new licenses have been issued, rather, license return has been financially subsidized/supported.

Management and conservation of bivalve molluscs has been partitioned among management consortiums (D.M. 12 January 1995), which, within a regulation framework can exert a restricted decision-making role.

Through D.M. July 4th 2003, the suspension Law February 11th 2003 concerned with the "Conservation and management of bivalve molluscs and new provisions for management consortiums" has been postponed.

Main regulations for rational resources management are reported in D.M. December 22nd 2000 "Regulation on fishing for bivalve molluscs". These regulations are concerned with minimum size (25mm, Reg. 1639/68), daily catches (600 kg), limits of fishing activities within the area where vessel is registered, minimal fishing depth (3 m), technical characteristic of the vessel, fishing gear and selection gear.

- Main characteristics of typical fishing vessels are the following:
- Maximum length 10 m
- Maximum of 150 hp of propulsion engine
- Maximum boat displacement 10 t
- No auxiliary engines for the pumps
- Simple propeller, not ducted

The hydraulic dredge is a rectangular steel cage capable of penetrating into the bottom with an adjustable blade and a number of jets running the full width of its lower leading edge; it must have the following characteristics:

- Horizontal front
- Hard box where the product is collected
- Jets where high pressure water comes out from

- Hydraulic pipes
- Maximum dredge mouth width 3 m
- Maximum pressure from the jets 1,8 atmospheres
- Maximum dredge weight 600 kg.

The lower part of the cage must have a mesh or bar spacing to ensure the gear selectivity. Bar spacing can not be smaller than 12 mm, with less than 1 mm tolerance.
Minimum mesh sizes of the selective gear called *vibro-vaglio* must be at least 12 mm for bars with at least 21 mm diameter for perforated plates with round holes.
The trawling method is established by the consortium. Where there is no constituted consortium, or for unregistered vessels, the trawling must be carried out by hauling the anchor.

Two months of closed season (*Fermo pesca*) are compulsory: they are fixed in the period April 1st-October 31st, throughout the year the closure is obligatory also on weekends and holidays. In the period between April 1st and September 30th one working day chosen by the Consortium must be added.

Further obligations concerning statistical data collection are provided for this fishery method. The license holder has to fill a form within the 5th of each month. The form is to be sent to the Consortium. The Consortium will put together the statistics of all the vessels registered and will send a summary form to the Ministry within the 15th of the following months.

The D.M. December 22nd provides also that the Consortium draws up an annual management plan of seed stocking and other management measures.

6.3. Bivalve molluscs trade regulation in the EC countries, and relative issues in respect of third countries

The European Communities Council with a view to harmonize the relations among Member States, to bring about competition on equal terms while ensuring quality products for the consumer and to establish regulations apt to ensure the health of live bivalve molluscs placed on market, has issued the Council Directive 91/492 July 15th 1991. The normative contains the principles concerned with resources utilization and product trade, including products of non-EC countries' origin. A Community regulation framework has been established for imports, within which provisions of Chapter III must be implemented. These conditions must be at least equivalent to those applicable for trading within the Community.

Bivalve molluscs exports from a third country to an EC country must be authorized through inspections carried out on the spot by Community and Member States experts to ensure that production and trade can be deemed equivalent to those of the Community on the basis of the following conditions: the legislation in force in the third country; organization of the competent inspection authority; the effective implementation of sanitary controls, especially in the production areas; the rapidity of the information provided by the third country about the sanitary conditions of production areas; the assurance that a third country can give on the compliance with the standard sanitary controls on both fish and culture product.

Countries that comply with the provided conditions and are allowed to export to EC, are listed in the Annex to Decision 97/20/CE of December 17th 1996 (updated in Decision 2002/469/CE). Two lists are provided: the first includes the so called “harmonized” third countries, which are subject to a specific decision based on Directive 91/492. They can sell their product in EC countries with fewer restrictions and less control at the border inspection points. The second list includes countries that can be subject to temporary decisions according to Decision 95/408/CE June 22nd 1995 (prelisting condition). In the EC they are allowed to trade only with those countries with which they have a bilateral agreement, and do not benefit of inspection controls relief. For all countries included in either list, production areas and authorized establishments are listed. For countries in the list 1 the identified sites are valid within the entire Community, whereas for countries in the list 2 it depends on bilateral agreements between Member States.

Inspection procedures applied to bivalves at the border inspection points are laid down in the Directive 97/78/CE in accordance with Reg. CE 136/2004, which provides for the control of imports authorizations and veterinary certificates, the consistency between identification certificates and the product, the product itself through sampling and lab analysis. Sample control is the only step that can be derogated from inspection procedures of “harmonized” countries.

In order to limit the spreading of transferable diseases and to protect the zootechnical resources of the Member States, zootechnical health controls are also provided for in the trade product regulation. The classification of “recognized” zootechnical health sites and establishments included in Directive 91/67/CE, requires safeguarding and monitoring actions, as well as historical data acquisition referring to molluscs diseases. The fact that classification is valid as long as products are exclusively traded among “recognized” establishments, has so far represented a strong limit to the application of this rule.

7. References

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APPENDIX A

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APPENDIX B

Greetings to the participants by the State Undersecretary for agricultural policies with responsibility for fisheries On. Paolo Scarpa Bonazza Buora

In sending greetings to the AdriaMed Expert Consultation "Interactions between Aquaculture and Capture Fisheries" I recall Italy's commitment to the development of responsible fisheries in the Mediterranean and especially in the Adriatic region in which AdriaMed is operating with great effect.

In particular the issue that you will be discussing related to the interactions between aquaculture and capture fisheries is a highly important modern issue. Indeed one only needs to observe the markets and the growing presence of aquaculture products that together with products from capture fisheries satisfy an increasingly complex and articulate demand. The development of fisheries production integrated with policies for coastal zone management cannot ignore the interactions between aquaculture and capture fisheries because these two activities, although they are different, compete to provide the same markets and sometimes, especially on the coast, are located in the same areas.

It is necessary to understand economic biological, sociological and legal aspects so that Governments can make all relative choices in an informed manner and above all so that international bodies such as the GFCM can work with a solid knowledge base.

I do not intend to enter into the technicalities of the issues in hand, however if I consider the interactions between aquaculture and capture fisheries, the complex relations within the tuna industry come to mind, as well as the use of spaces for the cultivation of molluscs in open systems or in closed seas and on a global scale the interactions which occur on production of marine origin.

The results that your work will provide, with the coordination of FAO, will certainly be observed more and more closely by our Government where Mediterranean policies are concerned. I greet all participants once more and I wish you every success for this Consultation.

APPENDIX C

Prospectus of the Consultation

1. Background information

The FAO Regional Project AdriaMed, "Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea" was established to contribute to the promotion of cooperative fishery management between the participating countries (the Republics of Albania, Croatia, Italy and Slovenia), in line with the Code of Conduct for Responsible Fisheries (CCRF) adopted by FAO.

Particular attention is given to encouraging and sustaining a smooth process of international collaboration between the Adriatic Sea coastal countries in formulating and implementing cooperative fishery management plans. Consideration is also given to strengthening technical coordination between the national fishery research institutes and administrators, as well as between the fishery organizations and relevant stakeholders of the Adriatic countries. The AdriaMed Coordination Committee was established to discuss, orientate and approve the work programmes of the Project and to monitor and assist in coordinating Project activities.

During the first meeting of the AdriaMed Coordination Committee (Termoli, March 2000), delegates recognised the important issue of responsible aquaculture. Aquaculture could determine market and environment effects on fisheries activities and particularly on the prime species market. The Committee suggested that AdriaMed organize an expert consultation on the interactions between aquaculture and capture fisheries.

This initiative would represent a contribution at basin level towards the establishment and implementation of the principles of the CCRF concerning responsible aquaculture activities. Furthermore the results of such an expert consultation could support the Adriatic countries in promoting guidance, which may be used in the development of national fisheries strategic policies and to advance relevant issues at sub-regional level.

During the Consultation on the "Application of Article 9 of the CCRF in the Mediterranean Region", held in Rome in July 1999, interaction and potential conflicts between resource users in the Mediterranean had already been highlighted, and enhancement of harmonisation between aquaculture development and environmental conservation was recommended. Moreover, during the Twenty-fourth Session of the Committee on Fisheries (COFI), held in Rome at FAO HQ, in 2001, in-depth research on the relationship between aquaculture and fisheries was recommended. The recommendation of the Code regarding the interaction of aquaculture with the fishery sector was also recalled during the First COFI Aquaculture Sub-Committee held in Beijing in April 2002.

Within the framework of cooperation with the General Fisheries Commission for the Mediterranean (GFCM) and according to its mandate, AdriaMed introduced this initiative during the Second Committee on Aquaculture (CAQ) of the GFCM. At the Third CAQ-

GFCM in September 2002, the Committee confirmed that priority should be given to issues concerning "Interactions between Aquaculture and Capture Fisheries" and invited the AdriaMed Regional Project to consider welcoming the participation of experts from the CAQ at the Consultation.

The aims of this Expert Consultation are to have an exhaustive description and analysis of the aquaculture sector in the countries which border the Adriatic Sea and to improve the knowledge of the relationship between aquaculture and capture fisheries in the area. The Expert Consultation will take into due consideration the current levels of aquaculture development and expectations in the Adriatic countries. The results of this Expert Consultation could also be useful to other Mediterranean areas.

2. Objectives and expected outputs of the Expert Consultation

The principal objective of the Expert Consultation will be to explore the main issues dealing with interactions between aquaculture and capture fisheries using the existing knowledge available at Adriatic basin level. The national contributions should provide background information on the aquaculture sector in the Adriatic countries. Furthermore, on the basis of the information available, a preliminary commented inventory of the main (or potential) relationships will be presented and discussed, including mention of: local fishing communities (i.e., competition for coastal area use), the impact of aquaculture on local aquatic resources (i.e., genetic pollution, exotic species introduction, pathology spreads), market competition, quality products, mechanisms to control and prevent competition as well as existing agreements.

The Expert Consultation will provide specific recommendations related to the interactions of aquaculture and capture fisheries using the systemic approach (ecology, economy, governance, legal framework). The Expert Consultation will be an opportunity to generate information to create a data base set on the status of aquaculture. The identification of some reliable indicators will help future analysis

The report of the Expert Consultation will be issued in the AdriaMed Technical Document Series and it will be widely distributed and made available on the Internet through the AdriaMed website. Furthermore, the results of the Expert Consultation will be presented to the Adriatic countries through the AdriaMed Project Coordination Committee, as well as being reported to the GFCM and the CAQ.

3. Organization

The following two phases are proposed for consideration:

In the first phase, general preparatory documents will present the status of aquaculture and fisheries in the Adriatic Sea: these include the Aquaculture Profiles of the Adriatic countries (Albania, Croatia, Italy, Montenegro and Slovenia) and the presentation of the Adriatic capture fisheries profiles at sub-regional level. In these background documents the more relevant topics on the relationship between aquaculture and capture fisheries will be considered.

In the second phase a discussion will be held on four thematic areas considered relevant for the Expert Consultation. The first theme will concern general issues related to the interactions between aquaculture and capture fisheries; a further two themes will deal with conflicts between aquaculture and capture fisheries concerning quality products on the market and the fourth theme will concern a case study: tuna farming. Discussion of the thematic areas will be conducted in plenary or in sub-groups, depending on what emerges from phase one of the Expert Consultation and on the background papers presented.

4. Participants

The Expert Consultation will be attended by national and international experts on aquaculture and fisheries. The multidisciplinary participation of experts and fishery administration representatives, as well as the presentation of further scientific contributions from outside the Adriatic Region are encouraged. Participants from other regions are also welcomed.

5. Date and venue

The Expert Consultation will be held in Rome from 5 to 7 November 2003, hosted by the Fisheries Directorate of the Italian Ministry of Agriculture and Forestry Policies (MiPAF).

APPENDIX D

Agenda

1. Opening of the meeting and welcome address
   Presentation of the Expert Consultation

2. Interactions between aquaculture and capture fisheries

3. Aquaculture profiles of the Adriatic countries

4. Exploitation of the fishery shared stocks in the Adriatic Sea

5. Lectures and discussions on specific issues related to interactions between aquaculture and capture fisheries

6. Other matters

7. Synthesis and recommendations of the Expert Consultation

ÉTUDES ET REVUES DE LA CGPM DÉJÀ PUBLIÉES
GFCM STUDIES AND REVIEWS ALREADY ISSUED

1 Standardisation de méthodes d'étude biométrique et d'observation de clupéidés (en particulier de *Sardina pilchardus*) utilisées en biologie des pêches. Division des pêches de la FAO. 1957

1 Standardization of biometric and observation methods for Clupeidae (especially *Sardina pilchardus*) used in fisheries biology. FAO Fisheries Division. 1957

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2 Mediterranean trawling Preliminary observations in the study of Italian trawl nets. FAO Fisheries Division. September 1957

3 La pollution des eaux provoquée par les déversements des sucreries. Carlo Maldura et Paul Vivier. Avril 1958

3 Water pollution caused by wastes from sugar refineries. Carlo Maldura and Paul Vivier. April 1958

4 Filets tournants et coulissants en fibres synthétiques. Gerhard Klust. Septembre 1958

4 Ring nets made of synthetic fibres. Gerhard Klust. September 1958

5 La pisciculture dans les eaux intérieures des pays membres du CGPM. Secrétariat du CGPM. Février 1959

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7 La technique des pêcheries dans les lagunes saumâtres. Ruggero de Angelis. Août 1959

7 Fishing installations in brackish lagoons. Ruggero de Angelis. August 1959

8 La situation de la pêche en Italie, en particulier dans le secteur de la distribution. Paolo Pagliazzi. Octobre 1959

8 Situation of the fishing industry in Italy, particularly regarding distribution. Paolo Pagliazzi. October 1959

9 Documentation graphique sur certains engins de pêche utilisés dans les lagunes littorales espagnoles. Fernando Lozano Cabo. Novembre 1959

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10 Mediterranean trawling. Fourth report. J. Schärfe, FAO Fisheries Division. March 1960

11 Le traitement du fond des étangs piscicoles et ses effets sur la productivité. La pisciculture dans divers pays européens. Alfred G. Wurtz. Juin 1960

11 Methods of treating the bottom of fish ponds and their effects on productivity. Fish culture in certain European countries. Alfred G. Wurtz. June 1960

12 Exploitation et description des lagunes saumâtres de la Méditerranée. Ruggero de Angelis. Août 1960

12 Mediterranean brackish water lagoons and their exploitation. Ruggero de Angelis. August 1960

13 Contrôle d'un chalut opérant entre deux eaux ou sur le fond et tiré par un seul bateau. J. Schärfe, Division des pêches de la FAO. Septembre 1960

13 A new method for "aimed" one-boat trawling in mid-water and on the bottom. J. Schärfe, FAO Fisheries Division. September 1960

14 Le chalutage en Méditerranée. Cinquième rapport. J. Schärfe, Division des pêches de la FAO. Mai 1961

14 Mediterranean trawling. Fifth report. J. Schärfe, FAO Fisheries Division . May 1961

15 La madrague sicilienne de course. Vito Fodera. Juillet 1961

15 The Sicilian tuna trap. Vito Fodera. July 1961

16 Influence de la température et de l'éclairement sur la distribution des crevettes des moyennes et grandes profondeurs. Walter Ghidalia et François Bourgois. August 1961

16 The influence of temperature and light on the distribution of shrimps in medium and great depths. Walter Ghidalia and François Bourgois. August 1961

17 L'amélioration des techniques de la pêche au feu. F. Bourgois et L. Farina, Experts de la FAO. Novembre 1961

17 Improvements of techniques for fishing with lights. F. Bourgois and L. Farina, FAO Experts. November 1961

18 L'élevage des huîtres en parcs flottants. M. Nikolic et I. Stojnic. Mars 1962

18 A sytem of oyster culture on floating shellfish parks. M. Nikolic and I. Stojnic. March 1962

19 Pêche au feu. Raimondo Sarà. Août 1962

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21 Diagnoses démographiques sur les populations de poissons dans les cours d'eau à truites. R. Cuinat et R. Vibert. Octobre 1963

21 Demographic diagnosis on fish populations in trout streams. R. Cuinat and R. Vibert. October 1963

22 Dommages causés par les marsouins et autres animaux marins déprédateurs en Méditerranée. C. Ravel. Novembre 1963

22 Damage caused by porpoises and other other predatory marine animals in the Mediterranean. C. Ravel. November 1963

23 Etudes sur la sardine (*Sardina pilchardus* Walb.) et l'anchois (*Engraulis encrasicholus* L.) dans le golfe de Naples et sur leur comportement sous l'influence de la lumière artificielle. Olav Dragesund. Juin 1964

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24 Réglementations concernant certaines industries de transformation des produits des pêches maritimes dans les pays méditerranéens. D. Rémy. Septembre 1964

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26 Revue critique des effets des détergents synthétiques sur la vie aquatique. R. Marchetti. Octobre 1965

26 Critical review of the effects of synthetic detergents on aquatic life. R. Marchetti. October 1965

27 Méthodes permettant d'économiser la main-d'oeuvre à bord des chalutiers méditerranéens. M. Ben-Yami. Novembre 1965

27 Labour-saving methods on board Mediterranean trawlers. M. Ben-Yami. November 1965

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28 Preliminary report on fish distribution and marketing in Sicily. G. Bombace. November 1965

29 Réglementation sanitaire des mollusques. R. Coppini. Décembre 1965

29 Sanitary regulations for molluscs. R. Coppini. December 1965

30 L'élevage de la truite fario et de la truite arc-en-ciel dans les eaux à température très élevée. E.G. Calderon. Décembre 1965

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31 Mortalité initiale de la sardine dans les conditions expérimentales et mortalité due au marquage. R. Muzinic. Août 1966

31 Initial mortality of the sardine under experimental conditions and in the tagging work. R. Muzinic. August 1966

32 Study of hake (*Merluccius merluccius* L.) biology and population dynamics in the central Adriatic. S. Zupanovic. February 1968

33 Unités de stock de la sardine de la Méditerranée occidentale et de l'Adriatique. M.G. Larrañeta. Juin 1968

34 The system of currents in the Adriatic Sea. M. Zore-Armanda. July 1968

35 Investigations of mullet fisheries by beach seine on the U.A.R. Mediterranean coast. S. Zaky Rafail
Rehabilitation of the fisheries of an inland saline lake in the United Arab Republic. S. El Zarka
Variations annuelles des captures de mulet dans le lac de Varna. D. Morovic

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Effects of fresh water and saturated sea-water brine on the survival of mussels, oysters and some epibionts on them. M. Hrs. Brenko and L. Igic

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Distribution et densité des oeufs de sardines (*Sardina pilchardus* Walb.) dans l'Adriatique centrale au cours de la saison 1965/66. J. Karlovac
Coincidence and alternation in Yugoslav pelagic fisheries. R. Muzinic

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39 Selectivity of gillnets for Nile perch (*Lates niloticus* L.). R. Koura and A.A. Shaheen
Cod end mesh size effect on Italian otter trawl efficiency. R. Koura

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Long term observation of plankton fluctuation in the central Adriatic. T. Vucetic and T. Pucher-Petkovic
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Explorations of the possible deep-water trawling grounds in the Levant Basin. O.H. Oren, M. Ben-Yami and L.. Zismann
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50 Commercialisation du poisson frais et congelé dans certains pays méditerranéens. CGPM. Décembre 1971

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52 Aquaculture en eau saumâtre dans la région méditerranéenne. CGPM. Août 1973

52 Brackish water aquaculture in the Mediterranean region. GFCM. August 1973

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Fluctuations of zooplankton and echo-trace abundance in the central Adriatic. T. Vucetic and I. Kacic
November 1973

54 Study of fish populations by capture data and the value of tagging experiments. S. Zaky Rafail
Les ressources halieutiques de la Méditerranée et de la mer Noire. D. Levi et J.-P. Troadec
Perspectives for fisheries development to 1985 in the GFCM Member Nations. GFCM Secretariat
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The principal objective of the FAO AdriaMed Expert Consultation "Interactions between Aquaculture and Capture Fisheries" (Rome, 5–7 November 2003) was to explore the main issues dealing with interactions between aquaculture and capture fisheries by using the existing knowledge available at the Adriatic basin level. This initiative would represent a contribution at subregional level towards the establishment and implementation of the principles of the FAO Code of Conduct for Responsible Fisheries concerning aquaculture activities. A preliminary matrix for the identification of indicators emerged and was drafted from comments made by the experts from the Adriatic present at the meeting. This matrix represents a first step towards the definition of a set of indicators to monitor the relationship between aquaculture and capture fisheries in the Adriatic Region following the criteria for sustainability. Moreover, the expert consultation adopted a series of recommendations that could be directed to the Adriatic countries underlining that positive and negative interactions between aquaculture and capture fisheries must be considered in the context of integrated coastal zone management.

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