Foresight study on the productive chain of the fishery industry in the region of the South American Pacific coast

Final summary report

UNITED NATIONS
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Technology Promotion Unit
Investment and Technology Promotion Branch

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Contents

Abbreviations and acronyms

AZTI	Marine and Food Technological Center
CAF	Andean Development Corporation
CPPS	Permanent Commission for the South Pacific
CPUE	catch per unit of effort
DHC	direct human consumption
DNA	Deoxyribonucleic acid
EPESPO	Eastern Pacific School of Fishing
FAO	Food and Agriculture Organization of the United Nations
GloBallast	Global Ballast Water Management Programme
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Points
IADB	Inter-American Development Bank
ICT	information and communication technologies
IHC	indirect human consumption
IMARPE	Maritime Institute of Peru
ITQ	individual transferable quota
MAP	modified atmosphere packaging
MARPOL	International Convention for the Prevention of Marine Pollution from Ships
OPTI	Spanish Observatory for Industrial Technology Foresight
PCR	polymerase chain reaction
SOLAS	International Convention for the Safety of Life at Sea
TW	Technology Watch
UNIDO	United Nations Industrial Development Organization
VMS	Virtual Memory System

1 Introduction

This document constitutes the final report on the project of the United Nations Industrial Development Organization entitled: "Foresight study on the productive chain of the fishery industry in the region of the South American Pacific coast". As its title indicates, this is a foresight study and, more precisely, it is a technology foresight study. Its main purpose is to promote collective thinking on the future of the production chain concerned in the countries of the region, Chile, Peru, Ecuador and Colombia, and to identify the extent to which the evolution of technology will play a role in this future. This comment is made because one should not expect solutions to immediate problems from foresight studies, but rather basic data for drawing up medium-term or long-term scenarios. Moreover, foresight is an instrument: it does not replace planning, or say what decisions should be adopted, but represents a tool to assist planning and decision-making. It does not tell us what will happen; it tells us what may happen if consensus and agreements towards its realization are reached.

The purpose of the project was the preparation of a foresight study, or a consideration of possible futures in the area under study. As a first step, an analysis was made in each of the countries involved to diagnose the present condition of the production chain in each country. These analyses were to serve as a starting point for the foresight study for each country, but in parallel a regional synthesis—highly simplified—was undertaken, with the aim of bringing out characteristic features, potentialities and common problems in the broader regional framework. This synthesis does not replace the national diagnostic studies, nor is it a cumulative summary of them. Its purpose is solely to present an overall view, and supply the initial data for such an overall view.

Later, this synthesis document, the regional diagnostic study, was debated by a panel made up of representatives of the countries involved and has served as a basis for the foresight study being submitted here, which itself is not necessarily a summary of the national foresight studies undertaken in the individual countries but utilizes the results of the panel discussions and the surveys carried out to identify common aspects and development trends which allow conclusions of regional utility to be presented.

In short, then, the project proceeds on two levels, the national and the regional, and its findings are intended to be of use at both levels. The present report relates to the regional level and does not replace or seek to describe, even in summary, the studies that have been carried out for each country. It may even happen that a particular conclusion at the regional level conflicts with a conclusion or various conclusions arrived at the national level, since one is naturally referring to different countries, with differing interests in this sector, and with their own, very legitimate national priorities. It must be stressed, therefore, that these documents are intended as a support for decision-making and nothing more. Political decisions, whether at the national or at the regional level, must be taken on the basis of political parameters that go well beyond the scope of the studies carried out under this project.

2 Methodology

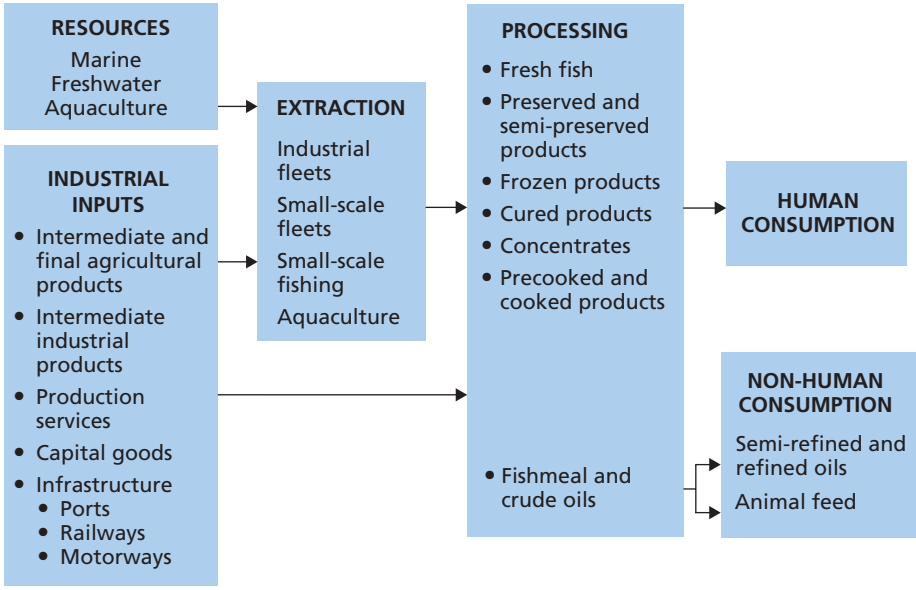
Principles

The first and main difficulty encountered in tackling this project was the absence of any background history—that is to say, the non-existence of similar projects in which sectoral foresight studies of multinational scope have been undertaken. This made it necessary to design a methodology from scratch and then, along the way, adapt it to the developing situation of the work as the limitations of the initial theoretical model became apparent. However, the principles on which this methodology was based and the basic criteria used in its application have been maintained unchanged throughout the project. These basic principles are as follows:

1. The complete production chain of the fishery industry was taken as the subject of study, including aquaculture in it. The links in this production chain are, in a highly simplified form:
   - The inputs for fishing and aquaculture activities
   - Fishing
   - Aquaculture
   - The processing of the products of fishing and aquaculture
   - Marketing
   - Consumption
2. National teams were set up, one in each country, under common technical and operational supervision;
3. The distinguishing feature of the project is articulation between the two levels, national and regional;
4. The basic principle of foresight studies was applied, namely collective thinking by as broad as possible a range of experts on hypotheses drawn up regarding the future in a particular field.

Figure 1 shows a first, very rough, approximation to the fishery production chain which constitutes the project's frame of reference.

Figure 1. Fishery industry production chain



Participants

The project relied on a somewhat complex organizational network consisting of the following categories of participants:

- UNIDO
- A high-level political counterpart in each country
- A national coordinator in each country
- An agency with foresight expertise (subcontracted)
- Technical advisers

UNIDO was responsible for the design and management of the project, coordination among the participants, the preparation of and updating of information, a database and the website, final evaluation and the preparation of reports.

The *political counterparts,* at deputy minister level, ensured the commitment of the participating countries to the project.

The *national coordinators* were the executive officials in charge of the tasks to be carried out in each country.

The *agency with foresight expertise,* the Spanish organization OPTI, was responsible for technical direction of the project.

Lastly, the following participated as *technical advisers:* the Spanish technology centre AZTI, which made a preliminary analysis of the production

chain prior to the national diagnostic studies; Professor Antônio Gomes de Castro, of Brazil, who contributed to the conceptual framework for the production chain; and Professor Juan Alfonso Alfaro Fuentes, of Chile, who provided a diagnostic report on the production chain in his country.

Methodological outline

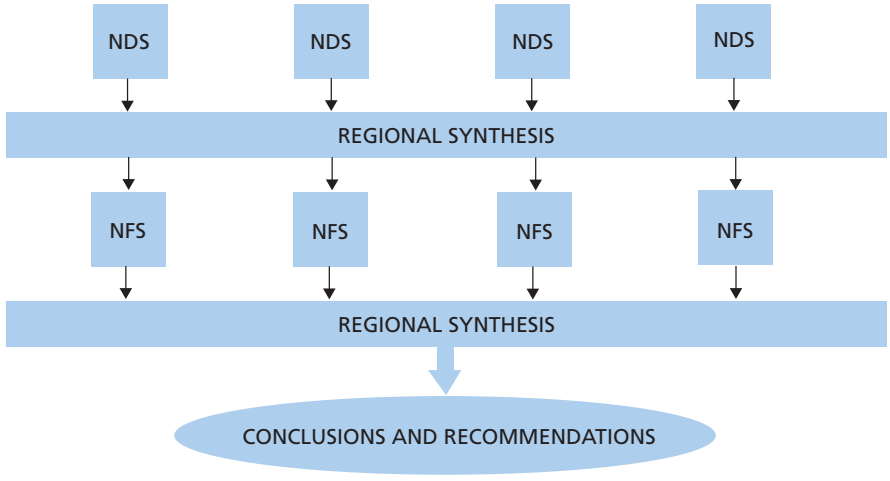
Structure of the project

The project was implemented in various stages:

1. A diagnostic study of the fishery production chain in each country, with an analysis of the status of its components;
2. A regional diagnostic study, in which the characteristics of the region were identified, and which was to serve as a basis for the regional foresight study;
3. A regional conference, where all the project participants met for the first time and the national teams had an opportunity to exchange their experience and concerns;
4. Foresight studies at the national level;
5. Final regional-level report;
6. Final regional conference for the presentation and discussion of the results of the project.

Figure 2 sets out in graphic form the reports to be drawn up in the course of the project.

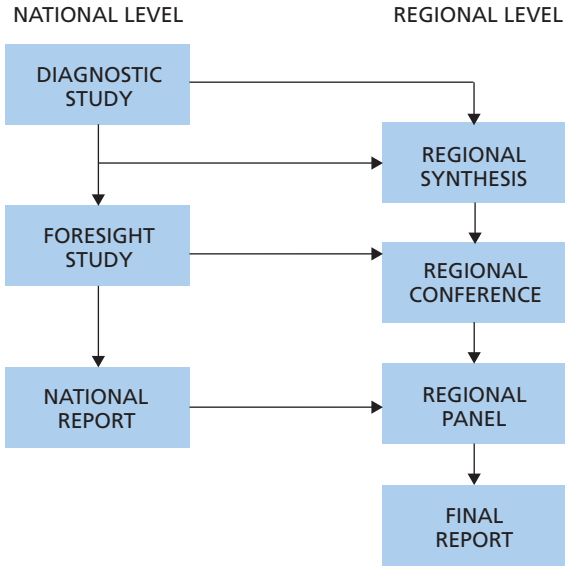
Figure 2. Structure of the project



NDS: National diagnostic study NFS: National foresight study

Figure 3 shows the activities at the two levels, national and regional.

Figure 3. Implementation of the project at the national and regional levels



Diagnostic studies

In connection with the diagnostic studies, the following methodological aspects should be mentioned:

1. *National diagnostic studies*

The *objective* of the national diagnostic studies was to describe the present situation of the production chain, identifying its limitations and possibilities, so that this description could serve as a basis for the long-term foresight study.

The *inputs* utilized in the preparation of the diagnostic study were:

- The technical report of the technology centre AZTI
- A methodological manual on production chains
- The knowledge of the national coordination team
- Information available in the country

Obviously, the most important element was the national coordinating team's knowledge.

The *key aspects to be considered* were productive efficiency, the quality of the products and environmental sustainability.

2. *Regional diagnostic study*

The preparation of the regional diagnostic study was based on the national diagnostic studies and other available information, which was not to consist of a collation and repetition of the content of the national studies. The intention was to identify major issues and challenges to serve as a framework for the foresight studies.

Foresight analyses

The methodology used for the foresight studies in each country was based on two basic elements:

- Establishment of a panel of experts
- Survey: Consulting, by questionnaire, the broadest possible range of persons familiar with the subject and representing different viewpoints

The panel of experts was a working group composed of between 10 and 15 persons selected because of their knowledge of the relevant subjects. It is important to note that, although these persons inevitably represented sectoral institutions, they were invited to participate in the project on account of their personal knowledge. A balance in regard to professional backgrounds and also, as far as possible, in regard to age, gender and geographical origin was aimed at.

The *functions of the panel* were:

Before the survey:

- To develop the hypotheses which would serve as a basis for the questionnaire
- To select the variables for assessing these hypotheses
- To propose persons to be surveyed

After the survey:

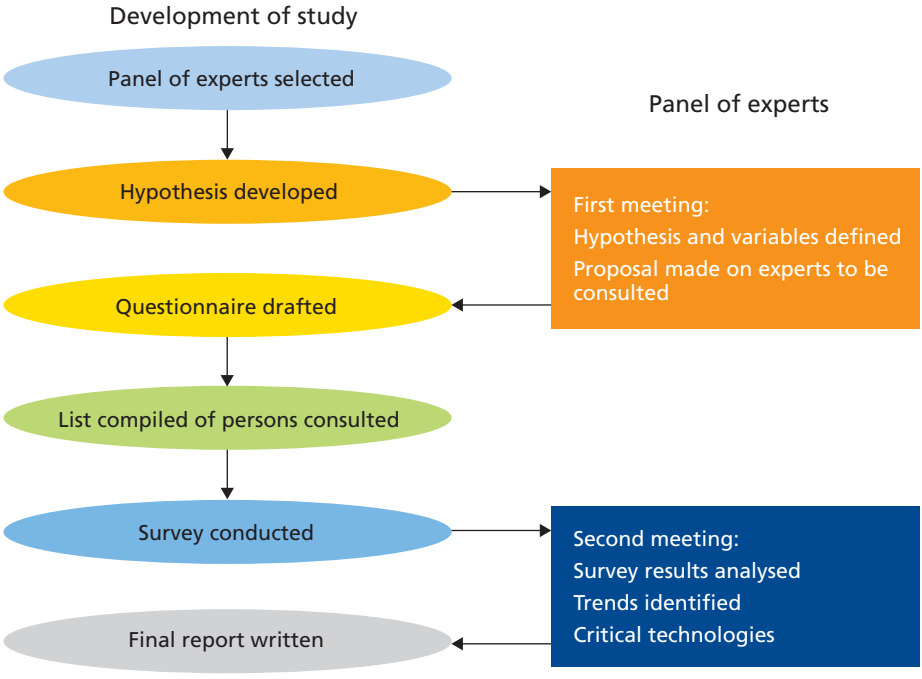
- To analyse the results
- To identify future trends
- To draw up conclusions and recommendations

The hypotheses evaluated by means of the survey were the key to the study. They were discussed by the panel of experts and were to be the subject of consensus. They were to be reasonable and, at the same time, not dependent on day-to-day developments.

With regard to the variables for evaluating these hypotheses, the most significant were considered to be the degree of importance of the particular hypothesis and the anticipated time needed for materialization, together with obstacles and constraints in the way of such materialization in a specific country and, as applicable, measures to facilitate it.

Figure 4 shows how these foresight analyses proceeded.

Figure 4. Organization of the foresight study*



*The documents mentioned in the figure are available for consultation (www.unido.org/en/doc/13004).

3 Trends

The information derived from a comparison between the results of the surveys and the debates of the expert panels in the three countries, together with an analysis of available reports and studies, allows one to identify some possible trends which are summarized in this section. They have been grouped under various thematic headings:

- Fishing
- Aquaculture
- Processing
- Quality/traceability
- Consumption
- Environment
- Human resources/training

Fishing

With regard to fishing, the following lines of development or mega-trends were identified:

1. Organization and information;
2. Diversification of catches to include new species;
3. Prospecting for and detection of resources;
4. Improvement of techniques for handling, storage and processing on board;
5. Trend towards direct human consumption of species used in the production of fishmeal and fish oils.

Fishing

Trend 1: *Organization and information*

The experts foresee and, moreover, consider desirable the *development and introduction of regulations, common to the countries of the region, concerning fishery resources.* There was nevertheless a high level of abstention when it came to adopting a conclusion on this subject, which undoubtedly has controversial aspects since it is an issue with a highly political content. However, there was a general consensus on the need to agree on common criteria in approaching the whole set of problems affecting fishing activities in the South-East Pacific. The first of these problems is over-exploitation of resources, with the danger that they may become exhausted; associated with this, consideration needs to be given to the excess capacity of fleets, the impact within the zone of sovereignty of the countries of the region of the deep-sea fleets of third countries, non-compliance with handling regulations, illicit practices of every kind, etc. All these problems point to the advisability of collective action by the countries involved to ensure the rational utilization of the region's resources.

At the country level, the need is becoming evident to supplement existing schemes for organizing the exploitation of both marine and inland resources, paying special attention to the *situation of small-scale fishing* and the tensions between small-scale fishing and the industrial fleet in areas where the two activities overlap.

Improved regulation is also expected in the area of *safety of crew members,* both physically and in terms of workers' protection. There is an awareness that regulations are insufficient in this field if monitoring measures are not introduced to guarantee their application. It is also important, and this is an aspect where developments in technology have an impact, that safety norms are appropriate and convenient in order not to hamper normal activities on board vessels.

Advances in these regulatory aspects are generally expected in the short term, before the year 2009, although there is an awareness of the difficulties, especially of a political nature, which reduce their likelihood.

Another noteworthy aspect in this matter of regulations is the establishment of *effective information systems on fishing:* reliable systems at the national level incorporating basic data to facilitate fishery activities and decision-making in that regard—number of vessels, type of fishing, species, areas, catches and unloading, CPUE, etc. The situation in this field differs from country to country, but the subject is important because statistics are needed that are comparable with those existing in other sectors, and also comparable at international level. The restraints here are not usually of a technical nature but rather economic, linked with the maintenance of the information system. A dedicated technical structure and a commitment to supporting it on the part of the public institutions are required. Attention is drawn to the desirability of international cooperation measures to make this possible.

Fishing

Trend 2: *Diversification of catches*

Fishery activities will be diversified to include new species, for which purpose exploratory fishing cruises will be required, using the most appropriate electronic equipment and fishing methods.

Diversification is necessary, but exploratory cruises are very expensive and will be possible only with cooperation between the public and private sector—that is to say, the allocation of State resources to supporting and encouraging private initiatives—and with international cooperation. The capacities of the countries considered here differ greatly in this area, and it would be desirable for these capacities to be placed in the service of common objectives. It is not simply a question of possibilities for financing but also, above all, of specialized resources and technical capacities. In short, to make joint exploration by the countries of the area possible and more viable, an institutional commitment by the individual Governments, the participation of private actors and international cooperation are required.

A particular aspect is the extension of fisheries to deeper waters. Prior to the years 2010-2014, the availability of fishery units with suitable technology for the *development of fishing based on potential mesopelagic and deep-water resources* is foreseen. This is a controversial line of development, because the impact that deep-water fishing may have on existing species, or even on adjacent ecosystems, is unknown. These species have a very long maturation period and low fertility rates (as an illustration, the Chilean sea bass reaches maturity after nine years), so that their possible exploitation raises problems. An issue arises here that is frequent in the context of fishing, namely that the exploitation of a resource nearly always takes place ahead of scientific research on its effects, so that what might be called a "fait accompli" strategy is adopted, sometimes with irreparable consequences for the sustainability of the resource. It would seem prudent for this activity to be made dependent on the results of research on its effects, something that will require an active role on the part of administrations.

To sum up, new fishery resources will be available in the medium or long term as a result of new areas of exploitation. This will be linked with the existence of a *multi-purpose fleet conducive to the diversification of fishing*. In Peru, this development is seen as practically inevitable (it is considered that diversification will take place in any event). Building up a multi-purpose fleet raises no technological problems, because the technology exists and is known. However, economic constraints limit the possibilities. Peru's oversized fleet (as also, to a lesser extent, the fleets of other countries) is antiquated and much of it is engaged in fishing for indirect human consumption (that is to say, for meal and oils) and is not suitable for fishing for direct human consumption. The reconversion of the fleet is thus a major problem, not for technological reasons, it must be stressed, but for economic reasons. This subject, which has been discussed here in connection with diversification to include fishing for other species, will be taken up again later; it is also

relevant to the problems of production efficiency in relation to the resources already being exploited. Although the Peruvian case has been mentioned in particular, the question of the excessive size of the fleet and the need for its modernization is crucial also in Ecuador and, perhaps to a lesser extent, in Chile.

Fishing

Trend 3: *Prospecting for and detection of resources*

The combination of mechanisms and systems to collect information on the quantity, identification and location of shoals, the positioning of vessels and data of an environmental nature may, in the medium term, allow the development of forecasting systems which will contribute to improving the efficiency and profitability of fishery activities.

The advanced technologies to be applied in detection of and prospecting for resources are well known: they are based inter alia on sonar systems, satellite images and the development of software. In theory, they could be applied in the short term (before 2009), but in reality their utilization faces practical barriers of various kinds, such as insufficiency of infrastructures for the processing of satellite images. These are technological barriers with an economic basis, because the main problem is the cost of the technological infrastructure that needs to be set up. Once more, international cooperation may help to alleviate these problems.

This possibility is envisaged for the period 2010-2014, the integration of sonar with the analysis of three-dimensional and four-dimensional images being seen as one of the most probable combinations of technologies in the shorter term. It is considered that this type of development, to be effective, requires technological support centres with relatively extensive infrastructures.

One of the problems of greatest seriousness and urgency is that of reducing discards, which are estimated to represent between 20 and 25 per cent of total catches. The problem of reducing the quantity of fish thrown back into the sea is obvious from the viewpoint of the sustainability of species. To identify species prior to catch would be the optimum solution, to which the systems that have been mentioned could contribute.

It will also be possible to advance in this direction through the *introduction of modifications in fishing equipment, using various electronic devices (probes, monitoring of drag, devices for the attraction of fish) and mechanical devices coupled to them, which will permit greater selectivity and contribute towards increasing the precision of operations;* this will also lead to a reduction in costs for the maintenance of equipment and to greater efficiency of operations. It is anticipated that the development of fishing equipment will have the dual effect of increasing the possibility of selectivity in catches and improving efficiency in the fishing operations. The extensive adoption of such improvements is not foreseen before the period 2010-2014, the principal constraints being

technological and economic in nature. Once more, the difficulty is the cost of the technology that needs to be incorporated. With regard to the problem of reducing the discard rate, consideration needs to be given to whether the selectivity resulting from new equipment will avoid the death of the unwanted individuals, or only their loading onto the vessel. In the latter case, a problem of efficiency in on-board management would be resolved but not the basic environmental problem.

It seems fairly clear, particularly taking into account the fact that the technological trends in question are not expected to occur immediately, that this question of discards requires other types of measures in the short term which come within the purview of services such as those responsible for drafting regulations or ensuring compliance with them. Along with regulations and their monitoring, active awareness-raising efforts will be needed to highlight the importance of the subject and its effect on the future of fishery activities, even leaving aside environmental considerations.

Fishing

Trend 4: *Improvement of techniques of management, storage and processing on board*

The application of automation and process control technologies in the handling of fish on board will increase significantly with a view to ensuring hygiene and reducing the risks of contamination to the minimum, reducing occupational hazards, incorporating more value in the product and guaranteeing traceability of origin.

Opinions are divided regarding the time within which an increase in these on-board technologies can be expected to be "significant", but in any event one is speaking of a time frame of between 4 and 10 years. These technologies are very widespread among deep-sea fleets (factory ships), and the challenge is their large-scale extension to industrial fleets. There is a dual objective: firstly, to ensure that the fish arrives at the port with as much value added incorporated as possible and, secondly, to make the on-board tasks less arduous for the crew members.

What is under discussion is the renovation or modernization of the fleets, and this means major investments, which, in principle, are beyond the capacity of most shipowners. There are insufficient credit facilities for the renovation of vessels, and the almost unanimous view is that this process, which is considered necessary, will only be feasible with the help of a government policy of financial support.

At the same time, it is expected that, by the years 2010-2014, *the majority of industrial vessels will be equipped with systems of conservation and storage which are already available on land: modified and/or controlled atmospheres, liquid ice with ozone, etc.* However, difficulties are being encountered in ensuring the satisfactory functioning of these systems on board. Apart from these constraints of a technological nature, what has just been said regarding conditions of financing is valid.

Fishing

Trend 5: *Trend towards direct human consumption of those species used for fishmeal and fish oil*

The organization of fleets will be adapted and supplemented to emphasize direct human consumption. The use of insulated holds will become generalized in order to improve handling and conservation on board for catches intended for direct human consumption.

Especially in Peru, but also in Ecuador and Chile, a definite tendency is becoming evident to shift to direct human consumption as a significant portion of the catches of small pelagic species which are mainly used for the production of fishmeal and fish oils (so-called indirect human consumption). In this way, it is hoped to generate products of higher value added for the external market. These are strategic decisions because they will have very important consequences for the industrial structure, for the fleets and for the marketing mechanisms of the fishery sector. In the case of Peru, a thorough-going reconversion of part of the fleet will be involved. Nevertheless, assumptions relating to the subject foresee quite early realization, before 2009.

There are, in principle, no technological limitations to such a reconversion of the fleet, but the economic constraints are obvious. Financing requirements are very substantial and a strong institutional commitment will be needed to allow these expectations to be fulfilled.

Aquaculture

In aquaculture, trends have been identified affecting the critical aspects of this activity:

1. Feeding;
2. Pathologies;
3. Production of new species;
4. Genetics.

Aquaculture

Trend 1: *Feeding*

Knowledge about the metabolism of the various cultivable species will permit the development of diets or feeding patterns that will improve conversion rates and the growth index.

The nutrition of cultivated species has become one of the most important areas of research in aquaculture, owing to the special metabolism of aquatic species which, unlike terrestrial species, do not convert the major

part of the foodstuffs that they ingest into energy. From the point of view of efficiency, an appropriate diet is the precondition for achieving optimum conversion rates (the ratio between the weight of food supplied and animal flesh weight). Moreover, the diet used from the beginning of life may determine susceptibility to particular pathologies, malformations, etc.

However, the level of knowledge regarding metabolism varies greatly from species to species, with the result that a considerable research effort is still necessary. The fact must also be taken into account that the composition of the appropriate diet depends on the actual conditions of cultivation, a factor which sometimes limits the value of results obtained in the laboratory. This is therefore a crucial subject, regarded as one of the most decisive for the future of aquaculture. In the opinion of most of the experts consulted, both during the surveys and in the panels, significant advances can be expected in this area in the relatively short term, before 2009. The constraints identified are technological and economic in nature. In view of existing research capacities, international cooperation at the regional level and an exchange of technology and experience with third countries are advisable.

A particular line of exploration within this area of research, with great practical consequences, concerns the attempt to *partially replace the diet of certain carnivorous species by vegetable components, in order to reduce dependence on fishmeals and fish oils and limit their consumption.* One of the aims is to be able to divert part of the resources going into the production of meal towards human consumption, taking into account the limited nature of marine resources and the unstoppable growth in demand for high-value aquaculture products (precisely the carnivorous marine species that are fed with fishmeal). It must not be forgotten, however, that the largest demand for fishmeal and fish oils, in quantitative terms, comes not from aquaculture but from land farm animals (especially poultry and pigs). A reduction in the consumption of fishmeal in aquaculture will certainly have an effect, but it will not be completely decisive in reducing demand.

Although there have been some successful experiments, for example with the gilthead bream in Europe, this trend is expected to become well-established in the relatively long term, between the years 2010 and 2014. It must also be remembered that the consumption characteristics (taste) of fish and crustacea fed in this way may suffer changes that will be difficult for the market to accept, a market—and this aspect must not be underestimated—in the higher range, supplied by products which are already highly priced and whose price may increase as a result of the trends in feed inputs resulting from current research.

Mention should also be made of work taking place with micro-algae with a view to their use as feed for cultivated species. This is a line of research that is still at an early stage, although experts have great hopes in its possibilities since these micro-organisms are essential in the initial phases of development of most species cultivated in aquaculture. However, the production of micro-algae requires major investment and is affected by great instability. In addition, there are research results indicating that some of these

micro-organisms have negative effects. In any case, the agreed assessment is that this development will not have practical consequences of any general significance until 2010-2014.

Aquaculture

Trend 2: *Pathologies*

Susceptibility to diseases will be substantially reduced through a suitable balance of nutrients and the inclusion of immunostimulants and probiotics in the diet.

This trend complements what was said in the previous section regarding feeding and its influence on susceptibility to diseases. The incorporation of immunostimulants in the diet increases the animal's resistance to infections, and the use of probiotics may contribute to the improvement of its microbiological quality. Further investigation is needed in both fields, because much is in fact unknown about the form and means of action of both of these types of agent. Although the majority view is that this development will materialize before 2009, there is also a significant sample of experts who expect it later, some even after the year 2015. It may be said, therefore, that there is a considerable degree of uncertainty regarding this expected occurrence. It is also to be noted that research on these subjects is taking place in other countries, which creates a situation of dependence affecting estimates of when its results can be applied.

The fight against disease is the great issue in aquaculture development. It is thought that 10 per cent of the world aquaculture population dies as a result of diseases. Reasons for this high morbidity rate include the fact that the operations tend increasingly to be concentrated: with the move from semi-intensive to intensive cultivation, the quality of life of the animals declines radically, causing them stress which makes them much more vulnerable to infectious pathologies. An epidemic can ruin the sector in a very short time, as was discovered in the region when so-called "white spot" spread among shrimps. There are still doubts, particularly in Ecuador, regarding the extent to which any recovery from this disaster will be feasible, and in the course of the present project, in the expert panel meetings, this experience, whose consequences are still being suffered today, was ever-present. It is worth noting that half of the experts from Ecuador did not expect such a recovery before 2010.

It is expected that *methods of diagnosis based on molecular techniques* will be developed and applied for the rapid detection of different pathogenic agents and species. Such methods are in fact already being used in some countries; however, although the majority of those consulted expect them before 2009, a significant minority (approximately 40 per cent) do not think that they will spread before 2010. The real problem is the very high cost of these techniques, making them prohibitive for most private undertakings. The challenge, therefore, is for the scientific progress taking place in this field to have an effect on the costs of application of the diagnostic techniques

within a reasonable period of time, making them accessible for medium-sized establishments.

In the very long term (not before the year 2015), *recombinant vaccines (specific antigenic proteins) and DNA vaccines (insertion of a genetic sequence conferring specific immunity)* will be developed; these will be the most common preventive therapy for viral disease immunization. Some vaccines of a bacterial type already exist, although this is a new field and requires technological development as well as an analysis of the legal limitations that may affect the use of such vaccines. It may be said that this is a possible future scenario that will depend on many factors. However, there is agreement that this will be the way to find effective solutions for the prevention of epidemics.

Aquaculture

Trend 3: *Production of new species*

The development of techniques for the reproduction, larval rearing and fattening in ponds of new species will produce an increased diversification of supply on the market.

This is a very attractive prospect from the commercial point of view, but there will be legal constraints because of administrative factors. The techniques for the rearing of new species will require substantial infrastructures and, consequently, investment. Some experts estimate that the development of the technological package for a new species requires about 10 years, so that any plans in this field for the period before 2009 (as suggested in many replies to the questionnaires) seem to them over-optimistic.

In this area, there will be increased use of production techniques which will make it possible to *obtain progeny of the desired sex, as well as sterile and/or polyploid progeny* in order to increase production significantly. The manipulation of the sex of fish is a factor in improving aquaculture management. An attempt is made to produce male or female individuals depending on whether they grow more, or faster, in particular species (for example, with salmonids the female grows faster and in the case of the tilapia the male), or sterile individuals to avoid reproduction, during which the females stop growing. At the present time, these changes are achieved through temperature control throughout the process of development of the individual. These techniques have already been developed for certain species, such as the sea bass or the turbot, but much knowledge still needs to be acquired in view of the extreme complexity of the reproductive apparatuses of fish, among which all the possible forms of reproduction existing among vertebrates are found.

The establishment of centres for the production of seed of adequate quality and in the necessary quantities will be decisive for the development of national aquaculture in the various regions and with the species selected in the light of their suitability for culture and commercial and/or social interest.

This idea is being advocated in Peru, a country whose level of aquaculture development is far below the other three, and whose experts are proposing

a national plan for the development of aquaculture. This is of regional interest, because the problem of seed is not totally resolved in other countries either, and because the Peruvian plan may make much more sense if it is placed in the context of regional cooperation. It is recognized that the establishment of such centres faces economic constraints as well as scientific limitations if the aim is to seek genetic improvements in native species; in any event, the majority do not foresee such centres before 2010. The expense of such installations is stressed, but also the research that is needed. International cooperation is requested for this purpose, in a Latin American and specifically a regional framework. The experts are conscious of the need for the establishment of political priorities regarding this question, and for the development of an aquaculture policy at the national level, situated in the regional context.

This idea is linked with the control of infectious pathologies, discussed earlier, since it is considered that the genetically improved seed produced locally will reduce the susceptibility to diseases of the species under cultivation. Here too the need for international cooperation is stressed, in this case with countries that are more advanced in genetic manipulation techniques.

Aquaculture

Trend 4: *Genetics*

Genetic engineering, supplemented by an understanding of the complete genome and of genetic maps, will have an important and positive effect on organisms capable of improving productive efficiency. The use of molecular markers will be a habitual practice to accelerate programmes for genetic selection and improvement of the characteristics of species of industrial interest.

The importance of these possibilities is recognized, but there is a certain degree of uncertainty regarding the likelihood of their application in the more or less near future; in any case, this will not take place before 2010-2015 and, in the view of many, it will be later. External cooperation and transfer of technology will be necessary.

The use of molecular markers represents an alternative to traditional genetic improvement and selection, making it possible to optimize the response to the selection of varieties and species and to minimize the time involved. It is based on the selection of individuals bearing certain markers associated with a characteristic that is of interest. A molecular marker is a DNA sequence of variable length, from a nucleotide to a group of genes that can be associated with various phenotypic and/or genotypic characteristics. The types of molecular markers permitting the genetic study of populations are very many. In the genetic improvement of animal species by selection, the basic objective of markers is to detect associations between the presence or absence of certain alleles and desirable phenotypic characteristics capable of being manipulated by selection.

The use of marker-assisted selection is possible knowing the association between marker and characteristic, independently of their chromosome location or of the availability of a complete genetic map, although it is optimized by fuller phenotypic and genotypic knowledge of the species. These techniques are already being used in the laboratory, but their industrial application depends on many factors and can probably not be expected in the very short term, as already pointed out. Everything will be related to advances in the research on each species and, as this research is being conducted by centres and groups scattered over various countries, international cooperation is decisive. The authorities must facilitate this cooperation, firstly by promoting the linking of national research centres and groups with international networks, and secondly by encouraging industrial enterprises to use these research networks.

Work is beginning on the sequencing of the genome of some species that can be used in aquaculture, but long-term processes are obviously involved here. However, these are the future trends that can be expected in the study and practical application of the genetic regulation of the essential biological processes: reproduction, larval development, nutrition and immunity to pathologies.

Processing industry

With regard to the processing of marine products, the trends observed have been grouped under three headings:

1. Conservation technologies;
2. New products and by-products;
3. Processes.

Processing industry

Trend 1: *Conservation technologies*

The use of such technologies as modified atmospheres, bioconservation and "active" and "smart" packaging will become general, permitting an expansion of the range of refrigerated and frozen products and increasing their stability and quality.

The large-scale application of modified atmosphere techniques is linked with demand; its spread will depend on the market's acceptance of the price increases that it will entail. At the present time, it may be said, these techniques are not making the same progress in the case of fishery products as with meat and vegetable products. The experts consider that their use may generalize in the period 2010-2014, although some expect this to occur sooner.

The techniques of modified atmosphere packaging (MAP) have become very widespread with other types of products, and enjoy broad acceptance on the market. For their efficient use, the cold chain must be carefully

managed, and it is desirable to combine them with "smart" packaging. This system of conservation consists in storing fresh foods in an atmosphere different from normal air in order to decrease microbial growth and gradually reduce the respiration rate of the products. The modified atmosphere is a combination of gases in which the concentration of oxygen is reduced and the concentration of another gas (nitrogen, carbon dioxide) increased. Carbon dioxide slows the growth of those micro-organisms that grow at refrigerated temperatures and inhibits product respiration. Nitrogen is an inert gas that replaces other gases, reducing their concentration. It should be stressed, however, that modified atmosphere does not replace refrigeration, and it is therefore important for the producer, the transporter, the seller and the consumer to respect the cold chain scrupulously in order to keep the food fresh and avoid microbial growth.

Packaging in a protective atmosphere, together with correct handling and application of cold, makes it possible to increase the useful life of refrigerated fresh fish by two or three times in comparison with other methods used traditionally. It requires considerable investment in industrial plant, as indicated above, and its introduction in the area of fishery products (about which many experts are somewhat sceptical) will depend on basically commercial considerations.

Active packaging—in which an interaction between the packaging and the food product takes place—is the option of the future from a scientific and technical viewpoint, but it needs to be borne in mind that packaging plays a very important role in acceptance of the product by the consumer. At the present time, the trend is towards "easy-open", recyclable and individual-portion containers, etc.—that is to say, the competing enterprises tend to base their commercial strategies on criteria related to customer convenience. This process will be modified through the incorporation of other criteria, such as those relating to the interaction referred to above between packaging and product, particularly relevant in the case of marine products, and this in turn will result in changes in commercial strategies and in ways of communicating with consumers.

The consumption of raw fish and seafood will lead to the regulation and application of irradiation as a means of conserving this type of food product.

Irradiation techniques—i.e. the exposure of food products to energy sources such as gamma rays, X-rays and electron beams—constitute an effective procedure for destroying bacteria and the micro-organisms that can cause infections and for prolonging the life of food products. Owing to the vigorous controversy concerning their use, most of the experts consulted do not foresee their immediate application. In addition to the technological barriers (much research is still needed in this area) and the economic constraints (the technologies are expensive), there are cultural barriers because an important section of the consumers reject products treated in this way. Regulations differ from country to country; they are highly restrictive in the European Union (Directive 1999/3/EC) and less so in the United States and Japan, for example. Worldwide, ecologist groups are very belligerent on this subject.

The generalization of these conservation procedures depends on important factors. Regulatory aspects are decisive, since these products go to a large extent to the international market. In all probability, these regulations will require consumers to be informed of the use of irradiation, so that they can choose whether or not to consume the product. As is already happening with genetically modified food products, a long period of polemics can be foreseen during which it will be essential for citizens to be informed of the results of technological advances, tests and studies in an adequate and dispassionate manner.

Processing industry

Trend 2: *New products and by-products*

Anchoveta will be increasingly used by industries producing for direct human consumption, in the manufacture of products of higher value added such as easy-open canned goods, frozen blocks (for preserved products, for baits, etc.), dried fish and the preparation of minced fish of the surimi *type.*

This trend, which particularly affects Peru, is of regional scope in view of its extension to Ecuador and Chile, also major fishmeal producers, and because of the significance of the resources involved. The process has already begun and great importance is attached to it. There is an unquestionable political component and success in this field will largely depend on the commitment of the authorities.

In the discussion of this trend in the section on fisheries, the need for the reconversion of fleets was stressed, and here too the considerable installed industrial capacity for the production of fishmeal and fish oils, far above actual production levels, must be borne in mind, together with the problems that this entails. Marketing structures, both domestic and international, are also affected to quite an extent. The experts consider, too, that the production of meal and oil that continues should be oriented towards products of higher range and greater value added. Altogether, what is envisaged is a project of great magnitude and complexity in the field of economic policy, requiring, as has been said, leadership and commitment on the part of the government institutions, but also a major pact among the economic actors involved, centred on the proposed objectives.

There will be a strong trend towards the development and marketing of a wide range of new marine products.

There is complete agreement regarding the fact that the appearance of new products will be one of the most significant future developments in industrial production based on fishing and aquaculture. The intense competition characterizing markets for all types of goods is also a factor that will influence this development. The possibilities for new products concern three areas: the manner of presentation of fish on the market, the marketing of new marine products in the strict sense and the development of functional products.

Presentation on the market

The export of frozen, breaded, preformed products with a high value added based on fish and squid will expand. Noteworthy among these are nuggets, rings and fillets ready for consumption.

The replacement of whole fish by cut-up products or products in the form of fillets is a reality in the marketing of frozen products, and the expected trend would be for this approach to extend to fresh fish also. There are quite significant technical limitations standing in the way of this. Most of the experts commenting on the issue foresee this development between 2010 and 2014, but a significant number expect it earlier.

New products

The expected new products based on new species or species already used will include *pâtés, burgers, sausages,* etc. This is a product line which already exists and products of this kind are already encountered on the markets. The technology is available and the idea would be to establish an industrial structure to produce goods of higher value added of this type.

Also foreseen is the *development of drying technologies* which will make it possible to offer dried fish on Asian export markets of much higher value added than frozen and canned products. For this purpose, it will be necessary to establish an industry that does not exist today and to select suitable species, some of which are not yet being utilized.

The development of methods for the economic exploitation of current by-products will permit the full use of the different parts of the fish: skin and bones as sources of collagens, the use of fish products in leather manufacture, the exploitation of viscera for silage, shells of crustaceans as a source of chitins, etc.

The full utilization of the various parts of the fish represents a qualitative leap with respect to the profitability, not only in economic terms but above all in terms of sustainability, of marine products. For example, the use of the skin of fish in leather production (for footwear) already exists for certain species. Although the trend has started, this is a new activity and much remains to be done in the development of technology. For the countries of the region, the effective materialization of the trend is expected in the long term (2010-2014), with a representative number of experts expecting it in a still longer term, and technological constraints being the main obstacle. Given the volume of fish being processed, however, this is a challenge of the highest order, which could have consequences of great importance. It will require cooperation with countries that are already advanced in this emerging field, and a certain institutional commitment for start-up support for business initiatives exploiting these possibilities commercially.

Functional products

The reference here is to the possible use of by-products of the industry in the chemical and pharmaceutical sectors. Several of the hypotheses put

forward relate to this question, which is undoubtedly of potential interest, at least in theory.

An accurate and detailed knowledge will be acquired of the relationship between the specific components encountered in marine products and their effects on various diseases (cardiovascular disorders, cancer, bone diseases, etc.), which will facilitate the development of functional products in this sector.

The residues and effluents of the fishery industry, such as gibberellic acid, hyaluronic acid and others, will be among the principal sources for obtaining certain chemical and pharmacological compounds.

New molecules of interest for the pharmaceutical and food industries, unknown up to now, will be detected through the application of analytic techniques in the recycling of waste from the fishery and aquaculture industry.

These possibilities are regarded as of great importance, but there are obvious difficulties, in the view of the experts, in the way of their realization. They are all expected to materialize in the period beginning with the year 2015—that is to say, in the very long term. An exception, in the view of a significant minority of the experts, is the first hypothesis relating to the advance in basic knowledge regarding relationships between the components of marine products and certain diseases; they believe that this may be a reality before the year 2009. The limitations here are predominantly technological, followed by the related economic constraints due to the cost of the technologies (whether in terms of development or of acquisition). It is assumed that this trend, which will undoubtedly be a future trend at world level, presents opportunities for countries that are major fish producers, opportunities which, in order to be realized, will require the definition and adoption of a strategy of cooperation with the decision-making centres of the chemical and pharmaceutical industries.

Processing industry

Trend 3: *Processes*

In regard to the processes applied to marine products, foreseeable trends do not involve radical changes, at least in a reasonable short or medium term, but relate to the use to a greater or lesser degree of technologies that are already known and may be more efficient than those used at the present time. The most influential advances will be those that contribute to more profitable utilization of the resource.

Integrated and automatic equipment and machinery will be developed which will incorporate the processes of filleting, scaling, gutting, deboning and processing of fish, reducing product losses to less than 0.1 per cent of the fillet.

This equipment, the introduction of which is foreseen in the period 2010-2014 (with a significant number expecting dates prior to 2009), will not rely on mechanical means for achieving the necessary levels of precision but will use changes in temperature, pressure, etc. In addition to technological limitations (external cooperation will be needed) and economic constraints, some

experts mention cultural difficulties and problems relating to the training of personnel to use this equipment. The importance of adopting machinery with these characteristics is directly related to the trend mentioned earlier towards the increasing marketing of fish in pieces or in the form of fillets.

In the same context, it is expected that *biotechnological processes for the utilization of residue and viscera of fish and invertebrates in the production of hydrolysates, gelatines, etc.,* will be available. This is expected before 2009 provided that the technological barriers now identified can be overcome.

The availability at the national level of an efficiently managed *cold chain* is a necessity felt in all the countries. Problems regarding the correct maintenance of existing installations arise because of inadequate training and/or awareness in this field in the responsible organizations (frequently small-scale fishing associations). Here the institutional commitment is not simply a matter of promoting adequate investment (which has already been made available or is being made available, at least in part), but also involves promoting an improvement in the training of all the actors in the fishery production chain and in their awareness of the importance of the cold chain.

The utilization of cooling agents such as *liquid ice or refrigerated seawater* is foreseen as an alternative that will replace the traditional systems based on flake ice. Liquid ice presents advantages over the flake ice normally used, such as permitting lower temperatures and better thermal conductivity and not damaging the product, because of the absence of edges. It is already being used for rapid cooling or cooling for short periods of time, and it is incorporated in some boats; but quite a number of experts doubt whether there will be a general displacement of flake ice. The economic barriers are considered to be important.

Also in connection with the cold chain, it is thought that *new methods of heating (high frequency, microwaves)* will become general in the industry for the de-icing of fishery products in large quantities. There is some uncertainty as to when this will take place, although the majority view is that it will be after 2010. There are problems regarding the mastery of the technology and obvious economic problems in the area of investment and financing.

Quality/traceability

Quality/traceability

Trend: ***Introduction of systems for quality assurance, traceability of products and indication of origin***

Food safety is one of the great issues of concern to society and a field in which action is being taken by the public authorities at the national and international level, leading to the gradual introduction of increasingly strict regulations regarding the quality and traceability of food products. For the food processing industry, guaranteeing the safety of its supplies in terms of these regulations is a strategic priority and a condition for survival. Questions

relating to quality and traceability arise at all stages of the production chain: fishing activities, aquaculture and processing and marketing. They will be dealt with together, because what is important is the final product that reaches the consumer.

Food safety is a subject of research, especially to identify the relationships between the various toxic substances and the food products, and the way in which such substances may affect human health. By way of example, a current line of research is aimed at enabling the big distribution chains to ascertain the origin of fish using DNA tests. Based on the results of this research, regulations are being drafted or the regulations applied are being amended. Public administrations are responsible for ensuring that the regulations are observed. For the various economic actors constituting the production chain, the legal requirements in this sphere are increasingly exacting, and they are frequently evaded. However, in the medium term, when all international markets apply effective systems of traceability, adaptation to the regulations will be a necessary factor for exporters wishing to be competitive.

Procedures to ensure the traceability of products, to protect the final consumer, will be usual.

The introduction of such systems necessarily includes the *standardization of data transmission systems,* to make possible exchange of information on the product and traceability among all the actors participating in the production chain. To a large degree, this is a problem of information and communication technologies, but it is also, above all, a problem of organizational management. Financial problems are noted, because the cost of these measures may be very high for enterprises. Mention is also made of technological and cultural difficulties: in many cases, a change in mentality will be needed.

There will be a need for support from public administrations which, through the existing scientific bodies and international scientific cooperation, must identify the dangers and risks associated with each type of process and product, permitting enterprises to *introduce more rigorous HACCP systems.* It will almost certainly be necessary to amend existing legislation and draft technological regulations directed towards the prevention of dangers and risks. Health control and inspection systems will also have to be perfected. This trend will take effect, according to the opinions collected, before 2009.

This trend is expected to affect aquaculture and industrial processing, where its introduction seems likely to be easier, but it can also be extended to fishing through *systems for the rapid identification of species,* such as "computer vision", which were mentioned earlier, and which will contribute not only to more efficient management on board but also to facilitating the traceability of products.

Appellations of origin and quality seals will be established as a way of encouraging customer loyalty and assisting competitiveness.

This is a movement that has already started, and many experts regard it as an immediate necessity rather than a future trend. The most important issue is considered to be that national technical standards, internationally

recognized, should be established for the main fishery products as a basis for the development of a "quality seal". Great attention must consequently be paid to the evolution of international standards in areas where demand for the region's export products is concentrated. This trend is also expected to be observable before 2009.

The large-scale use of rapid quality control methods for fishery products, such as techniques associated with the polymerase chain reaction (PCR) and other biological methods, is considered desirable; these techniques are being used in veterinary diagnosis, but they are expensive methods whose large-scale use will not be possible, at least under present conditions. It will therefore be necessary to develop a low-cost method, and this will certainly be a challenge for technological agencies.

Consumption

Consumption

Trend: *Increase in the consumption of fish*

Both in Colombia and in Ecuador per capita consumption of fish is very low, below the average for Latin America, which in turn is below the world average. In these two countries it is considered desirable, in order to contribute to improving the diet of the populations concerned, to increase the share of fish products in the diet, the objective being to arrive at a consumption level similar to the average for the subcontinent—i.e. 9 kg/year per capita. The results of the surveys carried out and the findings of the expert panels indicate that this goal will be achieved before 2009.

The strategy envisaged for this purpose is based on *the dissemination of information on nutrition combined with the use of new forms of communication adapted to consumers to facilitate their education, improve their confidence in the fishery industry and permit an increase in the consumption of fish.*

This must be supplemented by *rationalization and monitoring of the marketing channels for the products of fishing and aquaculture, which will permit a substantial reduction in intermediary mark-ups and a better price for the final consumer.*

Lastly, *wharves and wholesale and retail markets equipped with modern infrastructure to ensure the safety and quality of the products supplied* will be available. There will be a greater involvement of local and regional governments in the promotion of such infrastructure.

This strategy for the development of consumption raises some questions which are worth mentioning. In the first place, this is something new, since so far publicity campaigns of this kind have not been organized (except in Peru), and a certain cultural inertia will therefore be encountered which it will be necessary to study and overcome. Secondly, cold chains are absent or defective within the countries, and this—in Ecuador, for example—contrasts with the high level of equipment of the tuna exporting sector. There is a

tendency to forget that there is not the same wealth of fishery resources in inland waters, in the interior of the countries. In any event, the supply of the raw material cannot be taken for granted, and will also call for specific measures which may prove very costly.

Colombia, it should be added, is a net importer of fish for consumption by the population, even though the consumption level is low. At the same time, Colombia exports certain marine products, and intends to continue to do so. The programmed utilization of inland and aquaculture resources is suggested. A model could be devised for the promotion of an industry producing value-added products, supplied by raw materials imported from the neighbouring countries, especially Peru.

Environment

Environment

Trend: *Sustainability in all activities of the fishery production chain*

One of the main environmental problems is the sustainability of the various species, an aspect already mentioned in the section on fishery technologies. Identified in this connection were trends in the direction of the regulation of fishing, which should include agreements to reduce fleets and limit pressure on resources, and techniques directed towards reducing discards and identifying resources. Intimately related to this also is the trend towards reductions in catches for indirect human consumption (fishmeal and fish oils) and a shift towards direct human consumption.

Here, only trends relating to aquaculture and industry will be discussed. In aquaculture, two of the most important causes of environmental damage have been considered: the use and pollution of water, and the generation of waste.

The view is that *increased knowledge and technical improvements (interaction of pathogens and flora, accumulation of metabolites, changes in feeds employed, reductions in the cost of equipment, etc.) will allow water recirculation systems in on-land facilities to become usual*. There are uncertainties and a division of opinion regarding when water recirculation systems will become common, whether before 2009 or between 2010 and 2014. Although this is a critical topic for the effective use of water resources, and international environmental regulations will probably impose a move in this direction by 2014, implementation depends on a certain level of scientific and technical knowledge, which in any case will be different for different species. To these technological limitations one must add the cost of the equipment (a reduction in its cost is considered to be a precondition). A commitment on the part of the public institutions will be necessary, together with international cooperation, both within the region and from outside it, especially as far as the transfer of knowledge is concerned.

Regarding the generation of *waste, there will be a substantial reduction per unit of output thanks to improved efficiency in production (fuller utilization of the food, reduced releases into the water, use of effluents in the production of other species, etc.)*. One of the major polluting factors in aquaculture is feeding, whether because of feed not ingested or not digested (excrement) or metabolic wastes (nutrients not metabolized). Depending on the type of feed, the portion not ingested may vary from 5 per cent to 30 per cent, which, besides contributing to pollution, directly affects the economic efficiency of the installation. It is therefore assumed that enterprises are very interested in contributing towards rationalization in the use of feed. This does not depend only on the characteristics of the feed, such as particle size, stability, digestibility or composition, but also on the method of feeding—i.e. the manner, frequency, quantity and scheduling of the supply of feed. In parallel, advances will also be made in the use of *effluent recycling* technologies. A majority of the experts believe that substantial advances may take place in this direction before 2009. The obstacles are mainly technological.

An issue taking on great importance in the industry is the utilization of waste instead of its release into the environment, an aspect already discussed above in connection with the trend towards the development of new products or functional products. The other major source of specific pollution (apart from the characteristics of any industrial plant, independently of the sector concerned) is waste water. The fishery industry is highly intensive in the utilization of drinking water (it consumes approximately 15 litres per kilogram of processed fish) and is regarded as one of the main sources of pollution of the marine environment in the region (together with household waste). *Modern systems for the recycling and purification of waste water from the technological processes of the fishery industry will be installed, so that the effluents do not harm the environment*. The purification systems will be improved through the incorporation of technologies such as *microfiltration, ultrafiltration and electrocoagulation* which will permit the recovery of proteins for later application (hydrolysates, gelatines, feeds, . . .) and the industrial utilization of the water. The prevailing opinion is that this will be effective, in terms of its consequences, in the period 2010-2014, although many experts believe that it could come about before 2009. The constraints are technological, economic and also political, inasmuch as strict regulations would be necessary as well as measures to assist enterprises that showed an interest in reducing their contribution to environmental degradation.

Human resources/training

Human resources

Trend: ***Improved training for the population involved in the fishery production chain***

In all the activities that make up the fishery production chain, human beings are the most important element and, in paying attention to the human factor,

emphasis has been placed on training needs because the deficiencies in this area are patent and may have a big effect on opportunities to improve the level of living of those concerned, and on raising the levels of efficiency and competitiveness of the production chain. In connection with this trend towards *increased training for the population involved in the fishery production chain,* there are various hypotheses regarding the future. *Fishery training schools will be expanded to cover demand, especially in the area of new technologies, and it will be possible to count on fishery personnel with a broad awareness of ecological issues.*

Steps will be taken to meet the training needs of the aquaculture sector, with the establishment of centres for training and the development of human resources.

Training is needed both for fishery personnel (crew members) and for aquaculture workers. In both cases, high priority is given to training in environmental aspects, this being particularly so with regard to crew members. It is believed (and, above all, considered desirable) that such training capacities will be operational before 2009, although a number of experts regard this date as over-optimistic. The constraints explaining this scepticism are economic and political, since a substantial promotion effort by the public authorities will be required. Worth noting in this connection is the experience already gained by the Eastern Pacific School of Fishing (EPEPSO) in Ecuador.

Account is also being taken of the possibilities offered by information and communication technologies (ITC) for the use of *distance training* as a strategic factor in improving the mastery of new technologies by crew members, taking advantage of the considerable dead time during trips. The training imparted by these means would be basic training on safety and environmental issues. It is thought possible for this to be implemented in the medium term, with a practically even division of opinions between those who expect implementation before 2009 and those who expect it between 2010 and 2014. The constraints are economic and technological, social and cultural obstacles also being very important. It should be mentioned that evaluation of the possibility of using ITC on board was much more positive in Ecuador than in the other countries. In any event, in all countries the need for a vigorous training policy is recognized.

In this context, steps have been proposed for *retraining some of the small-scale fishing population for aquaculture*. Experiments in this field have been made in Chile and, although experts on aquaculture have expressed scepticism based on the differences of educational level existing, which have to be recognized, representatives of the small-scale fishing communities have supported this idea as positive. There has clearly been a lack of sociological and cultural sensitivity in the approach to the problems of small-scale fishing, and the populations concerned have not been prepared for participation in cooperatives. It is sometimes forgotten that the cooperative spirit and a mastery of the necessary techniques for a cooperative to function do not arise out of nowhere, and that enthusiasm and goodwill are not enough. The retraining of fishing populations as aquaculture workers, if it is undertaken, will therefore not be just a matter of technological training. Another question

that arises concerns the need for the State to take charge of the programme and whether this should be on a permanent basis, which would result in a kind of paternalism. Comprehensive projects are needed: it is not a question of offering financing ("supplying cash"), although this may be essential, but of giving fishing communities a sense of responsibility for their own future. Important, once again, will be international technical cooperation (particularly from countries that have experience in this field), the support of Governments to enable programmes to begin and to give them continuity, and cooperation between public agencies and private organizations. Finally, it must be borne in mind that the role of a producer is to produce for the market. These retraining projects must be based on a partnership approach; the functions of the actors must be clearly delimited and an overall coordinator will be needed to guarantee marketing.

In any event, it is proposed that, as a matter of priority, an inventory should be made of the human resources capability existing in the region in relation to the production chain, and a core action group established for the purpose of training the trainers.

4 Conclusions

The countries of the region, taken together, constitute one of the world's largest suppliers of fishery products, and they are potential protagonists on the world stage in a scenario of greater demand for fish. For this purpose, it will be desirable for them, going beyond their present very valuable capacities, to give priority attention to rationalizing their area of operations, to guarantee, in the first instance, its sustainability and to obtain the maximum advantage from their catches. Taking into account the trends observed in the present report, the first condition for achieving this result will be an effort by the countries of the region to organize fishery activities jointly, making the protection of their resources a common objective and a basis for cooperation. Such cooperation should extend to prospecting work and the exchange of experience and technologies. The capacities of the various countries differ greatly and are, in many respects, complementary, and it would seem reasonable to hope that points of convergence can easily be identified so that all can benefit.

Common objectives in the sphere of *fishing* are those identified in the report:

- Diversification of operations to include new species found in the exclusive economic zone, adjacent national and international waters and deeper waters where fishing operations take place at the present time. This will require exploratory commercial fishing cruises to ascertain the potential for these species, in order to be able to guarantee their rational and sustainable exploitation with adequate organization and management measures by countries.
- Better detection of and prospecting for resources, to permit a reduction in discards and to provide a basis for the subsequent traceability of the products. This will call for the incorporation of advanced technologies—i.e. considerable investment in modernization of the fleet and fishing equipment and the training of crew members in the efficient use of the new facilities.
- Fleet modernization which will allow improvements in techniques for handling, storage and processing on board, including the necessary

reconversion of fleets now devoted to fishing for indirect human consumption, for the purpose of direct human consumption. Governments will need to establish long-term soft credit lines to guarantee the operationality and profitability of this initiative. An effective training programme for crew members will also be required, taking into account the different needs and activities to be developed.

In the area of *aquaculture,* the first conclusion relates to the strengthening of this activity in Ecuador and Colombia, and the need for a strong expansion in Peru. In the latter country, the introduction of a national plan for the development of aquaculture is being proposed, with the participation of the public and private sectors. Ecuador and Colombia have offered cooperation, in view of their greater experience in this domain.

The objectives suggested by the trends identified in this field are:

- An effort to improve feeding patterns, a notable area of research being the possibilities for replacing totally carnivorous diets by diets including vegetable foods, of great importance for the future of shrimp cultivation, for example;
- The eradication of viral diseases through diagnostic methods and vaccination;
- The production of new species and the development of reproduction methods permitting the selection of progenies;
- The availability of seeds in adequate quantity and quality for efficient operations;
- The utilization of genetic research and development to ensure greater productive efficiency and an improved yield.

In the *processing industry,* the following objectives are foreseen:

- The incorporation of advanced conservation technologies, such as modified atmosphere, "active" packaging or, potentially, irradiation technologies. All these developments, especially the last-mentioned, are subject to external conditions that may hinder their materialization. In any event, conservation technologies are a key factor for competitiveness in this sector.
- The development and introduction on international markets of new products, among which mention may be made of those resulting from the use for human consumption of species previously utilized for the production of meal and oils, fish derivatives with a higher value added and degree of handling and products related to the use of the different parts of the fish and of residues for other sectors, such as tanning or the chemical or pharmaceutical industry. This will significantly improve the economic efficiency of marine products, but there will also be very positive effects for the environment.

- The modernization of production processes through the incorporation of new equipment and new methods. This will give rise to needs for financing and the training of human resources.

Together with these sectoral aspects, there are certain topics which affect the whole productive chain and are of great importance in guaranteeing its overall competitiveness and efficiency.

The first aspect is the *quality* necessary for access to international markets and the product *traceability* that these markets require or will require in the future as a result of the international standards established, inter alia, by the Codex Alimentarius and FAO.

Secondly, there is a need to protect the *environment* at all stages in the production of fishery and aquaculture products.

Thirdly, there is the need for the *training of the personnel* involved in the production chain, who must adapt to the use of new techniques and also (and more important) be made duly aware of the delicate questions of safety, for themselves and for others, and of respect for the environment.

Lastly, both in Ecuador and in Colombia a desirable objective is considered to be *increasing the consumption* of fish products among the population so as to reach at least the average level for Latin America, which in any case is considerably below the average world consumption level.

5 Recommendations

Prior observation

A foresight study allows the identification of probable trends, in order to facilitate the task of fixing objectives and of medium-term and long-term decision-making. As has been explained, the exercise does not result in guidelines that must be followed but in possibilities that need to be taken into account. This applies to the present project, and the trends presented in chapter 3 of this document therefore represent elements to be considered in taking decisions and defining policies. Their potential in this regard is not replaced by the recommendations that follow which, although they are also based on the analysis carried out, are of a more general character and, while they also form part of the framework to be established to facilitate the activities of the fishery production chain, do not go into detail regarding the technical, organizational and technological options to be chosen.

In the recommendations below, a common feature is the concern to contribute towards international cooperation among the countries of the region. Their shared interests and points of convergence far outweigh any differences in interests, as has become clear during the course of this project, and, moreover, regional structures have existed for decades, which serve as a basis for cooperation, including, above all, the Andean Community, with its financial agency the Andean Development Corporation (CAF), and, more specifically for promoting the sector covered by this project, the Permanent Commission for the South Pacific (CPPS). It should not be interpreted as interference if some measures are suggested that may reinforce the activities of these supranational institutions.

The recommendations that follow should be seen in the context of the above considerations.

Recommendations

1. *Drawing up of a common fishery policy within the framework of the Andean Community and the Permanent Commission for the South Pacific, taking into account firstly the specific needs of each country and then regional needs.*

The objectives of this common policy should be, in principle:

- The utilization, under conditions of sustainability, and protection of the coastal maritime zone, the exclusive economic zone and the deep-sea zone;
- The development of sustainable and profitable aquaculture;
- The consolidation of an internationally active industry.

For these purposes, the capacities and experience of the different countries will be used in conjunction, with maximum exploitation of complementarities between them.

2. *Establishment of plans for the management and organization of the fishery resources shared by the countries concerned, principally in the following areas:*

- Utilization of resources in a manner ensuring the sustainability of species;
- Control and regulation of the number of fishing vessels to avoid excessive fishing of resources;
- Defence of the sovereignty of the countries of the region in the coastal maritime zone and the exclusive economic zone;
- Compliance with fishery standards, regulations and legislation in force at national, regional and international levels;
- Sanctions for illegal, undeclared and unregulated fishing;
- Recovery of species that have been over-exploited or are in danger of extinction;
- The harmonization of initial criteria regarding individual transferable quotas (ITQs);
- The development of marine aquaculture.

3. *Reconversion and modernization of the fleets,* consisting in the following medium-term or long-term policies:

- Adaptation of a substantial proportion of the fleet used for fishing for the production of fish meal, in Peru and to a lesser extent in Ecuador, so that the catches can be used for direct human consumption;
- Adaptation of at least 50 per cent of the Colombian fleet of shrimp vessels for the exploitation of new resources;
- Introduction in industrial and small-scale fishing of advanced technologies for management, storage and processing on board and for detection and prospecting;
- Long-term programming of the reduction of the capacity of fleets where required;
- Establishment of satellite-based control for all industrial fishing vessels.

These developments are hindered by a lack of financing capacity. The Inter-American Development Bank (IADB) and the Andean Development Corporation will need to be approached. Such negotiations will be more effective if initiated by a consortium of countries, based on a long-term joint programme.

It is essential that the region's capital goods industry should be incorporated in this process. Additionally, given the importance of the Spanish naval construction and technology industry, thought may be given to the possibility of financial support from Spanish cooperation funds, linked with technical support and supplies provided by Spain's industry.

4. *Formulation and implementation of a national plan for the development of aquaculture in Peru,* with assistance and advice from the other countries of the region. The plan will provide for the cultivation of marine and inland species, and should give rise to a valuable exchange of experience and knowledge. Cooperation in this field could include the establishment of common centres for the production of seed. In connection with the development of aquaculture, consideration should also be given to the possibility of re-training for this activity population groups now engaged in small-scale fishing.

5. *Establishment of a large Andean centre for fishery training,* in which training would be provided in all the disciplines relating to the fishery production chain, at all levels. The long-term goal would be for this centre to become an educational reference point for fisheries similar to the Zamorano Institute in the case of agriculture, except that, unlike the latter, it would cover all levels of education. It would be responsible, for example, for initiatives concerning the small-scale fishing populations, their training in organizational aspects and matters relating to the formation of associations and their possible retraining for aquaculture.

Suitable bases exist for the development of a centre with these characteristics: the Eastern Pacific School of Fishing in Ecuador, the Merchant Marine School in Peru and the Nautical and Fisheries Centre in Colombia.

It is proposed that a regional workshop should be held at which these, and possibly other institutions would participate in order to examine the viability of the regional centre proposed.

6. *Establishment of a Technology Watch (TW) service for fishery technology* at the service of all those working in the production chain in the various countries. Technology Watch consists in a periodic, systematic exploration of information sources on technological innovations and the selection of those considered most interesting in relation to activities or concerns previously defined. The sources explored are data banks on patents, technical journals, papers submitted to congresses, announcements by major corporations, etc.

A possibility would be for this service to be located in Peru and backed up by IMARPE, which already has an operational scientific information network, with the cooperation of the Peruvian Patents Office. Ecuador is also

cooperating in a pilot CAF programme concerned with this topic. The organization OPTI and the Spanish Patent and Trademark Office, which offer similar services in some sectors of the Spanish economy, would be ready to offer technical assistance for the planning and setting up of such an activity.

It might be desirable to establish a multinational working group to consider this idea.

7. *Establishment of a "trademark" policy, on the basis of a denomination of origin ("Fishery product from the South-Eastern Pacific")* and a corresponding quality seal. This is an effective marketing technique. A regional task force should be set up to design and implement the system, with representation from Governments and the production chain. The introduction of the quality seal will need to be preceded by an extensive publicity campaign at the international level.

The quality seal must be validated by an independent control agency on the basis of certain specifications and standards to be drawn up with the participation of the producers, aimed at identifying those characteristics that will be considered reference elements for the purpose of marketing. It is also important that the certification system established should be accessible for small producers.

In addition, an effective programme should be established to ensure the traceability of the various products at both the national and the regional level, as an adequate back-up for the quality seal.

This "trademark" policy will be especially important upon the entry into force of the Free Trade Agreement currently being negotiated.

8. *Reorganization of existing industrial activities at the regional level*. It will be important to orient fishery and aquaculture production towards products with a higher value added, taking into account the capacities of each country and possible complementarities between them. The first step should be an objective country-by-country analysis and the identification of possibilities for the production of one country to be complemented by another. In the foresight analysis, the spaced introduction of various new products to serve as a basis for country specialization was envisaged.

At the regional level, Colombia has relatively limited fishery production and, to meet domestic demand, imports a wide variety of fishery products coming mainly from Ecuador and Peru. In order to share national and regional experience in marketing, it is recommended that a high value-added programme for fishery and aquaculture products should be instituted in Colombia.

9. *Promotion of regional fishery and aquaculture enterprises*. A study should be made of the support mechanisms in the various countries for the establishment of such enterprises, in order to establish a unified approach and the necessary regulations to facilitate the normal, legal conduct of this activity on a regional basis. In this context, particularly desirable would be

the introduction of a specific programme directed towards small and medium enterprises.

The importance of Spain as a strategic ally, mainly in the technological, scientific, financial and operational fields, should be emphasized.

10. *Formulation and implementation in Colombia of a project for the utilization of new fishery resources,* with assistance and advice from Ecuador and Peru. The project will concern the catching, processing and marketing of new marine species that can be commercially exploited on national and export markets.

11. *Coordination among research and development centres and groups* on subjects relating to the fishery production chain. Thought should be given to setting up a permanent coordinating structure, with representatives from all countries at the level of Governments and/or scientific institutions and/or production chain actors, to develop existing capacities and relate them to the needs of the industry.

It would be desirable to establish a multinational working group to take up this question.

12. *Establishment and coordination of programmes for promoting the consumption of fish in Colombia, Ecuador and the interior regions of Peru,* supported by international technical cooperation. Such a programme will include radio, television and press campaigns aimed, inter alia, at showing the nutritional value of fishery and aquaculture products and publicizing the different forms of presentation and preparation of such products.

13. *Cooperation arrangements*

- The Permanent Commission for the South Pacific offers itself as the natural institutional framework for all the proposals (except perhaps for those concerned with aquaculture), with a defined role in monitoring the agreements reached.
- The matters referred to in recommendations 4 (training centre), 5 (technology watch service) and 9 (coordination of technological development and research efforts) may call for the establishment of a single coordinating body, with high-level representation from the countries concerned, to jointly study and negotiate all these proposals, which are closely interrelated. UNIDO specifically recommends the establishment of a *virtual technology centre,* based on efficient use of information and communication technologies, to embrace all these aspects.
- Continuous emphasis was laid on the importance of being able to count on Spain as a strategic ally for many of the activities planned.

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