Postharvest Fishery Losses

Proceedings of an International Workshop Held at The University of Rhode Island

Co-sponsored by the U.S. Agency for International Development and the International Center for Marine Resource Development at The University of Rhode Island

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POSTHARVEST FISHERY LOSSES

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Edited by

Michael T Morrissey

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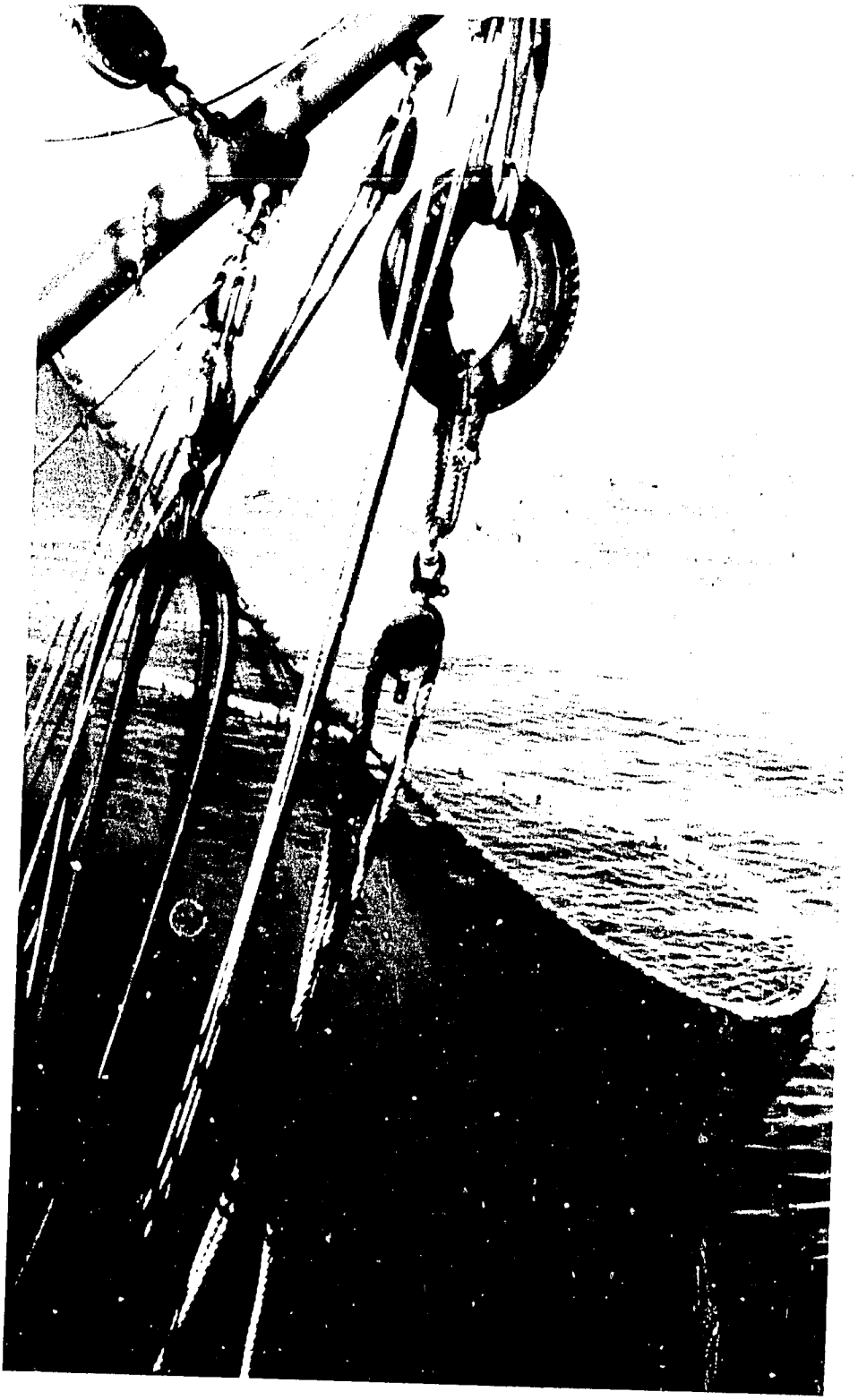
PREFACE

Postharvest fishery losses play an important role in maintaining or increasing the domestic supply of fresh fish or fishery products that can be purchased by middle and lower income level families. In several regions of the world, especially those where the dietary protein levels are marginal, the reduction of fish losses can help alleviate shortages of other protein foods. In areas where fish is a commodity of domestic trade and a significant income generator, a reduction in postharvest fishery losses through inspection and quality control programs can help stabilize the commercialization of fish and fishery products. Scientists and technologists have studied the causes of postharvest fishery losses for several decades. The transfer of appropriate technology that is both cost effective and gives results in the shortest period of time has helped reduce losses. Basic research and the training of scientists from both developed and developing countries, in research as well as in applied technology, are necessary to further reduce losses and increase the utilization of our marine resources.

Although the capture of fish has increased through the past decade, many fishery scientists believe that we will soon reach maximum sustainable yields in many of the commercial species. It was noted throughout the workshop that the emphasis in commercial fisheries has shifted from increased production to increased utilization. Implied in increased utilization is the need for reduction of losses due to poor handling and sanitation throughout the distribution chain. The use of non-conventional species, especially fatty fish, for human food needs to be expanded as well. This concept of utilization was emphasized in the last day of the conference in a statement that the majority of the participants agreed upon. The declaration reads as follows: "The right to harvest national fishery resources carries with it the responsibility on the part of government, fishermen, processors and distributors to maximize its utilization." This workshop took a step forward by establishing guidelines on how this can be accomplished.

The papers in these proceedings represent the authors' views and do not reflect the policy of their agency nor USAID or ICMRD.



RESEARCH AND PROJECT GUIDELINES FOR POSTHARVEST FISHERY LOSSES

There was general agreement at the Postharvest Fishery Losses Workshop that progress has been made over the last two decades in reducing losses. This is due, in part, to a modest success in transfer of technology and to the increased economic importance of fisheries in both domestic and world markets over the last several years. There was unanimous agreement that there is a lot more to be done and that there are various avenues available to further reduce postharvest fishery losses. One afternoon of the Workshop was devoted to work sessions in the following areas:

I. Policy Implementation in Developing Countries

II. The Handling of Fish

III. Preservation

IV. Quality Control and Inspection

V. Fish Processing

VI. Training

The attendees of the Workshop were divided into groups to discuss these topics and formulate guidelines for postharvest fishery loss research and project goals for the next decade. These guidelines were presented the following morning to the assembled Workshop and further refined by editing and correspondence in the ensuing months. It is the desire of the participants that the resulting document be made available to researchers and technologists in postharvest fish technology in both developed and developing countries for their use in soliciting funds from various donor groups for future projects. Policy decision makers will find this document useful as a guide for allocating funds for postharvest fishery projects. In many areas fisheries have become a new and significant part of a nation's economy and many institutes and governments are devoting time and resources to this field. During the last several years, the shift has been so dramatic that in some cases the basis of past research has been

inadequate for the task. It is hoped that these proceedings can play a valuable role in providing a basis for research and development. A tremendous amount of fishery development experience was represented at this meeting which comes through in the observations and guidelines as what works, what can work and what is needed. Fisheries projects and research require continued funding. This document can serve as an important reference that can be used when soliciting funds on a national or international basis.

This chapter is also directed to the researchers from developed countries who are involved or will be involved in fishery development projects in their own countries. As new statistics show that more than 50% of the catch in recent years is from developing countries, there is an ever increasing importance in fostering collaborative research as well as projects in LDCs. Although there is a growing body of literature based on published research on fish and fish handling in the tropic zone, it is not as comprehensive as the published data available on postharvest fish technology for cold water species. There is reason to believe that deterioration in fish harvested in the tropics is different from fish caught in colder waters. Because of this, new techniques need to be developed with research and at institutes in the vicinity of capture. This will have important implications over the next decade and will lead to a rethinking of how research in postharvest handling in tropical conditions can be most effectively carried out.

Administrative roadblocks in both developed and developing countries can be serious handicaps to the efficiency of fishery development projects. Project implementation is often overly dependent on a single institute or research group. The idea of linking key institutes in developed countries with several institutes in a region is an appealing one. Linkages expand the areas of in-country expertise by giving institutes in developing countries access to training and advice on methodology for projects in the region.

Networking, which can be defined as an intra-regional collaboration and collaboration between these institutes and those of developed countries, fits in well with the need to integrate fishery projects. Development projects are complex in that they often require input from disciplines outside the area of seafood technology. A truly integrated project is difficult to accomplish within a single college or institute even in the developed world and it would drain the resources of many research centers in LDCs that often specialize in a certain area. Collaborative research between one or more institutes in developed nations and institutes in several less developed countries allows an integrated approach to regional problems and ensures the continuity of the project work plan despite occasional slowdowns.

This is not to say that fish technology projects on a smaller scale should be discouraged in the future. They will always play an important role especially in defining specific problems indigenous to certain areas. They should also be incorporated into the overall picture of the regional handling, distribution and marketing of fish. All of the Workshop attendees were in agreement regarding the importance of both small- and large-scale postharvest fish technology research to the areas of loss reduction and resource utilization. The importance of these two areas cannot be overstated and need a larger input from donor organizations in the future.

POLICY IMPLEMENTATION IN DEVELOPING COUNTRIES

These recommendations are directed to decision makers in governments and agencies providing technical assistance. The Workshop considered the factors listed below to be of importance in the formulation of policies to reduce postharvest fishery losses and in requesting assistance to address the problems in the postharvest field.

National fishery policies can include the following objectives:

1. To increase income and employment within the fishery sector.

2. To improve the levels of national nutrition, especially the availability of fish protein.

3. To maintain maximum utilization of fishery resources.

4. To increase foreign exchange earnings.

5. To reduce inequities in the distribution of income and food supplies within the fishing community.

The reduction of postharvest fishery losses, although a goal in itself, would best fit these objectives if directed toward maximizing the utilization of fishery resources for direct human consumption. Even with the increased capture of fish over the last few years, there is a growing recognition that fishery resources are approaching maximum exploitation. The reduction of postharvest fishery losses in present catches, therefore, becomes much more relevant in order to sustain supplies to a growing world population.

Although much has been accomplished in fisheries over the past two decades, this workshop looked at important areas that deal directly with postharvest fishery losses and much discussion centered on factors that contribute to the success

and failure of projects in postharvest fish technology. With this in mind, a set of recommendations were made regarding policy implementation in the future. It was felt that the following recommendations will have a positive effect on projects designed to reduce postharvest fishery losses.

Integration of Development Programs

An integrated approach, combining expertise in the fields of fish technology, economics, marketing, sociology, food science and nutrition is required. This need has been recognized in recent years but means of implementation still have to be worked out. The postharvest field with its emphasis on handling, processing, distribution and marketing is a complex series of events that is challenging to the project team involved in its implementation. Vertical integration of the seafood industry into project implementation as well as the horizontal integration of the disciplines mentioned above in solving postharvest fishery problems is necessary not only during execution of the project but also in its planning stages to ensure a greater chance of achieving project goals.

Research

The backing of research institutes in all the integrated disciplines is a fundamental requirement to identifying and reducing postharvest losses. Collaborative networks, established on a regional basis, in which institutes from developed and developing countries can participate would be the most effective mechanism of carrying out research goals. To maximize the utilization of fishery resources, governments should be encouraged to stimulate active participation by the private sector in fishery projects through joint funding in cash or kind. Benefits to the targeted population in projects with private sector involvement should be evident.

Training and Extension

Fishery development programs with elements of postharvest loss prevention should include provisions for training the technologists who will become trainers at the national level. Training in all the integrated disciplines should be included in this package. An effective extension service backstopped by these trainers is essential in order to carry the message to the beach level and throughout the distribution chain. Although new techniques will play an important role in reducing losses, the extension service should remain responsive to the traditions of the fishing community emphasizing the utilization of human resources and applying technology that is socially and culturally appropriate.

Information

Better exchange of information about ongoing activities is required. While publications are an effective medium, a series of workshops or seminars is also a necessity. Research scientists and technologists from developing countries need access to an on-line source of reference material. Project information from institutes will help refine methodologies used in the research field to reduce postharvest fishery losses, define areas where expanded research is necessary and help promote the successful transfer of appropriate technology.

Monitoring and Evaluation

More effective means of monitoring and evaluating projects are required to ensure that corrective action is being taken and that technology is being successfully transferred. Ongoing project evaluation rather than post project reports could be effective in determining whether target populations are benefiting from implementation. How the project will be evaluated and monitored should be determined in the planning stages and a certain degree of flexibility should be built into the project if evaluators deem it necessary to change methodologies or some project objectives.

Transfer of Technology

The successful transfer of appropriate technology is a common goal of most fishery projects. The success or failure of this transfer is dependent on several variables, not always apparent during the planning or implementation of the project. In many cases the technology of traditional methods of preservation and handling is available but not utilized by targeted groups due to impediments that range from untrained personnel to inadequate infrastructure. In some cases an intermediate semi-government group may be needed to act as a go-between for the government, scientists/technologists and the fishery sector that has studied regional problems. The international community should become involved to help these groups and international pressure should be applied when required. Funding should be available when there is a commitment from a government to reduce postharvest fishery losses. The success and failure of projects in the field of postharvest fish technology and the transfer of this technology for reducing postharvest losses, although difficult to measure accurately, need to be discussed in an open forum. A global network in this field is needed to provide continuity. Development technology meetings, at regular two-year intervals, would greatly facilitate this exchange of information. These meetings could be a major function of a donor agency.

New Initiatives

New techniques should be introduced and new directions taken. With increasing world wide demand for fresh fish and fishery products, there will be an added emphasis on utilizing all the fish that is captured from the sea. There is a need to increase efforts to transfer technology to small-scale entrepreneurs and this can only be done with an understanding of their needs and constraints as well as the needs of targeted populations. Efforts to stimulate domestic fish consumption, especially for underutilized fish species, should be applied through social marketing studies that incorporate socio-economic research as part of an integrated approach to postharvest fishery research problems.

THE HANDLING OF FISH

One of the stated policy goals was to improve the national level of nutrition in developing countries. The targeted populations are the lower economic fraction that normally have low animal protein levels in their diet. The highly priced species of white fish are outside the purchasing ability for this segment of population and therefore research or project emphasis would be on the utilization of low value species of fish. Often these fish are small in size, of little economic value and are presently handled in bulk in such a way that they can only be utilized for fish meal. To increase their utilization for human consumption it is necessary to:

1. Optimize the handling of small fish in bulk for human consumption.

2. Design boats and gear to better accommodate this type of catch.

3. Increase the number of studies of the use of refrigerated or chilled sea water or other methods of preserving the catch.

4. Devise systems for sorting fish on board for storage and preprocessing.

THE PRESERVATION OF FRESH FISH

In this work session the preservation of both high value and low value fish species was discussed: low value fish for the purpose of presenting an acceptable quality product for processing and direct domestic consumption, and high value fish for satisfying the needs of the domestic market as well as allowing for export opportunities. It was noted that the

majority of fish that are utilized by LDCs are harvested in tropical waters and that there is a great need for more basic information on the microbiological, biochemical and physical changes that occur after capture. Specific needs are as follows:

1. The chemical composition of many species of fish from tropical waters is not known. Basic studies on their composition are necessary.

2. More research on the microflora of tropical fish is needed to understand shelf life parameters.

3. The important biochemical reactions that occur in tropical fish should be looked at and compared with studies done with fish from temperate zones.

4. Laboratory research into new methods, both chemical and physical, to preserve fish should be encouraged.

5. Preservation of small pelagic fish on board using known and new techniques should be studied from both an organoleptic and economic approach.

6. Rancidity studies, especially in high fat fish such as sardine and mackerel, should be intensified. The use of natural antioxidants and different packaging methods should be explored.

7. The optimal use of ice, often in short supply in LDCs, both during storage on the fishing vessel and during distribution and sale on land should be investigated.

QUALITY CONTROL AND INSPECTION

Quality control and its ramifications will play one of the most important roles in reducing postharvest fishery losses in the future. There is an increasing demand for expertise from developing countries for technical assistance to establish quality control and inspection programs for fresh fish and seafood. At present this is directly related to the current demand for high quality fish for export. Many governments see this as a means to obtain foreign capital. Whether the same emphasis will be placed on evaluating opportunities for improving the quality and increasing the value of products for domestic markets remains to be seen. This will depend upon consumer perceptions of quality, real demand for better products and consumer purchasing power. There is no doubt that an improvement in quality and inspection programs would, in the

long run, reduce postharvest fishery losses worldwide. Some of the recommendations in this area are:

1. Sensory evaluation of fish should be standardized, especially if import regulations are more stringent in the future.

2. Standardization of instrumental quality control should also be done on a world wide basis when possible. The feasibility of a grading system based on standards should be studied.

3. Acceptance of uniform international criteria for quality need to be established for both export and domestic use.

4. Development of codes of good manufacturing practice (GMP) for the hygienic processing of aquatic products under conditions prevailing in the tropics. GMPs presently incorporated in textbooks or guidelines emanate from developed countries which are in temperate zones. There has been no critical study of hygiene or sanitation of processing under tropical conditions.

5. Reasonable health risk standards need to be established and when established, strictly enforced. These include standards for:

   - disease causing microorganisms
   - mycotoxins and nitrosamines in cured fish
   - chemical contaminants

6. The indiscriminate use of insecticides has caused great concern in several LDCs. Establishment of enforceable insecticide guidelines for cured fish products as well as more research into insecticide alternatives such as insect attractants or physical exclusion by equipment design and packaging is needed.

7. A manual on how to export fish and seafood products, including quality assessment, packaging and import laws needs to be developed for countries requesting this type of assistance.

PROCESSING

There was a strong feeling within the working group that dealt with seafood processing that the major emphasis for future research and projects in this area should be on processing for domestic consumption. There are relatively good information and research programs at many institutes in the

developed world dealing with the processing of seafood, its protein interaction in gels, behavior under thermal processing parameters, freezing techniques, etc. Although there is a need for continued funding for this area of research, many of the attendees felt there were other more important fields that are seldom looked at in a scientific manner. These areas deal more with traditional processing methods, most often for cured fish products. They are at present poorly defined and poorly understood. The optimization of traditional methods for preparing fish should be a major goal in the reduction of postharvest fishery losses. Some of the more specific areas are as follows:

Cured and Dried Products

1. Definition of the principles (biochemical, microbial, and physical) which are involved for each of the processes.

2. Assessment of proposed methods for product improvement, accelerated production, and simplification of technology that will allow optimization and improvement of economic viability of these processes.

3. Definition of product characteristics important for consumer acceptance that can be used to monitor the effects of changes in processing methods.

4. Design changes for equipment and accessories.

5. Assessment of the use of new materials for bulk packaging that will exclude moisture and prevent insect penetration.

6. Review of hygiene and sanitation parameters throughout all processes.

Thermally Processed Products (Exports and Domestic)

1. Nonmetallic containers (pouches) need evaluation for sterilization, and organoleptic parameters for different seafoods and economic feasibility need to be established.

2. Plastic "canning" should be seriously studied as an alternative, especially in countries where metal costs are prohibitive.

Frozen Fish Products

1. An evaluation of frozen product potential as an alternative to canning should be looked at on a country by country basis.

2. Energy efficient means of freezing and of frozen storage of seafoods need to be developed.

3. Product stability, especially of high fat species, during long term frozen storage needs further research.

New Products For Nutrition Enhancement And Resource Utilization

1. Social marketing, which identifies real needs and perceptions within target communities, should play a more important role in product development.

2. Enrichment of traditional products needs emphasis.

3. Methodologies for measuring consumer acceptance in LDCs need refinement in order to better evaluate products.

4. "Classless" products appealing to all ranges of socio-economic levels are recommended for product development (e.g. noodles, partially made from fish paste as in Asia).

5. Minced fish has potential uses in dispersed and structured forms that should be explored.

TRAINING

In implementing a world wide strategy for reducing postharvest fishery losses, there was general agreement at the workshop that training is one of the most important factors in accomplishing this goal. This was strongly felt by representatives of both the developing and the developed world. There is no question that a large body of information exists but is only utilized to a limited degree. Many institutions in developed countries have run successful training programs that have had low impact on LDCs due to misguided attempts to direct the courses at policy makers rather than extension workers. Training programs in postharvest technology need to include an avenue to the beach level. Administrative personnel cannot improve the quality of the prime material or reduce its loss if good procedures are not taught to the fishermen and fish handlers themselves.

A program directed at the trainers - those who bring the message to the fish handlers - is needed so that a transfer of information and technology can occur. This type of training can often be best accomplished in the ho : country or region. It is more cost effective, especially in terms of travel and living expenses, for instructors from institutes or universities to collaborate in training programs with institutes in developing countries with whom they have an

agreement of cooperation. This ties in well with the concept of establishing links between regional institutes in developing nations with institutes in developed countries.

Several scientists from LDCs also stressed the importance of overseas training for researchers from developing countries. The need to continue this type of training is important to incorporate new ideas, scientific contacts and methodologies in order to expand the research capabilities of the country. Many of them feel that this has been successful in the past and should continue in some form whether it be formal degree training or training involved with joint research projects.

Training at the industry level has been neglected in the past and should be increased both domestically and on the international level. The seafood industry, both large and small-scale, will play an increasing role in the policy goals of many developing countries and the integration of the industry into various development projects will serve to better articulate projects aimed at the reduction of postharvest fishery losses.

Some specific goals for training and information transfer are summarized as follows:

1. Training programs should be established on a regional basis and should address specific problems.

2. Training the trainers should be emphasized.

3. Specialized courses in traditional fish processing, handling small pelagic fishes, sanitation and hygiene, and quality control need to be developed and focused on the needs of LDCs.

4. Development of training programs for officers in national fish inspection and quality control services should be implemented.

5. Development of a fishery extension service and training programs for extension officers should be encouraged. Where these programs exist, the extension mechanism needs expansion to identify problems, obtain solutions from local experts and provide these to users.

6. Joint research projects should include formal training of scientists and technicians from LDCs who participate in the projects.

POSTHARVEST FISHERY LOSSES: A DEFINITION OF TERMS

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INTRODUCTION

Reports by various international institutions and funding agencies indicate that, within the entire postharvest food system, losses in the small-scale fisheries sector are among the highest for all the food commodities. It has been estimated that from time of capture to the point of consumption, fishery losses range from 20 to 40% of the harvest (National Research Council, 1978). Major losses are due to improper handling, poor preservation and storage techniques, distribution and marketing problems as well as the non-utilization of edible species.

From the nutritional standpoint, fish is one of the most important animal protein foods available in many of the less developed countries (LDCs) (James, 1984). Approximately 53% of the world's harvest is captured by developing nations and a large portion of that catch is consumed domestically (FAO, 1985). In regions of Southeast Asia 60 - 70% of the animal protein in the human diet is supplied by fish. Other areas in Asia as well as Africa depend on fish to supply a significant part of the animal protein in the diet. Fish can be regarded as an indispensable food item for large segments of the world's population where protein needs are great (Pariser, 1973). Furthermore, small-scale fishery operations directly affect the well-being of a major portion of the poor in these countries by means of employment opportunities as well as food consumption.

The limited supply of sustainable fishery resources dictates that increasing demands for fishery products in the future will not be satisfied solely by increasing the fish harvest. However, a net increase in production and availability of good quality fish and fishery products can be achieved through an effective postharvest fishery system that will reduce losses of this commodity.

A definition of postharvest fishery losses (PHFL) is a relatively simple task for this workshop. Defining the complex

interaction between the various disciplines that are involved in PHFL is more difficult as we shall see throughout the workshop presentations. My talk will be divided into two parts. The first will be a definition of terms and concepts that have been traditionally presented with reference to PHFL. The second part will be an attempt to shed some more light on the interweaving of technological, economic, sociocultural and other factors that influence the success or failure of projects to lessen PHFL throughout the world.

PHFL can be defined as nutrient and/or economic loss from fish that can be potentially utilized as human food. PHFL can occur for fish specifically captured for other uses such as fish meal, as in the fishing of small pelagic species when a larger percentage could be directed to human consumption. One type of economic loss is physical deterioration due to spoilage from improper handling or mechanical breakdown. This may result in the total or partial loss of the catch and temporary economic hardship for the fisherman and/or distributor. Economic losses can also occur from an overabundance of catch, especially for seasonal fish. Lack of cold storage or processing capabilities may cause the market to be flooded drastically reducing the market value of the fish and negating profits to the fisherman. Economic losses in seafood that is exported and subsequently rejected is a recognized problem in highly priced products such as shrimp and swordfish. These products may be rejected due to bacterial contamination, presence of heavy metals, chemicals or pollutants, or because they don't meet the quality standards of the importing country. Changes in quality can affect the value of domestic seafood products as well. In developed countries a reduction of quality or grade is usually reflected in a lower value for the fish and an economic loss. This direct relationship between quality and economic loss is not as readily apparent in many LDCs when the fish is consumed domestically. Quality can be a two-edged sword. On the one hand, we have the need to improve the quality of fresh fish and fishery products in LDCs in order to reduce PHFL, present a more palatable product to that nation's consumer and create new markets and employment opportunities. On the other hand, there is the possibility that improvement in quality can represent an increase in cost. We should realize that if we are targeting lower income populations to benefit from improved technology and improved quality, we need to understand how the market system of the region works and how the purchasing power of the targeted populations will be affected. The interrelationship between improved quality and increased price is an important one and needs to be addressed in a workshop such as this.

Nutritive losses, with regard to PHFL, are also not well defined or studied. Fish that has decomposed to such a degree that it is unfit or unsafe for human consumption can be

considered a nutritive loss. Likewise, fish that is discarded at sea due to its low economic value or lack of marketing schemes are regarded by many as a nutritive loss (this is one example where economic loss and nutritive loss are not directly related). Where it remains unclear is in the relationship between quality and nutrition. No one would argue against the positive effects of eating fresh seafood as opposed to seafood that has decreased considerably in quality. One can argue, however, that seafood that has dropped in quality, and may represent a lower economic value, may not suffer a similar downgrading in nutritional value. This is almost certainly true in fresh seafood as long as it can be consumed and there is no safety hazard related to its decrease in quality. Processed seafood, especially the traditional processes of hard smoking in certain regions in Africa, may represent a nutritional loss if the process is to the extreme for the sake of extending its shelf-life indefinitely. Quantifying these losses is very problematical as again there has been little research in this area.

DEFINITION OF TERMS

For this workshop, there is need for a definition of terms. The basis of these definitions come from the National Academy of Sciences (NAS) report of 1978 and restructured for PHFL.

Postharvest - This period begins when the food item is separated from its growth medium. With regard to fisheries this would mean capture in a net (including a gill net in which the fish may still theoretically be in its medium but is now concentrating its efforts on escape and survival rather than growth), on hook and line or by stunning. Traps and weirs represent a special case and can be thought of as holding tanks such as aquaculture pens in that they do not inflict physical damage on the fish.

Fishery - Although our focus is on fish and related species, we should also include other edible resources such as shellfish and molluscs, aquatic plants, etc. Basically anything that is captured by small-scale fishermen that will be later used for human consumption can be included in this definition.

Losses - Losses, as we had mentioned earlier, can be divided into nutritive loss and economic loss. Quantitative and qualitative losses should be considered within the framework of nutritive and economic loss and should be determined under the backdrop of the socio-cultural constraints of the region where problems in PHFL projects occur.

Again, using the NAS report as a guideline there is a need to define loss assessment.

Quantification of Losses - This is one of the critical areas of PHFL because of the fact that good accurate data is hard to come by. Quantification methodologies can be further subdivided into:

1) Assessment: a rough quantitative approximation of loss of the product as a food item. This is a subjective judgement due to the lack of information and usually used to help identify priority areas in the distribution chain for remedial action.

2) Measurement: a more precise and objective evaluation of the losses that occur between harvest and consumption. This implies a developed methodology, usually for a specific fishery product in a specific region with a defined set of variables, i.e. season, type of harvest, distribution system, etc.

3) Estimation: the interpretation of several scientific measurements to give a reasonably accurate picture of PHFL in an area.

One of the major problems that scientists and technologists face in the PHFL field is the estimation of losses. One of the reasons for this is the fact that if a project goal for a country is to reduce PHFL for one or more products, there is a need for some form of quantification or base-line data describing the losses. There has been, with the exception of the loss estimation projects in West Africa most notably by the Tropical Development Research Institute (Wood and Walker, 1986), very little generation of hard data. Some of the reasons for this paucity of accurate information are related to the problem of developing a methodology that is accurate in measuring PHFL within a given region. Some of these complications are due to the number of species of fish that are involved in fisheries in tropical waters, the lack of uniformity in weight and shape that occurs with small-scale fisheries and their variability of spoilage rates under different conditions. In addition to this is the fractured distribution system of fresh fish that is found in LDCs with the involvement of many fishing groups and several levels of middlemen throughout the distribution chain. The cost of a loss estimation project would be very high and this presents an ethical question to the donor institution and/or the country in which these studies need to be done. With limited funds for postharvest fishery projects, we can ask ourselves would it be more valuable in financing studies to generate baseline data or

would researchers and the targeted population be better off to redirect the funds for actual project implementation. The latter would employ a rapid assessment study to hopefully identify priority areas. It is not an easy choice, and what is needed is a middle ground so that fishery projects in this area can be effective and have some basis for success.

Other terms that are important to the area of PHFL and need to be defined are the following:

Incidental Catches - Edible aquatic resources which are captured along with the targeted species (Slavin, 1982). Unlike other food commodities, incidental catch, in fisheries can be considered a PHFL. Although, in this workshop, we will focus more on losses that occur in the directed capture of specific marine resources, we cannot ignore the fact that what was captured in trawls and discarded a decade ago is now actively harvested and utilized. For an industry that has been often maligned as overly traditional and not ready to change, we have seen a virtual revolution, brought about by higher consumer demand, in the utilization of the natural resources available.

Waste - That which is currently discarded from normal processing conditions, and not considered usable. This also has changed dramatically as evidenced by the increasing research in shellfish waste technology that has shown multiple potential uses for products derived from these wastes. Furthermore, waste will be an increasing problem in LDCs and how it is disposed can readily affect the final fishery product if it contributes to contamination.

PHFL will occur throughout the distribution chain from the moment the fish is captured until it is placed on the consumer's table. Some of the key areas in which PHFL occur are the following:

Methods of Capture

Different methods such as bottom trawl, purse seine, long lines or traps will all affect the quality of the fish that are brought aboard the fishing boat. Fish that are harvested in a manner that will physically damage the fish or cause delays in preprocessing or preservation are at a disadvantage from fish harvested as quickly as possible and with minimal abuse. An important role can be played by fishery technologists by developing fish capture mechanisms that are not only efficient and economical but also bring the fish aboard in the highest quality.

On-Board Handling

How fish are handled on-board is often indicative of how the fish will be treated throughout the distribution system. If ice or chilling systems can be and are used, there is a much greater chance for the catch to reach shore with less spoilage and be handled as a highly perishable food item. On-board handling sets the stage for quality and storage life of the captured fish.

Preservation and Storage

The preservation techniques of fresh fish begin on-board and are continued throughout the distribution chain. An overwhelming body of evidence has shown that ice and chilled storage, along with procedures such as evisceration and proper washing in conjunction with the general norms of sanitation have a positive effect on the quality and shelf-life of fish. In countries where the use of ice is not a realistic option, fish handlers are dependent on common sense practices such as keeping the fish clean, shading when possible or using alternative traditional processing procedures such as salting or drying to preserve the fish.

Distribution

In general, the more rapid the distribution system, the better chance we have to sell fish of good quality and reduce PHFL. Distribution has been a problem in many developing countries in moving the product from the coast to inland markets. If a strategic goal of a fishery project is to increase consumption of fish for a segment of the population, the project should include a plan on how the fish or the fishery product can get to the targeted population in relatively good quality.

Marketing

Increasing fish capture or the development of new fishery products does little to help solve nutritional problems of a country if the products are not consumed due to poor marketing or cultural impediments. Probably our greatest failures in reducing PHFL within a country is the lack of understanding and/or utilization of the driving economic forces of the marketplace for both fresh fish and fishery products.

Processing

Processing can be divided into two sections. Traditional processing includes the optimization of smoking, salting, and

drying techniques that are used to preserve fish in areas where ice and normal preservation methods are not available. There is often destruction of the micronutrients in this method of processing, but it allows for a wider distribution range as these products will keep well at normal ambient temperatures. Innovative processing, such as the development of fish minces and seafood analogues, can also lessen the nutritive quality of fish (seafood analogues are usually made from fish minces that have been washed several times, depleting the product of several water soluble nutrients and fish oils), while the trade off is the ability to develop edible products from several underutilized species that can be used for both domestic consumption and foreign export material.

INTEGRATION OF DISCIPLINES FOR LOSS REDUCTION

Improving methods in any one of these stages will help to reduce PHFL but will not completely solve the problem. An overall project plan that encompasses all of these stages will have a better chance of success. Fish is one of the more highly perishable food items yet can serve as an excellent animal protein source in developing countries. The last twenty years have shown an increase in the research of fish handling, preservation and processing and there is a better understanding of the basic principles in postharvest fishery technology. Also there is a renewed interest in fish utilization, i.e. the use of formerly discarded species of fish and fish waste and the opening up of markets, both domestic and foreign, for fish captured in developing countries. The dissemination of this information to appropriate LDCs has not been as successful as we would have hoped. Research institutes in developed countries in general need to be sensitive to the needs and capabilities of their counterparts in LDCs. Building network organizations or regional information distribution sources would be one method of focusing the scientific needs of a region in postharvest fishery technology.

A key problem in the reduction of PHFL has been the lack of integration of different disciplines in the project planning in this area. There has been a gradual change from purely technological projects to a more integrated approach to fishery problems but it has been slow going. PHFL projects should use the following disciplines to help insure some success for the project.

Fishery Technology
Food Science
Nutrition
Sociology
Economics

With regard to large-scale PHFL projects, we often find the fishery technologist improving the methods of capture and on board handling techniques, the food scientist devising better methods of preservation, storage and processing, and the nutritionist determining if the targeted population is benefiting from the project. Meanwhile, if the sociologist was not brought into the planning stages of the project, he or she will gladly show us why the project isn't functioning properly due to the socio-cultural factors that we failed to recognize. Finally, the economist is called in at the end for an evaluation study and to give a detailed explanation of why the project didn't work. Ideally, we should reverse the order listed above and have economists and sociologists in at the initial project planning stages to help determine the appropriateness of the technology we are trying to transfer. Over the past several years, various organizations and donor groups that give technical assistance have realized the importance of an integrated approach to large-scale fishery projects. The implementation of a truly integrated project is a difficult road however, and integration itself will not guarantee the success of the project. Specialists tend to be negative about the applicability of other fields of study in a multi-disciplinary approach to projects in developing nations and thus be negative about the project in general. This is due in part to the need to protect one's own self interest and to the lack of understanding the principles of other disciplines. A technologist/scientist prefers to work at the level of 90% or better probability of experimental success while the sociologist or economist cannot predict the outcome with such accuracy because there are often more variables to be taken into account and the correlation between any two variables is inevitably weaker. This can result in prejudices that need to be overcome if a good working relationship is to be developed. Integrated projects require strong yet flexible project leaders to bring these several different disciplines to a consensus about fishery project proposals. There is no set methodology for inter-disciplinary cooperation in international development projects and institutions need to develop their own mechanisms. It is important enough that these mechanisms be worked out if we are to be more successful in the implementation of project ideas and goals in the future.

For this reason, it is necessary to foster joint projects whether they be within one organization or whether they combine the technical and economic resources of two or more institutions in countries that fund projects in developing nations incorporating various disciplines in an effort to solve PHFL problems. There is recognition among ourselves and various funding organizations that fishery related problems, including those that deal with PHFL, have less of a chance of being solved without an integrated approach. It is

no longer a question of who can build the better smoker for a West African nation but rather who can assure that the fish going into and the product coming out of that smoker is of good quality, will have adequate distribution and be marketed in such a manner that targeted populations will benefit. Some of the institutions represented here have the financial and human resources to implement projects on a larger scale, others do not. Although cooperation between countries and between different institutions working within a country may seem idealistic, it should be tried and with the right guidelines can be successful. It is an important enough issue, as you have demonstrated by your participation in this workshop.

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FISHERIES POLICY AND ORGANIZATION: INFLUENCE ON POSTHARVEST LOSSES

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ABSTRACT

The paper discusses the influence of fisheries sector policy and organizational alternatives on postharvest losses. The discussion concentrates on the articulation between the capture and onshore strategies and how their performances may be affected by location of investment and choice of fisheries management approach. The establishment of a quality gradient, development of manpower training and consumer education are organizational features which are reviewed in relation to the efficiency of the fish production chain. The paper concludes that significant reductions could be made in postharvest losses following careful manipulation of policy and organization factors.

INTRODUCTION

For workers in the fisheries sector who have an interest in the reduction of postharvest losses there is an understandable need to quickly come to grips with the technical issues. This approach has led to the identification and in some cases the remedy of the postharvest problems which occur in various parts of the fish production system. While much of the time at this workshop will be devoted to an analysis of the success and failures of these remedies, this paper considers the influence of policy and organizational alternatives on the generation or limitation of postharvest losses.

The structure and function of the fish production system for a given state will be determined within the fisheries sectoral plan. The plan will cover operations ranging from resource harvesting through processing and product development to marketing and consumer acceptance, but more often than not, it will be concerned with the articulation of the two major components - the harvesting and onshore operations. Ideally a

well developed and implemented sectoral plan should result in a smoothly run production chain in which production fits capacity and there is a minimum of postharvest wastage. This ideal is seldom achieved and the symptoms of disharmony are those familiar to all postharvest technologists: catches in excess of capacity, by-catches, discards, damage of raw materials and products caused by poor handling, biochemical and microbiological spoilage and the sometimes less apparent losses incurred through adverse changes in nutritional value. Given that the majority of the world's marine exploitation fisheries are either fully or over-exploited there is the incentive to overcome postharvest wastage.

Location of Sectoral Investment

The choice of location of investment in the fisheries sector is possibly the earliest point where decisions are taken which can have a bearing on postharvest losses. As in any other sector, there is intense competition for funds. Elements in the fisheries sector and even parts of the same fish production chain might have to compete for funds from the same source. Thus a project to develop an underexploited resource might be in competition with a project to improve postharvest handling of the catch. This is currently the case in Mauritania where a shrimp fisheries exploitation project is competing with a project aimed at improving the country's market infrastructure (Crown Agents, unpublished data). In such circumstances the comparatively easy profits to be made from expanded catching capacity may seem a more viable investment than a project which seeks to boost earnings by reducing wastage and improving quality. However as the number of "green field" exploitation options is reduced, it is likely that projects for reducing postharvest losses will be in a stronger position to compete for funds.

In certain fish industries the dominance of investment in one area can have an adverse effect on development potential in others. In Mexico, for example, the shrimp industry is arguably the most powerful subsector of the nation's fish production systems. The high market value of the shrimp export product has attracted substantial investment to the fishing fleet and onshore infrastructure. There is no doubt that the industry is overcapitalized and should be looking to diversify its activities. However, there is little interest in financing schemes to develop the less valuable fin fish exploitation, especially use of the shrimp by-catch. In Mexico it has been estimated that at least 300,000 tons of by-catch is disposed of at sea each year (Young, 1979).

In some states, changes in fisheries policy aimed at boosting earnings from resources exploited by foreign fleets within a nation's exclusive economic zone (EEZ) have had

repercussions on the level of the postharvest losses and catch value. For example, Mauritania now insists that licensed vessels land their catches in Mauritania and not in foreign ports. It is believed, however, that inferior handling facilities and poorly trained workers in the port of Nouadhibou have led to a decrease in the graded value of the catch and an increase in postharvest losses (Li, personal communication). This contrasts with the situation that prevailed before when the catches were landed in Las Palmas. Comitini and Hardjolukito (1986) comment on a similar situation in Indonesia where the government insists on indigenous exploitation and handling of large species of tuna when it is known that the foreign licensed fleet performs better in terms of operating and financial results.

There is a growing awareness in developed and less developed countries that it is essential to invest in quality assurance programs in order to develop and maintain national and export markets. It is interesting to note that the level of investment in quality assurance (determined in US dollars per kilogram of product inspected) is of a similar order of magnitude measured from country to country. Slavin (1987) quotes a range of US$ 0.009 to 0.017 per kilogram of inspected product for New Zealand, Canada and Japan. Slavin further comments that values of inspection for meat and poultry in the United States also fall within this range. Encouraging this investment is essential for the reduction of postharvest losses, which Herborg (1987) believes could be halved in companies which hitherto did not have quality assurance programs and as a consequence suffered postharvest losses of the order of 5-10% of the company turnover.

Fisheries Management Strategy

The success of the fisheries exploitation sector depends upon employing an effective system of fisheries management. However, the implementation of such a system represents one of the greatest challenges facing fisheries administrators and there are few systems which are regarded as successful (Beddington and Rettig, 1983). Whichever system is employed will have a significant effect upon postharvest losses especially in the generation or limitation of by-catches and discards. (NB: By-catches are defined as the incidental catch of other species associated with a particular target fishery, while discards are defined as undersized specimens of the target species.)

The by-catch problem is particularly acute in the world's penaeid shrimp fisheries where it has been estimated that the global by-catch is between three and five million tons per annum (Slavin, 1981). This represents a considerable loss of marine biomass which is harvested but not utilized. The

economic aspects of the problem are brought sharply into focus when considering the effects of the Bering Sea fishery for Alaskan pollock upon the artisanal fisheries in the same area. Marasco and Terry (1982) estimated that postharvest losses (mainly by-catch of halibut and chinook salmon) attributed to the Alaskan pollock trawl fishery cost the artisanal fishermen a total of US $10.4 million in lost revenue. This observation has been instrumental in determining an appropriate fisheries management plan for the region and this has in turn led to a less wasteful relationship between the target fisheries.

A variety of techniques is available for managing fisheries and these techniques are also important in limiting by-catches and discards. The main methods used are as follows:

1. Reduction of fishing effort - a diminution of fishing effort reduces pressure on the target stock(s) with a consequent reduction of effort on non-target species and discards. In certain tropical demersal fisheries, the level of fishing effort may be so intense that long-term changes in the composition of the catch will occur, resulting in high value fin fish and crustacean species being replaced by low value fin fish and invertebrates (Pauly and Murphy, 1981). Once again this will contribute to a significant level of postharvest wastage.

2. Alternative harvesting methods - the use of more selective fishing methods will reduce by-catches and can often limit mechanical damage to the catch. For this reason squid jigging is preferred to trawling for squid. The jigging operation leads to much reduced by-catch and better quality squid, but the yield per unit fishing effort may not be as high as in trawling. In Indonesia a number of the regional fisheries authorities have banned trawling in favor of more selective fishing methods.

3. Increased mesh sizes - it has been shown that an increase in trawl mesh size from 70 mm to 90 mm in the North Sea trawl fisheries would lead to significant long-term benefits (other factors remaining constant) in the haddock and whiting fisheries (MAFF, 1986). The level of discards would be reduced and in the case of haddock, the overall yield per recruit would increase. Similarly a larger mesh size used in shrimping operations would reduce the level of by-catch but would also very likely reduce the catch of the target species.

4. Licensing or quota regulation - some success has been achieved in reducing postharvest losses by legislating for certain tolerance levels of by-catch. For example, in the North Sea sprat fisheries the permitted level of herring

by-catch is 10% of the catch total. Obviously the success of the method depends very much on effective enforcement.

5. Restricted areas - by-catch and discard levels can be reduced by declaring zones in which certain methods of fishing or fishing gears may not be used. Thus the foreign fleets fishing within the Mauritanian EEZ are not permitted within three miles of the coast. Similarly the "pout box" off the NE Coast of Scotland is a closed area to industrial fishing for Norway pout, and is designed to protect juvenile white fish from sustaining incidental fishing pressure.

6. Closure of a fishery - this severe form of management policy, only used when the fish stock is deemed to have collapsed, can have rather negative effects upon the onshore sector and indeed upon postharvest losses. The North Sea herring fishery was closed for a period of three years during the 1970's. On reopening the fishery a catch of 30,000 tons was recorded for UK vessels. Before closure of this fishery, virtually all of the catch was used for the preparation of products for human consumption. Unfortunately during closure the processing and marketing infrastructure had undergone change and when the fishery was reopened was unable to deal with the landings in the traditional manner. Consequently a considerable proportion of the catch (11,000 tons) was "lost" to fish meal production and thus was not available for direct human consumption (MacSween, 1984).

There is no doubt that the management techniques exist to give a better utilization of the world's fish catches. However there are other competing objectives which ensure that fisheries management is a difficult science to apply. Nonetheless with the appropriate political and investment support, it should be possible to restructure the activities of the world's fleets to substantially reduce the levels of postharvest losses particularly of by-catches and discards.

Onshore Strategy

It is important that the harvesting element of the fish production chain articulates well with the onshore sector. The fisheries management strategy can help in achieving this but there will be problems as is exemplified when a fishery is closed to exploitation. The main concern of the onshore sector with regard to postharvest losses is to limit quality decline as the products pass to the consumer through the processing, preservation, storage and distribution chain. The smooth running of the distribution system is crucial to the

maintenance of quality, and all fish production systems are subject to problems caused by overlong retention of products in the system, excessive handling, unnecessary trans-shipment and a fragmented distribution chain.

A recent survey (Crown Agents, unpublished data) of the fish production systems in Mexico considered the relative merits of the various operations which are responsible for the distribution of fish and shellfish throughout the nation. Integrated operations, in which a single organization or company is responsible for all the elements in the fish production system from catching through to marketing the products to the consumers, are mostly restricted to the public sector. The private sector consists of small scale processors, distributors, wholesalers and retailers. Broad estimates of postharvest losses which build up in the distribution chain in Mexico are put at between 10 to 15% for chilled fish. There is however a distinct difference in performance between the private and public (parastatal) organizations with regard to onshore strategy. The parastatals tend to run rather inefficiently in that low loadings of product pass through the system. However the storage and distribution infrastructure of the parastatals is adequate, resulting in the delivery of relatively high quality products to the consumer. The management authorities of the parastatals are keen to minimize aggregate postharvest losses, and it is estimated the the total annual losses are less than 5% for specific parastatals. Not so in the fragmented private sector where individual operators in the production chain are less concerned with the performance of the entire chain. It is not easy to build in incentives to maintain quality and reduce losses in the fragmented system especially if malpractices in one part of the chain causes losses at a later stage when the product is the responsibility of a different operator. The situation in Mexico is exacerbated by illegal fish traders, capable of hiking fish prices, and consumers who are not discerning with regard to fish quality. Furthermore there is heavy reliance on distributing fish from the production areas direct to Mexico City, thus other areas of the country away from the coast do not have access to fish supplies, or must rely on securing supplies via Mexico City and not directly from the production areas. In some cases the fish and shellfish landed in coastal states is not available for retail in those states until it has first journeyed to and from Mexico City. Extra handling and trans-shipment of this type appears to be carried out with the motive of securing a higher price for the catch. However this may not always be the case and will lead to a decline in the quality of the raw material and consequently the build up of postharvest losses. Improvements in the provincial market infrastructure, more rapid distribution of chilled fish and decentralization of the

national marketing system are some of the important measures which have been proposed to enhance fish consumption and improve the onshore strategy.

A different approach to the problem of by-catch which takes advantage of onshore organization and infrastructure is that of utilization. Indeed some national markets, notably in Spain and Japan, will absorb incidental harvest as readily as harvest of target species. For other nations however the inherent problems of the by-catch as a raw material (i.e. extreme heterogeneity of composition; presence of toxic or venomous species; small size of individuals of the component species) preclude ready utilization through existing market outlets. Indeed the most appropriate usage for by-catch in these circumstances is deemed to be production of animal feeds, notably fish meals. This route of utilization has not proved to be very successful as the fish meals derived from, for example, shrimp by-catch are not as competitive as those derived from the more conventional sources, notably small pelagics. There is a technology problem to be overcome in utilizing by-catches, and this leads us into the consideration of the role of improved technology as a mechanism for reducing postharvest losses.

Improved Technology

There are many other areas of the production chain to which improved technologies have been applied to control wastage and have contributed to reductions in the postharvest loss problem. A fuller discussion of these technologies will take place elsewhere at this workshop, and the remainder of this section will be devoted to some observations on the application of improved technologies to by-catch.

The by-catch problem especially has stimulated a flow of imaginative and flexible technologies. In line with the fisheries management strategies has been the development of modified fishing gears designed to reduce or even eliminate by-catch. In the shrimp fisheries, work has been carried out on the use of electrified tickler chains and sonic deterrents which are attached to shrimp trawls in order to prevent non-target species entering the main body of the net (Sternin and Allsopp, 1981). Similarly it is believed that the problem of discards could largely be solved by the correct design and construction of trawl gear, especially the use of extension pieces and specialized cod ends which enable juvenile fish to escape (World Fishing, 1987). The major drawbacks of these methods to reduce by-catch are that they are costly, not completely effective, may reduce the catch of the target species and require effective enforcement to ensure that they are adopted by the fishing fleets.

Other workers have accepted that by-catch is a resource which should be utilized and technologies have been developed for: sorting the catch at sea (Olsen and Hansen, 1981), handling and storage at sea (Crean 1981; Tamayo, Poulter and Young, 1984) producing products for human consumption based on deboned minces (Hansen, 1981; Poulter, 1981; Tan Sen Min et al., 1981 and Young, 1981). These applications of improved technology have lead to the development of products for human consumption at a pilot scale level (Young, 1979). However a more widespread market acceptance of these mostly novel products has yet to be achieved and sound investment support has not been established. From the work carried out to date, it seems that the problems of marketing and securing investment are the main factors limiting effective utilization of by-catch. There are many other areas of the production chain to which improved technologies have been applied for the control of wastage and have contributed to reductions in postharvest losses problem.

Training

To complete this discourse on organization and policy issues, the author would like to turn to the issue of manpower training. The extensive survey of the fish distribution network in Mexico carried out by Crown Agents (unpublished data) revealed that there was scope for reducing postharvest losses through a training program. The program would be targeted at the manpower associated with the various elements of the distribution network ranging from the fishermen through to retailers. The study concentrated on chilled fish distribution and the results indicated the following:

1. 60% of all fish dealers commented that irregular or insufficient supplies of fin fish limited the development of their businesses.

2. Only 10% of all fishermen interviewed, iced their catch after capture.

3. Consumers usually receive fish which is of class B and C quality. It is not the best quality fish (Class A) and is often only just fit for human consumption (Class C).

4. It was estimated that the total losses of marine produce for the North West states of Mexico, occurring as a result of postharvest deterioration, can be valued at US dollars 1 million annually.

One of the main factors responsible for this level of wastage was a lack of skilled manpower at various levels in the

production chain. Some of the key areas in relation to postharvest losses that required attention were as follows:

1. Training of industry personnel to select and make use of appropriate technologies for on-board preservation of marine produce.

2. Instruction of fish industry personnel in the use of ice to preserve the catch and where appropriate to introduce or upgrade other preservation technologies.

3. Instruction of fish industry personnel in the choice, setting up, running and maintenance of ice plants.

4. Training in fish business operation and administration for both the private and public sector personnel.

An annual program of short courses has been developed to meet these training requirements. The central aim of the program is to reduce postharvest losses. The justification for funding of the program is that the wastage problem will be reduced by 1% annually. Thus for a ten year cycle of training courses, it was envisaged that postharvest losses might be rendered negligible.

CONCLUSION

Technologists have applied themselves well to the task of solving the technical problems associated with postharvest losses. The author feels, however, that through the manipulation of policy and organizational factors the problems that confront the technologist could be lessened, and might lead to a more effective prevention of wastage than can be achieved through technology alone.

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POSTHARVEST FISHERIES RESEARCH AND THE FOOD SYSTEM IN DEVELOPING COUNTRIES

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ABSTRACT

Research programs to address the concern for reducing postharvest losses in fisheries have almost exclusively been designed from a technological viewpoint. There is now a wealth of information on technologies formulated to overcome the wastage occurring in large-scale fisheries, such as shrimp trawling, and also that resulting from small-scale, traditional processing operations. Actual implementation of these technologies for the benefit of traditional fisheries and developing country consumers, however, has been minimal. This lack of success in the adoption of technology may be related to the conventional, monodisciplinary nature of fish processing research.

Research is often conducted on the basis of assumptions regarding the existing postharvest system. Loss assessment in specific situations may be inaccurate and the effects of variations in fish supplies unappreciated. Moreover, until recently, inadequate consideration had been devoted to consumer demand, buying capacity, food habits and economic incentives for processors. Interventions aimed at improving the quality of fish products are not usually generated from analytical evaluations of market perceptions and pricing systems in particular localities.

It is argued that a systems approach to postharvest fisheries research, involving collaboration between the biological, social and management sciences, will provide a more viable framework for the development and adoption of improvements. This paper draws upon experiences in Asia and Latin America to re-examine the components of research on postharvest fish losses and to illustrate some alternative directions and fresh initiatives.

INTRODUCTION

Postharvest fisheries research is normally conducted from a monodisciplinary standpoint. The considerable literature which is currently available on the topic is separately grouped into resource aspects, technology, marketing, economics or socio-economics. It is rare to discover a truly integrated approach to fisheries development either in the postharvest sector or in other areas. In view of the perceived need to fully exploit technical training, technologists and engineers generally opt for seeking technological solutions to food problems in the developing world. However, wide application of innovations arising from such work is uncommon, even though technical viability may be proven. This is not to imply that technology development should be relegated to a minor role in the food supply issue. It is rather to suggest that research investments in technology design should be guided by accurate knowledge of the environments in which the technology is to be adopted. While this requirement has been often recognized, such knowledge may be acquired at a late stage in the research program, when technology development has already been completed. To increase the likelihood that research results will be utilized, systems approaches need to be adopted on a wider scale. Few institutions, however, encompass all the disciplines required to undertake complete systems studies.

This timely forum on postharvest fishery losses provides an opportunity to reassess past efforts aimed at resolving an apparent food problem. The following discussion describes some previous technological developments, intended to address problems of fishery losses, and examines constraints to their adoption for the benefit of fishermen and consumers. An attempt is then made to reformulate approaches to research on postharvest losses, in the light of knowledge on the kinds of food systems which currently exist in the developing countries. Finally, policies through which to achieve a more integrated approach to loss reduction are recommended.

ESTIMATION OF FISHERY LOSSES

The National Academy of Sciences (1978) noted that the figures for actual postharvest losses, due to various causes, were highly speculative. This observation is probably still valid. Clearly, substantial losses occur in certain fishery operations, such as the non-selective shrimp trawl. However, loss figures on which research is based tend to be global or generalized for a region. Moreover, there are wide variations in estimates. Even when extensive, systematic loss studies are undertaken, as was the case with Mexican shrimp by-catch, the main conclusion is the considerable variability in amounts of

discarded fish per vessel because of environmental and logistical factors (Perez Mellado et al., 1982).

The estimation of losses in small-scale fishery operations seems to be even more problematic. The complexities of traditional landing and marketing systems tend to defy the application of standard methodologies for assessing degrees of infestation or spoilage. Moreover, the extent of postharvest losses in traditional fisheries may vary remarkably, depending upon the location. For example, although losses of cured fish have been quoted at 3 million tons on a global basis (National Academy of Sciences, 1978), certain cured fish systems in northeast Thailand appear to produce negligible losses. There, research may be more profitably directed to increasing fish supplies, rather than reducing losses.

Rather than embarking on expensive and time-consuming loss assessment techniques, it may be preferable to carry out rapid appraisals of particular fish processing and marketing systems. Although not focussing on fish losses per se, the application of rapid rural appraisals (RRA), adapted from those used in designing rural development programs and farming systems research, could provide a more useful data base (Chambers, 1981; Honadle, 1982). Such data would permit a wider appreciation of the interrelationships existing in the system in which losses occur. Perhaps the real advantage of RRA lies in the reallocation of the surveyor's time from excessive data collection to liaison with those involved in, and benefiting from, the traditional system. The economic and market implications of loss reduction also require careful consideration. Although referring mainly to losses of farm produce, Greeley (1986) signals the importance of addressing the effects of loss reduction programs on pricing policies, market demand and labor displacement. These approaches to developing a base line for research are related to the discussions in subsequent sections of this paper.

TECHNOLOGICAL INNOVATION AND CONSTRAINTS TO IMPLEMENTATION

Technological developments geared to ameliorating postharvest fishery losses are extensive and detailed descriptions of these are available elsewhere (Tropical Products Institute, 1977; FAO, 1981; FAO/IDRC, 1982). Some of the technologies are revisited in this section. The main intention, however, is to review these developments within the socio-economic framework in which they are to be applied. It may then become possible to identify the main factors precluding their implementation or those requiring further attention in order to encourage their adoption. Two case studies are employed as illustrations - shrimp by-catch utilization and reduction of cured fish losses.

Shrimp By-catch Utilization

That vast quantities of fish caught incidentally during shrimp trawling are wasted has attracted the worldwide attention of national and international research agencies (FAO/IDRC, 1982). Annual losses of some 5-16 million tons of fish represent a considerable wastage of food resources in regions where large proportions of the population suffer malnutrition. Research programs designed to confront this problem were conceptualized as resource utilization efforts. Market and economic orientations were only introduced at a later stage. Because of the small size and species variability of by-catch fish, there was much scope for innovative work in the product development field (Table 1). For example, work in Mexico hinged on the application of suitable mechanical deboning techniques for small fish. The boneless fish mince which was recovered could be formulated into a range of dried/salted, canned and frozen products for direct human consumption (Young, 1983). Process improvements were introduced to enhance the palatability of these products (Young, 1982a). Wastes from evisceration and deboning operations were converted into fish silage, a by-product which was shown to be a valuable feed for monogastric animals (Trevino et al., 1982). Parallel work was proceeding in Guyana where by-catch utilization was also a major concern (Gordon, 1982).

TABLE 1
Predominant Shrimp By-Catch Fish Species and Their Physical Characteristics

Scientific Name	Common Name	Average Weight (g)	Average Length (cm)
Citharichthys spp.	Lenguados	105.06	21.50
Eucinostomus spp.	Mojarras	20.75	10.06
Paralabrax maculatofasciatus	Cabrilla	76.59	16.87
Orthopristis reddingi	Rayadillo	77.06	16.56
Diplectrum sp.	Cabaicucho	55.31	14.94
Calamus brachysomus	Mojarron	74.60	12.50

Source: Tamayo et al., 1984.

Later phases of shrimp by-catch utilization programs were devoted to market assessment of minced products, economic evaluations of models for factory processing operations and the design of practical systems for on-board handling (Young, 1980). A daily flow chart for a by-catch processing plant, which employs minced fish technology, is shown in Figure 1. Cost/benefit analyses of these industrial models conducted in Mexico provided positive results (Street et al., 1980: Young and Marter, 1981). Break-even costs for all product forms indicated that these items could be manufactured at costs considerably lower than those of other animal protein foods available in the country. Of course, this analysis was based on certain assumptions regarding initial raw material prices. Because of the proximity of large production units for poultry and pigs to the shrimp landing facilities, a ready market for the silage by-product was apparent.

In view of the promising technical and economic results which emanated from by-catch utilization studies, considerable attention was devoted to seeking ways to implement the work. In Guyana, by-catch recovery proceeded under firm government initiatives, involving legislation enacted to promote such recovery. The main contribution in that country was to increase supplies to the market for frozen block fillets (Petersen, 1982). The rather different nature of the by-catch resource in Mexico, comprising as it did of a wide variety of extremely small fish, seemed to demand more novel approaches to utilization. While the complexities and risks involved in dealing with the shrimping industry tended to discourage private investment in by-catch utilization, various government channels, through which nutritious, low-cost fish products could be marketed had been established. In particular, the state trading company (CONASUPO) focussed its activities on supplying basic foods to the poorer sectors, and other programs formulated to improve food distribution, family welfare and nutrition (eg. SAM and DIF) appeared to represent appropriate outlets for by-catch products. Of special interest was the fact that dried/salted minces from by-catch could be stored and widely distributed without the risk of spoilage. For the urban sector, the government firm, Productos Pesqueros Mexicanos, had developed a cold chain for marketing frozen minces, particularly as children's food (PPM, 1982). This form of utilization was suitable for selected and carefully handled species of the by-catch. The primary consideration for the various processing and marketing options was that the price competitiveness of minced by-catch products offered distinct advantages for consumer acceptance (Young, 1980). It was thought by many involved in institutional feeding programs, and even in private sector fish processing, to be sufficient to overcome any market resistance to by-catch products. This perhaps was a misguided assumption.

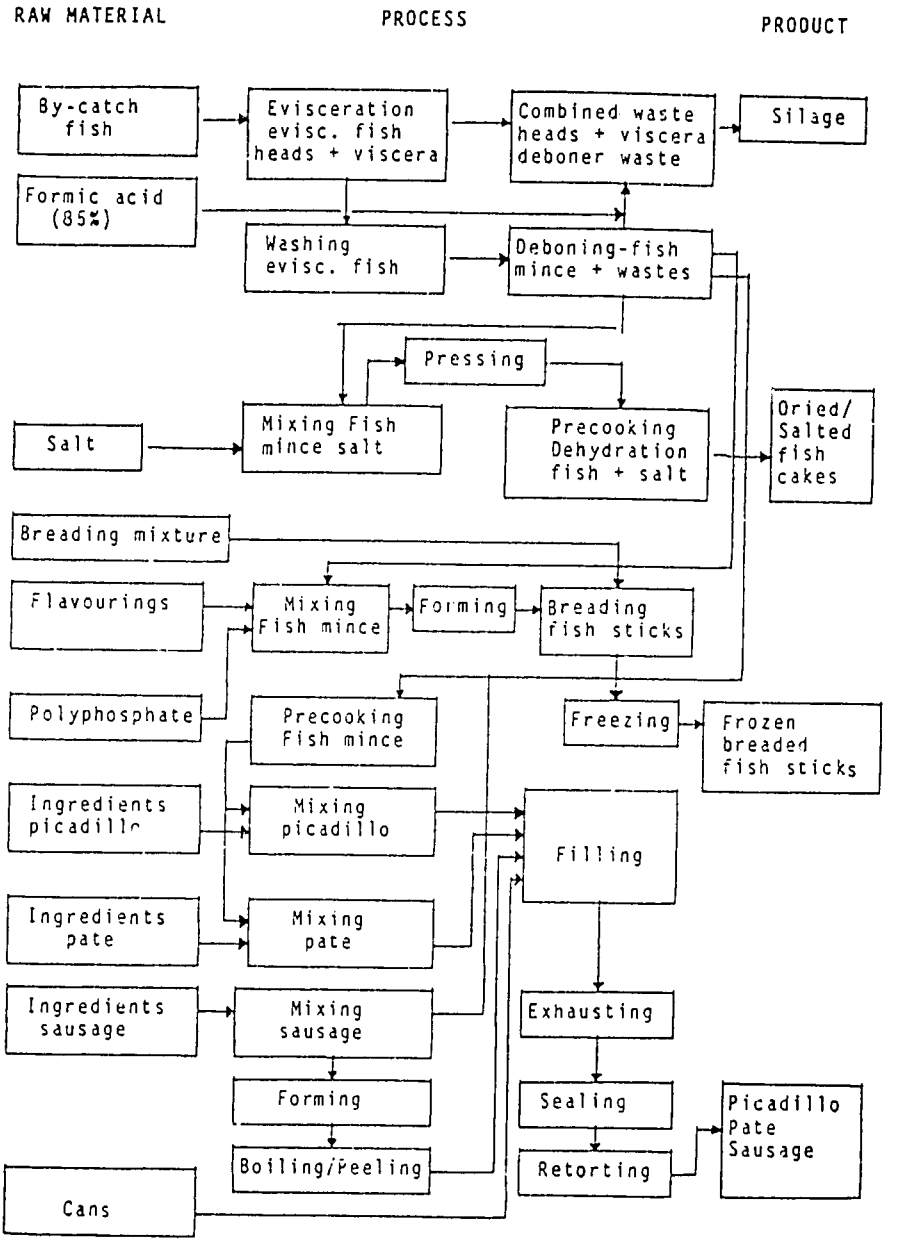


FIGURE 1. Daily flow chart for a shrimp by-catch processing plant. Source: Young, 1983.

To underpin the extensive activities on processing and marketing of by-catch, efforts have also been made to devise practical and economically viable means of handling the incidental catch at sea. Most researchers have largely dispensed with novel ideas of transfer at sea, on-board mincing and freezing in blocks, in favor of icing and storage of whole fish in available space and the use of chilled sea water (Tamayo et al., 1984). Modified boat designs have been proposed to accommodate CSW tanks. Tamayo et al., (1984) recommended the incorporation of CSW tanks into existing shrimping vessels in the areas found between bodegas. Two tanks per vessel were proposed, each tank having a capacity of 6.3-9.4 m depending upon boat design. This permitted the storage of 4.5-6.7 ton/tank of fish and CSW. In this manner, the quality of small by-catch fish could be retained for up to 12 days. These modifications could be effected at low-cost and would not influence vessel stability or reduce normal storage capacities. Moreover, minimal additional labor is required to operate the storage system. Certainly in Mexico and Guyana, the use of icing and chilling, exploiting unoccupied storage space aboard shrimp vessels, appears to be technically and logistically feasible.

From a reassessment of past experiences on reducing fish losses from shrimping operations, strategies to consider in any future efforts to address this global fishery problem have been developed (Young, 1982b). Utilization programs are achieving limited success in specific localities. Present constraints are mainly related to unfavorable economics, inadequate market acceptance, lack of political will and organizational capacity and, often, gross changes in political direction and economics of shrimping nations. However, there are no universal solutions which can be generally applied. Linking the complexities of the shrimping industry with those of food systems directed to the needs of the poor masses is a daunting prospect, demanding the highest level of systematic and organizational aptitude. Clearly, though, approaches must be flexible and knowledge of existing systems and needs in different regions where shrimping is practised is required. If anything, previous efforts were not based on clear evidence of market demand and economic potential. A strict technological approach was usually adopted. Future developments should stem from accurate systems analysis, supported by firm government willingness to encourage by-catch utilization through legislative and fiscal measures.

Reducing Cured Fish Losses

The curing of fish, through salting, drying and sometimes smoking, has been practiced for centuries and is a universal method of preservation in poor societies. Losses in this

traditional system may be categorized as: i) physical losses due to infestation or spoilage, ii) quality losses due to inadequate processing techniques, and iii) losses in nutritional value. The technical advances which have been made in offsetting infestation and improving drying, smoking and packaging have been amply reviewed by FAO (1981). Particular emphasis has been placed on the development of solar dryers, intended to supersede the traditional open sun drying operations (Curran & Trim, 1983; Commonwealth Science Council, 1985). The studies are based on the premise that traditional drying is inefficient and produces inferior products. Various designs for solar tents, solar chimney dryers and solar box dryers are now available (Bassey, 1982; Commonwealth Science Council, 1985). It has been argued that such dryers would be attractive for small-scale fish processing because of their simplicity and lack of mechanical components. Nevertheless, there is little evidence that solar fish dryers have advantages over conventional sun drying in commercial operations. The drawbacks include capacity limitations, low resistance to adverse environmental conditions, inability to prevent infestation and poor internal air flow. Even in humid conditions when natural drying is impaired, the additional investment required in solar drying equipment may not justify the minimal benefits to be gained. With regard to air flow, it is often difficult for solar dryers to compete with traditional processes without the use of a mechanical blower. When sunny conditions prevail, traditional processors continue to opt for open sun-drying.

As with other commodities, however, fish harvesting and processing may coincide with the advent of rainy seasons, precluding the application of sun or solar drying. This observation has prompted research on the design and testing of low-cost mechanical dryers, which are able to use agricultural waste materials (biomass) as fuel. Materials such as rice husks and coconut husks and shells are frequently to be found in large quantities in regions where fish are traditionally processed. Carpio (1982) describes the development and testing of a 1-ton capacity fish dryer, which burns rice hulls in a brick furnace. Air is blown through a heat exchanger into the drying chamber. This dryer was field tested in the Philippines and elsewhere and, although technical viability was demonstrated in the laboratory, there were clear constraints to commercial adoption of this technology. These constraints are listed below to illustrate the gaps in knowledge of traditional processing infrastructure, local conditions and individual processor requirements that were evident:

1. Mechanically-dried products were generally of lower weight than traditional products. Since prices were quoted on a

weight basis (rather than on quality criteria), processors would be paid a lower price per unit of fish.

2. Fishing activities were highly seasonal and the dryer would have remained inoperative for most of the year. There would have to be substantial savings and increased product output during the active season to justify investment in the dryer.

3. The dryer was highly dependent on a continuous electricity supply to operate the blower. Recurrent power failures at the testing sites considerably hindered experimental work on the dryer, a prediction of serious problems during commercial operations.

4. Adverse weather conditions in the region, particularly strong winds, caused power failures and promoted rapid combustion of fuel and reduction of drying temperatures. On one occasion, a typhoon damaged the dryer and repair was costly. Had this represented a processor's investment, it would have been an appreciable financial loss. Processors using traditional sun drying lose less and recover more rapidly after such storms. Investment in mechanical drying is therefore risky for the small processor.

5. Even though the dryer appeared relatively simple to the design engineers, it proved to be a complex operation for rural processors. Commercial implementation would have required extensive training programs, as well as appropriate investment and management schemes. In addition, local artisans experienced problems with dryer construction. The heat exchanger presented particular difficulties.

6. Because of improvements in local road communication, it was becoming easier to market fresh fish. Drying activities were thus declining in any case.

Clearly, in the case of fish drying, there is a need for further work in two areas - i) more adequate definition of the existing system to ascertain points for improvement and ii) technical improvement and development of appropriate hardware. There have been some recent innovations in the latter area. At the International Rice Research Institute (IRRI) in the Philippines, a range of dryers has been designed, incorporating improved furnaces for burning agricultural biomass and novel vortex wind machines to generate air flow through the drying chambers (Bockhop et al., 1984; Jeon et al., 1984). The vortex principle offers an alternative to the utilization of expensive blowers and power sources. Performance evaluation has revealed

that vortex wind machines can generate suction of 5-30 m per min. which is considered satisfactory for drying purposes (Bockhop et al., 1984). Briquettes may also be formed by partial combustion of agricultural wastes for direct heating of air in vortex dryers. Based on these concepts a small fish dryer has been constructed at IRPI and preliminary tests indicate satisfactory performance for community fish drying operations (Y.W. Jeon, personal communication). Multipurpose drying, for a range of commodities, is also being examined as a means of extending dryer use throughout the year.

Again, the issue of whether real problems are being identified, and whether the scientists' perception of losses is the correct one, needs to be raised. It is generally assumed that improved product quality is demanded by consumers of cured fish in developing countries. Market evaluation is rarely performed to determine whether this hypothesis is justified. Moreover, minimal attention is given to assessing marketing and pricing systems in particular localities, to establish the existence, or lack, of incentives for quality improvement. Current evidence suggests, however, that low-income rural and urban markets do not differentiate significantly, through price incentives, between sun-dried and artificially dried fish (Breslin and Hoffman, 1975; Young & MacCormac, 1987). In most circumstances, lack of purchasing power of consumers of cured fish would prevent the absorption of the additional processing costs necessary to improve quality. A better understanding of these social and economic factors is required prior to embarking on research to generate technologies.

CONFRONTING SOCIO-ECONOMIC FACTORS

The preceding discussion highlights the need to integrate social and economic considerations into technical research programs if any practical impact on loss reduction is to be achieved. In addition to addressing quantitative knowledge on the extent of losses, programs should respond to the cultural, socio-economic and political characteristics of target areas. For more effective delivery, the objectives of postharvest fishery programs might be realigned towards systems improvement (including creation of employment and income opportunities) and away from loss reduction objectives per se.

Factors associated with the postharvest food system which may influence loss reduction are diagrammatically presented in Figure 2. Entrenched attitudes, both at government and community levels, may mitigate against upgrading food conservation in general. These may vary according to time and place. For example, the National Academy of Sciences (1978)

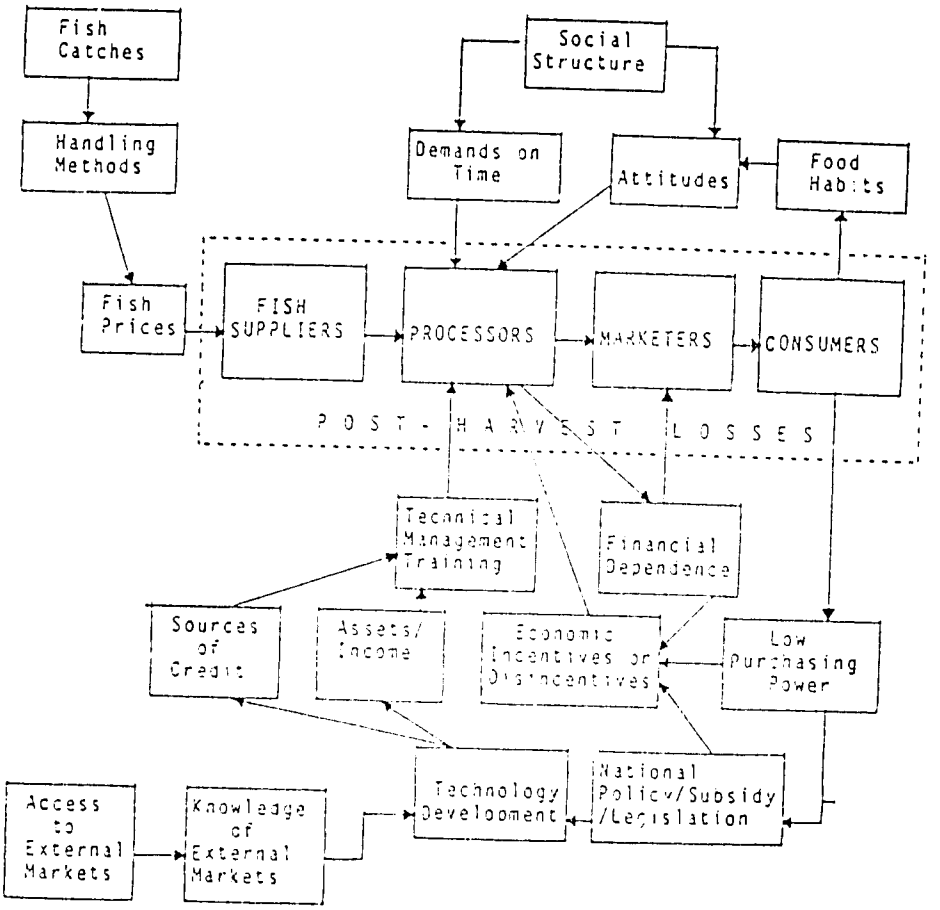


FIGURE 2. Factors which may influence the reduction of postharvest losses in traditional fisheries.

noted the following conditions which act as disincentives to technical improvements in food conservation:

- Price depression resulting from increased food availability;
- Taxation on amounts of food stored;
- Fixed quotas for commodities to be purchased after harvest;
- Inadequate means of storing or marketing surplus production; and
- Obstacles to reaching larger markets.

Accurate information on such issues is essential for intelligent policy planning and priority setting by national governments. If the prevailing conditions are not conducive to loss reduction, but it is considered a priority to minimize losses in the interests of nutrition and food security, then appropriate policies may be devised.

As may be seen by referring to Figure 2, cost effectiveness is only one factor in the socio-economic environment which may bear upon loss reduction policies. These policies should be formulated in terms which extend beyond the objectives of loss reduction and increased food supply. For example, while improving the quality of fish products may allow access to more discerning markets, it may on the other hand remove a source of low-cost food for poor consumers. As Greeley (1986) notes, poorly conceived programs can impose social costs that negate the benefits derived from saving food. Conversely, well conceived programs, in addition to conserving food, may assist in generating employment and income in depressed areas.

The potential income generating function of fish saving schemes requires greater attention. In Asia, processes such as fish drying, fish curing and fermentation form the basis of small cottage industries, which serve as major sources of employment and income in many areas. When applied to these rural industries, modified operational research techniques can identify key points where technical or market improvements would be beneficial (Edwardson and MacCormac, 1984). Often, these improvements result in increased competitiveness of cottage operations with larger, centralized industries, which may otherwise gradually absorb existing markets.

Greater attention might also be directed to enterprise development. Food processing could be employed more widely in the developing world to confer "value added" on available agricultural commodities, and create assets and income in needy areas. Fish may be an especially important commodity in this sense. Developments in the field of aquaculture may provide new opportunities for income-generation through fish processing. Crucial issues to confront to promote new fishery enterprises include market knowledge, market access, training and availability of credit. Despite the existence of

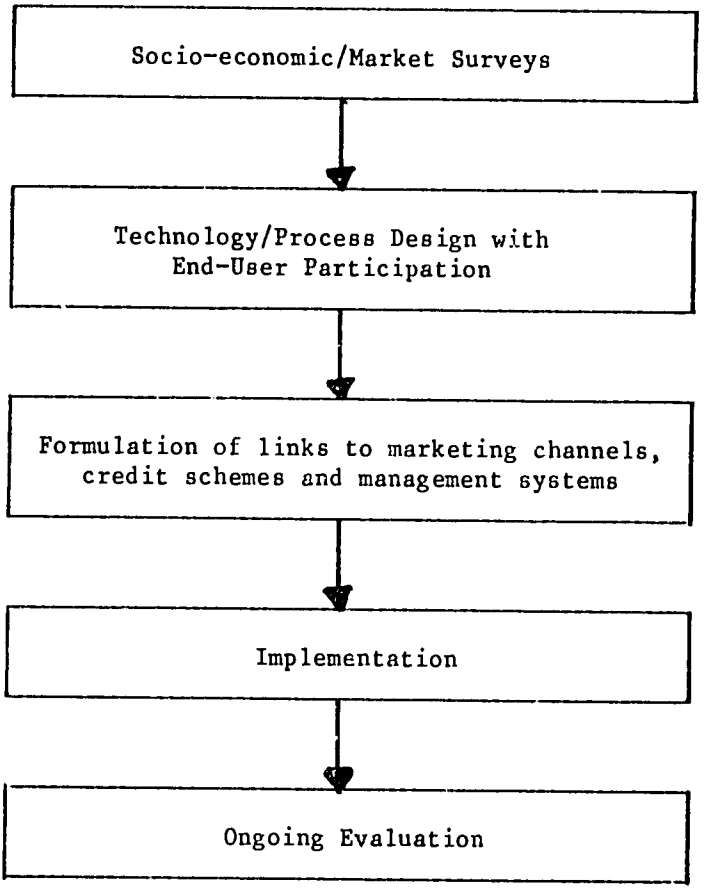
agricultural and fishery development banks, credit is usually unavailable to the lower income sectors. There is room for innovation in modifying banking procedures and policies to stimulate enterprise development for the poor. Considerable progress is being made in Bangladesh, however, where the successful Grameen (Countryside) Bank has been established to provide viable credit schemes aimed specifically at the poor (Hossain, 1983; Ghai, 1984). Many of the loans awarded so far have enabled the creation of small fishery businesses.

Improved market knowledge will be a vital factor for the progress of new developments. Here, the work "market" is quoted in its broadest sense to include the poorer, traditional sector as well as the conventional markets of industrialized societies. Gaps in selecting and implementing appropriate technology frequently arise from deficiencies in information where the gains are not apparent, weaknesses in market informational institutions and inaccurate identification of acceptable product or process characteristics. Loss reduction programs should essentially be based on market analysis and consider raw material procurement and marketing strategies. IDRC has recently reviewed the application of social market research in the design of food and nutrition projects in the developing world (Young & MacCormac, 1987). A market orientation is now invariably encouraged in projects supported by IDRC. Knowledge of handling, marketing and consumer systems is usually gained through ex ante surveys prior to planning technology intervention and improvement programs.

CONCLUSION

Clearly, if the developing countries are to derive practical benefits from postharvest fisheries research, more integrated, systems approaches need to be formulated. The interdisciplinary coordination necessary to accomplish the above program is difficult to acquire in the developing countries. As previously stated in this paper, few national research institutions possess the required infrastructure and human resources. In general, developing country scientists gain recognition solely for technical achievements. There is little insistence on systems thinking in the design and conduct of research programs. Achieving good collaboration between institutions with the necessary expertise in the fisheries and food sciences, and social and management sciences in a common program often proves problematic. Nevertheless, in several instances wider approaches to resolving postharvest problems are being achieved through institutional linkages.

As a general rule, the overall research plan in any situation might adhere to the following sequence of events:



For example, in Sri Lanka, social scientists from the University of Sri Jayawardenepura are working closely with fishery technologists from the National Aquatic Resources Agency in the evaluation and improvement of local fish handling, processing and marketing systems. In other projects, technological institutions are incorporating marketing and management expertise by means of appropriate consultancy arrangements.

If one accepts the view that closer association with the intended beneficiaries of research is an important future requirement, ways to achieve this need to be considered. Greater emphasis should be given to problem identification through evaluations such as rapid rural

appraisal. At present, the value of qualitative assessment for guiding technological research may be underestimated.

The international research community should assist in strengthening interdisciplinary approaches to postharvest fisheries problems. Better communication and information exchange between institutes and individuals with experience in different areas is warranted. In this respect, the development of research networks on common fishery problems would be beneficial. These networks would incorporate specialists of several disciplines. In addition, more information on research utilization is needed. Policy makers and scientists could be instilled with a greater awareness of the necessary ingredients for research implementation through the documentation of successful case studies. Through the adoption of systems-oriented research designs, science and technology may make more direct contributions to improving the postharvest fisheries sector in the developing countries.

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QUALITY ASSURANCE: IS IT FEASIBLE IN LESS DEVELOPED COUNTRIES?

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ABSTRACT

Consumers in less developed countries (LDCs) are just as aware of quality as consumers in developed countries. The simple systems for marketing and distribution in LDCs mean there is little opportunity for applying effective quality assurance programs for fish products entering the domestic market. For some products, such as dried fish and fermented fish, there are no well developed criteria of quality that can be used in quality control procedures. Many LDCs have important export trades in fish, usually in high value products like frozen shrimps and molluscs, canned fish, and selected fresh fish air freighted stored in ice. These countries have introduced official quality control and inspection systems to assure the quality of exported fish products. These quality assurance programs are not always as effective as they should be and more effort needs to be devoted to in-plant quality control systems and less to end product inspection.

INTRODUCTION

"Quality Assurance" is defined by the British Standards Institution (1979) as "all activities and functions concerned with the attainment of quality". This definition, though succinct, encompasses the many aspects of quality assurance and sees it as a total system which includes the functions of administration and management as well as technical operations like inspection, testing and quality control. It makes a good starting point for any discussion of quality assurance.

A further definition is useful in focusing the discussion. The BSI Glossary (British Standards Institution, 1979) defines quality as "the totality of features and characteristics of a product or service that bear on its ability to satisfy a given need". The definition highlights two important aspects of quality that influence the objectives and execution of a

quality assurance program. Firstly, quality is not an abstract property - though fish technologists may have some notion of ideal quality in a fish product - but is related to needs. These needs need not be the same for all users of fish products in all circumstances of use. Fish usually goes through a series of transactions between catching and consumption and at each stage there is a user with particular needs in respect of the product being manufactured or traded at that time. However, throughout these transactions, the persons responsible for the product must have in mind an ultimate consumer whose requirements must be met and these requirements dominate awareness of quality through the marketing, processing and distribution chain. But consumers are not homogeneous in their requirements; a brief survey of patterns of consumption of fish reveals the wide diversity of fish and fish products that are eaten, and the marked differences between countries and within countries in what is acceptable or not. Apart from the intrinsic quality of the product the consumer takes cost into account and is willing to trade quality against price. An affordable price is a need which must not be ignored in any quality assurance program.

The second important aspect of the definition of quality is that quality is not dependent on only one property of a product, rather it is the aggregate of several. The diversity of fish and fish products that are consumed means that a variety of features and characteristics influence quality. Some of these properties can be assessed by the user or consumer at the time of purchase or use, others not. The buyer in most cases, and almost certainly so in circumstances prevailing in the marketing of products in LDCs, can at least see, if not touch and smell the product, and so can make some judgement as to its quality in relation to the needs. Quality parameters like the presence of toxic substances or harmful microorganisms are not immediately apparent to the buyer (though their effects may subsequently be only too apparent), and quality assurance programs, particularly those operated by official agencies, have an important role in controlling such defects.

It should not be assumed that although consumers in LDCs may not always be getting good quality fish they are not aware of quality or are willing to accept poor quality. The quality may not be the best because of deficiencies in the marketing and distribution system, perhaps coupled with a lack of awareness of good technological practices, but in general consumers in LDCs are well aware of what constitutes good and bad quality in the products they want. Poor quality products meet consumer resistance in LDCs just as they do in economically developed countries. Quality assurance programs for fish products, whether they be private commercial or official regulatory, are not well established in LDCs, (for

that matter, they are not well established in some developed countries either!) and consumers often have little or no choice when it comes to selecting for quality. The question is not whether quality assurance programs are needed in LDCs but whether they are feasible given the constraints imposed by shortages of technological and economic resources.

General Aspects of Quality Assurance

Quality assurance systems are used by official regulatory agencies and by industry to achieve their objectives with regard to quality of products within their supervision or control, though the objectives and the means for achieving them are somewhat different for the two sectors.

Any responsible government is concerned for the well-being of its citizens and enacts regulations intended to protect them from unsafe food (FAO/WHO, 1976). Fish products are foodstuffs and come within these general regulations designed to ensure that food is wholesome, is not contaminated with harmful substances or microorganisms, and is not adulterated. To achieve these objectives governments set up administrative structures to inspect, and if necessary, test food products in order to meet these criteria, that is they establish quality assurance programs. Just how the food hygiene laws are enforced differs somewhat among countries but it is not uncommon to have distinct operations for the inspection and quality control of fish products. A number of national fish inspection systems were described at conferences held in 1969 (FAO, 1971 a & b) and 1976 (Tropical Products Institute, 1977). General aspects of official fish inspection and quality assurance have been summarized by Connell and Howgate (1986) and particular aspects of the situation in the Indo-Pacific region and in Europe by Howgate (1984, 1987).

Official fish inspection systems are oriented towards assuring the consumer that the product is safe to eat though not necessarily pleasant to eat, but there is no hard dividing line between the two approaches. It is very common in technologically advanced countries at least for fish to be inspected at the landing sites, and fish which is considered by official inspectors to be "unfit" for consumption is removed from sale for human consumption. The criteria for condemnation are essentially aesthetic and predominantly related to freshness; with few exceptions fish when first landed are not unsafe even when very spoiled.

Quality assurance as related to acceptability to the consumer is considered to be the responsibility of the processors and sellers of the product. Just how formal and sophisticated the quality assurance is, or needs be, depends on many factors. For a small company dealing mainly in buying and selling with no or very little processing, quality assurance

can be informal and hardly more than the good intentions of the merchant. A large company dealing in processed products, particularly those with high added value intended for a discriminating market, may have a formal and detailed quality assurance system with a complete management structure and full technical services. Whatever the nature of the quality assurance program - official or commercial, formal or informal - there are concepts and procedures that are common to all. Since quality assurance is concerned with the attainment of quality any program of quality assurance must have criteria for the quality that is to be attained. In the case of official systems some quality characteristics may be laid down in legislation. Examples are levels of heavy metals or pesticides, presence or levels of permitted additives, and absence of toxic substances like ciguatera poisons. It is not usual for regulations to lay down specific microbiological standards for fish or fish products but guidelines have been proposed (FAO, 1977; Int'l Comm. on Microbiological Spec. for Foods, 1986). Official regulations do not usually specify eating quality other than that the product shall be fit to eat.

Commercial companies have their own "in house" standards though these are often more implicit than explicit. In general a merchant or processor knows the requirements of the market he is dealing in and strives to meet them. There may be no formal exchange of contracts between the parties to a transaction and no formal statement of the quality of the products sold or bought - there is merely an "understanding" of the required quality. Larger companies in technologically advanced countries are more likely to manufacture to formal, written specifications which may be entirely derived within the company or result from discussions between the company and its customer.

In some countries official, or quasi-official, regulatory bodies extend their activities to quality characteristics other than those related to wholesomeness - a good example is the National Marine Fisheries Service (NMFS) of the United States Department of Commerce. Often these activities are primarily oriented towards the quality assurance of exported fishery products but, as in the case of the NMFS, can extend to products for the domestic market (Gorga et al., 1982). Regulatory bodies which are involved in monitoring "commercial" quality will usually issue standards of quality and again the NMFS is an outstanding example in this respect (U.S. Department of Commerce, 1977). Countries in which the official fish inspection agency is involved in the quality assurance of exported products will often use the international standards issued by the Codex Alimentarius Commission (FAO/WHO, 1981) or national standards based on them (Howgate, 1984).

A specification is an important component of quality assurance since it defines the quality that is to be attained.

A specification consists of a list of the characteristics that govern the quality, the definitions of these characteristics if necessary, and the intensity or level of the characteristic for an acceptable product. For some characteristics the level may just be "present" or "absent". Where a specification of quality is associated with official regulations it is usually referred to as a standard.

Associated with the standard is a procedure for sampling and testing a product for compliance with the standard. In official quality assurance schemes, sampling, inspection, approval, and if necessary certification, of a batch of produce is a central function of a service and most of its resources are devoted to these activities. Procedures for sampling and inspection will often be built into commercial transactions between producers and purchasers where specifications of quality are included in the contract. A quality assurance program within a company will provide for sampling and testing of the end products prior to dispatch to ensure that specifications for the product have been met.

Quality control, defined in the British Standard (British Standards Institution, 1979) as "the operational techniques and activities that sustain the product or service quality to specified requirements", is very important in industrial quality assurance but not prominent in official programs. The latter are principally concerned with the quality of the product as it exists after production and before consumption; how it arrived at that condition may be important but is the responsibility of the producer. (Official quality assurance schemes for exported fish products may be involved in quality control but this aspect will be discussed later in this paper.) In industry, effective quality control is essential. It involves control of the quality of the raw materials entering the process, of the process itself, and of the environment in which the process is carried out. Process quality control is based on the premise that good quality material processed according to good manufacturing principles is bound to result in a good quality product. End product inspection then takes on the secondary role of confirming that quality control procedures during production have been effective.

Quality Assurance in LDCs: Fish Products for the Domestic Market

Fish on a worldwide basis contributes only about 15% of the animal protein in the human diet but is more important than that in many LDCs (James, 1984). This is especially true for many countries in Southeast Asia (FAO, 1986a). Developing countries have general food hygiene laws but in those countries where fish products are important in the domestic market or the

export market there are often specific regulations directed towards their quality assurance (Howgate, 1984). To the extent that the regulatory frameworks and associated administrative structures exist, developing countries can be considered as having official quality assurance programs for fish products. If the programs are not fully effective it is a problem of performance, not of lack of intention.

There are many problems faced by developing countries in attempting to set up fish inspection and quality control services on the lines of those existing in developed countries, problems which will differ in detail among countries but generally are bound up with the structure of the fish catching, distribution and processing industries, and the availability of resources.

In LDCs much of the fish catching is at an artisanal level and fish landings consist of small quantities of fish landed at very many sites. In such circumstances it is not possible to examine all landings to check that the fish is fit for consumption. However, fish landed from artisanal fisheries is rarely spoiled even under tropical conditions because the fishing trips are very short - typically a few hours - and hence there is little justification in devoting resources to inspecting fish at its landing site to remove the small proportion that might be unfit for consumption at that point. There might be more justification for inspecting the quality of fish during subsequent handling and distribution but here again the distribution systems often prevailing in LDCs involving large numbers of small traders make any control very demanding on resources.

An aspect of fish handling in LDCs which presents some problems in quality control is that an appreciable proportion of fish going to the domestic market is preserved by traditional methods, commonly drying perhaps accompanied by smoking or by prior salting. FAO statistics show that 21% of the world catch of fish going for human consumption is cured (FAO, 1986a), the major part in developing countries. Though this is a very high proportion of the total catch - similar to that going for freezing, a technologically advanced method of preservation - there has been very little systematic investigation of the features and characteristics of cured fish that bear on its acceptability to consumers. Nor do technologists have much quantitative data on the storage lives of cured products under the ambient conditions prevailing in LDCs. Hence, it is not possible to specify in detail the quality of these products nor the requirements for good manufacturing practices for the manufacture and storage of them. The efficacy of official quality assurance programs for fish products for domestic consumption is thereby impaired because of the lack of background information.

Official fish inspection and quality control services require trained personnel to operate them, and there is often a shortage of such people in LDCs. FAO and other aid organizations have done good work in arranging training courses in fish technology and quality control at regional and at national levels and consequently many developing countries now have a nucleus of trained staff for their quality assurance programs. In some cases, though, much of the resources, both of trained people and of laboratory and other technical services, go to the inspection and quality control of products for export (this market is discussed in the following section), and quality assurance in the domestic market has a low priority. Private industry, which in economically advanced countries is responsible for almost all the quality assurance of fish products, cannot contribute much in LDCs because it consists predominantly of small operations working at low levels of technological awareness.

Quality Assurance in LDCs: Fish Products for the Export Market

A surprisingly high proportion of the world catch of fish enters international trade (FAO, 1986a) and developing countries accounted for about 44% of the trade in 1984 with a value of just over US$ 7×10^9 (FAO, 1986b). Much of this trade is in high unit value products like frozen shrimp and squid, and canned fish. These products are exported to economically advanced countries where high standards of quality are demanded by the consumers and regulatory bodies in those countries require that the products comply with the food hygiene regulations in force in the importing country. This requirement on the part of processors in exporting countries to meet the demands of the importing countries leads to the contrast a fish technologist sees in many LDCs. On the one hand there is the traditional fish processing and distribution industry operating at a relatively simple technological level in the domestic market with limited quality assurance systems; on the other hand there is a modern industry producing for consumers in economically and technologically advanced countries and with quality assurance to match. Some of the shrimp processing factories in developing countries compare well with the best in technological countries and are better than many.

Exported fish products from LDCs have been refused entry into importing countries frequently enough to cause concern to governments in both. Since exported fish products are valuable foreign currency earners for many LDCs - for some countries they are the major source of "hard" currency - their governments have been willing to devote resources for the establishment of official quality assurance systems. An INFOFISH report (Howgate, 1984) has reviewed the difficulties

with regard to the quality of fish products exported from the Indo-Pacific Region and the fish inspection and quality control services that have been established in order to assure the quality. The efforts of FAO and other international aid agencies referred to earlier have often been directed to supporting the quality assurance of exported products.

In some ways quality assurance programs for exported fish products are easier to formulate than those for the domestic market. Since the exported products - or those very similar to them - are already being produced in the importing countries, standards of quality and the requirements for good manufacturing practices are already well developed. The task for LDCs is to establish these practices in countries where they are not traditional and to get the management and staff in processing plants to accept the discipline of consistently manufacturing products to high standards of quality. This is by no means an easy task.

Official quality assurance programs in LDCs have operated in the main by requiring exporters to submit their products for pre-shipment inspection. Samples are taken, examined for quality, usually including microbiological testing, and approved or not for export. End product inspection is not a particularly effective form of quality assurance because, as has been pointed out earlier, it can only check that the manufacturing process has been carried out properly. In-plant process control is more effective and in many cases official agencies are pressing the processing companies to establish true quality control procedures in their factories. The companies are able to respond to such pressures because it is in the nature of the industry that the added value of the products and the increased returns on improvements in quality make investment in quality assurance cost effective. However, availability of technical staff and to some extent the lack of detailed knowledge about handling and processing fish products under conditions prevailing in most LDCs pose restraints on the adoption of quality control procedures in industry.

CONCLUSION

The question posed in the title concerns the feasibility of quality assurance in LDCs. In the sense that feasible means capable of being carried out then the answer must undoubtedly be "yes". To my knowledge, all LDCs have at least the rudiments of a quality assurance program for fish products and many have very well developed programs. However, the well developed programs are almost invariably oriented towards the quality assurance of fish products for export and quality assurance of products for the domestic market receives only a very small fraction of the available resources. The need to make provision for the quality assurance of exported products

does mean that the expertise and the facilities for extended programs are there in many developing countries. In addition, the fish processing industries in many developing countries are gaining experience in quality assurance procedures because of their involvement in the export market for processed fish products to developed countries and this expertise will transfer to the manufacture of traditional products.

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ECONOMICS AND SEAFOOD QUALITY

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ABSTRACT

This paper suggests some of the socioeconomic causes which create market inefficiency and hence postharvest quality losses in seafood. Reasons include fisheries regulation and management, observability of quality factors and the accountability of those who supply seafood, poor understanding of buyer needs, lack of buyer knowledge and awareness, income and budget constraints, imperfectly competitive market structure, externalities from consumption, inefficient pricing mechanisms, poor price information and other regulation.

Several approaches to quantifying the value of quality losses are discussed. Market based approaches such as hedonic price models are most frequently used. Other approaches suggested include simulation models and experimental methods such as willingness-to-pay studies and conjoint analysis. The methods suggested in this paper can often be adapted to determine who will benefit and who will lose from quality improvement projects.

INTRODUCTION

The importance of evaluating the economics of quality is frequently mentioned but rarely analyzed. A major impediment to the analysis of seafood quality is the issue of definability. Defining seafood quality is not easy. Beyond basic palatability, quality can be indicated by nutritional value, incidence of parasites, bacteria level, shelf life, taste perceptions, level of additives or preservatives, amount of flesh discoloration, size, number of bones, number of scars or cuts, uniformity and a host of other factors. Consider for instance, two fish; one is fresh, the other is frozen at sea. One buyer may consider the fresh fish to be of higher quality

because it is thought to be of a higher nutritional value or it is perceived as better tasting. Another buyer, however, may be concerned with parasites, bacteria or additives and therefore will consider the frozen fish to be of higher quality. It is conceivable that analogue seafood products such as surimi-based imitation crab may be considered higher quality than real crab, despite nutritional losses, because the buyer finds it easier to handle, more uniform, better tasting or less likely to be a health risk.

Seafood quality is in the eye of the beholder. Different aspects of quality are important to different users. Quality to a chef at a white tablecloth restaurant, a Japanese fish trader, an American consumer (eating at home), a buyer for a fast food chain, a fish trader in Ecuador, a feed manufacturer and a nutritionist may be defined quite differently. Quality depends on the needs of the user, which are determined by user knowledge, available technology and end use of the product.

There are two primary objectives of this paper. The first is to suggest the causes of postharvest quality losses. The second is to present several approaches which can be used to analyze the economics of postharvest quality losses.

AN ECONOMIST'S VIEW OF THE CAUSES OF POSTHARVEST QUALITY LOSSES

Technological and infrastructure problems are often cited as causes of postharvest quality losses. In many cases, these are only symptoms of the primary causes of postharvest quality loss or they represent only part of the actual causes. For example, failure to use ice and improper handling are often cited as causes of postharvest quality losses. Yet, sometimes when systems for improved handling and icing are put in place, they are not used at a level which a food technologist might consider appropriate.

The root causes of many quality losses both in developing and developed countries can most likely be found in socioeconomic factors which cause market inefficiency. Theoretically, in order to function efficiently a market must be purely competitive. A purely competitive market is characterized by many buyers and sellers, by free mobility of resources, by homogeneous products, by free entry and exit of firms, by property rights that are clearly defined, and by all market participants possessing complete and perfect knowledge. Under these hypothetical circumstances postharvest quality losses would not exist. This is of course not the case. The important issue is how do seafood markets deviate from the ideal and how great are the costs of these inefficiencies? The socioeconomic causes of these inefficiencies must be dealt with along with technological factors. The following discussion suggests some of the economic forces, as well as structural and

institutional constraints, which result in postharvest losses through market inefficiency.

Fisheries Regulation, Biology and Common Property Fisheries

A discussion of the causes of post-harvest quality loss should begin with the natural biology of the fish in question. Fish vary widely in terms of storability and natural decay rates but also in catch rates. Of particular importance is the way many fish are caught on a highly seasonally basis, resulting in gluts and dearths. This natural seasonality can be exacerbated by regulatory regimes and the common property nature of most ocean fisheries. Gluts result in capacity constraints and the inability of relatively more stable demand side of the market to absorb the large supply of fish. The result of this is spoiled fish, poorly processed fish or processing fish into low value forms (such as canned). The common property nature of the fishery can exaggerate these gluts through intense harvest early in the season instead of distributing effort throughout the season. Certain regulations have also exaggerated gluts. An example is the Pacific halibut. These fish can be caught most of the year but due to the common property problem compounded by an annual quota regulation which was not distributed throughout the year, the entire yearly quota was caught in a matter of days. Therefore, most of the halibut are processed as relatively lower valued frozen product and high quality fresh product is only available for a short period. The common property fishery and regulation results in substantial waste of quality fish.

Observability and Accountability

Quality characteristics can be segregated into three broad categories. Some quality characteristics are usually observable at the time of purchase, such as size and flesh color. Other quality characteristics are not observable at the time of purchase but can be ascertained after consumption, such as taste, texture and some types of product contamination or spoilage which causes sickness. The third type of quality characteristic is one which is unknown both before and after consumption such as nutritional level seafood and nondetectable levels of pesticide contaminants or other additives.

The lack of observability of many seafood quality characteristics coupled with a lack of accountability among seafood traders can lead to market inefficiency and a disparity between product quality attributes supplied and those desired. The lack of observability and accountability creates a common property problem resulting from competition for the stock of buyer goodwill. The common property characteristics of buyer goodwill in an undifferentiated fish market causes sellers to

chronically put low quality products on the market. In an undifferentiated fish market, providing the lowest quality fish within the acceptable range does not yield lower prices in the very short run and the lower buyer goodwill resulting from consuming the lower quality fish is absorbed by all participants in later periods. The low quality fish supplier causes all the fish sellers to bear the long run cost of lower buyer goodwill for fish. This is a negative externality to the rest of the traders. As pointed out by Nichols (1981), this is analogous to the common property problem found in the open access harvest of fish. Therefore, even if costs of higher quality fish are negligible, there is no reason for an individual producer to supply a presale-unobservable high quality characteristic since in the short run he will not receive a price premium. If accountability were improved in the seafood trade, the external cost of supplying low quality seafood would be internalized and the effects of the observability problem would be minimized. This can be achieved in a variety of ways such as through brand names, vertical integration, accurate monitoring of fish as it moves through the market channels or by grades and standards.

Poor Understanding of Buyer Needs and Preferences

Not only are observability and accountability problems in the seafood marketing system, but often sellers of seafood have remarkably little understanding of the buyers' needs and preferences. It is a chronic problem especially for fish products which are traded internationally. Exporters often attempt to sell seafood with improper specifications and packaging. This results in attributes and quality levels that are unacceptable to buyers. Improper packaging or grading which may not affect the nutritional quality of seafood can result in price discounts which amount to postharvest losses. The seafood demanded by different cultures, different market levels, and different market segments need to be well understood in order to maximize gains from an improved seafood quality system. Objective marketing research can help eliminate the losses which result from not understanding the buyer.

Buyers' and Final Consumers' Knowledge of Seafood

Lack of knowledge on the part of consumers regarding parasites, nutrition, sanitation, and other handling techniques will also result in postharvest quality losses. If quality fish are sold in a market where consumers are not knowledgeable, price premiums will not result and in the long run high quality fish will not be supplied. Resources are wasted simply because buyers are unaware of the value of

quality or they do not know how to use the resource. This leads to the implication that consumer education and informative grades and standards will improve demand for higher quality seafood and reduce both physical and economic postharvest quality losses.

Income and Budget Constraints

Retaining the quality of seafood as it travels through the marketing system raises costs. If consumers are constrained by income, postharvest quality losses will occur. In the long run, quality improvements must pay for themselves. If income constrains the price increases consumers can absorb, sellers of high quality seafood must either find wealthier consumers, probably through export, or lower cost by lowering quality.

Not only is consumer income a factor but firms' and governments' ability to generate capital may determine whether or not investment is made in new technology and infrastructure improvement. Individual firms in developing countries may find it difficult to raise capital for investment in improved facilities. The current debt situation in most developing countries severely limits their ability to improve infrastructure even if the projects will have positive payoffs in the long run. These income and budget constraints are probably caused, in large part, by the more fundamental problems of political instability, bureaucratic inefficiency and corruption which is pervasive in many developing countries.

Market Structure

The market structure will also affect the level of postharvest losses. As mentioned previously, in a competitive market, unobservable quality traits will tend to be undersupplied. If costs are internalized through increasing market power through vertical integration and accountability, quality may improve but the distribution of revenue generated will not necessarily be returned equitably to factors of production.

For example, in order to assure quality seafood inputs for its processing facility, a large multinational corporation may buy or contract with the primary producers such as fishing vessels and shrimp farms. This may reduce physical postharvest quality losses from the farm (vessel) to the processor but it is conceivable that returns to the firm (vessel) will be reduced as a result of monopsony behavior by the processor (A monopsony occurs when one firm is the sole buyer from many small firms. In general a monopsonist will buy less at a lower price than would occur under perfect competition). Recent research by Kinnucan and Sullivan (1986) found that monopsonistic behavior in catfish processing may result in a

12-35 percent decrease in prices received by West Alabama catfish producers.

Pricing Mechanisms and Price Information

Inefficient pricing mechanisms and poor price information lead to a misallocation of resources and therefore postharvest losses. Inefficient pricing mechanisms are common in seafood markets. Examples include auctions like the New Bedford fish auction where entire boatloads of multispecies catches are auctioned off at once. The price signals which are generated by this type of auction system are inefficient in reflecting the value of different quality and different species of fish. Other pricing mechanisms which are based on highly dissaggregated or secret negotiations between individual buyers and sellers undermine the market's function of assigning the appropriate price to a variety of different fish. Even if prices are determined in a relatively competitive and efficient market, price reporting and communication between markets is important to allocate resources spatially and over time.

Policy and Regulation

In addition to poorly conceived fisheries regulations, policy and regulations on food, agriculture and business can cause postharvest quality losses in seafood. Taxes or subsidies on inputs, user fees, packaging restrictions, foreign exchange regulation, export taxes or subsidies, legal constraints and permit requirements can all cause significant market inefficiency if poorly designed. For example, the high taxes on trucks and automobiles in many developing countries essentially insure that the distribution system for seafood and other perishable products in these countries will remain undercapitalized and in disrepair. One of the costs will be lower quality fish.

Externalities from Consumption

In some cases there may be costs to society from consuming or using low quality seafood which is not valued by the decision makers in the seafood market. These externalities are not considered in production and consumption decisions. A clear example for a nonseafood product is cigarette smoking. Individual smokers may not be willing to pay more for lower tar or reduced smoke cigarettes, but smokers are not considering all the costs. There are externalities in the form of health risks to those inhaling unwanted smoke, increased insurance premiums, costs to firms due to added sick days for smokers and reduced productivity. The benefits of reducing these costs

should to be accounted for when considering quality improvements.

In the case of postharvest quality losses in seafood there are analogies to the smoker case. In some cultures the preferred seafood product form (e.g. whole uneviscerated fish or very heavily smoked fish) may be of lower quality than that which could be available with current technology. In this case, the buyers may place zero or negative value on improved quality. One might conclude that an improved quality program is unwarranted. This may be reasonable if the external costs are negligible. However, external costs to society in terms of health risk and nutritional deficiency need to be considered. The benefits of lower health risk may outweigh the utility derived from customary procedures. When evaluating a quality improvement program, one must not only consider the market value of quality and the costs of providing quality but also the external benefits of improved quality and cost of internalizing the externalities through education, regulation or taxation.

EVALUATING POSTHARVEST QUALITY LOSSES

Market Valuation

It is relatively straight-forward to determine the marginal costs of providing a product of a definable quality level to the buyer given alternative technologies. However, the more difficult question is to assess the marginal value of those qualities to the buyer. Innovative market research can provide many of the answers.

If data on price, quantity-quality and other attributes is readily available and buyers in a competitive market are fully informed, the value of specific qualities can be estimated directly from market data. One of the most common approaches found in the literature is the hedonic price model. These models are based on the hypothesis that the observed price can be determined by the levels of specific qualities the goods contain (Lucas 1975). The observed prices are therefore a composite of the values of each product's qualities. These models have been applied to agricultural commodities but not to seafood to our knowledge. Recent examples include Texas rough rice (Brorsen, Grant and Rister, 1984), Minnesota malting barley (Wilson, 1984) and Texas cotton (Ethridge and Davis, 1982). One of the reasons hedonic models have been used for agricultural commodities is that data is available and the quality attributes are measurable and observable. In the case of rough rice, quality variables: percent of red and damaged kernels, percent chalky kernels, off-color, number of weed seeds, percent of green rice, and percent of smutty rice are all measurable and known to the buyer. Unfortunately, such

measures are rarely available for seafood products, especially in developing countries.

The models above are used to calculate the price premiums received by products which have certain quality attributes and are useful for comparing these price gains to the marginal cost of obtaining the quality attributes. However the price premium does not measure the complete gain to consumers of quality improvement. A frequently used measure to capture changes in social welfare are consumer and producer surplus (Just, Hueth and Schmitz 1982). Consumer surplus is used to measure the value consumers would be willing to pay above that actually paid in the market. It is typically measured by the area under the demand curve above the price line. Producer surplus has an analogous interpretation from the supply point of view. It is generally measured by total revenues minus the area under the supply curve. Unnevehr (1986) has used a consumer surplus measure derived from a hedonic price model to determine the gains from improved rough rice quality in Thailand, Indonesia and the Philippines. Unnevehr estimated a hedonic price equation for rough rice which includes the following quality parameters: whiteness (% pure white), brokens (%), shape (length/width), chalkiness (%), amylose (%), Gel consistency (mm), gelatinization temperature and fragrance. Price data and rice samples were collected in retail markets. Quality characteristics of the samples were analyzed in the Cereal Laboratory at the International Rice Research Institute (IRRI).

Any measure of the gains from quality improvements based on market data is dependent on the quality of the data. It usually implicitly assumes the buyers and sellers are well informed (information is costless and available) and the market is purely competitive (there is no collusion, no monopolistic or monopsonistic behavior and there are many buyers and sellers). The results are conditioned on current state of knowledge, technology, income levels and infrastructure. Therefore even with readily available market data there are some major difficulties in determining the actual value of quality, especially in a developing country.

Simulation and Experimental Methods

When detailed market data is unavailable or quality variables are unobservable and consumers or buyers are uninformed, experimental or simulation models can be used. Take, for example, a retail store selling seafood in some uniform package. If buyers are uninformed or unable to differentiate between quality levels in the store and therefore pay a uniform price for seafood, is there no way to determine the value of improved quality? Even if improved quality does not enhance price, there may be value in improving quality (i.e. shelf life) which will reduce spoilage losses. If the

extended shelflife seafood or technology is not in place and market data is lacking, how can one determine the value of extended shelf life if it were available? Brooks (1987) used a mathematical programming model of seafood retail outlets to simulate inventory management, sales and spoilage of cod, bay scallops and flounder. By parameterizing on the shelf life of the seafood, one can determine how spoilage and profit changes with changes in shelf life. From this, it is straight forward to determine the marginal value of an added day of shelflife. It was found that for a fixed ordering schedule the value of shelf life increases with demand uncertainty, wholesale cost and the wholesale-retail markup. The marginal value of extending shelf life can then be weighed against the costs of improving shelflife to determine what retailers should be capable of paying for shelflife improvements. This simulation approach avoids some of the need for detailed data. However, the values derived are what could be, not what will be. If the market structure is monopsonistic, buyers may not pay the marginal value of improved shelf life. If inventory management is not profit-maximizing, the value on shelf life will be overstated. If long shelflife seafood actually commands a higher price at the consumer level, the value to the retailer will be understated.

Values for seafood quality attributes can also be determined by willingness-to-pay studies and conjoint analysis based on experiment. In willingness-to-pay studies researchers employ a variety of techniques to reveal how much they would pay for products with various attributes. Seafood qualities which are not currently in the market or are unobservable can be considered non-market goods. Willingness-to-pay values are then regressed on the set of product attributes deriving an implicit willingness-to-pay for the component attributes as in hedonic price models. These studies are frequently used to value non-market goods such as crowding on beaches (McConnell 1977), and number of encounters in outdoor recreation (Menz and Mullen 1981). Willingness-to-pay studies are frequently criticized for a variety of biases which can occur, such as those caused by strategic behavior by the consumer, information biases and other problems. However, they could be considered for valuing seafood qualities especially those qualities related to health risk.

Another experimental approach is conjoint analysis which is based on the assumption that buyer preference is based on product attributes. In this case, willingness-to-pay is not elicited but the degree of buyer preference (buyer satisfaction) is obtained through survey or interview. The first application of market-oriented conjoint analysis was by Green and Rao in 1971. Since that time, it has found favor in the business literature for developing and designing new products by determining what level of particular attributes

would be most preferred by consumers. Recently, conjoint analysis has been applied to the salmon market (Anderson 1987 and Anderson and Brooks 1986). This research uses conjoint analysis to quantitatively evaluate buyer trade-off for aquacultured salmon products. Attributes evaluated include species, country of origin, shelf life, fresh versus frozen, product size, product cut, year-round versus seasonal availability, consistency of supply, wild-caught versus aquacultured, flesh color, delivery time, and price. Buyers of salmon (restaurant chefs and buyers for retail outlets) were asked to scale eight salmon products defined from the attributes listed above. The scale represented the degree of preference of the salmon (0 = least preferred, 100 = most preferred). The results from numerous buyers of similar characteristics were grouped and preference scale was regressed on quality attributes and price. The coefficients, therefore, represent the marginal value, in terms of buyer preference, of the quality attributes and price. For example buyers for expensive seafood restaurants had an estimated coefficient of 0.91 on days of shelf life for fresh salmon and -6.98 on price (Anderson and Brooks, 1986). This implies that if shelf life is improved by one day, the price could be raised by nearly 13 cents and the the buyer would be just as satisfied. If the shelf life could be increased by one day with a price rise of less than 13 cents the buyer would be more satisfied than he was with the lower cost, lower priced salmon.

Both willingness-to-pay and conjoint methods could be useful in measuring the value of both observable and unobservable quality attributes as well as quality attributes which may not exist in the current market. The advantage of these methods is that a functioning market is not required for estimation. Some problems of market data are avoided such as those resulting from an imperfect competition and other market efficiency problems. There are, however, many pitfalls in survey and experimental design which can introduce serious biases into the results. The results from these approaches also must be conditioned on consumer knowledge and income. If these studies mentioned in this and the last section are done over a cross-section of income levels or education groups, the effects of these factors can be determined.

Externalities from Consumption

In all of the valuation approaches suggested above, the gains from quality improvements are determined by the utility that individuals derive from consuming or using the products. Externalities to society resulting from consumption, such as unaccounted losses from nutritional deficiencies and health risks, are ignored. Measuring the value of externalities caused by consuming low quality fish is probably more difficult

than determining the market value of quality. However, in many cases, externalities from consumption are probably minimal relative to the value of quality which can be measured by the methods suggested above. In order to measure the magnitude of the external costs one would need data on the incidence and severity of losses of life and income resulting from consuming fish with given quality deficiencies.

Distributional Questions

If a program is introduced to reduce postharvest quality losses in a developing country and the costs of instituting the quality-improving infrastructure is absorbed by an altruistic third party at no cost to any buyers or sellers of fish, serious distributional questions may be raised. If higher quality fish are now available, new buyers with high incomes such as buyers from a highly developed nation, may be attracted to the market. There are several possible distributional scenarios. One possibility is that the foreign buyer will have monopsony power to buy all the quality improved fish at lower than competitive prices resulting in the majority of the benefits of quality improvement being exported and the fish consumers and possibly the fish producers being made worse off. Another case might be where the market is competitive but all the quality improved fish is exported because the consumers in the developing country are constrained in bidding by income. In this case if the profits from export are distributed equitably to factors of production, producers in the developing country may be better off but consumers will most likely be worse off due to increased prices. There are of course many other possibilities. It often becomes a philosophical question as to the appropriate distribution of gains and is usually determined by economic and political forces. However the research must address these issues at least in the positive sense of attempting to determine who gains and who loses. One may however take a more normative approach and use the Pareto criterion, that no one is made worse off and at least someone is made better off when quality enhancing measures are put in place. Or use the compensation criterion that the gains to the winners are great enough to compensate the losers.

CONCLUSION

The economics of postharvest quality losses is clearly a complex topic. This paper has attempted to illustrate some of the socioeconomic factors which are the root causes of postharvest quality losses. They include fisheries regulation and management, observability of quality factors and the accountability of those who supply seafood, poor understanding

of buyer needs, lack of buyer knowledge and awareness, income and budget constraints, imperfectly competitive market structure, externalities from consumption, inefficient pricing mechanisms, poor price information and other policies and regulation.

Several approaches to quantifying the value of quality losses were discussed. Market based approaches such as hedonic price models are most frequently used. These models require substantial data from an efficiently functioning, competitive market to yield results which reflect the value of quality. Such data is often lacking in developing countries especially for fish.

Other approaches suggested include simulation models and experimental methods such as willingness-to-pay studies and conjoint analysis. These models have the advantage that a functioning market is not required nor is it necessary that the qualities in question even exist at the time of the study. In all of the approaches mentioned the results are conditioned on the current level of buyer knowledge and in most cases income.

Externalities from consumption are not addressed by the aforementioned approaches. These are costs of quality losses which are not included in the buyers or sellers decision processes. The costs accrue to individuals not directly consuming seafood and society as a whole. The costs in reduced productivity associated with reduced health caused by low quality seafood may be an example. These costs need to be accounted for in policy decisions.

Distributional questions may be some of the most important for developing countries. The methods suggested in this paper can often be adapted to determine who will benefit and who will lose from quality improvement projects. Unfortunately economic studies usually do not consider distributional aspects even though it is generally not difficult to incorporate them. Political constraints and processes probably inhibit some of the research on distributional impacts.

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FISH QUALITY IN THE PHILIPPINES

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ABSTRACT

The existing postharvest handling of wet fish in the Philippines is reviewed in terms of handling from the landing site to the market and the use of ice and containers. Reference is made to the existing fish marketing and distribution system in the country. Results of surveys regarding the evaluation of wet fish quality are presented.

The paper identifies weak points in the present system and summarizes local research work in the area. Problems range from economic to lack of quality consciousness on the part of the fisherman and fish handler.

INTRODUCTION

The Philippines, an archipelago of 7,100 islands, has a long coastline indented with numerous bays, harbors and inlets. The fishing industry operates over an area of about 1.7 million square kilometers of seawater, 9,000 square kilometers of freshwater and 3,000 square kilometers of brackishwater. The coastal waters and shallow seas are intensively exploited but the offshore areas and the deep seas are largely untapped (Gonzales, 1976). Total fish production in 1985 was a little over 2 million metric tons valued at about 1.3 billion US dollars. Commercial fisheries contributed 25%, municipal and sustenance fisheries, 53% and aquaculture, 22% to the total catch (Table 1).

An attempt to quantify the level of fish spoilage in the Philippines yielded a value of 1% (Juliano and Yutuc, 1977) while Craib and Ketten estimate this figure for tropical countries at 20-40% (both authors cited by Sumner et al., 1985).

The Ministry of Natural Resources (Philippines) reports a 20% postharvest loss for selected years between 1970-1981

(Floyd, 1985). With an annual per capita fish consumption of 40 kilograms and a 54% share in the total protein supply of the Filipino, postharvest losses in fisheries represent waste of an important commodity. Wastage becomes more significant in the light of recent reports on the depletion of marine and inland fishery resources of the country. It is estimated that the present biomass levels in the case of Philippine demersal stocks have declined to about 30% of the biomass level in the 1940's (Silvestre and Pauly, 1986; Silvestre et al., 1986). Although less documented, there are good indications of a downtrend in catch rates of pelagic stocks.

POSTHARVEST HANDLING OF WET FISH IN THE PHILIPPINES

The problems of postharvest handling are shared by all sectors of fisheries. Municipal fisheries use small craft which have limited space that often does not allow for proper handling and preservation of the catch on board. These vessels are slow, requiring considerable time to reach landing places and they do not have roofs to protect the catch from the sun. In many cases, the small-scale fisherman lands fish which has started to spoil, depending on the distance from fishing ground to fish landing as well as on weather conditions. Commercial fishing vessels, on the other hand, have generally better on-board facilities which enable them to bring ice to chill the catch. However, the long period of time during which the vessels stay at sea, averaging a month, often causes significant loss in fish quality.

Handling at the Fish Port

Fish ports in the country are classified either as municipal or national. There are at present 29 municipal ports and three national ports. The Navotas Fish Port Complex, situated in the National Capital Region is where about 40% of the total commercial fish is landed. This port supplies close to 80% of the fish requirement of Metropolitan Manila. Nightly landings average 600 mt (Cruz, 1981) and 70-80% of the landed fish come from commercial fisheries (Thomas, 1986).

Fish are transported to the fish port either by water or land. Land transport may be the sole transport system for the fish or may provide the link between the port and the pier where the commercial vessels which carried them from the catching or collection site dock.

In the hold of the carrier, fish are contained in metal tubs called baneras with a liberal quantity of crushed ice on top. Unloading at the port is done manually: two men are usually stationed inside the fish rooms and another two are assigned on deck to receive the metal tubs and slide them through a makeshift wooden plank. A team of batillos (dock

workers) carry the banera to the market hall. The fish are douched with harbor water from a high-pressure pump to remove adhering dirt, blood, slime and unmelted ice. If the banera contains mixed catch, the fish are douched with water, emptied into another banera and partially sorted.

If the catch is bulk frozen in the fish hold, the stack of frozen fish is broken with shovels and gaffs. The fish are placed into a basket which is hoisted on the quayside, the bottom of which can later be opened and the fish discharged into a heap on the ground for sorting. The baneras are filled to the required weight.

Filled baneras are arranged for sale. One of the selling methods in the fish landing which is perhaps unique in the Philippines is the whispered bidding or "bulungan" system. The buyer whispers the bid to the broker who, after receiving other bids, settles the sale in favor of the buyer whose price-quantity-credit combination suits the broker. Sale may either be on cash or credit basis.

Fish for transport to the wet markets are washed in harbor water, and repacked into containers with ice or ice water slurry. Containers may either be the banera, styropore boxes of various makes or native baskets. The common transport vehicle is the jeepney. In the retail markets, the fish are poured out of the banera/container and put on display with little ice or none at all.

Use of Ice

Block ice, flake ice and tube ice are available. In many cases, crushed ice is made from block ice by ice-crushing machines.

A nationwide survey of existing ice plants and cold storage facilities (JICA, 1985) showed that the supply and demand for ice in the fisheries sector was almost balanced in 1983 for the country as a whole but there were significant regional differences largely because of limitations of transporting ice between regions. There is oversupply in the National Capital Region (NCR) and shortage in regions outside Luzon (Table 2).

According to the same survey, the ice to fish ratio used for on-board handling of fish ranges from 0 to 2.4 depending on distance to the landing site and duration of the trip. For transport and marketing, the ratios range from 0 to 1.35 (JICA, 1985).

A separate inter-agency study cited by Sumner et al. (1985) provided ice expenditure data for various types of fishing vessels in San Miguel Bay (Table 3). Orejana et al. (1984) report that in some fish landings the ice to fish ratio may be as low as 1:20. Actual survey of Sumner's team confirmed the regular absence of ice from the catch at Navotas market. They also found that 20 of the 58 retail stalls in the wet market

TABLE 1
Fish Production in the Philippines

Year	Total Quantity (in millions of metric tons)
1981	1.77
1982	1.90
1983	2.11
1984	2.08
1985	2.14

Source: BFAR, 1986

TABLE 2
Supply of Ice for the Fishery Sector in 1983 by Region
(in tons per day)

Region	Supply	Demand	Net Supply
NCR	2311	931	+ 1380
I	645	140	+ 505
II	237	20	+ 217
III	1542	539	+ 1003
IV	1534	2051	- 517
V	469	532	- 63
VI	1193	2118	- 925
VII	340	207	+ 133
VIII	205	200	+ 5
IX	420	1741	+ 1321
X	142	391	+ 249
XI	464	434	+ 30
XII	156	327	- 171
TOTAL	9658	9631	+ 27

Source: JICA, 1985.

surveyed did not use ice (Sumner et al., 1985). An interesting observation of the same team was that ice usage was independent of the value of the produce, for example anchovies which sell at US $0.60/kg is iced the same way as Penaeus monodon priced at US $4.50/kg. From the wide variations in the ice to fish ratio, a wide variation in wet fish quality can also be expected.

TABLE 3
Catch and Application of Ice in San Miguel Bay

Category	Avg Catch/Trip (kg)	Use of Ice/Trip (kg)	Ice:Fish
Gillneter	47	2	1:25
Mini-trawler	135	5	1:27
Small trawler	470	146	1:3
Medium trawler	520	200	1:2.6

Source: Smith and Mines, 1982 cited by Sumner et al., 1985.

Fish Containers

In the Philippines returnable fresh fish containers come in various forms and sizes:

1. conical galvanized steel tubs ("banera")
2. bamboo baskets ("bakol" or "tiklis")
3. wooden boxes ("kaha")
4. rattan baskets ("luenleng")
5. styropore boxes reinforced with wooden materials or galvanized iron

None of these containers measure up to the requisites of a good container (Alvarez, 1981). Bamboo baskets are structurally fragile. Wooden boxes are cumbersome to handle, seldom exceed six months working life, absorb moisture and harbor bacteria. Rattan baskets do not stack. Styropore boxes suck up bacteria and are prone to damage. Baneras do not insulate well. The unsuitability of existing containers is reflected in a large percentage of fish being landed at the national fishing port in varying degrees of physical distortion. Some are slightly bruised, others are crushed while still others show burst gut damage.

In the late 1970's, the ASEAN-ACIAR Program introduced the high density polyethylene (HDPE) containers. Field trials were conducted at the national fishing port and in Camarines Norte. Some commercial fishing vessels in Western Visayas have started to use the HDPE containers. Quite recently, one of the large multinational companies in the country started to manufacture plastic fish crates which can be nested when empty and the company claims have a life span of five years (San Miguel Corporation, 1987). Having been on the market only three months, it is too early to evaluate the container's performance.

The banera has remained a favorite among local fishermen and fish handlers. It is inexpensive, costing about US $4.00, reasonably durable and light in weight. The banera also serves not only as a container but as a unit of sale as well with an average loaded weight of 40 kilograms (Alvarez, 1981). In a comparative cost analysis of different fish containers, however, Peralta et al. (1985) recommended the bamboo or rattan baskets over the banera. The baskets have been found to cost 22 percent less than the banera and even exhibited a lower rate of ice melting. Structural considerations however were not mentioned in relation to fish quality.

Marketing Channels for Wet Fish

The present marketing system for wet fish in the Philippines is described as dispersed and uncoordinated. Market structure is classified as oligopolistic (Librero, 1985) and the number of sellers is generally smaller than the number of buyers. As the level goes down from wholesale to retail, the ratio of buyers to sellers increases logarithmically.

Direct marketing between producer and consumer is rare and practiced only by some municipal fishermen. Figure 1 shows distribution channels for wet fish in Navotas. An unpublished study of the Philippine Fish Marketing Authority cited by Librero (1985) showed that fish is traded at least four times before it reaches the consumer. In the process, prices increase by as much as 200% and the quality of the produce suffers.

Wet Fish Quality

Very little literature is available on the quality of wet fish in the Philippines. A project undertaken in 1985 by the Department of Fish Processing Technology, University of the Philippines in the Visayas (DFPT, unpublished) involved the determination of the temperature and microbiological quality of fish landed at the National Fishing Port. Temperatures of 1.4-9.9°C were recorded for fish taken out of the vessel and temperatures of 0-20.5°C for fish in the market halls of the

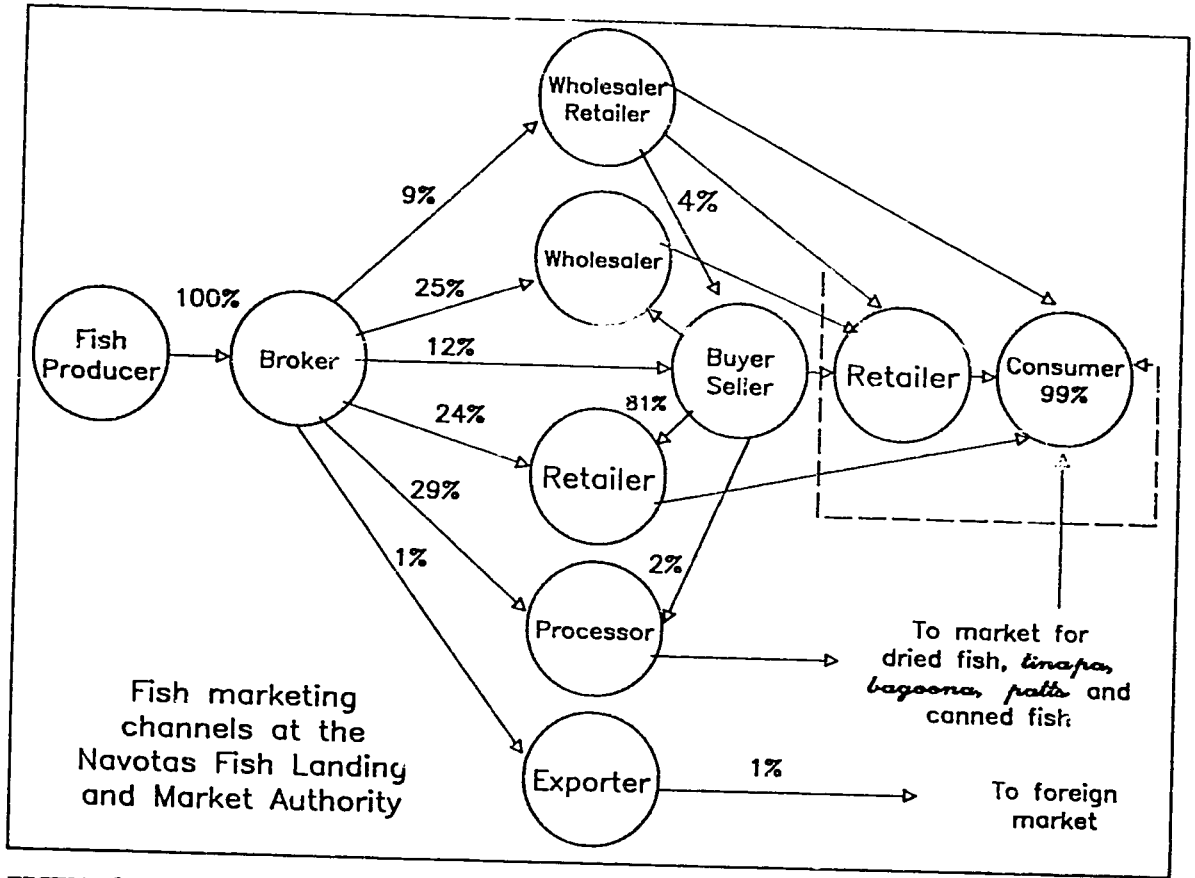
Fish Producer
100%
Broker
9%
25%
12%
24%
29%
1%
Wholesaler Retailer
Wholesaler
Retailer
Processor
Exporter
4%
81%
2%
Buyer Seller
Retailer
Consumer 99%
1%
To market for dried fish, tinapa, bagoong, patis and canned fish
To foreign market
Fish marketing channels at the Navotas Fish Landing and Market Authority

FIGURE 1.

port. Sumner's group (Sumner et al., 1985) reported a temperature profile for fish in the same port market of 3-14°C (21 samples) corresponding to Torrymeter readings of 0-11. Using a large retail market (Cubao Farmer's) as the sampling site, Sumner et al. (1985) found fish temperatures of 5-23°C and Torrymeter readings of 0-12 (Table 4).

TABLE 4
Temperature and Torrymeter Readings of Species on Display at Navotas Fishing Port and Cubao Farmers' Market

	Temperature (°C)				Torrymeter Reading			
	n	mean	max	min	n	mean	max	min
Milkfish								
Navotas	9	9.8	14	6	60	8.2	11	6
Cubao	20	12.4	23	5	64	7.5	7	5
Roundscad								
Navotas	6	18.1	11	7	40	7.2	10	4
Cubao	11	14.0	19	8	32	5.3	8	4
Yellow-tail tuna								
Navotas	3	4.1	5	3	6	5.7	10	2
Cubao	7	17.0	20	10	30	4.9	11	0
Spanish mackerel								
Navotas	3	7.7	9	6	5	1.4	3	0
Cubao	5	21.0	24	10	10	5.7	7	4
Lapu-Lapu								
Cubao	11	21.7	22	13	30	4.6	8	0
Tilapia Cubao	6	20.8	24	17	42	9.6	12	8
Mullet Cubao	--	--	--	--	20	7.5	9	5

Source: Sumner et al., 1985

Microbial determinations conducted by the DFPT showed standard plate counts (SPC) of 10,000 - 1,000,000 cfu/g on fish taken out of the fishing vessel and SPC of 1,000 - 10,000,000 cfu/g for fish sold in the port market. Further studies show

that the SPC does not necessarily reflect the acceptability level of the product. In the case of squid, an SPC of 1,000,000 cfu/g corresponded to an unacceptable product while siganids with a count of 10,000,000 cfu/g were highly acceptable.

Barile (1984) recorded a wide range of temperatures in tuna received at one of the processing plants. She observed however that histamine levels in the same batch of fish were quite low (0.45-0.93 ppm). In the same plant, levels of 1.28-3.66 ppm histamine were detected in mackerel but the incidence of honeycombing in the canned product was relatively high. K-values ranged from 2.26 to 39.42% for mackerel and 3.38 to 67.69% for tuna.

PROBLEMS AND ISSUES

A number of weak points could be identified in the present postharvest handling and marketing system for wet fish in the Philippines.

Proper Icing and Cold Storage of Catch

Studies have repeatedly shown the merits of proper icing. The shelf life of Faugh's mackerel (Rastrelliger faughni Matsui) is reduced by one day for every hour delay in icing or exposure to ambient temperature of 28-30°C (Barile et al., 1985a). For the same species, a 50% reduction in shelf life occurs for every 5°C increase in temperature over 0°C. It has also been shown that the method of chilling is of minor importance (Barile et al., 1985b). Similar relationships between shelf life and chilling temperature as well as delays in icing have been established for roundscad (Decapterus moruadsi) (Estrada et al., 1984 a and b), and squid (Sensupa, 1985). Reilly et al. (1986) observed that for every 1°C above zero that prawns are stored, storage life at 0°C is reduced by one day. Orejana et al. (1984) further reported that when the ice to fish ratio exceeded 1:10, frigate mackerel were not only of poor quality but had high levels of histamine (120 mg %) as well.

Dolendo et al. (1978) also emphasized the importance of prechilling milkfish. They found no advantage in chilling milkfish to 0°C over 4°C if icing is done immediately after harvest. It takes 900 kilograms of ice and 4 hours of immersion in ice water to chill a ton of milkfish to 0°C and only 450 kilograms of ice and 2 hours of immersion to reach 4°C.

The problem of proper icing and cold storage of the catch is related to economic and cultural factors. As earlier mentioned, the problem does not appear to be adequacy of ice plant and cold storage facilities but location and

availability. Ice plants are concentrated in the NCR which contributes only a small fraction to total fish production. In many regions especially in isolated fishing villages ice is very expensive or not available at all. There is also a general dislike for iced fish especially in rural areas. Smith et al. (1980) report that iced fish in Cebu is regarded with suspicion, thus retailers tend to display fish uniced. Posadas et al. (1986) found that consumers in Iloilo ranked fresh fish without ice over fish which is iced. Cold storage facilities have not been fully availed of especially in periods of oversupply. Two reasons have been cited: high freezing and storage charges, and pilferage (Thomas, 1986).

While the importance of proper icing has not been doubted, there has been no in-depth study to establish the profit margin for properly iced fish vis-a-vis that which is not, and to find out if the present cost of proper icing is within the capability of small-scale fishermen who are living way below the poverty line (Sumner et al., 1985).

Reusable Fish Containers

The high ambient temperature in the tropics not only speeds up spoilage rates but melting rates of ice as well. The insulating property of fish containers for the tropics is therefore a very important attribute in addition to those which are generally required of fish containers. Modifications which have been tried include reinforced styropore boxes with galvanized iron sheets, sawdust as an insulator, and application of the isibox system on the banera. The applicability of indigenous materials like "pandan" leaves for the construction of fish containers has also been studied (Aganus and Mangahas, 1981). Villadsen et al. (1985) compared various fish containers against the styropore box, and found that a container made of fiberglass insulated with polyurethane had 40% more insulation efficiency than the styropore box, is very hygienic and has a projected life span of two years against the styropore box's life span of three months. The isibox system also proved to be 50% more efficient than when the containers are used in the traditional way. The study of Dolendo et al. (1978) also looked at suitable containers for the transport of milkfish by air, sea or land.

Alvarez (1981) warns, however, that the complexity of the country's fish marketing system and the dearth of well-managed markets casts doubts on the feasibility of using expensive standard containers despite their superiority to the traditional banera. The incidence of loss through pilferage which is unavoidable in a fragmented marketing system makes the use of these superior but initially more expensive containers seemingly impractical.

Lack of a Rational Fish Collection and Distribution System

The lack of a rational and well-coordinated fish collection and distribution system brings about areas of surplus and areas of deficit with the consequent price differentials. The regional gap in supply and demand is expected to become more critical in the years ahead (JICA, 1985). The absence of collection centers forces the fisherman to sell his catch for local consumption or to process the fish, usually by drying. Economic returns are reduced. The archipelagic nature of the country exacerbates the problem of transport and distribution.

In one of the collection centers established by the Philippines Fish Marketing Authority, the carrier vessel may have to wait two or three weeks for maximum capacity to be filled up before sailing to the fishing landing.

Lack of an Efficient Marketing Scheme

A long chain of middlemen and several marketing channels characterizes the present system. Cost is necessarily increased as the fish changes hands and the extension of the cold chain is detrimental to fish quality. While the presence of middlemen is generally taken as undesirable, a study has shown that there is actually a complex web of interpersonal relationships that exists between the fisherman and the middleman and it is unlikely that the middleman can be removed from the marketing chain (Pomeroy, 1986).

The whisper bidding system has also been alleged to result in lower selling costs compared with those if the bidding were open. In the assessment of a survey team who worked in San Miguel Bay, changes in the whispered bidding system would have marginal benefits for fishermen (Yater et al., 1982).

Attitudes of Fishermen and Fish Handlers

Practices such as the use of harbor water to wash fish, dumping fish on the floor, shovelling the catch, use of artificial dyes to color the seawater (to enhance the appearance of colored species) promote deterioration of fish. Poor handling practices become more pronounced during periods of glut when the fisherman anticipates very low prices in the market.

CONCLUSION

A review of the existing postharvest handling techniques for wet fish as well as of the present fish marketing system shows a number of points where modifications are warranted in order to reduce postharvest losses and maintain quality. The use of ice, improved fish containers, establishment of an

efficient fish distribution and marketing system and the promotion of quality awareness on the part of the fisherman and fish handler are suggested programs of action. In most cases, however, the introduction of changes and better technology have a radial effect cutting across economic, social and cultural aspects which are not necessarily affected in the same direction. For example, in 1977, there was a proposal to mechanize the unloading system at the National Fishing Port complex. From all technical angles the proposal was advantageous; however, the government could not exclude the significant number of workers to be dislocated. Thus the present manual, messy unloading system still appears to be the most appropriate arrangement (Cruz, 1981).

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HISTAMINE AND CLOSTRIDIUM BOTULINUM IN FRESH AND SALTED SEAFOODS

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ABSTRACT

This paper reports the main results obtained in an evaluation of the problem of histamine and Clostridium botulinum in fresh and salted seafoods.

Histamine producing bacteria were isolated from surface samples and the viscera of seafoods (shark, croaker, white fish, sardine, mackerel, tuna, skipjack tuna and shrimp), both at 35°C and 25°C. Morganella morganii was the prevalent histamine producer, followed by strains of Proteus, Vibrio, Aeromonas, Acinetobacter, Pseudomonas, Enterobacter and Klebsiella. Histamine levels of over 1,000 mg/100ml were produced by 7.8% of these cultures when inoculated into histidine broth. When inoculated into sterile sardine and mackerel tissues, followed by incubation at 7°C, 15°C and 25°C, higher histamine production was observed at 25°C followed by 15°C, with no production at 7°C.

Histamine and free histidine levels were also determined in the same seafood species, with the samples being collected immediately after landing. The results showed histamine levels varying from 4.5 mg/100g (mackerel) up to 12.8 mg/100g (shrimp). while the free histidine levels were higher in tuna, skipjack tuna, mackerel and sardines (239, 496.8, 317.7 and 196.6 mg/100g, respectively), moderate in shrimp (20.4 mg/100g) and very low in white fish, croaker and shark. These latter species do not offer any risk with respect to the presence of potentially toxic histamine levels.

In a second piece of research, the occurrence of Clostridium botulinum was evaluated in a total of 500 seafood samples, being detected at levels varying from 4.0% (sardine) up to 35.0% (shrimp). C. botulinum type E was prevalent (50.0% of the isolations) followed by type F (16.7%), B (10.1%), and A (9.4%). The possibility of C. botulinum type A growth during the salting process of sardines was also evaluated, based on

analyses of water activity (Aw), moisture content and salt concentration in the muscle tissue of whole and eviscerated sardines, and finally by spore inoculation experiments.

The results showed that safe moisture contents (61%), Aw (0.94) and salt levels (10%), sufficient to assure the complete inhibition of C. botulinum type A growth, were only reached after 2 days of salting. In the spore inoculation trials, the detection of C. botulinum toxin was confirmed in one sample of whole sardines, with no positive samples amongst those which had been eviscerated.

INTRODUCTION

According to Brazilian statistical data (from 1984), the total capture of fish, molluscs and crustaceae was approximately 959,000 tons, with seafoods comprising 77.8% of the total and fish of fresh water origin only 22.2%. Most of the catch took place in the Southeast and South of Brazil (35.6 and 22.6%, respectively), followed by the Northeastern area (20.7%).

Fishes (both of marine and fresh water origin) represented 87.4% of the whole catch, followed by crustaceae (10.1%) and molluscs (1.1%). When considering only marine fish and based on the 1982 data, it becomes evident that sardine was the leading species captured (23.6% of the whole catch), followed by croaker (4.6%), mackerel (3.8%), shark (2.8%), white fish (2.2%) and several other species.

A significant part of the captured seafood is exported to USA, Japan and Europe, with an emphasis on lobsters, shrimps, red snapper and other fish species that are usually preserved by freezing, after the preliminary processing steps. In Southern Brazil, the canning of sardines (in oil or tomato juice) is probably the main activity with respect to fish processing, this production being directed mainly at the internal market. However, when the catch is excessive, resulting in too much raw material, part of the sardines are processed by salting giving a product of inferior quality that is usually sold in the local market at relatively low prices.

In a critical evaluation of the Brazilian seafood industry, with an emphasis on postharvest fishery losses, some deficiencies are clearly apparent, probably the most critical ones, being related to the inadequate storage conditions under ice refrigeration aboard the fishing boats, followed by problems during transport and a lack of continuous refrigeration up to the point where the seafood reaches the final consumer. When one considers that seafood in general is very susceptible to microbial and chemical spoilage when not maintained under adequate storage conditions, the above mentioned deficiencies would partially explain the great losses of raw material, the reduced shelf life of all seafoods and the

fact that the product available to the final consumer quite frequently presents quality and hygienic conditions which are both inadequate and unrecommendable.

These considerations and also the lack of experimental data which would permit the evaluation of seafood quality under our conditions, were the main reasons justifying the proposal for a study concerning some public health aspects related to microbial contamination.

Emphasis was placed on the problem of histamine in fresh and refrigerated seafoods, and on an evaluation of Clostridium botulinum in the marine environment and its growth potential during the salting process of sardines.

HISTAMINE IN SEAFOODS

In the first part of the project (Leitao et al., 1983c) the occurrence of histamine producing bacteria on the surface, muscle tissue and viscera of fresh seafood with high local consumption was calculated. The selected species were sardines (Sardinella brasiliensis, Steindachner), mackerel (Scomber japonicus, L), skipjack tuna (Katsuwonus pelamis, L), tuna (Thunus alalunga, Bonnaterre), croaker (Micropogon furnieri, Desmarest), white fish (Macrodon ancylodon, Boch), shark (Sphyrna sp.) and shrimp (Xyphopenaeus kroyeri, Heller).

The histamine producing bacteria were initially isolated in the differential medium proposed by Niven et al., (1981), followed by identification up to the genus or species level. These bacteria were frequently isolated from the surface (52.6% of all isolations) and viscera (33.0%), both at 35° and 25°C, and more rarely from the muscle tissue.

Morganella morganii was the prevalent histamine producing bacteria (58.8% of all isolations, followed by Proteus spp. (12.4%), Vibrio spp. (11.4%), Aeromonas spp. (9.3%) and strains of Acinetobacter, Pseudomonas, Enterobacter and Klebsiella.

By using an experimental inoculation of pure cultures into broth developed by Niven et al., histamine levels higher than 1,000 mg/100ml were produced by 7.8% of the tested cultures, although 63.1% of them only produced histamine at levels between 100 and 500 mg/100ml. M. morganii and Proteus spp. were those producing the highest histamine levels, producing more at 25°C than at 35°C, although some Aeromonas and Acinetobacter strains were also active histamine producers.

Finally, by the inoculation of M. morganii into sterile sardine and mackerel tissues, followed by incubation for 7 days at 7°, 15° and 25°, higher histamine production was observed at 25°C or 15°C (approximately 200 mg/100g in mackerel at 25°C and 115 mg/100g in sardines at 15°C), with no production at 7°C (Figures 1, 2).

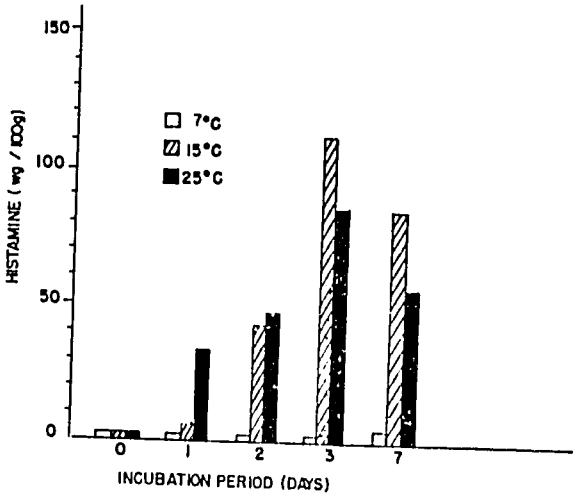

FIGURE 1. Histamine production in muscle tissue of sardines, inoculated with Morganella morganii 54, with incubation at 7°, 15° and 25°C during 7 days.

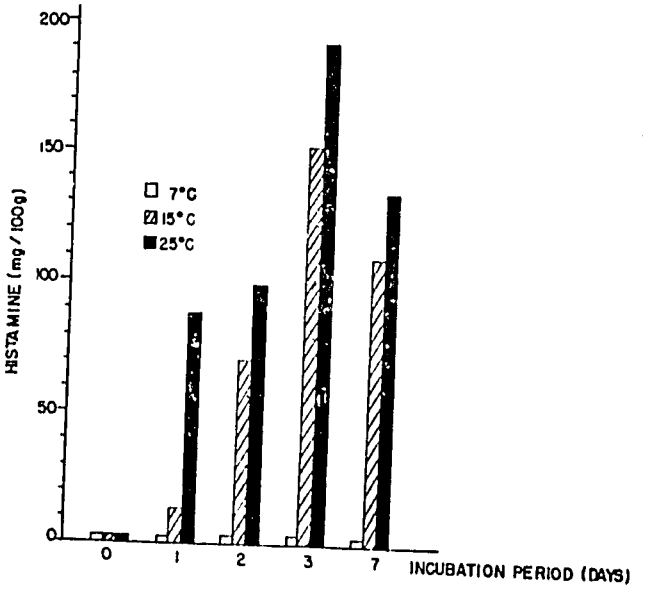

FIGURE 2. Histamine production in muscle tissue of mackerel, inoculated with Morganella morganii 54, with incubation at 7°, 15° and 25°C during 7 days.

As a sequence of this research, the histamine levels in refrigerated seafood collected immediately after landing were also evaluated. The same seafood species mentioned above were analyzed during three different sampling periods, and the average results are shown in Table 1.

TABLE 1
Average Histamine Levels in Refrigerated Seafoods Analyzed Immediately after Landing

Seafood	Histamine content (mg/100g)
Tuna	7.5
Skipjack tuna	4.7
Mackerel	4.5
Sardine	9.2
White fish	5.9
Croaker	5.6
Shark	10.1
Shrimp	12.8

According to Ienistea (1973), foods containing histamine levels between 10 and 100 mg/100g are potentially toxic for humans, while the ICMSF (1978) states that histamine levels above 100 mg/100g are generally capable of producing human intoxication. Based on these data the examined samples should be considered safe. However, when compared to the results obtained by other authors, the histamine levels are considerably higher. Frank et al. (1981), examining fresh tuna fish samples caught in Hawaii, detected maximum histamine levels of 0.13 mg/100g, and Taylor et al. (1978), analyzing fresh and frozen shellfish and crustaceae, observed maximum levels around 0.64 mg/100g. Therefore the present results suggest that inadequate fish storage conditions in the boats probably allow some microbial multiplication, resulting in higher histamine levels.

It seems important to evaluate the potential risk of histamine accumulation in different fish species, at least in those with higher consumer acceptance. Thus in addition to the histamine analyses, the free histidine levels of all the examined samples were also determined, the results being expressed in Table 2.

TABLE 2
Histamine and Free Histidine Levels and Maximum Potential Histamine Accumulation in Different Seafoods

Seafood	Free histidine content (mg/100g)	Histamine cpmtemt (mg/100g)	Maximum histamine* accumulation (mg/100g)	Total histamine (mg/100g)
Tuna	239.0	7.5	171.2	178.7
Skipjack tuna	496.8	4.7	355.3	360.0
Mackerel	317.7	4.5	227.0	231.5
Sardine	196.6	9.2	140.4	149.6
White fish	0.3	5.9	0.2	6.1
Croaker	2.0	5.6	1.4	7.0
Shark	2.5	10.1	1.8	11.9
Shrimp	20.4	12.8	14.3	27.1

*Observation: The maximum histamine level was theoretically determined based on the free histidine content of each sample and assuming that each histidine mole being decarboxilated resulted in the production of 111.15g of histamine.

Assuming a maximum safe level of histamine of 100 mg/100g, as recommended by the ICMSF (1978), the results in Table 2 show that the Scombridae (tuna, skipjack tuna and mackerel) are the species which offer the highest potential risks. However, the sardines, if stored under inadequate conditions, can accumulate high histamine levels, while the shrimps may eventually affect more susceptible human beings, according to Ienistea data (1973). Finally, based on our data, some fish species like croakers, white fish and shark do not appear to offer any potential risk with respect to the histamine problem.

CLOSTRIDIUM BOTULINUM IN SEAFOODS AND ITS GROWTH POTENTIAL DURING THE SALTING OF SARDINES

Based on the few available data related to the occurrence of C. botulinum in Brazilian seafoods, Delazari et al. (1982) working in the Food Microbiology lab of ITAL, made an extensive evaluation of seafoods caught along the Sao Paulo coast. A total of 500 samples were analyzed, including white fish, catfish (Netuna barba, Lancedede), sardine, oysters (Crassostrea brasiliana, Lamarck) and shrimps.

The results, expressed in Tables 3 and 4, show the widespread occurrence of C. botulinum in the different seafood samples.

TABLE 3

C. botulinum Isolated from the Intestinal Tract of Marine Fish and Homogenized Samples of Oysters and Shrimps

Seafood	No. of samples examined	C. botulinum detection (% positive samples)
White fish	100	31.0
Catfish	100	31.0
Sardine	100	4.0
Oyster	100	34.0
Shrimp	100	35.0

TABLE 4

Prevalence of C. botulinum types in contaminated seafood samples

C. botulinum Type	No.	Prevalence %
E	69	50.0
F	23	16.7
B	14	10.1
A	13	9.4
NI*	19	13.7

*NI = Not Identified.

It is interesting to note that among the fish samples, sardines were those with the lowest incidence of C. botulinum, while all the other species showed high contamination levels of between 31.0 and 35.0%. As confirmed in worldwide surveys, C. botulinum Type E prevailed among the types isolated, with a 50% incidence, followed by type F, also common in the marine

environment. However, it is important to emphasize that C. botulinum types A and B, commonly isolated from terrestrial environments, represented 9.4 and 10.1% respectively of all the isolated C. botulinum types.

In southern Brazil, the capture of sardines continues for the greater part of the year, the fish being directed to industrial processing (canning) or refrigerated and sold to the final consumer at the local market.

However, there are occasions when the level of capture is so high that part of the production is diverted to salting, the final product being sold at relatively low prices to local consumers. This salted product is popular, at least amongst the lower income population, which lives in the poorest areas, and cannot afford to buy expensive seafood products. However, it generally presents very poor quality due to chemical changes (mainly rancidity) which occurs during the processing steps. According to Brazilian regulations, the sardines must be eviscerated before the salting process, in order to assure a better quality and safer product, and the salting must continue for 21 days in order to reach equilibrium. However, local industries are generally reluctant to follow these regulations, arguing that the eviscerating step, even when done mechanically, does not allow the processing of large volumes at the desirable speed. Based on these considerations, and with an emphasis on the public health aspects of the processing operations, the salting process of sardines was studied, analyzing water activity, moisture and salt concentration in the muscle tissue of whole and eviscerated sardines and in the viscera of the former (Leitao et al., 1983b). All the analysis were made at variable intervals of around 10h during the first 2 days, and at daily intervals up to 21 days. The main objective of this study was to evaluate the possibility of the growth of C. botulinum type A during the initial salting procedure, and to compare eventual differences in the processing of whole and eviscerated sardines.

The results showed that the salt penetration rate and reduction of water activity and moisture levels varied in relation to the conditions of the raw material. However, safe moisture (61%), Aw (0.94) and salt levels (10%), sufficient to assure the complete inhibition of C. botulinum type A growth were only reached after 2 days. After 6-7 days of salting, these levels reached equilibrium, with practically no further change up to 21 days. Usually the rates of change in whole sardines were lower when compared to the eviscerated ones, but the differences were not remarkable (Figures 3, 4, 5).

In order to evaluate the potential for C. botulinum type A growth during the first 48 hours of the salting process, spore inoculation experiments were performed, both in whole and

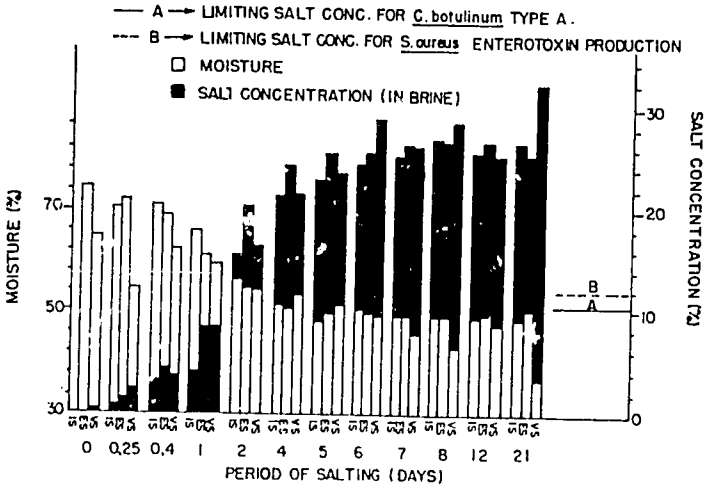

FIGURE 3. Variation in moisture and salt concentration levels in viscera and muscle tissue of whole and nobbed sardines during the salting process (first experiment). IS = muscle tissue of whole sardines; ES = muscle tissue of nobbed sardines; VS = viscera.

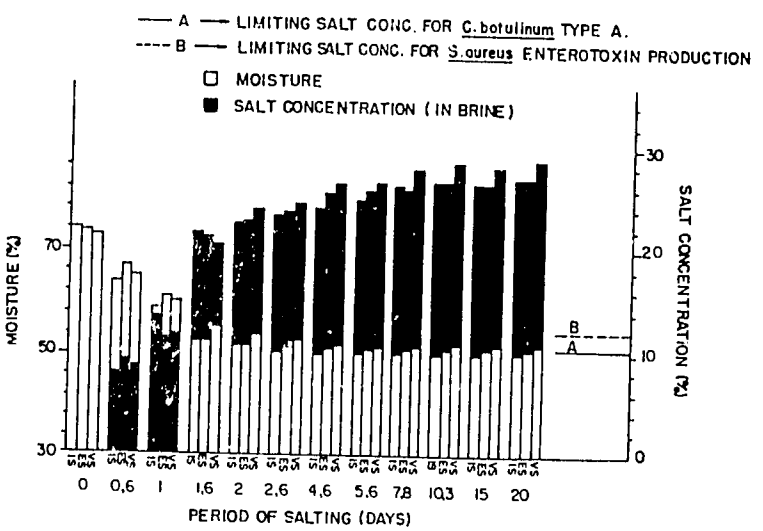

FIGURE 4. Variation in moisture and salt concentration levels in viscera and muscle tissue of whole and nobbed sardines during the salting process (second experiment). IS = muscle tissue of whole sardines; ES = muscle tissue of nobbed sardines; VS = viscera.

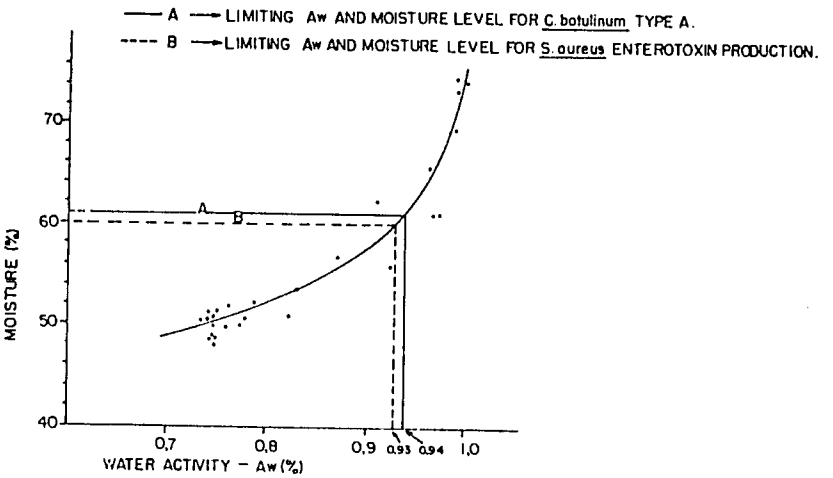

FIGURE 5. Relation between moisture level and water activity - Aw in muscle tissue of sardines during the salting process.

eviscerated sardines. The results showed the detection of C. botulinum toxin in one of the whole inoculated sardines with no positive samples amongst the eviscerated ones.

Considering that the salt penetration rate and Aw reduction were similar both in whole and eviscerated sardines, a possible explanation for these results could be based on a lower redox (Eh) potential in the viscera and muscle tissue of the whole sardines. This hypothesis is based on the experiments of Huss et al. (1979) with C. botulinum type E spores inoculated into herrings. These authors observed that the Eh potentials were lower in the visceral and spoiled muscle tissue as compared to the fresh samples and they also confirmed that the botulinum toxin titer was much higher in the viscera than in the muscle tissue, probably due to the lower Eh in the former.

As a conclusion, and based on the experimental results, it seems justified and safer from a public health viewpoint, to recommend the utilization of eviscerated sardines for the salting process. However, considering that a safe salt equilibrium in the muscle tissue is reached after 6-7 days of salting, it does not seem necessary to extend the process up to 21 days, as most industries usually do.

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THE REDUCTION OF POSTHARVEST LOSSES BY IMPROVED CATCH HANDLING AND STORAGE AT SEA

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ABSTRACT

The main postharvest fishery losses at sea derive from catches of small fish which are either discarded at sea or which deteriorate and lose quality and nutritive value before or during landing. New, fast and precise salt preservation and dehydration of small fish may be applied to reduce postharvest losses from fish intended for curing and consumption in LDCs. The main reduction of postharvest losses should come, however, from improved ice or ice water chilling of catches of small fish intended for marketing as fresh, frozen, cured or canned fish, replacing their present reduction to fish meal and oil. Improved vessel design and equipment will often be needed in order to improve the chilling and stowage of large catches of fresh small fish on board.

INTRODUCTION

Postharvest losses at sea occur in all fisheries, but are often larger in the fisheries of less developed countries (LDCs) than in those of industrialized countries having a long tradition of sea fisheries. The large losses of some LDC fisheries are due to many causes, such as lack of experience and training, unsuitable equipment and vessel design and insufficient ice or other means of preservation and facilities. The fisheries of LDCs may also suffer from inadequate unloading and storage facilities ashore as well as from inadequate processing and distribution technologies. These reasons for some LDCs having large postharvest fishery losses may explain also why some of them have large underutilized fishery resources.

Some fisheries of LDCs take place at high temperature, nearly 30°C, at which dead fish and shellfish spoil within a few hours. Some tropical fish may, however, keep for several

weeks if chilled to 0°C immediately after catch (Lima dos Santos, 1981). It has been shown recently (Jensen and Machava, 1986) that small whole fish, weighing less than 35 g, can be preserved by salting at ambient tropical temperature, while the interior of larger fish spoils before the salt penetrates to the viscera (Jensen and Machava, 1986). Larger whole fish can be preserved, however, by an initial chilling followed by salt preservation (Owens and Mendoza, 1985).

The main postharvest fishery losses of LDCs are small fish of low commercial value. Their preservation at sea should therefore be simple and cheap, including only such elements as chilling in ice or ice water, salt preservation and combinations of these.

The ice or ice water chilling should be undertaken immediately after catch and should keep all the fish surfaces wet at temperatures between 0 and -1°C. In this way, the interior of the small fish is cooled to 0°C or below within a few hours.

Salt preservation at sea should be initiated either immediately after catch or after an initial chilling to 0°C. The small fish should be immersed in strong salt brine, which is circulated between the fish in order to speed up the salt absorption and avoid stratification. Figure 1 illustrates Russian observations of the weight changes of whole sprat being treated in brines of different salt concentrations. Although the sprat absorb salt in the early stages, they lose weight by losing water. Later on, however, they gain weight by absorbing brine (Zaitsev et al., 1969). Similar studies should be made with other small fish intended for curing by salting and drying. Such studies might be used to develop fast curing in two steps, the first being brine salting until the time when the fish have lost most water to the brine, which is then removed. The second stage is drying until the water activity has been reduced sufficiently to make the fish stable.

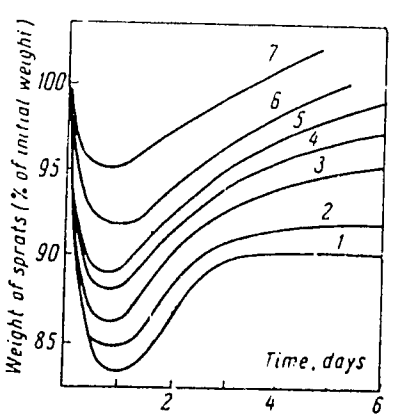


FIGURE 1. Change in weight of salted sprats:

1 - 26.4% brine
2 - 24% brine
3 - 21% brine
4 - 19% brine
5 - 18% brine
6 - 12% brine
7 - 10% brine

MAIN POSTHARVEST FISHERY LOSSES OF LDCs

The postharvest losses at sea can be divided into the following main categories:

a. The loss of commercial value due to autolysis, rancidity and bacterial spoilage of dead fish during storage on board.
b. The discarding of fish protein and oil with "blood water" from dead fish, mainly small whole fish, which autolyze and disintegrate during storage at elevated temperatures at sea. Rough handling and storage under pressure increase these losses.
c. The rejection of small dead fish, the commercial value of which is too low to cover the cost of their storage and preservation on board by presently available technology.

The main postharvest fishery losses are derived from catches of small demersal or pelagic fishes. Most small pelagic fish have colored flesh with a variable and often high oil content, which may oxidize fast in contact with air. They are mainly found in purse seine catches comprising few species and sizes. Most small demersal fish have white flesh with a low oil content (IDRC, 1982; Bello, 1986). They are mainly found in trawl catches comprising many species and sizes.

POSTHARVEST LOSSES FROM PURSE SEINE CATCHES

Several hundred purse seiners, operating from the west coast of India, have no fish holds. All catches are

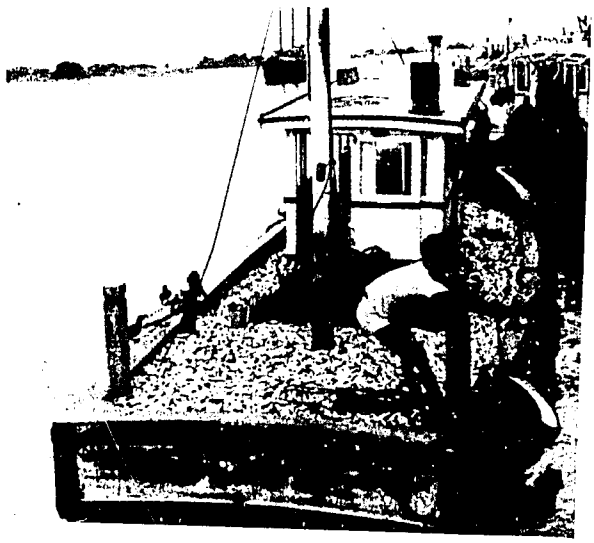


FIGURE 2. Small carrier vessel filled with sardines.

transferred at sea from the net to the deck of small carrier vessels, which bring them ashore in a race against time and the high ambient temperature. Large quantities of these small fish are successfully sun dried for local food use. Some quantities, however, spoil and have to be reduced to fish meal and oil. Small fish to be canned have to be processed very soon after being landed.

Many purse seiners, operating from the west coast of Latin America, store their catches at ambient temperature in the fish hold, where they die very soon. Even if such catches have been dead for only a few hours when landed, they have often disintegrated too much for being canned or otherwise processed for food use. Large quantities of these small pelagic fish are therefore reduced to fish meal and oil. The same applies to sardines which are chilled very slowly, e.g. by 1°C per hour as shown in Figure 3 (Hansen et al., 1980).

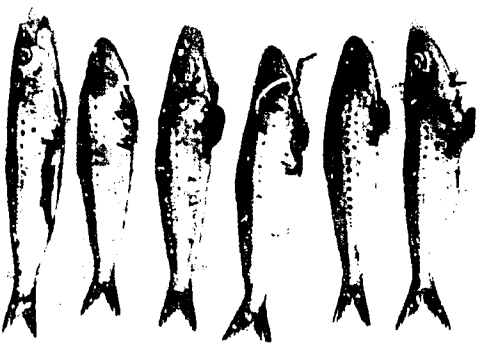


FIGURE 3. "Belly burst" of Monterrey sardines chilled slowly, 1°C/hour, before landing.

Table 1 shows the advantage of fast chilling to 0°C or below in ice cold seawater. This can be done in efficient RSW tanks with mechanical refrigeration alone or supported by adding ice to the tanks. Fast chilling can be achieved also in CSW tanks, using ice only to chill the seawater and the fish. Large CSW tanks first appeared in large numbers on vessels operating from the west coast of Canada. Their operation is described in a recent Canadian report (Lee, 1985). CSW tanks can be very suitable for some fisheries of LDCs, where large quantities of small fish are taken on short voyages.

Table 1 also shows that unloading by pumping dead fish from tanks can damage the fish more than by brailing. The damage during unloading and further handling of the fish until processing can be further reduced by CSW storage in mobile containers from catch until processing. The latter may include

an intermediate chill storage ashore in order to increase the flexibility and productivity of food processing industries having no other chill stores ashore (Hansen et al., 1977).

TABLE 1
Percentage of Unbroken Monterrey Sardines

Chilling in RSW tanks:	slow	fast (ice added)
Unloaded by pumping:	2%	99%
Unloaded by brailing:	84%	100%

Figures 4 and 5 show that a battery of mobile containers may be installed under the hatch of the fish hold for fast and easy stowage of the first catches in seawater with ice, agitated by compressed air injection at the bottom. Surplus catches may be stored in the remaining, irregular part of the fish hold for subsequent reduction to fish meal and oil (Hansen et al., 1977).

Very few vessels use heat-insulated containers because they are expensive and take up much space in the fish hold. Non-insulated containers could be made much cheaper and still be suitable for the stowage of catches in ice-chilled seawater. Single wall polyethylene containers can be fitted into steel frames giving strength and maintaining the shape of the container when filled up with fish, ice, water or salt brine. The water and salt brine may be lifted from the bottom to the top level by injecting compressed air into the lower part of the container at the four corners.

POSTHARVEST LOSSES OF TRAWL CATCHES

Demersal trawl catches often comprise many different species and sizes of fish and shellfish, which have to be divided into several categories and stowed apart from each other. Grading by hand may involve much time and labor and delay the chilling or other preservation of the catches at sea. Figure 6 shows deck equipment used on board many large Danish trawlers to divide large trawl catches into thin and thick fish. At present, fish less than 35 mm thick are those used by the fish meal and oil industries. These small industrial fish are mechanically mixed with crushed ice before being stowed in fish hold sections below. Such mixtures, however, could easily be stowed in large tanks or mobile

FIGURE 4. A battery of nine containers placed under the hatch in the fish hold of a purse seiner may carry 12 tons of sardines in chilled seawater. 100 vessels making 200 journeys per year may land a total of 240,000 tons of raw materials highly suitable for canning or curing.

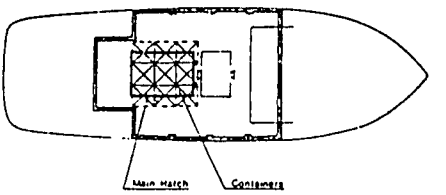
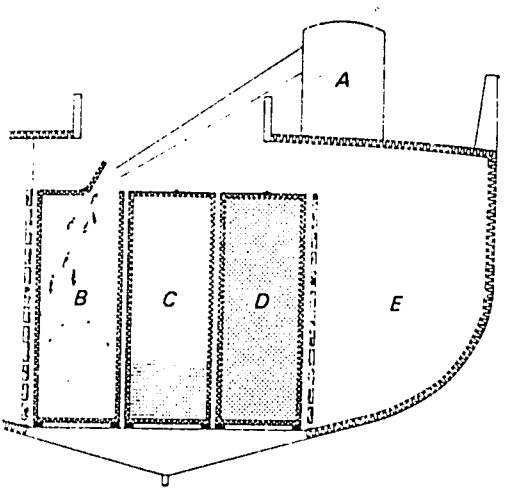


FIGURE 5. Cross section through the hold of a purse seiner equipped with mobile containers in the central part, below the hatch. Live fish are pumped from the purse seine at more than one ton a minute. From the water separator (A) the fish fall into a mixture of ice and seawater which is being agitated by compressed air in container B. Container C contains the preloaded dose of ice. Container D has been filled up with a mixture of fish, ice and seawater which, after an initial air agitation, has stabilized at 0°C. When all containers have been filled and closed, surplus catches overflow to bulk storage in the surrounding irregular hold sections (E).



containers, while seawater is added so that the fish are chilled very fast and they float in ice cold water, relieved from pressure and protected against physical damage and oxidation. About 15 large Danish trawlers have recently installed large CSW tanks, in which they chill and stow large catches of small whole fish, including herring. Similar cheap and simple CSW tanks may serve similar purposes on trawlers operating from LDCs.

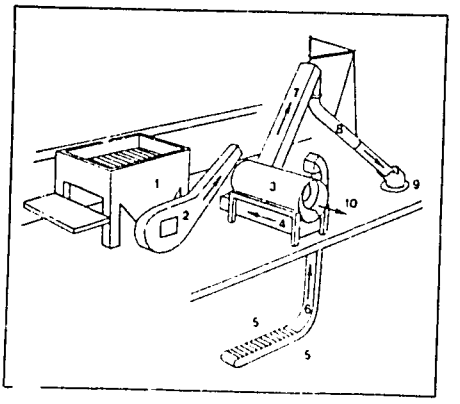


FIGURE 6. Deck equipment for the separation of mixed trawl catches into thick and thin fish.

1. Receiving box covered with a grid of heavy steel bars.
2. Conveyor taking the fish into the grader (3).
3. Rotating grader separating the small industrial fish from the food fish.
4. Trough receiving the small fish and ice, coming from the hold (5) via the conveyor (6).
5. Ice store in hold from where the ice is fed into the conveyor (Bello, 1986).
6. Ice conveyor built into the central gangway of the fish hold. The vertical part brings the ice into the mixing trough (3) under the grader (4).
7. Conveyor lifting the mixture of ice and industrial fish two meters above deck level, discharging it into the funnel (8).
8. Funnel and plastic tubes leading the mixture to the ice scuttle (9) in the deck.
9. One of the number of ice scuttles installed over the hold sections for industrial fish.
10. Discharge of food fish from the rotating grader (3).

Among the main postharvest fishery losses of LDCs are the large by-catches of small fish taken by shrimp trawlers from tropical waters (IDRC, 1982; Bello, 1986). Each year, millions of tons of such small fish are discarded at sea. Deep containers, such as those shown in Figure 5, or built-in tanks of similar shape and air liquid circulation arrangement, can be used for an initial chilling in ice water, followed by rapid brine salting until all fish are lightly salted and dewatered. In order to facilitate their removal from the brine and transfer to shore, or to a carrier boat, the small fish may be handled in deep net bags. Salt may be added to the brine, which can be reused for more batches of fish. The small fish may be dried or otherwise further processed ashore.

Chilling and stowage of trawl catches in ice water in tanks or containers can be combined with ice packing in boxes

(Petersen et al., 1977; Olsen and Hansen, 1977). In such cases the boxes are mainly used for the larger and more valuable food fish while the smaller fish are stowed in ice water.

In recent years, the traditional wooden fish boxes have been replaced by plastic boxes, which allow for better hygiene on board (Whittley, 1985). In present practice, however, boxing of fish with ice is very time and labor consuming and does not provide fast and even chilling to 0°C. Improved ways of boxing with ice should be developed for use in large-scale trawl fisheries, both in industrialized countries and in LDCs. A faster and more even chilling can be achieved by rapid prechilling of the fish in circulating ice water before packing them in boxes, using only the small quantity of ice needed to maintain the fish at 0°C. Figure 7 indicates another improvement of boxing fish with ice, eliminating all manual handling of full boxes.

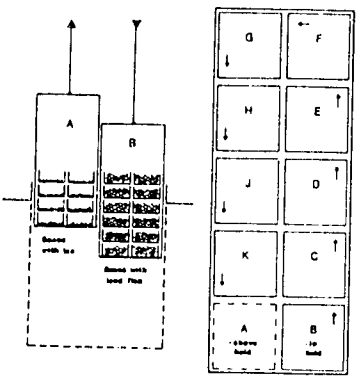


FIGURE 7. A cross section of the fish hold, the hatch and two frames with boxes. Frame A is being moved upwards with boxes with ice to be loaded with fish and transferred to frame B. While the latter is being loaded with boxes with iced fish, it is lowered into the fish hold.

On the right, 10 frames are seen from above. One empty frame, A, is at deck level, leaving position A empty in the hold. The 9 frames with boxes should now be moved as follows (see arrows):

1. Frames G, H, I and K are pushed forward, frame K to position A.
2) Frame F is pushed to position G.
3) Frames B, C, D and E are pushed forward, frame E to position F.
4) The empty frame A is moved (above deck) to above position B, ready to be loaded gradually into the hold with boxes with iced fish.
5) Frame K is now lifted up, the boxes being loaded with fish and transferred to frame A, which is being lowered into the hold.

These operations are continued until all frames hold boxes with iced fish in the fish hold.

POSTHARVEST LOSSES OF SMALL CATCHES OF COASTAL VESSELS

Some fish and shellfish caught by coastal vessels during brief journeys are landed alive. Other catches, however, die on board and suffer from exposure to sunshine and wind while stored on deck. A good remedy to damages inflicted by sunshine and wind is chilling in ice or ice water, using boxes or mobile containers with some heat insulation.

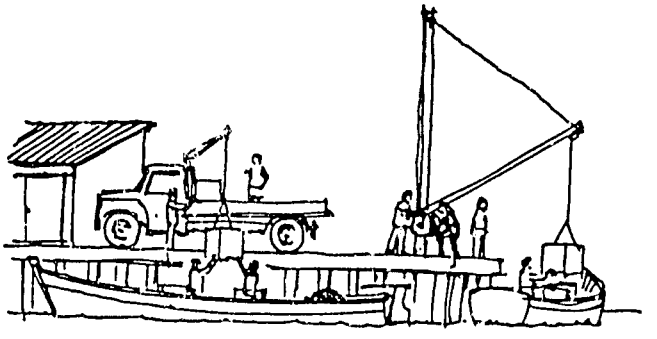


FIGURE 8. Loading and unloading of containers with ice or with iced fish are fast and easy. Insulated containers are also suitable to protect the ice or iced fish during land transport on open lorries.

If ice is not available, the catch should be kept moist and in the shade until landing. In some cases, salt preservation and partial dehydration may be initiated at sea. Fish catches may be "roused", i.e. mixed with solid salt, in plastic containers such as those illustrated in Figure 9. Such containers should be rotated at intervals, ensuring that the limited amount of salt used is evenly distributed among the fish and within the thin and thick parts of the fish. Fish "roused" briefly with salt at sea may be further cured and preserved in many ways after landing.

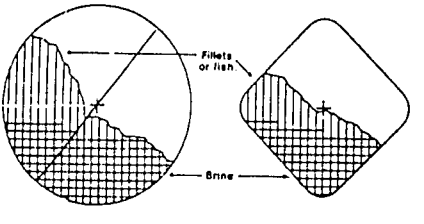


FIGURE 9. Vertical cross section of containers, in which fish is "roused" with salt/brine. The cross indicates the horizontal axis of clockwise rotation. Round containers should be divided into two or three equal rooms to prevent the fillets or fish from remaining in the same position.

CONCLUSION

Some of the presently industrialized countries have many centuries of fisheries tradition and experience, stretching back to before industrialization. Their catches were then either distributed live, fresh or cured. Some of the fish curing traditions such as salting, drying and cold smoking may be useful in the LDCs of today. They may be improved, however, through recent knowledge and by further studies of fast salting and dehydration methods, resulting in intermediate moisture products of fish or fish fillets with long storage lives.

Other main reductions of postharvest fishery losses in LDCs would involve improved ice or ice water chilling and stowage of large catches of small fish in boxes, containers or tanks. Some of these improvements would require improved vessel designs to give better facilities for fast, efficient and economical catch chilling and stowage in the fish hold and to always keep the fish surfaces moist and ice cold.

Many large trawl catches need to be quickly divided into different sizes and species, which may need different treatments on board and may be used for different purposes ashore. Such grading equipment exists but is not yet used in LDCs.

Great improvements could be derived from an increased exchange of information and experience among the LDCs and between these and some industrialized countries with long traditions as well as modern development of their fisheries. The ICRD/FAO Technical Consultation on Shrimp By-catch Utilization, October 1981, may be quoted as a good example of what is required (IDRC, 1982). A similar international workshop on the handling and food use of small pelagic fish is now needed. National, regional and international organizations offering technical assistance to LDCs should cooperate to prepare such a workshop/seminar and support further research and development to increase the food use of small fish by many million tons per year.

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THE SARDINE FISHERY OF THE GULF OF CALIFORNIA, MEXICO: PROBLEMS AND POSSIBLE SOLUTIONS

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ABSTRACT

In the last eight years, the Mexican fishing sector has shown increasing and continual development. The sardine fishery has played an important role and today, it accounts for about thirty percent of the total national catch. It supports and supplies several cannery and fish meal industries, and at the same time is an important source of employment. At present, the sardine is the cheapest animal protein available to the low income population whose diet is generally protein deficient. In spite of the efforts made by the Mexican government, the utilization of sardines for direct human consumption has decreased in the last several years. Today, fish meal factories are processing almost 80 percent of the total sardine catch. This situation can be considered a loss from a nutritional and energetic point of view. There are several technical aspects within the fishery that can be improved. However, we must realize that some economical, financial, social and political issues should be reoriented before new technology can be applied.

INTRODUCTION

In the last ten years, the Mexican fishing sector has been characterized by a fast and constant development. This has placed Mexico among the twenty countries with the highest catches in the world. It has been estimated that with 11500 kilometers of coast and an exclusive economic zone of 3 million square kilometers, Mexico's fishing resources should be over 6 million tons per year (SEPESCA, 1985). During the last 8 years, the Mexican fleet has reported catches of over 1 million tons per year and for 1987, a catch of approximately 1.5 million tons is expected. In 1986, the sardine catch off the Pacific coast reached a record of 469,000 tons, which

represents more than thirty percent of the total national catch. Today more than eighty percent of the sardine catch comes from the Gulf of California. Monterrey sardine (Sardinops sagax caerulea) accounts for eighty percent of this catch, followed in importance by thread herring (Opisthonema spp.), and Japanese sardine (Etrumeus teres). Mackerel (Scomber japonicus) and sardina bocona (Cetengraulis mysticetus) are captured occasionally.

The importance of the sardine fishery in Mexico is evident from an economical and social standpoint, as it sustains a large number of cannery and fish meal factories and generates a large number of jobs. Furthermore, the sardine is the cheapest raw material available to the canning and fish meal industries, as well as the cheapest animal protein available in the domestic market to the low income population whose diet is generally protein deficient. During the last several years, the utilization of the sardine for direct human consumption has decreased even further in spite of the efforts made by the Mexican government. Today eighty percent of the catch is destined to the fish meal factories. This situation is considered a loss in terms of nutritional value, and also can be considered an energy loss.

Several studies done in order to increase the production of the canning factories have shown positive results. Most of them are concerned with the improvement of the techniques of handling the catch onboard and with the increase of preservation time of good quality raw material. However implementation of these new techniques has taken place only on a minimal level, and in most cases, it has not solved the more general problems of the fishery. It is clear that there are not only technical problems, but also economical, financial, marketing, social and political issues that, to a greater or lesser extent, have a negative effect on the efficiency of the fleet and industry, and are impeding an appropriate transfer of improved technology.

GENERAL ASPECTS OF THE FISHERY

The sardine fishery in the Gulf of California began around 1967 with only three boats and a total catch of 126 tons. According to Lluch-Belda and co-workers (1986), the catch data and the number of boats in the fishery are not reliable until the 1969-70 fishing season (Figure 1). From the beginning through 1977, all the boats were of small capacity and had neither ice nor refrigeration systems for preservation. Until 1981, all the boats fished from October-November through May-June along the east coast of the Gulf close to the ports of Guaymas and Yavaros, Sonora (Figure 2).

From 1977 until 1983, 30 purse sieners were added to the fleet. This was a 75 percent increase in number, but a much

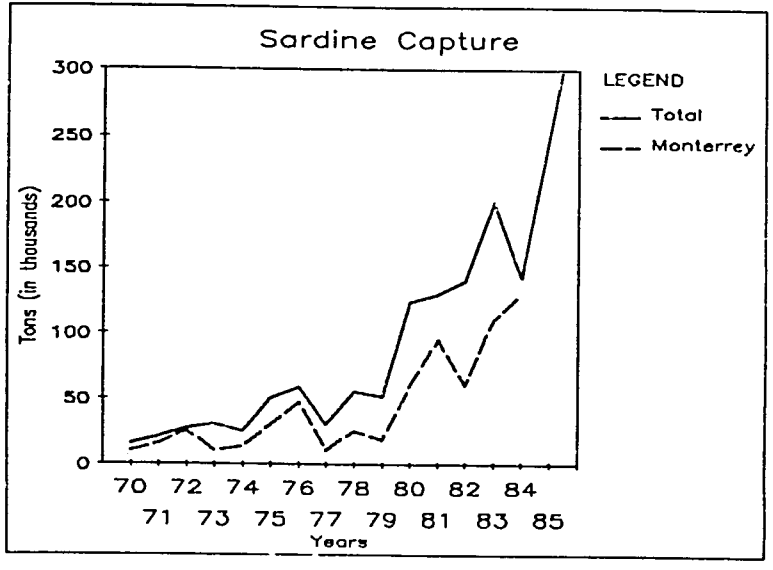

FIGURE 1. Sardine Capture

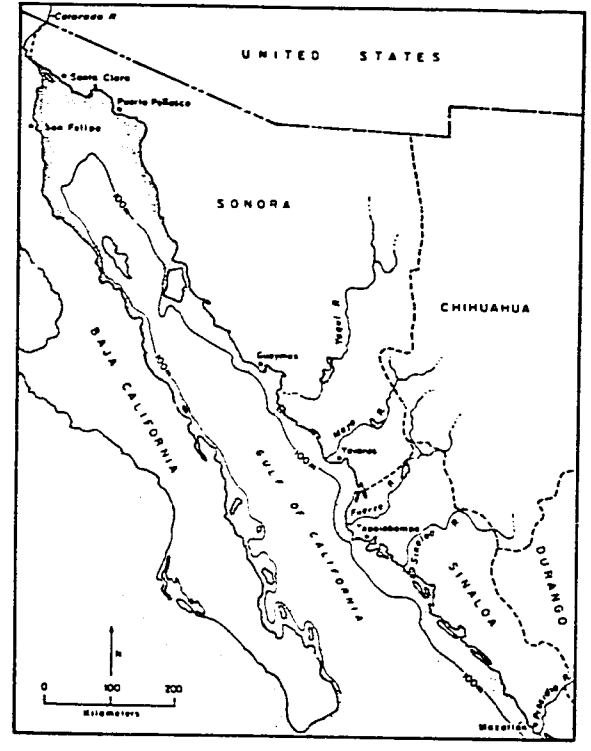

FIGURE 2. The Gulf of California

greater increase in fishing capacity because the boats were larger and able to preserve the fish for a number of days before having to go to port to unload. Since 1982, the fleet added the summer months to its fishing season and fished in the zone between the northern and central Gulf, near the large islands of Tiburon and Angel de la Guarda. As a result of the increased fishing activity, the 1979-80 Monterrey sardine catch increased by 169 percent from the previous year (Lluch-Belda et al., 1986). Last year, the total sardine catch landed in the state of Sonora set a record of 386,000 tons (Delegacion Federal de Pesca en Sonora).

The sardine fishery in the Gulf has fluctuated widely since its beginning, causing considerable management problems. Even though there are no recent estimates of the biomass of this species, it is known that upwelling and cold water correlate with higher catches of Monterrey sardine, whereas warmer water produces lower catch, especially during an "El Nino" event. These climatic conditions produce the opposite effect on the crinuda sardine fishery (thread herring) (Lluch-Belda et al., 1986). They also concluded that the large fluctuations of the November-May catch of both the Monterrey and Crinuda sardines are due to their availability (either abundance or accessibility to the fishing fleet), and that availability is largely influenced by the ocean climate in the Gulf of California. The large sustained increases in the catch from 1979 through 1983 were due to the growing number of larger capacity vessels and their ability to preserve the catch for several days.

The sardine fleet moves south and north as the sardine populations migrate south in the winter and spring, and north in the late spring and summer. Fishing takes place along the east side of the central gulf during winter and spring when the Monterrey sardines are spawning. During this season, operation costs are low and catches are high. During the summer, the fishing takes place on the west side of the northern gulf, further away from the landing ports, hence the trips are longer and the operation cost increases.

Due to the increase in fishing effort as a result of a larger number of fishing boats and trips, as well as the summer fishing when a higher percentage of juveniles (120-150 mm standard length) is caught, it is possible that the sardine population is currently being overexploited. In order to prevent overexploitation, the Mexican government is now restricting the sardine fleet from certain areas during the summer months, where mostly juveniles are captured. This restriction may have an immediate effect on the fleet and industry that are accustomed to capturing and processing sardines throughout the year. However, in the long run, this measure will benefit both the fleet and the industry.

THE ROLES OF THE PUBLIC, PRIVATE AND SOCIAL SECTORS WITHIN THE FISHERY

At this point and in order to understand the problem, we must first take a look at each of the participants of the fishery and the roles they play within it.

The Public Sector

The government plays the most important role in the fishery. Its main objective is to utilize the resource as much as possible for direct human consumption and sell the product in the domestic market at the lowest possible price, so that it can be available to the low income population. To accomplish this objective, the Mexican government participates in the fleet and industry activities through state-owned enterprises. The government owns about 70 percent of the fleet, but the vessels operate through association and participation contracts with either the private or the social sector. The associated sector is responsible for providing supplies, conditioning, and preventive maintenance to the vessel, and must give a portion of the catch to the government processing plants. The government's vessels are obligated to bring the catch to port in good condition, and they must first satisfy the demands of the government canneries, then the canning and fish meal industries of the private sector.

In the processing segment of the industry, the government owns only canneries that process sardines as the main product. However, these plants also process fish meal and fish oil as by-products using the wastes of the canning factories. Today, the installed capacity of the government factories is a little more than 50 percent of the total canning production capacity in the country. Besides having an active participation within the fleet and industry, the federal government also has control of the price of both the raw material and the final product. The Mexican government also reserves for itself exportation privileges of canned sardines.

The direct and active participation of the public sector within the different aspects of the fishery are actions that reflect the government's interest in achieving their goals. Nevertheless, it is evident that in spite of the efforts made by the government, the goals have not been reached and year after year this situation remains the same.

The Private Sector

There has been an increase in activity in the private sector with respect to the capture of sardines. Approximately 50% of the total fleet is run by private individuals or companies. Of these, less than half of the private sector

fleet in the sardine fisheries are boat owners themselves, while the rest have contracts with the state enterprise "Sardineros Mexicanos, S.A. de C.V." to operate the boats in an agreement of association and participation which splits the profits or losses with the state. This type of agreement has proven fruitful, especially in terms of keeping an active fleet and introducing entrepreneurs into the fishing industry who could not afford the outright purchase of a sardine boat. With regard to private ownership of sardine boats, it has proven economically beneficial for the companies that run their own fish meal or canning plants to have their own boats. Over the last several years, the production of fish meal has given larger net returns than the canned sardine for human consumption. Therefore, the majority of the sardine capture (latest estimate 80%, Secretaria de Pesca, 1986) is reduced to fish meal. This co-ownership of both boats and fish meal plant assures that there is sufficient raw material to maintain an efficient operation in both the boat and the plant.

In spite of the pressure imposed by the government, the majority of the sardine captured by the private sector goes to fish meal. Economic forces are such that means are taken to produce fish meal rather than a canned product. This was evident by the increase in the construction of fish meal plants in Sonora which enjoys the highest concentration of sardine capture. It should be mentioned that there has not been a reduction in the production of canned sardine, but rather the increased sardine capture that Mexico has witnessed over the last six years has disproportionately gone to fish meal production.

There is a strong debate in Mexico at present, due to the controlled price of sardine, (at the primary and final product level) as to whether an unsubsidized sardine industry could become financially solvent with the production of canned sardine. Interestingly, one of the newest plants (private) in Yavaros, Sonora that also cans several agricultural products, including tomatoes, has shown that a profitable canned sardine operation can happen even at government controlled prices. The profitability of a single plant, however, should not oversimplify the overall picture in Mexico with regard to sardine processing, as we will discuss several other factors that have an important impact on the final use of sardine.

The Social Sector

The social sector plays an active role within the sardine fleet, but its participation in the industry is much less than that of the public and private sectors. This sector is organized through fishing production cooperative societies. As in the private sector, this cooperative operates their boats through association and participation contracts with the

state-run company "Sardineros Mexicanos, S.A. de C.V." or with national credit institutions such as BANPESCA.

Sometimes the lack of technical training for the fishermen in the handling of different systems of the boat (especially the refrigeration system), has caused the boats to operate at low efficiency levels. When cooperatives operate with low administrative capacity, we find that the boat's profitability diminishes drastically. This type of cooperative tends to disappear because it cannot fulfill its contracts. Consequently, it becomes a problem for the associates and for this reason, participation of this sector in the sardine fisheries has decreased in the last few years. However, it must be mentioned that cooperatives well prepared by the former experiences are reaching greater production levels and a greater profitability in their activities.

The participation of this sector in the sardine industry is minimal when compared in terms of production capacity to the public and private sectors. Recently, some cooperatives with freezing plants dedicated to the shrimp fishery have shown interest in processing fresh-frozen sardine during the closed shrimp season. The fresh-frozen sardine might not have good acceptance for direct human consumption in the domestic market, but the international demand for this product makes export feasible. It is possible in the near future for the social sector to more actively participate in the sardine industry to an extent comparable to the other sectors. For now its activity is practically limited to catching the sardine, an activity in which improvement and a better performance is expected.

The Sardine Fleet

During the last season (1985-1986), approximately 70 purse seiners were operating in the Gulf of California. Capacity varies from 50 to 350 metric tons, but the majority of the boats have holding capacities between 100 and 200 tons. It is the latter boats that have contributed the majority of the total catch.

Actually all the boats that catch sardine in the Gulf are purse seiners, and in some cases, their 3/4 inch mesh size nets can span 2000 feet lengthwise and 40 fathoms of depth. The purse seiner is considered one of the less selective fishing gears. That is why the fisherman's experience, knowledge, and tactics are important for success during the catch.

Sardine fishing takes place almost only at night and during days without moon. The fleet normally operates twenty consecutive days and rests eight days. By tradition, the localization of the sardine schools is visual even though the vessels are now equipped with sonar, depth sounder and radar. In certain seasons during the year, especially in summer, the

sardines form dense schools that might be of 500 tons or even greater. Some ships with overdimensioned nets can completely enclose one of these schools. Nevertheless, they do not have enough capacity to hold all their catch, causing a useless mortality of the sardines that remain in the water. During certain months when the fishing activity is intense, it is possible within a few days to accumulate several hundred tons of dead sardines in the ocean. This represents a considerable physical loss of the resource. The only way of solving this problem is by making the fishermen more aware that these mortalities can be avoided by realizing specific handling practices during the catch. Once onboard, the sardine is mass stored in containers with refrigerated sea water and transported to port for its posterior processing.

Sardine is a fish with high fat content that is captured in large volumes and is subject to rapid deterioration. Consequently, low temperatures and rapid capture, storage and discharge are important factors in maintaining the prime material's good quality. In the winter and spring months, the sardine stocks are very close to the main fishing ports, and low water temperatures during these months help preserve the catch. Due to high water temperatures, at times more than 30°C in the summer months (July-September), and the need for longer trips (up to 72 hours) due to seasonal migration of the sardine stock, several potential problems make it even harder to preserve the sardine in good condition as demonstrated in several studies (Hansen and Jensen, 1982). Under these circumstances, optimum operation of the refrigeration systems onboard do not always assure a high quality product in the summer. Moreover, because of unfamiliarity with refrigeration systems and a lack of knowledge of good handling procedures with regard to temperature and sanitation, the summer catch has a greater chance of returning in a deteriorated state. This is reflected in Table 1, which demonstrates the increased production of fish meal rather than canned sardines in the summer. It has been suggested in some studies that other types of refrigeration systems, such as the Champaign system which uses sea water, ice and compressed air, might better preserve the sardine, especially during the warmer summer months (Jensen and Hansen, 1983).

To promote good capture and handling procedures among the sardine fleet, the Secretary of Fisheries maintains a price differential of nearly 38% between sardine captured and sold for human consumption (high quality) and that for fish meal (low quality). Ideally, the sardine fisherman would like to sell all of his capture at the higher price, but due to varying circumstances, this is virtually impossible. In part, due to the higher operating cost of canning sardines as compared to producing fish meal, which has enjoyed an increased demand over the the last several years, the plant operators are often

TABLE 1
Percentage of the Monthly Catch Destined for the Fish Meal Industry During 1986

Month	Capture (tons)	Percentage of Fish Meal
January	18,500	78%
February	21,500	77%
March	23,500	72%
April	21,500	72%
May	24,500	75%
June	15,500	81%
July	28,000	80%
August	16,000	84%
September	8,500	94%
October	17,500	91%
November	27,500	84%
December	27,000	85%
TOTAL	249,500	80%

willing to pay a higher price than the official price for sardine going to fish meal production. Furthermore, due to the delays that occur at the unloading docks of several of the canning plants, individual boat owners find it more profitable in the long run to unload their capture at fish meal plants, and so return to fishing in as short a time as possible.

Because the national fish meal market is strong today due to high demand, fish meal plant owners are often willing to offer financial assistance to the private fleet sector, which is a further inducement for the sardine to be unloaded at the fish meal plant rather than the cannery. In the simple words of the fishermen, "I'll go where I can get in, unload, be paid, and be back fishing in the shortest time possible."

Making this situation worse is the contaminated condition of some bays, especially at the unloading zones. This is caused by the direct discharge of waste waters from the sardine industries (mainly fish meal industries) due to the lack of an industrial drainage system that would collect and send the waste waters to a treatment plant. A vessel's refrigeration system cannot function in the bay while waiting to unload, because the great amount of grease, oil and scales in the water can damage its cooling system.

The Sardine Industry

The fishing industry has developed mainly in the northwest zone of the country, located in greater concentration in the cities of Ensenada, B.C., Guaymas and Yavaros, Sonora, Topolobampo and Mazatlan, Sin., Santa Rosalia and Lopez Mateos, B.C.S. The major part of the sardine fishery takes place in the Gulf of California. Sardines are unloaded in the ports of Guaymas and Yavaros, from where they are transported by land to the cities of Ensenada, Topolobampo, and Mazatlan, where they are canned for direct human consumption.

In 1986, the installed capacity for fish meal processing was 3.1 times greater than the capacity of the canning industry. It should be mentioned that the public sector has an active participation in the canning industry, producing more than 50% of the total canned sardine products in the country. The private sector focuses its production on fish meal processing, and only some plants focus their production on the canning process.

The Fish Meal Industry

At present, the installed capacity for processing fish meal is more than 4 thousand tons per 8 hours. It is characteristic of the fish meal industry to operate with low efficiency levels and low yields, mainly due to the utilization of obsolete or bad equipment, as well as poor maintenance of the equipment. Undoubtedly, the use of adequate equipment would cause sensible increments in the production. Consequently the economical benefit would also increase, better utilizing the resource and obtaining a better quality product.

During the most active period of the fishing season, the carrying capacity of the sardine fleet is greater than the unloading capacity at the industry's docks. As a result, the ships have to wait their turn to be unloaded. The fish that arrive at port in good condition deteriorate during the delay. Consequently, high quality sardine is destined to the fish meal process with the consequent economic loss for the vessel. Usually the fish meal processing plants receive as raw material sardines which are not for human consumption, as well as the leftovers of the canneries (heads and guts). However, today it is frequently seen that good quality sardines are destined for fish meal elaboration which indeed represents a loss from an energetic and nutritional point of view.

Studies show the effects that good and bad quality raw material have over the finished product. A sardine that has been carelessly handled since its capture will show a low yield during the process. Besides a loss in its nutritional value, the low protein percentage of the finished product directly affects the sale price.

The Canning Industry

The sardine canning industry consists of 23 plants, 8 in the public sector and 15 in the private sector, with the total installed processing capacity of 1,288 tons of raw material in eight hours. In 1986, 12% of the installed capacity remained completely inactive, and the plants that were operating produced below their real capacity. They processed approximately 50,000 tons that were equivalent to one million fifty thousand boxes, the lowest production in the last three years.

The handling of the catch destined for the canning industry requires special care, because fish quality is fundamental in the process. Even when the catch arrives at port in good condition, it may suffer physical damage, such as fragmentation and crushing. This is a consequence of inadequate systems used during unloading (Jensen, 1984). At the plants, the qualitative and quantitative fish losses are increased due to the lack of preservation systems.

Comparing canning with fish meal processing, it becomes evident that the lower operation costs, the lower level of workmanship needed in the process, the diminished quality demand, together with the unsatisfied demand by the domestic market that helps to quickly commercialize the product and to quickly recover operation costs, make the fish meal industry an attractive business for the private sector. On the other hand, the canning process, besides having a greater operational cost, greater required workmanship and stricter quality control, has the inconvenience that its product has a slow commercialization process and, therefore, a slow recovery of the costs. Perhaps the most serious problem that the strong sardine industry in Guaymas is facing today, and one that has been overlooked so far, is the great contamination that surrounds the industrial park. This is generated by their own plants when their waste waters flow into the bay. In many cases, they have to use water from the bay for their industrial processes. So far, it seems to be considered only an aesthetic problem, but soon it could affect the production of both the cannery and the fish meal industries causing a serious economical impact if their products are rejected at the marketplace.

COMMERCIALIZATION

Mexico commercializes the sardine for human consumption almost exclusively canned. There have been sporadic attempts to commercialize it as a fresh-frozen product, but there has been little success in the national market.

Today, the national sardine consumption is low (less than 250 grams per capita per year), and its volume is distributed unevenly between the different sectors of the population. The

consumption of canned sardine is almost limited to the urban centers and big cities. In 1982, Mexico City absorbed 49.4% of the national production, followed by Monterrey and Guadalajara with 6.6% and 6.1%, respectively (Martinez y Lara, 1982). The rural consumption of sardine is insignificant, since it is not commonly included by the rural people in their diet.

There are diverse presentations of canned sardine, although the canned sardine in tomato sauce (oval can of 425 grams) has the highest production and distribution levels. This product's sale price is controlled by the government in such a way that it is accessible to the low income population. One of the few studies done about consumption and demand of sardine in Mexico shows that the flavor, followed by the nutritional value, was the main reason for consuming canned sardines (Investigacion de Mercados "Sardina", Mexico, 1982). However, this study also showed that the demand of canned sardine is principally from the upper middle class and, therefore, the desired object of regulating prices is not being achieved because the upper middle class has access to other types of goods due to their income. The targeted population in the medium and low classes present low consumption levels of sardine which correlates with the low acceptance of the product.

Promotion of sardine products has been done only at the institutional level, in contrast to other goods and services that have developed good promotional campaigns through several communication channels. A strong promotional campaign, focusing on its nutritional value and low cost could modify to a certain extent consumers' attitudes toward sardine products and increase its demand in the marketplace.

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USES OF FISH WASTE FROM THE ARTISANAL FISHERY OF ECUADOR

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ABSTRACT

Ecuador has shown a rapid growth in its fisheries over the past decade. Much of this growth is due to the success of shrimp aquaculture, the increased harvest of commercial marine species, as well as an increase in the large-scale fishing industry. Based on this investigation, we can say that large industries with diversified processes make relatively efficient use of waste material. On the other hand, small industries with just one type of process make no use of this waste at all. The artisanal sector uses fish waste material depending upon the fishing method applied and the type of interaction with the market. At the same time, artisanal industries have been limited because of poor technology and poor linkages for the distribution of their product.

ARTISANAL SECTOR

The existing information on the artisanal sector does not allow us to give a clear vision of the real situation of this group due to conceptual problems and that only 70% of the artisanal boats are registered in the official statistics. However, it is possible to establish estimations to characterize it in general. In the last ten years there has been an increase in the artisanal fleets not only in number but also in capacity (Table 1). The table shows that artisanal boats are mainly catching white fish species and secondly, lobster and shrimp. By 1985, the total capture was 1820 net tons (Direccion General de Pesca, 1985).

This sector can be divided into three categories according to the level of capitalization and the fishing system used: bongos, pangas and lanchas, fiberglass boats and purse-seiners. Bongos are traditional canoes made of one piece of wood, normally a tree trunk. Pangas and lanchas are the

traditional version of the present fiberglass boats. They fish with or without outboard engines and comprise the least financed sector. Generally they use two systems for capture: hook and line and different types of gill nets with a relatively low fishing capacity. The type of fish species determines the connection with the market. Fish are sold directly for domestic consumption as a fresh product. Shrimp and lobster are commercialized for either domestic or foreign markets depending on the type of business the fisherman is involved in.

A second category is represented by fiberglass and outboard engine-equipped boats. They use different types of fishing methods. Among others they use "espinel" which is a variation on the long-line system. With this system they catch species such as shark, swordfish, dolphin fish, "corvina", etc. The use of fiberglass boats has increased in the last few years and these boats have generally replaced smaller boats such as the bongos, pangas and lanchas. The distribution of the capture depends on the type of species. Small white fish are distributed through an intermediary network that begins at sea or at the seashore and ends in the national market.

The third category are the purse-seiners. These types of boats started to be used at the end of the 60's. Their small capacity does not allow the use of alternative fishing methods making this business relatively unstable.

The artisanal fishery constitutes an important source of employment in this country. It has been estimated that the total number of boat owners in the three categories is around 5,200 employing 15,500 persons as crew.

INDUSTRIAL USES OF FISH WASTE NATIONWIDE

The purpose of this section is to give an estimation of the percentage of waste material produced by the fishing industry. From different interviews obtained in industries, we estimate the following average percentages of waste material by species:

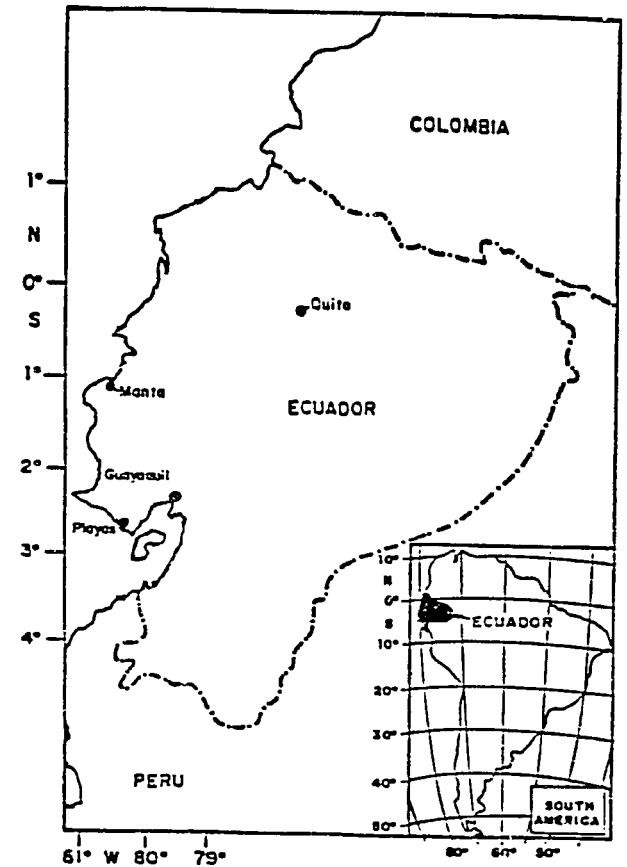
Frozen and canned sardines and mackerel	50%
Canned tuna	45%
Frozen shrimp	35%
Frozen white fish	20%

The use of waste material depends on two factors: the type of species being processed and the category of the processing industry. Shrimp and white fish industries produce little waste material that is utilized. As we mentioned previously, the shrimp industry cleans and freezes their raw material. Since they do not produce fish meal, the remaining waste material obtained from cleaning is being disposed of and

TABLE 1
Artisanal Fishery Fleet Capacity

	No. of Vessels	Net Tons
Total		
1975	220	437
1983	1,475	1,815
Shrimp		
1975	30	31
1983	217	227
White Fish		
1975	155	353
1983	1,006	1,519
Lobster		
1975	35	58
1983	37	69

Source: Agenda del Sector Pesquero. Subsecretaria de Recursos Pesqueros. 1984



can be supplied to other industries processing fish meal. A recent study showed that "approximately 20,000 tons of shrimp heads would have been produced but presently only a small volume of shrimp heads are dried and ground to obtain shrimp headmeal, a component of shrimp feed" (Barrett and Montano, 1986).

Dolphin fish are being gutted in the sea and come to the processing plant to be cleaned and deheaded. Therefore, the waste material from this species constitutes only heads which amounts to a total of 16% of waste. Presently, this material is not being used. Shark, swordfish and others are gutted once they are unloaded from the fishing boats on shore. Waste from tuna species is readily used for fish meal production.

In 1984, out of the total annual capture of fish, 768,878 tons (Subsecretaria de Recursos Pesqueros, 1984) were used for fish meal and fish oil manufacture. This data includes not only fresh fish but also waste material obtained from the manufacture of canned tuna, mackerel and "pinchagua". The annual production of fish meal and oil for the same year was 170,671 tons. Only 10% of raw material for this total production came from fish waste. This data clearly shows that a high percentage of fresh fish that can be used for human consumption is being used to produce fish meal. We consider that an efficient use of waste material depends on the economic functionability of the fishery sector and the different ways it markets its catch not only in national and foreign markets but also in the industrial and artisanal sector.

THE ARTISANAL FISHERY AND USES OF WASTE MATERIAL IN A REGION OF THE PROVINCE OF MANABI

We will now analyze the fish waste utilization in the area of the province of Manabi which is located in the middle of the coast. The province can be divided into two different regions: the wet region and the dry region. The city of Bahia de Caraquez physically divides these two regions. From Bahia de Caraquez in the north we find the wet region mainly devoted to agriculture and cattle raising activities, and from Bahia de Caraquez down to the south of the province we find the dry region (Ferrin, 1986). Crop culture in the dry region is done only during rainy season. Between Bahia de Caraquez and Salango there are 13 artisanal coves or fishery communities. The city of Manta is also located in this region and has two important unloading ports: Tarqui and Esteros.

The two main sources of income and employment of the province are agriculture and fishery activities. Manta is the principal city for industrial and artisanal fishery activities. Two other important cities are Bahia de Caraquez which controls the shrimp activity of the north and Puerto Lopez. Manta is the main commercial marine port of the

province and one of the four ports that exist in Ecuador. During the 60's and 70's many processing industries and the main tuna fleets were established in Manta. At present, four of the biggest canning industries of the country are there: INEPACA, SEAFMAN, CONSERVAS ISABEL S.A. and PESQUERIA FERNANDEZ. In addition, there are at least ten other small canning and fish meal industries. During the 80's shrimp processing industries were established and eventually also processed white fish.

REGIONALIZATION OF THE ARTISANAL FISHERY IN MANABI

In order to have a clearer idea of the different ways to utilize fish waste from the artisanal sector, it will be necessary to present the main characteristics of the region under study which extends from San Clemente, close to Bahia de Caraquez from the north to Salango, close to the frontier with the province of Guayas in the south. According to the type of fishing system used and the interation with the market, we can distinguish three small regions. The first region is formed by coves or fishing communities such as San Clemente, San Jacinto, Crucita and others. Traditionally, these coves use long-line fishing with two or three fish hooks to catch large and small white fish. Later on, factors such as tourism and the construction of shrimp ponds opened new opportunities for employment in the field of catching shrimp larvae. This activity has helped to decrease and at the same time reorganize the artisanal sector. Fishermen and traders from San Jacinto buy shrimp by-catch from the shrimp fleet in the sea. These middlemen use fiberglass boats to bring the fish to the shore, they also gather fish caught by the artisanal fishermen from the region or from Jaramijo. High volumes of landed whole fish at the seashore have made it possible to build an artisanal center for gutting fish in San Jacinto. This provides raw material to processing industries located in Manta . well as small artisanal industries elaborating fish meal. Most of the artisanal fishery in this region has been destroyed due to strong competition with shrimp activity.

The second small region goes from Jaramijo, in the north, to Santa Rosa, in the south. The distinguishable characteristic of this region is the strong linkage that exists between the artisanal fishermen and the city of Manta, the main fishery port of Manabi. Traditionally, fishermen of this region were characterized by their ability to use harpoons to catch large white fish. In the last few years, they have improved their system according to the type of interaction each cove has with the industry or with the market. For instance, Jaramijo was basically catching sardine and mackerel as demanded by the processing industries located in the area. The importance that these species have attained in this area have

even made possible the operation of a small processing industry in this community. Nowadays, new semi-industrial ships are being incorporated into their fleet. These ships are usually owned by artisanal fishermen that could capitalize on this investment. Similarly, Jaramijo has one of the major facilities in the province for gutting fish. San Mateo has different characteristics since its people still use traditional fishing systems. Despite that, San Mateo has become one of the main centers for the capture of big species such as shark, dolphin fish, marlin and swordfish. This was made possible by the foreign market these species have found in the last ten years. In this case, fish are unloaded and sold at the seashore to the traders of the area. There is no activity related to the collection and use of waste material in this community. San Lorenzo and Santa Rosa, small villages located in the area, have a less developed system. They basically use long-line methods to catch small species that are sold in the domestic market. In general, the main characteristic of the small communities located in this region is the interaction they have with Manta, the main commercial marine port in the province.

The third and last region is located from Puerto Cayo to Salango. This region traditionally uses nets for its activity. In the middle 60's, this system disappeared when purse-seiners and canoes started to be used. Purse-seiners are mainly devoted to catching small pelagic species while the traditional canoes are catching lobster and shrimp. This type of cove does not produce considerable volume of waste material due to their low volume of capture in relation to crustaceans and their commercialization system of small pelagic species. These species are commercialized in the sea to traders of Puerto Lopez where the fish is finally unloaded using fiberglass boats.

Machalilla, Puerto Lopez and Salango basically use purse-seiners as their fishing system. This system has made possible the existence of a small number of fishermen that use "bongos" and wooden "pangas" for their work. Machalilla's local fleet produces a considerable volume of capture. Many artisanal fishermen could become ship owners having boats from 10 to 100 net tons of capacity. They mainly capture small pelagic species that are generally gutted in their coves. Another part of their capture is sold at sea to traders for fresh consumption in the internal market or for processing industries. Puerto Lopez used to be the main fishery port of southern Manabi and northern Guayas. This was no longer possible after the development of road engineering systems during the 70's which decreased the artisanal fishery activity of this area. Nowadays, fishermen from Puerto Lopez still use purse-seining but it is considered to have less importance than the system used in Machalilla. Lately, the main activity of

this port has been the commercialization of fish at sea as is happening in San Jacinto. Although this commercial activity is important to this area, there is not a significant fish gutting facility in this port. Fish unloaded in Puerto Lopez is transported to Guayaquil or Manta without being gutted. Salango has a similar fishing system as Machalilla although it possesses a smaller fleet. Fish are not unloaded in this cove. All captured fish are commercialized at sea or are transferred to Puerto Lopez. This is the reason why they also do not have any fish gutting facility in this area. The singular characteristic of this cove is the presence of a sardine and mackerel canning and fish meal industry. This particular industry will be referred to in the next section.

TYPE OF LINKAGE BETWEEN FISHERY INDUSTRY AND ARTISANAL FISHERY SECTOR

This section analyzes the particular situation of four industries in order to illustrate the type of linkage between the fishing industry and the artisanal fishing sector. The first situation can be represented by Conservas Isabel, a big industry financed by foreign investment. Conservas Isabel produces and exports canned and frozen tuna for which it possesses its own tuna fleet. On the other hand, it produces canned and frozen sardines and mackerel as well as fish meal and fish oil, in these cases the industry receives raw material from the artisanal fishery in the area. Conservas Isabel supplies ice to its providers and the providers give to the industry not only fresh raw fish but also fish waste material. Sardine and mackerel come from San Jacinto, Crucita, Jaramijo, Machalilla and Puerto Lopez. This particular situation shows a successful linkage between the two sectors and an efficient use of waste material.

The second type of linkage can be represented by a smaller industry called COSACE which produces and exports frozen shrimp and white fish. COSACE has only one processing line and does not possess any fleet to provide raw material. It is supplied by the artisanal fishery that provides only clean product but not waste material. San Mateo, Santa Marianita and Tarqui supply this industry with raw material. In this situation there is less connection between the industry and the artisanal fishery since there are middlemen between these two sectors who establish the first quality control of the raw material. COSACE does not use waste material.

The third type of linkage is represented by SEAFMAN, a multi-national industry producing canned and frozen tuna. At present, they have no linkage with the fishery sector since the industry owns its fleet. This industry is constructing a reduction plant for fish meal and fish oil production in which they will be utilizing waste material in the near future.

The fourth type is represented by "Industrias Polar" which is established in Salango. This industry produces canned sardine and mackerel as well as fish meal and fish oil. It is a large industry with its own fleet for its own supply. This makes any linkage with the artisanal fishery difficult, although the artisanal fishermen of the area are specialized in the capture of the small pelagic species this particular industry uses. There are reasons to believe that the capacity of this processing plant is inferior to the supply capacity of its fleet.

USES OF FISH WASTE FROM THE ARTISANAL FISHERY SECTOR OF MANABI

The uses of fish waste from the artisanal coves are determined by three factors:

a) Type of species caught which depends on the fishing system
b) The commercialization system which is determined by the site where the fish is unloaded and the presence of industries in the area
c) Type of articulation to the industrial sector which determines the economic feasibility of the use of waste material.

From these three factors, we can establish three different situations of fish waste utilization.

1. Fishing areas producing and utilizing waste material
2. Areas producing a certain amount of waste but not using it
3. Areas not producing waste at all

The first situation is characterized by San Jacinto, Jaramijo, Tarqui, Machalilla and Puerto Lopez. First of all, the common characteristic of these coves is the type of species captured. The interaction with the industries is based on the type of species being used for fish meal and fish oil manufacture. Secondly, these coves are important centers for fish unloading not only because of the fishery activities developed there as in Jaramijo and Machalilla, but also because they constitute a gathering center for this activity. The third aspect favoring this situation is determined by the presence of local traders. They operate at a regional level either using their own vehicles for land transportation or using small boats to buy fish at sea.

Traditionally, fish waste material was sun dried in places called pampas for fish meal manufacture. Nowadays, with the industrial development, the industrial use of waste material is a very profitable business. But any modification in the external or internal demand of this product will affect its industrial production. The uses of waste material from the

artisanal sector represent only a small part of the supply to the industrial fishery. This situation places the artisanal sector in a relatively weak position in front of the industry, although the use of fish waste is relatively efficient.

The second situation is represented by San Mateo, Santa Marianita, Linguique, San Lorenzo and Santa Rosa. They focus their activity on the capture of white fish regardless of the volume obtained. For this reason, these coves are connected to the shrimp and white fish industries located in Manta. The reasons why fish waste material is not commercialized in these areas despite the fact that fish are being unloaded at beaches located close to Manta may vary. First of all, waste material obtained from dolphin fish is thrown to the sea. On the other hand, the waste material obtained from shark, marlin and swordfish, which are species that are gutted on the beach, is mainly used to feed pigs. Part of this material is also being used by the fishermen as bait, which constitutes an economy. In this situation, any modification of the use of waste material from these areas can produce an unbalanced condition in their economy.

The third situation is represented by San Clemente, Crucita, Puerto Cayo and Salango. There is little utilization in these areas because of the small volume of fish unloaded. San Clemente and Crucita sell their capture at sea to San Jacinto's traders while Puerto Cayo and Salango sell it to Puerto Lopez's traders. Puerto Cayo's situation shows the lack of importance of having the fish unloaded in its own cove. A few months ago, a new sun drier started to function in this community, but the lack of raw material in this area obligated the industry to buy fish in Puerto Lopez.

In general, only areas pertaining to the first category are considered relevant to waste utilization. Since in the surrounding areas there are places called "pampas" for the artisanal elaboration of fish meal, we considered it important to briefly discuss their function and analyze their viability in this context.

"Pampas" are places where the artisanal fish meal is elaborated. This kind of process is found along the coast of Ecuador. The techniques used demonstrate the rudimentary characteristics: the raw material is basically sun dried, ground and then packaged for marketing. It has a cheaper price than the industrial fish meal. For this reason, it is mainly used by small farms particularly the ones located in high lands that do not have enough resources to purchase the industrial fish meal. In general, the commercialization is done through middlemen located in Guayaquil who purchase most of the production and then distribute it to other parts of the country. The type of production and raw material used present many problems. First of all, since most of the raw material is being used by industries, they are forced to utilize small fish

that are captured along the coast which is straining the resource in this area. On the other hand, the final product has a very poor quality; it sometimes contains salmonella which damages any animal being fed the product. This happens in part, due to the poor hygienic conditions under which the product is manufactured and due to the poor quality of the prime material.

Furthermore, the artisanal fish meal contains a lower nutritive value as compared with industrial fish meal. Artisanal fish meal contains an estimated protein value between 38 and 40% while industrial fish meal has between 67 and 70%. For this reason, the use of artisanal fish meal is limited to situations when the supply of industrial fish meal is insufficient. At present, the production of artisanal fish meal is steady and used principly by smaller farms.

CONCLUSION

The first interesting aspect that we can conclude out of this study is the fact that there does exist a relatively efficient use of fish waste at the industrial level. This is basically due to the importance that fish meal and fish oil markets have. The production of this raw material has made possible the interaction between the artisanal and industrial sector.

Although the official statistics show the opposite, the domestic demand is more important than foreign demand. Obviously, this is true because domestic market prices are superior to international market prices.

The industrial production of fish meal shows an inappropriate utilization of the fishery resource. This industry uses species that can be used for direct human consumption. As we saw, there is a minimum percentage of waste material being used for fish meal elaboration.

With regard to the artisanal sector, we can verify that the areas or communities in which fishing is in decline are the ones that produce waste material for industrial use. In the case of the communities that are doing well, San Mateo being the best example, the use of fish waste is part of the strategy in their fishery activity. In this case, it will not be appropriate to reorganize the method of exploitation of fish waste material within this community since this can affect the equilibrium of the market.

The demand for fish meal and fish oil for the internal market is basically composed of industries producing balanced meals and edible oils. Therefore, the success of the fishery industry depends on the stability of demand. In both cases, fish meal and fish oil, meal and oil can be substituted for other raw materials that are produced internally. The choice depends on the variation of the prices of the substituted

items. Then we can affirm that the strategy of the fishery industry is fragile. A low demand of fish meal will provoke an immediate drop in the use of fish waste, at least at the industrial level.

An alternative for the artisanal use of fish waste could be the artisanal "pampas". Nevertheless, this will require the development of models to improve the quality of the product. This type of product cannot hold a permanent space in the market due to its poor quality. Improving the technological level, the artisanal production of fish meal can make good use of certain advantages that this industry offers as compared to industrial production: lower cost of investment, operation and labor.

We have tried to present some empirical evidence about the use of fish waste in a region of the country. In general, we consider that the utilization of waste material depends on the logical functionability of all fishery activity. The design of an alternative policy related to the efficient use of fish waste material should be derived from an understanding of the various factors involved in fish waste utilization.

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POSTHARVEST LOSSES IN TRADITIONALLY PROCESSED FISH PRODUCTS IN LESS DEVELOPED COUNTRIES

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ABSTRACT

This paper describes losses of fish which have been cured by salting, drying, smoking or a combination of these processes. There are three main types of loss, nutrient availability, economic value and physical loss. Losses in nutrient availability have been studied to only a limited extent, but they can be serious especially in developing countries where nutritional levels may be low. Processing delays and poor processing methods may lead to poor quality products, low in value; this represents a financial loss to fishermen or processor, but it may make the food available to poor sectors of the community. Physical losses are often caused by insect attack, particularly blowflies and beetles which can consume large quantities of the fish flesh. The causes and extent of the different types of losses are described, with critical factors resulting in physical loss. Published data on the magnitude of losses is reviewed and the extent to which these reflect the true position is discussed.

INTRODUCTION

Over the last 10 to 20 years, as a generalization, the global emphasis has been on the increased production of fish through traditional capture fisheries. More recently it has also been recognized that aquaculture will play an increasing role in providing fish for human consumption. As a result of the inputs to these areas, world fish production rose from 40 million tons in 1960 to 70 million tons in 1970. Since that time, catches appear to have reached a plateau around the 70-80 million ton p.a. mark. FAO, however, estimates that by the year 2000 the demand for fish will be in excess of 100 million tons. If this demand is to be satisfied, it is clear that the

major emphasis during the next 10 to 20 years will need to be placed on the improved utilization of fish.

Fish has been described as one of the most perishable of all staple commodities and postharvest losses are generally accepted to be high (U.S. NAS, 1978). Various reviews in recent years have included estimates of total losses and Table 1 contains typical figures. Such estimates as 25 percent postharvest losses of dried fish (3 million tons lost of the 12 million tons produced) have become accepted figures, and are commonly used for planning and project justification purposes. This paper reviews the documentary evidence to support this level of loss in traditionally processed fish products distinguishing between estimates and objective measurements. Initially, however, it is useful to briefly outline the major causes of loss in traditionally processed fish products.

TABLE 1
Under-Utilization of Conventional Fish Stock

		10^6 t/year
Wet fish	Postharvest losses	2
Cured fish	Postharvest losses	3
By-catch	Discarded at sea	5 to 20
Pelagic fish	Used for fish meal	20
Pelagic fish	Under-exploited	20

TYPES OF POSTHARVEST LOSS IN TRADITIONALLY PROCESSED FISH PRODUCTS (TPFP)

This paper will concentrate on cured fish i.e. salted, dried and smoked. Very few investigations have been carried out on the losses of other traditional fish products such as fermented, boiled, marinated fish etc.

Three broad categories of loss connected with TPFPs can be identified as follows:

(a) Loss of nutrient availability
(b) Loss of economic value
(c) Physical loss

Loss of Nutrient Availability: Nature of Loss

Some loss of nutrients is inevitable during most processing procedures and traditional fish processing is no exception. Much of the older literature appears to indicate that salting and drying effectively preserves much of the original nutritional value of fresh fish (Cutting, 1962). This, however, is largely based on the gross composition of the product and it is now clear that biological availability of the muscle constituents is a more appropriate yardstick for measuring nutritional loss.

Excessive heat treatment is known to impair the availability of amino acids such as lysine in fish protein (Carpenter and Booth, 1973). This is a particular problem in fish meal where much work has been undertaken to study the reactions involved. Much less work has been done on cured fish for human food processing using the heating and drying conditions normally encountered. The muscle constituents most at risk during normal processing by curing are amino acids such as lysine, the sulphur amino acids and, possibly, vitamins such as A and D.

Loss of Nutrient Availability: Extent of Loss

Hard data on the extent of loss of nutrient availability in TPFP is limited. Further, those reports which are available are often conflicting. For example, Hoffman et al. (1977) found a significant reduction in lysine availability and net protein utilization in tropical fish dried at 75°C and smoked at 100°C whereas Obileye and Spinelli (1978) found only minor losses in lysine availability in tilapia smoked for two hours at 30°C and dried to a moisture content of 40 percent before hot smoking at 70°C. Obviously the conditions of processing are of paramount importance to the extent of loss. Factors such as whether the product is held at elevated temperatures when still moist are relevant, as is the time and storage conditions for the fish post mortem. The latter will affect the reducing sugar concentration in the muscle at the time of processing and hence the potential for damage to protein availability. The fat content of the fish will also have a significant effect on the protein availability as oxidized fish fat is known to be able to react with and damage the protein thus reducing its nutritional value (Carpenter and Booth, 1973).

A further problem in identifying the extent of loss of nutrients is that the analytical methods traditionally used were not very sensitive. Using these methods a loss of 5 to 10 percent in protein availability, although highly significant in a diet low in protein, is unlikely to be picked up. Recently

more sensitive methods have become available and further studies are required in this whole field.

Loss of Economic Value: Nature of Loss

Economic loss implies a net reduction in potential revenue from a given lot of fish. As a result of a combination of handling, marketing and socio-economic factors, fish tends to be downgraded into lower categories resulting in economic losses which are likely to be extremely important in many situations.

Generally speaking, fresh or wet fish attains the highest price in most LDCs. Certainly to the fishermen or trader the risk is small and return on capital and labor is rapid if fish can be sold to the consumer within a few hours of capture. Processing usually represents a financial loss; not only is the price of cured fish lower than that of fresh fish but the processor incurs the processing costs, fuel, equipment, salt etc., plus real or nominal labor costs. So every effort will be made to sell fish in the wet state and processing is normally done only when there is no quick access to a suitable market or at times when there is a surplus of fish. As fish spoils the price will fall and, in most LDCs, even what would normally be considered as heavily spoilt fish would find a market, albeit at a low price (often to the poor sectors of the community). As an alternative to the latter many processors would process fish, for example, by curing. A similar pattern would then be found for the processed product in which, as the spoilage proceeds, the price falls. Therefore, spoilage of fish, and in many cases, processing itself reduces the economic value of the fish to the fisherman but does not necessarily result in physical loss. Indeed it could be argued that to the low income consumer, spoilage of fish either fresh or cured is a positive advantage as he would not otherwise be able to afford a food rich in animal protein.

Loss of Economic Value: Extent of Loss

Assessment of economic losses in the fish handling network have been made in several countries. By the very nature of the assessment they are open to a wide degree of error as major assumptions have to be made about market prices, consumer requirements, etc. However, Bostock (1987) in India estimated economic losses over potential revenue of $6 million per year in the marketing of fresh fish for domestic consumption from Gujarat to Delhi (60,000 t/annum), this representing approximately 10 percent of the total actual wholesale income of the market. It was reported that 10-15 percent of fish arriving in Delhi was of poor quality and attracted only about 50 percent of its high quality price. A further 5 percent loss

was incurred through net physical drip loss. The extent of the economic loss can be related to species value as greater care is taken in handling the higher value species in comparison to the lower value ones.

Fish damaged by insects during the traditional sun drying process can also result in economic loss. It was reported by Hanson and Esser (unpublished) in Indonesia that losses of flesh during drying of about 9 percent caused financial losses of about 30 percent.

Under the very humid conditions which are commonly found in some tropical countries, cured fish, particularly if salted, will reabsorb moisture and become susceptible to attack by molds. Suryanarayano Rao et al. (1962) found that a relative humidity of over 70 percent was conducive to mold attack. Fish damaged by molds will almost certainly attain a lower price resulting in an economic loss.

Physical Loss: Nature of Loss

TPFP are susceptible to three main causes of physical loss i.e. microorganisms, insect infestation and fragmentation. The type and extent of the microbial spoilage will depend almost entirely on the water activity (Aw) of the product. Hence in fish awaiting processing and in the early stages of processing the normal fresh fish spoilage flora will be active. In later stages of processing when the Aw has fallen halophilic bacteria and xerophilic molds will become the dominant causes of microbial spoilage.

At Aw below 0.6 (equivalent to 60 percent relative humidity) microbial growth ceases. To obtain such low Aw it is necessary to dry the product to a relatively low moisture content. In many tropical countries the atmospheric conditions are such that ambient humidity does not fall below 60 percent, making it impossible to fully sun dry the product. Under these conditions although microbial spoilage cannot be completely arrested, there will be a lag, dependent on the Aw, before spoilage occurs (Poulter et al., 1982). This allows a limited degree of distribution and storage.

In the early stages of curing, fish are susceptible to infestation from the larvae (maggots) of several species of blowfly (Diptera). More fully or completely cured fish are attacked by a rather wider range of pests of which Dermestes and Necrobia beetles are the most important.

Blowfly larvae are a particular problem in parts of the world such as inland Africa where salt is not traditionally used. The blowflies are attracted to the wet fish and lay eggs on it. When hatched the larvae will, if unchecked, completely consume the fleshy parts of the fish. The larvae, however, can only attack relatively moist material and in good drying conditions excessive losses are prevented; under poor drying

conditions this is not the case. Although, in general, salt reduces the blowfly attack on fish it appears that in some situations, e.g. Indonesia, there exist salt resistant strains of blowflies.

Beetle infestation is a major problem in unsalted dried fish and the level of losses is directly related to the length of storage. Little hard information is available on the relationship between beetle infestation and Aw/salt content of fish. Much work has been carried out by TDRI on the control of all types of insect infestation in TPFP and this is reported in the following paper by David Walker.

The final major cause of physical loss in cured fish is fragmentation; damage to the texture of fish due to spoilage before processing, subsequent molds and bacterial growth and insect infestation will all increase the tendency for dried products to fragment. However, fragmentation is most serious in hot-smoked fish. In this form of processing the excessive temperatures used damage the connective tissue and structural proteins of the fish muscle causing it to become easily broken or damaged. While in some cases pieces of fragmented fish can still be sold for human food the price attained is usually lower than intact fish and further many of the smaller fragments are completely lost.

Physical Loss: Extent of Loss

Published information on the extent of physical loss of cured fish is summarized in Table 2. The information must be viewed with considerable caution as overall quantitative losses have often been arrived at purely by estimates. Where measurements of weight losses have been made the results can be misleading due to variable moisture contents and the prevailing climatic conditions at the time the measurements were made. For example during periods of rain and high humidity losses will be much greater.

CRITICAL FACTORS RESULTING IN PHYSICAL LOSS

It is clear that postharvest losses in TPFP are variable. Physical wastage can undoubtedly be as high as 30 to 50 percent in some cases, but this is almost certainly the exception rather than the rule. In situations where the demand for fish is high and the conditions for fish curing are favorable it is likely that physical losses of TPFP are quite low. The reason for this is that production handling and distribution of TPFP is generally small scale. There are many people employed at all levels of the industry and each is effectively responsible for a small proportion of the commodity.

TABLE 2
Physical Loss of Cured Fish in the Tropics

Cause	Country	Type of Fish	%	Method of Assessment	Reference
Blowflies	Bangladesh	DU	25	E	Doe et al. (1977)
	Bangladesh	DU	30	E	Ahmed et al. (1978)
	Indonesia	DS	11-35	M	Esser & Warren (Unpub)
	Indonesia	DS	9	M	Esser et al. (Unpub)
	Malawi	DU	10-27	M	Meynell (1978)
	Malawi	DU	22	M	Walker & Donegan (1987)
	Sudan	DU	15-30	E	Mastaller (1981)
	The Gambia	DU		M	Walker & Evans (Unpub)
Beetles	Burkina Faso	DU	25	E	Guggenheim (1980)
	Kenya	DU	1-15	M	Wood & Walker (1986)
	Kenya	DU	16	M	Golob et al. (1987)
	Malawi	DU	18	M	Walker (unpublished)
	Mali	DU	14-25	M	FAO/PNUD (1970)
	Mali	DU	50	E/M	Aref et al. (1965)
	Mali	DU	50	E	Duguet et al. (1985)
	Mali	DS	23	M	Aref et al. (1965)
	Mali	DS	9	M	Aref et al. (1965)
	Niger	SD	40	E	Bouare (1986)
	Nigeria	DU	50	E	Rollings & Hayward (1963)
	Nigeria	DU	22	M	Mills (1979)
	Senegal	DU	20	E	Toury et al. (1970)
	Senegal	DU	10-30	E	Diouf (1980)
	The Gambia	DU	14	M	Walker & Evans (1984)
	UK*	SD	47	M	Taylor & Evans (1982)
	UK*	DS	15-41	M	Wood et al. (1987)
	Worldwide		25	E	James (1977)
	Zambia	DU	10	E	Watanabe (1971)
Beetles & blowflies	Senegal	S&D	15-35	M	Wood (1983)
Framentation	Nigeria	DU	25&56	M	Mills (Unpub)
	Nigeria	DU	35	E	Moes (Unpub)
General	Indonesia		30-40	E	Hanson & Esser (Unpub)
	Indonesia		15-30	E	Esser & Warren (Unpub)
	India	DS	0.3	M	Bostock (1987)

Type of Fish: DU = Dried Unsalted
DS = Dried Salted
SD = Smoke Dried
S&D = Smoked and Dried

Method of Assessment: M = Measured
E = Estimated

* Laboratory trials at 27°C and 70% relative humidity

For such small scale operators even a small physical loss of the product could mean the difference between financial profit or loss and they will therefore take great personal care of the product, re-drying or further processing if necessary. Further, trade and distribution channels are diverse which allows a high degree of flexibility. This, together with the relatively small unit batch size of fish either for processing or distribution, effectively limits the probability of large scale losses.

Notwithstanding the above, a number of situations can be identified which can result in very substantial physical losses. These are discussed below.

Glut Catches

Traditional processing techniques are generally time consuming. More often than not they rely on a drying phase and this requires space either in a smoking kiln or on sun drying racks. This drying phase is often the rate limiting step as far as the process is concerned. The drying facilities available are usually tailored to cope with normal catches and abnormal gluts therefore pose a problem. The species most commonly concerned in wastage through glut catches are pelagic varieties both small pelagic species such as sardines and also larger species such as skip-jack tuna. At times of glut catches many tons of such fish are becoming spoilt while waiting to be processed and further large quantities are lost as a result of improper processing.

Processing Problems

Curing of fish correctly undertaken with appropriate drying conditions is an excellent means of preserving fish. Problems and losses, however, can occur. These are largely due to adverse weather conditions preventing the rapid reduction of water activity required to prevent spoilage. Such problems are more severe when salt is not used in the processing method.

Thus in Malawi losses are low during the dry season when the relatively low humidity and long periods of sunshine mean that unsalted fish spread on racks dries quickly. However as the rainy season approaches the ambient humidity rises and drying is slow. Under these conditions blowflies proliferate and losses become serious. Salting fish prior to drying has been shown to reduce blowfly infestation in Malawi and other African countries but salt is expensive in inland Africa and salted fish is not generally liked. Salting does not therefore always provide a practical means of control. In Indonesia where much of the fish is salted before drying, blowflies have become tolerant to the levels of salt found in fish and are able to infest it.

Under certain circumstances, improved processing methods may not be effective in reducing physical losses and it then becomes necessary to consider the use of insecticides to control insect infestation in cured fish. This is the subject of the following paper in this meeting.

Storage and Transport Problems

A number of factors affect spoilage during storage and transport. Sometimes spoilage may largely be avoided by ensuring a rapid sale without allowing sufficient time for fish to spoil. For instance, near some big cities, where there is a good market for fish, it is possible to process fish by a short period of hot smoking. This gives the product a shelf life of a few hours/days such that the product can be sold locally without serious loss. On the other hand storage following processing is often necessary when fish are landed in areas remote from the market or to even out fluctuations in supply. Storage life of a product is dependent on the Aw and in countries with a high relative humidity products will absorb moisture during storage which will reduce the shelf life. This can be a major cause of loss.

Even in countries with low ambient relative humidities, losses during storage can be high due to insect infestation. As described above this is particularly a problem in unsalted fish. To keep losses to a minimum the cured fish should be distributed and sold as soon as possible. In remote areas, however, this is not always possible since transport may only be available periodically and it is often necessary to accumulate sufficient material to fill a complete truck; for small scale producers this can take many weeks. Further, where communications are poor regular transport often breaks down and hence cannot be relied upon. In addition, roads are often in poor repair and possibly impassable for part of the year due to floods etc. Under these conditions storage losses can be very high.

CONCLUSION

Throughout this paper it has been necessary to qualify statements on losses with terms such as "seems", "appears" etc. Very few quantitative studies of actual losses have been undertaken and much of the available data is therefore actually based on qualitative estimates sometimes involving rather massive extrapolation from single landing sites to whole countries or even regions. In the absence of other data this is an acceptable technique to assess needs for planning purposes but the inherent error in the data needs to be emphasized at all stages. This approach, however, also has the

danger that by making sweeping generalizations the critical areas where the major losses occur could be masked.

Detailed loss assessment work may appear unproductive in the short term but if development funds and resources are to be put to most effective use it is vital that the real levels and causes of loss are known. Furthermore, measurements of actual losses provide a yardstick for the assessment of possible alternative procedures and processes. A recommendation that further loss assessment work should be carried out could be one of the conclusions of the workshop.

Improvement of quality and reduction of economic losses is a more difficult area. Maximizing the return to the fisherman and processor by up-rating fish for example from domestic to the export market is undoubtedly a worthy aim. This, however, clearly has a negative effect on the domestic market. Quality of fish is a highly subjective concept and there are no absolute measures. If fish does not represent a public health risk and is eaten by consumers it is surely of acceptable quality. The question therefore remains as to what extent development projects should become involved in upgrading the quality of fish thereby pricing out of the market for the low income consumer.

Finally, surprisingly little is known of the effect of traditional processing methods on the availability of the nutrients in fish muscle. In recent years the methodology for measuring this has improved and more attention should be given to optimizing traditional processing techniques in the tropics to ensure maximum quality and yield.

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NEW METHODS TO REDUCE POSTHARVEST FISHERY LOSSES IN TRADITIONALLY PROCESSED AND FRESH FISH IN LDCs

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ABSTRACT

Growing world demand for more seafoods together with the recognized urgency to conserve fish stocks is signalling all nations not only to reduce postharvest fishery losses but to better utilize landings as human food. Although tradition often inhibits change in the fishing industry, this general overview indicates that there could be potential benefits through the wider use of newer technology. Advances ranging from fresh and frozen fish preservation to fish drying and surimi technology are highlighted. It is suggested that postharvest fishery losses in less developed countries (LDCs) may be reduced through the use of such measures as sorbate to extend the shelf life of fish, vacuum packaging to inhibit rancidity in frozen fatty fish, heat pumps for fish drying and more emphasis on minced fish as a versatile raw material.

INTRODUCTION

Although fishing is one of man's oldest and most primitive industries, today it is a high-technology enterprise enabling fishing operations to be devastatingly effective. World stocks of traditional species are generally over-exploited and fishing has become one of our most regulated industries. There are few, if any, unexploited stocks that can be readily caught and marketed by conventional methods. Fishing and fish processing have also become much more expensive and the gleaning of more fish from the depths of the oceans for conversion into consumer products no longer yields cheap protein. Indeed, many seafoods can be classified as luxury items and are beyond the purchasing power of those most needing additional animal protein in their diet.

Nevertheless, world market demand, seafood prices and consumption are at record levels buoyed by consumer recognition that eating more fish can be beneficial to health. Thus the development of new science and technology and novel approaches to reduce postharvest losses has become an issue of increasing priority for all fishing nations of the world. On the other hand, there are many who feel that much of our postharvest fishery technology has reached maturity and that research and development on new technology is not keeping pace with the rapid changes in other sectors of the industry. In fact we see effort decreasing in several countries and both government and industry have yet to recognize fully not only the high price to be paid for the decrease but also the time and effort associated with worthwhile research and development.

Postharvest fishery losses is not a new problem. In 1965, Dr. George Borgstrom wrote in the preface of his famous book on Fish as Food: "Only through wise utilization and efficient processing is it possible to save these extremely perishable riches of the oceans and freshwaters and place them within reach of the consuming public independent of seasons and of fishing fortunes - mostly far removed from the catching grounds". Most disturbing, however, is the fact that the problem is just as serious now as it was a decade and a half ago. At the Jubilee Conference of the Torry Research Station, Dr. Kenneth J. Carpenter (1979) commented on, "the willingness of scientists in the past to turn their backs to the economic facts of life and to have little sympathy or wish to understand the customs and values of people living in quite different societies from our own. The first generation of work on this problem has been almost entirely fruitless. The challenge to fisheries to make a greater contribution to the food needs of the poor remains, but it is obviously not an easy one".

Another factor contributing to the urgency to reduce postharvest fishery losses is the realization that world fish stocks are not limitless and we must therefore ensure optimum use of available resources. Much scientific effort has been devoted to calculating the productive capacity of the oceans and J. H. Ryther (1969) after considering the various factors wrote, "it seems unlikely that the potential sustained yield of fish to man is appreciably greater than 100 million metric tons". As shown in Table 1, global fish landings in 1984 were 83 million metric tons. Thus we are approaching Dr. Ryther's figure and records also show (Table 2) that fishing effort is already shifting from the more established fishing areas of the world to more non-traditional waters and species. Thus the search for more fish is well underway and the challenge to reduce postharvest fishery losses is perhaps more acute than ever before.

OPPORTUNITIES FOR NEW METHODS AND TECHNOLOGY

In highlighting opportunities for new methods and technological advancement we must recognize some of the limitations of fish as food. Fish are much more perishable than most other foods and in addition we have seasonal factors to contend with and the fact that not all fish have the same processing and storage characteristics. Thus, to a far greater extent than in the processing of beef or poultry, we must take into account the technological properties of individual fish species when deciding how they will be handled, processed and marketed. This is a major consideration and failure to recognize the difference, for example, between a squid and a cod, or a mackerel, can be disastrous.

Examination of Table 1 reveals that fresh fish, long the dominant seafood in world markets, has recently been surpassed by frozen products. This is not only a reflection on the utilization of improved technology and increased consumer confidence but the establishment of more and more freezing and storage facilities throughout the world enabling the expansion of markets for frozen seafoods. In addition, many of the non-traditional fish now entering the market require freezing as they are highly perishable, and do not stand up in the fresh state.

The figures in Table 1 also show that about 50% of world fish landings are processed into seafoods with the remainder being sold as fresh fish or converted into animal feed. Although we continue to emphasize the need to use industrial fish as human food, the right mix of technology and economics has yet to be found. Many feel that fish marketing and distribution could be markedly advanced if we would move toward seafood products wherein fish protein is sold primarily as an ingredient rather than where the integrity and identity of the various fish species are retained. Surimi is the closest that we have come to in this regard and advancements in this field have been most dramatic in the last few years. However, the problems of making high quality surimi from industrial fish have yet to be resolved. We must also remember that past experiences, like that with fish protein concentrate, have demonstrated that people will not eat a product just because it is good for them (Pariser et al., 1978).

Fresh Fish

Inasmuch as a major portion of all fish is sold in the fresh state, and it serves as the raw material for all processed seafoods, reduction of postharvest losses at this stage is of fundamental importance. Written recommendations on the handling of fish on vessels, based mostly on observations made over the past sixty years, are widely available. Typical

TABLE 1
World Fish Production and Disposition
Metric Million Tons (%)

	1960	1970	1980	1984
Total Catch	40.2	70.0	72.0	82.8
Total Human Food	31.6 (78.6)	43.5 (62.1)	52.9 (73.5)	59.9 (72.3)
Fresh	16.9 (42.0)	19.5 (27.9)	15.7 (21.8)	17.3 (20.9)
Frozen	3.5 (8.7)	9.7 (13.9)	15.9 (22.0)	19.8 (23.9)
Cured	7.5 (18.7)	8.1 (11.6)	11.1 (15.4)	12.2 (14.8)
Canned	3.7 (9.2)	6.2 (8.9)	10.3 (14.3)	10.5 (12.7)
Total Animal Feed	8.6 (21.4)	26.5 (37.9)	18.4 (25.5)	22.0 (26.6)

Source: FAO Fishery Statistics

TABLE 2
World Fish Landings - Selected Areas
(Million of Tons)

	1960	1970	1980	1984
World Catch	40.2	70.0	72.0	82.8
Marine Species	35.6	62.4	64.4	73.1
Inland Species	4.6	7.6	7.6	9.7
North Atlantic	9.8	14.9	14.7	13.9
North Pacific	11.3	16.6	20.7	26.4
Northern Regions	22.0	32.7	35.3	40.4
Central Regions	6.3	11.7	18.3	20.0
Southern Regions	5.6	17.5	10.6	12.7

Source: FAO Fishery Statistics

of this is the "Recommended International Code of Practice for Fresh Fish" published jointly in 1976 by the Food and Agriculture Organization and the World Health Organization (FAO/WHO, 1976). In these recommendations a great deal of emphasis is placed on the need for cleanliness and cooling in order to prevent bacterial spoilage and maintain freshness. Careful bleeding, gutting, washing and chilling of the catch as soon as possible after capture is recommended to minimize physical damage and to remove surface bacteria, blood and gut enzymes. Observations in northern waters and best present practice have been described by Strom et al. (1985). There would appear to be a need for further work along similar lines in warmer regions.

Bacterial and biochemical (autolysis and oxidation rancidity) spoilage remain the prime factors responsible for quality deterioration in fresh fish and chilling with ice is the most effective means of control. Enhancing the effects of ice and/or extending the shelf life of fresh fish is still an area of major study and interest. We can look back on the use of additives like nitrite and antibiotics (chlorotetracycline) which inhibited the bacterial spoilage of fish but these substances are now prohibited. Subsequent attention was focused on physical methods of extending shelf life like superchilling and nuclear irradiation. These too have not been successfully applied to reduce fresh fish spoilage.

At the present time potassium sorbate treatment shows the most promise for inhibiting bacterial spoilage of fresh fish. Sorbate is a well known food additive which is commonly used to inhibit mold and yeast growth. Tests at the Canadian Institute of Fisheries Technology (Shaw et al., 1983) have shown that a fillet dip of 10 seconds in a 3% solution of potassium sorbate was very effective in preventing bacterial spoilage and was equivalent to that found for chlorotetracycline or irradiation (Figure 1). The same treatment did not produce as pronounced an effect on gutted cod but incorporation of the potassium sorbate in the ice was more effective in controlling bacterial growth as indicated by trimethylamine formation (Figure 2). Wessels et al. (1972) had earlier found that 0.1% potassium sorbate ice extended the shelf life of gutted South African hake and Australian workers (Bremner and Stratham, 1983) have also experienced considerable success in using sorbate to inhibit bacterial spoilage of scallops. It should be mentioned that sorbate is also effective in controlling mold and halophile growth on cured fish (Varga et al., 1979).

Another area that is receiving a lot of attention and study is the use of modified atmospheres containing carbon dioxide to extend the storage life of chilled fish (see Stratham, 1984). One of the drawbacks to this method is that the product must be enclosed in a gas-tight container or plastic bag. Some of the earlier work on modified atmosphere packaging did not yield

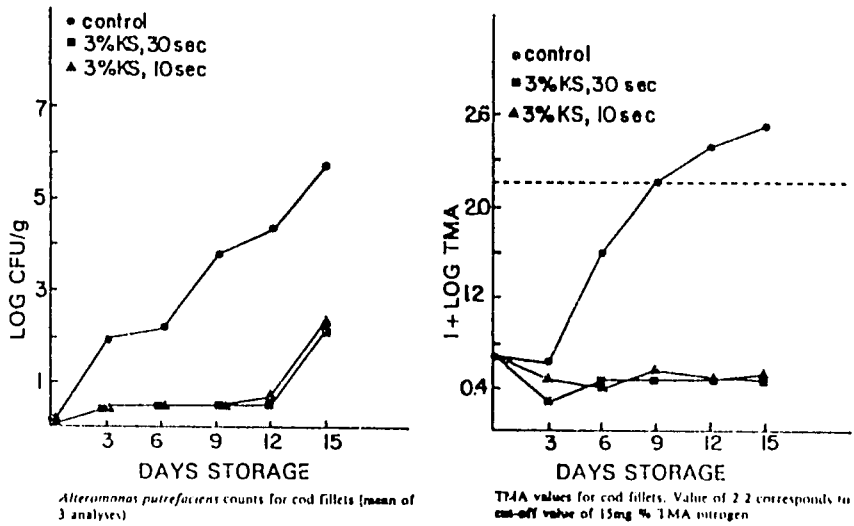


FIGURE 1. The effect of a potassium sorbate dip on the quality characteristics of iced cod fillets. Source: Shaw et al., 1983.

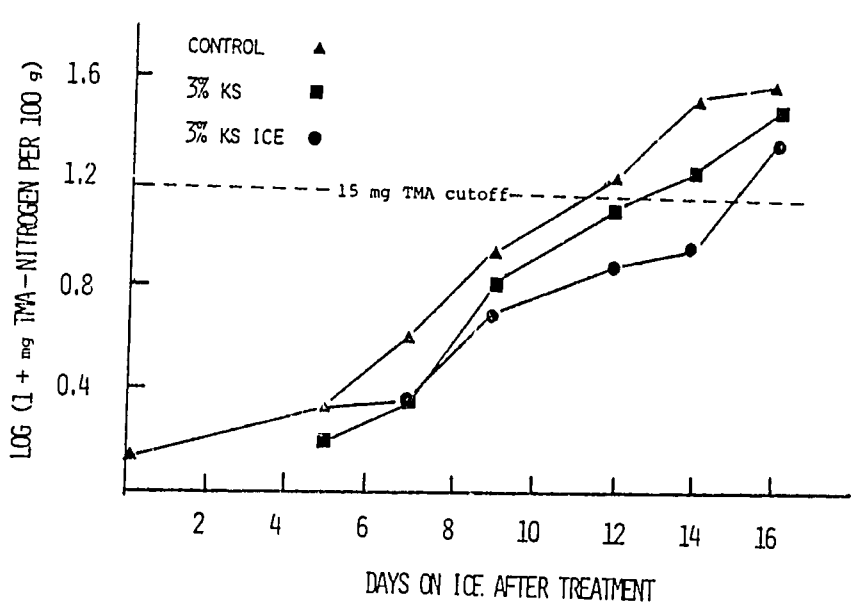


FIGURE 2. Trimethylamine (TMA) values of gutted cod following a dip in 3% potassium sorbate or storage in ice containing 3% potassium sorbate. Source: Woyewoda et al., 1986.

consistent results and may have been due to the use of stale starting materials.

A study on cod fillets at our Institute (Woyewoda et al., 1984) showed some benefit but the results were lower than expected possibly because of inadequate surface exposure of the fillets to the gas mixture. In subsequent tests wherein the fillets were well exposed to an atmosphere of 60% CO_2:20% N_2:20% O_2, we got considerable extension of shelf life as indicated in Figure 3. These results are similar to those of Cann et al. (1983) of the Torry Research Station who in addition reported little benefit from holding herring or hot-smoked mackerel in modified atmosphere storage. Fey and Regenstein (1982) also failed to realize a significant benefit of modified atmosphere storage over oxidative rancidity in salmon.

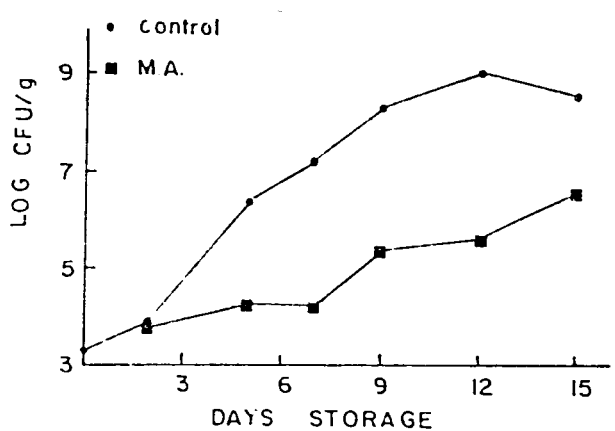
Developments in Refrigeration

Refrigeration plays a major role in fish preservation worldwide and we continue to see continued expansion of refrigeration facilities in both developed and developing countries. Some evolutionary changes in refrigeration systems themselves, now taking place, will help to ensure wider application. Refrigeration systems are becoming more reliable and easier to use. In recent years the screw compressor has been introduced into the larger installations, in favor of the reciprocating compressor. Microprocessors are being used to control and monitor industrial refrigeration systems. Pearson (1986) has described a number of important new microcomputer applications and pointed out that standard programs are available for most industrial refrigeration applications. Frith and Heap (1987) have given details of a prototype microprocessor for transport refrigeration units.

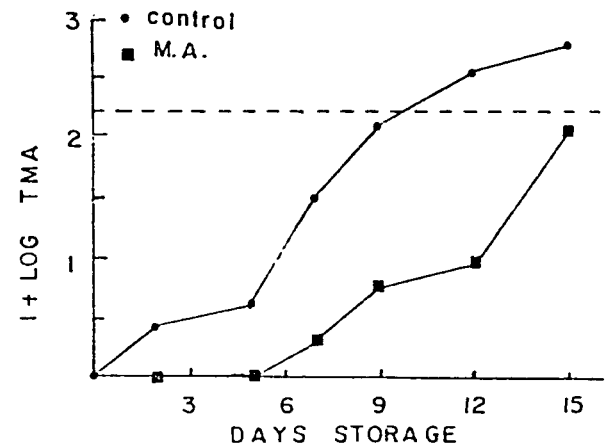
In a review of these and other current trends. Stoecker (1987) has discussed the safety and environmental issues associated with refrigerants - chlorofluorocarbons and ammonia. He has suggested that improved containment of these refrigerants may well be a major challenge in the years immediately ahead. Success in this no doubt would lead to greater application of refrigeration in developing countries.

Frozen Fish

The major quality changes that occur in frozen fish result from protein denaturation and rancidity. Protein denaturation is manifested by increased thaw and/or cooked drip and by tough or mealy texture. It can be inhibited by reasonably rapid freezing of the product, constant low-temperature cold storage at or near -30°C and proper packaging to prevent moisture loss through the package or migration of moisture from the



Total aerobic bacterial counts for cod fillets.



TMA values for cod fillets. Value of 2.2 corresponds cut-off value of 15mg % TMA nitrogen.

FIGURE 3. The effect of modified atmosphere (60% CO_2:20% N_2:20% O_2) packaging on cod fillets stored at 2°C. Source: Bartlett and Bligh, unpublished.

product to the inside of the package. There is considerable documentation available on protein denaturation in frozen fish and the deleterious effects of poor storage conditions and of temperature fluctuations such as encountered in transport and distribution (see reviews by: Sikorksi et al., 1976; Matsumoto, 1980; Shenouda, 1980).

Rancidity in frozen seafoods occurs when oxygen from the air is allowed to react with the polyunsaturated fats contained in the tissues. It is slowed down by low storage temperatures but continues as long as oxygen is available. The most practical way of controlling it today is through the use of laminated plastic packaging materials which are impervious to oxygen and air. These specially engineered films coupled with vacuum packaging are very effective in inhibiting rancidity and also prevent moisture loss and freezer burn. For example, the results shown in Figures 4 and 5 clearly demonstrate the effectiveness of vacuum packaging in oxygen-proof bags (in contrast to standard commercial practice) in preventing rancidity in mackerel and herring fillets even at the abusive temperature of -12°C. Current studies on minced herring and mackerel have shown that considerable fat oxidation is initiated just by deboning and water washing of fatty fish mince. Attempts to inhibit this through the addition of approved antioxidants are in progress.

Cured Fish

Smoked and salted fish have traditionally been widely accepted and have broad international market appeal. Many species marinate well also and are considered gourmet items. Nevertheless, the technology associated with these processes has changed little in the past twenty years. Some improvements have been made in the operation of mechanical smoking kilns, especially better controls and automatic smoke producers. Also it has been feasible to use liquid smoke in some applications. One fact that is often forgotten is that, for extended storage life, smoked fish products should be frozen to protect quality except for hard-cured items.

A project on smoking at the Canadian Institute of Fisheries Technology is being directed toward the development of a fluidized-bed aerosol filter for smoke. The filter will remove tarry particles and thus allow cleaner operation, reduce the level of carcinogens in the smoked products and improve product color, at least in some instances. Also, removal or reduction of the aerosol fraction is expected to aid in the introduction of better automatic control of the kiln since the measurement of smoke density and other parameters will be simplified.

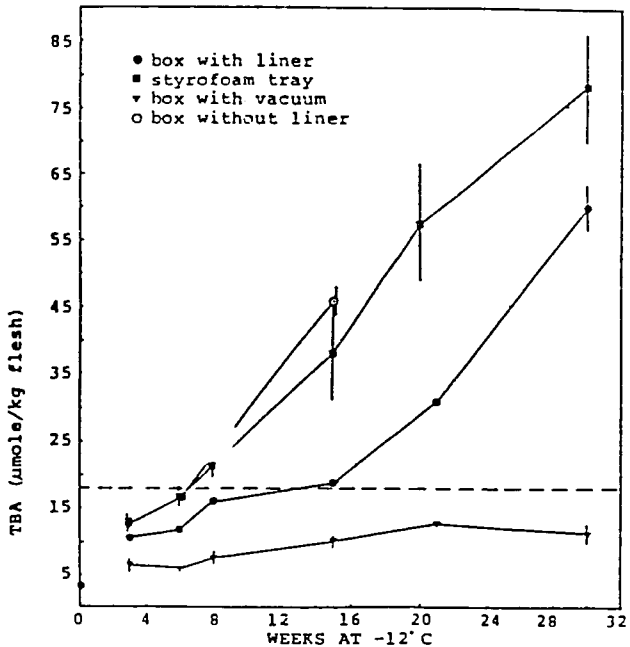


FIGURE 4. The effect of vacuum packaging (Cryovac "Barrier Bag") on the development of rancidity in mackerel fillets stored at -12°C. Limit of acceptability denoted by '---'. Source: Woyewoda and Bligh, unpublished.

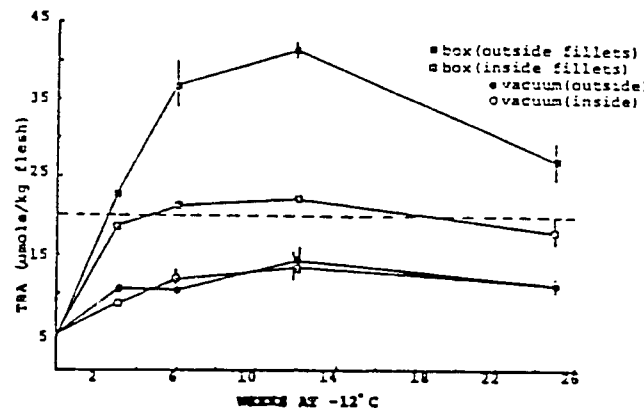


FIGURE 5. The effect of vacuum packaging (Cryovac "Barrier Bag") on the development of rancidity in frozen herring fillets at -12°C. Limit of acceptability denoted by '---'. Source: Woyewoda and Bligh, unpublished).

The processing of dried salted fish, once considered the mainstay of world fisheries has become increasingly expensive. It too has received insufficient attention and we need to improve our drying technology through the utilization of heat pumps, waste heat and solar energy. Furthermore, our salting and curing techniques need to be updated. Although mechanical and heat pump dryers are increasingly being used in developed countries, greater use in developing countries could prove beneficial since they can operate independent of prevailing weather conditions. A project supported by the Canadian International Development Research Center is underway at our institute wherein a pilot model heat pump fish dryer has been designed and equipped with a computer for control and data collection (Carpio and Merritt, 1987). The computer program allows continuous temperature scanning and dryer control and intermittent weighing of the product. Through the software, the dryer can be operated in three modes for control of air temperature and humidity: constant, variable with time and variable according to drying rate. The best results, with a high overall rate of drying with the salt fish under test, were obtained under a regimen with decreasing relative humidity. The developed control system is low in cost and thus pre-programmed drying operations for specific species of fish and kinds of products (i.e. including smoking) appear feasible and practical.

Canned Fish

Canned seafoods are generally well accepted and many fish can be successfully canned that otherwise would be difficult to handle. With a few exceptions (e.g. new cans and liners) fish canning operations have changed little in recent years and there are opportunities for advancement. For example, the retortable pouch warrants attention especially for luxury items with delicate flavors like lobster, crab, shrimp and possibly salmon. There should be less flavor loss and damage due to shorter cooking time yielding superior products. Heintz (1980) reported that cans for food products were reaching such a high price that he considered that retortable pouches could have an economic advantage not only in material costs but because of reduced cooking time. There is also room for greater use of computers in controlling and optimizing retort operations (see Gill et al., 1986). Other sectors of the food canning industry are examining (or using) such things as plastic cans, aseptic packaging, microwave blanching and continuous retorting.

Minced Fish

Minced fish is an area with tremendous potential as a means of improving yield from traditional species and for utilizing

fish that are not easily filleted. The technology and equipment are available but we lack avenues for marketing the substantial quantities of material that could be produced (Bligh and Regier, 1976; Regenstein, 1986). Minced fish has many versatile features as a protein ingredient but care is required to avoid its disadvantages (such as, subject to abuse, spoils more quickly, does not freeze well, etc.). The Japanese early on recognized this potential and today we see the results of their efforts to adapt their traditional kamaboko technology to producing surimi-based products with international market appeal. These products have had dramatic sales and are the greatest thing to hit the seafood industry since the fish stick. The principal products being consumed are crab sticks and simulated scallops made from Alaskan pollock. They are priced at approximately one-half that of the natural products and to date there is little evidence of negative market impact on the latter. Consumer acceptance appears to be generally good and demands continue to grow.

The surimi-kamaboko process involves sophisticated protein chemistry and process control and has been recently reviewed by Lee (1984) and Lee (1986). The tremendous surge of surimi research on this continent in the last couple of years has removed much of the mystery associated with the process. However, we are still experiencing difficulty with fish that differ substantially from Alaskan pollock. Fatty fish pose special problems and these are the fish that are most available as a raw material. In the United States a great deal of work is aimed at producing surimi from menhaden (Regier et al., 1985). In Atlantic Canada we are examining the use of underutilized quantities of capelin, herring and mackerel and many will recall the major study done in the United Kingdom on blue whiting. It would appear that some of the surimi technology, particularly the procedures for water washing, could have potential throughout the world for improving the characteristics of minces from small pelagic species. We know, for example, that water washing can greatly improve the color and flavor of fatty mince and at the same time remove at least 50% of the fat. Thus washing can yield a protein resource with enhanced characteristics for making such things as fish balls, sauces, and salted or cured products.

We have done further work at Halifax on the salting of minced fish (Bligh and Duclos-Rendell, 1986) and found that the addition of 13% salt to lean fish mince [rather than the 25% salt recommended by Wojtowicz et al., (1977)] produced a product with improved physical properties. Some protein functionality was retained by the lighter salt treatment and the end product had shape stability after drying and cooking and had improved water binding capacity and texture.

Workers at the Memorial University of Newfoundland (Raksakulthai et al., 1986) have demonstrated that a high

quality fish sauce (nuoc-mam) can be made from minced capelin through the addition of supplementary enzymes. In this process whole male capelin were minced and mixed with 25% salt and squid hepatopancreas. After 13 months at 20-25°C they observed superior protein solubilization and judged the product as highly acceptable.

A small deboning machine, for the recovery of fish flesh from underutilized species and from waste fish at a rated input of 100 kg per hour, has been developed in Atlantic Canada. In 1983, the International Development Research Center placed a contract with the Canadian Institute of Fisheries Technology and ABCO Industries Limited for the development of a small deboning machine that could be manufactured easily at low cost and would be suitable for fish processors in developing countries.

The main features of the deboner are an electrically-driven stainless steel perforated drum, a variable-pressure pneumatic assembly and rotating feed roller. The drum, which in turn drives the other moving parts, is driven by a gearmotor rated at 250 watts (one-third horsepower). It would be possible to adapt the apparatus to operate directly from manual power if required. An attempt has been made to produce a rugged, well designed, aesthetically pleasing piece of machinery. It is safe to operate, as all moving parts are covered with the exception of the feed roller which is explicitly labelled to indicate the danger involved when in operation. One of the main attributes of the machine is its simplicity, in that all components including the drive mechanism are readily accessible and operational parts can be removed for cleaning or replacement quickly and easily. The machine's stainless steel enclosure and working parts provide easily cleanable surfaces with an absence of crevices, etc. to trap fish particles and harbor bacteria. In view of its simplicity, ease of operation and low cost, the machine will be useful in a variety of circumstances, particularly in the smaller processing operations.

The prototype deboner has been tested in trials for overall machine performance as well as individual component performance analyzed on the basis of ergonomics, efficiency, workability and safety. It has been operated on various types of raw material; silver hake, argentine, Atlantic smelts and small mackerel. Optimum settings of drum speed, pneumatic pressure, etc. have been established. The deboned flesh is of high quality, substantially free of bones and skin. Further trials are currently underway in Thailand.

Fishery By-Products

There are various special by-products such as bait, fish glue, pearl essence, chitin, pet food and fertilizer made from

fish. However, they do not account for a great deal of the available raw material and fish meal and oil manufacture is by far the most widely used method of dealing with waste and underutilized fish. Largely because of the substantial investment required for fish meal plants, alternative processes have been sought. Two main products based on liquefaction of fish are of interest, silage and protein hydrolysate. Rao and Gildberg (1982) have published a major review of silage which is produced by the addition of acid to fish. Mackie (1982) has described the production of fish protein hydrolysate by the addition of commercial enzymes. Both methods have been applied on a commercial scale but to only a limited extent in a few countries because of a lack of versatility as a feed and difficulties in separation of oil of high quality. The Canadian Institute of Fisheries Technology is currently examining means of removing excess oil and water from fish silage. An important new market for these liquefied products and, indeed, fish meal is aquaculture, especially the rearing of salmonids and some other marine species which can tolerate higher levels of marine oils in their diets.

The hottest issue in fishery by-products these days is omega-3 fatty acids. Clinical evidence has shown that these special polyunsaturated fatty acids, only found in fish oils, can have beneficial effects on human health and may reduce cardiovascular disease and rheumatoid arthritis (Ackman, 1986; Eichner, 1987). This offers an excellent opportunity for increasing seafood sales and there is also renewed interest in the direct consumption of fish oils. Omega-3 fatty acids in fish oils [i.e. eicosapentaenoic acid (20:5n3) and docosahexaenoic acid (22:6n3)] range anywhere from 5-20%. Although these acids can be obtained through regular consumption of seafoods, particularly fatty fish, many consumers are looking at sources like cod liver oil which contains about 12% omega-3 fatty acid. It has been speculated that within the next couple of years we could see a therapeutic demand for 80,000 tons of fish oil per annum with a retail value in the order of 200 million dollars. The level of omega-3 fatty acids in seafoods and fish oils is somewhat low for therapeutic use and enriched oils containing 35-50% omega-3 fatty acids are now available in capsule form for daily consumption. In view of the great interest in this subject, and the fact that most of the research has been done on cold-water fishes, there would appear to be room for studies on fishes from warmer waters.

CONCLUSION

World demand for additional seafood and the limited availability of fish resources predicates that all nations take steps to reduce postharvest fishery losses. There is ample

room for the use of potassium sorbate and new packaging methods in preventing quality losses in fresh and frozen fish. New engineering equipment is available for improving the performance of cold storage facilities and for smoking, drying and deboning operations. Traditional processing methods for salting, smoking and canning fish are in urgent need of update. Continued effort needs to be directed at the use of surimi technology in utilizing small pelagic (fatty) species and by-catch resources. Opportunities to meet the growing demand for fish oils containing high levels of omega-3 fatty acids should be explored.

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CONTROL OF INSECT INFESTATION IN FISHERY PRODUCTS IN LDCs

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ABSTRACT

Insect infestations of traditionally cured fish and fishery products cause significant losses during processing and storage. Details are given of the species of blowflies and beetles concerned. Measures for controlling insect infestation such as improved sundrying, better hygiene, thermal disinfestation, salting, smoking, radiation, attractants and insecticides are described and evaluated with regard to their effectiveness and potential for improvement. There appears to be potential for reducing insect damage by the selective use of these methods. A major cause for concern is the present widespread and indiscriminate use of synthetic insecticides which are too toxic for use on food and which could leave harmful residues in the marketed product.

Pirimiphos-methyl is an organophosphorus insecticide which has been proved to provide safe, efficacious and economic control of the blowflies and beetles which infest fish. Its introduction, as part of an extension package, which would include training, supervision and regulation, is suggested as an effective replacement for current dangerous practices used in attempts to reduce losses caused by insects.

Fumigation, particularly with phosphine, appears well suited for the disinfestation of dried fish. However, further investigations are needed to confirm optimum dosage rates and exposure times, for the control of beetle pests.

INTRODUCTION

Fish which have been cured, or are in the process of being cured, by traditional methods in warm climates are often infested by insects. This is especially common when the curing procedure involves sundrying, smoking, salting, fermentation or a combination of these techniques. While fish is still relatively wet, i.e. with a moisture content of 50 per cent or

over, it is liable to infestation by blowflies. During processing the moisture content is progressively reduced until the fish become too dry for blowfly activity but then become susceptible to beetle attack during the storage and marketing chain.

The extent and nature of the infestations vary widely both within and between fisheries. Although the same insect may be present at two processing sites it is possible for it to cause significant losses at one but not at the other. Whether or not an insect achieves economic pest status depends on many factors, including: type of fish, particular processing technique, condition of local surroundings, rainfall, temperature, nature of storage facilities and time taken prior to marketing. Hence it is difficult to generalize on the extent of the problem; each situation should be assessed separately. Losses can be expressed in terms of weight, nutritive value, and economic loss. Some examples of significant weight losses and the countries in which they occur are given by Poulter et al. (1987).

There are very many different types of blowflies and although many adults are attracted to fish in order to feed, not all of them oviposit and cause infestations. Species belonging to the order Diptera, which have been recorded as infesting fish are listed in Table 1. The term blowfly is commonly used to denote any fly which infests fish but it is more meaningful to restrict the name to those dipterans in the families Calliphoridae and Sarcophagidae.

Blowfly infestation is characteristic of curing procedures that involve soaking the fish in water or brine and/or sundrying. The infestation persists only for as long as the fish have a high water activity. The duration of this will be longer in the rainy season when drying periods are prolonged. However, the larvae can very quickly consume the soft tissues and damage, leading to total loss, can occur in two or three days. Details of life histories of blowflies and the nature of their infestation and damage are described in FAO, 1981.

Some flies, in particular Piophila casei (L.), are frequently found infesting dried fish, occasionally in association with fish beetles. Beetle infestation begins when the fish or fish products have been dried to a moisture content of 40 percent or less, the optimum moisture content for successful beetle attack being approximately 15 per cent. Many beetles can occasionally be associated with fish but the main species belong to the families Dermestidae (Dermestes ater Degeer, Dermestes carnivorus Fab., Dermestes frischii Kug., Dermestes maculatus Degeer) and Cleridae (Necrobia rufipes (Degeer)). The latter species is thought to be more important for its predation on the other beetles than for the actual damage that it causes to fish. Details of the life histories of these beetles can also be found in FAO, 1981. The amount of

TABLE 1
Diptera Which Cause Postharvest Infestation of Fish

Family	Species	Country	Source
Calliphoridae	Calliphora terraenova (Macq.)	Canada	Morris & Andrews (1968)
	Calliphora uralensis Vill.	Norway	Somme & Gjessing (1963)
	Calliphora vicina Rob.-Desv. (=C.erythrociphala Meig.)	Norway	Somme & Gjessing (1963)
		USSR	Dorokhov (1965)
	Calliphora vomitoria (L.)	Norway	Somme & Gjessing (1963)
	Chrysomya albiceps (Wiedemann)	Malawi	Meynell (1978)
		The Gambia	Walker & Evans (1984)
	Chrysomya bezziana Vill.	The Gambia	Walker & Evans (1984)
	Chrysomya chloropyga (Wiedemann)	Malawi	Meynell (1978)
	Chrysomya chloropyga f. putoria Wiedemann	Malawi	Meynell (1978)
	Chrysomya megacephala (F.)	The Gambia	Walker & Evans (1984)
		India	Walker (unpublished)
		Indonesia	Indriati et al. (1985)
		PDR Yemen	Sachithananthan et al. (1986)
	Chrysomya regalis Rob.-Desv. (=C. marginalis Wiedemann)	Malawi	Meynell (1978)
		The Gambia	Walker & Evans (1984)
		Uganda	McLellan (1963)
		Zambia	Proctor (1972)
	Chrysomya rufifacies (Macq.)	India	Walker (unpublished)
	Cynomyia mortuorum (L.)	Norway	Somme & Gjessing (1963)
	Lucilia caesar (L.)	USSR	Dorokhov (1965)
	Lucilia cuprina (Wiedemann)	Indonesia	Esser et al. (1985)
		Malawi	Walker & Donegan (1984)
	Lucilia illustris (Mg.)	Canada	Morris & Andrews (1968)
	Lucilia sericata Mg. (?=Phaenicia sericata Mg.)	Canada	Morris & Andrews (1968)
		The Gambia	Walker & Evans (1984)
		USSR	Sharov (1948)
	Protophormia terraenovae (Rob-Desv.)	Canada	Morris & Andrews (1968)
Ephydridae	Discomyza maculipennis Wiedemann	Bahamas ?	Evans & Porter (1965)
		India	Soans & Adolph (1971)
Milichiidae	Leptometopa latipes Meig.	India	Pillai (1957)
Muscidae	Musca domestica (L.)	Indonesia	Indriati et al. (1985)
	Ophyra capensis (Wiedemann)	Malawi	Walker & Donegan (1987)
Phoridae	Megaselia scalaris (Loew)	Malawi	Walker (unpublished)
Piophilidae	Piophila casei (L.)	Indonesia	Indriati et al. (1985)
		Malawi	Anon (1963)
		Poland	Ciechan (1974)
		USSR	Sacharow (1921)
Sarcophagidae	Sarcophaga nodosa Engel	Malawi	Walker & Donegan (1987)
	Sarcophaga tibialis Macq.	Malawi	Walker & Donegan (1987)
	Wohlfartia sp.	PDR Yemen	Green (1967)

Notes: 1. This table includes only those species known or believed to have been bred out of infested fish.
2. The earliest reference is given where a species has been reported more than once for a particular country.

damage caused to a particular product is approximately proportional to the length of time between production and human consumption, i.e. the period spent in storage and in the marketing chain. Different fish and fish products have been shown to vary in their susceptibility to these insects. This may be related to the inherent characteristics of the product and/or to the moisture content (Osuji, 1974a) and the lipid content (Osuji, 1974b). No comparative studies appear to have been undertaken on the damage caused by different species of beetles or blowflies.

One of the difficulties in evaluating information on insect infestations of fish is that adequate data are only rarely recorded. All too often entomologists study the insects in detail but give only perfunctory descriptions of the type of fish and processing techniques. Fish technologists give a great deal of attention to the fish but traditionally pay little attention to insects. The problem appears to be that the infestation of fish does not fall within the established disciplines of either fish technology or agricultural entomology. Consequently there are also difficulties in locating relevant publications.

METHODS OF INSECT CONTROL

Sundrying

In order to minimise blowfly infestation it is necessary to optimise drying to reduce the moisture content to a safe level as quickly as possible. In doing this care has to be taken to prevent case hardening.

There is no doubt that sundrying of fish can be carried out in most countries for some part of the year without experiencing problems from blowflies. Unfortunately, in order to maximize the catch, to satisfy consumer demand, and to maintain a regular income for processors and the fishing community it is often necessary to dry fish throughout the year including under unfavourable climatic conditions. When the relative humidity is high or there is rain the time taken to dry the fish is prolonged. This facilitates infestation by blowflies whose population often appears to peak during the wet season. Examples are known where losses caused by blowflies during processing in the wet season are so great as to stop fishing at what would otherwise be a time of good catches.

Proper management of procedures to accelerate sundrying, such as using raised racks, turning the fish at frequent intervals, gutting, splitting or cutting the fish to reduce their size,and pressing, can greatly assist in reducing the damage caused by blowflies. Also it is apparent that some species of fish suffer far less damage than others. The reasons for this are not known but it would help to reduce

losses if it were possible to dry only these species during the wet season.

Blowflies are able to breed in any decomposing animal material. Hence it is important to clean up the areas around the processing sites in order to reduce the number of adults available to infest drying fish. All too often large amounts of offal, by-catch and spoiled fish are allowed to accumulate and provide breeding grounds for both blowflies and beetles. Blowflies are also attracted to the open latrine areas which are a common feature of many fishing camps and beaches. Experience in Malawi has demonstrated that improvements in hygiene and sanitation can markedly reduce the background blowfly population. However, it is important to realise that the adults are strong fliers and can travel a mile or more in search of attractive food and oviposition sites.

The screening of sundrying fish to exclude blowflies was investigated in Indonesia (Esser et al., 1985) and Malawi (Walker and Wood, 1986a) but did not appear to offer a practical solution.

Thermal Disinfestation

Solar driers have been shown, in some instances, to give protection from blowflies but at other times they have proved unsuitable (Walker and Wood, 1986a). Whilst the use of sunning or hot box techniques may be effective in disinfesting dried fish they do not provide any residual or long lasting protection. Walker and Wood (1986b) described methods of achieving thermal disinfestation of dried fish in Kenya and Malawi. They concluded that, although infestation could be reduced by means of solar boxes, or sunning on the ground, the treatments needed to be very labour intensive because dried fish do not readily conduct heat and therefore require to be spread in single layers. The use of artificial heat in ovens or kilns may be appropriate for very small consignments (FAO, 1981).

Salting

A traditional and one of the most widespread and successful means of reducing or preventing both blowfly and beetle infestation is salting. The salt can be applied in a variety of ways which present little technical difficulty.

Salt is normally readily and cheaply available near marine production sites. Hence coastal fisheries have utilised salt in their curing techniques since ancient times and many of the traditional products have a high salt content. Salt plays an important role in reducing bacterial activity and there is no doubt that heavily salted products tend to suffer less from insect attack than do those with a low salt content.

There may be potential for increasing further the use of salt in marine fisheries. Walker and Evans (1984) demonstrated in The Gambia that an application of dry salt to sundrying Ethmalosa fimbriata (Bowditch) was equally as effective in controlling blowflies as was an insecticide. However, it is important to note that in this study it was not possible to determine consumer reaction to the salted bonga. This raises the extremely important consideration of consumer eating habits and preferences. The use of salt produces marked changes in taste and texture; it is also necessary to remove much of it prior to cooking. Whereas some consumers prefer salted fish products others exhibit strong resistance.

In inland fisheries such as Malawi and Zambia there are no deposits of salt in commercial quantities. Consequently salt has to be imported from neighbouring countries. Transportation charges add greatly to the cost with the result that, although salt has been shown to achieve good control of blowflies infesting sundrying Cichlidae in Malawi its use at present is not economical. Consumers in such countries often have no experience of salted fish and most probably there would be difficulties in marketing such a product even if the cost of salt was to fall to an economic level. Thus there are countries where the use of salt does not offer a solution to the problems of insect infestation.

It used to be thought that all insect infestations could be controlled if a sufficiently high concentration of salt could be achieved in the fish. Whilst this may still hold true for beetles (Wood et al., 1987) there is now reason to believe that in some situations salt cannot be used to control blowflies. Recent observations in Indonesia by Esser et al. (1985) indicate that two species of blowfly, Chrysomya megacephala (F.)and Lucilia cuprina (Wiedemann) appear to have adapted to conditions of high salt concentration. Larvae of these blowflies appear to be able to develop in saturated brine and infest drying fish with salt contents in excess of 20 per cent. This may be an extreme situation which has arisen because continued heavy use of salt in West Java has exerted strong selection pressure on the blowfly population of that region. Thus it may well be that only certain strains of these species have this tolerance but it is clearly a situation which warrants further investigation and clarification.

Smoking

Wood smoke contains various phenolic compounds which are believed to have an insecticidal effect. Repeated smoking will increase the content of the phenolics but it should be noted that it will also increase the concentration of polynuclear aromatic hydrocarbons which are believed to be carcinogenic (Afolabi et al., 1986). The hot conditions in which smoking is

conducted in many countries will destroy any eggs or larvae already in the fish and deter any adults from further oviposition. Hot smoking reduces the moisture content of the fish and thereby renders it too dry to attract further infestation by blowflies. However, smoked fish do become infested with beetles during subsequent storage hence any protection offered by the phenolic compounds appears to be minimal. Additionally, wood suitable for smoking may be in short supply.

Radiation

The use of ionising radiation was reviewed in FAO (1981). The technique has proved successful in controlling D. maculatus in dried fish but it appears that the relative complexity and cost of the necessary equipment would hinder commercial development in countries which are seeking means of controlling insects, especially at remote fishery sites.

Attractants

It may be possible to lure the insects away from the fish to some form of trap in which they could be killed, probably by the use of an insecticide. The lure would need to be more attractive to the insects than was the fish. There would appear to be some potential in investigating the use of synthetic compounds based on the insects' natural pheremones (external hormones) which may promote aggregation or attraction (Hodges, 1984). Pheromones are currently being used successfully in the detection and control of various other insect pests.

Contact Insecticides

Insecticides are compounds which are used with the specific purpose of killing insects. Contact insecticides are only effective when they come in contact with the insect. They are commonly used as liquids or powders. For convenience they can be divided into traditional or "natural" insecticides, and the more modern synthetic equivalents.

Walker and Evans (1984) observed lime juice and ground chillies being used in The Gambia to control blowfly infestation of sundrying fish. The use of peppers was also reported in India by Pillai (1957) and in Nigeria by Rollings and Hayward (1963). Don-Pedro (1985) established that powdered sun-dried citrus peel could reduce infestation of dried Clarius sp. by D. maculatus. Sand is sometimes used in Malawi to deter blowflies from infesting fresh fish. The application of fish oil to dried fish was evaluated in Kenya (Walker and Wood, 1986b). Amorphous silica-based dusts which are virtually

non-toxic to mammals appear to be ineffective because they absorb oil and water from the fish (Proctor, 1977). In Mali traditional treatments include the use of pepper and the powdered leaves of Bossia senegalensis. It is very likely that these and other related practices occur throughout the world and it is important that as much information as possible is obtained on their usage and efficacy. The present indications are that such methods do provide some degree of protection but this does not appear to have been quantified. However, processors must consider the level of protection to be inadequate because so many of them turn to the use of synthetic insecticides.

The two groups of synthetic compounds which are used with fish and fish products are contact insecticides and fumigants. The former are very widely utilised and they constitute the group of chemicals which are generally referred to as insecticides.

The present use of contact insecticides is a major cause for concern. In some countries there is widespread use to control both blowfly and beetle infestation of many types of fish and fish products. With very few exceptions the processors and traders who apply the insecticides do so without the benefits of any training or guidance. Not surprisingly their choice of insecticide is most often governed by cost rather than by technical suitability. The result is indiscriminate and dangerous usage on a large scale. A recent review of the available literature (Walker, 1987) showed that thirty different insecticides had been or were still in use to treat fish in countries around the world. These included the organochlorines DDT and lindane, residues of which can accumulate in the human body, and the acutely toxic phosalone and dichlorvos. When insecticide preparations are contained in proprietary packaging there is little difficulty in identifying the active ingredient. However, Wood (1983) found an unlabelled insecticide powder being retailed in The Gambia for the specific purpose of protecting fish from insect attack. A series of chemical analyses revealed that the contents appeared to vary from time to time at the whim of the packager. There is no doubt that, in reality, unsuitable contact insecticides are used much more widespread than the literature indicates.

It appears that traders and processors use these insecticides when they find themselves with no other practical means of preventing or controlling insect infestation. The purchase of even the cheapest insecticides represents a substantial financial outlay and must be a further indication of the very real problem posed by the insects. It may also be taken to indicate that very often the available traditional or other non-chemical procedures are inadequate, expensive or otherwise unsuited in practice to the needs of the local situation.

There are some insecticides which are eminently suitable for use with food commodities (Halliday, 1986). This position is widely understood and accepted by many food scientists and agriculturalists but fish technologists appear reluctant to adopt the use of insecticides. Presumably this reluctance stems from the fact that few fish technology courses include training about insect infestation and the modern methods of control. However, no matter how widely accepted an insecticide may be in the agro-food industry it has to be acknowledged that there is no such thing as a totally safe insecticide. All insecticides are potentially dangerous to humans if they are misused and accordingly must only be employed when there is no safer alternative. This applies particularly to fish products which may be consumed with very little processing or preparation. The National Research Council (1978) outlined the circumstances under which insecticides should be used on fish.

Whenever insecticides are applied to foodstuffs it is important that the choice is made from the small group of insecticides accepted internationally as suitable for the particular situation. It is essential that users of insecticides have received adequate training, and most importantly it is necessary that the local fishery authority is capable of providing the necessary advice, supervision and regulation. Only within this framework can application be accomplished with safety and efficacy. To make available, or recommend or permit the use of an insecticide without these safeguards would be irresponsible.

The present difficulties and misuse arise from the absence, until recently, of authorative and effective recommendations for the use of contact insecticides on fish. Government departments in several countries have admitted that it is very difficult for them to prohibit the dangerous use of insecticides without being able to offer an equally effective and safe alternative. To do so would be to risk both technical and political credibility. Much of the early development work in the 1960's involved the use of pyrethrins, synergised (enhanced) with piperonyl butoxide, in the temperate climates of Norway and Canada (Somme and Gjessing, 1963, Morris and Andrews, 1968). The outcome of this was the establishment, by the Joint Meeting on Pesticide Residues (JMPR) committee of the FAO/WHO, of maximum residue limits of 3mg/kg of pyrethrins and 20mg/kg of piperonyl butoxide on dried fish (WHO, 1973). Synergised pyrethrins were used for many years on the assumption that they provided safe treatment of fish (McLellan, 1964). However, this assumption was difficult to verify at that time because of the technical limitations associated with the available residue analysis methods. It was only in the late 1970's that reliable and sensitive analytical procedures were finally developed for the accurate determination of insecticide residues in cured fish products. With the aid of these

techniques it was shown in Malawi that control of blowflies could not be achieved without exceeding the limits imposed by the JMPR (Walker and Donegan, 1984). Additionally pyrethrins are frequently difficult to obtain and often very expensive, hence a search was begun to identify a safe and efficacious alternative. The Tropical Development and Research Institute (UK) conducted trials in Indonesia, Kenya, Malawi, The Gambia and the UK to evaluate candidate insecticides. The most suitable compound was shown to be the organo-phosphate pirimiphos-methyl, for which the JMPR established a maximum residue limit on dried fish of 10mg/kg in 1985 (FAO, 1986).

Pirimiphos-methyl is capable of providing safe, effective and economical control of fish beetles and blowflies infesting a range of fish products in several countries. Information on its use is now available from Malawi (Walker and Donegan, 1984 and 1987), The Gambia (Walker and Evans, 1984), Mali (Duguet et al., 1985), Indonesia (Esser et al., 1986), and Kenya (Golob et al., 1987). There can be little doubt that its use will spread. It must be emphasised, however, that any recommendation to use this insecticide on fish, fish packaging materials, on the ground or walls of processing areas, must be an integral part of a program which includes: provision for demonstrations and training for the artisanal community at the processing and treatment sites; a knowledgeable, motivated and well trained extension service, and a regulatory body capable of supervising and monitoring the use of the insecticide. These requirements may appear daunting but the rewards for their establishment include the potential to reduce the present substantial losses and the ability to replace the many dangerous insecticides presently being used with a more effective and much safer alternative. Whereas the application of pirimiphos-methyl can be entrusted to the small-scale fish processors and traders, as has been demonstrated by subsistence farmers in many countries using it to protect stored grain, the same cannot be said of fumigation.

Fumigation

Fumigants are gaseous insecticides which require to be used under gastight conditions. Thus their application is limited to the control of beetles infesting dried fish. In practice this involves either the use of purpose built fumigation chambers or gasproof fumigation sheets. The technology is better suited to large-scale operators because of the toxic nature of the gas, the capital costs of the equipment and the economics of scale which result from treating large quantities. The expertise and equipment are already in use in most countries for the fumigation of grains and pulses.

A literature review of the use of fumigants on fish revealed that many different fumigants have been used in a

variety of countries since the first recorded usage by Kimura and Takakura (1919) in Japan. Methyl bromide was used extensively on dried fish throughout francophone Africa during the 1940's and 1950's. Since then it has been replaced by the more general and widespread use of phosphine. Present general recommendations for the use of these two gases, in the temperature range 20° to 25 C, are 320g of methyl bromide per ton of fish for a duration of two days, and 3 to 4g of phosphine per ton of fish for 3 to 4 days (World Food Program, 1983). There is reason to believe that repeated fumigations with methyl bromide may result in unacceptably high residues of inorganic bromide in the fish. There are no such worries about the repeated use of phosphine which does not react with the commodity.

Fumigation provides a means of disinfesting a consignment of cured fish without any additional repackaging or handling; the fumigant will diffuse through most of the conventional packaging and wrapping materials. It is well suited to a sale or shipment which requires the fish to be free of live insects. This is frequently the case when a phytosanitary certificate is necessary. Fumigation of dried fish with phosphine in Malawi, reported by Meynell (1978), is now a well established pest control procedure in that and other countries. However, it is especially important to combine fumigation with good hygiene and stock management because there is no lasting protection imparted to the fumigated product and the ingress of insects will initiate a further infestation.

There appears to be great potential for the increased use of fumigation, especially with phosphine, particularly in countries with warm climates which export dried fish or fish products. This will only result from definitive trials to establish precise dosages and exposure periods related to specific types of fish and particular insect pests.

CONCLUSION

Insects can cause significant postharvest losses of fish and fish products. In general blowflies cause damage before or during processing and beetles, along with some flies, during storage and marketing. Whether or not some species of blowfly or beetle may be capable of causing more damage than others has not been investigated. Neither is it understood why some types of fish are more susceptible to infestation than others. Data on aspects of infestation of fish are often difficult to locate and are frequently incomplete because the subject bridges the traditional disciplines of fish technology and agricultural entomology.

Better management of sundrying and attention to good hygiene would greatly assist in reducing insect infestation. Limited control can also be achieved in some circumstances by

solar driers, sunning and hot box techniques. There appears to be potential for increasing the use of salt, but it is important that full attention is given to the preferences of the consumer and any additional costs. The possibility that some strains of blowflies may have developed a tolerance to salt has serious implications and warrants a full investigation.

Smoking, particularly the hot almost roasting form found in many countries, is effective in preventing blowfly infestation but appears to offer no protection against beetles. Ionising radiation has an extremely limited potential for the practical situations in which dried fish become infested. However, the use of attractants or pheromones could be worth investigating judging by the success of similar techniques with other insect pests.

Applications of various types of "natural" or traditional insecticides have been recorded but, with few exceptions, they have not been scientifically evaluated. It would be a major contribution to the control of insects infesting fish if a survey of such practices could be conducted so as to permit a meaningful assessment, not only of their efficacy but also, of any health risks which they present to the consumer.

The present indiscriminate use of contact insecticides is a major cause for concern. No doubt there is potential to replace some usage with the alternative methods discussed above but it does appear that insecticides will continue to be used on a large scale because of their efficacy, relative low cost and ease of application. Therefore it is extremely important that processors, traders and purchasers are adequately trained and informed to ensure that the use of insecticides does not become a means of reducing the technical problems of the traders at the expense of the health of the consumers.

The recent development of treatments using pirimiphos-methyl offers a great opportunity for the fishery authorities in many countries to replace the present unsuitable and often dangerous compounds with one that can be used safely, cheaply and effectively. To date the only country to have taken full advantage of this opportunity is Malawi. As happened in that country, its introduction elsewhere must form part of an extensive program comprising demonstrations and training in the correct use of insecticide on foodstuffs, and education on the need for these precautions. It is also essential that in each fishery there are means of supervising and enforcing correct usage. This will often necessitate legislation and access to highly technical analytical facilities. The latter are expensive to install and operate, and they require a high level of operational expertise.

The use of the fumigant phosphine appears to have great potential, although there is a need to confirm the efficacy of the present recommended dosage and exposure time for a range of

dried fish commodities infested by different insects. It would also clarify the position if the present limitations on the repeated use of methyl bromide could be quantified.

RECOMMENDATIONS

1. Comparative studies to be undertaken on the levels of damage caused by different species of blowflies, other flies, and beetles.
2. Training courses appropriate to fishery technology in countries producing cured fish should include tuition on the damage caused by insects and means of achieving control.
3. Every effort should be made to reduce losses caused by insects by improving, where possible, the management of processing techniques and by paying particular attention to hygiene and sanitation.
4. Opportunity should be taken to increase the use of salt as a means of reducing insect infestation.
5. The indications that some blowflies may have become tolerant to salt should be investigated as a matter of urgency.
6. Preliminary investigations should be carried out to determine the feasibility of using attractants and pheromones.
7. An international survey should be conducted to identify the use of traditional or "natural" insecticides presently applied to protect fish. This could be achieved by a literature search and a questionnaire. The most promising practices should then be scientifically evaluated.
8. A major extension campaign, along the lines described above, should be mounted to reduce the indiscriminate use of unsuitable contact insecticides. This will best be achieved by replacing them with pirimiphos-methyl or improved managerial practices.
9. A comprehensive study of the use of phosphine and methyl bromide should be undertaken to enable wider application of fumigation techniques.

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8 BIS

VOLUME AND REDUCTION OF POST HARVEST ARTISANAL LOSSES IN SOME WEST AFRICAN COUNTRIES

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INTRODUCTION

A recent study estimates that the total catch per year from 1980 to 1983 for the sixteen West African countries varies between 0.9 and 1.35 million tons, and the regional catch provides 5.5 - 8.4 kilograms of fish per inhabitant per year for a regional fish consumption evaluated at 14.8 kilograms per year per inhabitant. Half of the fish consumed by these sixteen countries is imported particularly frozen pelagic fish, canned sardines and cured fish (121,000 tons imported in 1983). This failure to satisfy demand for fish by rural and urban West African populations is aggravated by difficulties related to preserving fish and reducing postharvest fishery losses. Data on these losses are seldom known, but a recent study done by TDRI/CEASM/CTA estimates the losses for the artisanal catch of the sixteen West African countries at 157,000 tons.

What can we do to reduce artisanal fishery losses and increase the human consumption of fishery products?

PRESERVATION OF FRESH FISH ON BOARD AND DISTRIBUTION CHAIN

Canoes without icing facilities represent more than 95% of the total number of canoes in most West African countries. Fish is put directly in the canoe hold without any special protection for high tropical temperatures, wind or direct contact with sunshine. This deficiency lowers the price of fish paid to fishermen by tradesmen because the fishermen have to sell quickly.

The quality of fish landed varies, but it is rarely very good and wastage (mainly pelagic species) is considerable during the hot periods of the wet season when traditional processing is limited. The level of losses varies depending on the weather and the fish supply and demand.

Senegalese canoes for demersal fish are used in Senegal, Gambia, Mauritania and Guinea Bissau. The use of ice-boxes in canoes is a technological innovation which has made it possible for fishermen to extend their fishing trips to two or three days, increase their catches by 50%, reduce wastage by 50% and save fuel (about 30% according to some estimations). The price paid by tradesmen depends on the quality of the fish landed. More than 70% of the catch which has been preserved in ice are rated 1 to 3 on the organoleptic scale. However, wastage still exists (20 - 25%) because insulation of ice-boxes is seldom good. The canoe builders, who also build the ice-boxes, are constantly improving the insulation of these ice-boxes but they do not get the perfect insulation. An FAO project started in 1983 to adapt insulated containers to the shape and size of Senegalese canoes and experiments concluded the following:

- fishermen extended trips to six days;
- improvement of ice to fish ratio to 1:2, i.e. a 50% saving on ice as compared to ice consumption with artisanal boxes;
- better quality of fish landed with the following organoleptic ratings: rating 1 (excellent quality), 80-85%; rating 2 (good quality), 7-12%; rating 3, 3% (fish crushed at bottom).

Long life and high value of the fish landed are the other advantages of these improved insulated containers. According to the requirements of the fishermen there is a need to increase productivity in the small-scale fishery and the total value of the fish landed. To improve the quality of the fish landed, there is a need to draw up and implement a policy designed to equip canoes used for demersal and pelagic artisanal fisheries with improved insulated containers.

Marketing of Fresh Fish Onshore

The fish traders have adapted refrigeration technology to local conditions using the materials available:

- ground nutshells arranged in huts for preservation of ice bars;
- woven baskets used for iced fish;
- icing operations conducted at ambient temperatures, often directly on the ground.

Excessive quantities of ice are applied (more than one kilogram of ice for one kilogram of fish on average) and chilling time is very long. This is due to the lack of insulated baskets, the type of transport vehicle used and the lack of knowledge of the basic principles of chilling.

Weighing and washing are seldom done before icing operations. The trucks used for transport are seldom new.

Fish is seldom sold packed in ice as ice is used only for the transportation of fresh fish between the landing places and the markets. Quality of fresh fish sold at markets is seldom good. Recent improvements of the marketing conditions of iced fish areas are as follows:

- chilling in boxes and transport using insulated vehicles with or without thermoking;
- retail selling to relatively well-to-do urban consumers in fish monger shops and supermarkets.

Most of the fresh fish traded in the different countries consists of pelagic species of low market value, the demersal species of average or high market value being marketed for export or for the relatively well-to-do urban consumers in good condition.

DEVELOPMENT OF NON-UTILIZED FISHERY RESOURCES FOR HUMAN FOOD IN THAILAND

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ABSTRACT

A large proportion of Thailand's marine fish catch is made up of trash fish, a wide assortment of cheap and small fish. Traditional food dishes offer a way of finding new uses for products made by processing the abundant supplies of trash fish. Several long-term projects conducted at the Institute of Food Product and Research Development, Kasetsart University have resulted in the production of two new products from the trash fish: roller dried fish and fish protein concentrate type B. Prepared foods have been made from roller dried fish: high-protein fish noodles, two types of ready-to-use curry soup powder, and two types of ready-to-use nam-prik condiment. From conducting panel tests and surveys these appear to be acceptable to consumers and have market potential. The fish noodles were used in a school lunch supplementation program in a nutrition problem area in North Thailand and first results show they were well accepted by the children. Other data is not yet complete as the project is still in progress.

INTRODUCTION

In Thailand fish is a staple food. In the past it was widely distributed and abundant in inland waters and rice fields, and a large part of the population lived on or next to rivers and canals. More than half of the animal protein consumed was derived from fish. However, a high rate of population growth and decreasing natural water resources have caused a decline in the availability and distribution of inland fish resources. Therefore, marine catches are very important, both for consumption and economically through the export of canned products.

Currently the over-fishing of marine resources has resulted in a decline in quantity and rising fish prices. Recent

catches have also yielded increasing quantities of small demersal and pelagic fish, which are classified as trash fish and are used for the fish meal industry. Therefore, every effort should be made to find ways of processing these fish to make them fit for human consumption.

THE STATUS OF FRESH FISH CATCHES

As shown in Table 1, catches of freshwater fish have generally remained fairly constant; 159,000 tons in 1974 and 162,000 tons in 1984. The marine fish catches over the same period increased from 1,352,000 tons to 1,973,000 tons. While the value of freshwater catches doubled the marine catches more than tripled in value from 4,000 million to 14,500 million baht (27 baht = $1US).

Marine products landed have increased from 1.8 million tons in 1979 to slightly less than 2 million tons in 1984. The main increases in landings were shown by Indo-Pacific Mackerel (89,000-129,000 tons) and squid and cuttlefish (80,000-129,000 tons). The most important products in terms of value in 1984 were shrimp (4,000 million baht), squid and cuttlefish (2,300 million baht), trash fish (1,600 million baht) and Indo-Pacific Mackerel (1,300 million baht), respectively but in terms of quantity the most important products were trash fish (760,000

TABLE 1
Annual Catches of Marine and Freshwater Fish
(in thousands of tons and millions of baht)

Year	Freshwater		Marine		Total	
	Qty	Value	Qty	Value	Qty	Value
1974	159	1,890	1,352	4,093	1,511	5,983
1975	161	2,092	1,395	5,102	1,555	7,194
1976	147	2,152	1,552	5,968	1,699	8,121
1977	122	2,038	2,068	8,622	2,190	10,660
1978	141	2,369	1,958	11,458	2,099	13,828
1979	133	2,685	1,813	11,318	1,946	14,004
1980	145	3,560	1,648	10,507	1,793	14,067
1981	165	3,920	1,824	13,213	1,989	17,133
1982	134	4,685	1,987	14,246	2,120	18,931
1983	155	4,002	2,100	15,236	2,255	19,238
1984	162	3,795	1,973	14,541	2,135	18,337

Source: Department of Fisheries

tons), shellfish (154,000 tons), squid and cuttlefish (129,000 tons), Indo-Pacific Mackerel (129,000 tons) and shrimp (117,000 tons), respectively. This shows the high value of shrimp (35,260 baht/ton) and the relatively low value of the trash fish (2,050 baht/ton) which accounted for about 40% of the total catch. The miscellaneous fish category consists of fish such as sardine, lizard fish and threadfin bream, with the quantities in 1983 of 124,901, 9,413 and 16,276 tons and prices of 2.90, 3.70 and 5.80 baht/kg, respectively. Normally, both marine and freshwater fish are consumed fresh, as shown in Table 2. Only marine fish is used for fish meal, with about 39% being used in this way in 1983. Apart from fresh, the rest is used mainly to make dried and salted products.

TRADITIONAL FISH PROCESSING

Drying and Salting

The normal practice for preserving freshwater fish and some small marine fish is sun drying, or salting followed by sun drying. Sun dried fish and shrimp are popular among Thais, as shown in Table 2.

Fermentation

There are many kinds of fermented fish and fishery products. The method of fermentation varies from place to place, depending on local preferences. Nam-plaa (fish sauce)

TABLE 2
Utilization of Marine and Freshwater Fish in 1983

	Marine %	Freshwater %
Fresh consumption	22.96	69.66
Dried and salted	16.53	15.67
Frozen	7.41	--
Steamed and smoked	0.98	3.64
Fermented	-	7.89
Fish meal	38.91	-
Fish sauce	4.39	1.79
Canned	5.54	-
Others	3.28	1.35

is a typical fermented fish product, for which both marine and freshwater fish can be used. Other kinds of fermented products are normally made from freshwater fish which are caught from canals and rice fields in small quantities each day by rural families. Salt fermentation is one way to prolong the shelf life of the fish so that it can be kept for consumption throughout the year. Recently fish ponds have been promoted by the Ministry of Agriculture and Cooperatives, so fermented fish, such as plaa-raa can be produced as a home industry. The products are kept in an earthen jar which is the most suitable cheap container. Small-sized marine fish seem to have good potential for the production of plaa-raa.

Shrimp paste is another fermented product widely consumed by the Thai people, although the amount consumed each meal is very small because of its salty taste.

Smoke Drying

This method is used just to dry certain kinds of fish e.g. cobia (kingfish), or marine catfish, rather than to get a flavor from the smoke. The fish are cleaned and gutted then placed on a bamboo rack which is placed over a fire in an earth-mud stove. The fuel used is normally wood or wood charcoal covered with sawdust; the product is brown and dry. This method is used locally in villages near the docks by fishermen or middlemen. The dried product is transported and sold throughout the country.

FISH PRODUCT DEVELOPMENT

Background

As previously mentioned, trash fish includes many kinds of small-sized fish. If these fish are handled properly instead of being used to produce fish meal they can be converted into fish products for human consumption. At present the sorting costs for separating the good quality fish from the trash is high because of poor handling methods. The Institute of Food Research and Product Development (IFRPD) with the support of FAO undertook research to produce roller dried fish (RDF) and fish protein concentrate type B (FPC) by using trash fish and some small-sized fish. In the beginning the processing technology was studied and the new products were incorporated into traditional Thai dishes. Also, acceptability tests were conducted among housewives in the rural and urban areas. The production of ready-to-use mixed fish products and fish protein-enriched noodles was also studied using RDF as a raw material.

There are two types of ready-to-use products in the form of a soup mix in which traditional dried fish pieces or cooked and

powdered fish are replaced by RDF. Recipes were pretested and selected for acceptability. The two types chosen were kaeng-som, a type of sour curry soup, and nam-yaa, a sauce poured over certain noodle dishes. There is also a ready-to-eat mixed product, a fish relish called nam-prik. All the recipes were developed for Thai tastes. There are various Thai dishes which use nam-prik, most are side dishes in which vegetables are dipped to reduce the hot taste. They are consumed almost every day especially in the rural areas.

Fish noodles have also been developed for the school lunch program. These noodles have minced fish or RDF incorporated into the wheat dough to increase their nutritive value.

Production of Roller Dried Fish

Trash fish, threadfin bream (Nemipterus Spp.), sardine (Sardinella Spp.) and lizard fish (Synodontidae fam.) were used to produce RDF. Although trash fish is very cheap, 2 baht/kg, it is time consuming and costly to sort out the good quality fish, and it is very hard to control the quality of the finished products because each lot of trash fish varies in quantity and species of fish. So other species of fish were selected because they don't need to be sorted, but the cost per kilogram is higher. The first stage in the process is the production of minced fish.

The minced fish was produced at the Fishery Technological Development Division (FTDD), Department of Fisheries. The fresh fish were washed, de-headed and gutted then fed into a BIBUN SDX 13 meat separator through 3 mm holes. The minced fish was strained through a sieve to remove remnants of bones and skin, then frozen before transfer to IFRPD for the production of roller dried fish.

The minced fish was thawed overnight at room temperature and fed into a steam roller-drier. A sample was also taken for microbiological analysis. It was found that minced fish made from lean fish with fat content less than one percent could be fed straight into the drier. Tapioca flour was required as a processing aid mixed with thawed minced fish at a 2.5% level to prevent excess fat from affecting the dried finished product. The most suitable temperature for mixing was 10-12°C. The moisture content of the minced fish should be less than 80% before feeding by hand or feeding-pump onto the drier. A single-roller drier was used with a speed of 4 rev/min and temperature 140-155°C for 8-15 seconds, depending on the fat content of the minced fish. For sardine and threadfin bream the optimal temperature was 140-155°C, lizard fish 145-150°C and trash fish 150-155°C.

Production of Fish Protein Concentrate Type B

The initial stage was carried out by FTDD using whole threadfin bream. The fish was steamed and dried in a hot air oven for 14-16 hours at 50-60°C and then ground and packed in plastic bags. The product was delivered to IFRPD where it was subsequently ground and sieved through a 40 mesh sieve and dried in a hot air oven at 100°C for 50-60 minutes.

Results

The yield of minced fish from trash fish was about 27-28% while the yields from sardine, threadfin bream and lizard fish were about 50, 60 and 61%, respectively. From Table 3 it can be seen that the moisture content ranges from 78% to 84% and the protein content from 13.6% to 18.7%. Tables 4 and 5 show that the product is dry and flaky (4-6.6% mc.) and has a high protein content (74.5-82%) and a low fat content (5.2-8.6%). FPC has a lower protein content and a higher fat content than RDF.

The total viable count and coliform count from sardines were considerably lower than that from threadfin bream. No pathogenic bacteria of Escherichia coli, Salmonella spp. or Staphylococcus spp. were found in the minced fish. Total viable count of RDF (240) is markedly lower than that of FPC (70,000,000). Such a high load of microorganism in FPC could come from fish skin or from personnel and/or utensils, or from post-processing contamination. In any case, these amounts are reduced by cooking because RDF and FPC are used as raw materials in preparing food dishes.

TABLE 3
Proximate Analysis of Minced Fish

Composition	Trash Fish	Threadfin* Bream	Sardine*	Lizard Fish
Moisture %	83.68	79.71	78.28	79.30
Protein %	13.62	16.66	18.66	17.51
Fat %	1.02	1.99	1.69	1.04
Ash %	0.73	1.17	1.25	1.10
Crude Fibre %	ND	0.47	0.33	trace

*Source: Bulan Phithakpol, 1984

TABLE 4
Physical Properties of RDF

RDF	Color	Appearance
Trash fish	Beige	Flaky
Threadfin Bream	Dark white	Flaky and fluffy
Sardine	Light grayish brown	Flaky and fluffy
Lizard Fish	Beige	Flaky with some powder

TABLE 5
Proximate Analysis of RDF and FPC

Composition	RDF				FPC*
	Trash Fish	Threadfin* Bream	Sardine*	Lizard Fish	
Moisture %	4.87	6.59	5.55	4.08	2.32
Protein %	81.99	74.51	75.20	81.99	64.15
Fat %	8.58	7.41	5.26	5.15	11.15
Ash %	4.07	5.15	5.19	4.97	22.27
Crude fibre %	0.49	0.10	0.12	0.38	2.06

*Source: Bulan Phithakpol 1984

The pilot plant production costs of RDF based on 5 baht/kg for fresh fish and producing 310 kg RDF/day were US$ 3.75/kg after packing (Bulan Phithakpol, 1984). The laboratory scale production costs for FPC using trash fish at 2.55 baht/kg were US$ 1.25/kg before packing (Bulan Phithakpol et al., 1982).

In testing the marketability of the products, both retail and wholesale markets were studied in three provinces, Khon Kaen and Nakhon Ratchasima in the northeast, and Songkhla in the south, where more fish is available because it is a fishing port. The average sales of the products per outlet and the sales volume of each type of product (RDF from sardine, threadfin bream, FPC, ready-to-use fish mix) were higher in Nakhon Ratchasima than in Songkhla, but lower than in Khon Kaen. This is probably due to the strategy used for marketing. Demonstrations of the products were performed throughout the market testing in Khon Kaen, whereas no

demonstration or any type of promotion was employed for marketing in Nahon Ratchasima. The low sales in Songkhla could have been due to different food habits; people usually consume whole fish rather than powdered fish since fresh fish is abundant.

Curry Soup Mix (Kaeng)

Four traditional curry soup recipes, which normally contain cooked and pounded dried fish were used in a pretest with RDF replacing the dried fish. From the pretest two recipes were chosen, kaeng-som (vegetable curry soup) and nam-yaa (fish sauce topping for rice noodles).

Fresh ingredients (various kinds of spice) were crushed and ground, RDF was added and the resulting mixture dried in a hot air oven. The dried mix was packed in polypropylene plastic bags for future use. The kaeng-som soup mix is added to boiling water and small pieces of vegetables are added. The soup is then boiled for a few minutes before being served with rice. Nam-yaa is prepared in the same manner but no vegetables are added. It is poured over rice noodles and accompanied by vegetables as a side dish. These products should have good potential because they are convenient and save cooking time. Besides, they are hygienic and cheaper than using fresh fish. The project is still in progress and final results have not been reported yet.

Nam-prik

Ready-mixed nam-prik (as a powder and a paste) and ready-to-eat nam-prik (as a paste) were developed from traditional recipes by replacing fresh fish with RDF. The ready-mixed nam-prik needs a little preparation before eating, such as adding hot water and fresh lime juice to adjust the taste. The ready-to-eat nam-prik needs no further preparation; it can be eaten directly as a side dish with rice and accompanied by vegetables. These products are expected to have no problem with the acceptability test, except that in the pretest, people preferred the nam-prik with water added to have the pasty texture of the normal nam-prik rather than the powdery texture of the processed product. The method of preparing the normal nam-prik varies from dish to dish and from town to town, depending on local preferences. The main ingredients are pounded fish, dried chili and salt or fish sauce. For the processed product six recipes were developed from traditional dishes, but only two were selected for the acceptability test with 82 home economics students. The data from this has not yet been analyzed but the products appear to have good potential for the home factories producing these kinds of nam-prik. The only problems are the factory owners,

who are afraid of using RDF instead of pounded fish because they have to keep up their brand image.

Fish Noodles

The production in the pilot plant is a semi-continuous process. The equipment can be separated into two parts, a mixer, and three pairs of rollers in series. The gap between the rollers is fixed for the first two pairs and adjustable for the third pair. The third pair can also be equipped with a cutter to cut the sheet of dough into strands.

Minced fish, salt, sodium carbonate and phosphate are mixed well with a little water before slowly adding wheat flour to make a dough. When RDF is used, water is needed to dissolve the ingredients before adding to the wheat dough. The dough is kneaded well and passed through the rollers to make a thin sheet before threading. The stringlike noodles are bundled, steamed for 5 minutes then oven dried at 60°C for 7-8 hours.

An acceptability test was conducted in the laboratory with a panel of 18 students majoring in home economics. The students were requested to evaluate the color, flavor, odor and texture, on the hedonic scale of 1-9, of plain boiled noodles and noodles with vegetables and sauce.

Results

The proximate analysis of the noodles is shown in Table 6 together with the texture of the cooked noodles measured by an Instron 1140 Texturometer with a Kramer shear cell. The cost of production at IFRPD is US$ 1.3/kg.

TABLE 6
Proximate Analysis and Texture of Fish Noodles

Fish Noodles Sample	Moisture %	Protein %	Fat %	Ash %	Fibre %	Texture Kgf
Control (Wheat noodles)	7.58	13.92	1.06	4.06	0.21	18.20
25% minced fish	9.40	17.99	1.20	4.74	0.16	13.30
30% minced fish	8.47	19.83	1.33	4.84	0.22	12.73
35% minced fish	8.82	21.00	1.54	4.67	0.41	9.63
5% RDF	8.81	17.36	1.69	4.24	0.16	15.20
7.5% RDF	7.74	19.64	1.81	4.43	0.20	13.67
10% RDF	7.86	23.11	2.35	4.59	0.21	11.73

In the comparison of noodles made from RDF, minced fish and 100% wheat (used as a control for the fish noodles), the wheat noodles were the most acceptable followed by noodles with 25% and 30% fish content. Noodles with 35% fish content was scored as "not satisfactory". For RDF noodles, the order of acceptability was control, 5% and 7.5%. In a total comparison, the order of acceptability was control, 5% RDF, 7.5% RDF, 25% minced fish, 30% minced fish. The students objected to the fish flavor of the samples, especially those made from minced fish. This should not limit the noodles' possibilities, however, for the main purpose was to increase the protein content of noodles for use as a food supplement in the school lunch program and, in this respect, the noodles are a success. Low-cost fish can be processed to make nutritionally valuable food to help solve the problem of malnutrition in Thailand and also has potential for further product development.

School Lunch Supplemental Food Program

Two criteria were used in site and sample selection: a poverty area, as indicated by NESDB and an area with nutrition problems. Mae Hong Son province, located in the far north adjacent to Burma, was chosen as the site. The provincial municipality is a small town surrounded by high mountains and the houses in each village are scattered over the hillsides. Communication is mostly by walking. Usually the village school is the place used for meeting to hear any news from the city. The school principal is the only government official in the village, apart from the village headman who is elected by the villagers. This means that the principal has to do many things in the village even though they are not officially part of his duties. Six primary schools were selected for the supplementation program. The age of the pupils ranged from 6-16 and the number of pupils per school ranged from 18-54, with a total of 204 pupils. The proportion of children with nutritional problems, measured by weight, height, age, sex (method adopted from Gomez) ranged from 23.4-46%. Two terms of the school year were chosen for testing the noodles.

Dried fish noodles with 30% fish content were sent by vehicle to the selected schools each month by IFRPD. The noodles were packed in plastic bags and corrugated cardboard boxes for transportation to the District Primary Education Office. From there they were collected by the school principals and taken on local buses to the schools or to neighboring villages and carried to the school by horse. Iodized salt was also supplied because the children suffered from iodine deficiency. Vegetables were either grown at the school or collected nearby, e.g. bamboo shoots. Vegetable oil or lard was easily obtained in the villages and soy sauce was recommended for cooking instead of fish sauce.

Most schools arranged lunch preparation by grouping the pupils and assigning one group to be responsible for the cooking each day. The supplementary fish noodles were selected mostly on Mondays, Wednesdays and Fridays. Sometimes the pupils could choose for themselves the recipes they would use. They could fry them with vegetables, make a souplike noodle dish or boil them and top with a sauce. The results have not yet been compiled for this program, but from personal observations, pupils liked the fish noodle dishes very much. The average amount consumed was one and a half bundles per pupil per meal. The weight and height measurements of the children to find the effects on their nutrition have not yet been analyzed.

CONCLUSION

In Thailand large amounts of trash fish, sardine, threadfin bream and lizard fish are available at low cost throughout the year. Transformation into dried fish products and ready-mixed curry soup powder is the best way of fully utilizing the available raw material, land and human resources.

Four types of dried fish products, RDF made from trash fish, sardine and threadfin bream, and fish protein concentrate type B were produced and tested for their acceptability and marketability. All products were well accepted in wholesale and retail markets. However, RDF was the most preferred. All products were nutritious and possessed no pathogenic microorganisms or toxicological effects. The average protein, fat and moisture content of RDF were 77, 7.1 and 5.7%, respectively. It was well accepted and fit into the food habits of large segments of consumers, particularly where similar products such as dried or fermented fish were appreciated and formed part of the usual diet of the consumers. It was used to replace fresh fish in preparing many traditional Thai dishes, eaten as such, mixed with rice or used as an ingredient in other fish products. Two recipes for ready-mixed curry soup powder and two other ready-to-eat products were tested for acceptability amongst home economics students, but the results have not yet been analyzed. If the test gives satisfactory results, RDF will have good potential and will be convenient and save time for the housewife in food preparation. Nam-prik producers will be able to prepare their products more conveniently because of ease of handling raw materials.

Pilot plant production of RDF is economically feasible. The production cost is estimated to be US$ 3.27/kg. It is suggested that a pilot plant for production of RDF be established, preferably in a town near the sea where all infrastructures are available. Further product and packaging development is recommended to increase the appeal of the

product and extend marketability in a geographical sense. These would be possible if funding and assistance from national and international agencies were available.

Fish noodles (dry) are a new product which is suitable for school lunch supplementation. The protein content is much higher than normal wheat noodles and they are expected to have a longer shelf life than the locally made noodles. They are also convenient, saving cooking time, and provide nutritious food to the pupils. It is possible to produce the dried fish noodles at a central kitchen or a home factory and transport them to schools.

Finally, these projects show that trash fish can be processed to produce human food. Roller dried fish or fish protein concentrate type B can replace fresh or dried fish in commercially produced foods or be sold for use in cooking at home, thus increasing the market and the value of the trash fish.

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ACCEPTANCE OF NEW PRODUCTS IN LESS DEVELOPED COUNTRIES

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ABSTRACT

This paper expresses the need for consumer education to aid in the acceptance of new products in less developed countries (LDCs). Guidelines are presented to introduce new fish species and fish products on the marketplace. Two cases, the introduction of shark meat products in Trinidad and Tobago and the introduction of Tilapia in Jamaica, are presented to demonstrate the need for a strong marketing component in the utilization of fishery resources for human consumption.

INTRODUCTION

Any marketing strategy aimed at the acceptance of new fish products or new fish species has to take into account the following factors:

1. What the market wants today and in the future. This means conducting research to find out the requirements of the consumer as well as those of vendors, processors, etc.

2. Choosing target markets. Target markets must be chosen based on the findings of the marketing research with technical possibilities and price taken into account.

3. Meeting the needs of target markets. Decisions are to be made on topics such as what species are preferred, should fish be marketed fresh or processed, what packaging and way of transport should be used.

4. Educating the consumer. No one will buy a product they don't have any background information on. How to approach the consumer? How, when and where do you give information?

Strategies which succeed in one country will not necessarily succeed in other countries. Every introduction has to be customized. The key to successful marketing lies in understanding the demands and needs of the consumer. If a product satisfies the desires of consumers they will buy it and be willing to pay a fair price.

My activities in the Caribbean focussed on the consumer. When you have an educated and motivated consumer, a product readily available at the right price will find a ready market. Educating consumers can be done by organizing seminars, demonstrations, radio and TV programs, lectures, cooking competitions and other means. To demonstrate the importance of consumer education in increasing consumption of seafood, I would like to present two case studies. This first is from the twin islands, Trinidad and Tobago, where I had an active part in the operations. The second case is the successful introduction of Tilapia in Jamaica.

Trinidad

Trinidad is situated on the continental shelf of northeastern South America, eight miles out from the northwest coast of Venezuela. Preferred species for consumption are Kingfish (Scomberocomorus cavalla), Spanish mackerel or Carite (Scomberocomorus brasiliensis), snappers (Lutjanus sp.) Cavalli (Cranx sp.), jacks (Decapterus), dolphin fish (Corypheana hipperus) and shrimps. This preference has contributed to high prices for these species and comparatively low prices for others.

The consumption of fish and fish products is roughly 12 kilograms per person annually. Half of the fish consumed is caught locally and the rest is imported. In monetary terms this means an annual food import bill of TT$ 30 million.

In a joint effort between UNDP/FAO and the government of Trinidad and Tobago, the project, "The Development of the Artisanal Shark Fishery" started in 1982 in Tobago. In 1984 the project was extended and carried out in Trinidad. The project team included a master fisherman, a marine biologist, a marine engineer and a processing expert. At a later stage a consumer education expert joined the team.

Fishermen were trained in shark catching and handling techniques. The increased supply of shark meat was marketed as fresh and processed products. The main product was salted sun dried shark as a substitute for the widely imported salted dried hake or pollock. Other products developed under this project were hot smoked shark fillets and a smoked salmon analogue.

The major emphasis of the processing part of the project was aimed at producing salted dried shark. This product was made of fillets of de-headed, gutted and skinned shark. The

fillets were cut with a 3 cm overall thickness. After cutting, the fillets were washed in sea water to remove the remaining blood in the tissue. The fillets were salted in a ratio of one part fish to one part salt and remained in the brine for one week in a cool and well ventilated place. After one week, the brine was drained off and the excess salt was removed. The fillets were then dried in the sun for three to four days. The moisture content after drying was approximately 10%. When sun drying was not possible, smokers for the drying process were used. The salted, dried shark fillets were then wrapped with cellophane on styrofoam trays. The shelf life of this product is at least three months.

Hot Smoked Shark Fillets of "Sea Ham"

This product was mainly made from the belly flaps of sharks. Good results were obtained with hammerhead sharks. The fillets were cut at an average thickness of 3 cm and then washed and lightly salted for flavoring and hot smoked for two to three hours. This product does not contain any additives. When stored for several days it should be refrigerated, for longer storage it should be frozen.

Smoked Salmon Analogue

This product was made from salted shark fillets. After seven days in brine the fillets were washed to remove excess salt, cut with an automatic slicer into 10 cm long and 2 mm thick slices and placed on trays to be dyed for 15 minutes ("Sealachs" dye). The slices were dried in open air for 30 minutes and then cold smoked for another 30 minutes to obtain a smoky flavor. After smoking, the salmon analogue was lightly brushed with vegetable oil to prevent it from drying out, wrapped in cellophane and stored frozen. It is a high-quality product which can be marketed as a gourmet type food.

Promotional Activities

The new products were quite different in taste and price and were developed for different target markets. The main effort was aimed at the introduction of salted dried shark. Existing recipes that used the imported salt fish were adapted for the salted dried shark. The adapted recipes, supplemented with newly developed recipes, were printed and distributed free of charge during demonstrations to home economics teachers and students and community centers throughout Trinidad.

At the request of the government of Trinidad and Tobago and UNDP, official functions were catered introducing the new products. The support of the authorities is very important to the acceptance of new products. After the initial campaign,

the product was introduced to the public. Demonstrations and tasting sessions were held at ministries, groceries, schools and community clubs. During these sessions surveys were held to evaluate the public taste for the shark product compared with the imported commodity. At World Food Day an exhibition was staged displaying the activities of the project. At the exhibition shark was smoked utilizing an Altona Oven and a drum smoker and samples were offered to the public.

More than 4000 persons have sampled shark products. From the evaluation sheets and observations the salted dried shark was preferred over the imported salt fish. There is a high demand from the consumer for this product as indicated by sales in groceries after the demonstrations.

From the point of view of consumer acceptance, the product was a success. Unfortunately due to the low landing price for shark, there is a definite lack of incentive to the fishermen to catch this fish. This results in an insufficient supply of shark for the large processors to operate on a commercially viable scale. However, courses are being given to transfer the technology of processing the fish to the cottage type of industry. The results, although limited by production resources, are very promising and in due time it is expected that Trinidad will supply the home market with locally caught and processed salted dried fish.

Jamaica

A similar approach was applied to the introduction of Tilapia (Tilapia N.) in Jamaica. The problems in Jamaica are entirely different from those in Trinidad. Jamaica has a rapidly increasing population and most of its agricultural crops are export oriented. Consequently, there is a continually worsening food deficit. Marketing of marine fish takes place on a very small scale, mainly small fishes, and prices for fish are rather high. The population of Jamaica likes to consume fish, however fish is beyond the means of many due to the limitations of budget and poor distribution systems.

In 1979, a pilot program was developed to culture freshwater fish (Tilapia) with financial assistance from U.S. AID. The main goal of the Fish Production Systems Development Project was to increase food production, income and employment to improve nutrition in rural areas and assist Jamaica in reducing its food import bill. Despite the fact that freshwater fish costs less and is easy to culture, there were some significant obstacles to be overcome.

First of all, people in Jamaica were not accustomed to freshwater fish and were reluctant to try it. The first variety of Tilapia introduced had a very dark color and looked unappetizing. During the promotional activities there was an initial dislike due primarily to appearance. Another problem

facing farmers was distribution. Around the farms the fish was readily available but further away distribution was inadequate and inconsistent.

The Home Economics Department was called in to assist in introducing Tilapia to the market. It was decided to introduce the fish as "African Perch". The home economic officers developed recipes for the new species based on traditional cuisine. The prepared fish were tested and introduced in various ways such as catering functions, parties and luncheons. Tasting sessions attended by the Minister of Agriculture and other top level representatives, field staff and farmers were organized at the fish culture station. The introduction to the public took place at the three-day Agricultural Show. This activity was attended by the prime minister, other ministers of government and heads of private organizations. Officials spoke favorably of the freshwater fish thus spreading the word to a wider sector of the public.

In the meantime, silver grey and pinkish varieties have become available and especially the pinkish Tilapia is in high demand by the public. The cultivated fish is cheaper than marine fish species, which encourages consumption. Up to 1984, imports of fish and fish products made up 16.5% of all food imports. Currently, on 1,050 acres Jamaica produces 2.5 million pounds of freshwater fish lowering fish imports by 5.5%. Better distribution of production over the island will further reduce imports while supplying a good and cheap protein source.

CONCLUSION

Both cases show that it is possible to introduce new products even if initially there is resistance from target groups. The most crucial factor in the introduction of new products is the needs of the consumer. Thus, a consumer education program is of great importance. A consumer will not buy a new product which is not familiar to him. That consumer education is important is proven by public interest in such programs, not only in LDCs but also in developed countries. In the United States organizations such as Sea Grant and Mid Atlantic Fisheries Development Foundation are involved in consumer education programs that promote fish consumption and result in increased fish available on the market. In addition, FAO attaches high importance to consumer education. In their global project in several regions of the world they have placed consumer education specialists to assist countries in the promotion of fish consumption.

To conclude my talk, I would like to quote Mr. Kerry R. Muse, executive director of the Mid Atlantic Fisheries

Development Foundation, who emphasizes the importance of consumer education:

> "Study after study of the seafood industry has shown that the key element in increasing consumption of fish and fishery products is not increasing supply, not cutting price, not intensive advertising, not even reducing regulations. The key of increasing fish consumption is educated consumers - people who understand the benefits of eating seafood, know how to purchase a product intelligently and possess the skills and information to prepare it successfully!"

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FISH MINCE: ITS POTENTIAL FOR LESS DEVELOPED COUNTRIES AND OTHERS

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ABSTRACT

Fish mincing systems that separate flesh from bones and skin have been the focus for many by-product or recovery systems throughout the world. Major successful uses in developed countries have emphasized primary products.

Examples are presented in which almost all food preservation methods have been successfully applied to minces. The major problems in application are associated with the identification of product forms that will be acceptable and economical in a given circumstance of resources, population, economy, and technological development.

INTRODUCTION

Fish minces are by-product or recovery operations in the minds of most people. The usual French translation of a description of the operation of a meat bone separator "recuperation" reflects this attitude. Similarly within the context of this workshop, one could readily follow this limiting line of thought. However, we would like to pursue a more inclusive approach that would include minces as potential primary products to be made from a variety of species in a number of countries. We would also like to emphasize that the applications of minced fish in the less developed countries is really not different from those in the more developed countries.

Extensive work on the recovery of flesh found on the frames or filleting residues from cod and other gadoid species has been done in many places. Probably the most thoroughly documented research has been that carried out by Baker, Regenstein and associates at Cornell University. (Baker, Regenstein and Darfler 1976; Baker and Darfler 1979, 1980, Baker 1980). Their continuing work has explored a number of

product forms from a variety of species. The by-product or by-catch approach for minced fish was probably the basis for most of the work in this area. Work in many countries has focused on the use of by catch species from shrimp trawling operations. The Consultation on By-Catch Utilization in Georgetown, Guyana in 1981 reported on work in a number of countries and included that done by a number of participants in this workshop (FAO-CIDRC 1981). The recent report in Infofish on the results of trials in Bangladesh are encouraging in that the concepts we have been advocating can be successfully applied for making use of minced flesh from shrimp by-catch (Etoh 1986).

Mince as a primary product approach is well recognized in the surimi/kamaboko industry of Japan which is now being extended worldwide (Suzuki 1981; Rhodes, 1986; Keay, 1986; Choi, 1986). The Russian approach to the utilization of Antarctic krill was also one in which the primary product of the fishery was a mince product (Martin 1979). Japanese investigators have also done extensive work with krill as a potential seafood protein source (Okada 1980; Suzuki, et al., 1982).

APPROACHES FOR UTILIZATION OF MINCE

Although the availability of a resource is the reason most often given for interest in the utilization of mince, its characterization or definition in any case is not obvious or simple. The questions of species and species mix, sizes, seasonality, year class fluctuations, physiological condition, resource management controls and method of capture must be defined and answered in the early stages of a development program.

The next logical question is one that has been considered earlier in this workshop. That is, will the product be oriented for domestic markets (food) or for foreign markets (financial return from international trade)? The development of a fish mince based product may be found to be economically unsound on either or both markets. This aspect will be considered later.

PRESERVATION METHODS AND PRODUCT FOCUS

All the methods that have been used for the preservation of high protein foods have been tried and/or should be considered for use with minced fish.

Drying: The product of a high grade sanitary fishmeal process called Joyfish, was made in Norway for markets in Africa. Resources were available and the process, equipment, and conditions were well known from the many years of fishmeal making experience.

Bello and Piggot carried out extensive studies on a number of species in the preparation of dried patties which were intended to be kept without refrigeration (Bello and Piggot, 1978, 1979, 1980). A variety of combinations of Alaska pollock mince and krill paste were formulated into products which were dried on a fluidized bed by Byt'eva and associates (Byt'eva, et al., 1977). A dried product (Yu-sone) designed to meet traditional oriental markets was developed from croaker mince (Gates and Wu, 1978).

Freeze dried mince products from cod and Alaska pollock have been prepared but both species exhibited significant loss of protein rehydration ability (Jensen, 1979; Matsuda, 1979; Noguchi, 1980).

The extensive studies on preparation of fish protein concentrate (FPC) in many countries must certainly be considered as part of the utilization of fish minces in dried form. The technological feasibility of producing FPC by a variety of processes, ranging from laboratory to full demonstration plant scale, has been reported and well documented (Tannenbaum, et al., 1974; Noguchi, 1980). Most of the FPC processes utilized dehydration with a solvent system followed by a solvent removal step.

Salting: The pioneering work of Del Valle in Mexico opened the efforts on the salting of minces (Del Valle 1973, 1973a, 1976). This salt/fish cake approach was extended by others (Poulter and Disney, 1977; Young, 1981). A slightly different tack in salting mince was taken by Anderson and Mendelsohn (Anderson and Mendelsohn 1971; Mendelsohn, 1974, 1974a). Studies on salt fish in Halifax, Canada, built on this work and included the production of six tons of dried salted mince that were used in worldwide acceptance trials (Bligh and Declos, 1981; Regier, et al., 1978; Varga, et al., 1979; Wojtowicz, et al., 1977).

Chilling: The intimate mixing and creation of a large surface area in the mince assures that the available bacteria will have a near optimum supply of nutrients and clearly limits the potentials for simple chilled mince products (Nickelson, et al., 1980). Also naturally present proteolytic enzymes are active under the conditions that typically exist in chilled mince products (Howgate, 1976; Hanierg, et al., 1980; Sun Pan, et al., 1980).

Frozen: Freezing has been the preservation method of choice for some significant commercial successes and failures. The current minced fish sticks on the US markets seem to be qualified successes. The minced Alaska pollock frozen blocks of the early 70's, severely crippled the fish stick industry because they were very rubbery, tough and watery by the time cooked products were made from them. Extensive research at a number of laboratories have verified that gadoid species are particularly susceptible to this type of frozen storage

deterioration. (Atkinson and Evans, 1980; Atkinson, et al., 1980; Bremner, et al., 1978; Dingle, et al., 1976; Whittle, et al., 1980).

In spite of these problems, successful minced fish products in the U.S. include fish sticks made from gadoid species. In addition, recently reported work on the non-gadoid species of the shrimp by-catch in Bangladesh indicates frozen fish fingers are quite acceptable in that country and have potential local marketability (Etoh 1986).

Fermented products: Fermented products based upon minced fish have been used in the countries of Southeast Asia as flavoring materials or sauces for many years. In most of these added salt and/or acid produced by the fermentation stabilize the product. A cheese type product was also made from minced fish in Denmark, (Johansen and Herborg 1976; Herborg and Johansen, 1977).

Canning: As a method for preservation, heat sterilization in a hermetically sealed container is probably the most attractive for an investigator when considering the development of a product based on minced fish. The micro-organisms and enzymes usually present in the product are inactivated and most of the chemical and physical changes have already taken place during processing. Products such as fish balls and cakes, sausages, soups, chowders, chunks, pastes, pates, and simple minces have been prepared in canned form (Alexander, 1980; Atkinson, 1980; Baker, Darfler and Mulnix 1981; Baker, Regenstein and Darfler 1976; Kai, et al., 1978; Mendelsohn 1977; Miller, 1987, Saralaya, et al., 1980; Valyavskaya, 1979).

Sausages: This type of product/process, which represents a semipreservation of minced fish, must be combined with another preservation method such as refrigeration or canning to prevent eventual spoilage. It does, however, provide a very logical pathway for use of minced fish. The very successful Japanese fish sausage market attests to this (Ueno, 1968). Both freshwater and marine species have been shown to be useful in the preparation of sausages made from minces in many countries (Angel and Weinberg, 1979; Budina and Rekhina, 1977; Daley, Deng and Cornell, 1978; Herborg 1977; Ivanova, 1980; Saralaya and Bhandary, 1978).

ECONOMICS AND MARKETING

To create a market for any fisheries product, including minced fish products, there must exist (1) a sustainable supply of fish in a volume that will allow the producers to effectively minimize their cost of production on a continuing basis, and (2) a sustainable demand for the product by an identifiable group of consumers that will allow sale price per unit of production to remain above average cost. These

economic considerations will be discussed as they relate to minced fish products.

There are four potential fish supply sources for minced products; fish may be captured from wild stocks and minced directly, the carcasses from fillet operations may be further processed to obtain mince, the incidental catch from a fishery may be utilized, and fish may be obtained from a culture fishery.

To utilize the entire harvest from a directed capture or culture fishery, well-established markets for the minced product must exist. A good example of this type of fishery is the Japanese Alaska pollock fishery where the majority of the pollock is utilized to make kamaboko. While kamaboko has only recently been exported to western markets as shellfish analogue, the products have been popular in Japan for centuries (Raizin and Regier, 1987). The stabilization of the proteins in frozen form resulting in surimi intermediate has only been practiced since the 60's.

Japan has recently imported croaker surimi, most notably from Thailand, for use in their domestic market (Choi, 1986). To effect this type of trade, the exporting country must have a comparative advantage in the production of croaker surimi relative to croaker surimi produced in Japan. Comparative advantage is usually gained by either greater resource availability or relatively cheaper labor and capital costs, or both. Less developed countries (LDCs), especially in Asia, may look to take advantage of the growing surimi/kamaboko markets in that region. Alternatively, some portion of the catch of a directed fishery may be utilized as a mince product. This depends on the relative input and output prices of the various production methods by which the fish are processed. A mathematical approach such as linear programming can be used to determine the appropriate product mix that will optimize profit.

Mince from the by-products of a fillet process has been utilized by the cod block industry of Canada for some years now. The product is made into frozen minced blocks or added as a filler for frozen fillet blocks. Since the recovery rate of mince from the frame is high, it appears that this process may be economically viable even for small-scale producers.

The underutilization of by-catch from shrimp fisheries represents a substantial postharvest loss for many LDCs. Some may argue that discarding the by-catch species does not represent a loss to the producer since he is not directing his effort towards these species, but in an economic sense, he may be foregoing profits from not utilizing these species and may incur lost opportunity costs. Alternatively, if there are no profitable methods of utilizing these species and opportunity costs are zero, he will be better off by discarding the by-catch. The trawling efficiency devices (TED), which eject

large objects from the shrimp trawls, may well be the basis for more selective gear to decrease the unprofitable by-catch in those situations in LDCs where the decision is made to leave most of the by-catch in the water. Again, as in a directed fishery, a linear programming approach similar to the one used by Brown and Waters (1981), is probably the best method to determine the appropriate process and marketing of the by-catch. From the viewpoint of the producer, the by-catch utilization is contingent upon profitability, however, this question of individual company profits does not address public policy issues. In a welfare context, the firms may be better off by not utilizing by-catch, but the LDC as a whole may be worse off, especially if the general population is protein-deficient. In this light, the discarding of by-catch may be seen as a substantial social cost. Therefore, a substantial emphasis should be placed on new product forms, including mince products, and new markets for underutilized species.

It is quite obvious that sustainable market demand must be coincidental with a sustainable supply of raw material to allow the development of an industry based upon minced fish. While the basic economic feasibility of the project under evaluation should be the controlling factor, the direction of the development must be set within the political context. The government as the assumed owner of the marine resource may want to consider the relative value of production for domestic consumption as compared to making products for export. Simply stated, the governmental decision may be between dollars in the bank and food in the bellies of its citizens.

Market demand is shaped by consumer's tastes and preferences for a given product (Goodrich and Whitaker, 1977, 1978, 1979; Morehead, 1974). In the more developed countries consumer tastes and preferences may be altered by advertising and promotion and their populations are oriented to try new foods. In LDCs large capital outlays to promote new products are limited by financial realities. To develop market demand for minced products in the LDCs the products must be able to satisfy preconceived tastes and preferences. In other words, traditional markets must be foci for parallel markets in minced products. An example of this occurred a number of years ago in work on the development of salt minced fish in Canada. Six tons of product were distributed to ten locations across the globe for trials through the World Food Program. Of the eight locations that provided evaluation returns, those that traditionally used salt fish (six) said the product was quite acceptable, while those that did not have salt fish in their diets (two) thought the product was unacceptable (Regier, et al., 1978).

A further example of this type of product is boneless minced milkfish (Bangus rellano), a Philippine product, that is

made by deboning and mincing milkfish and mixing it with vegetables and seasonings. Milkfish has been cultured for decades in the Philippines and is traditionally prepared by broiling (inihaw) or boiling in a soup (sinigang). It has a distinct flavor and is preferred to the many species of fish found in that country. The one drawback in eating milkfish is its many small bones. To process this product, the bones are removed by tweezers or forceps making the process labor-intensive. With labor being an abundant resource relative to capital, the process is cost effective for Philippine producers. However, if production reaches a large enough scale, the investment in capital equipment such as meat-bone separators may be economical. This may especially be relevant to projects that are geared towards export products.

RECOMMENDATIONS AND CONCLUSIONS

The factors that need to be in place for a successful minced fish development include: reliable and defined resource, effective harvesting system, acceptable product, suitable process, distribution system, and an established market. To do an effective job of evaluating the feasibility of a proposed development, all these factors should be considered. In terms of a time schedule, it appears that the first efforts should be placed on the two ends of the commercial chain: resource definition and characterization of the potential markets. In many of the earlier studies, the market research has been minimal or has been done on an intuitive basis.

Once the raw material and consumer desires are known, the appropriate product forms that might fit the situation can be selected from the technological bag of tricks that have been described by investigators throughout the world. Unless the government of an LDC has made an unshakeable decision between protein for people and export for profits, the development project based on minced fish should be evaluated for economical feasibility periodically. While the first approximation may be to make a product for domestic consumption, the results of market research may suggest making a product for export and using the money to import familiar products for the domestic market.

Whatever approach is taken, there are many product forms for which minced fish can be used in both developing and developed countries. Further, the convenience of not having to deal with bones in a food product is a positive factor in any culture and the availability of more raw material through the basic separation of mincing process increases the attractiveness of minced fish. The challenge then becomes the selection and application of the appropriate technology.

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THE ROLE OF THE INTER-AMERICAN DEVELOPMENT BANK IN FISHERIES DEVELOPMENT IN LATIN AMERICA

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ABSTRACT

The Inter-American Development Bank (IDB) has contributed to the development of fisheries in 22 countries of Latin America and the Caribbean through loans and grants for investment projects and technical cooperation. Projects with components that help reduce post harvest losses are identified. The IDB's experience in the sector is discussed.

MEMBERSHIP AND RESOURCE MOBILIZATION

The IDB is an international financial institution established in 1959 to accelerate economic and social development in Latin America. It was founded by the United States and 19 Latin American republics, and was the first regional development bank of its kind. Since its origin, membership has expanded to 44 countries, of which 25 are borrowing member countries of Latin America and the Caribbean; the other members are the United States, Canada, 15 industrial countries in Western Europe, Japan and Israel.

One of the IDB's major roles has been to serve as a catalyst in the mobilization of domestic and external capital for Latin America's development. Since 1961, it has mobilized approximately 110 billion dollars for investment in the region, including 35 billion of its own resources. Current lending is in the order of 3 billion dollars a year.

FISHERIES DEVELOPMENT PROJECTS

IDB financing covers a wide spectrum of sectors, which includes fisheries. Lending to this sector is small compared to other sectors and accounts for about 1% of accumulated financing with resources of the IDB.

Since 1970, when IDB started promoting artisanal and industrial fisheries development, a total of 32 investment

projects and 48 technical cooperation projects in 22 member countries have received financing. The table that follows shows a breakdown, in chronological order, of IDB lending for fisheries investment projects.

In recent years there has been a growing trend in the IDB towards multisectoral credit loans in which fisheries is included together with other sectors. No effort is made to establish lending targets by sector, instead, it is left up to the borrowers to utilize the financial resources on a first-come first-served basis. Each loan request is carefully evaluated based on its financial, technical, economic and legal merits by the intermediary lending institution in the member country, and by the IDB when the amount exceeds the limits established in the respective loan regulations.

In the fisheries sector the largest credit demand has been for vessels, followed by processing plants. Credit for shrimp farming ponds and hatcheries for post larvae production have also shown a good demand in some countries. On the other hand, there has been very little demand for investments in fish distribution and marketing. This is unfortunate because it is the area which requires most improvement in Latin America.

The technical cooperation programs related to fisheries development financed by the IDB are not detailed in this paper, however, they fall into the following categories: (i) project preparation and evaluation studies; (ii) institutional strengthening of project executing agencies; (iii) extension and transfer of technology to project beneficiaries; (iv) fellowships and training of public sector personnel in member countries; and (v) resource assessment studies.

POSTHARVEST FISHERIES LOSSES

Postharvest fisheries losses have been a concern to the IDB since it started promoting fisheries development. In every project where the IDB has had a hand in designing the main project components and their specifications, every effort has been made to preserve fish quality and to maximize fish utilization. Examples of this are the shrimp trawlers financed for Guyana and for Nicaragua, where separate refrigerated holds were specified for both shrimp and for by-catch.

Another example is a project in Peru in which one component is justified primarily on the basis of reductions in postharvest losses. Basic infrastructure is being built at 23 landing sights along the Peruvian coast for artisanal fishing communities who have been operating off beaches in very primitive conditions. At each of the selected locations, project personnel worked closely with local leaders to identify their problems and agree on recommended actions. Those recommendations are then used by the technical staff of the Ministry of Fisheries to design and prepare the specifications

of the infrastructure needed by the fishermen. In each case an agreement is signed by the fishermen's organization before construction starts, whereby they approve the final designs and agree to administer and maintain the installation when they become operational. They also agree to charge fees for services to cover operating and maintenance costs.

The project is only partially finished but the results are promising and fishermen's response has been good. Quality of fish is also improving as a result of better working conditions and training. Before the project is completed, small walk-in chillers will be installed as well as ice machines at some of the bigger sights.

CONCLUSION

The aggregate goal of all past and ongoing projects financed by IDB in the region is to increase fisheries production by 1.5 million tons and to create 39,000 new jobs. Although it is difficult to measure precisely how well those goals are being achieved, IDB's contribution to fisheries development in Latin America has been substantial. This contribution also extends to other positive factors such as institutional strengthening of regulatory, research and credit institutions dealing with fisheries. Transfer of technology and training of beneficiaries in many skills has also been achieved by consultants and local technicians working in these projects or in separate technical cooperation programs.

Not all projects have been successful, but important lessons were learned from past experience. Many of the problems encountered in the incipient years of IDB involvement in fisheries projects were more effectively addressed in the design of second generation projects.

The IDB is currently committed to continue to play a leading role in formulating an overall strategy for fisheries development in Latin America and the Caribbean, in consultation and collaboration with its borrowing member countries and other international organizations. This strategy is oriented towards developing maximum employment opportunities and increased utilization of fish and fish products while also developing adequate safeguards against destructive or counterproductive exploitation of fish resources.

IDB Lending for Fisheries Investment Projects

Country (Loan No)	Total Cost	IDB Financing	Date Complete	Project Description (Components)
Dominican Republic (358/SF-DR)	5.5	1.6	1979	Integrated Artisanal Cooperative Project (fleet, landings, chilled storage)
Mexico (265/OC-ME)	99.0	43.0	1980	Credit (shrimp trawlers, processing machinery)
Panama (396/SF-PN)	6.9	3.5	1981	Integrated Artisanal Cooperative Project (fleet, landings, chilled storage)
Costa Rica (429/SF-CR)	11.6	8.5	1983	Integrated Artisanal Cooperative Project (fleet, landings, chilled storage, marketing)
(1/VF-CR)	5.9	3.6		
Colombia (475/SF-CO)	1.5	0.8	1983	Aquaculture component of rural development project
El Salvador (502/SF-ES)	9.9	5.3	1983	Integrated Artisanal Cooperative Project (landings, credit, aquaculture)
Colombia (520/SF-CO)	1.2	0.8	1983	Port Feasibility Study
Honduras (534/SF-HO)	3.4	2.9	1983	Integrated Artisanal Cooperative Project (fleet, landings, chilled storage, marketing)
Peru (567/SF-PE)	14.0	8.2	1984	Fishery component of multi-sectoral credit loan
Bahamas (25/VF-BH)	4.2	3.3	1983	Credit (fleet, processing, storage, marketing)
(50/IC-BH)	3.4	2.1		Fish terminal
Brasil (362/OC-BR)	102.0	52.0	1987	Credit (fleet, industry, aquaculture), Cooperatives, Fish Terminals, Research, Extension
(602/SF-BR)	29.2	14.4		
Dominican Republic (585/SF-DR)	0.9	0.6	1986	Aquaculture component (hatchery), rural development project
Ecuador (SP/SF-79-15)	0.7	0.5	1985	Artisanal Fishery Small Project

Country (Loan No)	Total Cost	IDB Financing	Date Complete	Project Description (Components)
Peru (377/OC-PE)	24.5	14.5	1985	Fisheries component multi-sectoral credit (industrial fleet and plants)
Guyana (390/OC-GY)	14.4	12.7	1985	Renovation shrimp fleet and processing facilities
Guyana (SP/SD/80-05)	0.7	0.5	1985	Artisanal Fishery Small Project
Mexico (72/IC-ME)	200.0	80.0	1986	Credit (industrial fleet and plants) port infrastructure
Bahamas (SP/81/13-BH)	0.7	0.5	1985	Artisanal Fishery Small Project
Panama (98/IC-PN)	22.2	12.0	Ongoing	Credit (shrimp farming), Research Hatcheries, Extension
Peru (99/IC-PE)	30.0	13.5	1987	Fisheries component of multi-sectoral credit (industrial fleet, plants)
Chile (100/IC-CH) (101/IC-CH)	43.0	19.7	1986	Fisheries component of multi-sectoral credit (industrial and artisanal fleets, plants, marketing)
Peru (423/OC-PE)	28.0	14.5	Ongoing	Artisanal fishermen's infrastructure (landings, chilled storage, marketing)
Uruguay (424/OC-UR)	13.0	10.0	Ongoing	Research vessel
Nicaragua (SP/CE/82-09-NI)	0.7	0.5	Ongoing	Artisanal Fishery Small Project
Nicaragua (444/OC-NI)	40.9	30.7	Ongoing	Renovation, shrimp and lobster fleets and plants
Venezuela (458/OC-VE)	2.4	1.2	Ongoing	Research
Paraguay (SP/SF-83-20-PR)	0.7	0.5	Ongoing	Artisanal Fishery Small Project

Country (Loan No)	Total Cost	IDB Financing	Date Complete	Project Description (Components)
Barbados (484/OC-BA) (/56/SF-BA)	12.3	8.0	Ongoing	Fishing Terminal and Harbor
Mexico (369/OC-ME)	10.0	4.5	Ongoing	Aquaculture Credit Component of Agricultural Credit Program
Chile (183/IC-CH)	40.0	18.0	Ongoing	Fishery credit component of multisectoral credit program (fleet, plants, marketing, aquaculture)
Barbados (178/IC-BA)	3.0	1.3	Ongoing	Fishery component of multi-sectoral credit program (fleet, plants, marketing)
Ecuador (225/IC-EC)	10.0	7.0	Ongoing	Aquaculture component (shrimp hatcheries) of multisectoral credit progam
TOTAL	795.8	400.7		

Amounts represent commitments in millions of US dollars at current prices. Actual disbursements may vary from project to project.

RESEARCH AND THE REDUCTION OF POSTHARVEST FISHERY LOSSES

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My work at the National Fisheries Institute and its role in advising the private sector has allowed me to observe various aspects of postharvest fishery losses over the years. This paper reviews some of the reasons why I believe these losses occur and speculates where future research areas are that will reduce these losses.

Why do we lose seafood and what are the principle causes for these losses? I have outlined below nine reasons for postharvest fishery losses:

1. Seafood is hard to catch. To a certain degree, the word "harvest" is a bit of a misnomer, as it gives the impression of obtaining ones produce from the same location and under similar conditions year in and year out. We are still basically hunters in the fishing industry, and that means that fishermen often have to spend long periods of time away from home facilities, and proper care of the catch is often difficult.

2. Seafood is hard to handle. Unloading a ton or more of fish on a deck in rough seas does not lend itself to careful handling of the catch. Working conditions and facilities have an important impact on how a catch is treated. In general, attitudes toward fish handling are poor, not only in developing countries, but in many segments of the US fishing industry as well. There is a great need for training programs and increased education in most levels of the seafood industry.

3. Seafood is a very perishable product Physiologically and biochemically, fish is a food commodity that will spoil readily under poor storage conditions. For example, the pH of fish muscle does not fall as low as it does in butchered farm animals, thus inhibition of bacterial growth is not great. The factors of time and temperature weigh more

heavily on postharvest fishery losses than on any other food item.

4. The environment often works against maintaining quality. More than half of the fish are caught in tropical waters where both water and air temperatures are conducive to spoilage. Storms, wind, and rain all play an important role in not only when we catch fish but how the fish is handled.

5. Firancial resources are limited. It is a high risk business and few banks are willing to be partners in fishing and seafood operations.

6. Time/temperature controls throughout the distribution chain are often inadequate in order to assure the consumer of a high quality product.

7. We often see a total disregard for pest control which, as we have seen during this conference, is a direct cause of postharvest fishery loss.

8. There are still, in many regions of the world, sociocultural factors that limit the utilization of fish for human food and causes its redirection into production for fertilizers or fish meal.

9. In-shore pollution, which limits not only what we can take from the sea but also plays a role in the quality of the catch that is brought back to the shore to be pre-processed, such as washed and gutted, or fully processed such as canned, minced or cured.

Considering these factors that contribute to postharvest fishery losses, we need to ask ourselves what technologies are available to us to reduce these losses? Some of the following technologies may not at this time apply to LDCs, but they may in the future.

a) The use of good quality salt for drying or curing operations
b) Wind-powered cooling
c) Plastic replacement for wood and cooling
d) Conversion of non-utilized species of fish into mince and then into an engineered family of foods - such as surimi
e) Depuration to utilize shellfish from marginally polluted areas
f) Closed aquaculture systems
g) Irradiation
h) More training in postharvest handling for the fisherman

i) Controlled and modified atmosphere packaging techniques
j) Antioxidant release via packaging material
k) Use of chlorine compounds or new preservative ingredients
l) Plastic cans in place of metal cans
m) Use of microwaves
n) Use of a selected species for a source of fish oils - especially the omega-3 fish oils
o) Upgrading the processing of fish meal to a grade for human consumption
p) Changing some of the present nomenclature to more marketable names
q) Chemical and enzymatic modification of fish proteins.
r) Use of biological pest attractants
s) Application of biotechnology in both the seafood industry and aquaculture

I maintain that the key is education and training through some form of extension service. Research alone is not enough. You also need a delivery service, someone that can bring the information or the technology to the fisherman on the beach where it is needed the most. Long term extension agents who know these areas well and have been working in the regional fisheries need to understand the situation and should also be used to advise on the technological approaches most feasible to solve postharvest fishery losses for the area.

A strong interaction with the seafood industry is also essential. If you cannot reach your industry and their support is not there, someone else will be competing with you for the money that is available. There are other groups in government, at the bank, in other industries that will be going after the same pile of money that you would like to have. You are in competition, but the way to beat that competition is to be sure that you are working with your industry component and that they back what you plan to do. If they do not see any future in your applied research program, as well intended as some of these projects may be, you may have to re-evaluate some of your thinking.

There is a great deal of general, technical and scientific information about various aspects of fish loss in industrialized countries, and this information should and can be put to use in LDCs. There is a need for adaptive research to ensure that this information is technically sound and for socioeconomic research to ensure that the products of the research are socially acceptable and economically justifiable before it can be incorporated within the established postharvest system of the country.

The private sector in developing countries is potentially very important because its informational system and most importantly its experience in the handling of the resource should be taken into account. Further applied research is

needed to improve processing equipment so that it will work efficiently under LDC conditions. This applies particularly to equipment which is often old, inexpertly operated, and probably designed for other purposes. This can be considered a loss in the processing sector and this type of loss can be avoided. There is, in my opinion, a particular need for low cost simple cooling equipment which could dramatically increase the storage and marketing life of perishables.

Realistically, there is no known, simple and inexpensive technology that can, by itself, make a profound impact on postharvest losses. On the contrary, reduction of postharvest fishery losses can be achieved only through a combination of location-specific organization, problem identification, government and industry monetary support, training, information transfer and adaptive technology. Good preservation practices must be applied on a sustained basis, with continual refinement in response to new information. Significant worldwide reductions in food losses will only result as the aggregate of all these efforts. We also need to remember that research has its political consequences and impediments can develop unless the realities of the problem are clearly defined.

SOCIOCULTURAL ASPECTS OF POSTHARVEST FISHERY LOSS PROJECTS

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ABSTRACT

The paper examines the relationship between specific attributes of postharvest fishery loss projects, sociocultural aspects of intended beneficiaries, and project success. Examples of postharvest handling of fish from various parts of the world, as well as effects of selected projects aimed at improving techniques, will be used to illustrate the importance of sociocultural variables in PHFL projects.

INTRODUCTION

A great deal of research has demonstrated the importance of social and cultural factors in the transfer of technology and information (e.g., Cernea 1985, Heller 1985, Samli 1985, Glaser, et al., 1983, Cochrane 1979, OECD 1978, Foster 1973, Rogers and Shoemaker 1971). The success of technologically adequate postharvest fishery loss (PHFL) projects depends on the effective transfer of technology and information, its implementation, and sustained use by the intended beneficiaries; hence, social and cultural factors must be accounted for in the design and implementation of this type of project. Although the foregoing may be self evident to some, the examples described later will indicate that these lessons are far from being learned.

Many applied social scientists agree that effective programs of technology and information transfer consist of several interrelated steps: 1) development of a technology compatible with target environment and economy; 2) communication of idea of the new technology to intended beneficiaries; and 3) recognition by the intended beneficiaries that the new technology will fulfill a need and be compatible with existing beliefs, attitudes, and status and role relationships. These initial stages can be followed either by a trial or outright rejection. After a trial the proposed

changes can be rejected, revised, or adopted. Even after adoption, the changes may be rejected as incompatibilities become more salient. If not rejected, the changes eventually become part of the sociocultural system, and the transfer can be considered complete (cf Pollnac 1981, 1978).

A number of factors can influence the success of PHFL projects as they pass through the stages identified above. First, specific components of the PHFL project (e.g., changes in handling techniques, introduction of new equipment, etc.) manifest attributes which affect the project's success or failure. These attributes are discussed below in conjunction with an examination of several case studies. Second, the changes introduced by a PHFL project do not stand on their own. They are usually dependent on supplies of raw materials and consumer acceptance of changes in products (if any), which are also impacted by sociocultural factors. Finally, even where a PHFL project is compatible with the sociocultural and physical environment, there will be individual differences in adoption related to variables such as education, social status, change agent contact, levels of aspiration, etc. Rogers and Shoemaker (1971) have identified some thirty of these variables from published studies. These variables are related to characteristics of the fishing communities such as the social stratification system, educational opportunity structure, degree of market versus subsistence orientation, extent of communication and transportation networks, and degree of sociocultural stability all of which can also have an impact on the success of PHFL projects (Pollnac, 1976).

This paper focuses on the relationship between specific attributes of PHFL projects, sociocultural aspects of intended beneficiaries, and project success. Examples of postharvest handling of fish from various parts of the world, as well as effects of selected projects aimed at improving techniques described, will be used to illustrate the importance of sociocultural variables in PHFL projects. We begin by looking at several case studies.

SOCIOCULTURAL IMPACTS ON PHFL PROJECTS

The first example is drawn from a Middle Eastern fishery development effort. The project involved design and construction of fish marketing locations for small scale fishermen as a means of improving product quality and reducing potential for postharvest losses. The small-scale fishermen traditionally landed their catches and either sold the fish directly to consumers from a mat rolled out on the beach or auctioned their entire catch to middlemen. The middlemen either trucked the fish to another location or sold it to consumers from a small, open shed on the beach. During the morning hours the selling point on the beach was crowded with a

mass of fishermen, middlemen, and consumers. Conditions were less than sanitary - the author has observed fishermen rinsing their catch in a seawater filled depression on the beach adjacent to a spot where men were observed defecating. Further, mid-day temperatures well in excess of 38 degrees centigrade result in the traditional market closing prior to noon. Fishery development specialists decided that a new market should be built to deal with some of the limitations of the traditional system.

The new market was constructed about two kilometers up the beach from the old. It is a beautiful structure laid out on a semicircular plan with individual selling areas and compartments for the sellers. Provisions are made for fresh water and sanitary areas for cleaning the fish. Those selling fish would be spread out linearly along the semicircle of compartments. Overall, the new market appears to have overcome the problems of sanitation, storage, and the crowding associated with the traditional marketing system. Nevertheless, the expensive new structure is not used.

What went wrong? First it is important to note that the traditional fish market is located midway along the beachline of the town at what is both a center of population density and commercial activity. Fishermen are able to make purchases for home in local shops after selling their catch and prior to sailing home. They can also purchase gasoline for their outboards at a gas station adjacent to the selling point. Additionally, a high premium is placed on very fresh fish, and since the traditional landing place is at the center of population density, a maximum number of consumers have easy access to the market and are able to carry their fish home in a minimal amount of time, reducing the chance of spoilage in the very high temperatures characteristic of the area.

The traditional marketplace is also a scene of intense social interaction. Fishermen, fish sellers, consumers, and onlookers are clustered into what appears to be an unorganized crowd, but observation reveals patterns of interaction. Fishermen sit next to friends to sell their fish, and they talk while awaiting customers. All participants are close enough to one another to keep track of prices offered and paid. Fishermen hold some fish back in their boats, giving the appearance of a short supply, and when they hear that good prices are offered they bring them to the beach. Hence, sellers and buyers can observe most of what is going in and out of the market as well as discuss current events, the fishery, problems, family, etc. The traditional marketplace is thus an arena of intense social and economic interaction.

In contrast, the new, unused market is about two kilometers along the beach from the old. It is isolated from the other marketing activities and away from the center of population density. Hence, fishermen would be unable to make purchases of

gasoline and other goods for the home as easily, and buyers would have to travel farther for purchasing fish and returning home, thus decreasing the freshness of the fish when it finally reaches the home. In a climate where temperatures reach 49 degrees centigrade or more in the hottest times of the year, two extra kilometers of travel cannot be considered trivial. Further, fishermen, fish sellers, and consumers seem to enjoy the social interaction that characterizes activities at the market. The new market isolates them into linearly distributed stalls--an effort must be made to communicate in contrast to the swarm of social and economic interaction at the traditional market. These are all factors that contributed to the failure of the beautiful, but unacceptable, new market.

A second example comes from a Latin American fishery. Here the problem concerns inputs to a postharvest processing project involving an under utilized species. In this case an international development agency implemented a project designed to convert shark into an acceptable product. With respect to shark, errors in postharvest handling frequently result in an unappetizing product, and in some areas there are cultural values against eating shark (cf. Adams 1986). The project was quite well designed, involving development of a product demonstrably acceptable to the local population, packaging to enhance its acceptability, and televised programs concerning its preparation since it was a dried product and unfamiliar to the local population.

At the beginning of the televised educational program, there were some minor errors made. The cooking demonstrations were done on electric ranges, and most of the rural population cooked with wood or charcoal; hence, cooking techniques and times involved were inappropriate. The project was flexible, however, and this problem was noted and corrected. The product gained acceptability, and people in the fishing community learned to operate the drying and packaging equipment.

The project seemed to be viable when the development team left the area. The problem that developed, however, involved inputs to the postharvest processing and distribution scheme. During the project, a project supplied expert fishermen harvested the shark for processing. The local fishermen did not target shark. After the project team departed, the local fishermen still did not bring in shark due to various factors including a lack of knowledge concerning shark fishing and a fear of the animal.

Hence, a potentially useful project died because of a lack of attention to sociocultural factors influencing inputs. Shark was traditionally unacceptable as food; hence, the fishermen had no reason to develop a shark fishing method. In addition, shark were perceived as dangerous, reinforcing the lack of desire to harvest the species. Because shark were sometimes captured as by-catch when targeting other species,

and because shark are fished in some other Latin American countries, project personnel assumed there would be an adequate supply of shark for the processing technology. These assumptions were faulty, as could have been determined through adequate sociocultural research among the fishing population.

The foregoing examples illustrate several of the attributes of a PHFL project which may affect its acceptability among the intended beneficiaries. The first is the compatibility of project components with the traditional situation. For example, the location of the new market described above is not compatible with the local temperatures and the cultural preference for very fresh fish. The televised program concerning the preparation of dried shark in the second example was not compatible with the local cooking procedures, and finally, the required input of shark was incompatible with most fishermen's abilities and willingness to capture the species.

The attribute of compatibility also applies to food preferences. Cultural variation in food preferences is widely discussed in the literature, and PHFL projects frequently result in altered products which may or may not be acceptable. A few brief examples will suffice. A new type of oven was introduced for fish smoking in Biriwa, coastal Ghana. It required putting rods through the fish's eyes. Eyeless fish were unacceptable in the local market, and the new technology was rejected (Morss, et al., 1976). Perhaps less obvious is the fact that a change in fuel for a postharvest processing technique may result in an unacceptable product. In some areas of the world (e.g., West Africa) deforestation resulting from use of wood as a source of energy for cooking and other purposes has become a topic of concern. Much of the postharvest processing of fish in West Africa involves drying and smoking with the use of wood as the energy source. Due to deforestation, wood cutters have to operate farther and farther from the fishing communities as wood becomes more scarce, increasing transportation costs and the cost of fuel to the fish processors. Hence, it seems that a project aimed at replacing wood as an energy source may be desirable. Prior to such a project, however, it is essential to determine if the product produced by this alternative energy source will be acceptable to the consumers. Noronha and Spears (1985) provide several examples suggesting that the increase in the availability of a substitute fuel will not automatically decrease use of the other due to cultural preferences associated with the process or the product.

New PHFL techniques also must be compatible with traditional motor skills and availability of capital. For almost a quarter of a century fish technologists have been trying to improve the fish smoking techniques used in West Africa (cf. Collart 1986). One of the improved smokers introduced in the 1960s is the "Altona smoker" which manifests

excellent technical performance but was not accepted in the fishing communities. Collart (1986) attributes its lack of success to the fact that it is too expensive to construct; hence, incompatible with availability of capital among the fish processors. He also argues that its metal construction was too sophisticated and not compatible with traditional skills. Some 20 years later the "Altona smoker" was introduced in a more massive, sheet metal form with racks so heavy that manipulation was beyond the motor skills of the women processors. Collart (1986) reports that these new smokers have had no impact in the fishing communities and contrasts them with the socially and economically more appropriate "Chorkor" and "Ivory Coast Type" smokers which were successfully introduced into West Africa.

Another attribute illustrated in the above examples is the relative advantage of a project component. What does the project participant get out of the new PHFL methods above and beyond what he got out of the traditional method? In the case of the new market, the facility was more substantial, fresh water was provided, and sellers had secure stalls; nevertheless, its poor location with respect to other markets and the spatial distribution of sellers which inhibited the intense social and economic interaction which characterized the old market resulted in its failure. The advantages of the new were not enough to overcome the loss of these other features. Hence before developing new PHFL technologies, it is essential to understand all the functions of the old, social and cultural as well as technical, if we want to design an acceptable, appropriate technology.

Although not illustrated in the above examples, advantage can be a relative attribute. What is an advantage for one group of participants may be to the disadvantage of others. For example, in many LDCs fish commands a lower price as its quality begins to deteriorate. Although from our viewpoint low quality fish is to be avoided, it does provide food for people unable to pay the price for higher quality fish. A PHFL technology which reduces the availability of this "spoiled" fish may result in a lower level of nutrition for the impoverished group who depend on the lower prices associated with a low quality product.

Another example of relative advantage concerns employment. In many small-scale fisheries there are a relatively large number of "positions" or "jobs" between the fishing vessel and the consumer. In some fisheries there are specialists who earn part or all of their living by unloading the vessel. Others wash and/or eviscerate the fish. There are those who specialize in counting or weighing the fish, and some who carry the fish to waiting trucks or to the market. Others specialize in processing (smoking, drying, etc.), and some supply specialized products to the processors (e.g., salt, wood, etc.). In some fisheries all of these specialized positions

can be found. In others, just a few of them; nevertheless, changes in postharvest handling introduced by a PHFL project can affect the livelihood of some or all of these postharvest fishery workers, and the project could be to their disadvantage.

In some cases the various postharvest handling and processing activities are performed by different social groups within the society. In West Africa women traditionally process and market the fish in most countries, and in Tombo, Sierra Leone a distinct ethnic group supplies the wood used in smoking. Projects could thus differentially impact these distinct groups. For example, in Liberia Lebanese merchants gained control of the fish cold storage depots as the industrialized fishery began to supply more frozen fish (Akerele 1979). In many other countries the frozen fish stores are also run by men. We do not know how many women lost employment because of this change, but we do know that some rapidly adapted to the change. In many West African countries (e.g., Ghana, Sierra Leone, Togo, Nigeria, Liberia, and Ivory Coast) frozen fish from the industrial fleet are bought and smoked by the traditional women processors suggesting that the traditional processing industry can readily adapt to the new technology while at the same time provide a product that is apparently preferred by the consumer (Pollnac 1985). In Nigeria it is reported that up to one third of frozen imports are either sun dried, smoked, or deep fried somewhere in the distribution chain (Moen 1983).

This reprocessing of frozen fish into other products (e.g. smoked, sun dried, etc.) may reflect an incompatibility other than taste preference. Alsopp (1982) notes that while frozen products are accessible to relatively high-income urban dwellers in the tropics, poorer and rural people need products that remain stable at ambient temperatures (e.g., the traditional smoked, dried, or fermented products). Hence, frozen products provide refrigerator owning urban dwellers with an advantage of obtaining relatively cheap, high quality fish. In contrast, the poor and/or rural consumer will bear the burden of paying for the additional processing implied by the thawing and reprocessing of fish even in cases where there are rural cold stores if they want a product that they do not have to prepare immediately. In rural areas distances from cold stores are so great for some consumers that the reprocessing is a necessity to allow for traveling time; therefore, what is an advantage to some fish consumers may not be an advantage to others.

Hence, PHFL projects should be aware of the groups of individuals who will be negatively impacted by introduced changes. This is not to say that such groups should keep a good project from proceeding, but they should be considered in terms of alternative employment, etc., and the costs of their

potentially disadvantaged position in terms of the benefits of the project to the society as a whole must be weighed. Without this type of consideration, the project could increase differences in wealth and increase social stratification, a potentially negative impact.

The attributes we have discussed thus far are only two of the five that Rogers and Shoemaker (1971) have listed as significant in the diffusion of technology context. In addition to "compatibility" and "advantage," they list "complexity," "trialability," and "observability." It is important to note that this list of the generally important attributes of an innovation in the development context has been substantially supported by further research (cf. Glaser, et al., 1983). These latter three attributes are so self-evident that a brief discussion will suffice.

It is clear that if a PHFL project is to succeed it should not be too complex for the intended beneficiaries. This attribute is related to existing levels of technological development and training in the target group. A good example of the effects of this attribute was noted with respect to the "Altona smoker" noted above. Collart (1986) noted that the metal construction of the fish smoker was technologically too sophisticated for the intended fishing communities; hence, it was not successful. We must therefore determine if the proposed PHFL process is too complex for the target group; e.g., what levels of skills are necessary to carry out the construction, operation, and maintenance associated with the process, and is there a sufficient number of qualified individuals to perform these operations.

The trialability of a proposed PHFL technology can also influence its success. If it costs too much to implement, either it will not be adopted or only the relatively wealthy will be able to take advantage, possibly increasing levels of social stratification and associated social problems. Once again, the "Altona smoker" as described by Collart (1986) provides a good example. He suggests that although this smoker is technologically excellent, the costs associated with its construction made it too expensive for the fish processors, resulting in its failure to be adopted in the fishing communities. In cases such as these, where it is known that proposed PHFL technologies are too costly for individuals in the target group, plans can be made to introduce the changes through organizations such as cooperatives. This would, at least, insure that the intended beneficiaries have a greater chance of obtaining the benefits of the PHFL project.

Finally, with respect to observability of the effects of project components, many observers have pointed out that projects most likely to succeed are those for which a quantitative appraisal of advantages are possible with unsophisticated, casual observation. This is not always

possible, but the more clearly advantageous a PHFL project is to the intended beneficiaries, for example as demonstrated by a pilot project, the more likely they will take a chance on participation. We have to remember that the time and money invested by members of a small-scale fishing community can make a difference between their eating or not eating; hence, they are quite careful concerning their investments.

WHAT CAN WE DO?

The above has pointed out several potential sociocultural impediments to the transfer of PHFL technology in fishing communities. What can we do about it? How can we reduce the potential for making these errors and increase the chances for project success? Berg (1975) writes that "solutions which appear theoretically sound from a distant lab often turn out to be infeasible in the context of the highly personal, highly traditional, and socially motivated eating habits of developing societies..." This suggests that research concerned with developing appropriate PHFL technologies must be conducted, at least in part, among the intended beneficiaries and involve a careful assessment of the sociocultural factors associated with postharvest fish handling, processing, marketing, preparation, and consumption.

Attempts to make projects fit the people are best carried out by involving the intended beneficiaries in project formulation and implementation (cf. Uphoff 1985). In support of this call for "people's participation," Morss, et al., (1976), in a cross-national comparison of 36 rural development projects, find that 49 percent of the variance in project success rankings could be attributed to local action taken by the small-scale producers. Among the components of local action which contributed most to success was the small-scale producer's involvement in decision making in the implementation phase of the projects. This role in decision making helps make the project fit the local sociocultural context. The feedback provided by "people's participation" during the development and communication of a new PHFL technology can result in project reformulation and ultimate success without intermediate rejection which could hurt future credibility.

CONCLUSION

We have examined several examples of the interrelationship between sociocultural factors and the success and failure of PHFL projects. The importance of social and cultural variables is relatively clear with respect to PHFL projects as it is in other aspects of fishery development. As was illustrated in a recent paper on fishery development in the Third World, the technologies being promoted by international development

projects are not value neutral (Bailey et al., 1986); hence, we must be careful that the associated values are compatible with the societies and cultures of intended beneficiaries if we wish to succeed and/or not do irreparable harm in our attempts to provide assistance.

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TRANSFER OF TECHNOLOGY IN FISHERIES: SUCCESS AND FAILURE

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ABSTRACT

A retrospective view of fisheries development shows that the transfer of technology has successfully taken place, albeit against a significant failure rate. However, the major production increases that have resulted have come from the highly mechanized industrial fisheries.

The paper examines technology for small-scale fisheries and compares the traditional model of development with the more socially involved integrated development approach.

In most cases the failure of effective transfer has been due more to a lack of entrepreneurial ability at the receiving end than to shortcomings of the technology.

INTRODUCTION

The successful impact of technology on the fishing industry on a global basis can be inferred from increases in world production - up from 21 million tons in 1950 to 85 million tons in 1985. The expansion of catches was a response to increase in demand and has been brought about principally by two important technological innovations: the introduction of synthetic materials for fishing nets, and the introduction of freezing at sea. With these innovations, strongly backstopped by improved naval architecture, engineering and electronics, the world's fleets were able to diversify to previously inaccessible stocks. The major part of the increase naturally accrued to highly mechanized industrial fleets (FAO 1986), but coastal small-scale fishermen have also benefited.

It is the intention in this paper to concentrate on technology transfers to the small-scale fisheries. In this sector, the benefits are more dispersed and difficult to quantify. Nevertheless, there is sufficient coarse data to point to a significant technological impact. In the first place, what are loosely termed small-scale fisheries continue

to supply more than a third of fish landings for direct human consumption. Additionally, about a third of fish landed enters international trade and developing countries are now responsible for 45 percent of these exports, principally from the small-scale sector. The bulk of the shrimp supply and an important share of that of tuna and cephalopods originates in developing countries. These dramatic increases of exports, which now contribute US$ 5 billion in net earnings to developing countries, are the result of technology transfer. Starting with the shrimp fishery, and now extending to tuna and cephalopods, the technology transfer has been successful because the entrepreneurial initiative and skill was available. Experience has shown that the most important single factor which conditions the success of technology transfer to developing countries is entrepreneurial talent. More attention is given to this point below.

It has become fashionable recently to question or criticize the benefits that technology has brought to fisheries. Any development worker can tell horror stories of filleting plants built in the middle of deserts, of boats that do not float, equipment unused for want of power or rats nesting in cold-store insulation. Such litanies of complaint, when more closely investigated, are usually found to result from inadequate planning and implementation of projects rather than the choice of inherently unsuitable technology. Certainly, a retrospective view throws up spectacular and costly failures, but often a technology that has failed in one location is a great success somewhere else. Appropriateness of the technology to the conditions where it is to be implanted became the watchcry of the late 1970s, and has done much to reduce the number of mistakes.

When evaluating the success or failure of technology transfer, it is also necessary to try to separate the technology itself from projects in which it was applied. For example, there is no doubt that the outboard motor has revolutionized African fisheries, which implies that the technology was a success. Therefore, a project that has resulted in unpaid loans, no spare parts and a pile of rusty engines cannot be blamed on the technology. On the other hand, the outboard has been criticized as inappropriate on the grounds that it is expensive to operate and, being designed for recreational use, lacks the robustness required for fishing. Recent FAO work in Africa has shown that in many traditional craft outboards can be replaced with small diesel engines, reducing fuel costs by two-thirds. However, in the period when the outboard made its impact these units were not available. With some justice, one can claim that the outboard was the most appropriate technology at the time. The benefits of continued technological development are seen in the current availability of a more fuel-efficient solution (the higher investment costs

are to a certain extent offset by longer life-time and reduced cost of fuel).

Social and Political Framework

It would be unfair to single out individual projects or countries for criticism or, in a short space, to attempt to discuss the relationship between technological inputs and political change. However, it must be recognized that the social and political framework into which transfers are made to a large extent conditions the possibilities of success. The following examples illustrate the problem. Two very similar fish landing and storage terminals have been installed by development projects in recent years, one in the Caribbean and the other in St. Helena in the South Atlantic. The purpose in the Caribbean was to purchase and store glut catches. However, for social and political, rather than economic, reasons, it was decided to pay relatively high prices to the fishermen. Cash flow and storage problems soon arose, inhibiting the technical operation of the terminal. In St. Helena, on the other hand, the terminal has been planned and operated on strictly economic lines to purchase, store and process fish for local sales and export. After a running-in period, the operation is approaching profitability. Whether or not the technology transfer succeeded depended on the expectations and re-emphasizes that technology cannot substitute for proper planning.

Another example, this time from Asia, is a recently completed fish auction premises where block ice is available and an ice crusher was included in the plans. The installation has been strongly resisted by the market laborers who are traditionally paid a rate per block of ice they crush by hand, using lumps of wood as hammers. Personal observation indicates that up to 30 percent of the already expensive ice shatters or is lost during crushing and the resulting mixture of large lumps with fine snow is inefficient for chilling. A centralized mechanical ice crusher with insulated trolleys could complete the technological package, which at present works inefficiently. The acceptance of such an introduction would also involve social change to establish an alternative system of payment to the laborers.

Conservative views are also seen as responsible for a halfway approach to technology in the same country where iced fish is carried by truck over long distances. Fish is mixed with ice on uninsulated trucks, in a 1:1 ratio, and covered with a tarpaulin. Despite the obvious benefits in increased payload of pre-chilling and insulation, any change is resisted.

People

One cannot study technology transfer long before realizing the prime importance of people. Authorities from both ends of the industrial spectrum have acknowledged this. E.F. Schumacher, the guru of intermediate technology, said: "Development does not start with goods, it starts with people" (Schumacher 1973). Lee Iacocca of American Motors expanded this: "In the end, all business operations can be reduced to three words: people, product and profits. People come first. Unless you've got a good team, you can't do much with the other two." (Iacocca 1984).

If one narrows consideration to two groups of people involved - those concerned with the transfer of technology and its recipients - some consistent patterns emerge. Transfers are made either through development assistance or as a result of the specific recognition of the technical needs of a fishery by the recipients of assistance. Development assistance usually comes first and causes more concern for its higher failure rates. Using foreign expertise to try and insert sophisticated equipment into situations with marginal economic viability and a weak management structure is a certain recipe for failure. There has been in the past, and probably still is, a tendency for technical assistance donors to try to reproduce their own models in the field, without consideration of the technological needs of the recipients. The present move towards better integration of development, considered in more detail below, is helping to overcome this problem.

When the demand for the technology is based on the needs recognized by people in the fishery, the success rate is much higher. Under these circumstances, the technology is seen to be pulled towards the fishery rather than pushed at it. This requires a new breed of intelligent entrepreneur, who until recently has not been found in the fishing industries of developing countries. In many cases governments have tried to assume this role, through fishery development corporations, cooperatives, etc. All too often, these have failed due to a wide variety of causes, but principally lack of motivation, management ability and a faulty concept of the government's role. Where the conditions have existed for entrepreneurial initiative, the uptake of technology is more certain. A particular example is the shrimp industry in India which has been developed by the private sector, with government support. Today its annual foreign exchange earnings are US $400 million.

The foregoing does not imply a strengthening of the traditional middleman or moneylender but rather the emergence of educated entrepreneurs, who would preferably come from the fishing community. The importance of people is paramount. In so many situations, the fishing communities which are targeted by governments for development are on the outer margins of

society, socially and geographically remote from the mainstream of society. There seems to be an endless spiral of poverty and ignorance, which requires other inputs before technological success can be achieved.

There is a tendency for fish landings in remote places to be purchased by traditional traders who take a high profit, which they tend to remove from the business at the end of the day and not reinvest. Any business of scale finds this situation unprofitable - leaving the community dependent on tradition. Technology, supported by infrastructure (roads, transport, etc.) is irreversible, like a watershed. If it is acceptable to the community it is incorporated and retained, although it may be modified. Ignorance within the community or a failure to articulate the needs of its members are the biggest drawbacks. For example, some rapid studies of nutritional status were carried out in 1985-86 in six villages on the east coast of India (Heel 1986). Under-nutrition and stunting, together with vitamin deficiencies, indicated communities unable to achieve their potential. Before consideration of substantial inputs of unfamiliar technology, this type of community requires assistance to articulate their demands for education and health services, which have so far bypassed them.

The need for an integration of development efforts is general, but is more apparent in the marginal fishing communities. Technology is only one part of the package. In circumstances where it has been seen as providing a quick fix it has failed.

Integrated Fisheries Development

The traditional model of fisheries development as executed by FAO over the last 40 years has responded to the needs of the times by provision of expatriate technical expertise, accompanied by technology. Bilateral assistance and international development bank projects have concentrated more on technology or hardware. The response of the technologist in development has often been to suggest a technical solution without regard to social conditions. Rejection has then been added to the list of failures. Increased emphasis on social and economic studies as the basis for development has done a lot to reduce failures from this source. While a retrospective view could question the effectiveness of the previous approaches, production has nevertheless increased and more importantly there is now a reservoir of trained administrators and technicians available in developing countries as a result of traditional development projects.

With this necessary preliminary effort to create a pool of national talent accomplished, the pattern of development over the last ten years has changed substantially. There has

been a growth in the concept of integrated fisheries development, where technological advances are integrated with the other social aspects of development. In this way it is possible to reach the more intractable or marginal communities. Although the integrated approach attempts to view the community as a whole, it is important to re-emphasize that fishery communities are not stereotyped and pre-packaged social and technical solutions will not fit. In responding both to fishery and non-fishery problems in the community, the integrated approach works through vertical integration of the production chain, from catching to the market, with horizontal integration of community development. Meynell et al. (1987) give seven important features of the integrated approach which are based on the Program of Action adopted by the 1984 FAO World Fisheries Conference (FAO 1984).

1. A coordinated response to the different needs of fishing communities (both fishery related and non-fishery needs);
2. Active (but not forced) community participation in planning, implementation and self-management;
3. Use of local resources, skills and finances to ensure local "ownership" of the development activities, together with mobilization of national and international resources;
4. Long-term technical support and in-service training for sustained development;
5. Particular attention to the roles and needs of women and youth;
6. Community involvement in the management of local fisheries resources;
7. A system for participatory self-monitoring and evaluation in-built into the project.

Integrated fisheries development as a concept is still in the early stages but already encouraging signs are coming from a number of FAO projects. A most important prerequisite is a commitment to long-term involvement in technical, social and economic matters. The FAO/SIDA Project for Development of Small-scale Fisheries in the Bay of Bengal Region for example has been operational for more than ten years. Success has been achieved by integrating technical advances which increase production, such as beach landing craft and improved fishing gear, with social advances, such as credit schemes, particularly for women, and informal education. These are described by Drewes (1986), Natpracha (1986) and Saraswathi and Natpracha (1986).

Another example of successful transfer also comes from South India where, following careful ground work, plywood has been introduced to reduce costs of fishing vessel construction. In documenting this work, Gillet (1985) stresses the need for a long-term approach.

In West Africa, a more closely integrated development concept is being pursued by the FAO/DANIDA Program for Integrated Development of Artisanal Fisheries in Benin. Here the principal of community fishery centers described by Ben Yami and Anderson (1985) is being implemented. The community fishery center is designed to provide all the facilities required for catching, handling and marketing fish, repair and maintenance of boats and gear, but above all to act as a focus for the fishing community. Such centers need to be carefully planned and managed, with the maximum degree of community participation, and should not anticipate interminable donor funding or government support. With these strictures, they provide a convenient channel for the delivery and testing of technology. It is anticipated that a group of centers in a country will receive technical support from a government-run fisheries development unit. This comprises a multi-disciplinary team of specialists, able to extend technical and organizational support, and with the capacity to undertake the training required. As this will be the main channel for foreign technology and the assessment of its applicability, it is essential that the units be well organized and staffed by trained people.

Research and Development

When considering the transfer of technology, the lack of comprehensive research and development capacity in developing countries is often overlooked. This is particularly true in the post-harvest field. Technologies from developed countries inevitably require evaluation and adaptation to local circumstances. It is much better if this is accomplished on the spot so that monitoring and evaluation can be provided. In the past the lack of implementation of research results has been a cause for concern. The fishery development unit can serve as a most useful delivery mechanism to take results from the laboratory into practice. Arrangements to pool research experience among a number of countries in a region have also been successfully introduced by FAO in Asia, Africa and Latin America but increased support is required. Once again the people are important and the first investments should be made in them. Technology transfer only works if there is a receptive intellectual base.

CONCLUSION

There is sufficient evidence to support the view that transfer of technology in fisheries has been successful and in

general beneficial to the small-scale fisherman. The prerequisites for successful transfer are:

- technical and social acceptability of the technology;
- the presence of motivated people with a high level of entrepreneurial ability at the receiving end.

Conversely, apparent failure results if:

- technology is made the scapegoat for faulty concepts or inadequate planning;
- there is an expectation that technology alone will cure social and political ills.

There is cautious optimism that the evaluation and transfer of technology will be made easier in the future by the wider adoption of an integrated approach to small-scale fisheries development.

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ROUNDTABLE DISCUSSION

The following represents an attempt to abstract some of the relevant comments made by the participants during the roundtable discusion that occurred midway through the workshop. The editor assumes full responsibility for any errors or omissions, which are inevitable in an undertaking of this nature.

S. Constantinides: Has the situation changed in the last ten years in relation to postharvest fishery losses?

D. James: The market has certainly changed. The demand for fish has increased substantially over the last several years as a result of population pressures and public awareness of the health benefits of eating fish. You are in a situation where so many people are incorporating fish into their diet that the latest FAO survey shows that the consumer price index has risen substantially higher for fish than for any other food. This is occurring not only in developed countries but developing countries as well.

P. Howgate: You can see this in the attitude of fish technologists. Take my institute at Torry, 10 to 15 years ago we thought our world would revolve around the work of making fish processing more efficient. We now see our role in research and development as to maximize the utilization of the catch available. We are also looking at items such as postharvest non-utilization. We are looking at deboning processes to recover meat from bones after filleting, even utilization of sand eels as human food. With the horse mackerel, which is not used much in Britain because it is considered too small, we are looking for ways to develop products from the catch. This is what food technologists are all about now. One way to increase the consumption of fish products is to utilize all the fish that is captured. Deboners have come on as a technological item in the 1960s, but only recently are we seeing their full potential.

F. Peacock: Before the 200 mile EEZ (exclusive economic zone), there was a little bit of the idea that your resource wasn't limited to what was in front of your coast. If fish were not running, you could always take your trawler and go fishing somewhere else. In Europe, a lot of that was happening. Suddenly, we could only fish off our coast, and we realized we have only this limited resource and we have to make the best of it. I think this is one of the reasons there is a change in attitude with the idea of increased utilization of the catch. Now they know that they don't have the alternative of going somewhere else to fish.

M. Leitao: I think it is important to talk about the change in attitude regarding postharvest fishery losses. For example, in Brazil, at the fish market, we can find fish species that as little as a few years ago were completely discarded. Now with the technology of minced fish which utilizes a lot more species, we can find restaurants in Brazil selling fish burgers. A few years ago, the fish used for making these were discarded. So I think the concept of postharvest losses has changed. Ten years ago, really no one was as concerned about full utilization whereas now many institutes and countries are looking into the concept of utilization.

P. Hansen: Much of the postharvest fishery losses that occur in developing countries are from the small pelagic species that have little value and are not exported to the United States or Europe. I think there is not enough research done in this area. If we go back fifteen years to similar meetings, most of the papers and discussions would be about white fish or high value species, while little attention was given to small pelagic fish of little

value. There have been some particular strategies that have been wrong in dealing with developing countries and pelagic fisheries, especially when these countries convert to a more industrialized type of fishery.

R. Neal: Most people I have talked to have indicated that research in the area of postharvest technology has dropped off fairly dramatically over the last 10 years. Under the circumstances that we have been describing, is this a problem?

D. James: Looking at the research needs in the developing world, FAO recognizes that there is need, not necessarily to conduct research, but to apply the results of research that has already been done. For some time, we have been discussing prospects of doing this with the World Bank. One of the things that is strongly affecting postharvest technology research in the developing world is the lack of ongoing work in the developed world. The momentum has dropped off substantially.

T.C. Lee: One of the problems of being a researcher at a university in the United States is that there are very few funding groups that give money for basic research in fishery and seafood technology. The U.S. fish industry does not support these types of research programs where other food industries in the U.S. do. So as a university researcher who depends on grant money, I would say why bother doing research in seafood when I can get a grant and research money to study starch, gum technology or some other types of food. Not all countries are like this. For example, Taiwan in recent years has a lot of government support in the seafood industry. They are now becoming one of the principal exporters of shrimp and seafood to other countries. I envy my colleagues there at times, because they can get the support and buy the equipment to do the research they think is necessary. Unfortunately, a lot of this is geared toward seafood research for export when a lot of basic research still needs to be done and is not supported.

R. Young: I think there is still a need for research in developing countries. There are points which one can identify where technological research is required. I think there is ever a greater need to strengthen research in non-technological areas in order to establish the likelihood that technology which is developed will be transferred and successful. There is the area of market research dealing with product development and economics. Without any doubt, this type of market research should be included in the future in any strategy planning and design.

P. Howgate: It certainly is true in Europe and America that the research in various institutes is declining. This is due to a lack of government money for research. At Torry, we now have to charge for our services, even to FAO. Developing countries have to realize with this new system they are not going to get as much help from developed countries as in the past. So the ball is back in their court. I am struck by the fact, and I may be a bit overly critical, that the laboratories in developing countries are not being as effective as they should be. Although the number of scientists in fishery technology in developed countries appears to be going down, my impression is that the number of scientists in fishery technology in developing countries is actually going up, so the situation is not quite as bleak as we think it is. The problem that I would like to see addressed by people from the developing nations is how can we, from the developed world, help you make this research and development in fishery technology more effective? Should we be transferring more software, such as ideas, rather than hardware, such as equipment? So let me ask the people in these labs, do you think you are effective and if not, how can this be remedied and how can we help?

L. Santos: With respect to the concept of assistance, which Mr. Howgate has referred to, we are very glad to receive help in the form of foreign expertise or research grants per se. Such assistance helps us start something new, wonderful and useful, but when the foreign experts leave or the research grant ends, the project very often dies. Continuity of undertakings such as research programs depends primarily on government support. While we in the research institutes recognize the need for continuity of these projects, we cannot do it by ourselves. It worked beautifully when the funding institution was with us because we had funds both from the donor organizations and our government. When the support from the donor agency ends, we are supposed to be on our own. It is expected that we have developed some capability to go on by ourselves and to a certain extent, we have. However, the main problem is that of funding. Usually when the donor funds cease, funding from our government also stops. It seems that the government does not feel as committed anymore. It does not have to answer to a foreign institution. It only has to answer to us and being part of the national family, we could not be as imposing as a foreign agency.

A. Robles: There often is division of the scientific community, which is doing the research, and the decision makers. At times, they do not understand each other well. They talk a different language. The scientists do not want to take the time to explain their results to the decision makers whom they consider unable to understand complex situations in fisheries, or they have no faith that the politician will want to do anything. So the scientist keeps on doing research, goes to scientific meetings, and keeps on learning, but not really caring about what is happening with the decision makers. On the other hand, the politician thinks that the scientists are in an ivory tower, a bit out of reality. They are not facing the economic realities of the situation. They are not facing the social problems. I can clearly see that now as a scientist who is working more closely with politicians. We must as scientists make a better effort to bring our research to decision makers and as a scientific community have more influence on the society we are working for. This is not happening.

L. Santos: I think the situation is rather complicated. First as regards the thrust of postharvest research, I think there is a difference between research on products intended for domestic use and those for export. For instance, we are interested in increasing the production of fish for domestic consumption so more people can avail of this food commodity and increase their annual protein intake. On the export side, besides increased production, we know that we have to meet specific standards of importing countries. Attention is thus given to quality control. The export market is attractive because it brings in foreign exchange. The government therefore encourages research on quality assurance and quality control so products will meet the standards of importing countries. On the domestic front, interest is mainly in making the products available to a greater number of people. This means that research institutes will carry out work either on increased production/utilization or towards quality control. In view of the limited resources in developing countries, a choice between two areas has to be made, in other words, a definition of priorities. Priorities, on the other hand, are dictated by a complex number of factors which are interacting.

A. Robles: We have to get our priorities straight as governments. Are we going to feed poor people and hungry people, in which we can include the small scale fishermen, or do we want to think of supplying the demands of developed countries, selling them high quality products from the sea? I remember 20 years ago in Mexico, I could afford to eat shrimp. It was not so expensive, and more of the middle income people could eat them also. Now 10% of my monthly income is a kilo of shrimp. Twenty years ago, we had important

postharvest fishery losses, but now we don't have as many of these losses. This is not becaus we have made a concerted effort to reduce these losses, it is more that we are hungry and have to better utilize the fish that is available. So we have to set priorities and decide what we want to do, whether to build up an exportation market or first feed our people, and with what is left, try to develop the exportation market. I know exports have economic benefits, but we have to ask ourselves who benefits most in the developing countries. Most of the time it is not the fisherman; it is the distributor or exporter, and they are already economically well off.

B. Phithakpol: It is also true that a portion of the private sector does not understand how the research can be applied. So the first step should be an internal company or a company explaining how the research can be applied to the private sector. For example, in Thailand, we have projects with different organizations such as our project with FAO. When it is finished, a report is made. The next step would be to let the private sector come in and utilize the research or work that has been done and this is very hard to do. For example, for my project with the school lunch program, it is very hard to convince the private sector to take part in a project such as this because they don't see economic gain in term of investment from this research. So the first thing is to have a research extension as a lobbying force to convince the private sector of which projects are worth their while. This will, of course, aid the transfer of technology, and would help in terms of continuity of the research or the project.

M. Leitao: I think one of the most important points is the transfer of technology. You mentioned the necessity of contact with the seafood industry and I think this is the basis of many of our problems. We have the technology. We have capable people that are doing research, but the mechanism to transfer information or research to the industry is not always there. We have experienced this in our institute. We developed a complete process line for our soy industry 15 years ago, and we have tried to transfer this knowledge all this time without any result.

R. Martin: I think we have to get back to more basic thinking of how we can successfully transfer technology. If a country is not interested in aiding its own people and putting the financial resources behind the research to get the seafood from the shore into the infrastructure to the people that need it, these projects are not going to be successful. I have seen that too many times in too many places. Unless an institute or a company consults with their fishery people and the seafood industry of their country before they start one of these projects to decide what kind of a product they will produce, and unless the industry is agreeable to the idea that this is the approach they eventually would like to build a business investment around, it will fail. No matter how well intentioned we are, it is a business world out there and unless you are going to show the seafood industry a way to make a profit, unless the government backs a program to fit its own people, we will get failure upon failure in these projects. Whether it is based on seafood product as a protein source, or any other type of protein source such as a soy, unless there is an industry there to accept the results and to have representatives on committees and advisory boards, it will make it very difficult to carry these things through.

P. Hansen: The most useful research projects in my mind are the ones that have institute cooperation, such as the Torry Station working with a project in the developing countries or what the Danish Institute did with institutes in Chile. This fosters a relationship between institutes and investigators that can have a positive effect, and the people will know each other and continue after the project is finished, even when the project tends to be cut down in terms of support.

G. Bligh: The lack of money, the bureaucracy and the red tape makes seafood research unattractive to the investigator. People will then go into other lines of research or other jobs. I think one of the major efforts we have to make is to educate people who can then go back to their own labs and educate their own researchers and technologists. The training has to go on down the line. We cannot simply educate the top level people in developing countries and stop at that. We must be sure that the training goes down the line.

P. Howgate: Coming back to the point of transfer of technology - let us say we have someone from a developing country coming to Torry to get his doctorate. Now even if it were the best research facility in the world, Torry cannot give that person a project for his research that is relevant to his country. We do not have shrimp by-catch. I cannot go and feed people in the highlands of Thailand. I am not sure that this is right. The training that the person is getting is really benefiting Great Britain to a certain degree. It is not benefiting the person being trained because he or she is not working on their country's problems. Torry is working for the UK industry with a different set of needs and a different set of problems, and we cannot do the work that is necessary in the developing countries. This I think is a real problem. I am not sure we should encourage people to go for their training in developed countries.

L. Santos: Training as well as advanced education abroad has been an issue in the Philippines. Should the government send its people abroad for training and advanced degrees, during which they get exposed to technology which may, at that moment, not be applicable to the country, or confine training and education to the country? There are two sides to this question. When we are sent to other countries, we get training that we may never get in our own laboratories. It does broaden our horizons and increase the depth of our experience. It is expected that people who are sent abroad will take it upon themselves to modify whatever technology they have learned and make such technology applicable to their country. If they don't, then they have failed in the purpose for which they were sent unless the situation in the home country does not warrant the transfer of the technology. Confining training and education within the local domain creates the danger of inbreeding and consequent stagnation. By going to different laboratories, we pick up ideas, learn new things which we can put to good use when we return home, not exactly in that form but modified to suit local needs. I think, therefore, that there is some rationale for training and advanced education abroad although the cost is admittedly very high compared to local training and education. This is one question raised in the university I come from. Should the university spend so much in sending staff abroad or should it train its people under local conditions.

D. James: I can see over the last 10 to 15 years the initiation of a tremendous amount of new research in the developing countries' labs. Perhaps it has not been brought out enough in the international forum. In Asia and Africa as well, we have proceedings of recent meetings organized through FAO. Overall, it represents some very high quality work. I think this has come about because of collaboration, especially regional collaboration between the institutes. Perhaps rather than pairing off institutes in a developing country with institutes in a developed country, we should encourage regional collaboration such as we have in Asia, where we have 19 institutes, and in Africa, collaboration between 18 institutes. We are always looking for partnerships and funding from outside into a regional framework and you then have the possibility of less damaging consequences with the pull-out of one single institute of the regional network. Naturally it is a three-cornered arrangement. You have the regional institute from a developing country, a collaborative institute from a developed country, and there is a need to find a donor which is not easy.

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