POST-HARVEST LOSSES OF FISH IN THE TROPICS

NATURAL RESOURCES INSTITUTE

Overseas Development Administration

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The Natural Resources Institute (NRI) is the scientific arm of Britain's Overseas Development Administration. NRI's principal aim is to increase the productivity of renewable natural resources in developing countries through the application of science and technology. Its areas of expertise are resource assessment and farming systems, integrated pest management, and food science and crop utilization.

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PREAMBLE

Huge quantities of fish are lost after capture. This is an enormous waste of food, especially in the Third World, where much fish production is on a small scale, and where high temperatures make spoilage much more rapid. The situation is increasingly serious, at a time when the world's demand for fish is increasing, yet fishery resources are already under very heavy pressure. This publication seeks to explain just what the 'post-harvest' losses are, and the steps which can be taken to reduce them.

Introduction

Fish is one of the most important food staples on the planet. Its flesh is a source of top quality protein, and for many in the less developed parts of the world it represents a significant proportion of the animal protein in their diet, either as fresh fish or cured in a variety of ways, such as smoking, salting and drying. Fish can also be seen as a renewable natural resource, provided that the seas and lakes are not overfished. Unfortunately, however, fish is one of the most perishable of all staple commodities, and in the tropical climates of most developing countries it will become unfit for human consumption within about one day of capture, unless it is subjected to some form of processing. Even after the fish has been processed, particularly if traditional methods have been used, the fish is still subject to many forms of loss and spoilage.

Plate 1 *By-catch on a shrimp trawler.*

For the past twenty or so years, there has been increased global emphasis on fish production by traditional capture fisheries. World fish production rose from 40 million tonnes per annum in 1960 to 70 million tonnes per annum in 1970. Since 1970 the rate of increase in landings has slowed down, rising by about one million tonnes per annum to a provisional figure of just under 100 million tonnes per annum in 1989. This levelling off is because stocks of the more accessible fish popular for human food are being fully exploited. In some areas, catches are above the sustainable level, putting the future of the fishery in jeopardy.

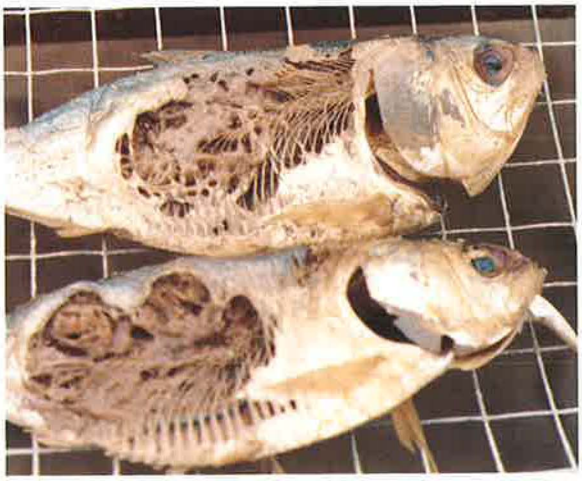

Plate 2 *Severe insect infestation. Maggots can eat nearly all the flesh, leaving a skeleton with skin.*

The demand for fish is increasing. Even a small increase in living standards in many developing countries leads to a greater requirement for fish. The health conscious, more developed countries are becoming increasingly aware of the high nutritional quality of fish.

The Food and Agriculture Organization of the United Nations (FAO) has estimated that by the year 2000 the total world demand for fish will be about 120 million tonnes per year. This cannot be met by landings from existng capture fisheries and aquaculture. If the demand is to be satisfied then other solutions will have to be found. Aquaculture can play a greater role in providing fish for human consumption, but so far it provides only 10% of fish production. The major emphasis will need to be on the improved utilization of marine fisheries. This will entail increasing landings by the exploitation of less popular and lower value conventional meso-pelagic fish types. It will also become increasingly important to ensure that fish once caught is fully and efficiently utilized.

The global pattern of fish utilization has changed markedly since about 1950, the proportion of fresh and cured fish falling, and that for frozen and canned fish increasing. Despite this trend, fresh and cured fish remain the most important items in the domestic markets of the developing world, and both fresh and cured fish are subject to high post-harvest losses; that is, a significantly smaller quantity of fish reaches the consumer than was originally caught.

It is difficult to estimate the extent of these losses, as very few quantitative studies have been carried out. However it is clear that post-harvest losses in the small-scale fisheries sector are among the highest for all the commodities in the entire food production system.

Post-harvest losses of fish are of various types. The most obvious are the losses of material, or physical losses, caused by, for example, poor handling and processing, or the discarding of by-catch. There are also economic losses which occur when spoilage of wet fish causes a reduction in its value or when there is a need to reprocess cured fish, increasing the cost to the processor. Traditional processing methods can cause a reduction in nutrient availability, leading to nutritional loss. Various reviews have included estimates of total losses, and typical figures are given in Table 1 below.

Table 1

Under-utilization of conventional fish stocks

Type of fish	Form of loss	Million tonnes/year
Wet fish	Post-harvest losses	2
Cured fish	Post-harvest losses	3
By-catch	Discarded at sea	5-20
Pelagic fish	Used for fish-meal	20
Pelagic fish	Under-exploited	20

This publication examines these three types of loss in some detail, describes ways of overcoming losses, and gives some examples of means of reducing losses.

Plate 3 *Insect infestation. Note that the damage is greater with the larger fish. The small fish dry much more quickly.*

Physical losses

Physical losses of fish after harvest can be regarded in two distinct ways. Firstly, there is what might be termed complete physical loss. Quantities of fish may spoil completely, becoming completely inedible. The by-catch from shrimp trawling is thrown overboard. Related to these losses are the under-utilization of resources, when small fish are converted into fish meal instead of being used for human food. Also there are many less popular fish which are seldom used for human consumption.

The second type of physical loss, which can be regarded as a loss of material, is a result of poor handling and processing of both fresh and cured fish.

Plate 4 *The sand on the fish will add more bacteria, and accelerate spoilage. If there's any animal excrement around that will provide even* ***more*** *bacteria.*

EXAMPLES OF COMPLETE PHYSICAL LOSS

Glut catches

For many fish species, glut catches occur, and then the distribution and marketing system may be unable to cope with the quantities of fish which are landed. In other places the processing facilities such as drying racks may be inadequate. Then much of the fish has to be left to rot.

Losses during distribution

If fish is handled carelessly, it may be crushed or broken during handling and can become unsaleable. Sometimes there may be transport problems, for example if floods block roads or bridges are damaged, and it is simply not possible to get fish to market before it rots.

Shrimp trawler by-catch

When shrimp is being trawled, other fish is caught incidentally; this is known as shrimp by-catch. The proportion of by-catch is very high, often 95% or more of the total material taken on board. The by-catch is very mixed, with many species of fish, some large, some small, and other species such as crabs. Usually the by-catch is thrown away at sea. Some of it, particularly the larger fish, could be landed and sold, but even those fish are of much lower value than the shrimp. Chilled or frozen storage facilities on board the trawlers are limited, so they have to be kept for the shrimp. Also, sorting the by-catch would require a lot of the time of the trawler's crew. It is currently estimated that between 5 and 20 million tonnes per year of shrimp by-catch are wasted in this way.

Plate 5 *Treading on the fish will crush and bruise them.*

Under-utilization of small pelagic fish used for fish meal

Fish meal is widely used, particularly in the developed countries of the world, as animal feed. Fish meal is made from small pelagic fish such as sardine, mackerel and anchovy, and it is estimated that some 20 million tonnes of this fish are converted into fish meal. Much of this quantity could be used directly as human food. Producing fish meal makes an indirect contribution to human food, since it is used to feed animals which will then be eaten by human beings. Unfortunately this fish has disadvantages; it is fragile, easily spoilt and damaged so it is difficult to distribute and market in good condition. It is acceptable in canned form, but in many countries canning is expensive.

Meso-pelagic fish

It was mentioned earlier (*see* Introduction, p.1) that stocks of the more popular and accessible fish are becoming fully exploited. One way of relieving the shortage of fish could be the exploitation of the less accessible meso-pelagic fish. However, practicable catching methods have to be developed. Also consumers are not yet familiar with this fish, so market acceptance would also have to develop.

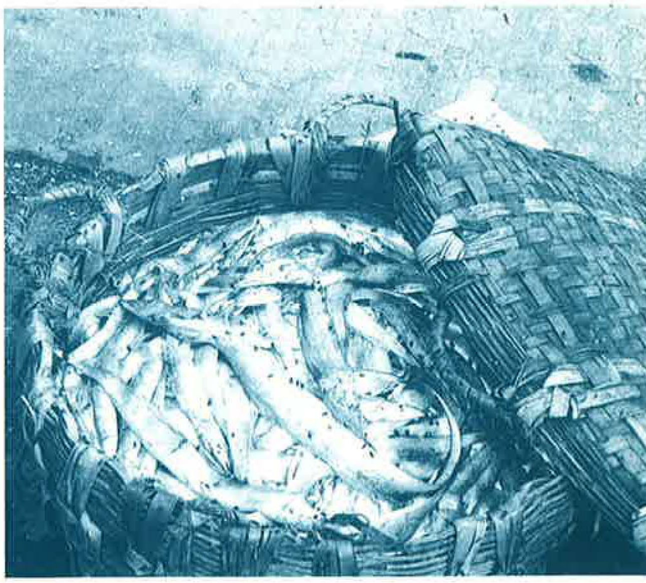

Plate 6 *Blowfly infestation.*

HANDLING AND PROCESSING LOSSES

Wet fish

Much of the fish caught by small-scale fishermen in developing countries is sold soon after landing, either for human consumption or for processing. However wet fish is highly perishable, and is subject to both bacterial and autolytic spoilage as soon as the fish dies. Often it is in poor condition when it is landed, especially if it has been physically damaged by poor handling techniques or carelessness.

Bacterial spoilage Bacteria are present on the skin and gills and in the gut of live fish, although the flesh itself is normally sterile. Bacterial growth and invasion of the flesh are prevented by the body's natural defence system during life, but after death the defence system breaks down and the bacteria multiply and invade the flesh. Bacterial spoilage is characterized by softening of the muscle tissue and the production of slime and offensive odours. Damaged fish are particularly susceptible to bacterial spoilage. Bacterial spoilage is slow at 0°C, in ice. It is increasingly rapid as the temperature is increased, and at tropical temperatures it is very rapid.

Autolytic spoilage Autolytic spoilage is caused by the continuation of the normal enzymatic digestive processes after the fish has died, and is in fact self-digestion of the fish flesh. The flesh of the fish softens, particularly in the gut area where the digestive processes are active. This process is also accelerated by high ambient temperatures.

Bacterial and autolytic spoilage generally occur simultaneously, and for most practical purposes can be considered together as a single cause of loss.

Poor landing techniques Physical damage to fish can begin as soon as it is caught, and while it is being brought aboard. Small pelagic fish such as mackerel, anchovy and sardine is fairly delicate, and can easily be bruised and broken when being pulled out of the nets, and damaged by being trodden upon. Mishandling can occur after landing and the fish is more prone to physical damage if bacterial and autolytic spoilage have already weakened the flesh. Environmental filth introduced by washing the fish with contaminated or polluted water, or by the fish coming into contact with dirt on land, will accelerate spoilage generally, and encourage contamination by pathogenic bacteria.

Delays in distribution and marketing Some fish is landed at or near the place where it is to be sold, for example close by a major city. Then the fish can be sold quickly after landing and spoilage should not be too serious. However much fish is landed in distant, often remote places. This is especially the case for artisanal, village, fishing. Then the fish may spoil while it is being taken to market, and there is much loss of quality. If there are unexpected delays, spoilage can be especially serious, as explained above.

Although physical losses in fresh fish post-harvest are generally assumed to be significant, it is extremely difficult to carry out quantitative studies, and few have been made. James (1977) suggested a figure of 10% as being typical, based largely upon a qualitative assessment, and this implies that losses are about 2 million tonnes per year (*see* Table 1).

Cured fish

Fish is cured by the traditional processing methods of salting, drying or smoking, which result in a product which is less perishable than wet fish. Depending on how much it is dried, it will keep for several weeks or even months. Cured fish constitutes an important part of the diet of many low income consumers in the developing world, and traditional methods are well suited to local circumstances, as they are cheap and require only simple equipment or facilities. The simplest method only involves laying the fish on the sand to dry in the sun. Alternatively the fish can be smoked over a fire to accelerate drying and to deposit anti-microbial compounds on to the fish. For either process, fish can first be salted, to facilitate drying. However, unless processing is very careful, physical losses can occur from microbial spoilage, insect infestation and fragmentation.

Plate 7 *Smoked fish. Or is it charcoal?*

Plate 8 *Traditional fish smoker. The fire is very hot at first, 'to burn out the guts'. Inevitably the fish gets charred.*

Microbial spoilage The type and extent of microbial spoilage depends almost entirely on moisture content or, more precisely, the water activity of the product. (The term 'water activity' refers to the water which is available for bacterial growth. In practice, this means the total water content less the water which is bound to the food tissues, salt, etc.) Normally for fresh fish, spoilage flora will be active in fish awaiting processing, and during the early stages of processing. When the water activity has fallen, during the later stages of processing, most bacteria will become inactive. Other halophilic bacteria (which can grow in salty conditions, and cause a red discolouration of the flesh) and xerophilic moulds will then become the chief causes of microbial spoilage. Microbial growth ceases at low water activity, equivalent to 60% relative humidity, and it is necessary to dry the product to a fairly low moisture content to achieve this.

Unfortunately, the ambient humidity in many tropical countries does not fall below 60%, making it impossible to sun dry the fish sufficiently fully, and microbial spoilage cannot be completely arrested. However Poulter *et al.* (1982) showed that there would be a lag, dependent upon the water activity of the product, before spoilage occurs, allowing a limited degree of storage and distribution.

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

Blowflies are a particular problem wherever fish is dried. They are attracted to wet fish, and lay eggs on it. Larvae (maggots) hatch from the eggs and eat the flesh of the fish; the fish can be completely hollowed out. However, the maggots can only attack relatively moist material, and excessive loss can be prevented in good drying conditions. Small fish will be less vulnerable to blowflies as it dries more quickly. Larger fish, and especially fatty fish, take much longer to dry out and then blowfly infestation can be particularly serious. Salt often reduces blowfly attack on fish, although salt-resistant blowflies exist in some parts of the world, for example, Indonesia.

Beetles, particularly *Dermestes* and *Necrobia*, are major causes of infestation in unsalted dried fish. If undisturbed, they can consume the flesh and soft tissue until only the bones and some hard tissues remain. Loss of cured fish due to beetle infestation may not be serious for short periods, but if the fish is stored for any length of time, it can become increasingly serious.

Fragmentation The tendency for dried fish to fragment is increased by damage to the texture of the fish caused by spoilage before processing; by subsequent mould and bacterial growth; and by insect infestation. If the fish is in good condition before drying, it will be reasonably strong. On the other hand, if it has deteriorated significantly before drying, the product will be much more brittle and friable. However, fragmentation is most serious in hot-smoked fish. The high temperatures used in this form of processing damage the connective tissue and structural proteins of the fish muscle. This means that the fish damages easily and breaks into small fragments, which may be completely lost.

Plate 9 *Fish deliberately covered with sand, allegedly to cool it. It makes it easier to handle, but adds to the bacterial load, accelerating spoilage.*

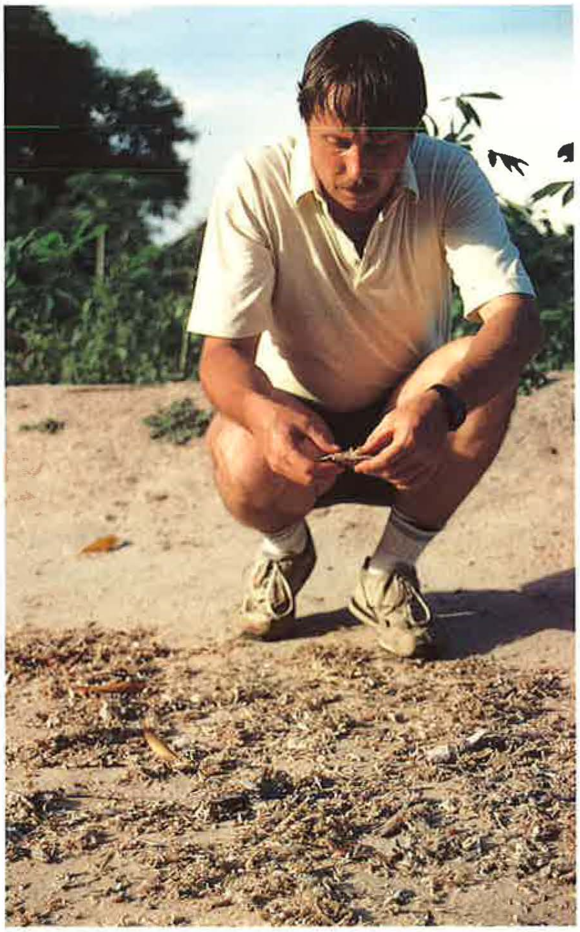

Plate 10 *How do we separate fish from sand?*

Table 2

Physical loss of cured fish in the tropics

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

Notes: M = Measured
E = Estimated
* = Laboratory trials at 27°C and 70% relative humidity

Fragmentation greatly reduces the value of cured fish, as the pieces sell for much less than intact fish. Generally only the small pieces are lost completely.

Post-harvest losses of cured fish were estimated by the US National Academy of Sciences in 1978 to be 25% or 3 million tonnes of the total annual production (*see* Table 1).

In 1988 Ames and his colleagues carried out a review of post-harvest losses of cured fish in which they summarized all the published data which could be traced, together with much unpublished material. Material losses of the main types of cured fish were covered, and whether the data were obtained by measurements or they were estimates was specified. This summary is reproduced here as Table 2.

It can be seen that although the values vary considerably, the National Academy of Science's figure of 25% falls well into the average range of the data shown.

It should be noted that the measurement or estimation of loss is not straightforward. Even when losses have been measured, the significance of the quantities is uncertain. For example, if material losses have been caused by insect infestation, not all the fish in one particular batch will have been attacked to the same extent, so some fish with little visible damage would be able to be sold at a reasonable price, while severely damaged fish would have to be discarded, and a percentage loss of whole fish would not be equivalent to the same percentage loss in *weight* of fish in a particular batch.

None of the measurements was made over any prolonged period. There could be very large differences at various times of year. For example, in the dry season fish can be dried quickly and losses could be much less than in the wet season, when drying may be slow or impossible, and when mouldiness can be more serious. The losses may vary greatly in different parts of the country. They can change a lot from one year to the next, due to climatic variations, levels of insect pests, etc. No measurements of losses have been carried out over wide areas or over a significant period of time.

Many estimates of losses are, of necessity, purely visual, so the observer's assessment is subjective rather than objective, however good his intentions. Probably all the estimates were based on observations in a small number of places on a very few occasions; this cannot produce a valid overall figure, and the rigorous observer will naturally qualify his comments accordingly. Unfortunately, qualifying phrases such as 'about', 'of the order of' or 'may be as much as' are likely to be omitted when the report or publication is referred to by others, and what was a guess comes to appear as a statement of fact.

Economic losses

Physical losses in fish tend to be absolute, as the fish can either be eaten or sold, or it cannot. They *could* be measured, but losses in value, or economic losses, are gradual and progressive and very much more subjective; different groups of people may hold different views of the 'worth' or value of a particular product. The value of a batch of fish of a particular quality will vary from one day or week to the next, and in different places.

Plate 11 *Beetle infestation of cured fish.*

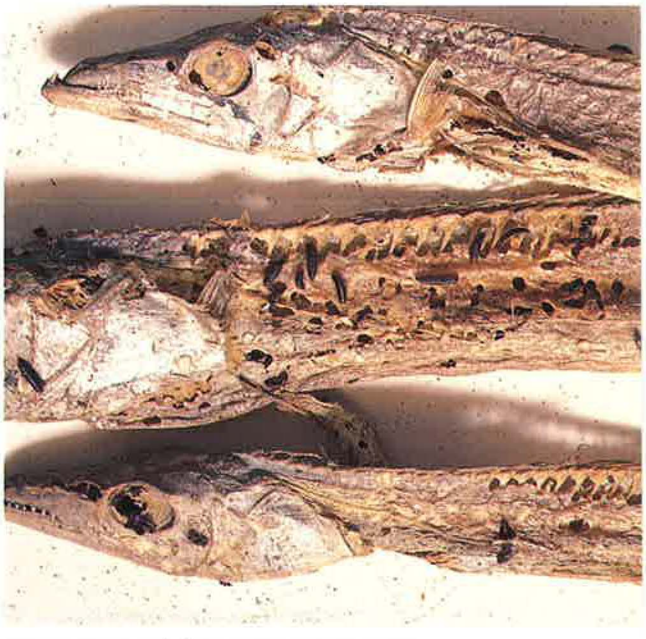

Plate 12 *Beetle infestation of dried fish.*

WET FISH

Much of the fish caught by small-scale fishermen in developing countries is sold immediately after capture, as fresh fish is usually more popular than cured fish, and it commands a higher price. Although ice is increasingly being used in more developed areas to preserve the fish, the greater part of the catch is sold without any further form of preservation. The various types of spoilage of fresh fish were described in the previous section, and it was emphasized that fresh fish is extremely perishable. Spoilage of fresh fish is usually accompanied by a loss in value of the catch, since most consumers will pay a higher price for fish which is in good condition. The relationship between the value of good quality fresh fish compared with poor quality fish is more complicated than it would first appear, as it varies considerably between different places and different countries. Sometimes iced fish can command the highest price, and sometimes uniced. This depends on local custom. Always consumers want *fresh* fish. In some markets fish is sold uniced, soon after landing, but if it is not sold quickly it is iced, to be offered for sale next day. Then uniced fish is fresh, iced fish is yesterday's. These attitudes may change, if supplies of fresh iced fish become available, and consumers come to recognize the better quality. What is beyond question, however, is that fish which is beginning to go putrid will not command as high a price as fish which is in a reasonable state of preservation. Therefore, if the fish can be landed and sold to the fish consumer within a few hours of catching, the loss of value can be negligible. Alternatively, if ice can be used on board, or at least after landing, the value of the fish will not drop for some days. If the fish cannot be iced the drop in value will be rapid, and the economic loss to the fishermen or trader will increase. Fishermen or traders will do their utmost to sell fish in the wet state, reducing the price as the quality deteriorates in order to make a sale.

Economic loss can also occur if the handling distribution/ marketing chain is inefficient, or breaks down, resulting in delays in distribution of the fresh fish, and consequently spoilage ensues.

Some highly priced seafood, particularly shrimp, is exported. Consignments may be rejected because the quality standards of the importing country are not met, because of bacterial contamination, the presence of heavy metals, chemicals or other pollutants. This will result in economic loss for the exporter.

Another form of economic loss occurs with glut catches. Presence of a glut on the market will reduce the price, and therefore the value to the fisherman or trader of the fish. If the fish is being sold for processing, traditional processing techniques are time consuming, and drying facilities are usually tailored to cope with normal catches. If there is a glut catch, then many tonnes of fish may spoil because processing facilities are inadequate.

Assessments of economic losses in fresh fish have been made in various countries, but by their very nature are open to a wide degree of error, as major assumptions have to be made about market prices and consumer requirements. Bostock (1987) in India estimated economic losses over potential revenue of US$ 6 million per annum in the marketing of 60,000 tonnes per annum of fresh fish for domestic

Plate 13 *Traditional type of fish smoking kiln – mud brick walls, fish immediately above the fire.*

Plate 14 *Not a good fish market. Too much fish is displayed, so some is left for a long time and some gets walked on.*

consumption from Gujarat to Delhi. This was about 10% of the actual wholesale income of the market, and probably represents a typical figure. It was reported that 10-25% of fish arriving in Delhi was of poor quality, and attracted only about 50% of its high-quality price and that a further 5% loss was incurred by net physical drip loss. Since greater care is taken in handling the higher value species compared with the lower value ones, extent of economic loss can be related to species value.

One factor which must be borne in mind in considering economic losses is the availability of food for lower income groups. Sadly, there are many people in developing countries who can only afford fish which has deteriorated and lowered in value. The economic loss to the fishermen, processor or trader makes food available for these people. It can often happen that improvement in quality of a product which is to be consumed domestically could increase the price beyond the means of some indigenous purchasers.

Plate 15 *Fish drying on open ground. This is for poultry feed, and presumably the chickens can separate fish from dirt.*

CURED FISH

The purpose of curing fish by smoking, drying and salting in developing countries is to preserve it for longer than is possible in the fresh state. Products such as smoked salmon are not considered here. In these cases, the main object of smoking is to modify the flavour, and the product is still perishable, and it has to be kept refrigerated. It is fundamentally different from most types of cured fish produced in developing countries. Cured fish, however, is generally not as popular for human consumption in developing countries as fresh fish and so its value is lower*. Therefore an economic loss can be sustained by the processor who has, in addition, to meet the costs of the curing processes.

Although traditional curing methods are well suited to the needs of developing countries, inefficiencies in such processes will result in a lower quality product, and there will be further economic losses to the processor, distributor or trader.

Plate 16 *Sun drying. The fish is spread on the ground but it is on concrete not sand or dirt. The concrete appears to have been swept.*

Inefficiencies in traditional processing

Smoking Fish is cooked over a hot, smoky fire, and the process reduces the water content of the flesh, kills bacteria and insects and denatures enzymes which would cause autolytic spoilage. If, however, the process is not carefully controlled, physical fragmentation of the fish will occur, and pieces will fall into the fire and be lost. Temperatures which are too high can lead to charring and burning of the flesh, resulting in nutritional and physical losses. If the smoking/drying process has not reduced the water content of the flesh sufficiently, the fish will quickly become recontaminated with bacteria, often more pathogenic than those present before processing.

Drying Fish can be dried by the sun and wind, and, as mentioned above, by prolonged smoking. If however the weather is wet or humid, the high water vapour content of the atmosphere will mean a very slow rate of evaporation from the surface of the fish and the fish will dry very slowly. If the moisture content is not reduced rapidly enough, the fish will remain susceptible to bacterial spoilage and blowfly

*For a comparable weight: remember that wet fish contains 80% water, while cured fish much less. It is the solid material which is the food, not the water.

infestation. A common source of loss is when processors are reluctant to buy fish from fishermen during wet weather, leaving the fishermen no choice but to discard their catch. Conversely, if the fish is dried at too high a temperature and too high a rate, the surface of the flesh can form a hard crust (case hardening) which reduces the rate at which water from the centre can reach the surface and evaporate. Then autolytic and bacterial spoilage can occur within the fish whilst its exterior appears to be completely dried.

Salting Salting can be an effective way of reducing the water content and water activity of fish flesh, before drying or smoking, and of accelerating these preservation processes. Salting is used mostly in coastal areas, where salt itself is cheap and plentiful. In inland areas, salt is often expensive and rarely used. Because of the cost, and because consumers are unfamiliar with salt-cured fish, this means of preservation is not generally popular in inland African countries.

If added in sufficient quantities to fish, salt competes with bacteria for water, leaving the bacteria unable to grow and reproduce. Insects are deterred and autolytic enzymes are inactivated by salt. Salting is only effective, however, if the salt is able to penetrate the tissues of the fish rapidly, otherwise the interior of the thicker fleshy parts remains vulnerable to spoilage.

Such inefficiencies in traditional processing will lead to economic loss. Hanson and Esser (unpublished) in Indonesia found that losses of flesh of about 9% caused by insect damage during sun drying caused financial losses of about 30%. It has also been found that, under the very humid conditions prevailing in some tropical countries, cured fish, particularly if it has been salted, will reabsorb moisture and become susceptible to mould attack, a relative humidity of over 70% being reported by Suryanarayano *et al.* (1962) as being conducive to attack by moulds. Mouldy fish will fetch a lower price in the market, resulting in economic loss.

In many countries, the consumer preference for cured fish is for a fairly moist product. This inevitably has a shorter storage life than the drier products. Unless the moist product is sold quickly it will start to spoil. Then it is necessary to re-dry or re-smoke it to extend the storage life. This reprocessing involves more labour and, in the case of smoking, more fuel. The cost of this reprocessing, even if it results in a sale, will represent an economic loss to the processor.

Nutritional losses

Nutritional loss can occur in fresh fish and some loss of nutrients is inevitable in all forms of food processing. Fish processing is no exception, and in traditional methods the losses may be serious. Procedures in which the fish is heated to fairly high temperatures, such as smoking, can result in damage to the nutritional value of fish protein, with losses in availability of lysine and other essential amino acids. These losses may not be significant if the people eating the processed fish have an adequate diet in other respects. In some parts of the world people eat relatively small quantities

Plate 17 *Cured fish packed in a basket. The basket layers and leaves provide protection against knocks.*

Plate 18 *Quite a good fish market. The floor has been washed recently. Most of the fish is displayed on sheets. It's a pity there's no ice but if the fish is sold quickly that is reasonable.*

of cured fish, and are able to obtain sufficient lysine from other foods. However, many people in developing countries rely on cured fish for most of their protein needs, and then the loss of available lysine may be significant. It is often the lower income groups who depend most on cured fish, and they are less able to afford other protein foods which are richer in lysine.

Plate 19 *Drying fish on a net, well off the ground to catch the breeze and angled to catch the sun.*

WHERE NUTRITIONAL LOSSES OCCUR

Fresh fish

Fresh fish, as has already been emphasized, is extremely perishable, and is subject to bacterial spoilage. As the fish spoils, its nutritional value decreases, as the bacteria causing the spoilage degrade the protein which is intended for human consumption. However, bacterial action produces nitrogenous compounds with noxious odours, and the affected fish will become highly unattractive before there is too much nutritional damage.

Bacterial spoilage in fresh fish can produce toxins which cause food poisoning; histamine contamination is prevalent among pelagic fish such as mackerel and sardine. Pathogenic bacterial contamination of fresh fish caused by poor handling, and washing the fish in polluted water can also cause food poisoning.

Plate 20 *Split fish spread out carefully on wire mesh racks.*

Cured fish

Traditional processing of cured fish frequently involves high temperatures, particularly when the fish is smoked. It used to be thought that salting and drying effectively preserved the nutritional value of the original fresh fish, and much of the older literature (for example, Cutting, 1962) seemed to confirm this. More recent work, particularly that carried out at the Natural Resources Institute (NRI), has indicated that this is not the case. Measurements used to be based on the gross composition of the product, but now more sensitive analytical methods are available. It has become clear that a more appropriate measure of nutritional loss should be based on the biological availability of the muscle constituents of the fish flesh. Recent work has shown that traditional processing methods can cause a loss of nutrient availability, when fish muscle constituents, although still physically present, are not able to be utilized by the human body. Carpenter and Booth (1973) showed that fairly high temperatures, of about 150°C, as are encountered in smoking, affect the availability of lysine, one of the amino acids found in fish protein. More recent work carried out at NRI has indicated that loss of availability of lysine and other essential amino acids could also occur at much lower temperatures, such as 60°C. This raises the possibility that nutritional losses can occur when fish is sun dried. Research is being carried out on the extent to which this damage occurs in practical fish drying operations.

Other nutrients present in fish muscle which can be affected by the heat used in traditional curing methods include methionine and other sulphur amino acids, and vitamins D and K.

Rancidity development in cured fish can also lead to nutritional loss. Rancidity is caused by the oxidation of fish lipids, and so oily fish such as sardine and mackerel is particularly prone to it. Oxidation continues during storage of cured fish, leading to the development of a bright yellow/orange colour and distinctive and unpleasant 'painty' odours. The product will become most unattractive to consumers, and may be completely rejected.

The development of rancidity is undesirable from a nutritional point of view for two reasons. Firstly, because as fish oils oxidize they react with and damage the protein, and their nutritional value decreases. Secondly, because there is evidence suggesting that rancid oils are toxic when ingested.

Measuring losses

If an accurate assessment of losses is to be made, information needs to be obtained or collated on:

(i) the fish resources: the main species landed; the quantities involved, and seasonal variations;

(ii) for cured fish, the types of process in use and the amount of fish processed;

(iii) for wet or cured fish, the nature of the distribution system: where the fish is sent and by what transport systems; who is involved in distribution and marketing; how much fish is involved;

(iv) packing systems;

(v) storage facilities; and

(vi) acceptability of the wet or cured fish at various product levels; the level of quality at which the fish becomes unacceptable to particular consumer groups.

After the preliminary appraisal, a detailed study plan can be organized. The basic objectives to be achieved during loss assessment must be kept in view at all times. These are:

(i) determination of the type of losses; and

(ii) measurements of the amount and extent of losses.

To know exactly what losses are, one must define carefully what *sort* of loss is involved. As shown above, there are many different sorts of loss. To assess any of the types, one must measure what losses are in several different places in the country or region in question. This must be done over a period of several years, as any one year may not be typical. This all involves a huge amount of work, and is it worth it?

The types of fish and the products, whether wet and/or cured, to be evaluated, must be specified. The types of loss, whether physical and/or economic, and the number of geographical locations to be sampled must also be considered. Careful thought should be given to this last topic, as too small a number of sites will not give results which are representative for an area or region, and too large a number will greatly increase the workload involved.

The duration of the survey is critical; seasonal variations will occur, often with handling and processing becoming more difficult during rainy seasons. Conditions can also vary from

Plate 21 *Salting fish. Fish is piled on a concrete floor with plenty of salt, and completely covered.*

Plate 22 *Fish drying on racks.*

year to year, so although limited base-line data can be obtained from one year's observations, an effective field survey in loss assessment should last for about three years, and for longer if possible. Background information based on one year's appraisal can be up-dated if necessary whilst improvements are actually being implemented.

Only after these data have been evaluated can attention be turned to actual measurement of losses. Loss assessment of fish post-harvest entails both qualitative and quantitative measurements at every stage of handling or processing, as has been stated above.

Spoilage losses of fresh fish are difficult to assess. In any marketing system which involves perishable produce, traders are prepared to accept a proportion of loss from spoilage, and any trader purchasing a given quantity of fresh fish will be able to estimate how much will have to be discarded instead of sold, although comments to outside observers would need to be treated judiciously. In the case of a regular marketing channel, for instance, the distribution of iced wet fish from landing sites to markets in distant towns, the marketing system will be finely adjusted to minimize losses. Traders are unlikely to be prepared to sustain say 50% losses regularly unless the price of the remaining 50% unspoiled fish compensated for the loss. It is more probable that handling procedures would be improved, or new markets sought in more accessible towns, if losses to the handlers were likely to be substantial.

Cured fish losses are difficult even to calculate. The water content changes during production, and perhaps afterwards if atmospheric moisture is absorbed. The moisture content of the fish must be measured at each stage, and calculations made to allow a valid comparison of weight changes.

Wood (1985) has drawn up a detailed scheme for assessing losses in cured fish which allows for changes in moisture, bone and salt content. This scheme is reproduced below, as Table 3. Unavoidably, it is somewhat complicated!

If economic losses are being considered in the survey, careful evaluation of the price of the fish at every stage in the system will be needed.

Not enough is known yet of what nutritional losses actually occur to make it possible to measure them.

Plate 23 *Improved fish smoking kilns. Several wooden frames holding wire mesh trays form a closed smoking chamber. The bottom tray is well above the flames, so the fish should be smoked, not burned.*

Plate 24 *Iced fish? Not really. Putting the ice on top of the fish means that some lukewarm water trickles down over the fish, cooling it a little. The fish and ice must be mixed thoroughly.*

THE NEED TO ASSESS LOSSES

The previous section has shown that measuring losses accurately will be a long and complicated process. Is it worth the expense involved? Will there be any benefit from knowing just what losses are?

It is known that substantial losses of fish occur at all stages in the chain from capture to marketing of fresh and cured fish. The extent of these losses is rather academic, as what is important is to reduce or prevent the losses, so as to enhance the incomes of those involved in fish production and processing, and to make more food for human consumption available. The instigation of an elaborate and lengthy loss assessment survey will not of itself increase the income of any fishermen, or improve the protein content of the diets of any impoverished people. There is just one set of circumstances when it is necessary to establish the extent of losses.

Table 3

Loss measurement over two consecutive processing stages

Processing stage of time when measurements are made	Flow of fish through the system	Fish removed from the system	Losses of material	Data required for loss measurement
Time t_1	acceptable fish, correct grade (weigh)	sampled for chemical analysis (analyse)		
Processing or distribution stage t_1 to t_2			fish physically lost (calculate)	
Time t_2	quality inspection (inspect, segregate) acceptable fish correct grade (weigh)	acceptable fish, incorrect grade(s) (weigh)	unacceptable fish discarded (weigh)	losses t_1 to t_2
		sampled for chemical analysis (analyse)		
	acceptable fish, correct grade (weigh)			
Processing or distribution stage t_2 to t_3			fish physically lost (calculate)	
Time t_3	quality inspection (inspect, segregate) acceptable fish, correct grade (weigh)	acceptable fish, incorrect grade(s) (weigh) sampled for chemical analysis (analyse)	unacceptable fish, discarded (weigh)	losses t_2 to t_3

That is when efforts are to be made to reduce losses. Then there will be a need for information on what losses actually occur and when, in order to identify improvements needed in existing processing systems. Careful studies of losses should indicate when improvements most need to be made, and what changes may be required. It will then be possible to assess the effect of improved methods or equipment. In order to monitor the effectiveness of any changes, base-line data are essential. Base-line data clarify and reduce the extent to which losses need to be studied. It is not necessary to know about total losses occurring over a whole region or country, only about those that occur in specific areas where improved methods or equipment are being tested.

REDUCING LOSSES

No matter how much or how little information is available on the magnitude of losses, the important issue is how to reduce them, to make more food available and, to raise fishing communities' income. The aspects involved are summarized in Table 4.

Table 4

Action areas for losses of fish post-harvest

Type of loss	Product	Cause of loss	Action
Physical	Cured fish	Fragmentation	Improved curing
		Mouldiness	Improved curing
		Insects	Pesticides?
		Spoilage before processing	All-weather processing
Economic			
	Wet fish	Spoilage	Use ice
			Improved transport
Nutritional			Improved communications
			Improved packaging
			Improved sanitation

Source: Ames (1990)

Ways of reducing losses

The types of losses in fish post-harvest, and the reasons for them have been described. The need for assessment of losses as a first step towards overcoming losses, ways of identifying losses, and defining solutions to the various problems have been explained. The final stage is to describe various of means of reducing losses. These are described in detail in two NRI reports (Clucas *et al.*, 1981, 1982).

Much can be achieved by simple improvements in handling and processing methods. The basic requirement is to take more *care*. Fish is easily damaged, and easily spoiled. Careless procedures will accelerate spoilage and increase losses. Careful methods will retard spoilage, reduce losses, and improve the quality of the marketed product.

Plate 25 *Smashing block ice. Note the sharp pieces which are likely to cut the fish, accelerating bacterial spoilage.*

Plate 26 *Smashing block ice.*

USE OF ICE FOR FRESH FISH HANDLING, DISTRIBUTION AND MARKETING

Chilling with ice is an extremely effective means of reducing spoilage in fresh fish. Ice is an ideal cooling medium; it is harmless, it has a very large cooling capacity for a given weight or volume, it is comparatively cheap, and it is able to cool the fish quickly by intimate contact with the fish. Although chilling can never prevent spoilage, the lower the temperature at which the fish is held, the greater the reduction of bacterial and enzymatic activity.

To chill fish, it must be surrounded by a medium which is colder than the fish itself. For effective chilling the ice must be allowed to melt; there are additional advantages in this as melting ice keeps the fish both moist and glossy, adding to its attractiveness to the consumer. The ice melt water also helps to wash away surface bacteria and clean the fish. Ice acts as a self-thermostat, and as about 80% of the total weight of fish is water, the fish is maintained at a temperature slightly above that at which it would begin to freeze. Another advantage of using ice to chill fish is that it can be transported fairly easily, as a portable cooling method.

If possible, fish should be iced on board ship, immediately after catch. Spoilage is so rapid, especially at tropical temperatures, that even a few hours' delay can mean that fish is starting to spoil before landing.

Chilling in ice at sea, soon after catching, will minimize spoilage and ensure that fish is attractive and in good condition on landing.

Many fishing vessels have a hold or fish room in which the catch can be kept in ice. Small-scale fishermen increasingly use insulated boxes to carry ice to sea, and to store ice and fish. These boxes are frequently made with walls containing expanded polystyrene of about 10-15 cm thickness, and they provide excellent insulation. Often they need to be made specially so that they fit into the hull of the fishing vessel. Placing them too high up might well endanger the stability of the vessel.

In one recent NRI project, on the east coast of India, ice boxes were specially made to fit the nava, the traditional type of fishing vessel. Using these boxes enabled the fishermen to land much better quality fish, increasing their income by 20%. The widespread use of ice in other traditional vessels shows that many fishermen had themselves made similar observations.

Ice on shore

If fish is iced at sea, then it is important to maintain its quality by keeping it in ice during distribution and marketing. If it is *not* iced at sea, it is even more important to prevent further spoilage by icing it as quickly as possible. Insulated boxes like those described above may be used for transporting the fish to market. Often fish is loaded in ice in bulk, in open lorries.

Large insulated ice boxes may be useful at landing sites where fish has to be kept for a time before being taken to market. One such box is shown in Plate 32.

Plate 27 *Loading block ice into a fishing boat.*

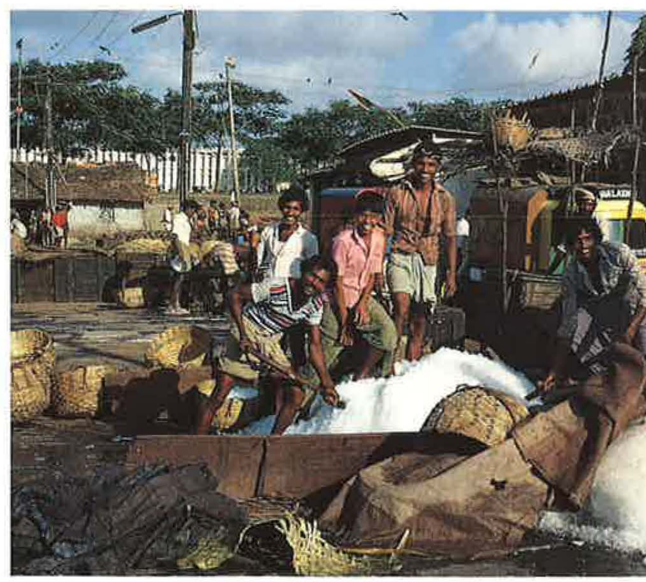

Plate 28 *Ground ice store, next to fish landing.*

Types of ice

This is important. Crushed or flake ice is best, as it gives the greatest possible area of contact with the fish, ensuring that the fish is cooled quickly. With larger pieces of ice the fish will cool more slowly. With very large pieces, such as block ice, only part of the fish will be in contact with the ice, and only that part will cool quickly. In the rest of the fish, the spoilage processes will continue for some time.

Block ice is used in many developing country fisheries. Smashing blocks of ice with a club or hammer (Plate 25) gives smaller pieces but these have sharp edges which can cut into the fish. These cuts enable bacteria to penetrate the flesh more easily, and spoilage is accelerated.

Alternatives to ice

For larger vessels, there are two alternatives to using ice on board. Chilled sea water and refrigerated sea water. These are systems in which the fish is kept in brine, which is cooled to about 0°C. This is a bulk storage system, and it is convenient for holding fish caught in large quantities at one time. The fish is landed in the wet unfrozen form.

Another alternative is freezing at sea. This is very much the industrial level of fishing, and it is usually used in tropical countries only for shrimp.

Although ice is often a cheap product, it can be expensive in developing countries. Although it is extremely effective in slowing down spoilage of fresh fish, its price can prohibit its use. Also many fishing villages have no electricity supply, and ice may not be available. The fishermen have little choice but to land fish as quickly as possible. Even so, there are some steps which can slow fish spoilage. It is useful to cover fish with sacking or other cloth, to stop direct heating by the sun. Pouring water onto the sacking will cause some evaporative cooling.

IMPROVED DRYING PRACTICES

Spoilage and loss of quality of fish can often be reduced by simple improvements in drying practices. Drying can be done on the earth, but then the fish is bound to get contaminated with dirt. Drying on mats on the ground, or a hard surface such as concrete is better. It is better still to put the fish on some sort of racks above the ground so it is more exposed to any breeze. If the rack is not too solid, say wire mesh or an old fishing net, then both sides of the fish can dry. Also, if the fish is away from the ground it is less vulnerable to domestic animals.

Smoking can be effected in any equipment which suspends the fish above a fire or in the smoke from a fire. However, in traditional smoking the fish often gets badly charred. Various types of improved kiln exist, in which the fish is placed in racks either over the fire or in a separate smoke chamber. These make it possible to control the process and cook and dry the fish, without burning it.

Salting before drying or smoking can expedite processing, as salting removes much of the water from the fish. However it gives a very different product. In much of inland Africa, salt is expensive and consumers are not accustomed to salted fish, and do not readily accept it.

Plate 29 *Block ice being fed into a grinder. Flake ice cools the fish much faster and there are no sharp edges to cut the fish.*

Plate 30 *Sardines being landed by canoe fishermen. Some ice (left) is put on the fish before unloading to start cooling it. As soon as the fish is landed, it is packed in a suitable quantity of ice.*

REDUCING INSECT INFESTATION IN CURED FISH PROCESSING AND STORAGE

Use of salt Salt is known in many parts of the world as an effective deterrent to blowfly infestation. Investigations have also shown that salted dried fish tends to be less susceptible to beetle infestation than non-salted fish. Although it is generally understood that high levels of salt will be effective in reducing infestation, it is difficult to determine the minimum effective concentration required. Moreover it is difficult to assess whether this is a practicable method in the long term. Most of the trials have been carried out in areas where salt is not normally used, and there is usually some unsalted fish nearby. It could be that blowflies merely prefer the latter, given a choice. In areas where most or all fish is salted, like Indonesia, blowflies attack salted fish very readily. Also in areas where salting is not normally used, consumers are unfamiliar with the salty produce, and may not accept it.

Prevention of blowfly attack without insecticides The use of insecticides is discussed below; these are important because other methods may be ineffective. Screens can be placed over fish which is being dried, and they do prevent blowflies getting to the fish. Unfortunately they also slow down the drying process, and the fish spoils. Also blowflies have been observed to deposit their eggs on the screens, from which they drop onto the fish. Plastic greenhouses have been used but it proved virtually impossible to place the fish inside them without blowflies getting in as well.

Beetle infestation can be controlled by reprocessing. One effective method is to 're-smoke' stored smoked fish which has become reinfested over a hot fire. Another method, used in Malawi and elsewhere, is to immerse infested dried fish in boiling water for a few seconds, then to redry it.

Use of insecticides The use of contact insecticides is extremely effective against insect infestation, but it is only justified under approved and controlled conditions. Insecticides are highly toxic; and many are dangerous. Only a few are safe to use on foods. One of the safe substances is pirimiphos methyl, and this has been approved internationally for use on fish. It is extremely effective in controlling blowfly losses during fish drying. When used under specified conditions, it leaves no harmful residues. Pirimiphos methyl is also effective in controlling beetle infestation during storage.

Use of fumigants Cured fish can be protected from beetle infestation during storage by the use of fumigants. These are insecticides existing in the gaseous form at ambient temperatures. As gases, they can diffuse into the dried fish and kill any insect infestation. It is important to remember that they do not provide lasting protection, and the product can become reinfested unless suitable precautions are taken. Two of the most effective fumigants for cured fish have been found to be phosphine and methyl bromide. It is crucial to remember that as fumigants are toxic gases they are very dangerous, so fumigation should only be carried out by trained personnel.

Packaging Careful packaging with suitable plastic materials can prevent insect infestation of cured fish. However such materials will only act as a physical barrier to insects, and they will not be effective against any insects already present in the fish when it is packaged. The packaging material should be

Plate 31 *Ice box on board a traditional boat. Note that the box is in the bottom of the boat, not perched on the top, which could lead to capsizing.*

Plate 32 *Loading a large insulated box for overnight storage.*

such that insects are unable to penetrate it by biting. The package should be well sealed, with holes that do not exceed 0.25 mm in diameter; perfect sealing is possible with some sophisticated materials, but these may have the disadvantage of being expensive. Such materials may also be waterproof, encouraging mould growth. Boxes sealed with adhesive tape or lined with cloth or paper will give useful protection against insect attack, as will closely woven heavy cotton sacking, although the stitch holes in the sack are potential entry points for insects.

REDUCING OTHER LOSSES OF CURED FISH

Reducing mould attack Mould growth is encouraged by damp, so cured fish which has not been fully dried is susceptible, particularly after a period of storage. Mouldy fish can be cleaned with water and redried or resmoked. Care should be exercised in the case of very mouldy fish because of the possible presence of mycotoxins (very poisonous substances produced by some moulds). Heavily salted fish is likely to absorb atmospheric moisture, so careful inspection should take place regularly, particularly during rainy seasons. The fish should be redried if it appears to be becoming moist. As a long-term measure, fish stores should be used which are designed so that they provide protection from rain and ground water and are well ventilated.

Good packaging of properly dried fish can prevent mould attack during transportation, as the fish will be kept dry. However if plastic sheeting is used its waterproofing properties will encourage mould growth if the fish has not been fully dried before packing. One solution is to use a woven plastic fabric which is water permeable, and, unlike hessian, does not become damp itself. Alternatively the fish can be packed in a water permeable cardboard box, then protected by plastic sheeting.

Preventing fragmentation Serious losses occur in cured fish from fragmentation during handling and transport, since by its very nature the fish is brittle and friable. The fish should be packed in rigid containers such as boxes or baskets with frames, which provide some protection, and not in sacks or cartons which are too flexible. If baskets or similar containers are used their frames will ensure rigid protection, but if the weave is such that the fish is likely to fall through, then a lining of cloth or paper will prevent this. Cardboard or wooden boxes will protect the fish, and have the advantage of being made from a single material. Rigid containers must be strong enough to be stacked without collapsing, or compressing the fish, and they must be able to withstand jolting encountered in vehicles, and on rough roads. Individual packages should be able to be handled easily; a maximum size holding 15kg fish is recommended.

Fragmentation is much more likely to occur if the fish were in poor condition before curing. The spoilage processes in wet fish gradually break down the muscle structure. Poor quality fish, even if it is dried or smoked carefully will be friable, and pieces of the flesh will fall out much more easily than if the fish were fresh originally.

Preventing charring Charring of fish can easily occur during processing. It is particularly common when very oily species such as mackerel are smoked and dried too close to the fire; the fat drips onto the fire and ignites, burning the fish.

Plate 33 *Loading fish into an improved smoking kiln. The smoking chamber takes a number of trays of fish. It is closed with a door before operation.*

Plate 34 *Aluminium container for transporting fish. Strong but light, and washable.*

This can be prevented by ensuring that the racks on which the fish rests above the fire are at a suitable distance from the fire, and that the fish is turned regularly during processing. Charring is also caused by the smoke from the fire or kiln being too hot, and control of combustion of the fuel should be attempted. In the simplest processes, when the fish is cured or dried over a wood fire, the wood used should be slightly damp, as then it will burn less violently and generate more smoke. If the fish is being smoked or dried in a kiln, then a well-designed kiln with flues to adjust ventilation will ensure greater control over the process.

Plate 35 *Fish baskets and new aluminium containers. The baskets leak, so women using them are not allowed on buses, and have to walk to market. The new containers enable them to go by bus.*

GOOD HYGIENE PRACTICES DURING FISH PROCESSING

For many types of processing, the fish must be split, gutted or cut; this often takes place on the ground or a beach, under unhygienic conditions. Often the fish waste is allowed to collect in heaps, or it is washed into the sea or lake, causing pollution. Such conditions are ideal for bacterial growth and contamination, accelerating spoilage.

Considerable improvements can be made by the use of simple hand-washable surfaces for cutting the fish, and by regular washing down of the surfaces with clean water. The fish waste should be disposed of well away from processing areas. Contamination can be reduced if the fish is processed as soon as possible after it has been prepared, provided that it is first washed in clean water to remove any remaining viscera and blood.

If salting vats are used they should be washed out with clean water before refilling. Drying racks and floors should be kept as clean as possible, as should all fish processing areas.

Plate 36 *Demonstration of fish salting.*

BACTERIOLOGICAL CONTAMINATION OF SHRIMP

Many tropical countries now earn much valuable foreign currency by exporting frozen shrimp and prawn. These may be whole or headless, shell-on or peeled, raw or cooked. In all these cases they are very vulnerable to bacteriological contamination. The importing countries have very strict regulations concerning levels of bacteria, and consignments may be rejected if these levels are exceeded. Processing factories must take extreme care in maintaining hygiene. Prawn farmers, fishermen, and everyone else involved must also take great care in keeping everything as clean as they possibly can, using clean containers, clean surfaces, good wash water, and ice made from the cleanest available water.

FINDING MARKETS FOR BY-CATCH

Much of the shrimp trawler by-catch consists of fish which could be sold and used if it could be kept in good condition while being transported to market. The basic problem is its low value, especially in comparison with the shrimp itself. Small shrimp trawlers, operating on short voyages, usually ice the shrimp, but the by-catch is often left to deteriorate. On landing priority is given, inevitably, to the shrimp. By the time the by-catch is taken ashore it may be fit only for use as fish meal, as an animal feed. Large shrimp trawlers have freezer facilities but they keep these for shrimp, and the by-catch is usually dumped overboard.

The huge potential food resource which by-catch represents has long been the subject of concern, and many efforts have been made to use it. In the 1970s particularly, these efforts were concentrated on the development of manufactured products from the by-catch. The plan was that if by-catch could be converted into higher-value products, then it would become profitable for trawlers to retain and land it. Much research was carried out on the use of by-catch in making food products such as fish soups, fish biscuits, etc. Unfortunately, very little came of this research, as there was seldom any commercial uptake of the products in question. There were two main problems. One was technical: the difficulty of producing any manufactured foodstuff from a starting material whose composition varied very substantially from day to day. The other was commercial: the limited consumer acceptance of the products in question. All too often, consumers preferred their soups or biscuits enriched with other types of protein.

The increasing demand for fish in its natural form and shortage of supplies in many areas, are leading progressively to the greater use of by-catch. Where there is a bigger demand for fish, and consumers are prepared to pay more for good quality material, it will be advantageous for trawler operators to retain at least some of the by-catch and keep it in good condition. Individual fishermen or crews find it becomes worthwhile to sort the bigger fish, and the preferred species, and to ice or freeze them. In Gujarat, in north-west India, King (1990) found that much of the by-catch was being iced on board small trawlers, and subsequently sent to cities like Bombay or exported to the Gulf. This practice had increased considerably over only a few years, compared with a study by Bostock in 1987. On the east coast of India, large trawlers making voyages of up to 30 days separate out of the by-catch many of the larger fish and freeze them for sale later in the major cities. In other places the demand for cheap fish for use as a feed for farmed shrimp encourages small trawlers to land by-catch, even in poor condition.

It seems certain that as the demand for fish increases, it will become more profitable to land by-catch and trawler owners will take advantage of this. In some places there may be a 'chicken and egg' problem: trawler owners may not land selected by-catch as no channel exists for distributing and marketing it, but no channel can develop until supplies of by-catch fish become available. One of NRI's current projects in the Bay of Bengal Programme is attempting to resolve this problem, and there may be scope for similar 'catalytic' work elsewhere.

TRAINING THE PEOPLE INVOLVED

Any effective action to reduce losses will depend upon persuading fishermen, fish processors, and others to adopt improved practices. This is seldom easy, as people are understandably reluctant to change long-established customs on which their livelihood depends. It will usually be necessary to demonstrate that improved methods do generate more income. The use of ice boxes on traditional fishing boats (Plate 31) is an example. If a few enterprising people will agree to help, a demonstration can be organized. Then if the new methods really do generate more income, or improve living standards or working conditions, other people will adopt them. The women shown in Plate 35 soon showed enthusiasm for the aluminium containers to take fish to market; with them, they could travel by bus, instead of having to walk many miles with leaky baskets.

Plate 37 *Demonstration of the use of ice and insulated boxes.*

Plate 38 *Publicity materials with concise text and simple pictures. The pictures can be used with a translation of the text in any relevant language.*

Demonstrating the advantages of improved methods will usually need the help of the local fisheries extension service. Training the extension officers themselves is then important. Training aids such as posters and leaflets (Plate 38), which can be translated into local languages can be very important, in disseminating information to the extension officers and the people involved in fisheries production.

Pesticides and cured fish

Pesticides are dangerous things. They are poisons. We use them to poison insects but they could poison us as well. It is obviously sensible not to use them if any alternative exists.

Unfortunately there is at present no other way of controlling blowfly infestation of fish which is being dried. As explained in the text, one insecticide, pirimiphos methyl, can safely be used on fish, under properly controlled conditions. It has been approved by the FAO/WHO Codex Alimentairius for use on various foodstuffs, including fish.

In many countries, fish processors do not know about pirimiphos methyl, or that it is the only pesticide which should be used on fish. They *do* know that blowfly left unchecked would consume much of their fish, that is, their income. Consequently they use on their fish whatever pesticides come to hand, many of which are highly toxic, and should not be used on food.

Because of the dangers of pesticides, and their adverse publicity, some governments have banned the use of pesticides on fish. Making something illegal does not necessarily stop it happening, and the authors have visited countries where blowflies appear to have developed an unexpected and mysterious dislike for fish. Pesticides are banned, and fish processors strenuously deny using them, but there is not a single blowfly on the fish. Or is it that processors *do* use them, when no-one is looking?

If pesticides *are* being used on fish, then it is vital to protect the consumer by making sure that only the safe one is used, and used properly, under the approved conditions.

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