**Advances in post-harvest technology (3Units)**

**FIS 708**

## Course outline

i. Principles of fish preservation and processing
ii. Factors that affect fish spoilage and deterioration of fish
iii. Fish by-products
iv. Methods of assessment of fish quality

## PRINCIPLES OF FISH PRESERVATION AND PROCESSING

In some islands, more fish is caught at times than can be consumed. Methods are used in keeping the surplus fish in good condition for later consumption. Again, fishermen sometimes cannot return to their villages promptly with fresh fish they have caught, and it will be of value to them to know how to preserve their catch by simple means.

## FISH PRESERVATION

Preservation of fish is done to prevent spoilage. Since fish is very perishable, it is therefore, necessary to preserve fish if not consumed or disposed immediately. Fish preservation is the method of extending the shelf life of fish and other fishery products by applying the principles of chemistry, engineering and other branches of science in order to improve the quality of the products.
Preservation methods maintain the quality of fish for a longer period of time. The dictionary meaning of the word “preserve” is to keep safe, retain quality, prevent decomposition or fermentation.

Some of the important reasons for preserving foods are

1. To take care of the excess produce.
2. Reaches areas where the food item is not available
3. Makes transportation and storage of foods easier
4. Preserving Foods at Home

Foods can be preserved at home by the following methods-

(i) Dehydration

(ii) Lowering temperature

(iii) Increasing temperature

(iv) Using preservatives

## PROPER STEPS IN HANDLING FRESH FISH

1. Avoid exposing the fish to sunlight. Keep them in a shaded area.

2. Ice the fish immediately after they are caught to lower their temperature.

3. Remove the gills and internal organs.

4. Avoid soaking the fish too long in the water after death as this easily spoils the fish.

5. Use mechanical refrigeration if there are facilities.

**METHODS OF FISH PRESERVATION**

a. **Salting**

Salt is the preservative agent used to lengthen the shelf life of fish and fishery products. This is used in almost all methods of preservation except in icing, refrigeration and freezing.

There many different kinds of salt, some being better than others for fish curing. However, in islands or in outlying places there is often no choice, and whatever is available in the way of salt has to be used, whether it is bought in a shop, prepared on the spot, or extracted from earth containing salt.
A distinction must be made between the two chief techniques of salting: wet salting and dry salting.
***Wet Salting:*** This is the cheaper, since it requires lesser amounts of salt. The principle is to keep the fish for a long time in brine. The equipment needed consists of a watertight container, which can be a tin, drum, canoe, barrel, etc. To make the brine, one takes four parts of clean water (sea or fresh water) and one part of salt. If the salt is coarse, it has to be ground or pounded first. It is then dissolved into the water by stirring with a piece of wood. To be good, the brine must float a fish.
The next step depends on what kind of fish one wants to salt. It is best first to cut off the head and gut, and clean the fish, though small fish can also be salted whole. Large fish must be cut open, and it is preferable to take out the backbone. Fish with heavy armour of scales must be scaled. In places where the flesh is thick, slashes must be made so that the salted brine can penetrate the flesh. Very large fish should be cut in thin fillets.
After the fish has been prepared according to its size, it must be cleaned and put in the brine. A plank or matting is laid over it and weighted with rocks so that the fish is entirely covered with brine.

This salted fish can be kept for a long time in a dark or at least a shady place. The remaining brine can be used three times, but water and salt must be added every time until a fish can again float on the liquid. In any case, fresh brine is always best.

**Dry Salting**: In this method the fish is salted but the juices, slime and brine are allowed to flow away. Dry salting can be done in an old canoe, or on mats, leaves, boxes, etc. In any case, the brine formed by the fish juices and the salt must be allowed to run away. For two parts of fish, one needs one part of salt.

Layers of fish must be separated by layers of salt. It is a valuable method when one has no containers. This method is used to salt down flying fish in open fishing boats while at sea, and the fish in this case are kept whole.

Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in fresh water before use.

## DRYING AND DEHYDRATION

Drying is the process in which moisture is removed by exposure to natural air current as humidity is regulated by climatic condition. Dehydration is the process of removing moisture with the use of mechanical device that provides artificial heat for drying.

Very small and thin fish can be dried straight away in the sun if they are brought in early enough in the morning (and if, of course, the sun is shining!). If these conditions are not fulfilled the fish must be put for one night in brine, or dry salted. They can then be dried the next morning. If it happens to be raining the next day, it is necessary to wait until the weather has cleared up, which could take from a few hours to a couple of days. In this latter case it will be necessary to wash the salt away from the fish by soaking it in fresh or sea water for a couple of hours before drying it; this depends again on the tastes of the consumers and on the purpose for which the fish is cured.

Small fish are mostly sun dried on mats, or suspended. When it rains the fish must be kept dry by covering or transferring them under shelter. If fish are laid on mats or other material to dry, it is best to turn them over every two hours so that they will dry quickly and not become maggoty. In the case of large fish, hanging is better if they are merely split.

Dry salted fish can also be dried, but they should first be cleaned in water. Normally the fish will be dried after three days. If a great quantity of fish has been dried and is to be kept for some time, the best way is to pile it up in a dark place, off the ground and preferably on wooden boards. It should then be covered with a sack or mat.

After a fortnight the fish should again be laid in the sun for one or two hours and then put away as before.

### Smoking

Any kind of fish can be smoked. There are three main methods of smoking:

(a) Smoking and roasting;

(b) Hot smoking;

(c) Long smoking.

**Smoking and Roasting**: This is a simple method of preservation, for consumption either directly after curing or within twelve hours. Re-smoking and roasting can keep the product in good condition for a further twelve hours. Fresh unsalted fish is put over a wood or coconut husk fire. This should be kept very small and the fish turned over every five minutes. In about half an hour the fish is ready for consumption or, if it is the intention to keep it for a while, it should be put in an aerated container.

Fish can be preserved in this way even in open fishing boats, but the smoking has to be done in a tin or a half-drum. Salted fish can also be smoked by this method, but this is used mostly for immediate consumption or in order to bring the produce in smoked form to a nearby market.

**Hot Smoking**: The hot smoking system can be used for immediate consumption or to keep the fish for a maximum of 48 hours. Small fish can be salted first for half an hour (see wet salting). After salting they are put on iron spits and dried in a windy place or in the sun for another half hour.

It is necessary to have an oil drum to make the smoking stove. The top of the drum is cut out and holes are made 8 inches below the rim to place spits. Near the bottom a rectangular opening is made to control the fire. This opening should be closed with a small door or piece of steel plate. A fire of hardwood or coconut husks is made in the stove, and once it is well started it is regulated so as to give no flames. The fish are then placed over the spits. During the smoking operations the top of the drum must be covered with a sack or with palm fronds laid as close together as possible; the fire control opening should also be closed. The fire must be watched from time to time. The fish will be ready in about one hour. An indication that they are done will be found in the golden yellow colour of the skin.

For big fish, l' to 2 feet long, the best method is to split them in halves, to the right and left of the backbone. Each half fish is fixed between two flat bamboo slats or sticks. These halves are then rested head down on racks built four feet above ground. A number of split fish can be lined up next to each other.

A fire of hardwood or coconut husks, or several separate fires, are then lit under the rack. The number of fires depends on the quantity of fish one has to smoke. There should be a slow fire for about half an hour followed by a brisk one for one hour. A small fire is then kept going for six hours (just smoking).

After this treatment the fish is ready for transport and will keep in good condition for two to three days under tropical conditions. This method is used in particular in the Celebes for skipjack and other tunas.

**Long Smoking**: If fish must be kept in good condition for a long time, for instance, two or three months or even longer, it can be done by smoking, provided the fish is not oily. For this purpose, a small closed shed made of palm leaves or other local material can be used. The dimensions of the shed depend, of course, on the quantities of fish to be smoked, but the height should in no case be less than six feet. In this shed, racks are built to hang the fish from or to lay them upon. Hanging the fish on spits is the best method, but they can also be laid on loosely-woven matting. One can start hanging fish three feet from the bottom up to the roof.

The preservation of fish is effected by smoke only in this method, and it is best to use coconut husks which should burn very slowly so that the fish is dry smoked after 48 hours. After such a treatment the flesh is dried throughout. If it is necessary to transport these fish to other islands, they should be packed in small packages wrapped in dry leaves and reinforced with bamboo or sticks.

**Cooking**

Fish can be kept for two or three days in the following way:

Small drums (possibly oil drums) are cleaned and filled with water. Salt is added in the proportion of four parts water to one of salt. Small oblong or round baskets made of

bamboo or leaves are filled with fish, and as many baskets as possible are put in the drum. Care should be taken that the top baskets are fully covered.

A fire is lit under the drum and the water boiled for about half an hour before the fish is well done. The baskets are then taken out and the water drained off. The fish can then be transported in the baskets. The water may be used three times for cooking, but more water and salt must be added each succeeding time. By evaporating the remaining water over a fire or in the sun, a good sh paste can then be obtained.

Fish can also be cooked in coconut water, but without salt. If there is not enough coconut water available, grated coconut can be added. The fish are put in baskets and cooked as described above. After cooking, the flesh is separated from the bones and is pounded and dried on mats in the sun (when the sun is not shining, the pounded fish can be dried over a fire). For this purpose steel plates, which can be made from flattened drums, are placed over a small fire. Mats of bamboo or other material are laid over the plates and the pounded fish is placed on the mats to dry. Fish cooked in this way should be thoroughly dried. The result is an excellent fish meal suitable for human consumption and retaining an excellent coconut flavour. This meal can be kept for six months in a dry place. It is ready for consumption, but may also be used for fried fish cakes.

## FISH PROCESSING

*Methods of fish processing*

a. Curing

b. Icing

c. Freezing

d. Canning

e. With the use of additives or chemicals

**Fish curing** is defined **as** the method of preserving fish by means of salting, drying, smoking **and** pickling. Fish to be cured are usually first cleaned, scaled, and eviscerated. Fish are salted by packing them between layers of salt or by immersion in brine. The fish most extensively salted are cod, herring, mackerel, and haddock. Small fishes are cured whole with the viscera removed through slits made across the belly. Medium-sized fishes are split through the backbone and top of the head, with the two halves joined by the belly skin, butterfly style.

**Fish canning**: - is a process involving heat treatment of fish in sealed containers made of tin plates, aluminum cans or glass, until the product has been fully sterilized.

During caning, heat treatment should be sufficient to destroy all heat sensitive bacterial and spores, in activate, the enzymes and cook the fish so that the product remains acceptable to the consumer after prolonged storage i.e. commercialized sterilization this is used in thermal

processing to describe the heat treatment designed to kill substantially all microorganisms and spores which is present and cable of growing in the product.

The canned food fish is also prevented from contamination by pathogenic organisms by storing them in a virtually airtight package. If heat treatment is properly carried out canned fish may remain in storage for several years without refrigeration.

Excessive heat treatment or over processing must still be avoided, as this will adversely affect the organoleptic and nutritional quality of the fish. Traditional canned fish are obtained from small pelagic fish species such as herrings (*Clupea spp*), Sardines (*Sardinella sp*), Mackerels (*Scomberomerus sp*), Anchovies (*Engraulis sp*), Tuna (*Thunnus sp*). Bonga (*Ethmalosa sp*).

Fish intended for canning must be in first class condition and must be handle in hygienic manner to reduce microbial load on the fish. Poor quality fish will produce canned fish with offensive odour and flavour, poor texture.

## FACTORS THAT AFFECT FISH SPOILAGE AND DETERIORATION OF FISH

### FISH SPOILAGE

Spoilage is the result of a series of changes brought about in the dead fish mainly due to enzyme and bacterial action. It starts in the fish as soon as the fish dies when caught. In areas where temperature is high, fish spoil within 15-20 hours depending on the specie and the method of capture.

Fish is extremely perishable. It spoils easily.

“Spoilage” can be defined as a change in fish or fish products that renders them less acceptable, unacceptable or unsafe for human consumption. Fish undergoing spoilage has one or more of the following signs: slime formation; discolouration; changes in texture; off-odours; off-flavours and gas production. The development of these spoilage indicators in fish and fish products is due to a combination of microbiological, chemical and enzymatic and physical phenomena

### Microbiological spoilage

Live fish is normally considered to be sterile, but microorganisms are found on all the outer surfaces (skin and gills) and in the alimentary tract of live and newly caught fish in varying numbers. A normal range of 102-107 cfu (colony forming units)/cm2 on the skin and between 103 and 109 cfu/g in the gills and intestines has been observed. When fish dies, its entire body resistance mechanisms breakdown, giving way to microorganisms or the enzymes they secrete to invade or diffuse into the flesh where they react with the complex mixture of natural substances present. During storage a characteristic flora develops, but only a part of this flora, known as the specific spoilage organisms (SSO), contribute to spoilage. The SSO counts reach a minimal spoilage level where the fish is sensorially rejected

*Pseudomonas* and *Altermonas putrefaciens* are probably the major bacterial species that cause fundamental spoilage of usually iced fish. These can use the non-protein nitrogen compounds present in the fish such as trimethyl amine oxide (TMAO) that result in

several volatile odoriferous compounds such as trimethyl amine oxide, TMA. These volatile compounds are responsible for the off-odours and off-flavours characteristic of spoiled fish.

Microbiological quality evaluation of fish aims to quantify the hygienic quality of fish, including temperature abuse and the possible presence of pathogenic microorganisms in the fish. Total aerobic bacteria, also called total plate count (TPC); specific spoilage organisms (SSO) and various pathogenic bacteria are examined using appropriate agar media. Quality levels are based on the plate counts for acceptance or rejection of fishery products for human consumption. With representative sample units not less than five, plate counts below 5105 are considered of good quality; between 7510105andmarginally accepted quality (sample units with plate counts between 5105and 107 not exceeding three) and plate counts at or above 107 are considered unacceptable in quality.

**Chemical oxidation**

Chemical spoilage processes are changes taking place in the lipid fraction of the fish. Lipids are oxidised to peroxides, aldehydes, ketones and lower aliphatic acids. The hydro-peroxides are tasteless but can cause brown and yellow discolouration of the fish tissue. The degradation of hydro-peroxides gives rise to the formation of aldehydes and ketones that result in rancid off-flavours. All the chemical by-products eventually reach a level where the fish is rejected

High temperatures are partly responsible for the speed of the oxidation processes. In addition, direct sunlight, wind, heat, light (especially UV-light) and several organic and inorganic substances may also accelerate oxidative processes. Living cells in fish have enzymatic protection mechanisms against lipid oxidation by having an enzyme, glutathione peroxidase, which acts by reducing hydro-peroxides in cellular membranes to corresponding hydroxyl-compounds. This reaction requires a supply of the enzyme in a reduced form and thus the reaction stops when the fish die.

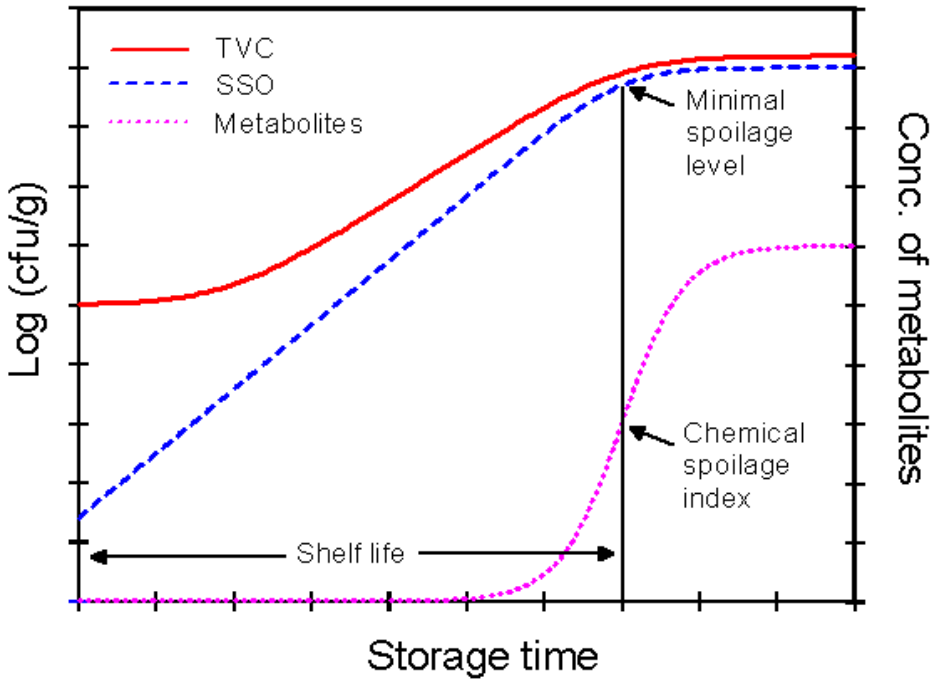


Figure 1: General pattern of microbial spoilage changes in total viable count (TVC), specific spoilage organisms (SSO), and chemical spoilage indices during chilled storage of a fish product (adapted from Dalgaard 1993).

**Autolytic spoilage**

As fish dies, its enzymatic activity doesn't stop immediately but continues resulting in proteolytic changes that are responsible for early quality loss in fresh fish. The more these enzymes get in contact with the fish's flesh the greater the spoilage. Adenosine triphosphate (ATP) is broken down through a series of products such as adenosine diphosphate (ADP), inosine monophosphate (IMP), inosine and hypoxanthine (HX). IMP and HX may be responsible for the sweet and mild tastes in the later stages of shelf life and these products accumulate especially when the respective step is rate-limiting (Regenstein and Regenstein 1991). From previous studies, these changes precede microbiological spoilage and have been seen to contribute very little to spoilage of chilled fish and fish products (Huss 1994).

**HOW TO PREVENT SPOILAGE**

Since bacterial spoilage takes place in certain conditions, changing these conditions can prevent and reduce spoilage. Heat, concentration and pH (acids) can be used for these purposes.

Fish preservation prevents spoilage. It also makes the transportation of preserved fish easier besides the fact that preserved fish is a good source of protein.

**Bacteria Spoilage**

Some bacteria are naturally present in the living fish but their multiplication and growth is limited by the general metabolic reactions of the fish (low pH of gut, anaerobic environment on the gut and its enzymes, acid in the viscera which often digest the bacteria and cause the gut condition to be favourable for their growth). When a fish dies, these metabolic actions are slowed down and micro-organisms begin to multiply. The bacteria lining the gills penetrate the flesh and the vascular system. Those lining the gut penetrate the nearby tissues through the peritorieuna. Bacteria in the slime penetrate the skin into the surrounding tissues. The powerful gut thus giving way for bacteria to enter into the tissues. These bacteria secrete digestive juices and enzymes which breakdown the tissues and cause spoilage of the fish. The end result of microbial invasion of the tissues is the loss of fresh flavour and odour of the fish replacing it with a sour and stale odour which changes to ammoniacal, putrid and faecal odour at the later stage of spoilage.

The initial elastic texture of the fish change to softer flesh with grittiness making the fish exceedingly soft flabby retaining finger identifications in the skin. The flesh of such spoilt fish is later torn from the backbone (unfit for human consumption and must be discarded, downgraded for the production of animal feed supplements).an economic loss hence minimize fish spoilage through better fish handling of fresh fish.

**ENZYMATIC SPOILAGE**

Enzymes are high molecular weight metabolic catalysts, protein in nature and are needed in small quantities. They operate in their native forms and become denatured when conditions become unfavourable. Temperature, acidity, substrate concentration, enzyme activation and synchronization affect enzyme activities.

Enzyme spoilage is known as AUTOLYSIS i.e. self digestion. It is a process whereby enzymes against which the fish is normally protected alive, under optimal conditions for enzymatic activity, post mortem, digest the fish tissues such enzymes are present in the gut, on the skin and in the tissue. Autolysis causes off-odours, off-flavour and softening of flesh and tissues. It causes general disruption and permission of movements of enzymes and oxygen in the muscle. Such enzymes include cathepsins and proteolytic enzymes. They make the fish unpalatable, unattractive and unfit for consumption. Gutting should be carefully and thoroughly done and belly cavity thoroughly washed (Athepsin in fish is more active in fish than in meat hence autolysis is faster in fish).

The breakdown of amino acids (lysine, histidine and) into toxic compounds such as cadaverine and $co_2$, histamine and $co_2$and putrescine and $co_2$ respectively is undesirable to consumer. Shell fish spoil faster than true fish due to higher content of non- protein N-compounds such as Arginine phosphate. Japanese allow these breakdown and use such for fish sauce and fish silage for delicacy in Japan.

**FACTORS THAT INFLUENCE THE RATE OF FISH SPOILAGE**

1. **Effects of time/temperature conditions on microbial growth**

The most crucial factors determining the quality of fishery products are time and temperature tolerance. Proliferation of microorganisms requires appropriate high temperatures, while at lower temperatures close to 0ºC, their activity is reduced, thereby extending the shelf life of fish products. Temperature is the single most important factor affecting post-harvest quality of the products. It is often critical to reach the desired short-term storage temperature rapidly to maintain the highest visual quality, flavour, texture, and nutritional content of fresh fish. The rate of spoilage is dependent upon the holding temperature and is greatly accelerated at higher temperatures, due to increased bacterial action. The shelf life at different storage temperatures (t°C) has been expressed by the relative rate of spoilage (RRS), defined by the equation

## 2. Effects of hygiene on fish quality during handling

Apart from the microorganisms that fishes have at the time of capture, more is added via unhygienic practices and contaminated equipment such as storage facilities. This was demonstrated by studies that compared the quality and storage life of completely aseptically treated fish (aseptic handling), washed fish, iced in clean plastic boxes, with clean ice (clean handling) and with un-washed fish, iced in old, dirty wooden boxes (normal handling). A considerable difference was found in the bacterial contamination of the three batches, the latter heavily contaminated with a reduction in storage life compared with the other samples. The design of a fish hold is of great importance as far as hygiene in the hold is concerned. Hold design should enable the purge (drip loss) to be collected easily. The amount of purge was suggested to be higher at 5-7ºC; at which temperature there is greater spoilage since the purge is a very good medium for bacterial growth.

## 3. Rough handling

Rough handling will result in a faster spoilage rate. This is due to the physical damage to the fish, resulting in easy access for enzymes and spoilage bacteria. Physical mishandling in the net, such as very large catches, fishermen stepping on fish or throwing boxes, containers and other items on top of the fish, may cause bruises and rupture of blood vessels.

When fish is in rigor mortis (a complicated series of chemical changes that result in stiffening of the fish's muscle shortly after death), rough handling can cause gaping.

## 4. Initial bacterial load

The microflora on tropical fish often carries a slightly higher load of Gram-positives and enteric bacteria but otherwise is similar to the flora on temperate-water fish. Basically, bacteria populations on temperate fish are predominantly psychrotrophic reflecting water temperatures of about 10oC while fish from the tropics have largely mesophilic bacteria.

## 5. Methods of capture

The fishing gear and method employed determines the time taken between capture and death. Fish caught in gillnets struggle much to escape, and in so doing, they are bruised by the net which increases exposure to microbial entry and subsequent deterioration. Fish caught by hook and line methods, on the other hand, die relatively quickly and therefore bruises and stresses are likely to be minimal. Physical mishandling in the net due to long trawling nets and very large catches accelerates spoilage. The large catches in the net are compacted against each other resulting in the fish getting bruised and crushed (especially small sized fish) by the heavy trawl net.

## 6. Mode of storage

In bulk-storage, the weight of the pile may crush the fish at the bottom, leading to a loss of weight (yield) as well as other physical damage. It has been reported that when haddock is kept in a short, deep pile of about 3 ft, the bottom fish lose 15% of their weight compared to a normal weight loss of 3-8%, which is entirely due to biochemical changes that cause a loss of water holding capacity leading to drip. Crushing of the fish by ice or other fish can seriously affect the quality of fish by releasing enzymes from the gut into the fish muscle thereby accelerating autolytic processes.

Further Reading:


1. Fish Processing Technology in the Tropics by Andrew A . Eyo pages 37, 104-153, 213 -297 , and 347.

2. Hand book of Practical Fisheries Technology by Olokor .J.O et al pages 1-21, 22-34

3.Take care of your catch by Torry Advisory Note No.4

4. The care of the fish monger's fish by G.H.O.Burgess Torry Advisory Note No.1

5.The Handling of wet fish during distribution by Torry Advisory Note No. 3.

6.Some notes on Fish Handling And Processing by J. Horne Torry Advissory Note No. 50.

7. The freshwater fishes of Nigeria by E.A Adesulu and D.H.J Sydenham pages 322-331.

8.Cleaning in the fish industry by I .N. Tatterson and M.L Windsor .Torry Advisory Note No.45.

9.Catching , Handling and Processing Crabs by E Edwards and J. .C Early Torry Advisory Note No. 26.

10. Which kind of ice is best? By J.J. Waterman Torry ADVISORY Note No. 21.

11.Handling and processing oysters by G. D Stroud .Torry Advisory Note No. 84.

12. Quality control in the fish industry by J.J. Connell . Torry Advisory Note No 58.