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# Seafood Handling

By

**Tony Chamberlain**  
**Gabriel Titili**

With contributions from

**Lyn Lambeth**

Community Fisheries Training Pacific Series 5

USP Marine Studies Programme / SPC Coastal Fisheries Programme:  
Training Materials for Pacific Community Fisheries



The University of the South Pacific



Secretariat of the Pacific Community

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NZODA



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## Preface to the Series

The majority of Pacific Island countries rely on the sea as a major source of food. While women are not involved in offshore deep sea fishing, they are active in collecting and gleaning shellfish and other edible sea species from the nearshore areas and inside the reef. Women also prepare fish either for sale or home consumption. In this preparation process, women are involved in cleaning, gutting, cooking and selling various seafoods. In many atoll countries, women are also involved in the preservation of seafood by drying or smoking. In view of women's role in fisheries activities and the importance of seafood in the region, it is vital that women learn not only the correct handling methods for seafood, but also how to use marine resources wisely for the future.

This manual is part of the Community Fisheries Training Series, and is designed to meet the wide need for community fisheries training in the Pacific, particularly for women. The series was originally developed for the SPC Community Education Training Centre (CETC). The fisheries course at CETC began in 1999 as a joint effort with the USP Marine Studies Programme. It was a response by the Centre to meet the needs of women in the region to improve their skills in small-scale fisheries activities. The USP Post Harvest Fisheries Project was also working to provide post harvest fisheries training for men and women in the region hence the joint venture between the two institutions in 1999. The two groups of women who have since been through the course have found the training interesting and useful.

Since its inception in 1999, the course has been taught jointly by the USP Marine Studies Programme staff in Fiji Islands and the SPC Community Fisheries Section staff based in New Caledonia. Funding has come from Canada, New Zealand and Australia and the International Ocean Institute-Pacific Islands.

I wish to acknowledge the assistance of and major contribution by Tony Chamberlain, Lecturer of the USP Marine Studies Programme/Post Harvest Fisheries Project; Patricia Tuara, previous SPC Community Fisheries Adviser; Lyn Lambeth, SPC Community Fisheries Officer and other trainers in previous years.

I am grateful to the Marine Studies Programme technical staff who have given their time to training women and also the USP for facilities and equipment used during the course. I acknowledge Dr Jimmie Rodgers, Senior Deputy Director-General of SPC in Suva and the SPC Management for supporting CETC, by providing facilities and resources towards the implementation of the Fisheries course. We hope you enjoy this manual in the series.

Best wishes for a successful fisheries training programme.

Nu'ufou Petaia  
Principal  
SPC Community Education Training Centre (CETC) Narere, Fiji Islands  
March 2001.

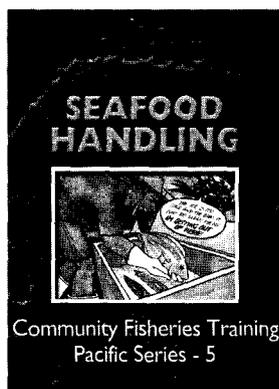
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# Seafood Handling:

Community Fisheries Training - Pacific Series 5



## How to use this book

This book is divided into three chapters: Chapter One looks at good fish handling practices; Chapter Two examines the handling chain and what happens along the chain, from capture to consumption; and Chapter Three looks at freezing fish and the storage of frozen fish. A series of Activities, Discussion and Demonstration suggestions are included in each chapter to encourage further exploration of the subject. The Objectives listed below may serve as a guide for learning.

## Objectives

After reading this book and completing the exercises you should be able to:

1. Explain the four rules of good fish handling practices;
2. Describe the steps involved in properly cleaning areas and equipment used to process, prepare or store seafood;
3. Know the critical steps of the handling chain to maintain fish freshness and quality;
4. Know how to make a simple insulated container;
5. Know how to choose a fresh fish;
6. Know how to identify critical points in handling and selling fish, and how to eliminate or reduce the risks presented at these points;
7. Describe the cold chain and its importance in maintaining fish quality; and
8. Know how to freeze and cold-store fish properly.



*Kiribati: Selling fish.*



*Suva market: Fish seller.*



*Honiara: Women selling skipjack.*

# Chapter One - Fish Handling

## Introduction

As a food, fish has always been important to people of the Pacific. It is nutritious, high in protein and helps bodies grow and stay healthy. It also provides employment and brings valuable foreign exchange to island countries.

Fresh fish is the most nutritious form of fish and the most sought after by local and international markets. Fresh fish is also a valuable raw material necessary for manufacturing safe, high-quality food products.

The reasons for fishing are, however, changing. Selling fish, rather than just fishing for home consumption, is becoming an increasingly important business in many countries. Along with the benefits of this business come a few problems: fresh fish must be protected from damage by poor handling practices, and from contamination by dirt and bacteria; the rate of spoilage must be controlled; transport to market must be quick and efficient; and post-harvest losses must be reduced.

Ensuring a safe, high quality product and making fair profits do not happen by accident, but occur through careful handling from capture to market.

## Challenges for small-scale fisheries in the Pacific

Understanding proper fish handling is vital to the many people involved in small-scale fisheries in the Pacific.

Success of those involved in fisheries activities is hampered by poorly maintained boats, lack of proper fish handling practices (on board and onshore), inadequate ice usage, and irregular shipping, which prevents the catch from easily reaching the market. All of these factors reduce the supply of fish to domestic markets. Meanwhile, strict foreign import regulations make it harder for small-scale suppliers to take advantage of export markets.

For example, the European Economic Union (EEU) demands that imports from non-EEU countries be subject to the same sanitary conditions as for European processors. Inspection services must also satisfy European standards of organisation and efficiency. Likewise, the United States Food and Drug Administration will only certify offshore processors when individual fish processing plants meet US standards, and when an acceptable, countrywide inspection system is in place.

Given the lack of awareness programs and shortage of technical expertise, Pacific fisheries face losing out on many economic opportunities. Appreciating customer requirements and obtaining practical training are the first steps toward developing an improved fishing industry.

## Understanding quality and freshness

Most people do not enjoy a fish that has soft flesh, slimy skin, cloudy eyes, discoloured gills or a foul odour. Carefully handled fish will keep longer and look fresher than poorly handled fish. This is important because fish that look fresh will generally:

- taste better;
- be healthier for you;
- be less likely to make you sick; and
- fetch a higher market price.

Better care means handling your fish as if you were handling a baby. It also means keeping fish and fishing gear clean, ensuring that fish are cooled quickly and stay cool, transporting fish quickly, and using fish soon after they are caught. Your family and your customers will notice the difference. Good handling practices result in providing consumers with the best quality product, and are especially important if fish is to be preserved or processed. If you start with a poor quality fish, you end up with a poor quality preserved or processed product.

Good handling means avoiding conditions that accelerate spoilage, introducing procedures that slow spoilage, and reducing **contamination** by spoilage agents such as **bacteria**. To accomplish this, it is necessary to follow the four rules of good handling.

## Four rules of fish handling

There are four important things to remember when handling fish:

- care;
- cool;
- clean;
- quick.



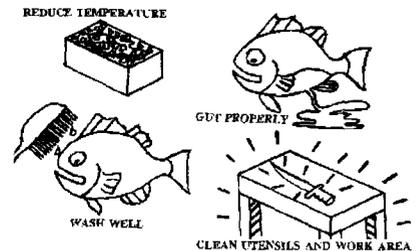
Fiji: Smelling snapper.



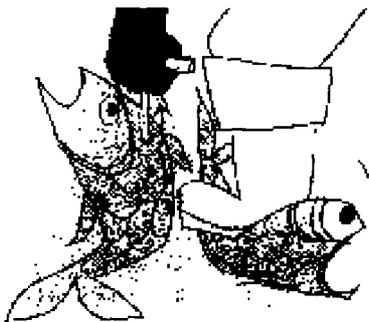
Suva: Inspecting fish gills.



Handle fish carefully.



Rules of handling.



Avoid rough handling.



Kiribati: Fish on ice.

### Care

Fish go bad quickly if they are bruised or the flesh is torn. Spoilage is hastened by mishandling that: bruises the flesh, splits the skin or bursts the gut. Fish should be handled with care at all times.

### Cool

In warm temperatures, bacteria and **enzymes** are more active and cause fish to spoil faster. Temperature control should be used to reduce bacteria and enzyme activity. Failure to keep fish cool immediately after capture means fish will spoil sooner and may make people eating them sick. Simple methods of cooling fish include keeping it wet or shaded with wet sacking. More effective methods involve icing, keeping the fish in chilled seawater or freezing. Icing and chilling are discussed in Chapter Two, and freezing is covered in Chapter Three.

Keep the fish cool as much as you can. The best method to keep fish “market fresh” is to chill them in an insulated ice box on board the boat. As soon as the fish has been gutted, gilled and cleaned inside and out, put the fish in the ice box.

Even without ice, it helps to keep the catch covered and out of the sun. Wet leaves or wet hessian bags can be used.



Keep fish cool on the boat.

### Clean

Contamination is caused by bacteria and dirt. Common sources of contamination are:

- bacteria in the gills, gut or body surface;
- bacteria and dirt from the surrounding environment; and
- bacteria from dirty equipment and people.

Fish and work surfaces must be kept clean. Fish guts and rotting flesh must be kept away from fresh fish. Any part of the boat or landing facility that comes in contact with fish should be thoroughly washed after each catch. Fish should not be placed on the ground.

Cross contamination occurs when clean or uninfected food comes in contact with dirty or infected food, and is especially a problem when cooked food comes into contact with raw food. Cross contamination can be minimised by observing the following procedures:

- use clean water for washing fish;
- use clean ice for cooling fish;
- use clean containers for keeping fish;
- keep fish iced and covered;
- do not put ice or fish on the floor;
- do not mix raw food with cooked food;
- keep working premises clean; and
- keep yourself clean.

Fish are contaminated by bacteria when they come into contact with:

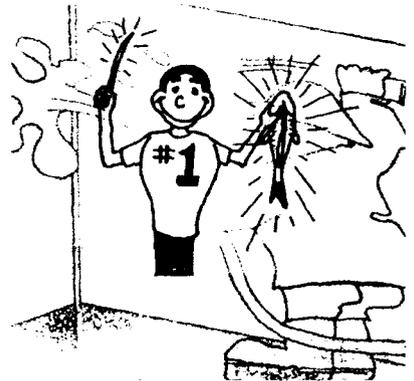
- fish and fish guts;
- uncleaned tables, floors, bins, knives;
- hands or runny noses;
- clothes;
- flies, cockroaches; and
- dogs, cats, rats, birds.

Keep food wrapped or covered. Keep equipment clean and use a clean garbage bin. If you are planning to sell your fish, good food **hygiene** is essential to protect consumers' health. The fish seller must meet certain quality and cleanliness standards to ensure that the customer is provided with a good service.

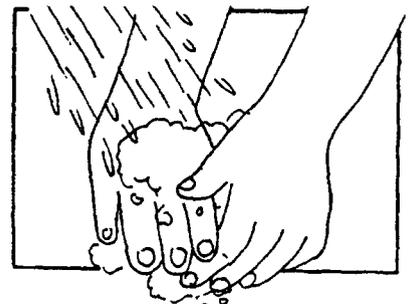
*Food hygiene is a set of required measures to guarantee the cleanliness, quality and purity of the food item in all its phases: production or harvesting, processing and consumption.*

It is also important to keep yourself clean. Always wash your hands after:

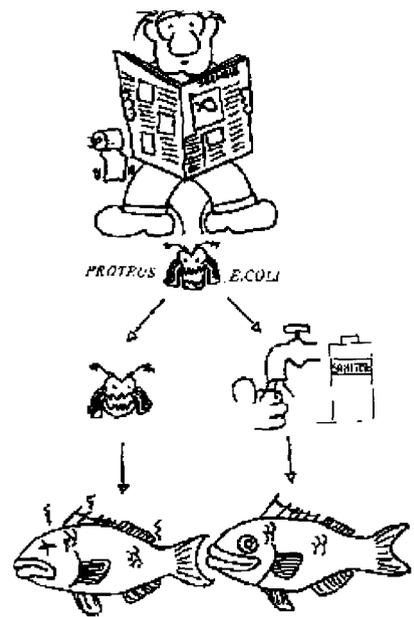
- handling raw food;
- touching your face;
- handling animals or garbage;
- cleaning the baby; and
- going to the toilet.



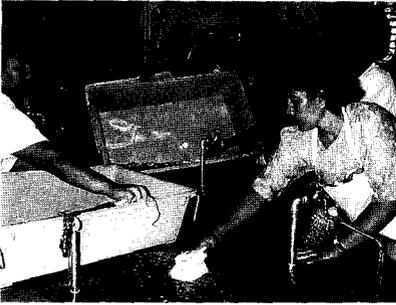
Good handler.



Wash hands correctly.



Wash hands after toilet.



Trainees do a clean up.

Clean-up - you need the right materials and methods to properly clean up areas and equipment used to process, prepare or store seafood. Remember to:

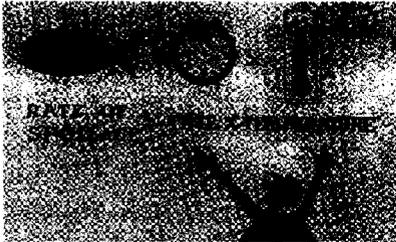
1. rinse with water;
2. wash with detergent;
3. rinse with water;
4. disinfect with sanitiser; and
5. rinse with water.

Detergents loosen and help remove dirt, fish slime and blood, while a sanitiser kills germs. Both should be safe to use in food preparation areas.

Don't forget the scrubbing brush and always use clean water!

### Quick

Under the right conditions, bacteria and enzymes work very fast in causing fish to spoil. The catch must be moved and cooled quickly. Bacteria grow exponentially, increasing in number very quickly after an initial slow period. Exposure to warm temperatures must be minimised to reduce bacterial growth. Fish must be quickly gutted, cleaned and covered. If salting or drying, salt the catch soon after landing.



Spoilage can occur quickly.

### Activity

1. Answer with a tick or cross:

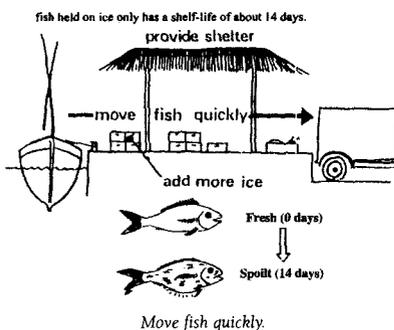
When handling fish:

- use clean water to wash fish;
- use clean bins for keeping fish;
- cover fish to protect from flies;
- keep raw and cooked fish in the same place;
- keep fish equipment clean;
- wash hands before and after handling.

2. Think: what areas or practices in your home could cause fish to become contaminated?
3. Think: how do you clean your knives, boards and bins, and is this enough to prevent contamination of the fish?

### Activity

1. What factors work together to make fish go bad?
2. How can you improve the way you handle fish?



Good Fish Handling Practices		
Problem	Example	Prevention
Bruised flesh	Someone throws or stands on the fish	Treat fish with care so that it is never bruised
Belly burst	The fish has been stored ungutted at warm temperatures	Keep fish cool and remove guts as soon as possible
Contamination	The fresh fish is placed on the ground next to rotting fish guts  The filleter did not clean his hands after going to the toilet	Keep the fish clean; anyone handling the fish should keep themselves clean
Putrefaction (rotting or decay)	The fish has been left in the sun and is starting to smell	Keep the fish cool. Cover it with a wet net or cloth  Chill fish with ice, refrigerate or freeze as soon as possible after capture, preferably immediately after it is taken from the water
Post rigor	The fish has reached and passed rigor mortis (where it becomes stiff) before being chilled or frozen	Chill the fish with ice, refrigerate or freeze as soon as possible after capture, preferably before it goes stiff

## Sashimi

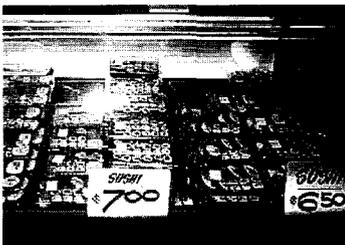
Sashimi presents a classic example of good fish handling practices. The term has come to be associated with raw seafood eaten by the Japanese.

Sashimi is not just food, but refers to an eating experience, which includes appearance, freshness, presentation, texture and flavour. The handling of sashimi is extremely important, not merely to reduce spoilage of the fish, but to maintain its quality.

The market for sashimi-grade seafood is large and profitable because the Japanese are willing to pay high prices for a top quality product. To obtain the best possible price, it has been necessary to change fishing methods, improve on-board handling practices, improve chilling techniques, improve packaging, and make use of air freighting.



Tivalu: Yellowfin tuna.



Sydney: Sushi bar.



USP student rolling sushi.



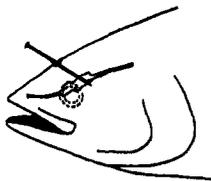
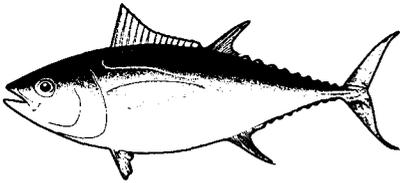
Fiji: Slicing sashimi.

The Japanese consume a large variety of fish as sashimi and are willing to taste new species. Some fish, while not suitable for sashimi due to their small size or irregular shape, are consumed as **sushi**. Cuts from these fish are placed raw on sushi rice.

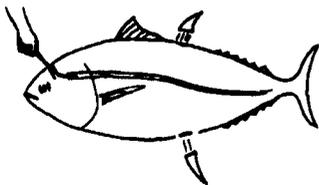
### Characteristics

Characteristics of a premium sashimi tuna are:

- weighs more than 30 kg;
- especially round (provides more meat);
- flesh is particular shades of red or pink; and
- flesh has a high fat content.



*Spiking.*



*Destroying spinal cord.*

### On-board processing

Sashimi-grade tuna must be handled and chilled in a particular way to meet the exacting standards of the Japanese fresh tuna market. Various techniques for certain stages of the handling process exist and different buyers may have different requirements. Essentially, the handling follows the procedures of the four good fish handling practices described earlier—care, cool, clean and quick—and results in the best possible quality product for the market.

Sashimi-grade tuna must be landed carefully and quickly. A gaff is placed only in the head to avoid damaging the flesh. Fish must be landed on a soft, washable carpet or rubber mat to avoid bruising, and gloves should be worn when handling the tuna. Using a fish club, the fish should be stunned with a sharp blow to the top of the head, between the eyes. This will avoid violent flapping, damage and subsequent lowering of the value of the tuna.

Next, a spike is inserted 3 to 4 cm deep into the soft spot between the eyes; if the brain is penetrated the fish will go rigid before relaxing. A further procedure for sashimi-grade tuna is to expose the brain by cutting out a small piece of flesh just above the soft spot, then inserting a length of rigid monofilament nylon. This is pushed as far as possible into the neural canal to destroy the spinal cord. This procedure slows down the processes that cause the flesh to deteriorate and produces a higher grade tuna.

The fish is bled immediately after killing by making a cut behind the pectoral fin in each side of the fish, and in the membrane between the gill collar and the gills. The gills and guts are then removed with a technique particular to the sashimi tuna market. The fish is carefully cleaned and placed in a slurry of crushed ice and seawater, or packed immediately in ice.

Species suitable for sashimi and sushi:

Sashimi		Sushi
RED MEAT SPECIES	WHITE MEAT SPECIES	
Bluefin Tuna	Sea Bream (snapper)	Garfish
Bigeye Tuna	Flounder	Jack Mackerel
Yellowfin Tuna	Sea Bass	Blue Mackerel
Skipjack Tuna *	Amberjack	Young Sea Bream
Striped Marlin	Yellow Tail Kingfish	
Swordfish	Whiting	
Blue Marlin	Some Trevallies	

\* Skipjack tuna is used for sashimi but is not regarded as a substitute for other tuna due to its distinct flavour.

# Chapter Two - Along the Handling Chain

## Introduction

The handling chain includes all the factors that affect seafood, from capture to consumption. How a fish is handled and what happens to it along the way will greatly affect its freshness and quality. The four rules of good fish handling practices discussed in Chapter One are only effective if they are practised by each person handling the fish along the chain. Every time the fish is exposed to poor handling practices or unclean conditions, the damage done is irreversible.

The handling chain begins on the reef or on the boat, where the fish or other marine product is caught or collected. The chain also involves the seafood arriving in the village, transport and distribution to market, and finally selling the fish.

## On the reef

### Shellfish

Make sure shellfish come from clean places. The **germs** from sewage or drains can be ingested by the shellfish and can cause food poisoning. Some parts of bays or lagoons do not have clean shellfish because of the rubbish and human waste that is thrown into the sea.

When harvesting shellfish keep the following points in mind:

1. Shellfish must be alive.
2. If a shellfish is kept for a few hours before eating or selling, it must be kept in a very cool and damp place.
3. Shellfish must be cleaned and washed well to remove all dirt and sand.
4. Shellfish collected from places near towns and villages must be cooked, and should never be eaten raw. Eating raw shellfish gathered from dirty areas can cause sickness.

### Freshwater mussels

Freshwater mussels must be cooked. They cannot be eaten raw.

Mussels should be put in a bucket of fresh water and left for a day (at least) before cooking. This allows the shellfish to get rid of mud and sand. Change the water daily. Mussels may be kept like this for 4-5 days.



*Samoa: Shellfish from clean water.*



*Fiji: Fresh water mussels.*

**Seawater mussels**

This variety of mussel can be eaten raw or cooked.

Preparing seawater mussels:

1. Check to see that all mussels are fresh and alive.
2. Pour boiling water over shells and leave until they start to open. This makes it easier to open the shell and remove the flesh.
3. Insert a knife into the shell opening and force the shell apart.
4. Remove the flesh and wash well to remove sand.
5. Remove the brown hairy part with a sharp knife and wash well.

**Prawns**

Prawns spoil quickly and require careful handling. They lose fluid rapidly, which reduces their nutrient value and taste. They can be chilled to the core very quickly if ice is applied immediately after harvesting.

1. Prawns must be used or frozen immediately. They go bad very quickly soon after they are out of the water.
2. Sea and freshwater prawns are found in most parts of the Pacific.
3. Choose large prawns with well filled tails.
4. Check carefully to see that all prawns are fresh.

**Crabs and lobsters**

Two commonly eaten crabs in the Pacific are the mangrove crab and land crab. In many parts of the Pacific coconut crabs are considered a delicacy. The amount of flesh in the crab varies according to season, sex and type. In general, female crabs have more flesh than male crabs and crabs have less flesh immediately following moulting.

When storing mangrove crabs, wrap the bundle of crabs tightly in a damp cloth. This will keep the crabs alive for a week. The cloth must be kept damp. If you have a freezer, cook them and keep them in the freezer.

When storing land crabs, put the crabs in a large tin or container with leaves. Cover tightly to keep them from crawling out. The containers must have air holes. This will keep crabs alive for a few days. If you have a freezer, cook the crabs, then cool them and place in plastic bags before putting them in the freezer.

Two types of lobsters are commonly found: sea lobster (or crayfish) and the mangrove lobster. Lobsters can be prepared in the same way as crabs.



*Fiji: Digging shellfish from the sand.*



*Tonga: Lobsters.*



*Palau: Crabs.*



*Lobster.*



*Fiji: Seagrape harvesting.*

### Sea plants

Most Pacific people eat a variety of sea plants. They are a healthy addition to the diet and provide colour and variety to a meal.

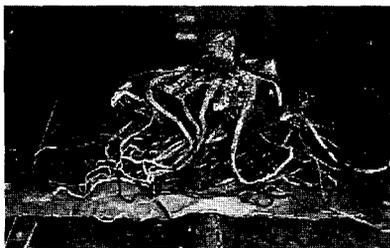
**Sea grapes** - are a green seaweed with many tiny lumps or bubbles on its stems. Clean thoroughly to remove all dirt and sand by washing several times in clean seawater. It is a good idea to leave the sea grapes soaking in a basin of seawater for about half an hour before cleaning. This helps remove sand.

**Maidenhair** - is used to make jellies. Sort by picking and using the clean strands and throwing away dirty ones and other foreign matter. Wash thoroughly to remove sand and dirt before cooking.

**Glassweed** - is coarse with thin brown, hair-like strands. Clean thoroughly to remove all dirt and sand. Pour boiling water over it so that it is completely covered and leave for five to ten minutes. Drain well.

### Octopus and squid

Octopus is eaten throughout the Pacific, although some countries have some beliefs or taboos about this food.



*Tonga: Dried octopus.*

Squid is similar to octopus in its preparation and food value. Squid flesh begins to deteriorate and discolour immediately after it is caught. The change in skin colour does not affect the taste of the squid, although it is an important indicator of freshness. Squid are extremely delicate as they lack the support structure of a rigid bony skeleton. It is important to avoid damaging the fragile mantle or crushing the squid, as organ rupture will result in spoilage.

Freshness of the squid is, as with all seafood, the most important requirement whether for sale or home use. Correct handling and rapid chilling help to:

- limit contact with warm air;
- limit contact with dirty surfaces;
- rapidly chill or freeze; and
- minimise physical damage.

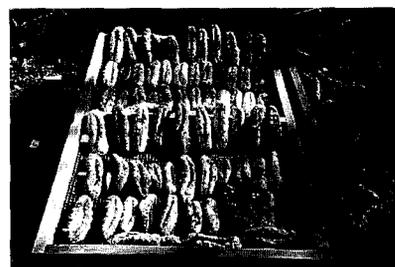
Maintaining quality and freshness begins with capture. Squid should spend no more than 30 minutes at **ambient temperature** before being chilled or frozen. When squid is caught commercially, a variety of systems are used, including icing, chilled seawater and freezing.



*Tonga: Wet octopus.*

## Sea cucumbers

There are many types of sea cucumbers (**beche-de-mer**). Some are found in deep water on clean sand in reef passages, others are found in shallow water on sand or sea grass. Some are gathered, preserved and sold overseas and others are used as food. High prices for exported sea cucumbers has in some cases contributed to dangerous fishing practices. Diving for sea cucumbers can be very dangerous if you use hookah equipment and dive too deep and for too long.



Tonga: Beche-de-mer drying.

## Sea urchin

In general, sea urchins live in shallow water near rocky coasts. They are slow, but mobile, using special tube feet to move along the bottom and climb vertical surfaces.

Handle the urchin carefully as the spines can injure the hand. Open the urchin by using a pair of scissors, knife or by biting the shell. Cut open the urchin horizontally around the middle and shake out the viscera. You will see the star-shaped **gonad** or **roe** attached to the top section of the shell. This edible portion of the sea urchin is found in the roof of both the male and female urchins. The gonad is the sea urchin's source of eggs or sperm and is largest just before spawning.

The brightly coloured roe (yellow, orange, pink) can be scooped out with a spoon. For commercially collected sea urchins, the roe is graded by colour, with bright orange the most desirable. It is eaten raw with a drop of lemon juice or soy sauce. There is a textural difference between the female and male roe with the female roe producing more egg-like material while the male roe has a finer texture. The amount of roe found in a sea urchin will vary from species to species and the stage of development of the roe. It may take up to a dozen urchins to provide enough roe to serve one person.



Tonga: Sea urchin.

## On the fishing boat

How your fish looks on the dinner plate or in the market stall depends very much upon how it has been handled before arriving at the village or market. The boat should be cleaned before and after a fishing trip. Use soap and clean water to wash the fishing boat and all fish containers.

Captured fish may be killed quickly by hitting them on the head with a hardwood stick. Hitting a fish on any other part of its body will damage the flesh and cause it to spoil more quickly.

Remove the guts and wash the inside of the fish with clean seawater. Avoid dropping any stomach waste on top of the catch as bacteria and digestive juices can cause the other fish to spoil quickly.



Keep the fishing boat clean.



Washing fish.



Yasawas, Fiji: Catch kept cool under palm leaves.



Fish stored improperly on uncrushed block ice.

*Good Idea: Do not throw fish guts away. Instead, if you have room, keep them in a covered container on the fishing boat. Remember not to let any of your fish come into contact with the guts. The guts can be boiled later - along with cassava, potato, yam or taro - and fed to pigs. You can even add some sea plants to make the feed even more nutritious.*

### Keeping the catch cool

Sometimes fishers who collect shells, crabs, sea urchins and sea vegetables from reefs and mangroves leave them in the open sun for long periods of time. Often this is due to a lack of understanding of the effects of high temperatures on fish spoilage and quality. Your catch will stay fresh longer if protected from direct sunlight. Cover it with shrubs, pandanus leaves or tree branches.

Offshore fishers should use copra sacks or coconut palms to shade their fish. Sprinkling seawater over the sacks now and then helps keep the fish cool.

Fishers who are at sea for more than one day need to carry ice. The best ice for cooling fish is flake ice, which is made of small pieces and does not damage the fish. Flake ice completely surrounds fish flesh, and so does a better job of cooling.

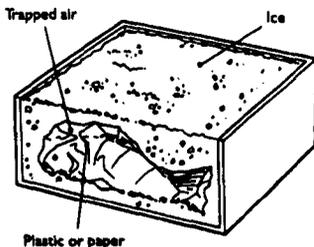
Some fishers prefer to carry large pieces of block ice on long trips because it melts more slowly. However, block ice has sharp edges on the heavy pieces that can damage fish; and it does not pack closely around fish (i.e. large air spaces between pieces means poor cooling).

Block ice should be broken into small pieces before use. To do this, place ice blocks in a copra or rice sack, tie the top and lay the sack on its side. Then, smash the sack with a hammer to make crushed ice (similar to flake ice).

To ice the catch you need clean storage containers and clean measuring containers. The rule is to use at least one part ice for every one part fish. This means that if you have about one bucket of fish you will need one bucket of ice to cool it and more ice to keep it cool for the journey back to the shore.

Take care to pack fish and ice in the storage container correctly. Use ice to minimise contact between the fish and the sides of the container and between the fish and other fish.

Never cool fish with previously used ice. This ice may have come into contact with germs. Although throwing away used ice may seem like a waste of money, you risk losing much more if your whole catch becomes contaminated.

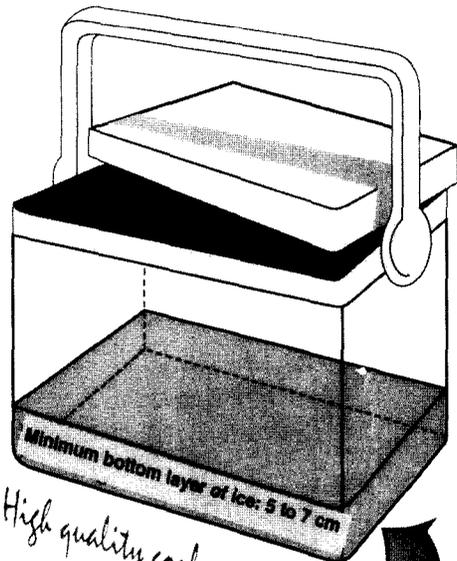


Fish do not chill properly if warm air pockets form.

# ICING SEAFOOD PRODUCTS

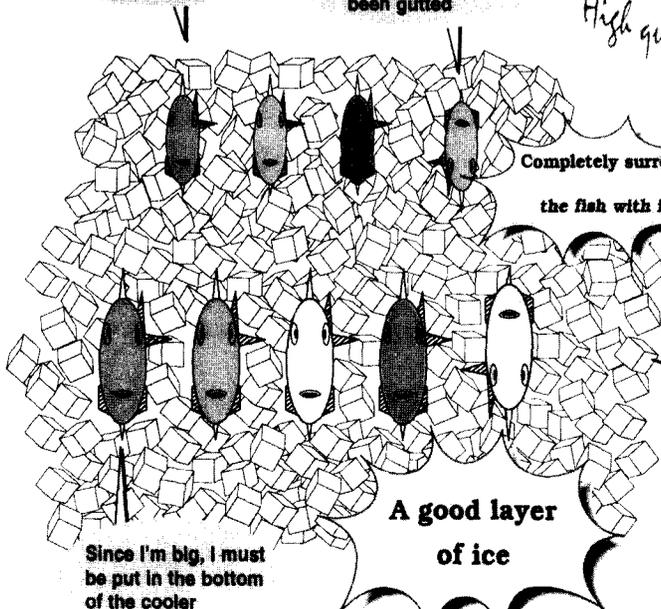
**Cooler must be kept tightly closed and covered with a wet rag**

TIME	WEIGHT	AMOUNT OF ICE
 < 6 hours	 1 Kg	 1 Kg
> 6 hours	1 Kg	2 - 3 Kg



Since I'm small, I must be put in the upper part of the cooler

Put me upside down if I have not been gutted



*High quality cooler, proper handling*

Completely surround the fish with ice

A good layer of ice

Since I'm big, I must be put in the bottom of the cooler

**A thicker bottom layer of ice for large-scale fishing or long excursions**

Graphic by New Caledonia School of Fisheries, Nouméa.

### Making ice from seawater

Salt lowers the freezing point of water. Temperatures of  $-5^{\circ}$  to  $-10^{\circ}\text{C}$  are needed to turn seawater into ice. Seawater is sometimes used to make ice in arid areas or on board factory vessels. Seawater ice chills fish rapidly due to the lower temperature, but it also has a number of disadvantages:

- lower temperatures are required for production and storage;
- fish may be held at too low a temperature and become partially frozen; and
- fish may take up salt from the ice.

### How much ice?

A rule of thumb for the tropics is to use a ratio of (at least) one volume of ice to one volume of fish.

The amount of ice needed depends on:

- fish temperature;
- how fish is packed on ice;
- whether the container is insulated; and
- trip duration.

Generally, for overnight trips, an amount of ice equal to the expected weight of the catch is usually enough. For longer trips, more ice than fish is required.

### Chilled seawater or ice slurry

Chilled seawater (CSW) is a seawater/ice slurry used for chilling fish. To make CSW, two parts of crushed block-ice or flake-ice are mixed with one part seawater.

CSW is good for quickly chilling fish that have just been caught. Fish can be taken off the hook and dropped immediately into the slurry. This saves time, particularly when fish are biting-the fish are quickly immobilised and chilled, leaving the fisher free to continue catching.

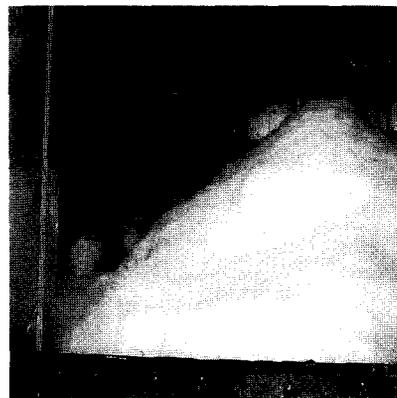
Fish should not be stored in the slurry for more than 6 to 8 hours. Otherwise, fish begin to take up salt, lose their bright colour, and their eyes begin turning white. After this period, fish must be properly packed in ice.

### Insulation

If you cannot afford an esky or chiller bin try using a coconut basket as a cheap and practical method to keep your fish fresh for longer.



*Kiribati: Fish stored without ice.*



*Samoa: Ice maker.*

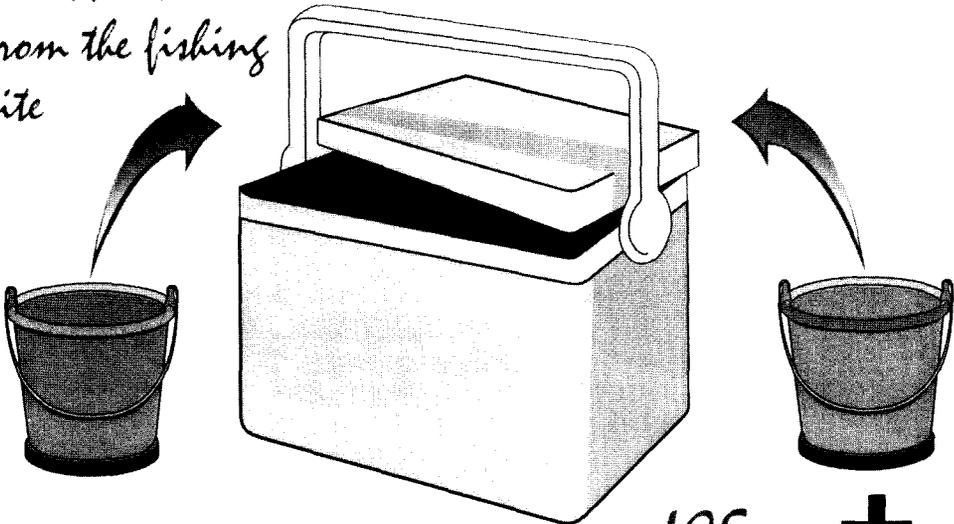


*Pohnpei: Fish in seawater/ice slurry.*

# MAKING SLURRY

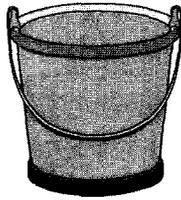
**Always use CLEAN equipment**

*Saltwater from the fishing site*



ICE: +

*crushed, chipped or broken block ice*

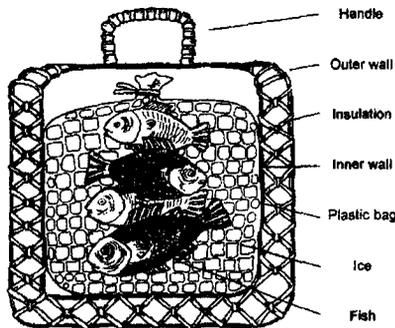


**Maximum fish storage time: 6 to 8 hours**



Graphic by New Caledonia School of Fisheries, Noumea.

The rationale behind the use of fish insulated containers (coconut basket) is very simple: ice keeps fish fresh and the insulated container keeps ice longer.



Coconut basket.



Fishing Village, Solomon Islands:  
Keep fish in clean containers.



Fiji: Chilled transport.

## Activity - Using a coconut basket

### 1. Equipment and material required:

- woven coconut basket (one big and one small);
- coconut fibres (properly dried);
- flake or crushed ice;
- plastic bags (5kg capacity); and
- candles.

### 2. Method:

- a) Fill plastic bags with coconut fibres. Seal the ends with candle wax. The number of bags used will depend on the size of the coconut basket used.
- b) Put the small woven coconut basket inside the big basket. Place the plastic bags with coconut fibre between the two coconut baskets to form the insulation in the walls of the container. Ensure that the entire inner wall of the basket is covered by insulated bags.
- c) Secure the two baskets by joining the internal and external walls together at the top of the basket.
- d) Place fish and crushed or flake ice (1:2 - ice:fish ratio) in a plastic bag. Tie the end.
- e) Arrange the plastic bag with fish and ice inside the small basket.
- f) Close the basket tightly and leave in a shaded place for no more than 24 hours.

## Arriving in the village

In the Pacific, fish is a staple food item and forms an important part of the daily diet. It is common for fishers to sell a portion of their catch and to keep some for themselves.

If you intend to sell fish to someone or to a retailer, this should be done as quickly as possible.

Likewise, fish should be cooked as soon as possible. While waiting for the oven to be ready, fish should be kept inside clean containers and away from flies.

## Transport and distribution

If you intend to sell fish in urban areas or inland, then you should store it in ice. Ice is especially important if you need to transport your fish for more than one day - the longer it takes to get the fish to market, the more chance there will be for spoilage and loss of quality. Ice will maintain quality and slow down the bacteria and enzyme activity that cause fish to spoil.

## Selling fish

Safe, good quality fish should be the aim of all those involved in fisheries activities - harvesting, processing, selling and buying. For the fish seller, it is important to keep customers happy so they will continue buying from them. If customers become ill or find they have bought poor quality fish, they will be less likely to buy fish from the same place again. The appearance of the fish, the shop or stall, and of the person selling the fish will also influence the customer's choice in deciding who to buy from.

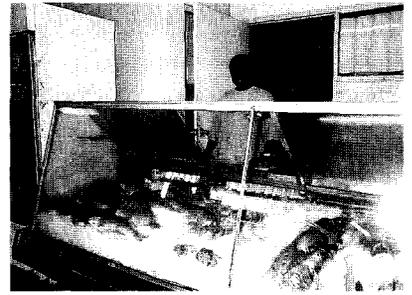
The ability to recognise and maintain good quality products, controlling environmental conditions that may pose a risk to the product, and maintaining good personal hygiene and appearance are the minimal requirements of a good fish seller. Identifying critical points in handling and selling fish and knowing how to reduce the risk of contamination is also part of being a successful fish seller. Often, fish sellers can insist on fishers improving the handling of the fish, such as using ice on board. A good fish seller will refuse to buy or sell poor quality fish.

## Recognising fresh fish

Fish sellers must be able to recognise the **organoleptic** characteristics of food suitable for consumption. This will enable them to select good quality products to sell to their customers. Customers should, however, be aware of how to choose safe, good quality fish for the family.

### Organoleptic characteristics

*These are a series of physical, chemical and biological characteristics of food that allow us to recognise its quality with the help of our senses - taste, smell, sight, hearing, touch.*



Port Vila: Chilled display unit.



Honiara: Central market.



Palau: Customers should choose safe, good quality fish for the family.

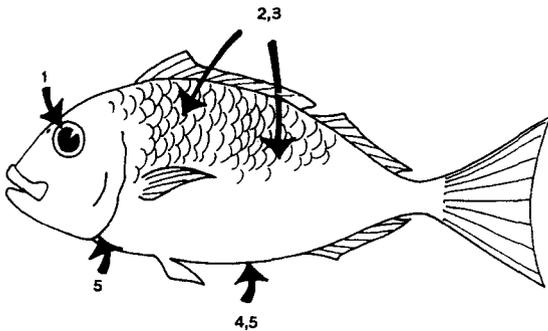
Optimal Properties	Undesirable Properties
<b>FISH</b>	
Prominent shiny eyes	Sunken opaque eyes
Red gills, no slime	Gills either pale, or greenish-black or brown, slimy
Firm scales	Scales that come off easily
Firm to touch	Opaque skin, sticky and soft to the touch
Characteristic smell	Unpleasant smell

**Seafood Handling**

Optimal Properties	Undesirable Properties
<b>SHELLFISH</b>	
Unbroken shells	Broken shell
Dull sound when tapped	Hollow sound when tapped
Closed valves	Open valves
Characteristic smell and colour	Unpleasant smell
	Greenish-black colour
Firm shiny contents	Sticky contents, disintegrate and come off the shell easily

**Activity**

1. Obtain a fresh fish and a spoiled fish.
2. Carry out steps 1 to 5.
3. Grade the two fish according to the table below.



1. **CHECK THE EYES** - they should be clear and jelly-like, not dark, shrivelled, or sunken.
2. **PRESS THE SIDE OF THE FISH** - meat should be firm and elastic. A thumbprint should disappear quickly.
3. **CHECK THE COLOURS** - the colours should be sharp and bright, not dull and faded.
4. **SMELL THE FISH** - if it's fresh, the body cavity will smell fresh.
5. **CHECK GILL AREA AND BODY CAVITY** - to be sure the fish has been properly cleaned. There should be no pieces of intestine, gills, or blood clots to be seen. If, for some reason, the gills are still in the fish, they should be bright in colour, not faded.

	😊 5	🙂 4	😐 3	😞 2	😡 1
GILLS	Bright Red	Red	Pink	Brown	Dark Brown
SMELL	Sea weed	None	Fishy	Stale	Off
LOOKS	Colours Shiny	Dull Colours	Grey	Dull	Bruise very dull
FIRM	Firm Springy	Firm Springy	leaves dent	Soft	very soft
EYES	clear	clear blood	cloudy blood	cloudy sunken	very cloud sunken
COLOUR	very Bright	Bright	Faded	Dull	Brown spots
TOTAL	30-25	24-19	18-13	12-7	6-1

High quality fish is fresh fish. High quality and freshness mean the fish:

- smells and tastes better;
- won't make you sick;
- is well packaged;
- has a longer shelf life; and
- has more value when sold or traded.

### A Story

A fish seller had built up a very successful business selling reef fish. He had a good shop with fly screens and stainless steel display cabinets, an ice maker and even a chill store. He started to export his reef fish to Australia and was doing very well at this too. The reason this man did so well was because he made sure that the fishers supplying him his fish handled the fish the right way. He gave the fishers ice, taught them good fish handling practices and always recorded the temperatures of the fish coming into his store with a thermometer.

Some fishermen didn't understand the importance of good handling practices though, and would leave their fish in hot and unclean conditions in the boats all day. Only when they got to shore would they cover the fish with ice before taking them to the shop. But by then it was too late for the ice to stop the fish deteriorating - the bacteria and enzymes had already started their work. Even though the fish was cold when they arrived, the fish seller knew that he could not buy the fish because they did not look, feel or smell fresh. The fish could never be sold as fresh or exported in this condition.

### Environmental conditions

(Adapted from FAO Manual, Training of Street Food Vendors).

The fish seller must try to control environmental conditions that may contaminate his or her fish products. It is important to use clean water, keep temperature and humidity within safe limits, and keep the fish stall free from garbage and pests that may contaminate the fish.

The environmental factors that can affect food include exposure to the sun, air and soil, water, and animals.



*Cook Islands: Wahoo left in sun.*



*Solomon Islands: Spoiled fish for sale.*



*Tonga: Fish sold on the ground and in the sun.*



*Tuvalu: Placing fish in an esky helps avoid contamination.*

### The sun

The sun determines the environmental temperature. As already discussed, high temperatures encourage the rapid multiplication of bacteria and increased enzyme activity. Fish must not be exposed to the sun, but should be kept in a cool place or refrigerated or frozen if it is not going to be prepared or eaten immediately. Fish is a perishable food and deteriorates quickly with high temperatures and poor handling.

### Air and soil

Bacteria live in the air and soil and some cause disease in humans. To avoid contamination, fish must be protected by a covering of some kind- for example wet sacks, palm fronds- or placed in an esky.

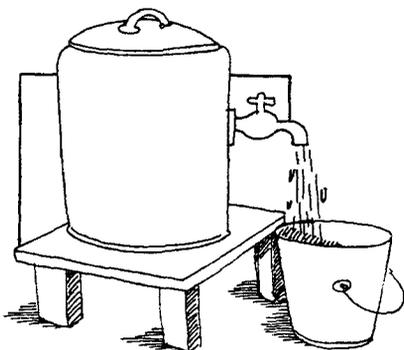
### Water

Although water is important for our everyday health it can be harmful if it becomes contaminated. Only clean, uncontaminated water should be used for drinking, preparing food and washing utensils used in handling food. If the water supply is not clean it may have to be purified before use. Contaminated water can cause diseases such as:

- typhoid fever
- hepatitis
- diarrhoea
- cholera.

Water can become contaminated:

1. when dirty water, excrement, garbage and pollutants are discharged into rivers, ditches, canals, pits, wells or reservoirs;
2. when the source is near a cesspool or latrine. The latrine must be at least 30 metres from the water source to prevent contamination; and
3. by using dirty containers that are exposed to pests, dust, dirt or other contaminants.



*Use clean water containers.*

Water from municipal water supplies sometimes contains chlorine, a chemical disinfectant that kills germs. Fish sellers should use this water to clean and prepare their fish and clean their stalls and utensils.

Use clean or purified water for:

- preparing foods
- washing hands and utensils
- washing foods
- drinking.

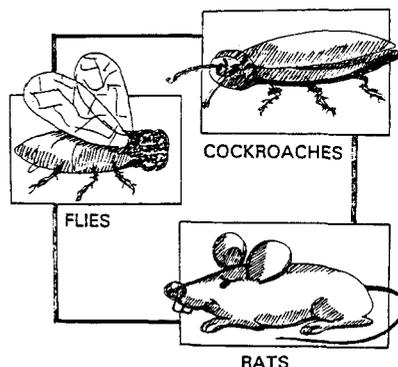
At the fish stall

- have a clean tank of drinking water for food preparation and washing, protected from dust, dirt, insects, rodents and domestic animals;
- have a system that produces a continuous flow of water;
- do not reuse water that may be contaminated;
- ensure a good drainage or water collection system so that used water is eliminated immediately.

## Animals

Animals can contaminate food and should never be allowed near a fish stall. They can contaminate the fish with their fur and they can carry germs from garbage or pass on parasites.

Animals that are very difficult to eliminate are called pests. Pests such as flies, cockroaches and rodents can cause serious food contamination, resulting in economic loss and disease. They are called **vectors** because they carry germs and parasites that can pass on diseases to other animals or humans.



Pests.

### Flies:

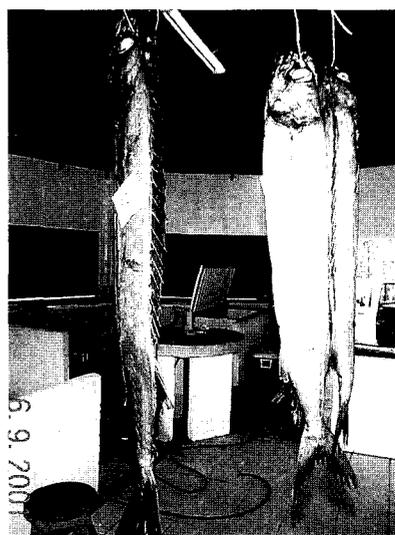
- Land on unprotected food, and deposit excrement on to it.
- Are difficult to eliminate in open spaces.
- Prefer dirty places such as garbage bins, decomposing matter, sewers, etc.
- Carry germs and contaminants adhere to the sticky substance on its legs, and to the body.
- Can pass contaminants on to unprotected food, utensils and food preparation surfaces.

### Cockroaches:

- Are attracted to unprotected food.
- Are active at night and are abundant where there is garbage or food items.
- Prefer dark and humid places.
- Carries germs on their legs and body and pass these on to unprotected food, utensils and food preparation surfaces.

### Rats:

- Can pass on germs from their urine.
- Contaminate areas where they leave their droppings.
- Are active at night.
- Are attracted by food that is left out.
- Carry germs and pass them on to unprotected food, utensils and food preparation surfaces.



Rarotongo: Hanging mackerel will help stop some pests.

To protect your family's health and the health of your customers, it is essential to eliminate vectors such as rats, flies, cockroaches and ants from food preparation areas and fish stalls.

Permanent hygiene of the fish stall is the best way to control these pests. Garbage must be covered and disposed of immediately and pests prevented from coming into contact with the fish.

**Activities**

1. Divide the class into small groups and ask each group to describe the habits of pests, such as rats, cockroaches and flies and the ways in which they may infect the fish being sold at a fish stall. Carry out a discussion on the possible ways that fish handlers and sellers may control these pests.
  
2. Field Work - Visit the local fish stalls. Questions to ask:
  - what is the method of garbage disposal and water waste management being practised by the fish sellers?
  - is there any evidence of poor handling practices or unhygienic conditions?
  - note pests seen at the fish stalls, if any.
  - what environmental contaminants may be affecting the fish at the stalls?



*Poor personal and environmental hygiene.*

**The fish seller**

(Adapted from FAO Manual, Training of Street Food Vendors).

Proper personal hygiene and appearance, good food handling practices of the fish seller, and proper hygiene of the food stall will ensure that the fish sold to customers is safe from contamination. This in turn will attract more customers.

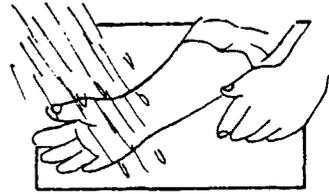
**Personal appearance**

Good personal hygiene and appearance will reduce the risk of food borne contamination. The purpose of good clothing for the fish seller is to protect the fish from contamination present on everyday clothes such as dust and dirt.

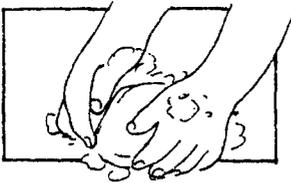
<b>Hygiene</b>	<b>Clothing</b>
Clean body and hands	Use a light coloured clean apron
Hair kept short or tied back, clean and covered	Cover hair with hat or scarf
Finger nails kept short, clean and without polish	Do not wear bracelets, watches, rings while handling fish



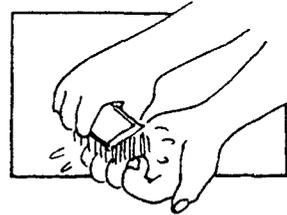
1. Roll sleeves up to the elbow



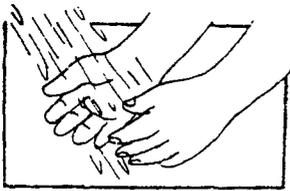
2. Rinse up to the elbow



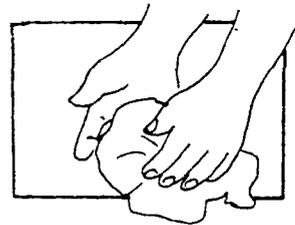
3. Apply soap carefully



4. Brush hands and nails



5. Rinse to eliminate soap
6. Rinse with clean water



7. Dry hands with a clean personal towel or, better still, with a paper towel.

### Personal hygiene

The fish handler or seller must keep his or her body clean by taking a daily shower, keeping hands and finger nails clean and keeping hair short or tied back and covered.

#### **Wash hands with soap:**

- before and after handling fish;
- after using the toilet;
- after touching contaminated objects (money, garbage, food scraps and fish offal, handkerchiefs, containers, animals);
- after touching hair, nose and other body parts; and
- after smoking.

### **Activities**

1. Practice the correct hand washing sequence - discuss.
2. Explore the local food hygiene regulations / policies that affect fish handlers and sellers in your community. How are these regulations enforced?

## Critical points in fish handling and selling

By looking at some of the critical points in handling and selling fish, a fish handler or seller may identify some the risks that could result in contamination and intervene to eliminate the risk.

By identifying the hazards that can contaminate fish - from the time it is harvested, until the point at which the fish is sold to the customer - the fish handler or seller may be able to intervene and reduce the risk of contamination.

### Ways to control hazards

#### Cold

1. Refrigerate to ensure that most bacteria and enzyme activity is reduced.
2. Freeze below -18°C.
3. Ice can be used as an alternative to keep fish cold when no refrigeration is available. Maintain temperature as close to 0°C as possible.
4. Ice can be a source of contamination when in contact with fish. Ice should be made using clean water and be kept in a clean and covered container.

#### Heat

1. Most germs die at temperatures above 60°C. Proper cooking will kill germs.
2. Heat can be provided directly by boiling or roasting etc., or indirectly through cooking in a double boiler.

#### Environmental

1. Keep in closed containers.
2. Cover with clean cloths.
3. Keep in glassed-in shelves or fly-screened cabinets.
4. Seafood should never be placed directly on the floor.
5. Clean up properly.



*Samoa: Keeping flies away.*

## Activities

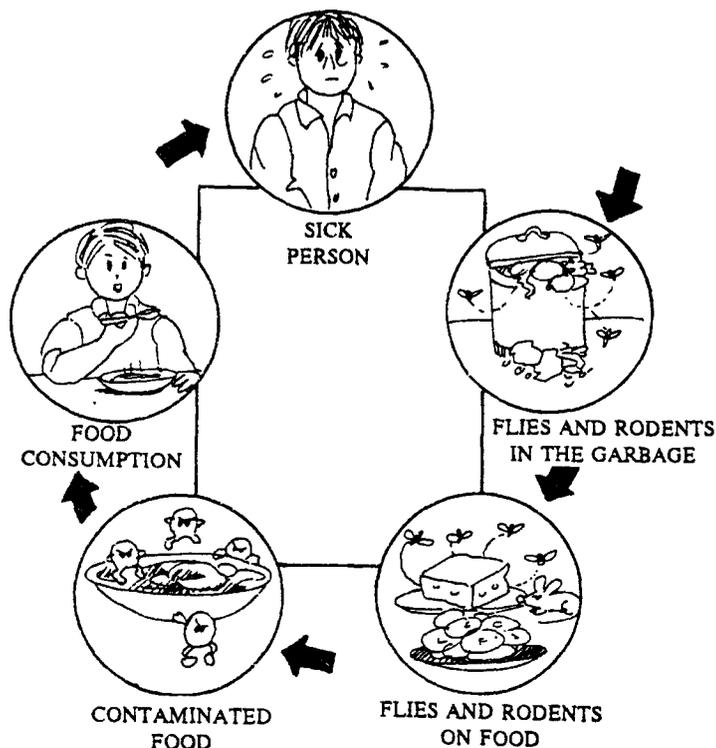
Identify and bring to the training room a range of fish products that are at various stages of decomposition. Ask the trainees to identify good and bad organoleptic characteristics of fish products in small groups. Discuss findings in the large group.

Prepare a chain of critical points from fish harvesting to consumption and draw or paste cut outs on a blackboard. In the large group discuss what intervention may be applied at each stage of the chain to minimise contamination. Complete the box below.

Critical Points	What to do
Fish Harvesting 1. 2. 3.	
Selling Fish 1. 2. 3.	
Preparing and Consuming Fish 1. 2. 3.	

## Demonstration

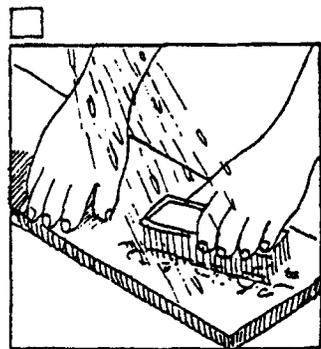
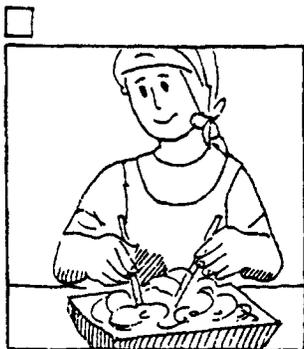
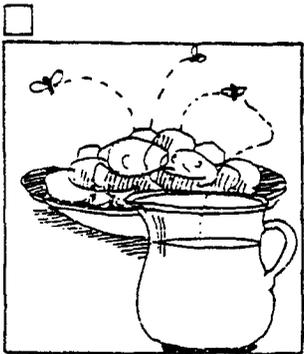
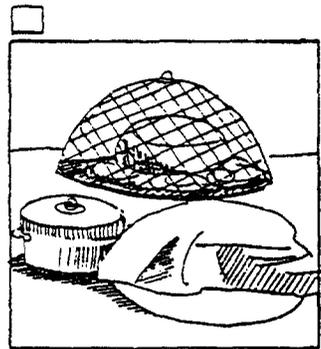
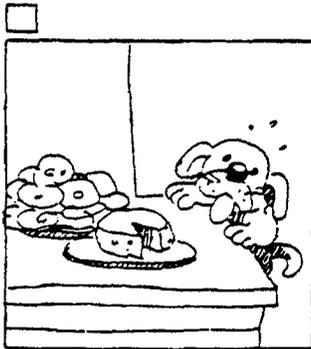
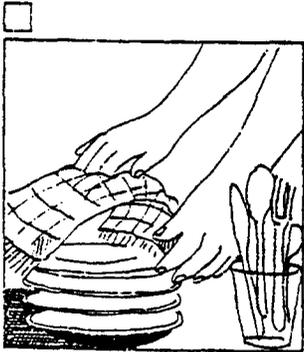
To show how food may be contaminated, cut out a drawing of a dish with food and draw/find a series of possible contaminants around the food dish to demonstrate the range of contaminating agents and mechanisms of contamination that may affect this food item.



*Food borne transmission of disease.*

**Activity**

Using the diagram below mark with a cross those activities that a food handler MUST NOT do to ensure that food remains uncontaminated.



## The cold chain

The cold chain is a temperature chain. For fresh fish it means 0°C from the sea to the consumer. The cold chain is broken every time the temperature of the fish is raised above 0°C. Every time there is a break in the cold chain, there is an increasing risk that the quality of the fish may be lost and can never be reversed. There are as many opportunities for the cold chain to break down as there are links involved.

At every stage of the chain someone must take responsibility for ensuring that the cold chain remains intact to ensure that the fish remains as close to 0°C as possible (or is maintained in the frozen state at -18°C or colder).

### Activity

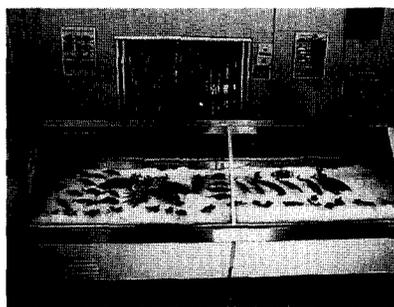
Count how many sets of hands a fish may pass through between the sea and the dinner plate:

- caught by the fisher;
- transported to shore by boat;
- trucked to market;
- stored before selling;
- purchased by the consumer;
- gutted, washed and prepared for cooking;
- stored again;
- cooked.

Look at this list again. Think of each step as one link in a chain - a chain that stretches from the ocean to your family.

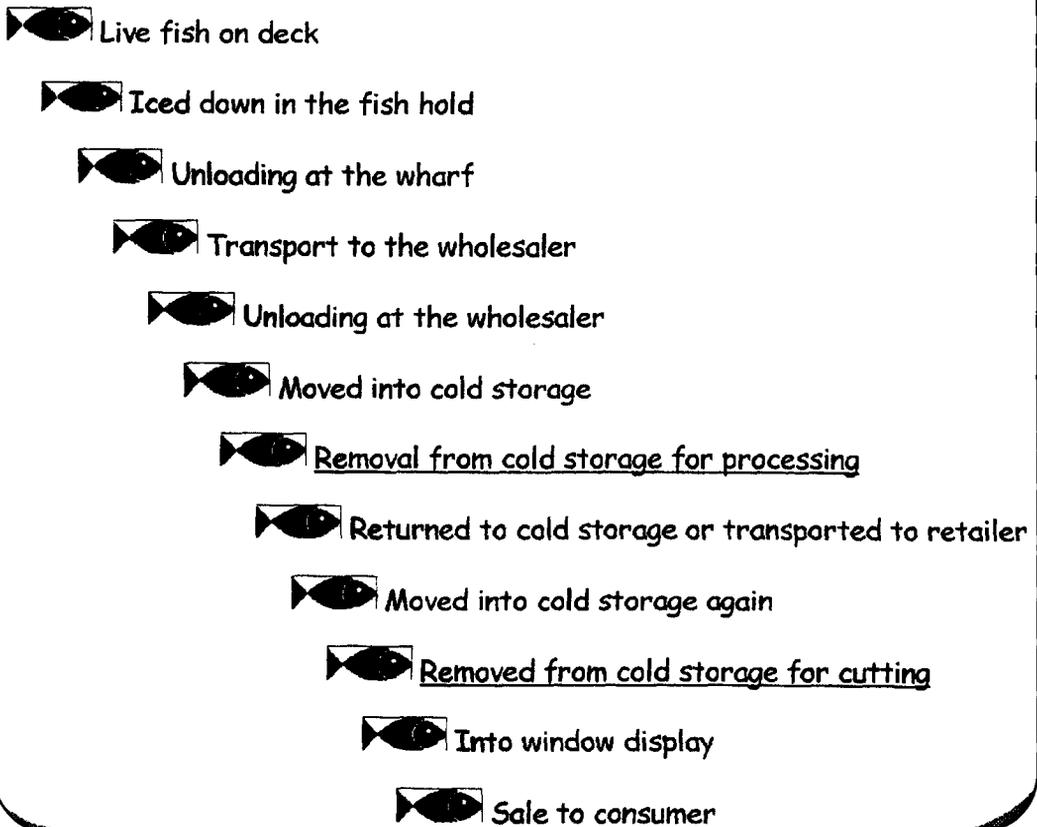


*Keep fish cool from capture...*



*...to sale.*

## Cold Chain

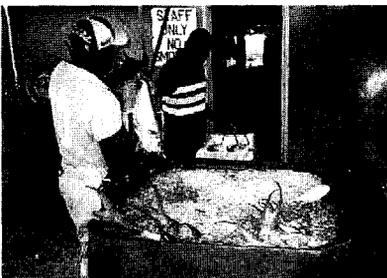


*Handling steps along a cold chain.*

Why must this chain be cold? That's easy: cold protects the fish from spoilage caused by bacteria and enzyme activity. Chapter Two explained how bacteria multiply rapidly in warm conditions, causing spoilage, which can lead to poor quality fish and to disease. Enzymes are also more active in warm conditions, leading to poor quality fish and spoilage.

Maintaining the cold chain means keeping the temperature of fresh fish close to 0°C, at every step from capture to consumption. Frozen fish should be kept at -18°C or below

The cold allows the fisher or retailer to deliver a good quality product, one that has a longer shelf life, is easier to sell, and fetches a higher price. If fish temperature rises - even at only a single stage, and even for only a short time - the cold-chain is broken and spoilage may occur.



*Tonga: Fish in ice slurry.*

Unfortunately, it is very difficult to keep fish temperature at 0°C (or -18°C if frozen). Most cold chains are broken, especially in an industry where there are many procedures to follow, and many potential distractions. However, maintaining the cold chain is worth the effort. Fish quality cannot be brought back once it is lost.

## Cold is not enough

It is important to be aware that cold conditions alone will not fully protect the catch and ensure a high-quality product. If poor handling and improper storage has occurred throughout the cold chain, fish quality will be reduced.

For example, the flesh of a roughly handled fish may become soft and spongy. Such a fish becomes tough and dry when cooked, and has little taste. Even the smoked products made from improperly stored fish will have a dull, unattractive appearance and taste.

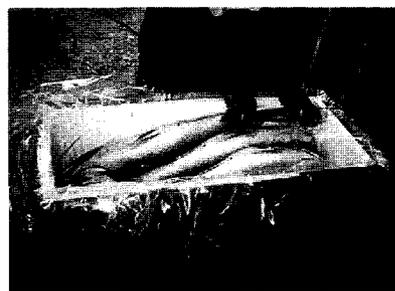
Frozen fish that have been improperly stored, or stored for too long, suffer from dehydration, leading to poor texture and taste. Good freezing practices are discussed in Chapter Three.

## On a commercial scale

Although a large retail operation may be complicated, the ideas behind the cold chain are simple enough for everyone to understand. Everybody in the fishing industry - fishers, boat owners, plant workers, plant owners, supervisors, quality controllers, transporters, buyers, sellers - should be a knowledgeable partner in cold chain management. Government inspectors, among others, must take responsibility for passing along up-to-date information to all people involved in handling, processing, hygiene, marketing and quality assurance.

In a commercial operation, a single person should be made responsible for the cold chain. That person's job is to remain alert for poor storage practices and ensure fish are kept at 0°C (or -18°C for frozen fish) all the way to the consumer.

Establishing cold-chain management systems would significantly improve how Pacific Island fishery resources are used. By providing quality, high-protein food, adding value to fish and fish products, generating employment, maximising revenues, increasing foreign exchange earnings and reducing post-harvest losses, everybody in the region will benefit.



*Tonga: Packing fish into an insulated box.*

# Chapter Three - Freezing Fish

## Freezing

Water normally changes from a liquid to a solid at or below zero degrees Celsius (0°C). This changing of liquid water into ice is called freezing.

Bacteria, like all living things, require water to grow and reproduce. However, most bacteria cannot use water in solid form. Enzymes are also inactive when water is unavailable.

Freezing changes the water inside a fish into ice. When liquid water is 'used up' in this way, bacteria and enzyme activity is reduced or stopped. The activity of enzymes is rapidly reduced once the temperature falls below -1°C and bacteria stop multiplying at around -10°C and below. Hence, freezing partly or entirely stops the deterioration caused by bacteria and enzymes.

Some large commercial boats freeze their catch at sea, allowing them to stay fishing for longer periods. Freezing is also used to store fish on shore before selling, or to transport fish long distances. If fish is frozen quickly and stored correctly there is very little change in quality from a fresh fish and it has the advantage of being able to be stored for several months.



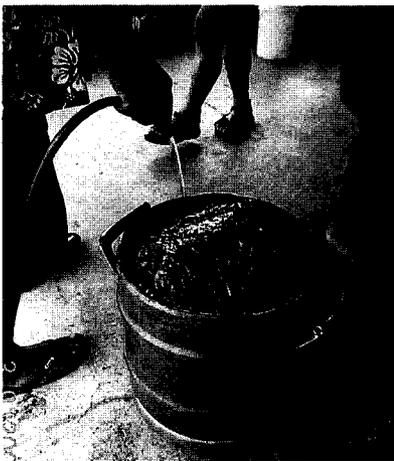
*Fiji: Fish in freezer*

### Advantages of freezing:

1. flesh is changed very little and there is minimal loss of quality;
2. fish can be stored for many months - for times when catches are scarce;
3. large quantities of fish can be stored;
4. good quality fish can be transported over long distances (e.g. export to areas where fresh fish are unavailable; fish caught in remote waters can be consumed at home).

### Disadvantages of freezing:

1. quality changes can occur if fish is not stored properly;
2. can be expensive due to the power or fuel needed to operate the freezer;
3. customers often have less regard for frozen fish, so there is less demand;
4. until it has thawed, it may be difficult to identify whether the fish has been abused.



*Rarotonga: Freezing has allowed this black pearl oyster meat to be kept for a long time.*

## Freezing stages

While almost 80% of the weight of a fresh fish is water, a fish also contains salt and other chemicals. These substances lower the temperature at which freezing begins. So, although pure water freezes at 0°C, water inside a fish begins to freeze at -1°C. As the temperature continues to fall, more and more water inside the fish becomes frozen.

To change a substance from a liquid to a solid - as happens inside a fish during freezing - energy has to be removed.

When heat is removed from fish at a constant rate, there is a period when the temperature of the fish does not drop. This period lasts from when the fish reaches its freezing point (-1°C) until when approximately 75% of the water is frozen. Subsequently, the temperature drops again.

Freezing has three clearly distinguishable stages:

1. Temperature falls rapidly to about -1°C.
2. Temperature remains constant (about -1°C) while the bulk of the water freezes. This is a critical stage where bacteria may still be active - it is important that temperatures fall rapidly through this stage.
3. Temperature drops again and most of the remaining water becomes frozen.

## Storing fish in the freezer

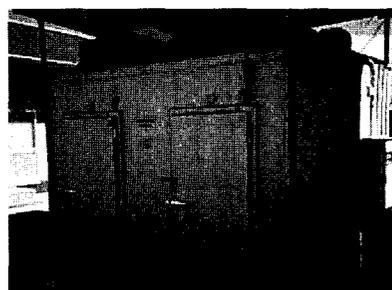
Although freezing preserves fish, it is wise to make use of older frozen fish before more recently frozen fish. Freezing keeps fish in good condition only for a limited time.

Frozen fish should be stacked so they can be easily rotated. Too often, fish are carelessly dumped into a freezer so that the old and the new get mixed up. A method called FIFO or 'first in, first out' encourages commercial operators to sell fish long stored in the freezer before those newly stored.

Rotation is easier when green bamboo splits are placed between layers of frozen fish. The bamboo splits are also helpful for a second reason, as shown by this true story:

### Story

An enterprising Solomon Islander started buying fish from local artisanal fishers and selling them in the provincial capital and surrounding villages. During his first year of business, the fish seller could never buy enough fish to meet local demand. His two freezers



*Fiji: Freezer at Nubawalu*



*Tonga: Fish in freezer box*

were rarely filled, and fish coming in were sold the same day. Business was good, customers were happy and so was the fish seller.

In the following year, many more fishers came to know about his fish retailing shop and flooded in to sell their fish. The fish seller filled his freezers. Supply was so good that part of the way through selling his fish, he bought more and filled his freezers again. The shop-owner didn't stop to consider that he kept selling fish only from the top and middle sections of his freezers, never from the bottom.

One day, the owner detected a foul smell coming from one of the freezers. The man was puzzled because he bought only fresh fish, froze them quickly, and his freezer was always cold. Unfortunately, the smell did not go away. Soon, fewer and fewer customers came to buy fish from the shop.

The frustrated shop-owner finally called on the Fisheries Division for advice. The friendly Fisheries Officer asked the man to remove all the fish from his freezer. To the retailer's surprise, fish at the bottom of the freezer were smashed and rotten.

The fish seller told the Fisheries Officer how he did everything properly before putting fish into his freezers. 'What about after you put your fish into the freezer?' asked the Fisheries Officer. 'What did you do with them then?'

'What should I have done?' replied the retailer.

'Well, it looks like you dump your fish straight into the freezer. Do you ever rotate the frozen fish?'

'No,' said the confused retailer. 'But isn't the freezer made to freeze all the fish inside it?'

The Fisheries Officer invited the man to sit down and explained the reason fish were going bad. 'When you loaded all that fish into the freezer, you did not leave any space for air inside to move freely between your fish.' The Fisheries Officer drew a picture in the sand.

'Here are some things you should remember,' he said. 'If the freezer is too full, cool air does not circulate well and some parts of the fish may get warm and spoil. But if fish is stacked in layers with green bamboo splits in between, cool air can flow freely over and under each layer. That means every fish will receive the same amount of cool air and stay frozen.'

'Also, when you load your freezer, do not fill it to the top. Leave lots of space for the lid to close easily. Overloading your freezer means fish at the bottom may get crushed from the weight of fish above.'

'Finally, every time you add new fish to the freezer you should make sure you rotate the fish so you are always selling the fish that has been stored the longest.'

'If you follow these guidelines, I am sure you won't have these problems in the future,' smiled the Fisheries Officer.

After clearing out all the fish and thoroughly cleaning the freezer, the fish seller's business is now running smoothly. Customers are happy again, and the fish seller is making a profit.

### Freezing methods

The principle methods of freezing fish are:

- blast - stream of cold air;
- plate - direct contact by refrigerated metal plate; and
- immersion - in low temperature liquid such as refrigerated brine or liquid nitrogen.

In the South Pacific, the immersion method is often used to freeze skipjack tuna. The procedure involves placing up to 20 tonnes of tuna into bins, which are tipped by forklift into two large tanks containing refrigerated brine solution. The brine is then cooled by ammonia gas from +15°C down to -17°C.

Scoops made of netting are used to remove the frozen fish. The product is placed into cold storage where a blast freezer keeps the temperature at -25°C. When 500 tonnes (or more) of fish are accumulated, it is transported by refrigerated vessel to cities such as Bangkok and Tokyo.

### Freezing rate

Freezer type and efficiency largely determines the rate of freezing. Freezing rate affects the size of the ice crystals - the slower the rate of freezing, the bigger the ice crystals. Large ice crystals may rupture cell walls and lead to water loss during thawing. Very slow freezing times can also result in spoilage as bacteria may still be active, especially during the critical stage after -1°C, when the temperature remains constant before rapidly falling again.

### Cold storage

Once fish has been quickly frozen, it is placed in a cold store. A common commercial cold store temperature is -30°C.



*Nauru: freezer display unit.*

### Quality changes in cold storage

While in cold storage, changes in quality accumulate and can not be reversed. Flavour may be lost and off-flavours may develop, reducing shelf-life of the frozen fish.

The main changes that occur during cold storage are:

- dehydration (freezer burn);
- drip loss;
- lipid oxidation; and
- loss of nutrients (vitamins, minerals).



*Arno, RMI: Blast freezer at outer island fish base.*

**Dehydration** can be a serious problem during cold storage. It is caused by moisture being drawn from the surface of the flesh into the dry, cold air of the freezer. The surface flesh and thin parts of the fish then become dry and porous. Dehydration results in weight loss and affects flavour, texture, and appearance of the product.

Dehydration is influenced by:

- temperature;
- humidity; and
- air movement (circulation and velocity).

Dehydration can be reduced by protective packaging or **glazing** (dipping frozen fish in iced water to provide a protective coating of ice) and by good freezing practices.

**Drip loss** is caused by changes in the protein of the flesh, leading to the loss of their natural structure and ability to hold water or moisture. Once thawed, the flesh drips excessively and looks dull white and spongy. When cooked the fish texture is wet and sloppy. The protein changes causing drip loss occur if the freezing process is too slow, or if the temperature fluctuates too much during freezing or storage. Slow freezing also causes large ice crystals to form in the flesh. These can puncture the cell walls, changing the texture and leading to drip loss when thawed.

Drip loss can be avoided by ensuring fish is frozen quickly and by not allowing freezing and storage temperatures to fluctuate too much.

**Lipid oxidation** is caused by the oils in the flesh of the fish going rancid, leading to an unpleasant odour and taste. Lipid oxidation can be reduced by ensuring the storage temperature is not too high and using packaging or glazing to prevent air from reaching the flesh.

**Loss of nutrients** can be caused by the oxidation of fat soluble vitamins such as vitamin A, the loss of unstable elements such as iodine and the loss of protein when fish becomes inedible due to dehydration and drip loss. Again, protective packaging or glazing, and good freezing practices are the best ways to reduce nutrient loss.

## Quality of frozen fish

A number of factors determine the quality of frozen fish:

1. speed of preparation, packaging, and freezing - quick is best;
2. quality of the raw catch - stale fish, when thawed, will still be stale;
3. handling before freezing;
4. storage time on ice prior to freezing - too long and the product assumes a soft texture, dull and opaque look, and poor flavour and odour;
5. fat content - lean fish are best as fatty fish spoil more quickly and can develop rancid flavours; and
6. freezing practices during cold storage.

The sooner a fish is frozen after capture, the better it will be when defrosted. Any delay before freezing allows time for bacteria to multiply - and for spoilage to begin.

It is important to realise that freezing cannot improve the quality of a fish that is bad from the start. A fish in poor condition when frozen will be even worse when thawed later.

### Good freezing practice includes:

#### **Keeping freezer doors closed**

Every time a freezer or refrigerator door is opened, cold air escapes and warm air enters, causing the temperature to in the freezer to increase. Opening the door too often puts frozen fish in danger of defrosting and spoiling. Changes in temperature increase the chances of dehydration, drip loss and lipid oxidation. Allowing warm, moist air to enter also increases dehydration.

#### **Controlling the temperature of the refrigerator or box freezer**

It is important to locate your freezer where there is a constant supply of power. Every time the electricity is cut-off - even for short periods - there is a chance that fish will defrost and spoil.

Although the inside part of a fish may remain frozen when the freezer is off, areas near the skin may have already warmed up and suffered attack from bacteria. Re-freezing the fish will not reverse this spoilage.

## Words & their Meaning

- Ambient temperature** - the usual surrounding temperature, most bacteria will grow very well in this temperature range. For example, in the tropics, bacteria are adapted to grow well at temperatures between 20 to 35°C. In colder climates bacteria are adapted to grow at much lower temperatures.
- Bacteria** - microscopic, one-celled organisms found in the environment, some of which cause illness and disease.
- Beche-de-mer** - sea cucumbers that have been processed into a dry food product.
- Contamination** - the spread of something unclean or unhealthy to something clean.
- Dehydration** - the loss of moisture from the fish while it is in frozen storage, also known as freezer burn.
- Drip loss** - is the excessive loss of water from the flesh of frozen fish once it has been thawed.
- Enzymes** - protein substances present in the muscle and gut which start or speed up chemical reactions.
- Germs** - a common name used for micro-organisms that cause disease, for example some viruses and bacteria.
- Glazing** - involves dipping frozen fish in iced water to provide a protective coating of ice.
- Gonad** - male and female organs, producing sperm and eggs.
- Hygiene** - conditions or practices of cleanliness needed to maintain health and prevent disease.
- Lipid oxidation** - oils contained in the flesh of fish can react with oxygen in the air and oxidise, or go rancid, leading to an off flavour and smell.
- Organoleptic** - acting on, or involving the use of the sense organs: taste, smell, sight, hearing, touch.
- Nutrients** - substances in our diet essential for health and growth.
- Rigor mortis** - stiffening of the joints and muscles after death.
- Roe** - another name for gonad, especially when used as food.
- Sashimi** - raw seafood, especially as eaten in Japan with soy sauce and horseradish paste (wasabi).
- Sushi** - Japanese dish of balls or rolls of vinegar-flavoured cold rice served with vegetables, eggs or raw seafood.
- Vectors** - animals or plants which pass on disease or parasites to other animals or plants.

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