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A REVIEW OF THE FACTORS AFFECTING THE SAFETY AND
QUALITY OF FISH AND FISH PRODUCTS PRODUCED IN THE
PACIFIC ISLANDS
WHOSE RESPONSIBILITY ?

by

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1. INTRODUCTION

- 1.1 During the last decade, the Governments and Administrations of the Pacific Islands have been increasingly turning their attention to methods of exploiting the vast natural resources of fish and other marine life which surround their islands.
- 1.2 This pre-occupation with the search for exploitable natural resources has been triggered largely by a realisation that true economic independence means the ability to earn foreign exchange, and also by offers of assistance made to Island Governments by commercial concerns who wish to share in the exploitation of these resources.
- 1.3 So far as fish is concerned, this means that increasingly large quantities caught within the South Pacific basin are being exported to overseas markets either frozen in the round or as processed fish products. Already fish canneries are established in American Samoa, Solomon Islands and Fiji, there are also a number of freezing depots for the freezing and storage of fish for export.

- 1.4 These developments however appear so far to have had little impact on the patterns of fishing for domestic consumption, and the majority of Islanders at the village level continue to catch their own fish from canoes and small boats as and when required for immediate consumption.
- 1.5 In the larger coastal urban centres, locally caught fresh fish may be offered for sale under a variety of circumstances - from markets, retail shops, hawker's vehicles, or even from the beach. The freshness of fish retailed under such circumstances is very variable, and depends mainly upon how it was caught, the type of handling it received after being caught, and the temperature at which it is stored.
- 1.6 Fish naturally, is a highly perishable commodity, more perishable than most other protein foods, and because of high ambient temperatures, fish is particularly vulnerable to spoilage in tropical climates. However, it is only in recent years, and then mainly in the urban areas, that facilities such as refrigerators, insulated containers, and ice have become available to fishermen and consumers. Even today, in many areas, they are not easily available, especially ice in bulk, and many cannot afford them.
- 1.7 The fishing potential may therefore be said to fall into two main categories :
 - (i) large-scale deep sea commercial fishing, mainly for export,
 - (ii) small-scale coastal and reef fishing mainly for the domestic market, and subsistence fishing.

In some countries there are also considerable resources of freshwater fish, particularly Tilapia in the Sepik River basin and other large rivers.

- 1.8 Since this paper purports to deal with the safety and quality of fish and fish products, it would be opportune at this point to review briefly the factors affecting these two conditions.

2. THE SAFETY OF FISH AND FISH PRODUCTS

- 2.1 Fish and shellfish not only transmit diseases to man, but are themselves subject to many diseases.

However, being cold-blooded creatures, fish take on the temperature of their environment, and fish, living in warm tropical waters such as the South Pacific where temperatures range from about 22°C - 30°C, are more likely to give rise to the transmission of human pathogens, than fish inhabiting the colder fishing grounds where temperatures rarely exceed 14°C.

The types of health hazards associated with fish and shellfish as food may be summarised as follows :

- (i) Bacterial infections and intoxications
- (ii) Viral infections
- (iii) Parasitic infections
- (iv) Poisonous biotoxins
- (v) Chemical poisoning
- (vi) Poisoning by contact.

Each group will be considered separately.

2.2 BACTERIAL INFECTIONS AND INTOXICATIONS

These infections are due either to direct contamination of the fish or fish product with polluted water or to secondary contamination during landing, processing, storage, distribution or preparation for consumption. Contamination of fish and shellfish with polluted water is of particular importance when these products are eaten raw or only lightly processed.

(i) SALMONELLOSIS (Bacterial infection)

This includes typhoid and paratyphoid fevers, septicaemia, shigellosis, and gastroenteritis. Caused by eating contaminated fish or shellfish raw or insufficiently cooked. Risk is greater in warm climates and where water is polluted with animal or human excrement.

(ii) VIBRIO PARAHAEMOLYTICUS (Bacterial infection)

Outbreaks reported from many parts of the world, particularly Japan, Southeast Asia, and the USA. Closely associated with the consumption of raw or inadequately cooked seafoods. The vibrios occur naturally in the marine environment and numbers increase in warmer water. The vibrios multiply rapidly in food but are destroyed by heating and freezing.

(iii) CHOLERA (Bacterial infection)

Fish are suspected of transmitting cholera although evidence is lacking. However, laboratory studies have indicated that V. cholerae can persist in fish and shellfish at room temperatures for 2-5 days and under refrigerated conditions for 1-2 weeks (1).

(iv) BOTULISM (Bacterial intoxication)

Clostridium botulinum type E spores are widely distributed in both fresh and salt water in many parts of the world.

Poisoning is due to the toxins produced under anaerobic conditions. The spores of type E organisms are more heat sensitive than those of other types and most outbreaks have been identified with raw or improperly processed fish or fish roe that has been fermented, smoked, or pickled.

The organisms of C botulinum type E are capable of growth at temperatures of 3.3°C (38° F) and above (2), therefore ordinary refrigeration does not necessarily prevent toxin production.

This is of public health importance because C.botulinum type E is not proteolytic, and growth and toxin production in fish cause no change in its organoleptic characteristics.

(v) STAPHYLOCOCCAL FOOD POISONING

(Bacterial intoxication)

Staphylococci are widely distributed and one of the principal causes of acute food poisoning.

The organisms multiply rapidly in food producing toxins which are stable at boiling temperatures.

The source of infection is usually of human origin, the fish or shellfish being secondarily contaminated through improper handling.

(vi) PERFRINGENS (WELCHII)

FOOD POISONING (Bacterial intoxication)

Clostridium perfringens (welchii)

The organism is widespread, and another cause of acute food poisoning.

Commonly found in waters polluted with human and animal excrement. The strains implicated are usually heat resistant and multiply rapidly in meat and fish.

The toxins are produced in the body after consumption of heavily contaminated fish or other foods. Fish or shellfish are secondarily contaminated through polluted waters or improper handling.

2.3 VIRAL INFECTIONS

Although there is a lack of information concerning the public health significance of viruses present in fish and shellfish, there is a strong epidemiological association between the consumption of shellfish from polluted waters and infectious viral hepatitis (2).

2.4 PARASITIC INFECTIONS

Several helminths inhabiting fish in the larval stages are capable of causing disease if ingested by human beings, but these have a limited geographical distribution.

Man becomes infected only if he ingests raw, insufficiently cooked, or improperly processed fish.

(i) TREMATODES

There are over 40 species of trematodes which may cause parasitic diseases in man (2) through the ingestion of raw or insufficiently cooked infected fish and shellfish.

They have a restricted geographical distribution and are not endemic in the South Pacific, but could be introduced. They have common characteristics in that their first intermediate hosts are molluscs, their second hosts are fishes or crustaceans, and their final hosts are humans or animals eating raw fish.

In man many of these trematodes parasitise the bile ducts, liver, and intestine, and may invade the lungs, brain and heart.

The following diseases are important because they are fairly widespread and can cause serious chronic disease in man :

(a) CLONORCHIASIS

Caused by Clonorchis sinensis, sometimes called Chinese or Asiatic Liver Fluke Disease because it causes serious liver damage.

The source of infection in man and animals is freshwater fish of the Cyprinidae family (carp, roach, dace, tench, chub, barbel, bream, etc ..) eaten raw, partially cooked, dried, salted or pickled.

Endemic in China, Japan, Taiwan, Korea and Vietnam, because of the practice of these people of cultivating fish in ponds fertilised with animal and human excrement. Can be introduced into non-endemic areas by imports of dried or pickled fish.

(b) OPISTHORCHIASIS

A disease similar to Clonorchiasis caused by Opisthorcis felinus and O. viverrini. Endemic in Eastern Europe, Russia, Philippines, India, Thailand, Laos.

(c) PARAGONIMIASIS

Caused by Paragonimus westermani sometimes called Oriental Lung Fluke Disease because it is endemic in China, Japan, Taiwan, Korea, Philippines, and parts of India, Africa, and South America.

The sources of infection in man and animals are freshwater crabs and crayfish eaten raw or not thoroughly cooked.

Affects primarily the lungs, but may spread to other organs.

(ii) CESTODES

The most important tapeworm likely to infect man through eating raw or inadequately cooked fish is Diphyllobothrium latum. If the eggs from the adult worm in the intestines of man or animals contaminate water through sewage pollution they develop into embryos, which when ingested by a copepod develop into a proceroid. When fish eat the infected copepod, the proceroids enter the bloodstream and reach the muscles and other organs where they develop into plerocercoids.

If raw fish muscle or roe containing the living plerocercoids reach the intestines of man or animals, the plerocercoids develop into adult tapeworms. In the mature stage the worms can reach lengths up to 10 metres.

a) DIPHYLLOBOTHRIASIS

Caused by Diphyllobothrium latum. Sometimes called Fish Tapeworm Disease. Endemic in Finland, N.W. Russia, USA (Great Lakes region), Alaska, Eastern Canada, Switzerland, Israel, Japan, Uganda, S. America, Australia, also possibly Papua New Guinea.

The sources of infection in man and animals are many species of freshwater fish including salmon, trout, grayling, pike, perch, barbel, burbot, ruffe, eel, etc ... Freezing of fish for 24-48 hrs at 14°F (= 10°C) or adequate cooking will destroy the plerocercoid larvae (3).

b) SPARGANOSIS

Caused by the presence of migrating larvae of several species of tapeworm related to D. latum. The plerocercoids of species other than D. latum are incapable of maturing to the adult tapeworm in man but migrate to the skin and subcutaneous tissues.

Reported from Japan, Korea, China, Vietnam, Indonesia, and USA.

Water containing proceroids or infested copepods, and the meat of other animals are more frequent sources of this disease than fish (2) (3).

(iii) NEMATODES

There are a number of roundworms which inhabit the organs of fish-eating mammals, birds, and possibly predatory fish, whose larvae can also infect man. The eggs of the worms must first reach water to mature and hatch. The larvae then enter copepods or molluscs as the first intermediate hosts, then fish, crustacea, reptiles, birds, and mammals serve as secondary hosts.

Man is infected when he consumes infected fish, terrestrial or aquatic molluscs or crustacea, in a raw, partially cooked, pickled, smoked, or slightly salted condition.

In the fish host the larvae are encysted in the abdominal cavity or musculature and signs of disease are not apparent.

Man is an abnormal host for these larvae, and while they cause little damage in their normal hosts, they may cause considerable damage in man.

The following are of public health importance :

a) EOSINOPHILIC MENINGITIS

Also called Angiostrongyliasis or Eosinophilic Meningoencephalitis. Caused by the rat lungworm Angiostrongylus cantonensis of which the third stage larvae are infective.

This disease is of considerable importance in the Pacific as it is endemic in French Polynesia, New Caledonia, New Hebrides, the American Trust Territory and other Pacific Islands, Hawaii, Japan, S.E. Asia, Thailand, Taiwan, Malaysia, Indonesia, and the Philippines.

Although the intermediate host is usually a slug, snail, or land planarian ; prawns, fish, and land crabs that have consumed snails or slugs also transport the infective larvae.

Man is infected by eating raw salads, fruit or vegetables contaminated by infected molluscs, or infected raw or insufficiently cooked prawns, crabs or fish (4).

b) ANISAKIASIS

Caused by the larvae of Anisakis marina.

The larvae occur in many marine fishes, and man is infected by eating raw or improperly processed fish.

Occurs in Japan, Europe, and other countries where the consumption of raw fish is customary, and distribution may be worldwide.

Exact life cycle not fully known.

The parasite is killed by heat and freezing.

c) GNATHOSTOMIASIS

The adult parasite Gnathostoma spinigerum is usually found in cats, dogs, pigs, and some other animals, and the disease is found mainly in Thailand, Japan, China, Malaya, Java, India, and Israel.

Eggs of the adult worms are passed in faeces, and on reaching water hatch into small first stage larvae which if ingested by a copepod continue to develop. When the infected copepod is eaten by a fish, frog, snake, or bird, the larvae develop further and become encapsulated in the flesh of the host. Upon ingestion by man or other animals the parasites migrate through the tissues causing lesions or abscesses.

Man therefore becomes infected with G.spinigerum through the ingestion of improperly cooked fish, frogs, birds, and snakes containing the encapsulated larvae (3).

(d) INTESTINAL CAPILLARIASIS

Caused by nematode parasite Capillaria philippinensis.

Endemic in the Philippines and Thailand. Man is infected by eating raw or undercooked freshwater fish harbouring infective larvae, but the life cycle of the parasite is uncertain.

Various animals including goats, water buffalo, dogs and pigs are suspected of being the principal hosts.

Fish in lagoons in the Philippines have been shown to serve as intermediate hosts (5) (3).

2.5 BIOTOXINS OF FISH AND SHELLFISH AFFECTING MAN

Although only a small proportion of the species of fish and shellfish used for human consumption throughout the world are likely to contain biotoxins which affect man, this type of poisoning is not an uncommon hazard in the Pacific and other tropical and sub-tropical waters.

Many of the fish caught locally around the Pacific islands, particularly reef fish at certain times of the year and in certain places, may be poisonous.

In the Pacific area we are concerned with three important types of toxic fish poisoning which are fairly widespread - Ciguatera Poisoning, Tetraodon Poisoning and Scombroid Poisoning. With regard to shellfish, both molluscs and crustaceans have from time to time been incriminated in cases of suspected toxic shellfish poisoning. The most well-defined and dangerous is Paralytic Shellfish Poisoning.

Fish poisoning caused by the ingestion of fish containing these naturally occurring toxins is generally called "ichthyosarcotoxism". (For further information readers should consult the SPC handbook) (6).

(i) CIGUATERA POISONING

Is a term used to describe a disease that may result from eating any of a number of species of tropical marine fishes and is characterised by gastrointestinal and neurological symptoms.

Ciguatera poisoning appears to present the most serious fish poisoning problem in the Pacific due to its fairly widespread occurrence, and the large number of food fishes that may harbour the toxin.

The fishes implicated in outbreaks of Ciguatera poisoning are usually closely associated with reefs and shallow water areas around islands.

They include snappers, groupers, barracuda, parrotfish, surgeonfish, jacks, seabass, wrasses, perches, and others. Little is known about the origins of the Ciguatera toxin, although research is currently being carried out, but it is generally assumed that fish become toxic because of marine environmental factors.

The possibility is that the toxin originates in a benthic organism (probably an alga) and is transmitted to fish through the food chain in the process of normal feeding.

Fish which are poisonous cannot be readily identified, because the toxin does not produce any distinguishing physical characteristics, and no simple scientific test yet exists to detect the toxin.

The toxin is also heat stable.

(ii) TETRAODON POISONING

Results from eating improperly prepared fish of the Tetraodontidae family, commonly known in English as pufferfish, balloonfish, blowfish, or globefish, and in Japanese as "Fugu", from the tropical regions of the Pacific, Atlantic, and Indian oceans. Most of the outbreaks have occurred in Japan, where "Fugu" is considered a delicacy.

The toxin, which is heat stable, appears to be concentrated in the gonads, liver, bile, skin, and certain parts of the flesh. Intoxication causes serious illness with a high mortality rate. Very special care has to be taken in the preparation of this fish to render it innocuous.

(iii) SCOMBROID POISONING

Is an allergy-like intoxication caused by toxins produced by certain bacteria arising from the unhygienic handling, storing, or processing of the pelagic mackerellike fishes of the Scombridae family such as tuna, bonito, skipjack, spanish-mackerel, etc.. These fish become dangerous to eat when certain strains of the bacterium Proteus morganii act on a naturally occurring substance in the flesh of scombroid fish called Histidine.

This bacterial action can be very rapid in tropical climates if the fish are badly stored or not properly refrigerated, and can occur without any of the usual signs of putrefaction.

The toxin is also heat resistant which is a significant factor in fish canneries.

Thus, although pelagic fish contain no known acquired toxin whilst alive in the sea, they can become toxic through improper and unhygienic handling after capture.

(iv) PARALYTIC SHELLFISH POISONING

Is caused by a highly toxic, heat stable toxin, causing tingling, numbness, paralysis, collapse, and in severe cases, death. Outbreaks have been reported in N. America, Europe, Africa, Asia, and the Pacific Islands.

It is thought that the toxin originates in certain types of dinoflagellates, a very minute form of planktonic algae which are used as food by filter feeding bivalves such as oysters, mussels, clams, etc.. PSP usually occurs only when shellfish are taken from an area affected by "red tides". These occur most frequently in the tropical and sub-tropical oceans at seasons when the temperature and nutritional factors of the water are favourable. Shellfish feeding on this type of plankton during the "red-tide" season absorb a strongly poisonous toxin.

The build up of toxin in the molluscs can take place over a few days, but even after environmental conditions return to normal, the natural loss of toxin from the molluscs may take several weeks.

Since the appearance of toxic plankton is sporadic it is very difficult to tell when shellfish are likely to become toxic. However, in areas where shellfish are cultured commercially, it is possible to monitor the toxin content on a routine basis.

When the concentration of toxin exceeds the accepted level harvesting should be prohibited until subsequent tests prove satisfactory.

Other types of invertebrates including crabs, lobsters, crayfish, squid, cuttlefish, etc., may cause toxic illnesses in man from time to time, but the precise cause of the toxicity is often unknown (2) (3).

2.6 CHEMICAL POISONING

The presence in the aquatic environment of naturally occurring chemical substances plus other pollutants of man-made origin, can cause chronic intoxication of fish and shellfish, making their consumption injurious to man. The most serious pollution arises from the discharge of industrial effluents and wastes containing the heavy metals such as mercury, lead, cadmium, arsenic, cobalt, copper, and other hazardous chemical substances, into oceans, lakes, and rivers. An example is the numerous cases in Japan in recent years of "Minamata Disease" due to organic mercury poisoning.

2.7 POISONING BY CONTACT

Ichthyocanthotoxism is the specific term used to designate intoxication resulting from injuries produced by the stings, spines, or teeth of venomous fishes.

There are many marketable and non-marketable fish taken during fishing which have these venomous characteristics, including stingrays, catfish, stonefish, scorpion fish, butterfly fish, eels, etc.. Severe pain, shock, paralysis, cardiac and respiratory distress, may result from such intoxication, and even deaths have been reported.

3. THE QUALITY OF FISH AND FISH PRODUCTS

3.1 Aspects of " quality " include such matters as :

- (i) the size and maturity of the live animal
- (ii) the physical condition of the live animal relating to age, season of the year, feeding, environment, etc..
- (iii) the method of catching used, eg, spearing, dynamiting, poisoning, type of trawl, etc..
- (iv) the health of the live animal in relation to its diseases
- (v) the degree to which the live animal may have absorbed poisonous chemicals from its environment
- (vi) the post-mortem condition in relation to staleness or spoilage when used for processing or for sale for human consumption.

3.2 The first three aspects are related to the methods and techniques of the fisherman, season of the year, environmental conditions, etc.. and will not be considered here.

3.3 The natural diseases of fish and shellfish are of importance as they affect the physical condition of the fish and may make them unmarketable even though the diseases may not be transmissible to man.

3.4 The accumulation of harmful chemical substances within the bodies of fish may make the fish potentially harmful for human consumption without detectable organoleptic changes. This has assumed greater significance in recent decades as a result of environmental pollution of coastal waters and rivers.

3.5 Staleness and spoilage is of paramount importance in the quality control of fish and fish products as these conditions make the article offensive, unmarketable or unsightly, and can also cause illness in man.

3.6 The last three aspects will therefore be reviewed.

3.7 DISEASES OF FISH AND SHELLFISH

(i) BACTERIAL DISEASES of fish and shellfish are caused almost exclusively by bacteria specific to this group of animals. However, fish and shellfish can become active or passive carriers of Vibrio parahaemolyticus in contaminated areas and infect man through consumption of raw or inadequately cooked or preserved fish and shellfish, and it is thought that this organism may also cause disease and mortality in some fish and shellfish.

Several species of mycobacteria cause chronic disease in over one hundred species of freshwater and marine fish. Fish occasionally suffer from a form of tuberculosis causing soft yellow deposits in liver, stomach, intestines, and abdomen resembling lesions similar to tuberculosis in other animals. It is not pathogenic to man.

" Salmon Plague " caused by Bacillus salmonis pestis spreads rapidly and has a heavy mortality. It causes white patches on sides, belly and head, which turn to spreading ulcers.

"Furunculosis" an infectious disease of freshwater fish caused by Bacillus salmonicida causes boils which break down and ulcerate (2) (7).

(ii) VIRAL DISEASES

Fish suffer from a number of chronic and acute viral diseases which affect the quality of fish as food, but at the present time none of them are known to be transmissible to man (2).

(iii) FUNGUS DISEASES

A few fish diseases are caused by fungus infections which can affect the appearance of fish, but there is no evidence that the fungal diseases of fish are transmissible to man.

(iv) TUMOURS

It is known that fish are subject to a variety of neoplasms and neoplastic transformations in all types of cell and tissue. Sarcomata producing coarse fibrous growths may occur in any situation.

Osteomata are not uncommon.

Epitheliomata causing epithelial ulcers may be caused by chemical irritants in polluted waters.

Fish affected with tumours and ulcers are unfit for food (2) (7).

(v) PARASITIC DISEASES

Fish and shellfish are afflicted with a large number of parasites of different types, but some of the parasites that are primarily pathogenic to fish are known to be pathogenic to warm blooded animals, including man.

Helminths inhabiting fish in the larval stages as intermediate host and capable of causing infections in humans have already been reviewed in para 2.4. The adult cestode Taenia tetrahynchus is found in the intestines of voracious fish, such as skate, shark, dogfish, etc .. and the plerocercoid stage in smaller fish.

Nematodes are quite commonly found in the stomach, intestines, and internal organs of many fish, and severe infestations may cause the fish to become weak and out of condition. In some cases the larval stages of these parasites may be found in the musculature.

Fish are also subject to infection by a number of myxosporidian parasites, which render the fish unfit for human consumption.

" Nodular Disease ", Fish Pox ", or "Boil Disease" caused by Myxobolus pfeiffari invades the connective tissue and muscles of freshwater fish, forming nodules and tumorous masses.

" Twist Disease " caused by Myxostoma cerebralis affects young fish of the salmon family, causing injury to cartilage and surrounding tissue.

" Wormy Halibut " caused by Unicapsula muscularius affects Pacific halibut, invading the muscle fibres and forming long swollen cysts (2) (7).

3.8 POISONOUS CHEMICALS

The absorption by fish and shellfish of poisonous chemicals from the aquatic environment has already been mentioned in para 2.6.

These days it is a matter requiring special attention since concentrations of harmful chemicals in fish and shellfish in excess of permitted safety levels can only be detected by laboratory examination.

When environmental contamination is suspected regular field monitoring should be carried out to assess the concentration of harmful substances in fish and shellfish taken from the area, and the concentration of these substances in the water.

3.9 SPOILAGE OF FISH AND FISH PRODUCTS AND SHELLFISH

The most detrimental effects to the " quality " of fish, shellfish, and fish products arise from a series of chemical and biochemical processes of deterioration which may loosely be termed " spoilage ". No matter how healthy the original animal is at its time of capture or of what quality, spoilage will occur unless correct procedures for post-mortem handling and storage are adopted.

3.10 Immediately a fish dies rigor mortis sets in followed by the processes of decomposition. These are the result of a series of complicated changes brought about in the dead fish by :

- (i) Bacterial action
- (ii) Biochemical action of enzymes which become active after death. (This is called autolysis or breakdown by self-digestion)
- (iii) Chemical processes of oxidation causing rancidity.

3.11 These chemical changes bring about irreversible changes in odour, flavour, and appearance. Compounds are formed having a disagreeable taste and smell, and various gases and effluvia are given off. The spoilage patterns in different types of fish tend to vary widely as regards time and effects of spoilage.

3.12 THE SPOILAGE PROCESS

The fresh muscle of fish after catching is practically free from bacteria, but there are bacteria naturally present on the fish externally and internally during life whose action is harmless until after death. In addition bacteria gain access to the tissues during the course of sorting, handling and gutting, and increase in numbers even though the fish are iced. Recent investigations seem to indicate that the fish caught in unpolluted water carry only a few psychrophilic micro-organisms on the surface and in the guts. Most of the bacterial contamination found on landed fish appears to be related to unhygienic handling of the fish and bacterial growth during storage on board ship (8).

3.13 Deterioration due to enzyme action is slow at first but becomes more rapid with time. This self-digestion in fish is an important factor because it is known that on ice, ungutted fish deteriorate more rapidly than gutted fish. Deterioration is continuous from the fresh to the unfit condition, and in between these conditions the fish is becoming progressively "stale". It is a question of degree, and a decision as to when and at what stage a fish passes from the stale but edible condition to the stale but inedible condition is one of the difficulties facing inspectors, particularly in tropical climates.

3.14 TESTING FOR FRESHNESS

Since freshness is important in determining the quality of wet fish much research has been carried out in the search for suitable methods of assessment.

Until the last decade or so, reliance has been placed mainly on well developed and well tried organoleptic tests. These have been based on changes in appearance of various parts of the anatomy such as eyes, gills, belly cavity, etc., changes in texture of the flesh and changes in odour.

3.15 The disadvantages of these tests are that they require training and long experience and are dependent upon the opinion of the person applying them. A simple and unequivocal scientific test for freshness would be of great advantage, and in recent years work has been undertaken on the development of suitable chemical and instrumental tests.

These include tests such as the Trimethylamine (TMA) Test ; the Total Volatile Bases (TVB) Test ; the Volatile Reducing Substances (VRS) Test ; the Hypoxanthine (HXI) Test, and testing instruments such as the Torry Freshness Meter ; the Intelectron Fish Tester, and the Hennings Meter.

3.16 In the United Kingdom the development of chemical and instrumental methods for assessing "freshness" of fish was stimulated by Britain's entry into the EEC, and the consequent requirement to introduce grading schemes for wet fish. Trials appear to indicate that the instrumental methods are the quickest and most economical (9). In the Pacific area however, fish freshness and quality are still largely determined by organoleptic methods. This work is carried out largely by Sanitarians and Health Inspectors of the Public Health Authority under the provisions of the Food and Drugs Acts and Ordinances.

3.17 IMPORTANCE OF TEMPERATURE CONTROL

Although cold storage is of vital importance in quality control, it can never improve quality.

If cold storage or freezing processes are properly applied, initial quality can be maintained within limits so that the difference between the final thawed product and the fresh article is small. Fish which are physically damaged during catching or by rough handling after catching will deteriorate very rapidly even under cold storage.

3.18 Fish, depending on species, comprise 60 % - 80 % water, most of the remaining 20 % - 40 % being composed of proteins and fats. Although pure water freezes at 32°F (0°C) fish flesh does not begin to freeze until about 30°F (-1.1°C). Most of the water in fish freezes at about 23°F (-5°C) but complete freezing is not achieved until the temperature reaches 0°F (-18°C). The interval between 30°F (-1.1°C) and 23°F (-5°C) is called the "critical range" (10).

3.19 As the temperature of fish muscle falls below its freezing point, ice crystals begin to form throughout the tissue, and the size of these crystals depends upon the rate of freezing. The quicker the freezing, the smaller the crystals and the less damage to the muscle fibrils.

If freezing time within the critical range is prolonged, then much larger ice crystals form in the space between the cells and rupture the muscle structure.

3.20 After thawing, the muscle of slowly frozen fish is of much poorer quality because of "drip" and protein degradation. Flavour and texture is also impaired because slow freezing results in a concentration of salts and enzymes within the cells producing spoilage changes that cannot be reversed when the flesh is thawed.

3.21 Under British practice, "quick-freezing" is defined as a rate of freezing at which no part of a fish or packet of fish takes more than two hours to cool from 32°F to 23°F (10). The temperature is then reduced to -20°F (-29°C) which is the recommended storage temperature for frozen fish.

3.22 Even if fish are correctly frozen within a few hours of catching and then stored at -20°F , they will not keep indefinitely. When fish are frozen, bacterial action is reduced, and below 14°F (-10°C) bacteria are prevented from multiplying and causing spoilage. Some bacteria are killed, but others will remain dormant and become active again as soon as the temperature rises. Autolysis however, continues to some degree at temperatures below that at which bacterial action stops, and will still go on at a slow rate at 0°F (-18°C) or lower. Oxygen will also attack the fat in fish causing unpleasant rancid flavours, and dehydration may occur.

3.23 At storage temperatures above -20°F (-29°C) these changes take place more rapidly, and the life of the product is reduced. To prevent deterioration over long periods in cold storage, it is necessary to ensure systematic turnover of stock in cold stores at regular intervals.

3.24 HANDLING AFTER CATCHING

The fisherman must bear much of the responsibility for the condition in which his catch reaches the consumer.

Good handling of fish at sea should ensure that the catch retains its initial freshness so far as is possible until landing. The important requirements are :

- (i) to chill the fish as rapidly as possible after catching
- (ii) to prevent the fish warming again
- (iii) to maintain a high standard of hygiene during storage and handling.

Quick and efficient chilling of the catch to as low a temperature as possible without actually freezing the fish is essential if spoilage is to be kept to a minimum.

This means storage in ice.

3.25 Although pure ice melts at 32°F , the temperature of fish stored in crushed ice will be about 31°F . This is because the melting ice absorbs heat from the surroundings, and even the biochemical processes of spoilage produce heat which is absorbed by the ice. It is therefore essential to distribute sufficient ice to ensure that each fish is surrounded by ice.

However, uncontrolled slow freezing of fish should be avoided for the reasons already mentioned.

The major cooling effect should be produced by the melt water flowing over the whole fish. Besides cooling the fish, a free flow of melt water also washes away bacterial slime, blood, and spoilage products and helps to preserve freshness.

It is however important to ensure free drainage of melt water in order to avoid immersion of fish in dirty water.

- 3.26 Gutting should be carried out as soon as possible after catching, the objective being to thoroughly clean out and wash the belly cavity and to bleed the fish.

The fish should then be washed in clean water to remove all blood and debris from the skin, gills, and belly cavity, before being put in ice. Smaller species of fish which are not gutted must be handled with special care to prevent spoilage.

3.27 SHELLFISH - MOLLUSCS

The molluscs exploited by man are divided into three classes :

- (i) the pelecypods or bivalves such as oysters, scallops, mussels, clams, cockles, etc..
- (ii) the gastropods such as winkles, whelks, and other univalves, abalone, sea slugs, etc..
- (iii) the cephalopods such as squids, cuttlefish, octopuses, etc..

- 3.28 The naturally occurring biotoxins of shellfish have already been mentioned in par 2.5, but probably the most consistently serious health hazard arises from shellfish taken from beds polluted with sewage effluents or even raw sewage.

- 3.29 Since molluscs are sedentary and will grow best in the fertile coastal or estuarine waters, layings are often found close to sewage effluent outfalls. Shellfish taken from such areas are likely to be contaminated with human pathogens - mainly typhoid and salmonella organisms and the virus of infectious hepatitis. More recently outbreaks of illness due to eating seafood contaminated with Vibrio parahaemolyticus have occurred in the USA, Hawaii and Japan.

- 3.30 Since many of these molluscs are eaten raw, or only lightly cooked, particular care is necessary to ensure that molluscs taken from such areas are not contaminated or are rendered safe by subsequent treatment.

- 3.31 Fortunately live shellfish rapidly cleanse themselves when placed in clean water, and this can be used as a method of purifying shellfish taken from polluted layings.
The shellfish are placed in sterilised seawater so that they live and function naturally, thereby ridding themselves of sewage matter and bacteria. The water is made sterile by chlorination (10 - 12 ppm) and then de-chlorinated with sodium thiosulphate before flowing into the shallow tanks containing the shellfish. Two baths of 24 hours are required.
Purification of bivalves may also be effected in 2 to 3 weeks if the shellfish are transferred to unpolluted beds.
- 3.32 Freezing in the raw condition is applied mainly to oysters, scallops, clams, squids and abalones.
Only fish in the live condition should be used. Cold storage temperatures of about - 4°F to - 11°F (- 20°C to - 24°C) are recommended (11).
Other molluscs such as mussels, cockles, whelks, are cooked before freezing.
- 3.33 SHELLFISH - CRUSTACEANS
Those caught for food are lobsters, crayfish, crabs, prawns and shrimps.
The shells of shallow water crustaceans are bluish-grey, they turn red on cooking due to chemical changes in the natural pigments. Crustaceans cast their shells (moult) during the breeding season, and they are then soft, watery, and unsound for food.
Crustaceans are marketed live, fresh or processed by freezing, canning, or drying. Most are cooked before eating.
- 3.34 Lobsters, crabs and crayfish may be stored alive in water or damp conditions for some time after catching.
They should then preferably be cooked alive or before rigor mortis sets in to produce firm meat.
All crustaceans may be stored chilled or frozen until cooking or processing can take place, but they must be chilled immediately after catching.
- 3.35 Crustaceans are highly perishable and care must be taken to preserve the quality during storage and transportation to consumer markets. Freezing is becoming more widely used in the preservation of lobsters, shrimps and prawns. All crustaceans may be frozen raw, but if whole crabs or true lobsters are frozen and stored, difficulties are encountered in peeling subsequent to thawing and cooking. The normal procedure therefore includes a heat treatment of the whole crustacea prior to freezing. Crabs are usually fully cooked while lobsters may be cooked fully or partially (11).

- 3.36 Crustaceans should be chilled rapidly immediately after catching and then frozen as soon as possible. Bulk containers should be plastic or aluminium or stainless steel. During thawing, temperatures should not rise above freezing point, except for very short periods. Cold storage conditions of not less than -21°C (-5°F) are recommended. (11).
- 3.37 Cooking is usually carried out at $200^{\circ} - 212^{\circ}\text{F}$ ($93^{\circ} - 100^{\circ}\text{C}$) - shrimps for 2-5 minutes, and crabs and lobsters for 5-20 minutes. Although this will kill active micro-organisms, it will not kill spores, therefore subsequent hygienic handling and good refrigeration are very important, especially if the cooked product is not likely to be heat treated again before consumption.
- 3.38 In the handling, storage, and processing of crustaceans, strict observance of hygienic practices is important because the large surface area to weight ratios, and the large number of handling operations during processing make such products very susceptible to contamination and spoilage.
- 3.39 Crabs and lobsters are subject to a form of deterioration known as "Black Spot" which causes a spotted discolouration of the shell and meat if kept under prolonged cold storage. This form of spoilage is thought to be associated with the formation of melanins.

3.40 CANNED FISH PRODUCTS

- So far as objectives and methods are concerned, the canning of fish products varies little from the canning of other foods. Both enzymes and bacteria can be destroyed or permanently inactivated by adequate heat processing, and if re-infection can be prevented, properly canned fish should keep almost indefinitely.
- 3.41 The procedures involved in the canning process vary somewhat with the type of fish to be canned, but are basically similar. Firstly the raw chilled fish is prepared for canning, secondly it is weighed and packed with oil, sauces or other condiments into suitable cans, and thirdly the cans are evacuated and heat treated for the required time in high temperature retorts.
- 3.42 In the tuna canning process the frozen tuna is received from the boats and placed in cold storage. When required for canning it is thawed, washed, cleaned and trimmed, and then precooked. After immediate cooling it is then boned and cut up and filled into cans with vegetable oil or water. The cans are then sealed and heat treated in retorts. In this process great care must be taken after pre-cooking not to allow the fish to stand around in a warm condition or exposed to contamination.

- 3.43 Only the freshest fish should be used for canning, and it must be appreciated that while heat processing will destroy bacteria and enzymes, it will not destroy heat-resistant toxins that may have developed in the fish before canning.

This is of particular significance in the canning of tuna and other fish of the Scombridae family, which because of unhygienic handling before canning may have developed poisonous heat resistant scombrotoxic toxins.

- 3.44 Spoilage of canned fish may be due to bacterial or chemical causes. Bacterial spoilage may be caused by inadequate processing or defective sealing of cans. This is best prevented by rigid control over the whole canning procedure. The raw fish must be fresh and hygienically handled. The water for fish washing and can cooling must be of drinking water standard. Oils, sauces, and food additives must be of good quality.

Visual gauges or automatic recorders should be fitted to all stages of the processing plant to record temperatures, times, and pressures. Mechanical can sealing equipment must be regularly checked for efficient functioning.

Factory hygiene and personal hygiene must be maintained at a high level.

- 3.45 Chemical spoilage is caused by a reaction between chemicals in the fish or the sauces, and the internal surface of the can. This is often caused by defective internal lacquering of the tin plate allowing acids in the sauces and the fish to attack the tin or even penetrate to the steel.

Crustaceans have the potential to produce sulphur compounds during spoilage which react with the tin plate to cause a dark staining due to production of iron and tin sulphides. Special lacquers or parchment lining of cans are used to prevent this.

- 3.46 OTHER FISH PRODUCTS

Other types of fish products produced in limited quantities in the Pacific Islands are smoked fish, dried fish, and salt cured fish. Since they are not produced on a commercial scale (except for the rather specialised Japanese Arobushi and Katsubushi and Bêche de Mer) they will not be considered in this paper.

4. PUBLIC HEALTH ASPECTS

4.1 From the foregoing brief review of problems relating to the safety and quality of fish and fish products produced in tropical and sub-tropical regions it will be appreciated that the potential health hazards involved are not inconsiderable.

In fact the matter was considered of sufficient importance for the World Health Organisation to convene an Expert Committee to consider these problems.

The Expert Committee on Fish and Shellfish Hygiene met in Geneva in 1973 and was opened by the Assistant Director General of WHO who stressed the increasing importance of the problems and the need for public health workers to recognise their significance.

4.2 In 1974 this Expert Committee published a report entitled "Fish and Shellfish Hygiene". In its introductory remarks it points out that due to the increasing use of the world's fishery resources and the increasing occurrence of newly recognised diseases in fish and shellfish, it is timely that an expert committee was set up to deal specifically with the public health aspects of fish and shellfish hygiene. It also points out that although fish is a nutritious and relatively safe protein food, the extensive utilisation of fish as food raises public health problems that will increase as new resources are exploited. This is because, in addition to transmitting many of the established foodborne microbial infections and intoxications there are also the dangers of other diseases more specifically associated with fish, shellfish, and the aquatic environment. Diseases of current concern include organic mercury poisoning, bio-intoxications, Vibrio parahaemolyticus infection, parasitic diseases and botulism.

The report also points out that further problems arise because of the perishable nature of fish and shellfish and any consideration of hygiene cannot ignore the effect of handling techniques on human pathogens as well as on spoilage organisms.

4.3 Food hygiene practices to control foodborne illnesses of microbial origin are well known to the public health authorities. These measures are equally applicable to quality control in fish and shellfish, and include the maintenance of high standards of hygiene and the proper use of heat-processing, cold storage and other production and processing controls that have wide applicability to all foods.

4.4 Further public health problems may arise as a result of aquatic pollution. This may necessitate the closure of shellfish beds and the relaying of molluscan shellfish in clean areas or the provision of special treatment facilities, the prohibition of marketing of species of fish known to be toxic at certain times of the year, the control of fish-borne parasites, and the control of man made aquatic pollution arising from the discharge of effluents containing hazardous chemicals or micro-organisms.

4.5 In this connection it is appropriate to quote the following from the WHO report : (2) (my underlining) :

" The relationship between the environment and the hygienic quality of fish and shellfish eaten by man are the concern of public health agencies at all levels, and the strategies to be adopted to improve quality will vary accordingly. Public health agencies should consider the following strategy, among others, to deal with the public health aspects of environmental pollution :

- (i) Public health agencies in co-operation with food scientists, epidemiologists, etc ..., should identify substances present in fish and shellfish that are a potential risk to man, or that reduce the acceptability of the product. This information must be sought from many sources, for such problems are multidisciplinary and public health agencies will need to call on scientists from many different fields to enable them to make an accurate appraisal of the problem.
- (ii) Public health agencies should then determine whether or not such problems relate to the fish and shellfish resources with which they are concerned. This usually requires local investigations which should include :
 - a) Monitoring of foodstuffs, including fish and shellfish, at the consumer level for the presence of potentially hazardous substances.
 - b) Monitoring the population to determine the pattern of food consumption, including that of fish and shellfish, to determine the magnitude and route of uptake of hazardous substances.
 - c) Monitoring selected components of the population at risk to determine clinical or subclinical effects caused by hazardous substances in food, including those derived from fish and shellfish.
 - d) Monitoring the environment to determine the distribution of hazardous substances and their likely source.
 - e) Additional specific scientific and epidemiological investigations that might be indicated from information obtained through monitoring.

These investigations embrace a wide range of disciplines, and the way in which the investigations should be directed and co-ordinated is a matter to be decided locally, but it is essential to maintain close co-operation between the various agencies and their scientists.

With regard to fish and shellfish quality and environmental monitoring, it may be necessary for investigations to be undertaken at a regional level. In such circumstances, coordination should then be the responsibility of the accepted regional body competent to deal with the problem. In order to allow the wider implications of such studies to be considered the results of national and regional monitoring schemes should be made available to those agencies concerned with global monitoring.

- (iii) From these activities, public health agencies should then be able to assess whether or not the consumption of fish and shellfish from a particular source presents an unacceptable risk to the consumer. The assessment of risk to the consumer as a result of accumulated hazardous substances in food and the relative role of fish and shellfish is complex.

Some guidance in this can, however, be obtained from specialist publications. (12) Such assessments are particularly difficult for fish and shellfish as many substances, particularly heavy metals occur naturally in the marine environment, and some species naturally accumulate these substances.

Where control measures are necessary, these can often be taken only after full discussions with other bodies, for the cost of preventing environmental pollution or of other steps to remove or reduce the risk to the consumer must be added to the social and economic costs that result from any action taken.

Action that a public health agency may take, or may recommend to other bodies for them to consider, include :

- (a) The prevention of contamination of the fish or shellfish by removal or reduction of the polluting source (ie cessation of the polluting discharge or treatment of the discharge).
- (b) Treatment of the product to make it safe for human consumption (eg. purification of shellfish to remove faecal pathogens).
- (c) Restrictions on exploitation of fish and shellfish resources from specified areas (eg. in areas polluted by metallic wastes).
- (d) Restriction on rate of intake of contaminated fish and shellfish by the general public or selected groups of the public (in relation to cadmium, lead, and mercury in fish).

In some instances one or several of these courses of action may be required.

In many instances it will be necessary to maintain some of the monitoring actions described previously to assess the effects of the control measures taken.

In view of the dynamic nature of aquatic environmental pollution and the increase in the amount of knowledge available in this field, public health agencies at all levels need to keep these matters under constant review.

Environmental investigations within the general framework of those listed above should be considered whenever new areas or new species are being exploited ".

- 4.6 Clearly the task of ensuring the safety and quality of sea-food produced for human consumption is a complex problem involving the efforts and skills of a number of specialists in different professional fields including fishery methods and techniques, marine ecology, environmental health and sanitation, and public health and food hygiene.
- 4.7 Since the Health Authority has overall responsibility for the protection of public health, including the prevention of health hazards arising from the consumption of unsound or contaminated foods, it is the responsibility of all Health Authority officials in whose area fish or fish products are produced to :
- (a) know the nature of the water and the areas from which fish and shellfish are harvested
 - (b) inspect and supervise the operation of establishments in which fish and shellfish are prepared for market
 - (c) inspect and supervise transportation facilities
 - (d) evaluate the eligibility of exporters to export fish and fish products
 - (e) inspect and supervise hygiene and sanitation in retail establishments.
 - (f) inspect plant facilities and sanitary procedures and techniques in fish processing plants
 - (g) advise on the drainage and sanitation of buildings and the disposal of offal, wastes, and effluents from processing establishments.

5. FOOD LEGISLATION

- 5.1 The main objectives of fish and shellfish inspection and control are to ensure that the consumer receives a safe, wholesome, and acceptable product. Consumers have the right to expect that the food they buy is safe to eat and of the quality they expect, and most countries have food control laws requiring that this should be so. These laws usually contain provisions which enable the administering authority to implement the control requirements outlined above.
- 5.2 These powers are generally embodied either in Public Health Acts or Ordinances or in food control laws such as the Food and Drugs Act or Pure Food Act, with subsidiary legislation made under these principal Acts and Ordinances.
- 5.3 In the United Kingdom, USA, and many other English speaking countries, including those of the South Pacific, much of this food control work is the responsibility of the officers of the Health Authority. In fact a very large part of the duties of Public Health Inspectors, Sanitarians, Sanitary Engineers and other authorised officers employed by Health Authorities is concerned with food inspection and food hygiene and the inspection of food processing and retailing establishments.
- 5.4 Under the public health and food control laws, these officers have power to inspect all types of food premises and food handling and processing equipment, and to examine and sample any food or food ingredient used in the manufacture or processing of foodstuffs for human consumption.
They also have powers to detain or seize for condemnation, food which is considered to be unsound or unfit for human consumption.
They inspect and approve the drainage and sanitation of buildings and prescribe methods of treatment and disposal for effluents and wastes.
- 5.5 This system is frequently not appreciated in other countries where different systems of administration prevail and where the Health Authority has no specialist officer covering the broad field of environmental health including food control.
- 5.6 So far as fish inspection is concerned, it is significant to note that as from 28 August 1976 exports of fish and fish products from the United Kingdom to France will have to be accompanied by a health certificate. This is the result of a Decree published by the French Government. These Health certificates are to be signed by Environmental Health Officers (Health Inspectors) of the local Health Authority or Port Health Authority.

5.7 In the international field of food legislation, mention should be made of the Joint FAO/WHO Food Standards Programme whose main responsibility is the preparation of the Codex Alimentarius. This is a collection of internationally adopted food standards presented in a uniform manner which aim to protect the consumer's health and ensure fair practices in the food trade. The Codex aims ultimately to include standards for all the principal foods, whether processed, semi-processed, or raw, for distribution to the consumer. The Codex also includes provisions in respect of food hygiene, food additives, pesticide residues, contaminants, labelling and presentation, methods of analysis and sampling. It also includes provisions of an advisory nature in the form of codes of practice, guidelines, and other recommended measures intended to assist in achieving the purposes of the Codex Alimentarius.

6. SITUATION IN THE PACIFIC ISLANDS

6.1 Most of the Pacific Islands possess food control Acts or Ordinances and subsidiary food control legislation, albeit much of it is out of date and requires revision. Their Health Departments also have an establishment of health inspectors or sanitarians whose work includes the inspection and control of foodstuffs.

6.2 So far as fish is concerned, it is only in recent years that some Pacific Islands have turned their attention to large scale commercial fishing and the manufacture of fish products for export. In order to keep pace with this development, there is no doubt that an urgent need exists for additional training in the fields of fish inspection and technology of those officers currently responsible for food inspection.

6.3 Not only that, but the facilities necessary for the proper catching and handling of fish are also often lacking - properly designed boats, ice in sufficient quantities, good quality water, electricity, properly equipped markets and retail outlets, and transportation.

6.4 All of these matters require special attention, particularly in tropical climates. However, in developing countries local economic and social considerations often make it very difficult to effect improvements. Traditional subsistence methods are not suitable for commercial production, and education of the public and persons engaged in fishing in the elementary techniques of handling and preserving fish is also of importance if satisfactory results are to be achieved.

As the WHO Report (2) has pointed out in discussing the special problems of fish and shellfish hygiene in warm climates and developing countries :

" Perhaps the most important single factor that will improve the hygienic quality of fish and fish products is the introduction or extension of refrigeration facilities or the use of ice, especially on board fishing vessels.

This technology is available and the limitations are entirely those of economics and education ".

6.5 The organisation, equipment, and personnel necessary to achieve these improvements will depend upon the size of the industry, the variety of products, the prevailing health hazards, the type of domestic and foreign trade, and not least the state of the local economy.

However, the basic requirements to safeguard the health of the consumer should be provided, and these requirements should be enforceable by law.

6.6 Therefore it must be acknowledged that in the Pacific Islands, and especially in those countries where fishing and the processing of fish products is developing on a commercial scale, there is a need for :

(i) improved basic training and refresher courses in fish hygiene, inspection and technology, for those persons involved in food inspection and control

(ii) improvements in the basic facilities and amenities necessary to promote good hygienic practices

(iii) improvements in food control legislation.

7. WHOSE RESPONSIBILITY ?

7.1 I now return to the question posed in the title of this paper - Whose responsibility should it be to ensure the safety and quality of fish and fish products produced for human consumption in the Pacific Islands ?

7.2 The WHO Report (2) recommends that - " The delegation of responsibility for administration of a programme of fish inspection should be well defined and preferably identified with one agency.

Where possible, inspection should encompass all phases from cultivation and harvesting to the final distribution. Where there are limited resources, the inspection programme should be developed in stages starting with surveillance of critical points, such as landing and marketing places. Strict regulations as well as frequent and thorough inspections are necessary for fresh and frozen fish and shellfish that are to be consumed raw ".

- 7.3 Fish hygiene must be assessed from the viewpoint of protection of human health, and since we are concerned with the safety and quality of food for human consumption and the public health consequences which may arise if it is unsafe or of unsound quality, then I have no hesitation in asserting that the overall responsibility should rest in the Health Authority.
- 7.4 In making this assertion, I am of course not unmindful of the essential skills which other highly specialised officers of other professions and disciplines can contribute to the attainment of these objectives.
The inspection and control of fish and fish products at all stages of production should be part and parcel of a Public Health Service based on sound scientific principles and performed by a team of specialists working in partnership to ensure that the products delivered to the consumer are safe, wholesome, clean, of good quality, and free from harmful toxins and chemicals which may have been absorbed from environmental sources. Such control requires close interdisciplinary co-operation between the health officers and other professions, particularly fish technologists, microbiologists, toxicologists, and marine biologists.
- 7.5 In many Pacific countries few, if any, of these specialists or the necessary laboratory facilities are permanently available. In this case the Health Authority Officers must still rely upon their own inimitable experience, local knowledge, and the well tried and time honoured organoleptic tests, to decide whether or not the fish is fit for human consumption.

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