PART IV: MANUFACTURED FISHERY PRODUCTS
IV-A: MINCED FISH

Minced fish, or mechanically deboned fish as it is sometimes referred to, is a new form of fish that has been investigated for use in this country.

Minced fish, a product akin to a fish hamburger, is obtained by passing fish through a machine which separates soft flesh from the rest of the carcass by using extreme pressure. The most popular design for the deboning machine consists of a continuous rubber belt which presses against a large metal cylinder with thousands of small holes. The belt and cylinder (or drum) are rotated in the same direction, but at different speeds by an electric motor. The fish are fed into the machine on the rubber belt where they come in contact with the cylinder. Due to pressure of the belt against the cylinder and the shearing action created by the different rates of rotation, the meat is pressed through the holes in the cylinder. The meat is then removed from the machine and the skin and bones are carried out to the other side by the belt. The consistency of the minced product can be changed from large flakes to a smooth paste by adjusting the pressure of the belt against the perforated cylinder, and by using cylinders with different size holes.

Minced fish is thought to have a number of advantages as a means of processing seafoods. The first is that deboning machines have the potential to obtain from $\frac{1}{2}$ to 2 times more usable meat from a given fish than does conventional filleting. This would have very significant economic effects as well as facilitating a much more efficient use of our fishery resources. Along with higher yields comes lower waste, which has economic as well as environmental significance. A second factor which makes the process attractive is that the machine will process all those species that, for reasons of size or anatomy, are not now filleted or used. For instance, small fish do not usually justify the labor involved in processing them, and some fish taste excellent but
contain far too many bones to be eaten easily. All of the species of fish that are not utilized because they fall into these categories could be processed easily into deboned or minced fish. Another advantage is that the raw minced fish is extremely versatile and can be blended, stabilized, flavored, formed, used as a stuffing or extruded, with numerous other possibilities.

Mechanical Flesh Separator
To date, minced fish is still experimental in this country and there are very few companies producing commercial products from it. One reason is that the equipment required is quite expensive and the industry is reluctant to make those expenditures until consumer acceptance of this new concept has been demonstrated. Another reason is that food scientists have identified some problems associated with mechanical deboning which remain to be solved. For instance, the texture of minced fish products tends to be either mushy or rubbery and cooked minced products will sometimes crumble. Scientists are exploring the use of additives and binders to overcome these defects. Another difficulty is that mincing sometimes reduces the frozen storage life from that achievable had the fish been left whole. Finally, it has not fully been determined how consumers will react to such a product. Many of the species that are being tried in mincing are darker in color, and stronger in flavor than the flaky, mild, white fish to which Americans are accustomed. For this reason, there may be some resistance to the minced products.

For the immediate future, it appears minced fish will not find wide usage. In the coming decades as fishing and consumption pressure increases on the favored species, minced fish may be used to obtain more meat from favored species and to utilize some of the others available.
IV-B: ENGINEERED SEAFOOD PRODUCTS

An engineered seafood product is one that uses a conventional seafood in some form as the primary ingredient, but is extensively changed in final appearance and character. Such products are generally subjected to fairly sophisticated processing, undergoing such steps as forming, extruding, or blending with other ingredients. A good example of an engineered seafood is the artifical or substitute breaded shrimp products that have appeared on the market in recent years. These breaded shrimp are made from blended shrimp paste recovered from small or broken shrimp, which is generally extended with other fish meat or even vegetable proteins. It would be possible to make them completely from fish meat which has been flavored to taste like shrimp. The raw material, however it is formulated, is forced into a mold that is shaped like a shrimp and is then heat-treated to set in that shape. Finally, the product is breaded and frozen.

Most people eat engineered or fabricated foods everyday now, but don't think of them in those terms. For instance, many of the snack foods available are engineered foods using corn or other grain flours as the raw material. Engineered seafoods have just as wide and varied a list of potential products, but as yet, there have been few commercially produced or marketed. Products such as fish sausages, fish jerky, fish hot dogs, and even shark cookies have been produced experimentally.

Engineered and fabricated seafoods may be common in this country in years to come as snack foods or as lower priced seafood substitutes, but consumer acceptance of seafoods in their natural form will probably have to increase before such products can be accepted by the general public.
IV-C: FISH MEAL AND FISH OIL

Sources and Types of Raw Materials

Fish meal and oil are obtained from either whole raw fish or wastes from fish canneries or other fish operations. The fish used most often, representing 80 percent of the American source of meal and oil is menhaden. Tuna is the second largest source and accounts for 10 percent of the annual production. Other sources are herring, anchovy, Pacific mackerel, and jack mackerel. Ground fish (e.g., haddock, cod, flounder, whiting, pollock, cusk, and hake) are usually dressed or filleted and a portion of the wastes is used to produce fish meal. Another group of fish called industrial fish or trash fish (i.e., non-food species) is also used to produce fish meal. Due to low oil content, the ground fish and industrial fish are used only in the production of fish meal. A few miscellaneous sources are salmon cannery waste, river herring (whole or waste from canning operation), waste of the blue crab industry, and shrimp cannery waste.

Manufacturing Processes

The four basic manufacturing processes for producing fish meal and oil are the wet process, dry process, solvent process, and digestion process. Of these, the wet process is used most frequently and the solvent extraction process, though found to be impractical in the past, is now being used to some extent to produce fish protein concentrate. The dry process and digestion process are used for manufacturing non-oily raw materials. During the wet, dry, and solvent processes, the fish oil is separated and refined if oily raw materials are used.

Wet Process: Approximately 95 percent of all fish meal and oil are produced by the wet process. In this operation, there are three main steps. First, the fish are cooked in a steam cooker. From the cooker
the fish drop into the presses. As the fish are pressed, the oil is separated, lowering the oil content from 20 percent to as low as 3 percent. This step forms a press cake which is then dried in a rotary dryer. As the drying proceeds, the press cake begins to separate, forming scrap. After leaving the dryer, a chemical reaction begins to produce heat in the scrap due to an unstable chemical condition. The scrap is allowed to cure (stabilize) prior to bagging. The curing is accomplished by increasing the air exposure, thus aiding the chemical reaction (oxidation) or by adding antioxidants to slow or delay the oxidation, thus deterring the excessive heat. When menhaden is used, it is necessary to grind the scrap into meal prior to bagging.

The oil which is separated during the pressing step of the wet process is then refined through screening and centrifuging to remove any solids in the liquid. After the initial treatment, depending on the ultimate use, this crude fish oil may be shipped or may undergo further refining.

**Dry Process:** This process is similar to the wet process, but is better adapted to raw materials in small quantities and with low oil contents. As in the wet process, the fish are cooked and dried, but this occurs simultaneously in a steam jacketed vessel. The pressing is omitted unless the oil content of the scrap needs to be reduced. The resulting scrap is then ground and bagged.

**Solvent Processing:** In this procedure the materials which may be processed are raw fish, cooked and pressed fish, dried scrap, or meal. The solvent extraction process uses solvents to extract the desired product. This process has not proved to be economically feasible in the past, but the prospect of producing fish protein concentrate for human consumption has increased interest in this method of manufacturing.

**Digestion Process:** Interest in the digestion process has also been renewed due to the possibility of producing fish protein concentrate for human consumption. In this process, whole fish or wastes are
"digested" by acids, alkalies, enzymes, or combinations of these ingredients (reagents), resulting in a liquid product called homogenized condensed fish. To produce concentrated fish protein, the liquids (homogenized condensed fish) are spray-dried, yielding the fish-protein concentrate.

Industrial Uses

**Fish Meal**: A major portion of the fish meal produced today is used for feeds. Products in which fish meal is found are pet food, dry feeds for fish, and poultry feeds. Fish meal provides valuable animal protein supplements, vitamins, minerals, and necessary growth factors for these feeds.

**Fish Oil**: Fish oil is also used in feeds and many other products. In a natural state the oil has limited use, but chemical modifications create many possibilities. Fish oil is highly recognized in the area of protective coatings. It is also found in the production of linoleum, oil cloth, printing inks, core oils, lubricants, greases, insecticidal compounds, candles and water paints. The oil also functions as an extender and modifier in rubber compounding and may be used as an ore flotation agent and fire retardant.
IV-D: FISH PROTEIN CONCENTRATE

Characteristics
A solvent extracted product, fish protein concentrate (FPC) is a fine, free-flowing grayish powder with high nutritive values. In contrast to fish meal, FPC has no fishy flavor or odor. FPC is not intended for direct consumption, but rather as a protein supplement to various foods.

There has been and is much research underway investigating possible raw materials, production methods, and uses of FPC. The reasons for this research are many, but the thrust is toward developing a product which will be an effective, economical protein food supplement.

Raw Materials
Presently, whole raw fish, usually hake, herring or menhaden, are ground and used in the production of FPC. Research has proved that the removal of viscera, skin, bone (part or all), and water solubles (part or all) increases the percentage of protein content. The value of the increased percentage of protein must be weighed against the increased cost of production. Also, the presence of bone has been found to increase the fluoride and lead content. For economic purposes, the use of fish wastes as the raw material is being investigated.

Manufacturing Process
Though other processes have been tried and are being studied, FPC is usually produced by one of many solvent procedures. Basically, during any solvent procedure whole raw fish are ground and mixed with a solvent which extracts most of the water and lipids (fats), thus dehydrating the fish. Depending on the particular process, the resulting "wet cake" may be dehydrated (extracted) with solvent from two to four times. Some procedures have a pressing step between each extraction.
Upon completion of extraction, the wet cake is dried with the use of steam, radiation, or conventional dry heat to remove the remaining solvent. The dried FPC is then ground to a fine powder and packaged.

Uses

The value and possible uses of FPC as a food ingredient or additive are beginning to be fully realized. FPC could be used to alleviate protein malnutrition in underdeveloped countries and as a protein supplement to foods in industrialized countries.
IV-E: MARINE COLLOIDS

A colloid is a chemical with the property of forming gels (e.g., gelatin, pectin, starch). Colloids are used as thickeners, humectants, coagulants, bulking agents, fluctuation agents, and antibiotic carriers. As mentioned in the section concerning seaweeds, marine colloids are usually obtained from seaweeds and are called phycocolloids. Following are the three colloids manufactured most often.

Agar

Agar is produced from red algae and is used as a culture medium in bacteriology. Chemical properties affecting the consistency of agar, the property of transparency, and the fact that few bacteria digest it, make agar well suited for use as a culture medium. Another area of major use is as an ingredient of bakery icing.

Algin

Algin is produced from brown algae. Kelp, because of its large size, can be harvested mechanically; therefore, it is the brown alga used most often as the raw material for algin. Algin is used in foods and pharmaceuticals, and has many industrial applications due to its ability to form films that are clean, tough, and flexible; to adhere well; to resist greases, oils, waxes, and organic solvents; and to mix well with plasticizers.

Carrageenan

Carrageenan is produced from red algae, which grow just above the low water level to a depth of 20 feet. Though harvesting is done by hand with rakes, one man may collect as much as half a ton in one day. For food, industrial, and pharmaceutical use, carrageenan is usually found in gel form. Carrageenan is commonly used to suspend cocoa
fibers in chocolate milk, and to stabilize ice cream by controlling ice crystal formation and improving melt-down characteristics.
IV-F: PHARMACEUTICAL AND BIOCHEMICAL PRODUCTS

Many of today's drugs are obtained from naturally occurring substances found in land-based plants and animals. Though the basic chemistry of life is similar in terrestrial and marine organisms, extensive research was not initiated until recently. During the 70's, this search for drugs from the sea has led to the following discoveries.

Though there are 400,000 species from which "marine bioactive substances" may be extracted, scientists have learned that the most productive species are sponges, anemones, algae, and opisthobranch mollusks which have no shells. Species such as these that are immobile, soft bodied, or otherwise unprotected often evolve chemical defense systems. Many of the substances we derive from land plants serve to protect them from insects and other herbivores. The heart stimulant, digitalis, is an example. Also, since sea water is an excellent carrier of potentially harmful substances, many species may have developed ways to deal with this threat. These are two speculative reasons for the abundance of usable drug compounds present in these organisms.

Researchers have discovered compounds from marine species which affect heart muscle, and others which inhibit cell division (i.e., anti-tumor and anti-cancer activity). Other compounds with potentially useful activity in the cardiovascular and central nervous systems have also been discovered. One active compound has been found to prolong the effect of the tranquilizer pentobarbital by slowing its movement into the bloodstream. Thus, hypothetically, much smaller and safer doses of pentobarbital may be used with the same results. A powerful cardiac stimulant has been found which is 300 to 500 times more powerful than digitalis and does not seem to have the side effects of digitalis. Chitosan is another new compound which is being studied in relation to wound healing abilities. Heparin is a drug used to prevent clotting of
human blood and has been in use for years. Recently, the animal supply such as lungs of cattle and the intestinal mucosa of swine has decreased due to increased use of these products in pet food. Scientists are now searching for a marine source of heparin. Thus far, crabs and lobster have shown the best results. Another area of research is concerned with a toxin associated with red tides, which may be useful in treating rare human reactions to sodium.

Though all of these compounds show signs of making tremendous contributions to human health, most of the drugs still face seven to ten years of clinical trials, synthesis, federal approval, commercial production, and marketing. Following are a few biochemicals and pharmaceuticals found on today's market which are produced from land-based animals. All of them can be produced from marine sources, but presently, production costs are prohibitive.

Nucleic acids and nucleosides are essential components of all cell nuclei and are found in combination with proteins, forming nucleoproteins. Nucleic acids may be isolated through a mild hydrolysis of nucleoproteins. Nucleosides are formed by heating nucleic acid at 356°F with dilute ammonia for 3½ hours. The best source of nucleic acid from fish is spermatozoa, which contains over 70% nucleic acids on a dry basis. Glandular organs are also a source.

Streptogenin, sometimes called the "protein utilization factor", improves the efficiency of protein metabolism and increases growth of certain microorganisms. Fish flesh is an excellent source.

Glutathione is found in all body tissues and, in the reduced form, is a tripeptide consisting of three amino acids: glycine, cysteine, and glutamic acid. Glutathione acts as a coenzyme in carbohydrate metabolism, is involved in oxidation-reduction processes, and may be used in detoxification in man. Fish waste is a plentiful and inexpensive source.

Cortisone is a steroid compound and can be obtained from fish plasma. There are many therapeutic uses, but cortisone is used most often to relieve pain caused by collagenous diseases such as rheumatoid arthritis.
Bile Salts are produced in the liver and aid digestion and absorption of fats by emulsifying them in the intestines. Use of bile salts in medicine and synthetic organic chemistry is common. Recovery of bile salts from fish is more expensive than recovery from animals (e.g., ox). The small size of fish gallbladders makes the process of extracting bile difficult. For this reason, the use of fish as a raw material is dependent on the availability of ox bile and the price of bile salts. As the price of bile salts increases or the supply of ox bile decreases, the feasibility of using fish as a source increases. Cod is the best source of fish bile salts.

Proteolytic enzymes are obtained from pyloric caeca of fish. The pyloric caeca are tube-like sacs which are attached near the lower end of the stomach. Their function is to secrete proteolytic enzymes.

Proteolytic enzymes break down proteins, and are used most often in leather bating. In this process, the enzyme causes leather to become more porous, thus increasing permeability and improving penetration of the leather by the tanning agents. Other uses of proteolytic enzymes include: degumming silk, chillproofing beer, tenderizing meat, and liquifying meat for consumption by the ill or infirm.

Insulin is a hormone which maintains blood-sugar in mammals at a relatively constant level under normal metabolic conditions. When insulin is not produced in sufficient quantities, diabetes mellitus occurs. In 1922 research using fish (skate, shark, dogfish) as specimens proved that the mammalian islets of Langerhans in the pancreas produced a substance that maintained normal blood-sugar levels. Later (1924) the name insulin was first used to describe the substance which, when injected subcutaneously in a diabetic animal, completely corrected and controlled abnormal blood-sugar levels.

In the early stages, production of insulin from fish seemed more economical than production from mammals. Today the natural resources of a country or area determine the raw material used for producing insulin.

Protomines are simple proteins which are soluble in water and can precipitate other proteins from watery solutions. Protomines are
obtained from fish sperm and are used in combination with insulin to improve diabetic treatment. These simple proteins show the absorption of insulin, thus prolonging its effectiveness.
IV-G: OTHER INDUSTRIAL PRODUCTS

The fishery products which have not been discussed thus far are products which use fish solubles, scales, shells, skins, bones, and sounds (air bladders) of fish as raw materials. Following are a few examples of products which make use of these materials.

**Pearl Essence**

Pearl essence is a substance obtained from fish scales (usually herring) which is used as a spray or dip to give an object a pearly appearance. This substance may be found on such items as beads, shoes, pencils, fishing rods, artificial flowers, ash trays, vanity cases, book covers, and finishes for textiles.

**Poultry Feed**

Clam and oyster shells are sometimes used in the production of poultry feeds. The shells are dried, ground to various specified sizes, bagged according to size, and shipped to the processing plant.

**Leather**

Fish skins may be used to produce leather. Sharks, due to their size and tough skin, are the main source of this product.

**Glue**

The raw materials for the production of glue are fish skins, heads, and bones. The processing of these materials involves cooking to withdraw the glue and evaporating the glue to reduce the moisture content.

**Isinglass**

Isinglass is used as a filtering aid in the processing of wine. The sounds (air bladder) are washed, air dried, moistened, and drawn

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into a ribbon which is rolled onto a spool. Due to the production of synthetic filtering aids in recent years, the demand for isinglass has declined.

Liquid Fish Fertilizer

The fertilizer manufactured from fish solubles (liquid fish) is a by-product of the wet process to produce fish meal. This organic liquid fertilizer is used when other forms of fertilizer are inadequate.
PART V: GENERAL INFORMATION
Table V-1. Common Finfish Species of Virginia

<table>
<thead>
<tr>
<th>Finfish</th>
<th>Season Harvested Locally</th>
<th>Spawning Eggs(Roe) Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray trout</td>
<td>Summer - Fall</td>
<td>May - September</td>
</tr>
<tr>
<td>Spotted trout</td>
<td>Summer - Fall</td>
<td>May - July</td>
</tr>
<tr>
<td>Croaker</td>
<td>Spring - Summer</td>
<td>August - December</td>
</tr>
<tr>
<td>Spot</td>
<td>Late Summer - Fall</td>
<td>December - April</td>
</tr>
<tr>
<td>Kingfish (sea mullet, king whiting, round head)</td>
<td>Summer - Fall</td>
<td>May - August</td>
</tr>
<tr>
<td>Red (puppy) drum</td>
<td>Summer - Fall</td>
<td>September - October</td>
</tr>
<tr>
<td>Black drum</td>
<td>Summer - Fall</td>
<td>February - May</td>
</tr>
<tr>
<td>Jumping (striped) mullet</td>
<td>Summer - Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>Striped bass (rock)</td>
<td>Fall - Winter</td>
<td>May - June</td>
</tr>
<tr>
<td>Black sea bass</td>
<td>Winter</td>
<td>May - June</td>
</tr>
<tr>
<td>Summer (left eyed) flounder (fluke)</td>
<td>Summer - Fall</td>
<td>December - February</td>
</tr>
<tr>
<td>Winter (right eyed) flounder (blackback)</td>
<td>Spring - Early Summer</td>
<td>Winter</td>
</tr>
<tr>
<td>Puffer (blow fish)*</td>
<td>Summer</td>
<td>*</td>
</tr>
<tr>
<td>Scup (porgy)</td>
<td>Winter</td>
<td>May - June</td>
</tr>
<tr>
<td>Mackerels</td>
<td>Spring, Late Summer - Fall</td>
<td>Early Fall</td>
</tr>
<tr>
<td>Tuna (bluefin)</td>
<td>Summer</td>
<td>-</td>
</tr>
<tr>
<td>Butterfish &amp; harvest fish (star butter)</td>
<td>Summer</td>
<td>Fall</td>
</tr>
<tr>
<td>Bluefish</td>
<td>Summer - Fall</td>
<td>June - August</td>
</tr>
<tr>
<td>American eel</td>
<td>Spring - Summer</td>
<td>-</td>
</tr>
<tr>
<td>Herring &amp; shad</td>
<td>Spring</td>
<td>Spring</td>
</tr>
</tbody>
</table>

*Never eat the eggs, skin, or viscera of the puffers. Those parts are poisonous. Eat only the meat of the tail.
<table>
<thead>
<tr>
<th>Mollusc</th>
<th>Season Harvested Locally</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conch (Whelk)</td>
<td>All year</td>
<td>Chowder, Specialty dishes</td>
</tr>
<tr>
<td>Moon snail</td>
<td>All year</td>
<td>Chowder</td>
</tr>
<tr>
<td>Periwinkle</td>
<td>May be collected all year</td>
<td>Steamed, roasted, chowder</td>
</tr>
<tr>
<td>Blue mussel</td>
<td>Mostly north of Virginia</td>
<td>Steamed, in tomato sauce</td>
</tr>
<tr>
<td>Surf clam</td>
<td>All year</td>
<td>Clam chowder, minced</td>
</tr>
<tr>
<td>Ocean quahog (Mahogany)</td>
<td>All year</td>
<td>Chowder, clam strips</td>
</tr>
<tr>
<td>Hard clam</td>
<td>All year</td>
<td>Steamed, raw, chowder, baked</td>
</tr>
<tr>
<td>Soft shell clam (manninose)</td>
<td>All year - mostly north of Virginia</td>
<td>Steamed</td>
</tr>
<tr>
<td>Razor clams</td>
<td>All year</td>
<td>Steamed, chowder</td>
</tr>
<tr>
<td>Rangia (brackish water clam)</td>
<td>Not harvested yet - edible all year</td>
<td>Relaying or depuration necessary to alleviate muddy taste. Used for chowder.</td>
</tr>
<tr>
<td>Manilla clam (Cobicula)</td>
<td>Not harvested yet - edible all year</td>
<td></td>
</tr>
<tr>
<td>Atlantic (Eastern) oyster</td>
<td>Fall, Winter, Spring - best quality</td>
<td>Fried, raw, stewed, baked</td>
</tr>
<tr>
<td>Sea scallop</td>
<td>All year</td>
<td>Fried, raw, stewed, baked</td>
</tr>
<tr>
<td>Squid</td>
<td>All year, mostly Fall, Winter, Spring</td>
<td>Fried, stuffed, specialty dishes</td>
</tr>
</tbody>
</table>
Table V-3. Common Crustacean Species of Virginia

<table>
<thead>
<tr>
<th>Crustaceans</th>
<th>Season Harvested Locally</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue crab (hard)</td>
<td>*Dec. 1 - March 31 (dredged) Apr. 1 - Nov. 30 (potted)</td>
<td>Steamed, boiled</td>
</tr>
<tr>
<td>Blue crab (soft)</td>
<td>Summer</td>
<td>Fried</td>
</tr>
<tr>
<td>Northern (Maine) lobster</td>
<td>Mostly north of Virginia (all year)</td>
<td>Steamed, boiled, baked</td>
</tr>
<tr>
<td>Spiny (rock) lobster</td>
<td>None locally</td>
<td>Steamed, boiled, baked</td>
</tr>
<tr>
<td>Shrimp (white, pink, brown)</td>
<td>North Carolina and south; early Summer, Fall</td>
<td>Steamed, boiled, baked</td>
</tr>
<tr>
<td>Rock shrimp</td>
<td>Mostly south of Virginia</td>
<td>Steamed, boiled, baked</td>
</tr>
<tr>
<td>Red crab</td>
<td>All year</td>
<td>Same as picking meat from blue crab and lobster</td>
</tr>
</tbody>
</table>

*These are legal seasons, and supplies vary depending on severity and length of winter season.
V-B: WATER QUALITY

Molluscan shellfish -- oysters, clams, and mussels -- are very dependent on water quality for survival and propagation of the animals as well as the health of consumers. Therefore, the concept of water quality has broader implications than may first be apparent. The scope and character of these implications were reported in a study conducted by the National Marine Fisheries Service (1977). The introductory remarks of this report on subject of water quality stated:

"An important aspect of the study of water quality is the specific needs of the molluscan shellfish organism for its survival and propagation. Chief among these needs are a suitable supply of food, adequate oxygen for respiration, a habitat relatively free of silting material, and a suitable range of temperature, salinity, and chemical parameters. These conditions are often interfered with or controlled, to a greater or lesser extent, by man's activities in the environment. Interference may also be the result of natural disasters, such as heavy runoff, floods, or hurricanes.

Man-caused water quality impacts on molluscan shellfish resources can be divided into two major categories. The first can be considered as water quality changes which generally do not kill the shellfish resource but may contaminate it so that it cannot be safely used for human food, or affect its flavor so that it is not desirable for human consumption. Mollusks that are contaminated with pathogenic organisms from sewage or other sources, pesticides, heavy metals or other toxic substances, are not suitable for human consumption. Contamination by petroleum derivatives, copper or other chemicals which cause undesirable tastes in shellfish significantly affects their marketability.

The second category of man-caused water quality impacts is those resulting in habitat changes which significantly alter the viability of the resource or even its continued existence. A positive habitat alteration such as improved oxygen, nutrient, salinity, temperature or water circulation conditions could increase the productivity of shellfish. Conversely, reductions in viability or elimination of the population can be caused directly or indirectly
by toxic pollutants, oxygen deficiencies, or other conditions which some organisms may not tolerate during certain phases of their life cycles. (This latter point is the primary reason the shellfish industry, both producers and processors, oppose certain types of shore development, particularly when such development occurs in the close proximity to nursery areas).

The sanitary quality of shellfish growing areas is by far the principal factor that currently influences the quality of molluscan shellfish as a food product. Shellfish meats are often consumed raw, or only partially cooked, and with few exceptions, the entire animal is consumed. Filter feeding mollusks pump prodigious quantities of water, entrapping plankton and some of the suspended and dissolved inert material from water passed over the gills. They are relatively indiscriminate in their retention of pathogens in addition to harmless bacteria and viruses. Of no less concern are the unknowns surrounding the many toxic compounds such as pesticides, other synthetic chemicals, heavy metals, and petroleum and distillates found in the environment.

Growing Water Classification

As mentioned, shellfish can be consumed raw; therefore, periodic monitoring of the sanitary quality of growing waters is essential for assuring a wholesome product. According to the National Shellfish Sanitation Program's manual of operations, shellfish growing water may be classified in one of the four categories:

- Approved
- Conditionally Approved
- Restricted
- Prohibited

Approved: Growing areas may be designated as approved when:

A. As determined by sanitary survey, the area is protected against fecal contamination through distance from sources of such pollution, dilution, and by time afforded for natural purification that there is no substantial likelihood of dangerous contamination.

B. The area is not so contaminated with radionuclides or industrial waste that consumption might be hazardous.
C. The area is not contaminated by large concentrations of domestic animals. The occasional presence of a few domestic animals and fowls or low-density wildlife is not considered to be of public health significance.

D. The area is protected from the discharge of human excreta from boats anchored at marinas during the period such marinas are in use.

E. The coliform median MPN* of the water does not exceed 70 per 100 ml, and not more than 10% of the samples ordinarily exceed an MPN of 230 per 100 ml for a 5-tube decimal dilution test in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.

F. In determining what constitutes satisfactory evidence that an area is fully protected against contamination from disease-producing microorganisms, judgment in any given case shall be based upon all the facts available considering different observations not separately but in their relationship to each other. Thus, the correct interpretation of bacteriological examinations of shellfish area growing waters depends upon what is shown by sanitary inspection, current studies, and pollution source information. The judgment and discretion of the responsible state shellfish control agency shall be totally relied upon in the classification of all shellfish waters within its jurisdiction.

Conditionally Approved: The suitability of some areas for harvesting shellfish is dependent on the attainment of an established performance standard by treatment works discharging effluent, directly or indirectly, into the area. In other cases, the sanitary quality of the area may be affected by seasonal population, or sporadic use of a dock or harbor

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*MPN is the standard abbreviation for Most Probable Number. The MPN is a statistical estimate of the number of bacteria per unit of volume.
facility. Such areas may be classified as conditionally approved when all standards will be met. Precautions must be taken to assure that shellfish will not be marketed from these areas subsequent to any failure to meet the performance standards and before the shellfish can purify themselves of polluting microorganisms.

The water quality requirements are the same as for an approved area. A closed safety zone is established between the conditionally approved area and the source of pollution, and potential sources of pollution are carefully monitored. Boundaries of conditionally approved areas are marked so as to be readily identified by harvesters.

**Restricted:** An area may be classified as restricted when a sanitary survey indicates a limited degree of pollution which would make it unsafe to harvest the shellfish for direct marketing. Shellfish from such areas may be marketed after purifying or relaying. The shellfish may be polluted with fecal materials, but not with hazardous radionuclides or industrial wastes. The coliform median MPN of the water cannot exceed 700 per 100 ml and not more than 10% of the samples exceed an MPN of 2,300 per 100 ml.

**Prohibited:** An area is classified as prohibited if the sanitary survey indicates that dangerous numbers of pathogenic microorganisms might reach the area. The taking of shellfish from such areas for direct marketing is prohibited. Relaying or other salvage operations must be carefully supervised.

An area is classified as prohibited if the median coliform MPN of the water exceeds 700 per ml or more than 10% of the samples have a coliform MPN in excess of 2,300 per 100 ml, or if the area is so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous.

No market shellfish can be taken from prohibited areas except by special permit. Additionally, areas in which sanitary surveys have not been made are automatically classified as prohibited.

A hypothetical use of the four recognized area classifications is shown in Figure V-1. This idealized situation depicts an estuary receiving sewage from two cities, "A" and "B". City "A" has complete
sewage treatment including chlorination of effluent. City "B" has no sewage treatment. The estuary has been divided into five areas, designated by roman numerals, on the basis of sanitary survey information:

Approved

Area I. The sanitary survey indicates that sewage from the cities "A" and "B" (even with the "A" sewage plant not functioning) would not reach this area in such concentration as to constitute a public-health hazard. The median coliform MPN of the water is less than 70/100 ml. The sanitary quality of the area is independent of sewage treatment of city "A".

Conditionally Approved

Area II. This area is of the same sanitary quality as area I; however, the quality varies with the effectiveness of sewage treatment at city "A". This area would probably be classified prohibited if city "A" had not provided sewage treatment.

Restricted

Area III. Sewage from "B" reaches this area, and the median coliform MPN of water is between 70 and 700 per 100 ml. Shellfish may be used only under specified conditions.

Prohibited

Area IV. Direct harvesting from this area is prohibited because of raw sewage from "B". The median coliform MPN of water may exceed 700/100 ml.

Area V. Direct harvesting from this area is prohibited because of possible failure of the sewage treatment plant. Closure is based on need for a safety factor rather than coliform content of water or amount of dilution water.

Some states may not use these four categories per se, but have designations which produce the same end results. For example, one state
may designate areas as approved, seasonally approved, conditionally approved and prohibited.

![Shellfish Gathering Areas](image)

**Figure V-1. Shellfish Gathering Areas**

**Coliforms: What and Why**

What are coliforms and why are they used as an index of the sanitary quality of potential shellfish growing waters? In looking at this question, let's answer the last part first.

Since shellfish are filter feeders, it would be extremely undesirable to consume shellfish from areas contaminated by fecal material, due to the potential transmission of disease organisms. Therefore, it is essential that some means exist to assay for the presence of fecal pollution. The analysis of water for the presence of coliforms is one method used for indicating the presence of fecal contamination.
Coliforms are a group of bacteria which are gram negative, aerobic to facultatively anaerobic, non-spore-forming rods which ferment lactose, producing acid and gas within 48 hours at 32 to 37°C. What this means is that coliforms can be a fairly imprecise indication of fecal contamination. The reason for the imprecision is that certain genera of the coliform group are normally associated with materials which are of nonfecal origin. Therefore, if high coliform counts are observed this does not always mean they are the result of fecal pollution.

For this reason, some states have adopted a fecal coliform standard in lieu of a coliform standard. The test for fecal coliforms relies on elevated incubation temperatures to separate coliforms of fecal origin from those organisms in the coliform group which are of nonfecal origin. While the fecal coliform test is not absolute, it has been successfully used and fecal coliform standards have proven to be practical. Virginia, for example, has a fecal coliform standard for approved growing waters of: median value not to exceed an MPN of 14 per 100 ml and not more than 10% of the samples to exceed 49 per 100 ml. The coliform standard used in some states is: a median of 70 with 10% not to exceed 230. Although the fecal coliform standard appears more restrictive, the test is also more selective. Consequently, the two standards -- coliform and fecal coliform -- are comparable to a limited extent.

Relaying

For purposes of discussion, the State of Virginia will be used as an example of how one state chooses to handle the practice of relaying. What is indicated with regard to Virginia may not be true in other states.

In Virginia the responsibility for monitoring shellfish growing waters is given to the Bureau of Shellfish Sanitation. Figures recently obtained from the Bureau indicate that about 93,000 acres of potentially productive shellfish waters are closed to direct marketing (Another 78,000 acres are closed in waters with salinity levels too low for oysters and quahog clams, but suitable for a potential new food resource, rangia clams). These 93,000 acres constitute 24% of the total productive acreage in the state.
Although Virginia has closed 24% of the total productive acreage to direct harvesting of shellfish, this does not necessarily mean that products from some of these waters cannot legally enter the market place. Relaying of shellfish from prohibited and restricted waters to approved waters is allowed under carefully supervised conditions.

The concept of relaying is relatively simple. Shellfish from polluted areas, which may have excessive bacterial counts and therefore potentially hazardous bacterial types, are harvested, transported, and then replanted in approved growing areas where they must remain for a minimum of 15 days with water temperatures higher than 50°F. During this residence in approved water, shellfish depurate themselves of potentially pathogenic bacteria and therefore render themselves acceptable for direct marketing. The water temperature, however, must be 50°F or higher. If not, the animals will not pump the clean water through their systems and depurate.

Since safeguarding public health is the principal concern in transplanting polluted shellfish, rather involved procedures have been developed to insure that polluted shellfish do not become confused with unpolluted shellfish during the harvesting and transporting processes. Yellow flags must be displayed by all boats engaged in harvesting shellfish from polluted waters. When these boats bring the harvest to the dock, they are met by an inspector of the Virginia Marine Resource Commission (VMRC). The VMRC inspector must witness the transfer of shellfish from the boat to a truck and then seal the truck on completion of the loading. The truck, which also must display a yellow flag, delivers the shellfish to a point near where they will be transplanted. There another VMRC inspector meets the truck and inspects the seal. If the seal has not been tampered with, he will break the seal and must witness the off-loading of the truck and the subsequent transplanting. After remaining in approved waters for 15 days, the shellfish may be reharvested and marketed.

Transplanting has proven to be a very successful method of utilizing the polluted resource while at the same time protecting public health. Virginia's record indicates that there has been no documented cases of illness attributed to shellfish which have been transplanted to approved waters in the prescribed manner.
Although transplanting has been a tremendous benefit to the shellfish industry, there are some major disadvantages:

A. Product loss - On reharvesting of transplanted shellfish, losses of 10% to 30% are encountered.
B. Seasonality - Transplanting is not a year-round venture since a water temperature of at least 50°F is required.
C. Labor - Transplanting requires the shellfish to be harvested twice.
D. Time - Transplanting requires the shellfish to purge themselves in approved water for at least 15 days.

Depuration Plants

While transplanting may be defined as the process of moving commercial size shellfish from waters not classified as approved to waters that are approved for natural purification, depuration is the process of controlled purification in shore-based plants (FDA, 1979).

Why would anyone want to depurate shellfish when transplanting has such a good track record with regard to protecting public health? The reason is to negate the disadvantages associated with transplanting which are outlined above.

Depuration offers the following advantages:

A. Recovery - Virtually 100% of the animals depurated are recovered.
B. Year-round Operation - Since weather is not necessarily a factor in bringing water temperature to 50°F, some plants are operational throughout the year.
C. Labor - Depuration requires the shellfish to be harvested only once.
D. Time - Depuration requires only 48 hours as opposed to 15 days for relaying.

An idealized depuration plant design containing all essential elements is illustrated in Figure V-2 (PHS, 1966). The proper functioning of this plant would be dependent on the orderly flow of product through the various unit operations, as well as monitoring the quality of water used for depurating the shellfish.
Depuration does not rely on mechanical or artificial mechanisms to cause the shellfish to purge themselves of high bacterial populations. On the contrary, depuration relies on the natural biological activity of

Figure V-2. Depuration and salination plant layouts
the shellfish; however, optimum water parameters for maximum shellfish activity may be mechanically controlled or artificially produced so that depuration can occur in a relatively short span of time. Water parameters which may be controlled or produced include: temperature, turbidity, dissolved oxygen, bacterial quality, and salinity.

Currently, only four states have depuration plants operating within their borders: Maine, Massachusetts, New Jersey, and New York. These states have instituted very specific regulatory measures regarding the activity of the depuration plants. While the regulations and evaluation processes do vary significantly among these states, the net result has been the same, the production of market quality shellfish from waters where direct marketing was prohibited.

With the increasing pressures of industry and urbanization on our coastal areas, it is becoming more and more difficult to "hold the line" with respect to further deterioration of water quality. Consequently, some individuals view depuration plants as a practical alternative to the loss of shellfish resources due to decreases in approved growing areas. Other individuals fear an attitude change among people who may give up the fight for cleaner waters because an alternative is available.

The real future of depuration may not be decided on the availability or non-availability of approved water, but rather on the issue of economics. Although not discussed here, data from the FDA (1979) indicates that depuration can be done more economically than relaying.

REFERENCES


V-C: HOME FREEZING OF SEAFOODS

Home freezing is not only an excellent method for preserving sea-
foods, but can be an added economy as well, since fresh seafoods may be
purchased in season when prices are generally lower. Because some fresh
seafoods are seasonal, it is important to learn the availability of sea-
foods during certain times of the year. The local fish dealer can
provide this information and indicate which varieties are the most
economical.

Selecting seafood for freezing is one of the most important phases
of freezing food for the family. When purchasing seafoods for home
freezing, be sure that they have not been previously frozen. Consult
the dealer to be absolutely certain. When transporting seafoods to your
home, keep them as cold as possible. A few hours at room temperature or
in the trunk of a car on a warm day can completely spoil many seafoods.

Whenever in doubt as to the freshness of seafood, do not freeze it.
If you have serious doubts, discard the seafood. Poor handling of fish
prior to freezing will make it impossible to obtain good results, since
freezing can only protect the quality of the fish. Freezing cannot
improve the quality; frozen foods can be no better than the material you
start with.

Preparation of Seafood for the Freezer

When preparing seafoods for the freezer, eliminate all inedible
material and debris. For example, scale fish and remove heads and
entrails. Dehead and peel shrimp. Eliminating unwanted material will
allow additional space in the freezer and lessen the work involved in
preparing and serving the dish.
Packaging Materials

The object of packaging is to protect fish from dehydration, oxidation, and contamination. A good package has several characteristics:

A. **Moisture proof.** Loss of water during frozen storage results in a condition often referred to as freezer burn. The loss of water dries and toughens the food and promotes oxidation. Freezer burn and oxidation are always accompanied by off-flavor, off-odor, and off-color.

B. **Low permeability.** Permeability refers to the rate at which the packaging material permits vapors and gases to pass between the product and the surrounding atmosphere. There are large differences in the permeability of packaging materials and films.

C. **Tightness of fit.** A tight-fitting package is essential to prevent moisture loss inside the freezer package. In a loose-fitting package, moisture evaporates from the fish and condenses as ice crystals on the inside surface of the package. If the product is warmed slightly during defrosting or each time the freezer door is opened, the moisture may move from the package surface back to the food surface. When the package cools again, the cycle is repeated. This may continue until a large quantity of water is removed from the food, causing severe dehydration.

D. **Other qualities.** In addition to the important characteristics listed above, you should look for packaging materials that are strong, easy to apply and relatively inexpensive. See Table V-4 following this section for a comparison of packaging materials.

Unfortunately, it is difficult to find packaging materials with all the desirable qualities listed. Each material has its advantages and drawbacks. Waxed paper, waxed cartons, cellophane, and polyethylene (the common plastic bag) offer little protection to seafood products. Bread wrappers (a kind of polyethylene bag) are widely used as a home freezer wrap. However, they should never be used because they are such
a poor barrier to water vapor and air. Aluminum foil is a wrap to be used with caution. The foil itself is impermeable to gases, but it is difficult to seal properly, thus allowing easy passage of water vapor and air. Additionally, aluminum foil is not a tight-fitting wrap and is easily punctured.

Of the plastic films, polyester, polyvinylidene chloride (saran) and polyvinyl chloride (P.V.C.) are all good barriers to oxygen, and also rank high in most other desirable characteristics of an ideal package. Both saran and P.V.C. will adhere to fresh fish and provide a good fit, if you are careful to crowd out air bubbles. However, saran is not strong at very low temperatures. It is a good idea to overwrap saran packages with a protective paper.

Polyester bags and sleeves are widely used for commercial packaging, but are not practical for home freezing, because air must be evacuated from the bags either by a vacuum pump or heat shrinking. Polyester is most suited for expensive, difficult-to-hold items such as cooked shrimp, salmon and crab, where the high value of the product offsets the relatively costly package.

Other Preparations for Freezing

In commercial cold storage, most whole fish are glazed with ice, because, with proper equipment, glazing is the least expensive method of packaging fish. Ice glazing is not easily done in the home, however, and the glaze will not stand up under continued handling. Some home freezer users do a form of glazing by packing fish in suitable containers and filling the containers with water. A good container for this purpose is a tin can such as a 2-lb coffee can. When using such a container, be sure to have at least one-half inch of water over the fish.

Fish and shrimp are often frozen in ice cream and milk cartons filled with water. This practice is acceptable as long as the seafood is completely covered with an ice glaze and the cartons tightly sealed to prevent the transfer of moisture and oxygen out of the package. If the fish touch the sides of the cartons, as often happens, rancidity and "freezer burn" result.
A technique recommended for preserving the quality of seafood is to dip it in a precooked and cooled solution of 5 percent starch. This process will help exclude air from individual pieces when they are frozen. Use about 6 tablespoonsful of corn starch per gallon of water. Be sure to rinse away the starch after the item is thawed and before cooking.

The importance of excluding as much air as possible from the package cannot be overemphasized. Air not only causes oxidation, it also acts as an insulator, slowing the freezing process. While it is advisable to package seafoods under vacuum, most homemakers do not have access to the necessary equipment. The next best thing is to wrap the seafood to exclude as much oxygen as possible. The drug store wrap is suggested. This is done by placing the item on the sheet of wrapping material and bringing the ends together at the top. "Roll the fold" until it is snug against the food. The ends should be folded in a similar manner while pressing out as much air as possible. The wrapping material should then be secured with tape to prevent unfolding.

Another important consideration in packaging is the size of the pieces. Fish to be stored for periods greater than three months should be left whole or in quite large pieces. There is less dehydration per pound when the fish are frozen in this manner.

Trying to guess the age and contents of a frozen package of seafood can be frustrating and wasteful. Many times food is discarded because the storage age is unknown. Although it is unlikely that properly frozen and stored food can become harmful at any age, top quality demands that extended storage be avoided. Label each package with the date, type of seafood, weight, and number of servings or pieces. A crayon or grease pencil is ideal for this purpose. Markers with water-soluble inks are to be avoided. A record attached near the freezer will also be helpful and should carry the same information included on the packages as well as the location of each package in the freezer, the package size, and a current record of the number of packages put into or removed from the freezer. This prevents unnecessary searching for a particular package and the harmful warming of the contents while the freezer door is open.
Using the Freezer

The homemaker can save time, avoid losses, and make freezing sea-food a pleasure by planning ahead. The following considerations are important, and should be noted:

A. Check the freezer to see that it is functioning properly. Set it to hold at -4°F. If it won't hold that temperature, it is time to have it repaired or replaced.

B. To maintain the quality of the frozen seafood, adjust the thermostat to the coldest setting about 2 hours prior to anticipated use. Do not guess; check the temperature with a thermometer.

C. Consider the size of the freezer. Generally, about 2-3 pounds of seafood for each cubic foot of freezer space will freeze in 10-12 hours. Try not to overload your freezer by putting in large loads at one time. It takes several days to freeze a hundred pounds of fish and pull it down to storage temperature.

D. It is important that packages be placed in the freezer as soon as they are ready. Usually, the faster the food is frozen, the better the quality and the longer the storage life. Slow freezing may actually allow bacterial and enzymatic spoilage to take place while the food is only partially frozen.

E. To obtain the fastest freeze, place the packages in direct contact with the freezer floor or walls or coils until they are frozen. If the packages take more than 5 or 6 hours to freeze, they are probably too large.

F. Leave the thermostat at the coldest setting until all the packages have frozen. Then maintain the temperature at 0°F or colder.

G. Avoid temperature fluctuation, which can be harmful to frozen seafood. Arrange the packages in the freezer so that there is adequate space between them to allow good air circulation. Never place unfrozen packages near frozen food. This procedure could cause frozen food to thaw, and the new packages might take 3-4 days to freeze. Generally, the farther away from the freezer door, the more stable the temperature.
Storage Temperatures

One of the most important factors controlling the quality of frozen seafood is the storage temperature. As storage temperature increases, the rate of quality loss also increases. A difference of 8 to 10 degrees can mean a great deal. You can safely assume that it is not possible to store fish at too low a temperature. Cold storage research shows that fish stored at 15°F for as little as two weeks show a significant loss of quality. Most home freezers are designed to hold temperatures between +4° and -4°F. Most of the older cold storage equipment operated at 0° to -4°F. Cold storage facilities for fisheries products are now being designed to hold temperatures from -10° to -20°F.

Storage Time

The length of time fish are held on ice or chilled storage greatly affects the storage time of the frozen product. Experiments have shown that several species of fish held two days on ice have a frozen storage life of twelve months, whereas the same fish held for seven days on ice have a frozen storage life of only two months. The need for rapid handling of fresh fish cannot be overemphasized. Storage life is also dependent on the species of fish. See the section below on the relationship between oil content and storage life.

Although commercial packaging may allow over a year of good shelf life, freezing methods available in the home generally will not permit seafood to be stored that long and still maintain its flavor and texture. Most home-frozen seafood should not be stored over 6 months, and salmon, crab and shrimp not over 3 months. Two to three months or less storage time is ideal for all seafood. A good rule for a continuous supply of high quality frozen food is "first in, first out". Seafood is delicate in flavor and deserves to be eaten at the peak of quality.

Rancidity and Oil Content

The biggest problem in spoilage of frozen fishery products is rancidity. Rancidity appears to be directly related to fat or oil content. Long ago, farm women learned to store their lard in crocks with as small a surface as possible exposed to the air and in a dark,
cool place. Heat, light, oxygen and the presence of heavy metal ions, such as copper and iron, enhance the development of rancidity.

Fish oils differ considerably from other animal and plant oils. The oil in fish is long-chain fatty acids, which contain many double bonds. Consequently, fish oil becomes very susceptible to oxidation. It is at the double bonds that atmospheric oxygen combines with the oil molecule to produce a variety of compounds such as ketones, aldehydes, acids, and many others that have not been identified.

Fish may be classified into three categories according to their oil content:

A. Low (less than 5 percent): examples are halibut, cod, flounder, and red snapper.
B. Moderate (5-10 percent): examples are mullet, croaker, and salmon.
C. High (more than 10 percent): examples are herring, mackerel, and lake trout.

Normally, fish of high oil content are more susceptible to oxidation and, therefore, rancidity. Fish possessing a high oil content will become rancid in three months in a freezer unless precautions are taken. Moderately oily fish become rancid in from 9 to 12 months. There are, however, exceptions. King salmon have a fat content of about 15 percent and pink salmon contain 6 percent fat or less. Even though the pink salmon have much less fat than king salmon, they develop a rancid odor and flavor much more quickly than the king salmon do. Some species of fish are extremely difficult to preserve in the frozen form in a home freezer. Herring is a fat fish which is particularly susceptible to rancidity; it should be held at -20°F or lower. Smelt are another group difficult to store for extended periods.

Freezing alone will not prevent rancidity but will slow down the reaction considerably. Treating fish with an antioxidant coupled with vacuum packaging will increase the shelf life. Antioxidants which have displayed excellent results in experiments are butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), ethylenediaminetetraacetic acid (EDTA), 3', 3-thiodipropionic acid (TDP), and propyl gallate. Other
good antioxidants which can be purchased at the grocery store are ascorbic acid and citric acid.

For those who glaze fish and wish to use an antioxidant, we recommend ascorbic acid. The fish should be soaked in a 0.1 percent solution for about 1 to 2 minutes, frozen, and then glazed with this solution. A second glazing is advisable. The fish may then be wrapped as previously described.

Other Causes of Spoilage

Besides rancidity, the two major causes of spoilage in frozen foods are protein degradation and brown discoloration. Protein degradation is caused mainly by autolytic and bacterial enzymes which are quite active at about 40°F. This spoilage is characterized by ammonia and amine-like odors often experienced in spoiled meats and seafoods. These enzymes are protein in nature, and mobilization or activity decreases as the temperature is reduced. Some enzymes remain active (though activity is low) even at 0°F. A prime example occurs in the freezing of corn on the cob without first blanching; heating inactivates the enzymes. In fishery products there is very little or no enzymatic degradation at 0° to -10°F and these products may remain palatable for many months, all other factors being equal.

Brown discoloration is also known as the browning reaction or the Maillard reaction. This reaction is particularly prevalent when white fleshed fish are cut into steaks or fillets. Extensive research has shown that the reaction is non-enzymatic and is caused by a combining of certain amino acids with reducing sugars. Pentoses (5 carbon sugars) react readily with amino acids which contain sulfur, those amino acids being methionine, cysteine, and cystine. Lysine is also involved. The reaction is characterized by the presence of a brown color much like that of brown wrapping paper. The reaction is inhibited by treatment with antioxidants such as ascorbic acid and TDP.

Proper Use of the Frozen Product

The method of thawing seafood is almost as important as proper freezing. Schedule thawing so that seafood will be cooked soon after it is thawed. Usually the more quickly a product is thawed the better, but
never in hot water. Surface spoilage can take place quickly when thawing at room temperature or in warm water if the surface of the package remains at that temperature for several hours.

Place the package of frozen seafood in the refrigerator to thaw. Allow from 18 to 24 hours for thawing a 1-pound package. If quicker thawing is desired, place the packages of frozen seafood under cold running water. Allow 2 hours for thawing a 1-pound package. Thawed fish may be held safely for a day in the refrigerator before cooking. Thawed seafoods should not be refrozen.

Some frozen seafood may be cooked without thawing. Breaded, frozen fish should be cooked this way. In addition, frozen fillets may be cooked without thawing if additional cooking time is allowed. If the fillets are to be breaded or stuffed, however, they should be thawed before cooking.

A warning is in order about thawing smoked or kippered fish. Never leave smoked or kippered fish in a tightly wrapped package after it has thawed. Some smoking methods do not ensure complete destruction of Clostridium botulinum spores. Smoked fish stored unfrozen over a few weeks in an airtight container may be harmful.

Comments

Seafood is tasty, nutritious, easy to prepare, and economical. It commands high priority on a list of preferences for any family meal. Consequently, these delicacies of the sea deserve to be served at their peak of quality. We say to the commercial processor: "Keep the product clean, keep it moving, keep it cold, and keep it stored at a temperature sufficient for proper preservation of the product." This is good advice to the homemaker freezing seafood for her family in the home.
### Table V-4. Characteristics of Freezer Packaging Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Permeability</th>
<th>Tightness of fit</th>
<th>Strength</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyvinylidene Chloride (Saran)</td>
<td>Low</td>
<td>Very Low</td>
<td>Very Good</td>
<td>Medium Low</td>
</tr>
<tr>
<td>Polyvinyl Chloride P.V.C.</td>
<td>Low</td>
<td>Very Low</td>
<td>Very Good</td>
<td>Medium</td>
</tr>
<tr>
<td>Polyester Bags and Sleeves</td>
<td>Very Low</td>
<td>Low</td>
<td>Good</td>
<td>Very High</td>
</tr>
<tr>
<td>Ice Glaze</td>
<td>Low</td>
<td>Low</td>
<td>Excellent</td>
<td>Very Low</td>
</tr>
<tr>
<td>Polyethylene Wrap and Bags</td>
<td>Medium</td>
<td>High</td>
<td>Poor</td>
<td>High</td>
</tr>
<tr>
<td>Aluminum Foil</td>
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</tr>
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<td>Cellophane</td>
<td>Very High</td>
<td>Medium</td>
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</tr>
<tr>
<td>Waxed Paper and Cartons</td>
<td>Very High</td>
<td>High</td>
<td>Poor</td>
<td>Adequate</td>
</tr>
</tbody>
</table>
V-D: FACTORS AFFECTING QUALITY OF FISH

Several factors may contribute to the quality of a product before it ever reaches the consumer. These factors include species, area of catch, method of catch, handling on board the fishing vessel, and processing techniques. The consumer has no control over the factors, and our purpose in this discussion will be to look at quality control factors over which the consumer can exercise control.

The spoilage of fresh fish has been found to be a rather complex process. There is no one factor or system which is solely responsible for quality deterioration; rather, it is caused by a number of interrelated systems. As soon as a fish dies, a whole series of complicated changes begins in the flesh: chemical changes, oxidative changes, and bacterial changes.

Chemical Changes (Enzymes)

The chemical changes in the tissues of dead fish are brought about by enzymes that remain active after death. When a fish dies, it loses its defenses against its own enzymes including the digestive enzymes of the gastrointestinal tract and autolytic enzymes of the tissues. These enzymes may even be active, though the activity is greatly reduced at sub-freezing temperatures.

Due to breakdown of muscle tissues by these endogeneous enzymes, it is possible to have spoilage in a completely sterile fish. However, from a more practical perspective, the effects enzymes have on fish products are primarily flavor changes, and these changes occur during the first few days of iced storage, before bacterial spoilage supervenes.

The enzymes associated with bacteria are the major cause of spoilage. The bacteria accomplish spoilage by releasing enzymes into their surroundings.
which then break down fish protein into smaller components. These components are, in turn, used by the bacteria as a food source. Bacterial spoilage will be discussed in more detail later.

Oxidative Changes

The bad taste and aroma of rancid fat are the result of oxidative rancidity. Oxidative rancidity results from the reaction of oxygen (from the atmosphere) with unsaturated sites on fatty acids. This reaction produces a variety of end products which cause disagreeable odors and flavors.

These unsaturated fats present in seafood are what makes seafood so attractive to many individuals who wish to limit their saturated fat intake. Yet, if not properly handled, they will cause the product to go rancid.

There are tremendous variations in the fat content of various fish species. Even within a single fish itself, there is a difference in the speed with which different portions undergo rancidity. Seasonal variations in susceptibility to rancidity have also been demonstrated.

Fish can go rancid at sub-freezing temperatures, unless adequate precautions are taken to prevent oxygen from coming in contact with the product. More on preventative measures later.

Bacterial Growth

The loss of quality due to the action of bacteria, probably the most familiar type of spoilage to consumers, has the most obnoxious effects.

Bacteria are found on live fish in the surface slime, intestines, and gills. Once the fish dies, it loses its defense against those bacteria which are capable of decomposing tissues. So what follows is a breakdown of the tissues by enzymes released by bacteria, thus producing what is characteristically seen as spoilage.

A question that is often asked is "why are fish so perishable?" Marine fish, that is to say salt water fish, have within their tissues low molecular weight nitrogenous compounds referred to as osmoregulators. The function of these osmoregulators in the live animal is to counter the osmotic pressure created by the salt concentration in ocean water.
A. Initial Number

\[ 10^8 \]

\[ \text{Numbers} \]

\[ \text{Time} \rightarrow \]

B. Temperature

\[ 10^8 \]

\[ \text{Numbers} \]

\[ \text{Time} \rightarrow \]

Ratio of product: ice

\begin{align*}
    a & : 2:1 \\
    b & : 1:1 \\
    c & : 1:2
\end{align*}

C. Type of Bacteria

\[ 10^8 \]

\[ \text{Numbers} \]

\[ \text{Time} \rightarrow \]

\begin{align*}
    a & : \text{Pseudomonas} \\
    b & : \text{Bacillus}
\end{align*}

*Figure V-3. Factors that affect the rate of bacterial spoilage*

If you have ever eaten marine fish, you may recall that the meat did not taste salty. In fact, doctors often recommend seafoods to individuals who are on low sodium diets. If these osmoregulators were not present, salts from the ocean environment would readily diffuse into the animal's tissues and, assuming the animal could live, the meat from the fish would be salty.
Table V-5. Shelf Life of Various Processed and Unprocessed Fish vs. Temperature of Storage.

<table>
<thead>
<tr>
<th>Type of Fish</th>
<th>Storage Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50°F - 68°F</td>
</tr>
<tr>
<td>Ungutted small fatty fish; e.g. sprats and herring</td>
<td>1 day</td>
</tr>
<tr>
<td>Ungutted small white fish; e.g. blue whiting, argentines</td>
<td>1 day</td>
</tr>
<tr>
<td>Gutted fatty fish; e.g. herring, mackerel</td>
<td>1 day</td>
</tr>
<tr>
<td>Gutted white fish; e.g. cod, haddock</td>
<td>1 day</td>
</tr>
</tbody>
</table>

Source: Keay and Hardy, 1978.

What do osmoregulators have to do with perishability? The best analogy is that bacteria are a lot like people; that is to say that bacteria tend to do what is easiest first. On the foods that lack these low molecular weight osmoregulators, bacteria must first break down large protein molecules into smaller units before they can use the protein as food. Consequently, it takes time before these proteins are degraded and there is not a large pool of readily useable food to support rapid growth. On the other hand, marine fish with the low molecular weight osmoregulators already present, provide an immediately useable food source for bacteria which allows them to multiply rapidly, rendering marine fish very perishable.

Dehydration (Freezer Burn)

Dehydration in frozen meat or seafood products is a serious problem, for severe dehydration alters the appearance, texture and flavor of the product. This problem seems to have become more acute in recent years with the advent of the frost-free refrigerators. Freezer burn is, however, preventable if proper attention is given the product prior to freezing.
Now that we have briefly surveyed the factors that contribute to the overall reduction in quality of fresh fishery products, how can we control these factors in order to delay the onset of spoilage?

Maintaining Quality

The quality of the seafood product you purchase decreases with time. The product is of the highest quality at the time of purchase and nothing will improve its quality. Refrigeration is the easiest means of maintaining quality. But only refrigerate products that are going to be prepared within 24 hours of purchase. Otherwise, it is best to freeze them.

As mentioned earlier, spoilage is caused by the activity of enzymes; those enzymes associated with the fish, and those produced by bacteria on or in the fish. As the temperature of the environment is reduced, the activity of these enzymes begins to decrease. Their activity may not be entirely stopped by freezing temperatures, especially at temperatures encountered in home refrigerators; however, it may be so reduced that the frozen shelf life can be as long as one year for certain species of fish and shellfish.

Oxidation occurs even in frozen fish. However, the rate at which oxidation occurs varies with species, depending on the amount of fat a fish may have. Additionally, precautions taken prior to freezing, such as wrapping, will go a long way in protecting susceptible species from oxidative rancidity.

Bacterial growth is slowed by refrigeration temperatures, but foods eventually spoil even in the refrigerator. By reducing the temperature even lower to the point of freezing, bacterial growth can, for all intents and purposes, be stopped. It is nonetheless a good practice to always clean fish prior to refrigeration or freezing by gutting to remove intestinal bacteria and digestive enzymes, cutting the head off to remove the bacteria associated with the gills, and then washing the fish in running cold water to remove as many bacteria as possible from the surface slime. As shown in Figure V-1 and Table V-5, the initial bacterial numbers are critical with respect to expected shelf life of refrigerated or iced products, and can also affect the quality of thawed frozen products.
Freezing

With respect to freezing, keep these three points in mind:

A. Freezing can only protect the quality of the product.
B. Freezing does not improve quality.
C. Frozen foods can be no better than the material one starts with.

Obviously, the colder the freezer, the more stable the product. As mentioned earlier, as the temperature is reduced, so is the activity of the enzymes naturally present in the fish.

Most shelf life predictions on frozen products are based on the temperature of 0°F. Unfortunately, most home freezers do not achieve 0°F, but rather 3°F to 7°F or higher. This small increase in temperature may have a profound impact on expected shelf life.

Another factor which affects freezer temperature is overloading, which restricts air circulation within the freezer. The introduction of new, unfrozen material into the freezer has the effect of warming the products surrounding the newly introduced product. If the freezer is overloaded so that proper circulation of air is prevented, a temperature gradient can be established within the freezer, with the coldest spot located at the very bottom of chest type freezers.

REFERENCES

V-E: U.S. GRADE STANDARDS AND INSPECTION MARKS
FOR FISHERY PRODUCTS

Bringing the harvest of the seas to consumers is a complex operation. By nature, fish vary in characteristics and quality. Processing and distribution involve many steps. The wide variety of packaged and prepared fishery products further complicates the task of bringing fish to our tables.

U.S. Grade Standards and Inspection Marks are important aids to orderly and efficient fish marketing. As part of the Voluntary Federal Inspection Program, grade and inspection marks provide useful standardized information for trade transactions in fishery products.

Grade Standards

Grade standards serve many purposes: they reflect different quality levels of products, they form a basis for sales and purchases, they provide guidelines for in-plant quality control, and they establish a basis for official inspection. Fishermen, wholesalers, processors, distributors -- all who are involved in production of fishery products -- use grade standards to buy and sell products of known and accepted quality. Consumers rely on gradings as a guide to products of assured quality. In general, then, grade standards identify the relative value, utility, and quality of each unit of fishery products.

The National Marine Fisheries Service assigns U.S. Grade Standards for many high-volume fishery products for mass feeding and direct consumer markets. These standards cover such products as frozen fish fillets and fillet blocks, frozen raw fish portions and fish steaks, frozen raw breaded and precooked fish portions and fish sticks, frozen raw headless shrimp and raw breaded shrimp, and frozen raw and precooked breaded scallops.
"U.S. Grade" Mark

The "U.S. Grade" mark signifies that:

a. The product is clean, safe and wholesome.

b. The product is of a specified quality, identified by the appropriate U.S. Grade designation, as determined by a Federal inspector in accordance with established requirements in U.S. Grade standards.

c. The product was produced in an acceptable establishment, with proper equipment and in an appropriate processing environment as required by food control authorities.

d. The product was processed under supervision by Federal food inspectors and packed by sanitary food handlers in accordance with specific Good Manufacturing Practice requirements.

e. The product is truthfully and accurately labeled as to common or usual name, optional ingredients and quantity.

What Different Grade Standards Mean

Grade A means top or best quality. Grade A products are uniform in size, practically free of blemishes and defects, in excellent condition and possess good flavor for the species.

Grade B means good quality. Grade B products may not be as uniform in size or as free from blemishes or defects as Grade A products. Grade B may be termed a general commercial grade, quite suitable for most purposes.

Grade C means fairly good quality. Grade C products are just as wholesome and are generally as nutritious as higher grades. Grade C products have a definite value as a thrifty buy for use where appearance is not an important factor. Consumers today will not find products labeled Grade B or Grade C in the marketplace because products of Grade B and Grade C quality usually are marketed without any grade designation.
Federal Inspection Marks

Federal inspection marks are official marks approved by the Secretary of Commerce and authorized for use on brand labels of fishery products. When displayed on product labels, these marks signify that Federal inspectors of the Department of Commerce have inspected, graded and certified the products as meeting all the requirements of the inspection regulations. The marks further signify that the products have been produced in accordance with official U.S. grade standards or approved specifications.

Inspection Reinforces Grading

Product grading is more valid when done by a neutral unbiased party. The National Marine Fisheries Service provides voluntary Federal inspection on a fee-for-service basis, paid for by the plant under inspection. Officially graded and certified products of such plants are eligible to carry the inspection mark and/or the prefix "U.S." on their grade marks, "U.S. Grade A" for example. Products which bear only the inspection mark must be at least Grade B, and most are Grade A. Knowledgeable consumers consider inspection to be an added service by concerned processors on behalf of consumers.

"Packed Under Federal Inspection" Mark

"Packed Under Federal Inspection" may be displayed as an official mark or as an official statement on the product label. The mark or statement signifies that the properly labeled product is clean, safe and wholesome and has been produced in an acceptable establishment with appropriate equipment under the supervision of Federal inspectors. The product has not been graded as to a specific quality level, rather, it is an acceptable commercial quality as determined by Federal inspectors in accordance with approved standards or specifications.
Seafood Products Bearing Grade and Inspection Marks

The distinctive inspection marks are symbols which signify two distinct but related functions in guiding the consumer to safe, wholesome products produced in a sanitary environment, and packed in accordance with uniform quality standards under the supervision of the U.S. Department of Commerce's voluntary inspection service. Many brand-name fishery products carry either one or both inspection marks on their labels. The following list illustrates the range of fish and shellfish products currently inspected:

A. Frozen Raw Fish Fillets, Portions, and Sticks
B. Frozen Fried Fish Fillets, Portions, and Sticks
C. Fresh or Frozen Whole or Dressed Fish
D. Frozen Raw Breaded Shrimp
E. Frozen Whole Cooked Crabs and Crabmeat
F. Fried Fish Seafood Cakes
G. Raw and Fried Fish Dinners
H. Fried Clams and Clam Cake Dinners
I. Fried Scallops and Fried Scallop Dinners
J. Raw and Raw Breaded Scallops
K. Frozen Fish Steaks
L. Raw Peeled and Deveined Shrimp
M. Cooked Crabmeat, Legs, and Claws
N. Fish and Shellfish in Sauce Dinners
O. Frozen Minced Fish Blocks
P. Frozen Fried Scallops
Poisonous Molluscs

There are three types of shellfish poisoning that are recognized by physicians. They are: (1) Gastrointestinal type -- characterized by such symptoms as nausea, vomiting, diarrhea, and abdominal pain. This type usually develops about 10-12 hours after eating the shellfish, and is believed to be caused by bacterial contamination; (2) Allergic type -- characterized by redness of the skin, swelling, development of a hive-like rash, itching, headache, nasal congestion, abdominal pain, dryness of the throat, swelling of the tongue, palpitation of the heart, and difficulty in breathing. This type probably results from a sensitivity to shellfish on the part of the individual; (3) Paralytic type -- this last type is caused specifically by the dinoflagellate poison present in shellfish. The disease is caused by certain toxic dinoflagellates of the *Gonyaulax* and *Gymnodinium* species. The early symptoms are a tingling or burning sensation of the lips, gums, tongue and face which gradually spreads elsewhere to the body. The tingling areas later become numb, and movements of the muscles of the body may become very difficult. Other symptoms frequently present are weakness, dizziness, joint aches, increased salivation, intense thirst, and difficulty in swallowing. Nausea, vomiting, diarrhea, and abdominal pain are relatively rare. The muscular paralysis may become increasingly severe until death ensues.

**Treatment:** There is no treatment available for this paralytic type of poisoning and no known antidotes. Evacuation of the gastrointestinal tract should be instituted as soon as possible. Vomiting can be stimulated by swallowing large quantities of salt water, egg white, or by merely placing one's finger down the throat. Alkaline fluids such as ordinary baking soda, are said to be of value since the poison is
rapidly destroyed by that medium. Artificial respiration may be required. See a physician at once!

Prevention: The extremely toxic nature of this poison cannot be overemphasized. Poisonous shellfish cannot be detected by their appearance, smell or by discoloration of a silver object or garlic placed in cooking water, etc., ad infinitum. It is only by careful scientific laboratory procedures (usually the mouse assay procedure) that this poison can be determined with any degree of certainty.

The digestive organs, or dark meat, gills, and in some shellfish species, the siphon, contain the greatest concentration of the poison. The musculature or white meat is generally harmless; however, it should be thoroughly washed before cooking. Dark tissues have been reported to be poisonous for over a year after the toxic organisms have been present in the water. The broth, or bouillon, in which the shellfish is boiled is especially dangerous since the poison is water soluble, and should be discarded if there is the slightest doubt. The tidal location from which the shellfish were gathered cannot be used as a criterion as to whether the shellfish are safe to eat. Poisonous shellfish may be found in either low or high tidal zones.

The state shellfish control agencies regularly collect and assay representative samples of shellfish from growing areas where shellfish toxins are likely to occur. If the paralytic shellfish poison count reaches 80 micrograms per 100 grams of the edible portions of raw shellfish meat, the area is closed to the taking of the species in which the poison has been found. The harvesting of shellfish from such areas shall be controlled in accordance with the recommendations described in The National Shellfish Sanitation Program Manual of Operations (U.S. Food and Drug Administration, Public Health Service Publication No. 33, Parts I and II).

Poisonous Fishes

The problem of poisonous fishes is an exceedingly complex one, and is quite mystifying to most persons encountering these organisms. One of the difficult things to understand is how a valuable food fish in one locality can be so poisonous in another. Nevertheless, this is the
situation that exists. The dual personality of these fishes has caused much confusion both in medical literature and among laymen in the field. The fact that a person may have eaten a particular fish on hundreds of occasions and never found it to be poisonous is no guarantee that this same fish under slightly different circumstances, or in some other locality, will not produce violent intoxication and rapid death.

The big question is how do fish become poisonous, and what are the factors contributing to the condition? Not all of the details as to exactly how fishes become poisonous are known at present. However, it is believed that in most instances fishes become poisonous because of their feeding habits. The poison is believed to originate in a marine plant. Plant-eating fishes feed on plants containing the necessary chemical substances, and the poison is either accumulated or manufactured in the body of the fish. Carnivorous fishes feed on the plant-eating fishes and the poison is thereby distributed to other groups of fishes. As in the case of paralytic shellfish poison, the toxic materials do not affect the fish but are lethal to man when sufficient quantity of the material is eaten. Scombroid poison develops in an entirely different manner, and this will be discussed later.

Poisonous fishes are widely distributed throughout the world, but occur in greatest numbers in tropical waters, particularly in the West Indies and the tropical Pacific. Poisonous puffers, which are extremely toxic, may be found in temperate areas, and the Greenland shark, which under certain circumstances is poisonous, is found in Arctic seas.

Types of Fishes Poisonous to Eat

There are currently recognized eight general categories of marine fishes whose flesh is dangerous to eat. However, only five of them are of practical significance to the average person.

Poisonous Sharks and Rays: A number of deaths and many illnesses have been reported from the eating of sharks and rays. Most illnesses have been caused by tropical species, and the most severe poisonings have resulted from eating the livers of tropical sharks. However, the flesh of the Greenland shark, Somniosus microcephalus (Block and Schneider) which inhabits Arctic waters, has been observed on numerous occasions to
cause intoxications in both humans and sled dogs. The chemical nature of these poisons is not known.

**Species Reported Poisonous:**
- Black-Tipped Sand Shark
- Seven-Gilled Shark
- Greenland Shark
- Six-Gilled Shark
- White Shark
- Hammerhead Shark

**Medical Aspects:** The most severe forms of poisoning usually result from the eating of the liver. The musculature in most instances is only mildly toxic with the symptoms seldom more than that of a mild gastrointestinal upset with a predominating diarrhea.

Symptoms from liver poisoning usually develop within 30 minutes, and consist of nausea, vomiting, diarrhea, abdominal pain, headache, joint aches, tingling about the mouth, and a burning sensation of the tongue, throat, and esophagus. As time goes on, the nervous symptoms may become progressively severe, resulting in muscular incoordination and difficulty in breathing due to muscular paralysis, coma, and finally death.

**Treatment:** Same as the treatment on fish poisoning.

**Prevention:** Avoid eating the liver of any shark unless it is known with certainty to be edible. The livers of large tropical sharks are said to be especially dangerous. The flesh of tropical and Arctic sharks should be indulged in only with caution.

**Poisonous Scombroid Fishes (Tuna, Bonito, Mackerel):** This heading is somewhat misleading for all of the fishes listed are, under most circumstances, edible. In scombroid fishes, the poisoning is due directly to inadequate preservation of the fish. They are included here, however, because of the danger that may come from eating stale scombroid fishes -- particularly in tropical areas.
Fishes normally contain a chemical constituent in their flesh, called histidine. When histidine is acted upon by bacteria, this substance apparently changes into a histamine-like substance called saurine, which can cause an illness in humans that resembles a severe allergy. This histamine-like substance is produced when scombroid fishes are left to stand at room temperature, or out in the sun for several hours. For some unknown reason, scombroid fishes seem to be more susceptible to becoming toxic by this means than most other types of fishes.

A list of the species will not be given since any of the tuna, skipjack, bonito, mackerel, sierra, Spanish mackerel, etc. may be involved. Representatives of these fishes are world-wide in their distribution.

**Medical Aspects:** The symptoms of acute scombroid poisoning resemble those of a severe allergy. Frequently, poisonous scombroid fish can be detected immediately upon tasting it. Victims state that it has a "sharp, or peppery" taste. Symptoms develop within a few minutes after eating the fish, and consist of intense headache, dizziness, throbbing of the large blood vessels of the neck, feeling of dryness of the mouth, thirst, palpitation of the heart, difficulty in swallowing, nausea, vomiting, diarrhea, and abdominal pain. Within a short time, the victim develops massive red welts which are accompanied by intense itching. There is danger of shock, and deaths have been reported. Generally, the acute symptoms last only 8-12 hours, followed by rapid recovery.

**Treatment:** In addition to such routine procedures as evacuation of the stomach and catharsis, the use of any of the ordinary antihistaminic drugs will be found to be effective.

**Prevention:** Under most circumstances, the eating of scombroid fishes is without danger as long as they are properly preserved. Commercially canned fish are without the slightest danger. Scombroids should be either promptly eaten soon after capture, or preserved by canning or by freezing as soon as possible. Fish left in the sun for longer than two hours should be discarded. Examine the fish before
eating, and if there is any evidence of staleness, such as pallor of the gills, or an off-odor, discard the fish.

**Puffer or Fugu Poisoning:** This group includes the puffer-like fishes, or members of the order Tetraodontoida, which is comprised of ocean sunfishes, sharp-nosed puffers, the puffers proper, and the porcupine fishes. The puffers proper are our greatest offenders. There are about 90 or more species of them, and over 50 have been involved in poisonings to man or are known to be toxic under certain conditions. A characteristic of all puffers is their remarkable ability to inflate themselves by gulping in large quantities of water or air. Puffers make considerable noise during inflation by grinding their heavy jaw teeth together. Some of them can, and do, inflict nasty bites. Puffers have a distinctive offensive odor, which is particularly noticeable when they are being dressed.

These fishes are among the most poisonous of all marine creatures, and must be treated with respect. The liver, gonads, intestines, and skin usually contain a powerful nerve poison which may produce rapid and violent death. The flesh, or musculature, of the fish is generally edible. Strange to say, despite the great toxicity of this fish, it commands the highest prices in Japan as a food fish. Puffers, called fugu in Japan, are prepared and sold in special restaurants, which hire specially trained fugu cooks. The fugu is given careful treatment so as to eliminate the danger of eating it. Nevertheless, it is still the number one cause of fatal food poisoning in Japan, especially among the fishermen, professional or amateur, who prepare and eat their catch. Unless you feel that you are a professional fugu connoisseur, leave puffers alone. You will probably live longer.

Although puffers are most numerous in the tropics, many species do extend into temperate zones. Puffers can be recognized by the characteristic shape and large teeth. The following list of species will serve to represent some of the more poisonous tetraodontoid fishes.
Representative Species of Poisonous Tetraodontoid Fishes:
Maki-Maki, or Deadly Death Puffer
White-Spotted Puffer
Black-Spotted Puffer
Gulf Puffer
Porcupine Fish

Medical Aspects: Symptoms of tingling about the lips and tongue and motor incoordination usually develop within 10-45 minutes after ingestion of the fish. This tingling may later spread to other parts of the body. In some instances, the numbness may involve the entire body, and the victim may feel as though he were "floating". Excessive salivation, extreme weakness, nausea, vomiting, diarrhea, and abdominal pain may soon follow. Twitching of the muscles, paralysis, difficulty in swallowing, loss of voice, convulsions, and death by respiratory paralysis may ensue. More than 60 percent of the victims poisoned by this fish die.

Treatment: Same as the treatment of fish poisoning. There is no specific treatment or antidote for puffer poisoning.

Prevention: Learn to recognize the puffer and leave it alone. It makes an excellent poisonous bait for stray cats, but a poor food for humans.

Ciguatera-Producing Fishes: Ciguatera is a type of poisoning produced by a large variety of tropical marine reef or shore fishes. More than 300 different species have been incriminated to date. Apparently, any marine fish under the proper circumstances, may become involved with this type of poison since all of the species listed as poisonous are commonly eaten in some localities, and considered good food fishes. It is, therefore, believed that these fishes become poisonous because of their food habits as previously discussed. There is a tendency for the larger fish of a species to be more toxic than smaller fish of the same species. In most cases the flesh is less toxic than the viscera. The liver is usually the most poisonous part of the fish.
Ciguatera is a serious problem in certain tropical areas such as the central and south Pacific Ocean and West Indies. It is unfortunately unpredictable, and therefore exceedingly difficult to control. The edibility of fishes in an island area has been known to change suddenly. For example, ciguatera intoxications first began to appear in the islands of Midway, Johnston, Plamyras, Fanning, and Christmas about the year 1943, caused by eating fishes which had previously been known to be edible.

**Representative Species of Ciguatera-Producing Fishes:**

Surgeonfish  
Ladyfish  
Jack  
Herring  
Surmullet (*Parupeneus cyclostomus*)  
Seabass, Grouper  
Seabass  
Trunkfish (*Lactoria cornuta*)  
Trunkfish (*Lactophrys trigonus*)  
Porgie  
Squaretail  
Porgie (*Pampus pagrus*)  
Filefish  
Triggerfish  
Anchovy  
Squirrelfish  
Oceanic Bonito  
Wrasse (*Epibulus insidiator*)  
Wrasse (*Julis gaimardi*)  
Snapper (*Aprion virescens*)  
Snapper (*Gratodyx aureolineatus*)  
Snapper (*Lethrinus miniatus*)  
Red Snapper (*Lutjanus bohar*)  
Red Snapper (*Lutjanus gibbus*)  
Snapper (*Lutjanus monostigma*)  
Red Snapper (*Lutjanus vaigiensis*)  
Snapper (*Monotaxis grandoculis*)  
Chinaman Fish  
Parrotfish (*Scarus coeruleus*)  
Parrotfish (*Scarus microps*)  
Seabass (*Plectropomus oligacanthus*)  
Seabass (*Plectropomus truncatus*)  
Seabass (*Variola louti*)
Medical Aspects: Tingling about the lips, tongue, and throat, followed by numbness, may develop immediately or any time within a period of 30 hours after ingestion of the fish. The tingling sensation may be accompanied by such other symptoms as nausea, vomiting, metallic taste, dryness of the mouth, abdominal cramps, and diarrhea. The muscles of the mouth, cheeks and jaws may become drawn and spastic, with a feeling of numbness. Headache, joint aches, nervousness, prostration, dizziness, pallor, cyanosis, inability to sleep, extreme weakness, and exhaustion are frequently present. The feeling of weakness may become progressively worse until the patient is unable to walk. Muscle pains are generally described as dull, heavy aches or cramping sensations, but may also be sharp, shooting, affecting particularly the arms and legs. Victims complain of their teeth feeling loose and painful in their sockets. Visual disturbances consist of blurring or temporary blindness. Sensitivity disorders are frequently reported consisting of intense itching, red papular rash, blisters, extensive areas of loss of skin, especially of the hands and feet, and occasionally ulceration. There may also be loss of hair and nails.

In severe intoxication, the nervous symptoms are particularly pronounced. The victim may interpret the feeling of cold as a tingling, burning, "dry ice or electric shock" sensation, or hot objects may give a feeling of cold. Difficulty in walking and generalized muscular incoordination may become progressively worse. Muscular paralysis, convulsions, and death may ensue. The mortality rate in this type of fish poisoning is relatively low, at about 7 percent. In those instances in which the victim survives, recovery is extremely slow if the person has been severely poisoned. Complete recovery may require months, and even years.

Treatment of Fish Poisoning

With the exception of scombroid poisoning in which the patient should be administered antihistaminic drugs, there is no specific treatment. However, a few general procedures have been of value in many instances.

The stomach should be emptied at the earliest possible moment. Warm salt water or egg white will be found effective. If these
ingredients are not available, stick a finger down the throat. A cathartic should be administered. If laryngeal spasm is present, intubation and tracheotomy may be necessary. Oxygen inhalation and intravenous administration of fluids supplemented with vitamins given parenterally are usually beneficial. If the pain is severe, opiates will be required. Morphine is the drug of choice when given in small, divided doses. Cool showers have been found to be effective in relieving the severe itching. It should be kept in mind that in rare instances scombroid poisoning may be combined with other types of fish poisoning. Fluids given to patients suffering from disturbances of temperature sensation should be slightly warm, or at room temperature. Vitamin B complex supplements are advisable.

Prevention

One cannot detect a poisonous fish by its appearance. Moreover, there is no known simple chemical test to detect the poison. The most reliable methods involve the preparation of tissue extracts which are injected intraperitoneally into mice, or feeding samples of viscera and flesh to cats or dogs, and observing the animal for the development of toxic symptoms. The viscera-liver and intestines of tropical marine fishes should never be eaten. Also, the roe of most marine fishes is potentially dangerous, and in some cases may produce rapid death. Fishes which are unusually large for their size should be eaten with caution. This is particularly true for barracuda (*Sphyraena*), jacks (*Caranx*), and grouper (*Epinephelus*) during their reproductive seasons.

If one is living under survival conditions, and questionable fishes must be eaten, it is advisable to cut the fish into thin fillets and to soak them in several changes of water -- fresh or salt -- for at least 30 minutes. (Do not use the rinse water for cooking purposes). This will serve to leach out the poison, which is somewhat water soluble. If a questionable species is cooked by boiling, the water should always be discarded. It must be emphasized that ordinary cooking procedures do not destroy or significantly weaken the poison. The advice of native people on eating tropical marine fishes is frequently conflicting and erroneous, particularly if they have not lived within a particular region
over a period of time. Keep in mind that a fish that is edible in one region may kill you in another.

Mouse Units

The toxicity of seafood is sometimes reported in terms of the Mouse Unit. It should be remembered that, in the United States, the mouse unit refers to the toxicity based on 100 grams of seafood. Other countries have been reported to use bases other than the 100 gram sample. Japan, for example, has reported the toxicity of certain seafood on a one gram basis. Consequently, their values are twenty times more toxic than those in the United States.
V-G: AQUACULTURE

Aquaculture is classically defined as the growing of aquatic organisms under controlled conditions. One further sub-definition that has evolved is that culture systems involving seawater and marine organisms are referred to as mariculture. Aquaculture is sometimes called "fish-farming" and rightfully so, for in many ways it resembles the traditional agriculture practiced on land. The culturist, like the farmer, applies modern management techniques, such as controlled seeding, fertilization, and genetic manipulation, to his crop in order to increase yield and quality. For instance, a culturist might obtain a pond to be his "field". He then prepares it by eliminating predators and pests, and ensures good growth by applying fertilizers. The crop is seeded at an optimal density, food and care are provided, diseases controlled, and eventually a crop is harvested. In some fields of aquaculture, the technology has grown to include maintaining brood stock animals, which are genetically controlled through cross-breeding to produce fast growing and hearty offspring for the next crop.

Two terms often associated with aquaculture are "intensive" and "extensive" and serve to indicate the degree of control the culturist has over the growing conditions and the organism. Intensive aquaculture is more advanced and attempts to control all those factors influencing growth, survival, and final yield. With appropriate equipment and skills, it would be possible to grow a marine organism in the mountains using intensive aquaculture. The major drawback to the approach, however, is the cost and level of technology required. Extensive culture denotes a lesser degree of control and often relies on nature to provide some requirements of the system, such as food, waste removal, or young for the next crop. One interesting example is a form of extensive culture called ocean ranching. Salmon instinctively return to the place where
they were hatched and culturists have found a way to take advantage of this trait. Salmon are hatched and released into a privately controlled river or stream. They eventually migrate downstream and out to fertile nursery grounds of the ocean. When they have grown to maturity, they return to their release point where workers are ready to harvest them. The advantage of the system is that there is no cost from the time of hatch to harvest since the salmon graze the oceans as cattle graze a pasture. The primary disadvantage is that the "owner" of the fish has no control over losses from predators, disease or fishing.

Aquaculture is an ancient concept practiced by many civilizations over the centuries. Currently, it is being utilized in such areas as Asia, the Pacific islands, Europe and North America. In much of the world, production involves extensive culture of low cost food fish for subsistence feeding. In more developed countries, economics have steered development towards intensive culture of high cost luxury foods such as lobster, shrimp, oysters and others. In the United States there are two major aquaculture industries, one raising trout and the other catfish. In the last decade, the U.S. Government has attempted to stimulate research in universities and private concerns, and new technologies and expertise developed to date promise to drastically increase the potential aquaculture holds for contributing food to our population. In the future, a substantial portion of the fish and seafood we eat may be aquaculture products.