Sea Grant
Extension Division
Virginia Polytechnic Institute
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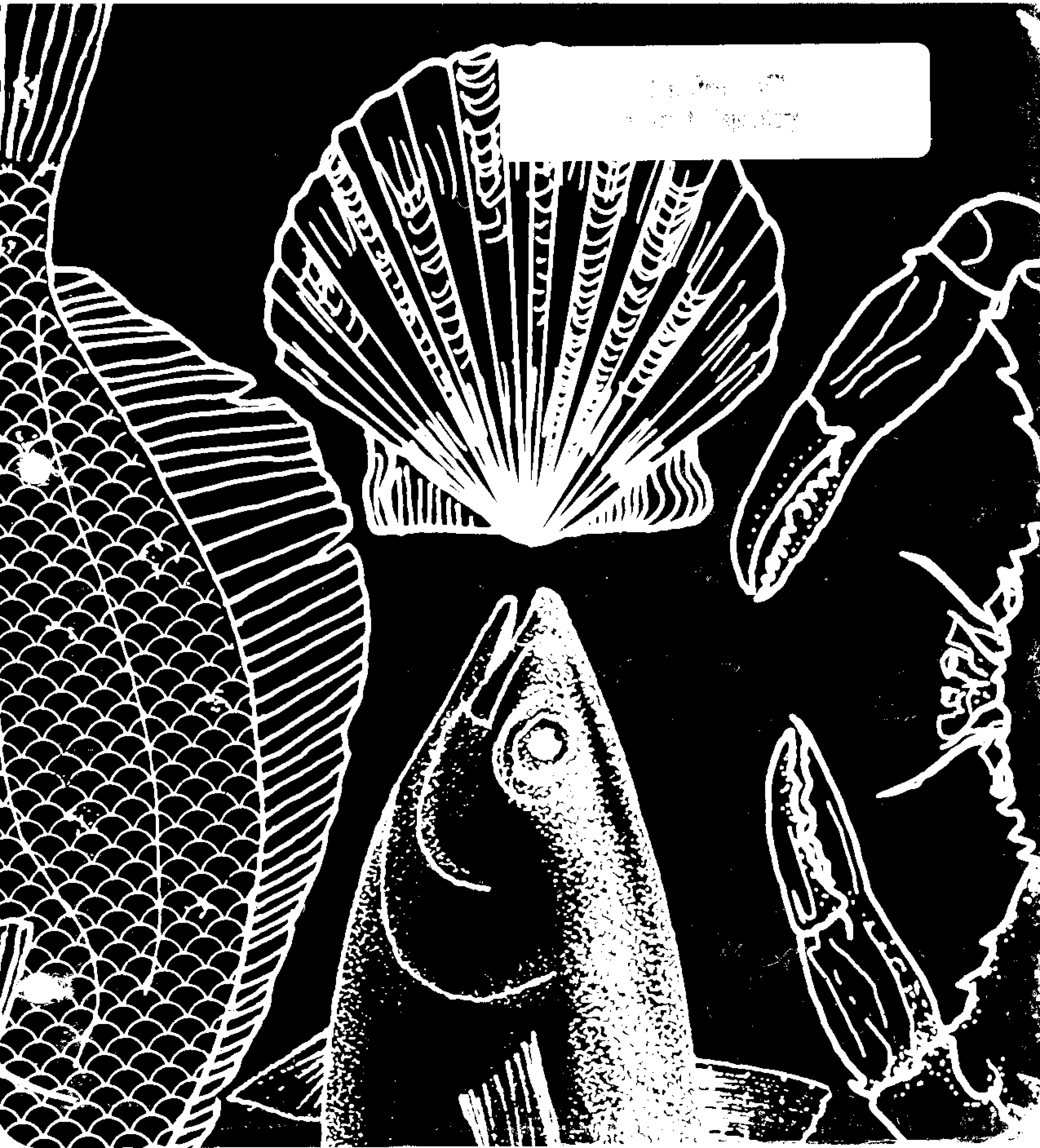
Blacksburg, Virginia 24061

SEAFOOD PRODUCTS TEACHER RESOURCE GUIDE



SEAFOOD PRODUCTS TEACHER RESOURCE GUIDE

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INTRODUCTION

Seafood products are a readily available and highly nutritious source of food in this country, yet these valuable resources have not reached their full potential among consumers. We feel that part of the problem lies in the lack of practical information about the characteristics and uses of seafoods.

This publication is intended to fill the void in several ways: as a seafood products program and teaching guide for home economics teachers, home demonstration club leaders, and extension agents; as a practical guide to the selection and preparation of seafoods for consumers; and as a general sourcebook on seafood products for seafood retailers and laymen.

The information contained in the manual should be sufficient for a discussion leader or lecturer to present informative general programs about seafoods. A demonstration of the shucking, picking, filleting and other preparations of the various species would require the assistance of a proficient individual.

PART I: SHELLFISH

I-A: CRABS

Characteristics

Crabs are broad bodied, flattened crustaceans. They are recognized by their hard shells or exoskeletons, and four pairs of jointed walking legs in addition to claws. Most species are found in the sea, from the tide line out to great depths.

There are more than 4,500 species of crabs in the world, ranging in breadth from fractions of an inch to nearly twelve feet. Most are scavengers, though some capture live prey and others filter plankton from sea water.

The female carries her eggs in a mass, called a "sponge", on her underside. In about two weeks they hatch into free-swimming larvae called zoea. After several moltings, zoea become adults.

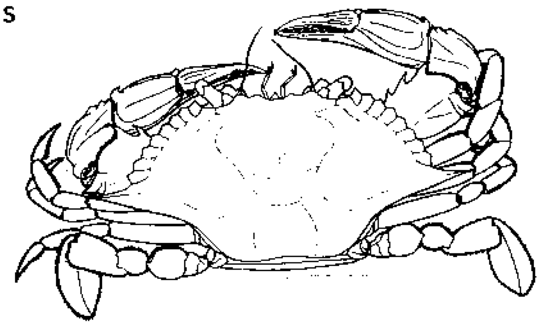
Crabs generally live three to four years. They may lose one or more legs during their lives, and are able to grow new ones through a regeneration process.

Hard and soft crabs: the molting process

Periodically, in order to grow, a crab sheds its external armor or shell. This process is called molting. Before the molt starts, a new, soft exoskeleton forms inside the old, and the crab backs out of the old shell as it loosens. The new shell is soft and elastic, allowing the crab to grow. It is particularly vulnerable to attack during the soft-shell stage and seeks refuge in a secluded spot until the new shell hardens.

Soft shell crabs are taken during the late spring, summer, and early fall, as the molting process takes place only during warm months. The crab houses which handle these crabs are known in the trade as "shanties" or "shedding houses".

Important Species



Blue Crab

Blue Crab: The blue crab (*Callinectes sapidus*) is found on the Atlantic coast from Massachusetts Bay to South America. When fully grown, it averages 5 to 7 inches across the back of the shell, which is brownish green or dark green. The underside of the body and the legs are white, while the tops of the claws show varying amounts of blue. The tips of the female's claws are bright red.

The blue crab is the most important commercial species. The Chesapeake Bay provides about half the weight and value of United States landings.

Blue crab meat is available in several different forms:

A. Lump (back fin) - the highest quality crab meat, includes all meat from the body portion adjacent to the back fin appendage which substantially remains in sizeable lumps.

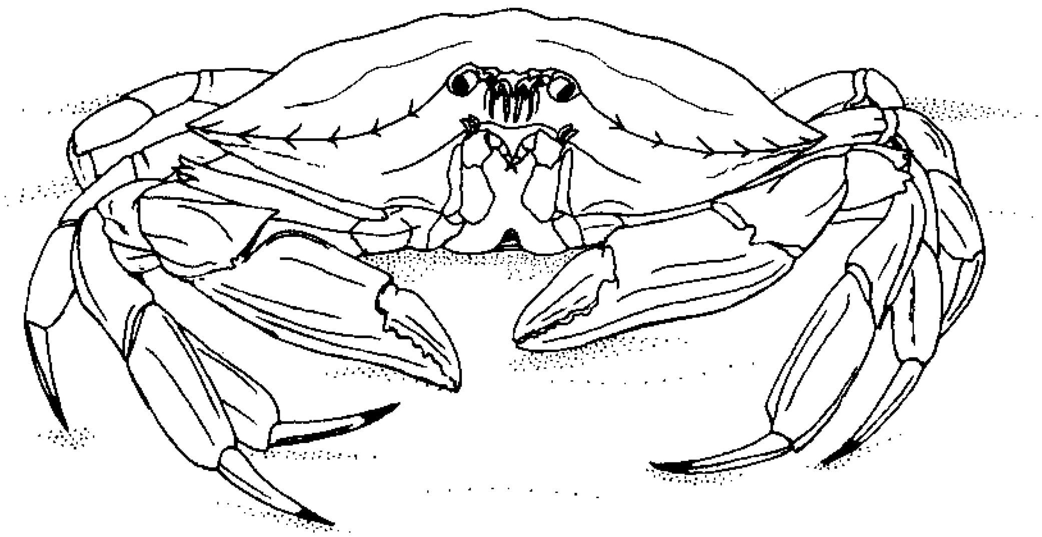
B. Flake (regular or white) - all meat from the body portion except the lump.

C. Claw - all meat from the claw appendages.

D. Mixed White (special) - all meat from the body part of the crab in normal proportions (consists of all the lump and flake meat).

E. Deluxe - This term is not an official market standard. Consequently, the type of parts and quality may vary considerably among wholesalers and retailers. The term is usually employed to define a variable mixture of lump and flake.

Stone Crab: The stone crab (*Menippe mercenaria*) ranges from North Carolina to the Gulf of Mexico and to the Bahamas. The oval carapace is dark purplish-blue in young crabs, brownish-red with flecks of gray in adults. The comparatively large claws are smooth, and banded with red and yellow. The principal fisheries are in Charleston, South Carolina, and Key West, Florida, but are not extensive because of the scarcity of this crustacean. Most meat comes from the claws, and compares favorably in flavor with the blue crab.

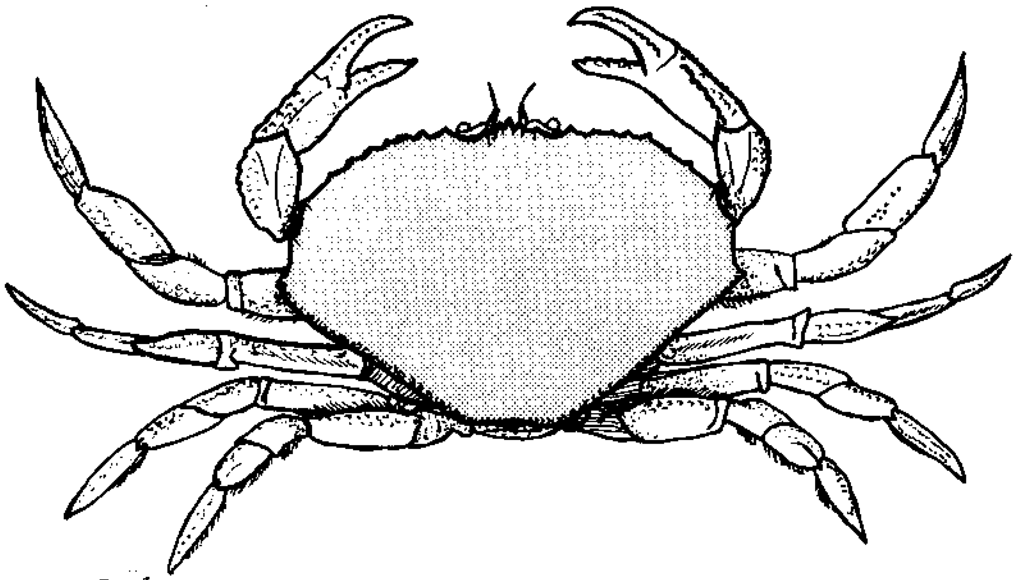


Rock Crab

Rock Crab: The rock crab (*Cancer irroratus*) is found on the North Atlantic coast from Nova Scotia to the South Atlantic states. It has a smooth, oval, ivory-colored carapace, with purple or crimson spots. Though moderate in size (5 inches, 7 ounces), its meat is equal to the blue crab in quantity and flavor.

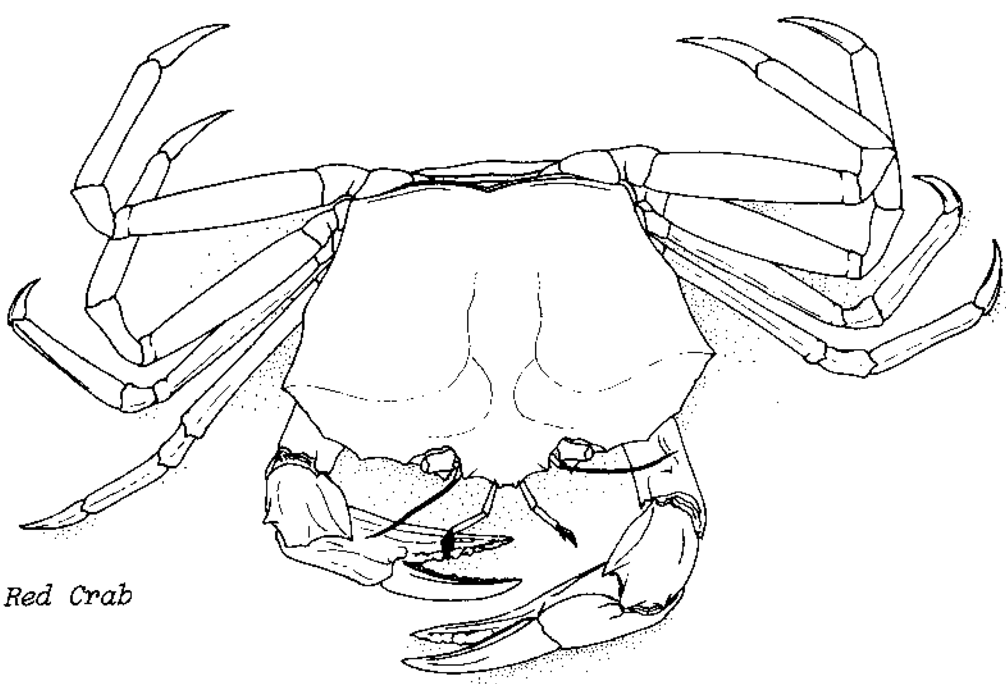
Brownish in color, the meat is picked from both body and claws and is marketed as one grade. Though this species is abundant, it is not fished extensively. It has great future potential.

Jonah Crab: The jonah crab (*Cancer borealis*) resembles the rock crab but is larger with a rougher, brick red carapace. It is found in the same areas as the rock crab, but usually in deeper water. Its flavor is excellent, but it has never been an important article of commerce because of its limited distribution.



Dungeness Crab

Dungeness Crab: The dungeness crab (*Cancer magister*) is the common crab of the Pacific coast from Alaska to southern California. At 9 inches in breadth, it is one of the largest edible crabs in the United States. It is light reddish-brown on the back with a pattern of lighter streaks and spots. It is marketed whole as cooked "dressed" crab, or the cooked meat is sold fresh, frozen, or canned. Fresh cooked meat is picked from both body and claws and packed as one grade. Body meat is white, while claw and leg meat are reddish.



Red Crab

Red Crab: The red crab (*Geryon quinquedens*) is found off the east coast of the United States from Nova Scotia southward to Cuba. The color is usually dark red, the legs are long and slender, and the body is somewhat square. This species reaches a width of 7 inches and may weigh more than 2.5 pounds. It may yield as much as 23% meat, which is approximately twice the yield of the blue crab. The commercial potential of this crab has not yet been realized, though seafood processors in several states have expressed interest in this new seafood resource.

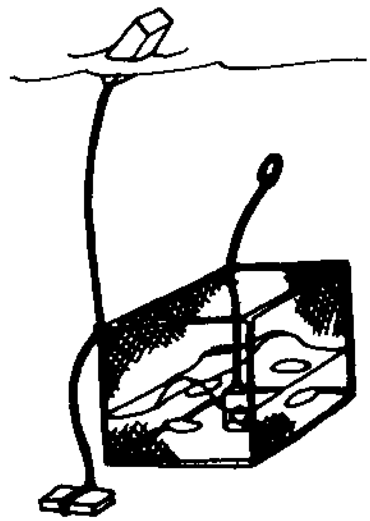
Fishing Methods

Soft shell crabs are usually caught in shallow waters, where they hide at molting time, by dip nets, push nets, or scrapes. A dip net is simply a net on a hoop at the end of a long handle, used by the crabber from his boat. A push net is similar, but larger, and the hoop is flattened on the side opposite the handle. This net is pushed along the bottom by a crabber wading in the shallow water. A scrape is a triangular iron frame two to five feet wide, with a cotton mesh bag about six feet long extending behind. It is dragged along the bottom by small boats.

Soft shell crabs are either caught in that condition or are obtained by holding "peelers", crabs about to shed, until they molt. Crabbers recognize peelers by a pink line that appears on the fourth pair of legs just before molting. These crabs are kept alive in boxes and floats until they "shed out". The majority of soft crabs are obtained in this manner.

Hard shell crabs are caught with scrapes, dredges, and trotlines. A dredge is a larger, modified version of the scrape explained above. A trotline is a rope, from 1/4 to one mile long, with a chain anchor at each end. A buoy is also attached to show the location and the owner. The line is baited about every 18 inches with salt fish or cheap meat. A boat moves along the line and lifts it by means of a roller. Crabs are taken off with a dip net.

Crabs are also caught by the crab pot method. A box about two feet square consisting of wire mesh on a rigid metal frame is used. There are two chambers, and the lower one is baited. The crab swims upwards after grasping at the bait, enters the upper chamber and is imprisoned. A crabber may set 35 to 50 crab pots and fish them from a small boat.



Atlantic Hard Crab Pot

Market Forms

Crabs are available in several forms: live, cooked in the shell, cooked and frozen, picked cooked meat, or canned meat. Some hard shell crabs are shipped alive in barrels of ice and sold within comparatively short distances from the point of capture. Soft crabs are shipped alive, carefully sorted and specially packed in wooden trays lined with seaweed, or they may be cleaned cleaned, individually wrapped, and quick frozen for shipping. With careful handling, they can be shipped hundreds of miles.

The most common market form of crabs is the picked cooked meat. It is picked from hard shell crabs which have been steamed, and then is shipped on ice or canned. Meat from the blue, dungeness, king, and rock crabs is available in cans ranging from 3 1/4 to 17 ounces. Pasteurized crab meat is available in some areas. It is produced by heating meat packed in cans to an internal temperature of approximately 185°F. Since the meat is not given a full heat treatment, it must be stored under refrigeration between 32-36°F. When properly refrigerated, a shelf-life of 6 months is usually expected. Sometimes the pasteurized meat may have a bluish or blue-gray color. This is caused by a processing temperature over 190°F. The over-processed product is safe to consume and usually does not contain off-flavor or odors.

Consumer Inspection

Fresh crabs bought in the shell should be alive; that is, they should move their legs when touched. Crab shells should not be slippery.

Cooked crabs in the shell should be bright red and should have no disagreeable odor. Odor can be easily detected by slightly lifting the lid under the body section of the crab. Frozen crab should be hard-frozen when bought, with no odor.

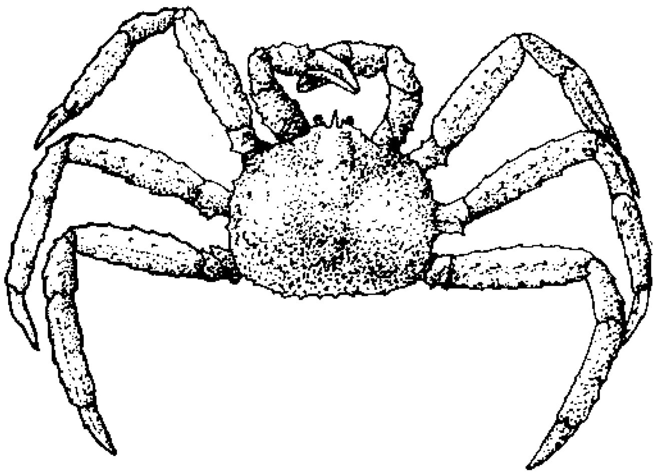
Alaska King Crab

Characteristics: The king crab (*Paralithodes camtschatica*) is found on both sides of the north Pacific Ocean. In Asian waters it is found from the Sea of Japan northward into the Sea of Okchots and along the shores of the Kamchatka Peninsula. The species occurs throughout the Aleutian Islands and the southeastern Bering Sea where large fisheries exist. On the western coast of North America, the northern limit for king crab is Norton Sound in the northeastern Bering Sea. The southern limit of king crab in the northeastern Pacific is Southern Canada.

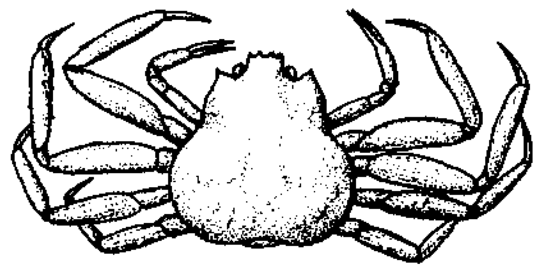
The king crab, one of Alaksa's most valuable marine resources, has several distinguishing features: (1) a rough, heavy shell; (2) a reddish carapace and legs covered with spines; (3) a last pair of legs that is small and hidden; and (4) its great size. Sexual maturity is attained at about 5 years when the king crab's carapace length is approximately 39 inches (100 cm), but growth through molting occurs until a maximum size is reached at an average of 14 years of age. Adult females molt annually and average 3/16 inch (4mm) per molt. Adult males molt annually through the eighth year and average 3/4 inch (20 mm) per molt. After eight years, an increasing proportion molts biannually.

Fishing Methods: King crabs are mainly caught in pots which are pyramidal in shape measuring 7' by 7' by 2 1/2'. A hydraulic pot hauler is used to ease the manual work of the harvesters who must brave severely adverse fishing conditions during winters in the Bering Sea. Large vessels normally have fish holds with refrigerated sea water circulation systems for holding the crabs alive. This circulation system makes many distant fishing grounds accessible, for dead crabs cannot be accepted by processors and the crabs perish if their water is not changed about every twenty minutes.

Market Forms: King crab meat comes from the processor in fresh



King Crab



Tanner Crab

frozen form and, in some instances, canned form, with the major wholesale buyer being the restaurant trade. Crab sections, consisting of the natural ratio of four legs and one claw, are the most common product of initial processing at Alaskan plants. The sections leave Alaskan plants in brine-frozen 75-150 pound bulk packages, and are sent to stateside plants for further processing. Frozen meat is the second most common crab product from Alaskan processing plants. The extracted meats are frozen into blocks weighing about 15 pounds and shipped to the lower states.

Alaska Tanner Crab (Snow Crab)

Characteristics: The range of the genus is: the Eastern Pacific from the Bering Strait and the Aleutian Islands to Cortex Bank which is opposite the United States - Mexico boundary; Western Pacific from Kamchatka to off Kinkazan, Japan; the Siberian, Alaskan and Canadian Arctic; and the Western Atlantic from the west coast of Greenland to Casco Bay, Maine. Like the king crab, the tanner crab (Chionoecetes opilio) is quite large and has a hard, rough-textured carapace and legs. But unlike the king crab, the tanner crab's last pair of legs is quite visible, though smaller than the other four pair. Like other crabs, the tanner crab grows through the process of molting.

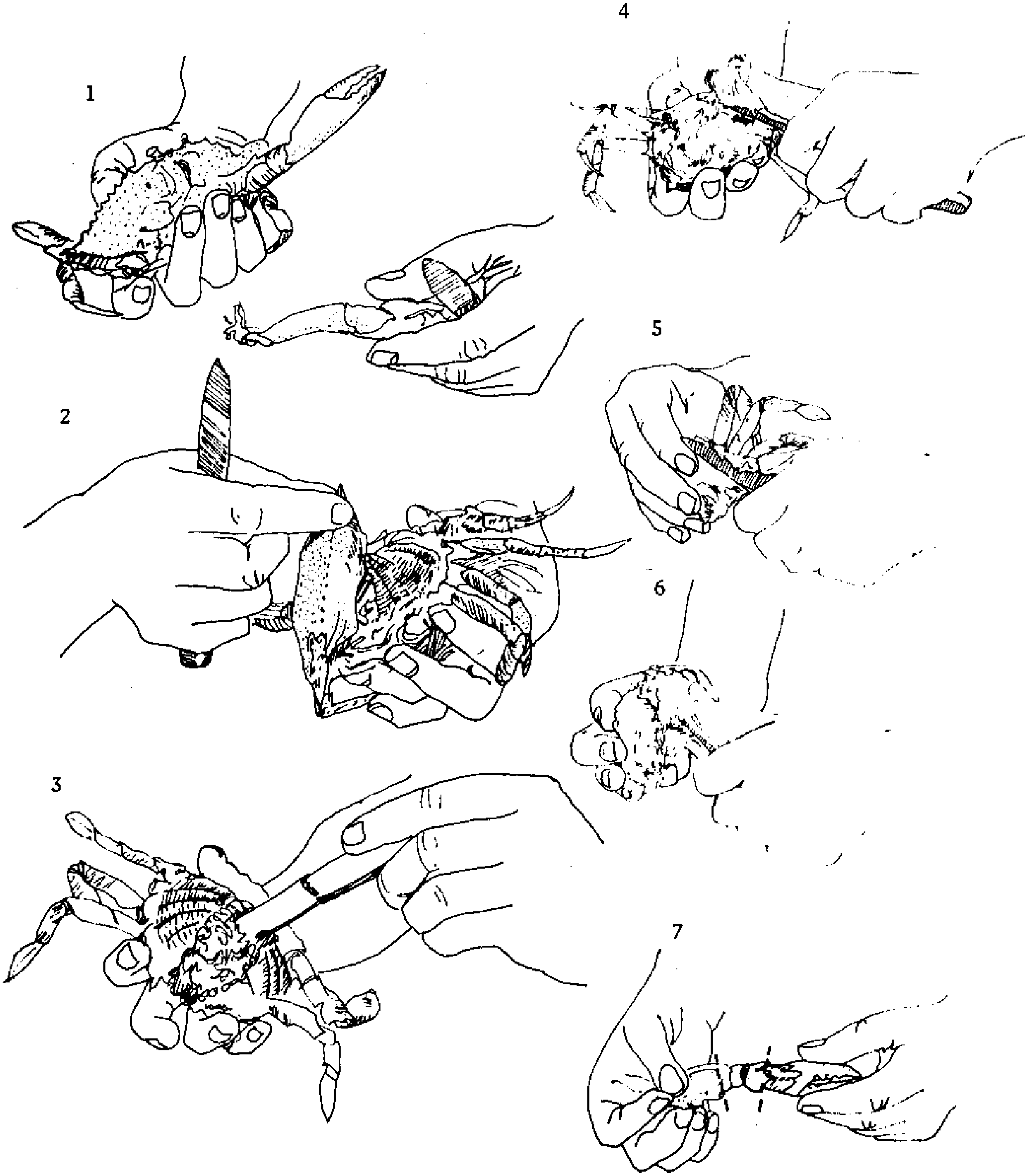
Fishing Methods: Fishing methods employed for tanner crabs are similar to those used for king crabs except that the pot is slightly smaller.

Market Forms: Tanner crab production has become increasingly important and public acceptance has increased so that tanner crab is a viable rival to king crab. Most of the tanner crab available on the market is frozen -- either sections or whole crabs -- and is purchased primarily by institutions like restaurants and grocery chains.

Consumer Inspection: Snow crab should have a fresh odor and no discoloration of the meat which runs from white to white with red.

Picking the Meat from Blue Crabs (Cooked in the Shell)

With the left hand, grasp the body of the crab with the large claws to the right. Break off the large claws (Illustrated on next page; 1). Pull off the top shell with the right hand (2). Cut or break off the legs. Scrape off the gills and remove the digestive and other organs located in the center part of the body (3). Slice off the top of the right side of the inner skeleton, beginning near the front (4), and cut off legs (5). Remove any meat on this slice; then starting with the right back fin pocket, remove the meat from the lower part with a U-shaped motion of the knife (6). Remove the meat from the other pockets by inserting the knife underneath and prying upward. Cut off the top from the left side of the inner skeleton and remove the meat in the same manner as for the right side. Pull the meat out of the claws (7).



Picking Meat from Blue Crab

Color Film, *"Picking the Blue Crab"*, Available

Sea Grant at Virginia Tech has developed an 8 minute, 16 mm color film with narration on the correct method for picking the blue crab. Instruction is given on removing the backfin (lump), flake, and claw meat for both right and left handed individuals. The film can be used as a training aid during or prior to demonstration and practice.

For film loan information call or write: Audiovisual Services, 2 Patton Hall, Virginia Tech, Blacksburg, Virginia 24061 (telephone 703-961-6718). When writing for a film loan, please give a minimum of 30 days notice. For videotape loan information call or write: Instructional Television, 287 Whittemore Hall, Virginia Tech, Blacksburg, Virginia 24061 (telephone 703-961-5149).

For film purchase information, call or write: Extension Division, Sea Grant Program, Food Science and Technology, VPI&SU, Blacksburg, Virginia, 24061. Phone (703) 961-6965.

When ordering a film or videotape for loan, please use the form that follows.

Please send the film ( ) or videotape ( ) *"Picking the Blue Crab"* on the indicated date(s).

Name ______________________________

Address ______________________________

____

City ______________ State ______________ Zip ______

Telephone Number ______________________________

Preferred dates ______________ (and,or) ______________

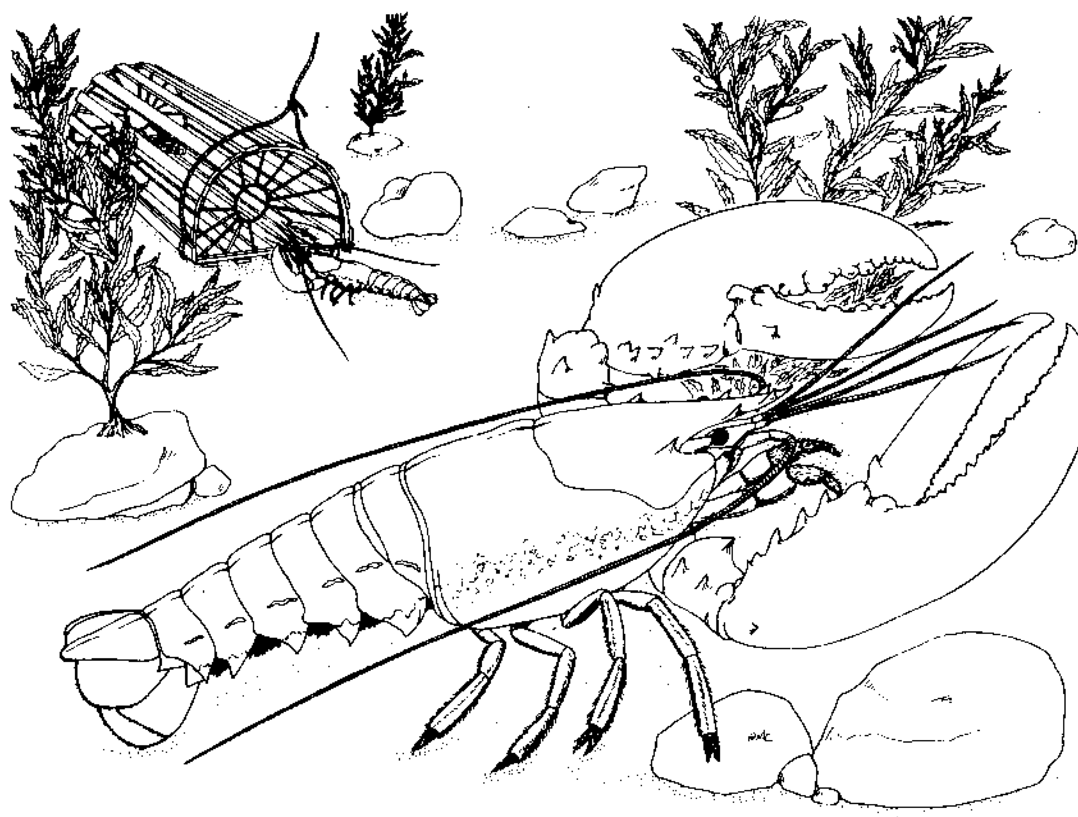
Alternate dates ______________ (and,or) ______________
(if possible)

(The film is loaned by Virginia Tech for a one to three day period.)

I-B: LOBSTERS

Characteristics

There are several families and more than 200 species of lobsters. They are crustaceans that live on rocky, sandy, or muddy bottoms from the shoreline to the continental shelf. Lobsters live singly in crevices and burrows, and are most active at night, scavenging for mollusks, sea worms, small fishes, and some plants. They have two claws, a larger one for crushing and a smaller one for cutting, and are capable of swimming backwards swiftly by snapping their abdomens down and under. It is the large muscle of this abdomen that is prized for its flavor. Lobsters' colors range from light green to deep blue.



Northern Lobster

Important Species

Northern Lobster: The northern or true lobster (*Homarus americanus*) is found in the waters of Great Britain, Canada, New England, and the middle Atlantic states. Primary production is centered in Maine, and this species is thus often called the Maine lobster. The northern lobster may grow to 25 pounds, though market lobsters average about 1-3 pounds.

Spiny Lobster: Spiny or rock lobsters (*Panulirus argus*) are actually sea crawfish, though they are related to lobsters. There are several distinct differences: the spiny lobster does not have the large heavy claws of the true lobster; it is covered with spines on both body and legs; and it has long slender antennae. It is caught off the coasts of Florida, and a similar species (*Panulirus interruptus*) is found off the coast of California.

Fishing Methods

Most lobsters are caught in traps called lobster pots. These are oblong boxes made of wood laths spaced to allow under-sized lobsters to escape. The ends of the pots have netting arranged in a funnel shape which permits lobsters to enter but makes it difficult for them to escape. The lobster pots are baited with fish, weighted, and lowered to the bottom. They are marked with a buoy. Some spiny lobsters are fished from small skiffs with the help of a dip net.

Since most lobsters are sold alive, the catch is often held in underwater cages called holding pounds until marketing. They are shipped alive in barrels, packed in layers of seaweed with surrounding ice.

Market Forms

Lobster may be found in many forms: live, whole cooked in the shell, frozen raw, boiled and frozen, fresh cooked meat, frozen cooked meat, and canned cooked meat. The meat comes from the claws and tail, except spiny lobsters which have no claws. Spiny lobster is often marketed as rock lobster and is usually the source of "lobster tails" available in stores and restaurants.

It has been reported that lobsters frozen raw retain their quality better than those which have been boiled. The deterioration of meat which has been cooked results in a toughening and loss of flavor over long storage. However, frozen whole lobsters suffer considerable breakage because the legs snap off easily unless they are handled with considerable care. In order to reduce breakage, lobsters are usually packed in cartons before they are frozen. Frozen lobsters are sometimes packed in individual waxed cartons.

The cooked meat of the lobster, picked from the shell, is marketed fresh, frozen, and canned. Frozen lobster meat can be purchased in 6, 14, and 16 ounce cans, or in waxed cardboard cartons.

Consumer Inspection

When purchased, lobsters should be alive. If alive, they will show movement in the legs when touched; and their tails should curl under the body and not hang down when they are picked up.

Though the shells of lobsters and spiny lobsters may vary in color, they rapidly change to "lobster red" during cooking. Whole lobsters cooked in the shell should therefore be bright red in color and have a fresh "seashore" odor, not disagreeable. Frozen lobster and lobster tails should be hard frozen and have no odor.

Lobster in the shell varies in weight between 3/4 and 7 or more pounds, and is graded by weight: chickens, 1 pound average; Chinese*, 1 1/8 pounds average; quarters, 1 1/4 pounds average; x-halves, 1 3/8 pounds average; halves, 1 1/2 pounds average; selects, 1 1/2 - 3 pounds; large, 3 - 7 pounds; and jumbos, over 7 pounds. Lobster tails usually run from 4 ounces to 1 pound each. A one-pound lobster will yield 2/3 cup of flaked, cooked meat.

Live lobsters missing one claw are marketed as "pistols" Those missing both claws are marketed as "culls".

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* Chinese restaurants are adamant in procuring this size only. There is no indication that U. S. standards are even needed or wanted.

I-C: CRAWFISH

Characteristics

Crawfish are found all over the world on every continent except Africa. Of the more than 300 species, a few species are consumed by a very small percentage of the world population. The remaining harvested crawfish are most often used as bait or lab specimens.

Crawfish have an arthropod body, which means they are invertebrate with jointed legs, and a segmented body. There are 18 true segments which are jointed and arranged in a linear series. The jointing of the body and appendages is necessary for movement, for the whole body is encased in a rigid, impermeable cuticle. This "armor" or exoskeleton acts as a support for internal organs and is used for attachment of muscles.

Important Species

In Louisiana where production surpasses that of all other states combined, the two species of commercial importance are the river crawfish and swamp crawfish. Neither species requires a river or swamp environment, but river crawfish do need a higher oxygen level than swamp crawfish. In size and outward appearance the two are very similar, the differences being the form of their pincers (claws) and legs, and their coloring. The swamp crawfish is dark red and the river species is pinkish.

Fishing Methods

Baited traps and nets are used most often for harvesting. In terms of cost and attention required, the traps are more economical than the nets and are, therefore, used most often.

Market Forms

In southern Louisiana which is one of the few areas where crawfish are consumed in the United States, 65% of the total volume is marketed live. Prepared or processed crawfish may be purchased as peeled tails, precooked meats in a bisque (stuffed crawfish heads in gravy with a roux) or etouffee (tails in a gravy with or without a roux), crawfish patties, or boiled crawfish. Of the above processed crawfish products, 75% is sold as fresh peeled tail meat. The remaining 25% is mostly sold in boiled form.

Consumer Inspection

If purchased live, the crawfish should curl the tail and its appendages should stiffen rather than droop. Boiled and bagged crawfish will have a strong but not a putrid odor. It is reported that a boiled crawfish whose tail is not curled was dead when boiled, and therefore, should not be eaten.

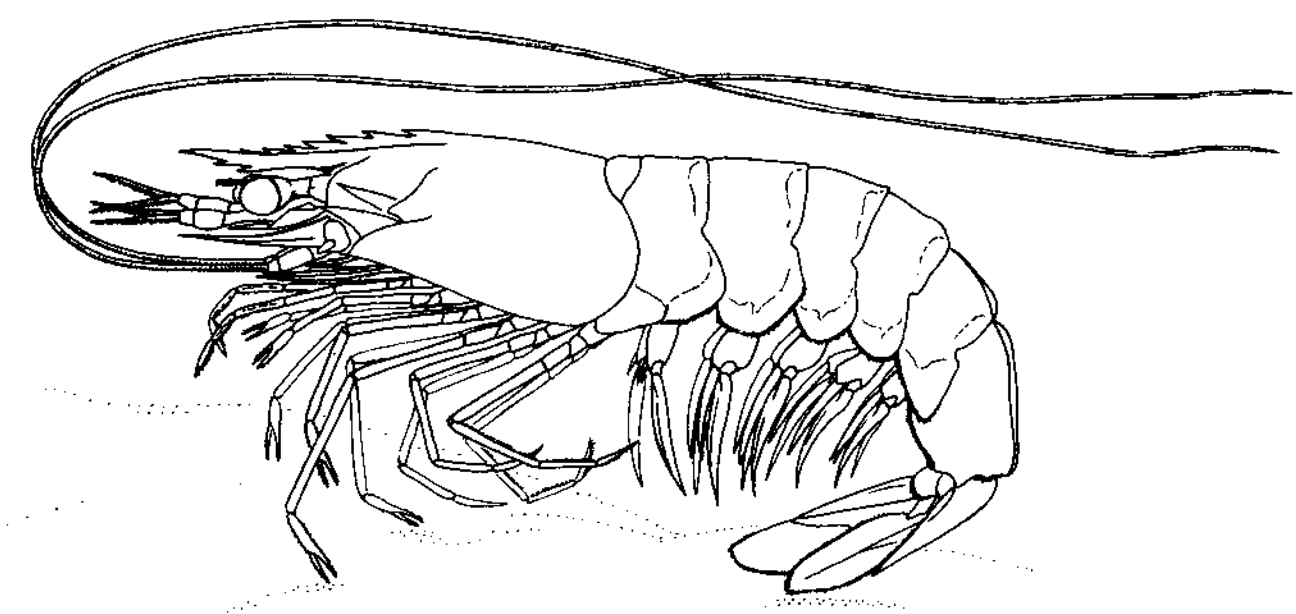
When freezing crawfish, the "fat" should be frozen separately. If crawfish are frozen with their fat, the freezing life is shortened. If crawfish tails or prepared products are stored for a long period of time, the tails may become dark in color and develop an undesirable flavor and odor.

I-D: SHRIMP

Characteristics

There are several hundred species of shrimp. They range from less than an inch to nearly twelve inches in length. Larger shrimp are sometimes called prawns. Shrimp resemble crayfish, having segmented exoskeletons and stalked eyes. Like other crustaceans, they shed their shells and replace them with larger ones in order to grow.

Live shrimp come in a variety of pale colors, including pink, brown, white, and gray; but all turn pink with cooking. Because shrimp are one of the most popular of seafoods, they are among the most valuable marine resources of the United States. They are fished commercially in the Atlantic Coast from Virginia south to Brazil, and in the Gulf of Mexico.



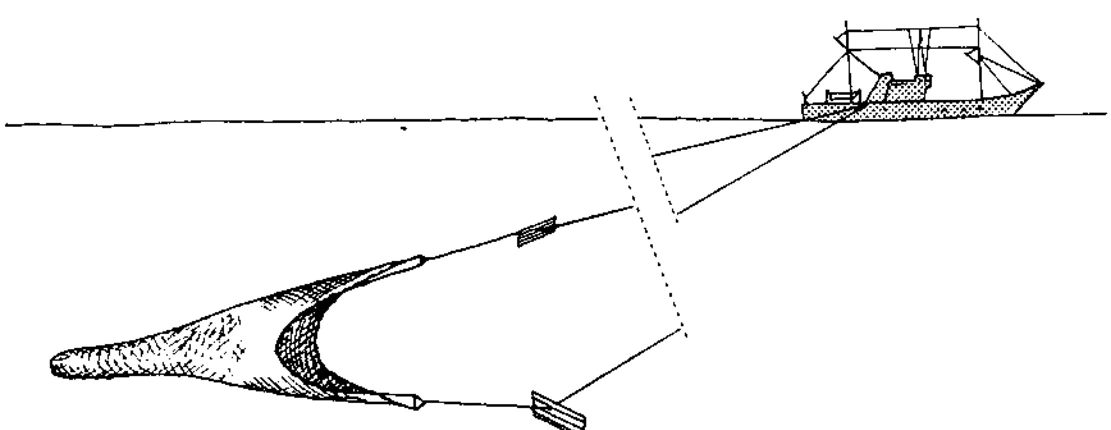
White Shrimp

Important Species

<u>White Shrimp</u>: The white shrimp (*Penaeus setiferus*) is the common greenish-gray shrimp found in the shallow waters of bays and other inshore areas. The white shrimp fishery is centered in Louisiana. The white shrimp accounted for about 90 percent of shrimp landings prior to 1948, but has now been overtaken by the other varieties.

<u>Brown Shrimp</u> and <u>Pink Shrimp</u>: The brown (*Penaeus aztecus*) and the pink (*Penaeus duoarum*) shrimp are often called "grooved shrimp" and are caught in the Gulf of Mexico off Texas, Alabama, Florida, and Mexico. Much larger quantities are caught at night than in the daytime. As the names imply, the brown shrimp is brownish-red in its raw state, and the pink shrimp pink or coral colored.

<u>Macrobrachium Shrimp</u>: The Macrobrachium or Malaysian prawn (*Macrobrachium rosenbergii*) flourishes in fresh and brackish waters. These prawns are indigenous to the lower reaches of Asian rivers, but are now being cultured (grown) in the United States (Hawaii, Florida, New Jersey, California, Texas, Puerto Rico) with success. The market for Malaysian prawns is unknown in most areas, but in Hawaii, due to a large population of Americans of Oriental extraction who regard seafood highly, the demand is high. Presently, the large prawns (4 to 6 pounds) are sold most often. They are marketed whole and fresh.



Otter Trawling

Fishing Methods

Although some shrimp are caught in nets and baited pots, most are collected by an otter trawl, which is towed slowly along the ocean floor by a boat. The trawl is a large funnel-shaped bag, sometimes 100 feet across, with boards on the sides to hold it open. It is hoisted aboard the pulling vessel at intervals and the shrimp emptied on deck. Often the shrimp are deheaded on board, and then stored in ice. On the Gulf Coast, butterfly nets are used at night to catch shrimp near the surface. A butterfly net is attached to each side of the boat and is lowered three to four feet into the water. The vessel then trawls through the water collecting the shrimp in the upper water column.

Market Forms

Shrimp are available in most areas of the United States either raw or cooked, peeled or unpeeled, and fresh or frozen. Near production points, they may be purchased with heads, though usually they are found already deheaded. The yield of whole shrimp is approximately 50%. Peeled meats of shrimp, individually quick frozen, may be bought in polybags or rigid plastic containers in a variety of sizes and weights. Shrimp may also be bought by the pound or in convenient, shelf-ready cans. They are also marketed as broken, imperfect pieces for use in salads or mixed dishes where shape is not important. Shrimp are termed "whole" if they consist of five or more segments of shrimp flesh.

Breaded shrimp are also popular. Frozen raw breaded shrimp are made from whole, clean, headless shrimp which have been peeled and deveined. The shrimp are coated with a wholesome batter and/or breading. Many consumers are unaware that frozen raw breaded shrimp are available with different amounts of breading material. "Regular Breaded" contain a minimum of 50% shrimp material. "Lightly-Breaded" contain a minimum of 65% shrimp material.

Two types of breaded shrimp are marketed: "Breaded Fantail Shrimp" and "Breaded Round Shrimp". Both types are available in three forms which vary in the amount of tail fin and shell segments retained. Breaded shrimp are highly suitable for inspection and grading, but not all these products on the market are inspected or graded. (See Part V-E for information on grading and inspection of seafood products).

Consumer Inspection

Fresh shrimp should have a mild odor and firm meat. Meat and shells should not be slippery. The color of the shell may be grayish green, pinkish tan, or light pink, but there is little difference in appearance or flavor when cooked. Cooked shrimp have red shells, and the meat also takes on a reddish tint, possibly with some dark-red spots.

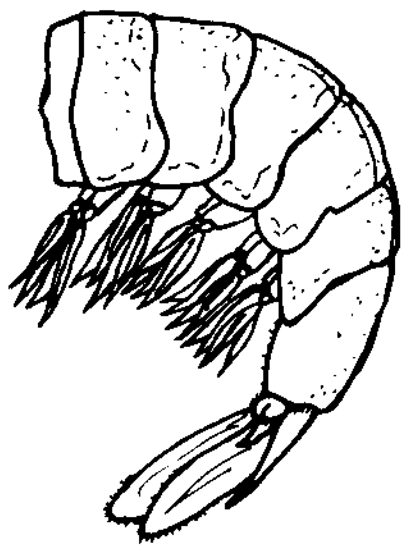
Shrimp are susceptible to a defect called black spot. This brown or black spotting is visually objectionable but is not harmful to the health of the consumer. It is not caused by excessive levels of spoilage bacteria, but is the result of a biochemical reaction called melanosis. This reaction is produced from naturally occurring compounds in the shrimp shell and is similar to the reaction that takes place when a person is suntanned. Black spot is also known as box ring, ice burn, and ringer burn and is a sign of age or of poor handling during the harvesting or processing.

Shrimpers and processors have devised several ways to eliminate or retard black spot on shrimp. First, on the boat, the shrimp are not kept on deck, in the sunshine which would encourage development of black spot. Instead, they are immediately washed thoroughly to remove organic material and the tyrosine (an amino acid) that is necessary for development of black spot. After being washed, the shrimp are stored in melting ice to remove spot-forming materials and maintain a low oxygen level.

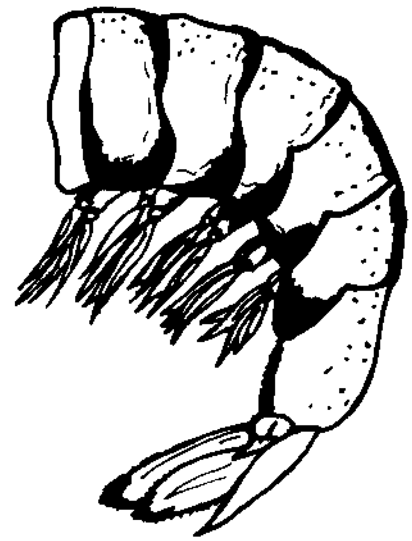
A number of chemicals may be used to control black spot, including lemon juice, baking soda, ascorbic acid, sodium sulfite, sodium bisulfite, sodium metabisulfite, and EDTA. The most commonly used of these, sodium bisulfite, is called dip. It is a strong reducing agent which ties up oxygen, and is used in many other foods -- especially wine, beer, and dehydrated fruits and vegetables -- for essentially the same purpose.

As with any other food additive, there are certain precautions which the shrimper or processor must take. Especially important are careful washing, not reusing the dip, and careful washing and icing after frozen shrimp are thawed.

Seafood Extension specialists state that shrimp with black spot but of otherwise good quality are perfectly safe to eat, especially if they are peeled and deveined before cooking. However, if the flesh seems



Normal Shrimp



Advanced Black Spotting

adversely affected, the shrimp probably should not be eaten. The black spot is, itself, not a quality defect in the shrimp and will not harm the consumer.

Shrimp are customarily sold according to size or grade, based on the number of heads off shrimp to the pound. The count or number designation may also be described by such general terms as jumbo, extra large, large, medium, and small. The largest size or grade runs 15 or fewer to the pound; the smallest size runs 60 or more to the pound. Today, however, most shrimp are sold by count ranges of 5 rather than grade. For example: 16-20, 21-25, and 26-30. The package usually contains the count for the consumer's information.

Since all species may be used interchangeably in cooking, the size of the shrimp assumes more importance if the cost and time required to prepare a recipe are taken into consideration. Jumbo shrimp generally cost the most, but take less time to peel and devein; small shrimp cost the least but take longer to prepare. They have the same fine flavor and food value.

Rock Shrimp

Characteristics: Rock shrimp are indisputably a member of the shrimp family, but because of their tough exoskeleton, the tails, when served, could be easily mistaken for a miniature lobster tail. The texture of the meat, too, is not unlike that of lobster, while the flavor is between that of lobster and shrimp.

Fishing Methods: Rock shrimp have a life cycle very different from regular shrimp and are harvested differently. Like deep sea lobster, rock shrimp spawn, live and are harvested in 30 to 40 fathoms of water, and only at night; the fishing is also measurably affected by lunar cycles. Harvesting is done with reinforced trawl nets all twelve months of the year.

Market Forms: Rock shrimp are highly perishable and are, therefore, marketed mainly in the raw, frozen state, as either whole or split tails, although some tails are available in fresh form. Rock shrimp, like other shrimp, are sold by "count" -- the largest size generally available being 21-25 per pound.

Consumer Inspection: Properly handled rock shrimp will have transparent or clear white flesh with no discoloration of the meat. The odor of fresh, high quality rock shrimp will be mild, with no objectionable "off-odor". Cooked rock shrimp yield about half the weight of the green tails. One pound of cooked, peeled, deveined rock shrimp will feed six people.

Cleaning: When available, split tails are the easiest to prepare. But if they are not available, follow the directions below according to intended use.

For simmering, frying or baking: To remove meat from the shell, hold the tail section in one hand with the swimmerettes down toward the palm. Using kitchen shears, insert one blade into the sand vein. Open and cut through the shell along the outer curve to the end of the tail. Pull the sides of the shell apart and remove the meat. Wash thoroughly in cold water to remove all the sand vein.

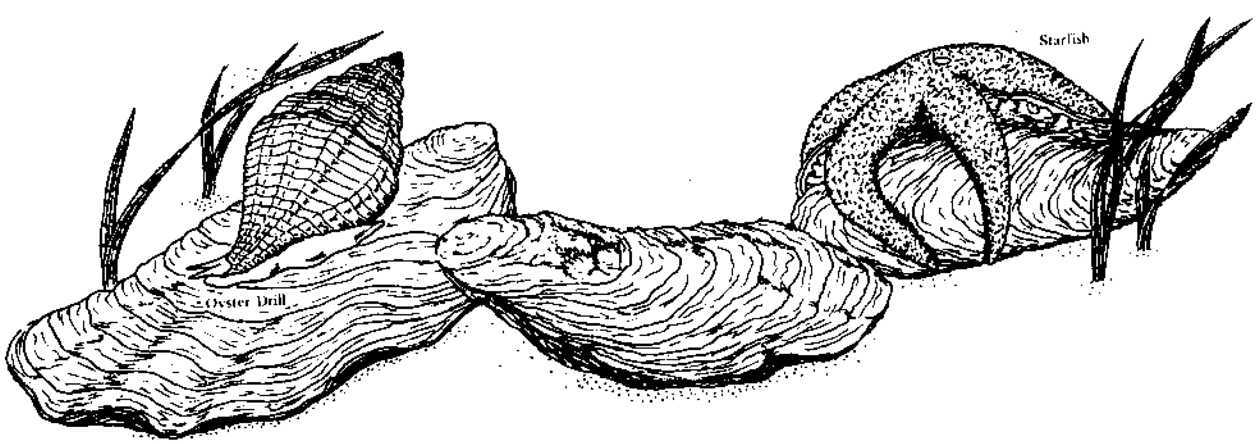
For broiling: Place tail on a cutting board with the swimmerettes exposed. With a sharp knife, make a cut between the swimmerettes through the meat to the hard shell. Spread the shell until it lies flat; wash thoroughly in cold water to remove the sand vein.

I-E: OYSTERS

Characteristics

Oyster is the name for over a hundred species of bivalved mollusks. They occur chiefly between tidal levels or in shallow, slightly brackish water along the coasts of temperate and tropical areas. Sedentary creatures, they attach themselves by a limy secretion to any support and, once located, never voluntarily move again. They feed on minute organisms, both plant and animal, which they filter from the water. They have many natural enemies, including oyster drills and starfish.

True oysters are distinguished by dissimilar lower and upper shells or valves, which are hinged together by a complex elastic ligament. The upper shell is normally flat, while the lower is concave, providing space for the body of the oyster. The two valves fit together to form a water-tight seal when the oyster closes. Near the center of the oyster's body is an adductor muscle, attached to both valves, which controls the opening and closing of the shell.



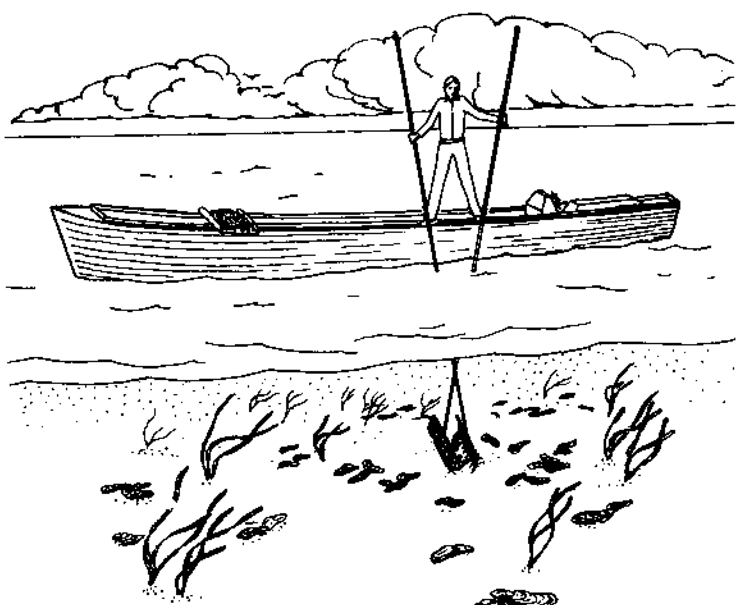
Eastern Oysters and Enemies

Important Species

Eastern, Atlantic, or American Oyster: The Eastern oyster (*Crassostrea virginica*) is found along the North Atlantic seaboard from the Gulf of St. Lawrence to the Gulf of Mexico. Commercially, it is by far the most important oyster, accounting for approximately 85 percent of the total production in the U.S.

Pacific, or Pacific King Oyster: The Pacific oyster (*Crassostrea gigas*), which is now the basis of the West Coast industry, was imported from Japan for trial plantings after experimental plantings of the Eastern oyster failed. It is grown in coastal waters from Alaska to Northern California, with the biggest production areas in the state of Washington. The Pacific oyster comprises about 15 percent of U.S. production.

Western or Olympia Oyster: The Western oyster (*Ostrea lurida*) is native to the Pacific Coast. It was of commercial importance until about the turn of the century; but the yield of this species has declined because of over-exploitation, predators, pollution, and increased costs of production. Some are still available, and it is hoped that through conservation methods the cultivation of this species can be increased.



Man Tonging for Oysters

Fishing Methods

The oyster was one of the first seafoods utilized by man. It was easily harvested by hand during low tide. Some oysters are still gathered in this manner, but many more are caught by boatman with "tongs", long handled rakes joined like the blades of shears. The most economical method of harvesting oysters, which now accounts for two-thirds of the harvest, is power dredging. The oyster dredge is a metal frame with a toothed bar across the front which dislodges the oysters and rolls them back into a chain mesh bag until they can be lifted to the boat.

Sea farming--or mariculture--programs produce most commercial oysters. A likely area is strewn with oyster shells, or other artificial attachment material, and young oysters ("spat") are introduced to the area and attach themselves to the shells. When the spat reach a breadth of about an inch, they are taken up as "seed" oysters and introduced into commercial beds.

This mariculture method was first experimented with by the Romans. The Virginia Institute of Marine Science (VIMS) of the College of William and Mary, University of Maryland, and other agencies are presently studying ways of producing "spat" in laboratories or other non-natural habitats. The James River in Virginia is one of the major producers of seed oysters in the U.S.

Market Forms

Oysters are available in several forms: live in the shell, fresh shucked, frozen, and canned. Oysters in the shell have been washed, chilled, and sometimes chlorinated by the processor. They are generally sold by the dozen, and are served in restaurants as "oysters on the half shell".

Many more oysters are "shucked" or removed from the shell before shipment. The meats are then washed in a "bubbler" or "blower" which churns the meats in fresh water by means of air blown in from the bottom of the tank. This agitation dislodges sand and silt from within the oysters. Meats are then graded for size, sealed in glass or metal containers, and shipped fresh in crushed ice. They are available in 8, 12, and 16 ounce containers.

In recent years, shucked oysters have also been quick frozen, a process which makes them available all year. Fresh shucked oysters are breaded, packed into cartons, and frozen. Individual meats may be removed as desired. Oysters are also diced, mixed with other ingredients, and frozen for oyster stew. Or, they may be found among the precooked foods in the market. Breaded, deep fat-fried, cartoned, and frozen, they need only reheating in the oven.

Canned whole oysters and oyster stew are prepared from steam-opened oysters. These have been passed through a steam retort for about ten minutes, which opens the shell for easy removal. They are then canned and sterilized in the retort. Ready-made oyster stew, needing only reheating for table use, is available, as are oysters smoked and packed with vegetable oil in glass or metal containers.

Consumer Inspection

Shell Oysters: Shell oysters must be alive when purchased. When alive, they have a tightly closed shell. Gaping shells that do not close when tapped indicate that the oysters are dead or nearly so and, therefore, not fit for consumption. The preferred method of storing shell oysters is to keep them moist with wet cloth or sacks and place them at 40°F. Cold temperature or the use of crushed ice may actually kill or weaken the oyster. Fresh oysters may be held for several days if stored properly.

Shucked Oysters: Fresh shucked oysters should be plump and should have a natural creamy color (some oysters have a natural tan, brown, or black film over the mantle). The liquid should be clear or slightly opalescent, free from shell particles, with no sour smell; and there should not be more than 15 percent liquid by weight in the original container. The oysters should have a mild odor.

Eastern oysters are generally packed and graded according to the number of meats to the gallon: very small, over 500; small or standards, 301 to 500; select or medium, 211 to 300; extra select or large, 160 to 210; and counts or extra large, under 160. Grade prices increase with size.

Color Variations: The usual color of a normal, fresh, raw-shucked oyster is variously described as creamy, gray, brownish, pale yellow, or some combination of these. However, other colors may not indicate spoilage.

If the oyster is green it is still probably fresh and good to eat. In fact, in Europe, gourmets actually prefer green oysters to cream-colored ones, as green oysters are considered more flavorful.

The green color may be chlorophyll from green plants the oyster had been eating before being caught. Or it may be copper, if the oyster came from waters containing high concentrations of copper.

If the oyster is red, or if the "liquor" in which the oyster is packed is red, the red may be a dinoflagellate or algae which has been in the oyster's food. The red pigment is water soluble, and appears when the dinoflagellate-eating oyster is cut during shucking or frozen after shucking.

This red pigment will be destroyed when the oyster is heated to only 120°F for a few minutes. Both the Food and Drug Administration and the U.S. Army Quartermaster Corps certify that this red color is a seasonal occurrence -- late fall and early winter -- and is not a health hazard. It has nothing to do with the "red tide" which occurs occasionally in Florida and in North Atlantic waters; red tide has never been reported in the Middle Atlantic.

Several Virginia oyster processors have prepared stick-on labels for their oyster packages, to assure the consumer that the red color is neither abnormal nor a health hazard.

If the oyster has brown spots, they are caused by a normal biochemical reaction that sometimes develops in southern oysters.

In the past, oysters or the oyster liquor was occasionally pink, a color caused by yeast growth; such a color indicated that the oyster was subjected to unsanitary conditions either on the harvesting boat or in the processing plant. Because of refrigeration on boats and inspection of both boats and plants, this problem seldom occurs now.

The pink color, however, might more likely be caused by a strange tiny animal, also a seafood in its own right -- if you get enough of them! This is the pea crab, which lives in the gills of the oyster and feeds on the same foods that the oyster is filtering for itself.

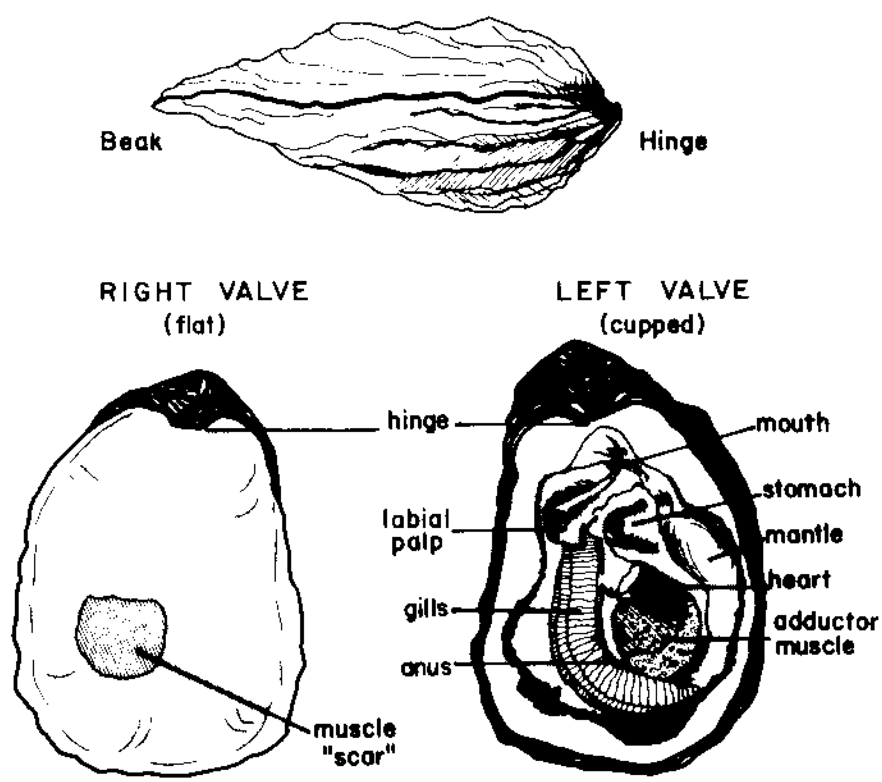
The color comes from a pigment in the pea crab's eggs, but pea crabs apparently do no harm to the oyster, either in its living habits or in its edibility and tastiness, even though one scientist found 262 pea crabs living in one oyster!

The tiny crabs, less than one millimeter in size, invade the mantle cavity of the oyster, usually in late summer or fall. Their growth slows during cold weather -- when oysters are most harvestable -- and does not begin again until spring and warm weather. Male pea crabs usually live only a year or less; females may live two or three years.

If you should be lucky enough to acquire oysters with pea crabs, be sure to save and eat both, as both are tasty and nourishing sea foods.

The "R" Rule

There is a common belief that oysters should not be eaten in months whose names do not contain the letter "r". This rule is not based on fact, however, as oysters can be and are eaten at any time of the year. Their transportation and storage during warm months do require special care, since oysters are highly perishable. Summer is also spawning time for most oysters, leaving them watery, with little flavor or consistency. But frozen and canned oysters are not affected, and there are localities in various states where good quality oysters are available throughout the year.



Oyster

I-F: CLAMS

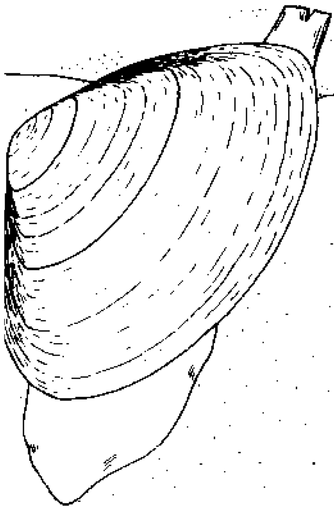
Characteristics

Clams are bivalved mollusks found in shallow waters all over the world. There are about 20,000 kinds of clams, all of which are edible; but only about 50 varieties are sufficiently large, tasty, and abundant to be commercially harvested. Depending on the species, they may be round, oval, elongated, or almost rectangular. They are found in both fresh and salt waters, usually buried in the mud or sand. All clams are vegetarians, straining algae from the water. They may live as long as 20 years, and reach maturity in 1 to 3 years. The giant tropical clam has been known to reach a length of 50 inches and a weight of 500 pounds.

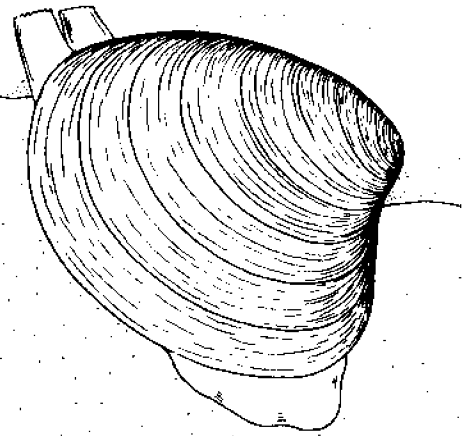
Important Species

Surf Clam: The surf clam (*Spisula solidissima*) is harvested in greater numbers than other species. It is also known as the skimmer, beach, giant, sea hen, or bar clam. Though abundant along Atlantic shores, it is not as valuable as the hard or soft-shell clam. The surf clam is smooth, tan colored, and oval. It reaches a length of 7 inches, and is found from Maine to South Carolina. Most canned clams are surf clams.

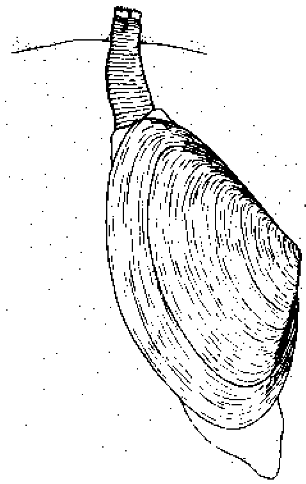
Ocean Quahog: The ocean quahog (*Arctica islandica*) is also called "mahogany clam", "mahogany quahog", and "black quahog". This clam is 3 1/2 to 4 inches long and averages 1/2 pound. The ocean quahog has a hard shell that is extremely difficult to open with a knife, and steaming produces unpleasant effects on the meats. At present, this clam is under investigation to serve as a new resource, and may take the place of the diminishing surf clam.



Surf Clam



Ocean Quahog



Soft-shell Clam

Hard Clam: The hard clam (*Mercenaria mercenaria*) or hardshell clam, is commonly known as quahog in New England, where "clam" generally means the soft-shell variety. In the Middle and South Atlantic states, "clam" is the usual name for the hard clam. Hard clams are common from Cape Cod to Texas.

Soft-shell Clam: The soft-shell clam (*Mya arenaria*) is known in the Chesapeake Bay area as "manninose", "long clam" "long neck", "squirt clam", "sandgaper", or "old maid". These popular clams, unlike the hard and surf clams, have elongated shells that are very thin and brittle. Soft-shell clams cannot close tightly because their long necks extend beyond the shells. The southern limit of these clams is Maryland and some areas of northern Virginia.

Geoduck Clam: A Pacific coast clam, the geoduck (*Panope generosa*) has been recently utilized as a commercial resource. Geoducks are the most impressive clams in U.S. waters, weighing up to 13 pounds. The average clam weighs 3 pounds, and yields 1 1/2 pounds of meat. The geoduck is mostly neck. Even the mantle bulges out of the shell, which is always far too small to contain the entire clam. This clam burrows as deep as 4 feet into the sand or mud, and sends its siphon to the surface. Although some scientists disagree, latest opinion is that it takes approximately four years for a geoduck to reach maturity.

Fishing Methods

Clams were first harvested by aborigines who waded into shallow waters feeling for clams with their bare feet. This method is still used by individuals. On the Pacific Coast where outrunning tides leave large beaches exposed, clams are located by their siphon holes and dug by hand. In other areas, tongs similar to oyster tongs are used by boatmen. A "basket rake" is another device used, similar to tongs but with longer teeth and a wire mesh bag to catch and hold the clams as it is dragged along the bottom. Power driven dredges similar to oyster dredges are used in larger operations.

Market Forms

Clams are available alive in the shell, fresh shucked, frozen or canned. Live clams should be stored in the same way as oysters. Shucked clams are the clam meats that have been removed from the shells; they are generally sold by the pint or quart. In recent years, shucked clams have been packaged and quick frozen, a process that makes them available all year. Depending on the variety, shucked clams may be sold as frozen breast steaks, neck steaks, minced meat, or chunks.

Hard, soft, razor, surf, and pismo clams are canned whole, minced, or as chowder, and are packed in various sizes of cans from 3 1/2 ounces to 4 pounds. Canned smoked chunks are also available. Clam juice, broth, and nectar are available canned or bottled.

Consumer Inspection

Clams in the shell are generally sold by the dozen or by the pound. They should be alive when bought. With hard clams, gaping shells that do not close when handled mean that the clams are dead and therefore no longer usable. In other varieties, the siphon or neck should twitch when touched.

The hard clam or quahog is marketed in Virginia in 3 to 6 size grades. However, most dealers use the following four-grade system:

littlenecks, 1.5 to 2.25 inches; cherry stones, 2.25 to 3 inches; sharps 3 to 3.75 inches; chowders, 3.75 inches and larger. Sometimes you will hear the terms New York Nick or Philadelphia Nicks applied to hard clams. New York Nicks are those clams 2 inches or larger, whereas Philadelphia Nicks are less than 2 inches in size.

Shucked clams should be plump, with clear liquor, and free from shell particles. They are sold packed in metal containers or waxed cartons.

Preparation of Gathered Clams

If you decide to obtain the clams from the sea shore yourself, it is important that the clams be handled properly. First wash off all surface sand with sea water. Cover clams with clean sea water or 2 percent brine (1/3 cup salt to 1 gallon tap water) and let stand for 15 to 20 minutes to allow the clams to cleanse themselves of sand. (Salt is necessary if the clams are to open and discharge sand.) The sand will settle to the bottom of the container. Change the water and let stand a little while; repeat two or three times. This step is important if the clams are to be steamed or eaten from the shell. Clams can then be shucked.

Shucking Hard Clams

Wash the shelled clams thoroughly, discarding any broken-shell or dead clams. To open a hard clam, hold it in the palm of one hand with the shell's hinge against the palm. Insert a slender, strong, sharp knife between the halves of the shell and cut around the clam twisting the knife slightly to pry open the shell. Cut both muscles free from the two halves of the shell. To serve on the half shell, remove only one-half of the shell. To use in other recipes, remove and rinse the meat. Since soft clams and surf clams do not have tight-fitting shells, they are easier to open.

An alternate method is to place the shell clams, after washing, in a small quantity of boiling water. Cover and steam 5 to 10 minutes, or until they are partially open. Drain, remove, and wash the meat from the shells. Another method is to first freeze the clams and then wash them under tap water for several minutes. This removes the sand and causes the shells to open sufficiently wide to permit shucking. This method is probably the easiest and most accepted procedure.

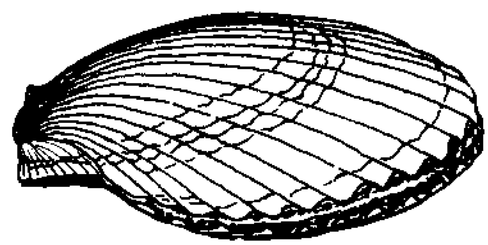
I-G: SCALLOPS

Characteristics

Scallops may be thought of as swimming clams. Like clams and oysters, they are bivalved mollusks, found in every sea. They usually rest on the bottom, but can swim rapidly by opening and closing their shells. The shells are rounded, with scalloped edges and radiating ribs. They vary in color from a yellowish to reddish brown and the meat may be white, gray, or bluish. Sea scallops grow as large as 8 inches in diameter, while the smaller bay scallop is about half as large. Only the excellently flavored adductor muscle or "eye", which opens and closes the shell, is eaten by Americans. Europeans, on the other hand, eat the entire scallop. There are more than 40 species of scallops, but only two are of commercial importance.

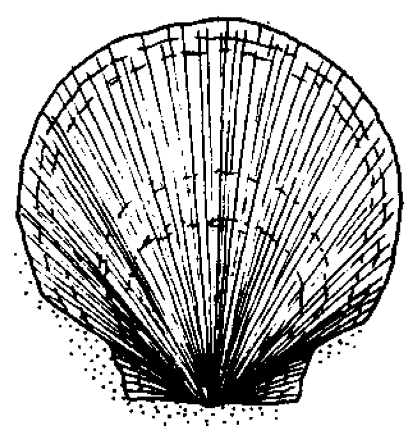
Important Species

Bay Scallop: The common shallow-water scallop (*Pecten gibbus* or *P. irradians*) is taken from inshore bays and estuaries from New England to the Gulf of Mexico. The adductor muscle is about 1/2 inch across.



Bay Scallop

Sea Scallop: The large deep water scallop (*Placopecten megellanicus*) is taken from the waters off the Northern and Middle Atlantic states, with nearly 60 percent of the catch landed at New Bedford. The adductor muscle may be as large as 2 inches in diameter.



Sea Scallop

Fishing Methods

Scallops in shallow water are sometimes taken with a device known as a "pusher". This is simply a long handle with a frame and web bag attached to one end. The user wades in shallow water pushing the device ahead of him, and catches the scallops in the bag when they rise from the bottom. But most scallops, especially the deep water variety, are now taken with dredges, several of which are pulled behind power boats. Scallops are usually shucked on board the boat, and the "eye" removed. The remainder may be discarded, or used as bait or fertilizer.

Though scallops are found from Maine to the Gulf of Mexico, the greatest beds known are east of Massachusetts, and the industry is centered in the area from Maine to New York. Scallop fishing is seasonal, since most states enforce a closed season (usually April to October) to protect the scallops from overfishing.

Market Forms

Scallops, especially the smaller variety, are usually "plumped" before they are marketed. They are soaked in water to increase the volume by about 40 percent. This process makes scallops difficult to preserve, and since they spoil very easily, they cannot be shipped to distant markets. Yet, because nearly all consumers demand the large plump "eyes", the practice will probably be continued indefinitely.

Scallops die soon after capture, and therefore are available only in the form of dressed meat. The meat is marketed fresh in 12 and 14 ounce cartons in the chilled display cases. Frozen scallops, both raw and precooked, are also marketed and are usually breaded.

Consumer Inspection

The meat of the sea scallop should be white; that of the bay scallop should be creamy white, light tan, or pinkish. The meat should be firm and, when bought in packages, should be practically free of liquid. Both fresh scallops and thawed frozen scallops should have a sweetish odor.

I-H: ABALONE

Characteristics

The abalone, a mollusk, is a marine snail with an oval ear-shaped shell and a large foot, which is used in attaching to hard smooth surfaces. Abalone are found along the Pacific coast from Alaska to Mexico, in the Indo-Pacific region of Asia and Africa, in the Mediterranean, around the channel islands between England and France, and off the Pacific coast of Chile.

Important Species

There are about 100 species of abalone in the world's seas, of which eight occur along the U.S. Pacific coast. The largest is the red abalone, which grows to a foot in length and may weigh eight pounds. The average is half this size, but still contains a very substantial amount of meat. The other important species of abalone in the U.S. are green, pink or corrugated, black, threaded, northern green, Japanese or pinto, and white abalone.

Fishing Methods

For an individual, abalone may be collected by hand. A diver using a knife or similar tool can pry the abalone loose if the abalone is taken by surprise. Pacific coast (California) harvesting of abalone is strictly regulated due to dwindling numbers, but baited traps are used to harvest in quantity in other parts of the world.

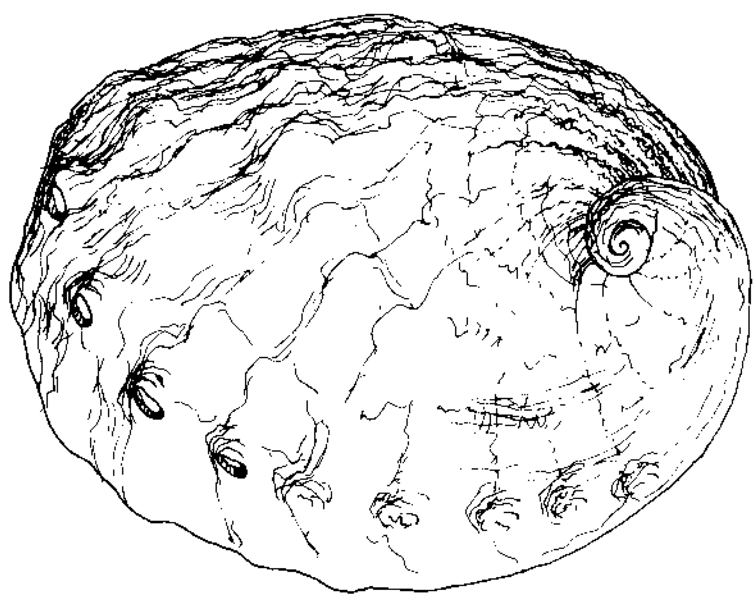
Market Forms

As a fresh food, the abalone is considered a delicacy, but is difficult to obtain. The large muscle or foot is the edible portion and may be eaten raw, sauteed as steak, or chunks may be used in chowder. Fresh abalone is seldom marketed except in California.

California laws prohibit the shipping of fresh abalone as well as the canning of abalone. Small quantities are imported from Mexico in frozen form.

Abalone may be purchased in dried form, shredded (kaiho) or powdered (meiho), for use in soups and vegetable dishes. A variety of dishes may also be prepared using steam-canned abalone, which is minced or diced. The dried and canned products are usually imported from Japan.

The beautiful shell is sold as a souvenir. Buttons, ornamental handles, and inlay make use of the mother-of-pearl lining of the shell.



Abalone

I-I: CONCH (WHELK)

Characteristics

The names conch and whelk are used interchangeably, though these gastropods are members of different families. The difference, for consumption purposes, is that whelk has a stronger flavor when compared to the refined flavor of the conch. Both are mollusks and have a single spiral-shaped shell and a large muscular foot.

Conch are found on the coasts of Brazil, Haiti, Puerto Rico, the West Indies, Bahamas, United States (North Carolina to Texas), and in the Indo-Pacific region. Whelk are harvested in waters near the British Isles, Italy, Northern Europe, United Kingdom, and may be found along the eastern and southern coasts of the U.S.

The beautiful spiral shell, which has a porcelain-like interior of bright pink, is a distinguishing feature of the conch. Whelks have a similar shell but colors range from brick red to yellowish gray.

Important Species

Conch: Edible pink or queen conch, and the samba conch are limited in the U.S. mainly to the Florida Keys. Other edible conchs are Verrill's conch, hawkwing conch, and milk or ivory conch.

Whelk: The waved, knobbed, and channeled whelk are the species that enter the U.S. markets most often. These range in size from 6 to 10 inches. There are other species of whelk which are all edible, but most are smaller.

Fishing Methods

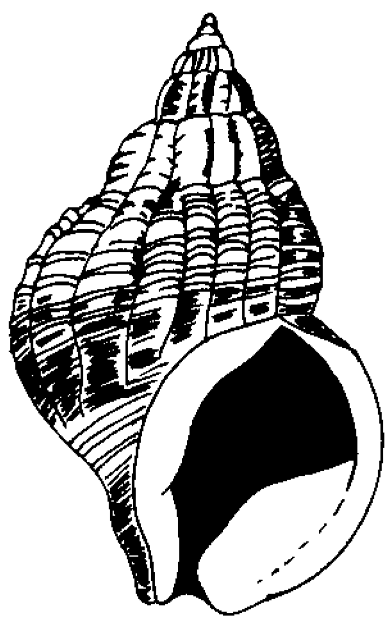
Conch and whelk may be caught by hand in a method similar to the one explained for abalone. When harvesting for large quantities, baited traps similar to lobster pots are used.

Market Forms

The edible portion of conch and whelk is the muscular foot, which is tough and must be tenderized by pounding, grinding, or cooking under pressure. They are marketed in the fresh state or as shelled, cooked meat (semipreserved in vinegar and salt), or canned meat. All forms are difficult to obtain in most areas.

Conch may be used in chowders, salads, and fried fritters. Sometimes the meat is marinated and eaten raw; fried in a batter, or cut into pieces and sauteed in butter, lemon juice, and garlic. Whelk, due to its' stronger flavor, is not used in as many ways (see scungilli marinara recipe).

The shells are sold as souvenirs, etched into cameras, made into beads for jewelry, and in underdeveloped areas, used as horns and tools.



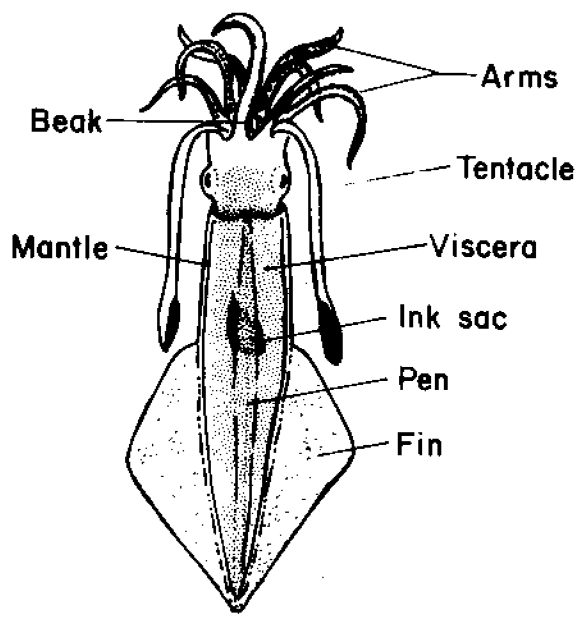
Conch, Whelk

I-J: SQUID

Characteristics

The cephalopods (which include squid, cuttlefish, and octopuses) may be among the most abundant of the underutilized fish resources of the ocean. Accurate estimates on the potential for utilizing this resource are hindered by limited knowledge of cephalopod fisheries, but it has been speculated that the continental shelf areas of the world could yield about 7 million tons of squid annually.

Cephalopods belong to the highest class of the Phylum Mollusca, a group which includes mussels, clams, scallops, sea snails, and oysters. While most of these animals are sedentary, cephalopods such as squid are quite active swimmers inhabiting coastal and oceanic waters. When young, they feed on small planktonic crustaceans and fish larvae. As adults, most are active predators, feeding upon pelagic and bottom living crustaceans, fish, and other living organisms. Squid consume large quantities of herbivorus and carnivorous fishes as well as other squid. Squid in turn are eaten by whales, dolphins, seals, sea lions, sea birds, sharks, and other large fish.



Squid

Squid are among the most successful and numerous of all larger animals in the sea, and there are an estimated 350 species in the world. Some giant squid reach a weight of two tons and a length of 55 to 60 feet.

Cephalopods or "head-footed" animals like squid usually have appendages which are a modification of the fleshy foot of their more primitive ancestors. Squid usually have ten appendages arranged in five pairs around the head. Eight, the arms, are short and heavy, while the fifth and lighter pair, the tentacles, are twice as long as the arms. Equipped with suction cups, the tentacles are used to seize and hold the prey.

The single slender chitinous pen that lines the internal body cavity is all that remains of the shell.

The circulation of water through the mantle or body cavity allows oxygen to be absorbed by the gills, which hang free within the forward part of the mantle.

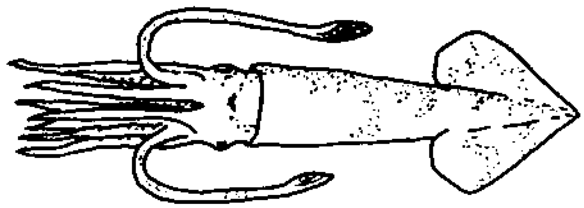
Squid have a screening or defense mechanism, the ink sac. This sac is a reservoir of brown or black viscous fluid which is ejected through the siphon when the squid is alarmed. This "ink" not only forms an effective screen behind which the squid can escape, but it is believed that the alkaloids in the ink paralyze the olfactory sense of the enemy, thus further aiding the squid's escape.

Squid are ordinarily a milky, translucent color, but when the squid is excited, the color becomes very intense. The squid's unusual coloration is caused by the pigment cells or chromatophores in the skin that contain red, blue, yellow, and black pigments in varying amounts depending upon species. The chromatophores are controlled by muscles which are activated to expand or contract by visual or olfactory stimuli, thus changing the animal's color and allowing it to blend with the surroundings.

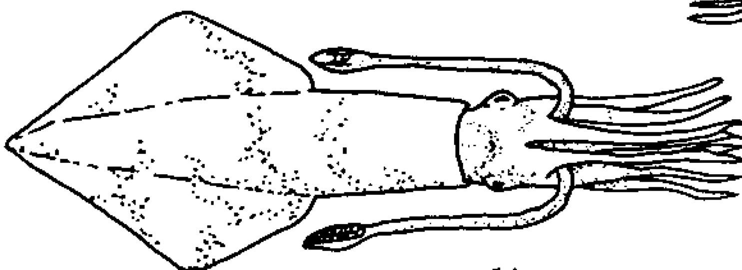
Because squid are generally high seas animals, inhabiting the vast waters beyond the continental shelf, little is known about their life cycle. However, we do know that squid grow fast; Loligo reach sexual maturity one year from hatching. The females spawn in their second year, when the mantle reaches a length of up to 18 cm, and then die. The males reach a length of about 30 cm at the end of the first year, and can be 50 cm long when two years old. The life span of squid is seldom more than two to three years.

Important Species

Three species of squid found along the East Coast are: (1) *Loligo pealei* ranging from Cape Cod to Venezuela; (2) *Loligo brevis*, found from Maryland to Argentina; and (3) *Illex illecebrosus*, caught along the continental shelf from north of Newfoundland to the north coast of South America. Another species, *Loligo opalescens*, is found along the west coast.



Illex



Loligo

L. pealei inhabit the inshore waters of the continental shelf of the Middle and South Atlantic states in summer and autumn and the outer shelf in winter and spring. *I. illecebrosus* come onto the shelf in early summer to feed. Nearly all the catches of this species is used for bait, primarily for the cod fishery.

Fishing Methods

Squid fishery in the U.S. has traditionally been more of a by-catch nature rather than of a "directed" vessel nature, with the catch being taken primarily in otter trawling that is directed toward groundfish. Some squid are also harvested in trapnets.

A very small domestic food market exists for squid, mostly among ethnic populations -- Italians, Chinese, Spanish, etc. The food market for squid abroad, however, is great and consequently, most squid destined to be eaten is exported to Europe.

Market Forms

The principal market forms available for squid are whole fresh or frozen with or without eyes. Canned squid is commercially prepared with or without its ink in brine, in oil, or in tomato sauce. Squid prepared in the U.S. for export abroad are frozen, canned, or dried whole. There is a potential for other products such as breaded rings, minces, and squid fillets and blocks.

Squid are also used for bait by recreational fishermen. Most of the bait squid, however, come from the West Coast, so it would appear that a potential for East Coast squid bait fishery also exists.

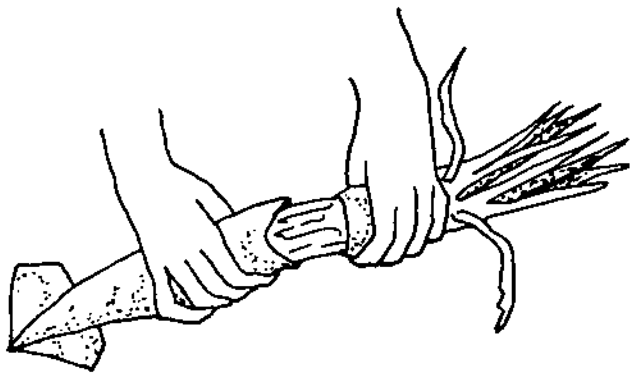
Consumer Inspection

Fresh and thawed frozen squid should smell clean and fresh; the skin of fresh squid should be creamy in color with tiny red flecks. As the squid begins to spoil, pigments are released into the flesh, causing an apparent change in the color of the skin.

How To Clean Squid

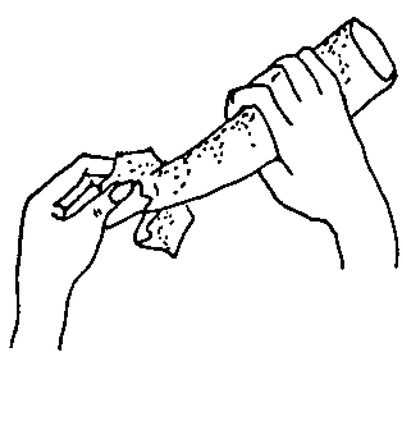
1. Thaw squid if frozen.

2. Hold the tube-like body (mantle) in one hand and twist off the head with the other. The intestines will pull right out with the head.

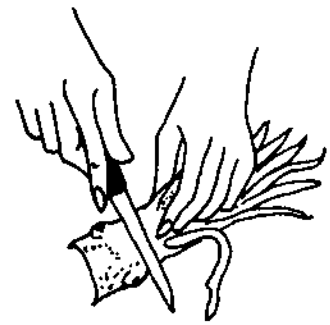


3. The remnant of a shell, or the pen, inside the body must be removed. Pull out the long, clear shell.

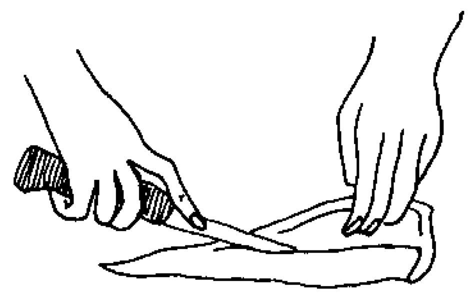
4. Grasp one of the wing-like fins and pull downward to remove the speckled skin. Scrape off the remainder.



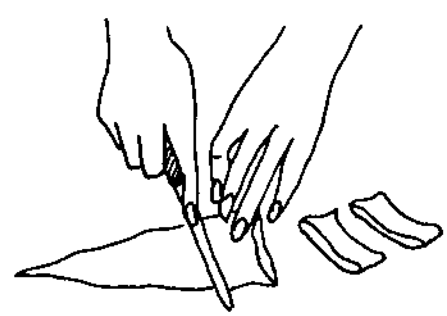
5. Cut the film over the eye very lightly (do not puncture the eye). Place your fingers on both sides of the eye and squeeze it out.



6. Clean out the mantle, wash thoroughly, and drain.



7. Squid is now ready for stuffing. To cut strips or pieces, lay the body flat and cut down the center from top to bottom. Spread open and cut into the size strips or pieces desired. To make rings, cut across the body. Arms can be chopped or left whole. Allow about one-half pound squid per serving.



I-K: GENERAL INFORMATION PERTAINING TO SHELLFISH

How Much to Buy

The quantity of shellfish to buy varies considerably with the serving and cooking method to be used, and the size of the shellfish. The following table is a general guide for serving 6 or 100 people.

SHELLFISH SERVING GUIDE

	To serve 6	To serve 100
Crabs:		
Hard:		
Live	6 to 12 lbs. (18 to 36 crabs)	90 to 100 lbs.
Cooked meat	1 to 2 lbs.	15 lbs.
Dungeness, cooked	4 to 6 lbs. (3 to 6 crabs)	50 lbs.
Alaska King Crab	1 1/2 lbs. of meat	25 lbs. of meat
Tanner Crab	1 1/2 lbs. of meat	25 lbs. of meat
Lobsters:		
Live	4 to 6 lbs.	75 to 100 lbs.
Cooked meat	3/4 to 1 1/2 lbs.	12 lbs.
Oysters and clams:		
In shell	3 dozen	2 1/2 bushels
Shucked	1 quart	3 1/2 gallons
Scallops	1-2 lbs.	15 lbs.
Shrimp:		
Headless (fresh or frozen) . .	1 1/2 - 3 lbs.	24 to 30 lbs.
Cooked meat	3/4 to 1 1/2 lbs.	12 to 15 lbs.
Rock Shrimp (green tails) . . .	2 lbs.	30 to 32 lbs.

Handling and Storing

Fresh shellfish should be stored at a temperature near 32°F. A temperature even a few degrees higher can cause considerable loss of quality in only a few hours. Fresh shellfish may be kept in the refrigerator in cracked ice or in the meat compartment. Fresh or cooked shellfish meats are easily spoiled, and care must be taken that they are not exposed to bacterial contamination. Ideally, fresh shellfish should be cooked within one day.

Frozen shellfish should be maintained at 0°F or lower. Correctly handled and frozen, lobster and crab meat have a shelf life of about two months; shucked oysters, scallops, and clams three to four months; and shrimp six months. Do not refreeze shellfish once it has thawed. (See "Consumer Inspection and Buying" for information on buying frozen seafoods. See "Home Freezing of Seafoods" for seafood thawing methods.)

Shellfish Tips

A. With the exception of scallops, shellfish prices are usually lower in winter than summer.

B. If you harvest oysters and clams yourself, be sure the water you obtain the shellfish from is certified by the State Health Department. If you eat shellfish from closed areas, you may get infectious hepatitis.

C. Crabs are dredged in the middle Atlantic states from December 1 to March 31 each year, but this season is noted for the poorest quality crab meat since sand is usually carried into the final product making it gritty.

D. Usually, oysters obtained in the spring of the year are superior to those obtained in the early fall.

E. The smaller the clam, the higher the price. The larger the shrimp, oyster, or scallop, the higher the price.

F. Oysters, clams, and scallops may be packed in their own liquid in jars, but must be completely covered by the fluid to prevent darkening.

G. Lobsters, crabs, and shrimps can be frozen but tend to become tough with storage.

PART II: FINFISH

II-A: CHARACTERISTICS

The term "fish" is applied to many aquatic animals which often have very little in common with one another. Over 20,000 species of fish are known to man. There are probably more fish than all the other vertebrate species combined. Fish are also the most important animals which inhabit the waters. Historically, fish have been sought by man for food and sport for at least 7,000 years.

In general, fish are cold-blooded animals having a cartilage (sharks, sturgeons) or bony backbone and rudimentary limbs represented by fins. They breathe by means of gills, swim with fins and tails, and float by controlling air in the swim bladder. Feeding on a variety of substances ranging from microorganisms, plankton, algae to fish, they normally swallow their food without chewing. Their skin is usually covered with scales or other plates. They may reproduce by spawning or by giving birth to living young. The mortality rates are high, which provides an ecological balance in the waters.

Each species of fish lives in a manner and environment suited to its particular biological requirements. An individual species may select specific times and locations for pursuing food or for reproduction. Thus, they may migrate to avoid extreme seasonal temperature changes, or may stay most of the time on the ocean floor. Migration can also be an involuntary action of the young or larvae carried by ocean currents. Some fish prefer salt water conditions, others could not survive except in fresh waters, yet, some live where salt and fresh waters meet (brackish water). Some fish are born in fresh water, become mature in salt water, and have to return to streams to spawn. These are anadromous fish, and salmon, smelt, shad, striped bass and sturgeon are examples. On the other hand, catadromous fish live in fresh water but enter salt water to spawn. Eels are catadromous fish.

II-B. FISHING GEAR

Fish are caught by many methods. They vary according to the regions, the economics, and the specific species sought. The major tools utilized to catch fish might be categorized as follows:

A. Spears, harpoons and guns

B. Lines

   1. Artificial lure or bait with or without hooks
   2. Longlines
   3. Drift lines
   4. Troll (trawl) lines

C. Traps

   1. Pots and baskets
   2. Pound nets
   3. Gill nets
   4. Entangling nets

D. Nets

   1. Scoop nets
   2. Dip (lift) nets
   3. Dragging or trawl nets
      a. Otter trawls
      b. Bottom trawls
      c. Mid-water trawls
      d. Stern trawlers
      e. Side trawlers
      f. Two-boat trawlers
      g. One-boat trawlers
   4. Purse seines (surrounding nets)
      a. Two-boat purse seines
      b. One-boat purse seines
   5. Drive-in nets
   6. Stow nets

E. Dredges

F. Pump fishing

II-C. IMPORTANT MID-ATLANTIC FINFISH

Menhaden

One of the most abundant fishes found along the Atlantic coast ranging from Maine to Florida, menhaden (*Brevoortia tyrannus*), is a herring-like fish. It is called by a variety of names, such as moss-bunker, bunker, porgy, fatback, and shad.

Menhaden travel in large schools along the Atlantic and Gulf of Mexico coasts (Gulf menhaden) and can be spotted from the air. They are generally caught in purse seines. Two purse boats carrying a purse seine (about 1,200 feet long and 60 deep deep) circle a school of fish. The trapped menhaden are then pumped into the hold of the carrier vessel. This is a highly efficient way of catching and harvests nearly 2 billion pounds of fish annually. In Virginia alone, 500 million pounds were caught in 1977.

Being rather oily, menhaden are not usually consumed directly by man in the U.S., but are processed into oil, meal, and soluble protein. The oil is used in paints, soaps, cosmetics, lubricants, and tanning oils. In Europe, it is also made into margarine for human consumption. The meal and soluble proteins are excellent food supplements in feed for cattle, swine, poultry, and mink.

Although menhaden is not considered edible in the U.S., its gigantic production volume makes it economically important. In addition, people in some African countries do use them for food, and the value of the fish may indeed improve as the demand for protein increases in the world. Other than its feed and industrial usage, menhaden is also popular for bait in crab pot fishing. The meal can also be used for fertilizer.

Croaker

Croaker (*Micropogon undulatus*) acquires its name because it makes a drumming croak during spawning season, and when being touched or pursued.

It is, therefore, sometimes called "drum". The upper half of its body becomes golden in color during spawning season, giving it the name "golden croaker". Croakers run from 1-4 pounds on the Atlantic Coast and slightly smaller in the Gulf of Mexico. At maturity (3-4 years), it can be 1½ feet long.

Though distributed along the Atlantic coast from Massachusetts to the Gulf of Mexico, the greatest croaker production is centered in the Chesapeake Bay and Mississippi River delta. It is caught from March through October in the Chesapeake Bay by pound nets and otter trawls. In 1977, 8.6 million pounds of croaker were landed in Virginia.

Flounder

Flounder, an important year-round food fish, are members of a large family of flat fish which includes winter flounder (or blackback, *Pseudopleuronectes americanus*), summer flounder (fluke, *Paralichthys dentatus*), starry flounder, yellowtail flounder, and a wide variety of soles and dabs. All flatfish have their two eyes on the same side of the body. Fluke is left eyed; both of its eyes are on its colored, left-hand side, and it lies on the bottom on its white, right-hand side. Contrarily, winter flounder is a right-eyed species of the family.

Summer flounder have been found from Maine to Texas, but are most abundant from Cape Cod to North Carolina. During May through September they stay in the shallower areas, while in the winter season they move offshore in the deeper continental shelf. They grow rather rapidly. In one year, a female can be 11 inches in length, and in two years 15 inches, and approximately 1 pound by weight. On the other hand, winter flounder are smaller. The average length for a 2 year old is about 8 inches. They are primarily inshore fish, commonly living in estuaries and coastal ocean areas from the Chesapeake Bay north to the Gulf of St. Lawrence. Favoring cool water, they migrate to areas of greater depth in the summer. For sport fishermen, they become a "winter" flounder.

Commercially, flounders are caught mainly by otter trawls. They can also be found in pound nets and seines. The 1977 landing in Virginia was 4.5 million pounds.

Gray Sea Trout

From southern Florida to Massachusetts, the sea trout (*Cynoscion regalis*) migrates in spring and summer when young. As they get older (over 4 years), they do not move further southward than Cape Hatteras. Gray sea trout are also known as weakfish and squeteagues. Being a member of the drum family, they also make drumming noises like croakers.

A gray sea trout can grow 7 inches in 5 months. Its length varies from 12 to 14 inches for a 4 year old, one pound fish, and up to 30 or more inches for older fish weighing 10 pounds or more. Otter trawls account for most of the commercial catch. Gill nets, pound nets, haul seines, and floating traps are also used. It is one of the prime recreational fishes. The 1977 commercial landing of gray sea trout in Virginia was approximately 4.3 million pounds.

Bluefish

Being a voracious and compulsive eater, the bluefish (*Pomatomus saltatrix*) has acquired names like "snapper" and "chopper". They will feed until sated, then regurgitate and feed again. In the U.S., bluefish appear along the Atlantic and Gulf Coasts from Maine to Texas. As a pelagic fish, bluefish is not unique to these areas. In fact, they are found worldwide in temperate, continental shelf waters.

Bluefish arrive in Virginia waters by late April or early May when the surface waters reach 59°F. Generally, the larger adults are caught in deeper water. However, the warmer waters of the Chesapeake Bay seem to attract them during the spring. In their inshore-offshore migration, great numbers of mature bluefish leave the Bay in early summer to spawn on the outer shelf. By late summer, these fish return to the Bay in large schools.

Bluefish become mature in 2 years and reach 3 pounds in 3 years. In 10 years, they may grow to an average weight of 15 pounds. They mainly feed on other fishes and invertebrates and are one of the most popular game fish. The average commercial landing of bluefish in Virginia is approximately 3 million pounds annually, and is mostly caught by using gill nets, pound nets and hand seines.

Spot

The spot (*Leiostomus xanthurus*) can be found in the Chesapeake Bay and its tributaries in early spring. They utilize the rivers as nursery areas until October when they leave the Bay. The spot caught during this time are generally of poor quality. But, by August through October, they have fattened up and started to move southward in the Bay. This is when they are considered to be in prime condition and are sold as "Norfolk Spot".

The bulk of the commercial spot catch in Virginia is made by haul seines and pound nets. The production fluctuates from year to year. In 1977, almost 2 million pounds were harvested. The record high was 8 million pounds in 1945, and the lowest was 400,000 pounds in 1935.

Black Sea Bass

Usually an inhabitant of Atlantic coastal and offshore waters from Cape Cod to northern Florida, the black sea bass (*Centropristis striata*) migrates inshore to spawn or forage in the spring. The black sea bass begins life as a female and transforms into a male at 2 to 5 years of age. Therefore, most fish larger than 11 inches and older than 5 years are males. They can reach a maximum size of about 24 inches and weigh over 9 pounds at an age of 9 years.

Black sea bass spend most of their life-time in deep offshore waters, and are usually caught commercially with trawls. In the mid-Atlantic area, unbaited wooden traps are also used. Because of the great pressure difference, it is not uncommon to find the internal organs protruding from the mouth of a sea bass in a fish market.

American Shad

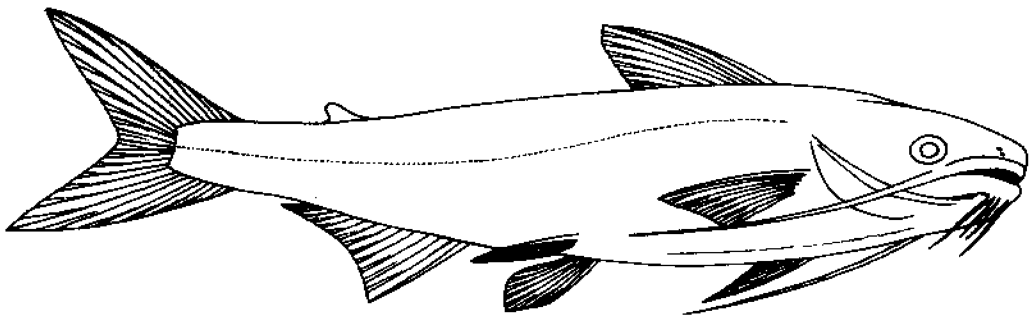
When the spawning migration starts, the American shad (*Alosa sapidissima*) come in great schools from the ocean into the Chesapeake Bay and its fresh water estuaries. This may occur in early February and continue until May or June in the northern section of the Bay. After spawning, they return to the ocean and can be found as far north as Nova Scotia and south to Florida.

The egg sac or the shad roe, is a popular delicacy and enjoys good market value. On the other hand, the fish has numerous fine bones in the body, a fact which seems to intimidate some gourmet eaters. Fishermen refer to the male shad as "buck"; to the female with roe as "roe shad". On the market, the roe are generally sold by the pair.

In the past, haul seines, gill nets, and pound nets were used for shad fishing. Today, more shad are caught by stake and drift gill nets. The 1977 landing was 1.5 million pounds in Virginia.

The charts following illustrate characteristics of various finfish, along with some applicable consumer information on each.

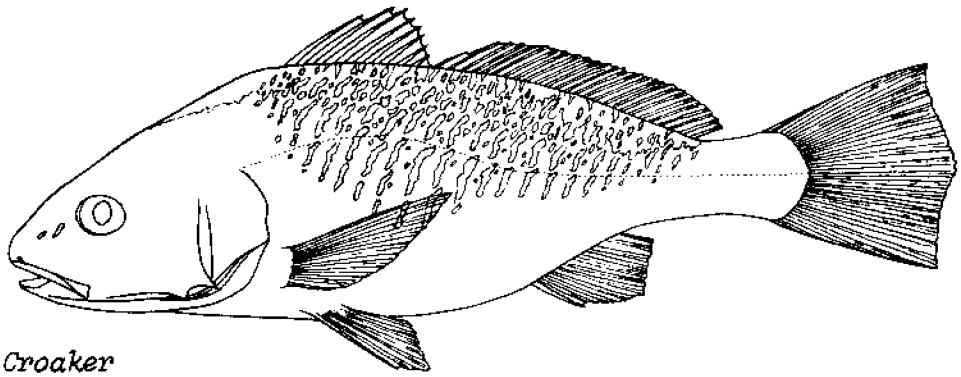
II-D: FINFISH SPECIES CHART
(Courtesy of the Pillsbury Company)



Ocean Catfish

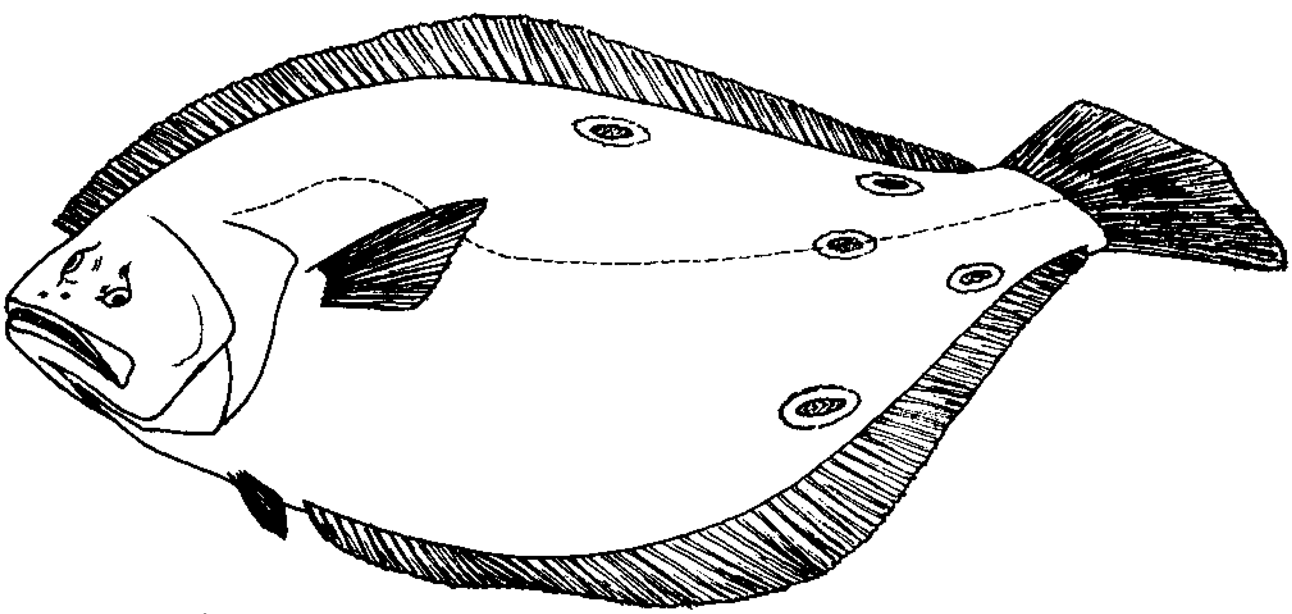
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Catfish	Bullhead, Blue, Channel.	Great Lakes, other U.S. lakes, inland rivers, ponds, creeks.	Lean	Whole, dressed. Fresh, frozen.	Southern catfish stew. Deep-fried catfish with hush puppies.
Ocean Catfish	Wolf Fish	Iceland, Germany, England, Denmark, Norway.	Lean	Fillets, breaded portions. Frozen.	
Cod	Codfish	New England, Middle Atlantic, Pacific Coast, Iceland, England, Norway, Germany, Denmark, Canada.	Lean	Drawn, dressed, steaks, fillets. Fresh, frozen, salted, smoked (tails). Breaded and precooked sticks and portions.	Baked cod with cream. Sticks or portions served with zesty mustard.

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve



Croaker

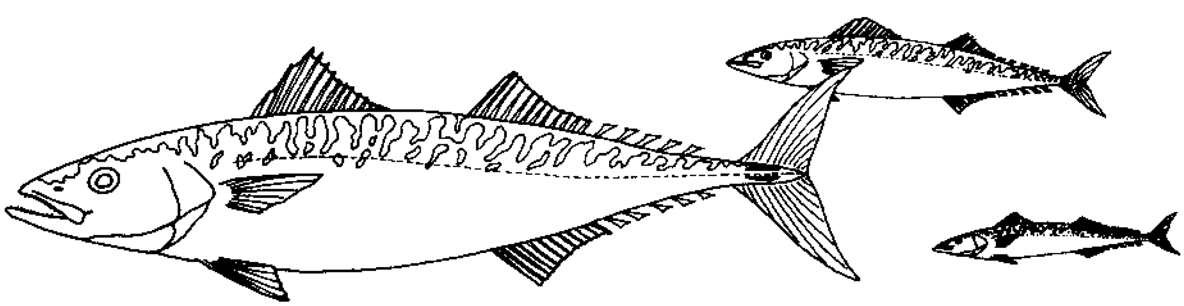
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Croaker	Hardhead, Drum.	New Jersey, Atlantic Coast to Texas Gulf.	Lean	Round, Pan-dressed, fillets. Fresh, frozen.	Chowder



Flounder

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Flounder	Sole, Fluke, Blackback, Yellow-tail Sand-Dabs, Dabs.	Northwest Coast, Gulf Coast, New England, Middle Atlantic, Canada, Denmark, England, Iceland.	Lean	Whole, pan-dressed, steaks, fillets, breaded, stuffed. Fresh, frozen, smoked, pre-cooked.	Grilled steaks. Baked fillets in orange sauce.
Grouper	Red, Black, Yellowfin, Speckled, Hind, Gag, Scamp.	South Atlantic, Gulf.	Lean	Whole, steaks, fillets. Fresh, frozen.	Fillet rollup with Spanish sauce.
Haddock	Scrod (baby)	New England, Canada, Iceland, Norway, England.	Lean	Whole, drawn, fillets. Fresh, frozen, salted, smoked. Breaded and pre-cooked sticks and portions.	Fillets in wine and tarragon sauce. Baked *au gratin*. Hearty fish sticks or portions in sandwiches.
Hake	White, Red, Squirrel, Ling, "Deep-Sea Fillet".	Gulf of St. Lawrence south to North America.	Lean	Dressed, fillets. Fresh, frozen, salted, corned.	Chowder. Baked.

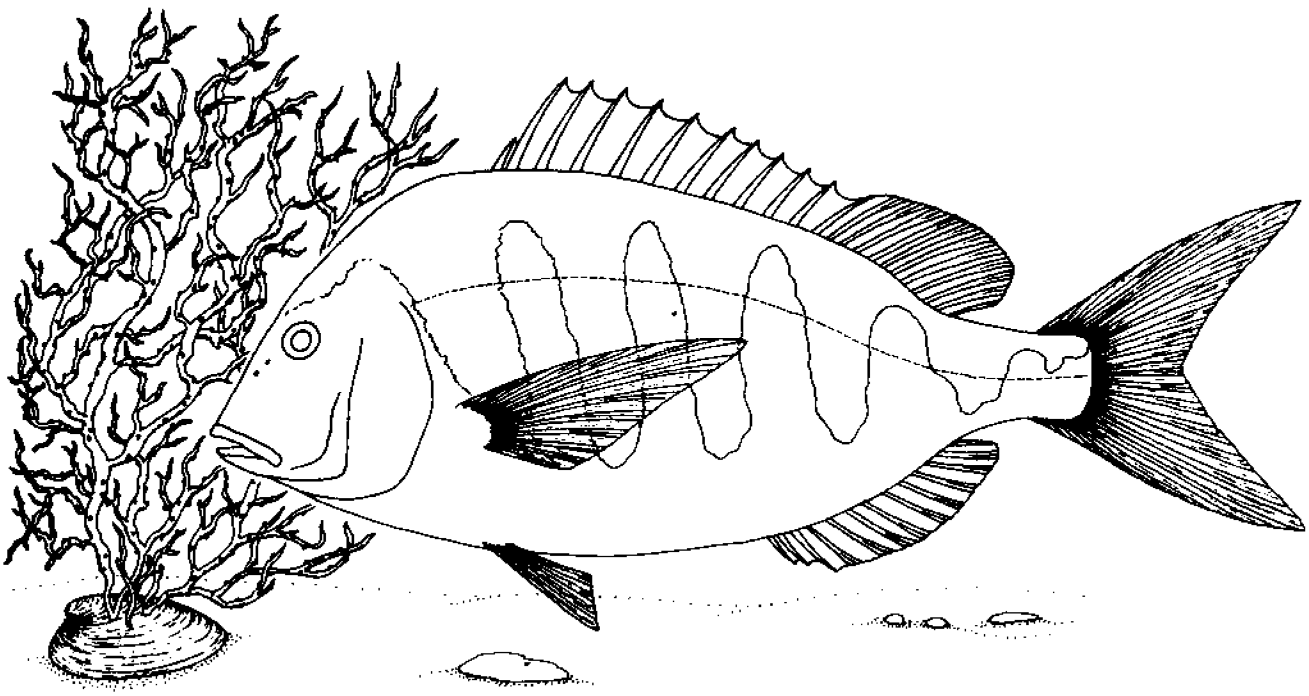
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Halibut		Pacific Coast, Alaska, New England.	Lean	Drawn, dressed, steaks, fillets. Fresh, frozen, smoked, canned. Breaded portions.	Baked. Stuffed. Broiled. Steaks in herb sauce.
Lake Perch	Yellow Perch	Great Lakes, other U.S. lakes, inland rivers.	Lean	Whole, pan-dressed, fillets. Fresh, frozen.	Deep-fried. Pan-fried.
Lake Trout	Togue	Great Lakes, lakes of British Columbia, Alaska, Northern, U.S.	Fat	Whole, drawn, fillets, steaks. Fresh, frozen.	Trout Amandine. Baked whole with herb stuffing.



Mackerel

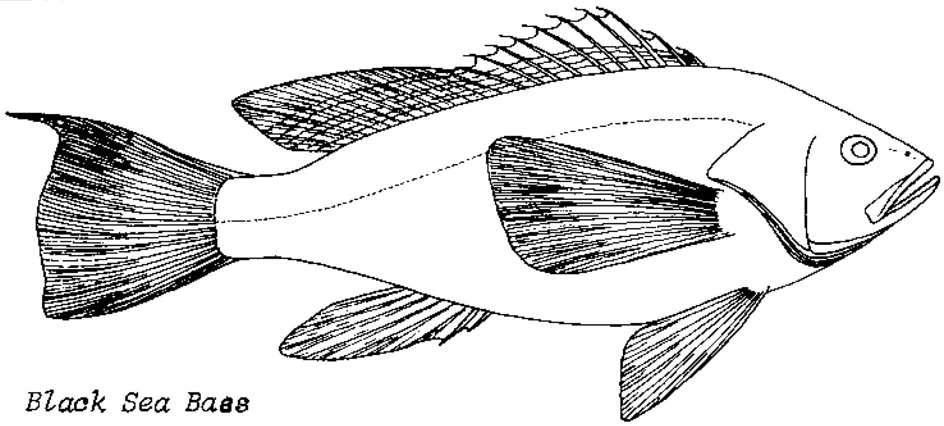
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Mackerel	Blue, American.	New England, Norway.	Fat	Whole. Fresh, frozen.	Broiled. Baked. Seafood casserole.
Spanish		South Atlantic, Gulf.	Fat	Whole, drawn, fillets. Fresh, frozen.	
King	Cero, Kingfish.	South Atlantic, Gulf.	Fat	Drawn, steaks, fillets. Fresh, frozen.	
Mullet	Striped, White, Jumping, Silver.	Atlantic (Florida to North Carolina), Gulf (Florida to Texas).	Fat	Round, fillets. Fresh, frozen, smoked, salted. Mullet dip.	Baked, with herb-seasoned stuffing.
Ocean Perch	Rosefish, Redfish.	New England, Northwest coast, Iceland, Germany, England, Norway, Canada.	Lean	Fillets. Fresh, frozen. Breaded fillets and portions.	Pan-fried. Baked in white wine sauce. Perch Cumaudine.

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Pollock	Boston Bluefish.	Cape Cod to Cape Breton.	Lean	Drawn, dressed, steaks, fillets. Fresh, frozen, salted, smoked. Raw and pre-cooked breaded sticks and portions.	Baked. Boiled with herb sauce.
Rainbow Trout		Northwestern U.S. (commercial fish farms), Denmark, Japan.	Lean	Dressed, boned, boned and breaded. Fresh, frozen.	Trout Amandine. Charcoal broiled. Baked with lemon butter. Saute Meuniere.
Red Snapper		Gulf, Middle Atlantic, Formosa.	Lean	Drawn, dressed, steaks, fillets. Fresh, frozen.	Poached snapper. Snapper fillet Amandine. Baked. Stuffed.
Salmon Sockeye Chinook Silver Pink Churn.	Red, Spring, King, Silver-sides, Coho.	Pacific Coast, Alaska, North Atlantic, Great Lakes.	Fat	Dressed, steaks, fillets. Fresh, frozen, smoked, canned.	Poached. Baked. Steaks Florentine. Planked. Charcoal broiled.



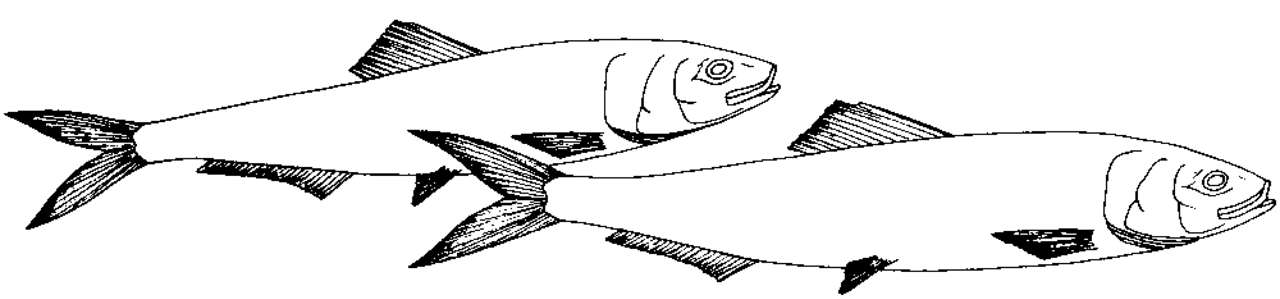
Scup

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Scup	Porgy, Paugy.	Southern New England to North Carolina.	Lean	Whole, pan-dressed.	Baked. Broiled with lime and butter.



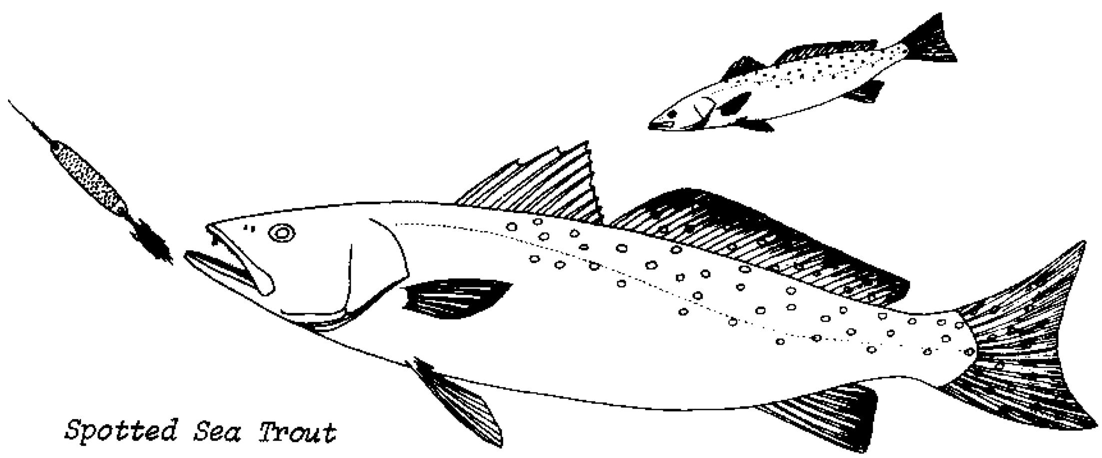
Black Sea Bass

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Sea Bass					
Black & white		Pacific Coast	Lean	Steaks, fillets. Fresh, frozen.	Baked and stuffed. Sauteed with tartar sauce.
Common	Blackfish, Black Sea Bass.	New England, Middle and South Atlantic.	Lean	Whole, pan-dressed, fillets. Fresh, frozen.	



Atlantic Sea Herring

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Sea Herring	Atlantic or Pacific Herring.	New England, Middle Atlantic Iceland, Denmark, Norway, Germany, England, Scotland, Holland, Sweden, (virtually world-wide).	Fat	Whole, Chunks. Fresh salted pickled, smoked. (Sardines).	Herring in sour cream or wine sauce.

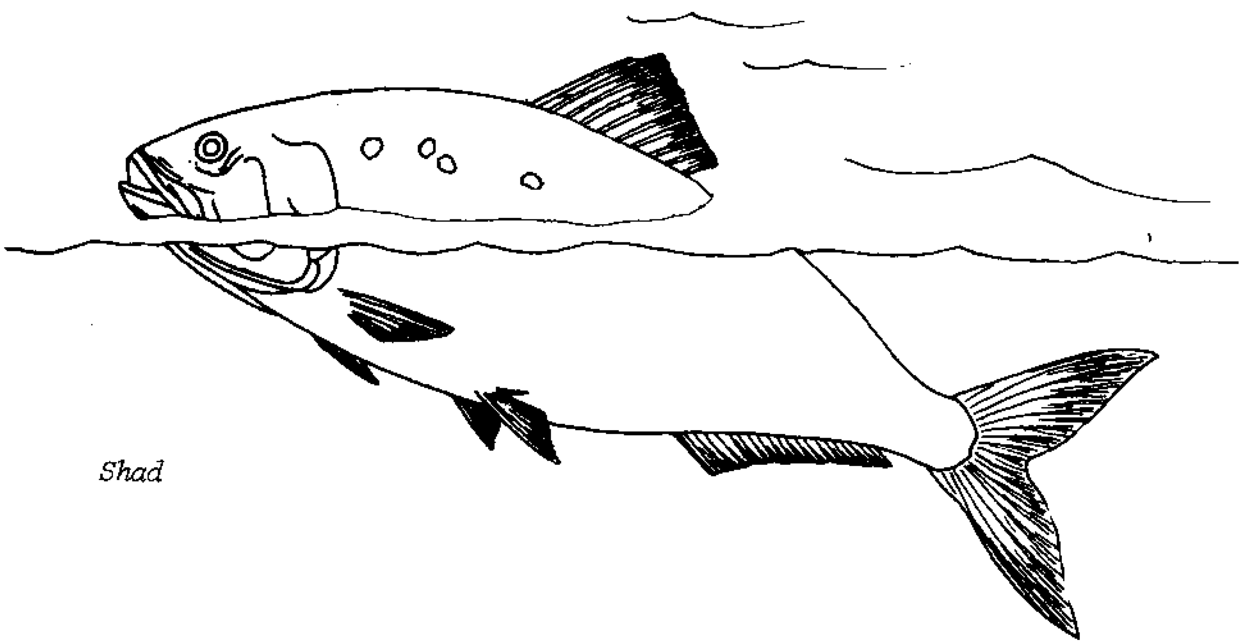


Spotted Sea Trout

Sea Trout

Gray	Weakfish, Squet-eagues.	Middle and South America	Lean	Whole, drawn, fillets.	
				Fresh, frozen.	Pan-fried.
Spotted	Speckled Trout.	Middle and South Atlantic Gulf.	Lean	Whole drawn, fillets,	Sauteed with lemon and butter.
				Fresh, frozen.	Trout Amandine.

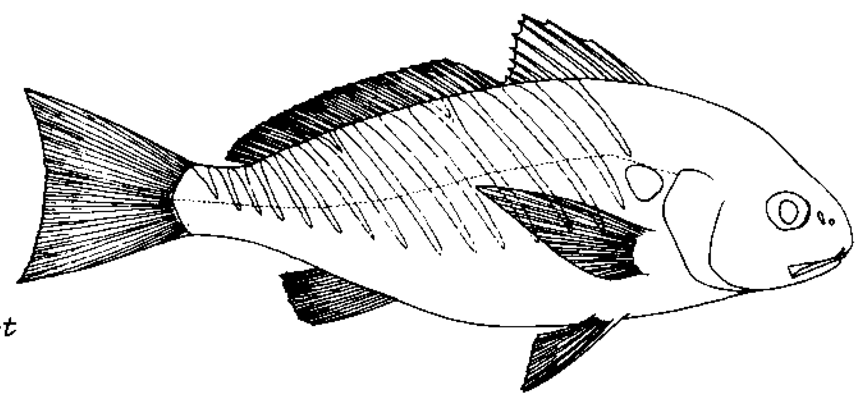
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Sea Trout (continued)					
White	Sand Trout	Gulf	Lean	Whole, fillets. Fresh frozen.	



Shad

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
<u>Shad</u>	Buck, Roe, White Shad.	Coastal rivers from Maine to Florida, Washington to California.	Fat	Whole, drawn, fillets, boned. Fresh, frozen, smoked, canned. Shad roe: fresh, frozen, canned.	Boiled with bacon. Baked with toasted sesame topping.

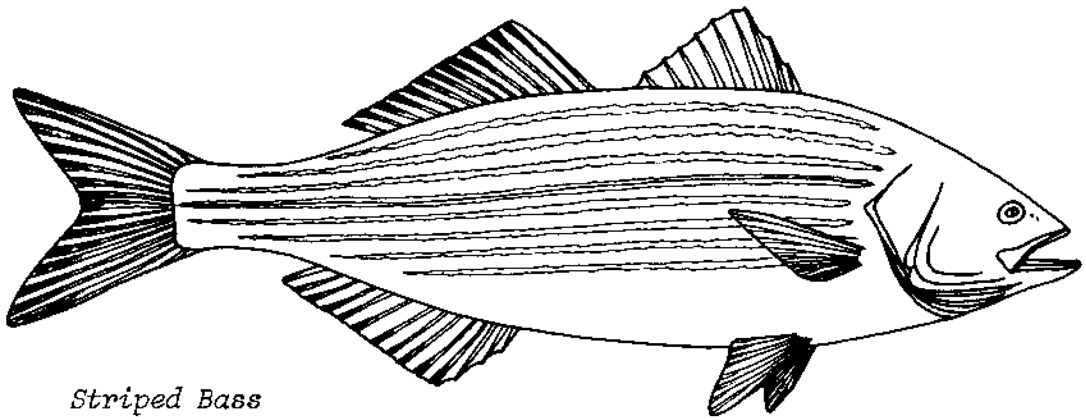
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Smelts	Whitebait, Surf Smelt, Grunion, Eulachon or Columbia River Smelt, Silverside, Jacksmelt, Bay Smelt.	North Atlantic, Pacific Coast, Columbia River, bays from Mexico to Canada, Great Lakes.	Fat to Lean	Whole, dressed, breaded, pre-cooked. Fresh, frozen.	Pan-fried. Broiled.
Sole	Rox, Petrale, Sand, Grey or Lemon Sole, Dover or English sole.	Pacific Coast, Alaska, Canada, Atlantic Coast, Holland, Belgium, Denmark, England.	Lean	Whole, fillets, breaded, stuffed. Fresh, frozen.	Sole Amandine. Baked fillet with seafood stuffing. Charcoal broiled with lemon and butter.



Spot

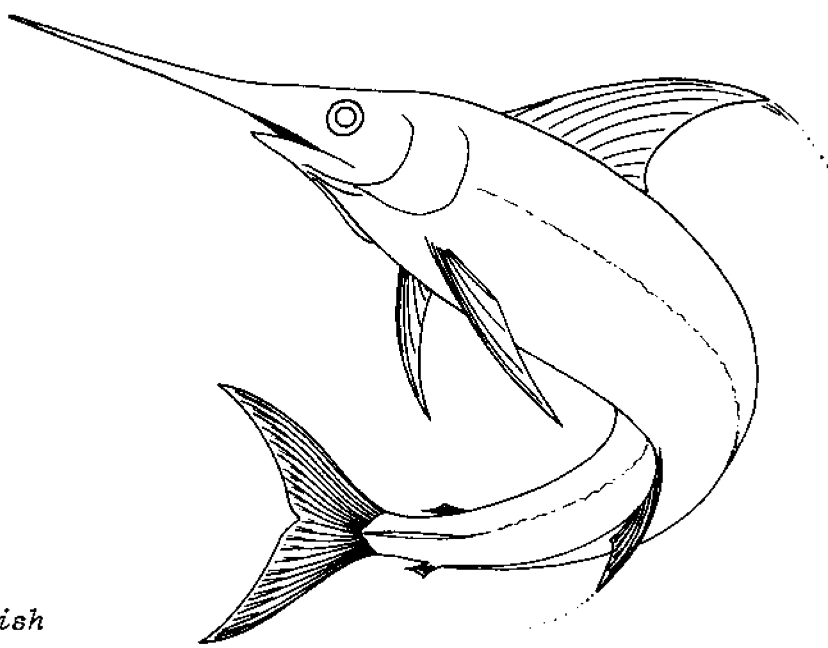
Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Spot	Goody, Lafayette.	New Jersey to Florida.	Lean	Whole, pan-dressed. Fresh, Frozen.	Pan-fried, Broiled.

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve



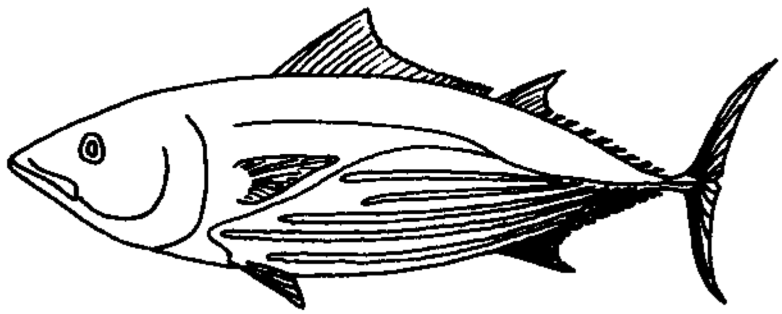
Striped Bass

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Striped Bass	Rock, Rock Bass, Rock Fish.	Atlantic Coast, Pacific Coast.	Lean	Whole, drawn, steaks, fillets. Fresh, frozen.	Baked with herb stuffing. Pan-fried with mushrooms.



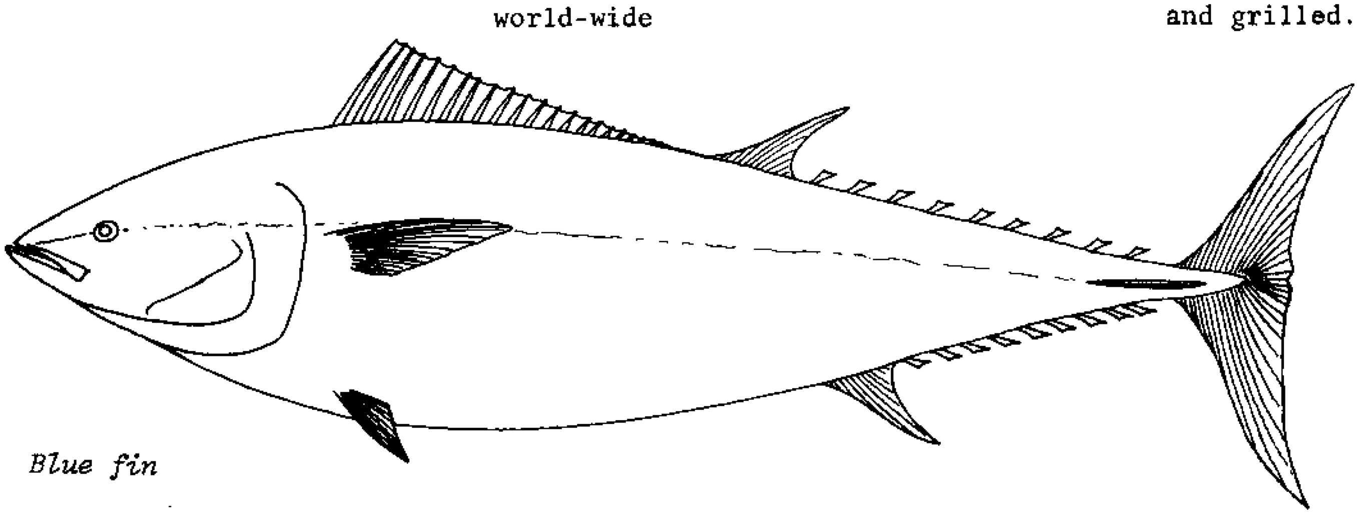
Swordfish

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Swordfish	Broadbill	New England, Middle Atlantic, Pacific coast, Chili, Peru, Japan	Lean	Dressed, steaks. Fresh, frozen.	Barbecued steak. Grilled. Broiled.



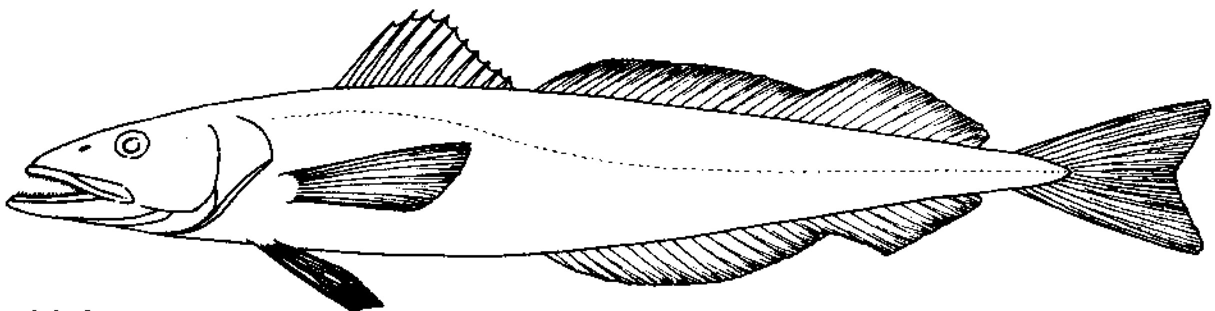
Albacore

Tuna					
Albacore		Pacific Coast,	Fat	Canned	
Yellowfin		Pacific Coast,	Fat	Canned	Tuna salad.
Skipjack		Southern waters	Fat	Canned	Scalloped casserole.
Blue Fin		Atlantic and Pacific coast	Fat	Canned	
Little		Atlantic and world-wide	Fat	Drawn	Marinated and grilled.



Blue fin

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Whitefish		Great Lakes, Minnesota, Canada.	Fat	Whole, drawn, dressed, fillets. Fresh, frozen. smoked.	Baked. Broiled. Poached with Hollandaise.

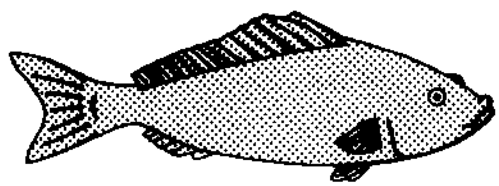


Whiting

Species	Other Names & Types	Where Caught	Fat or Lean	Market Forms	Favorite Ways to Serve
Whiting	Frostfish, Silver Hake.	New England, England.	Lean	Drawn, skinned, breaded. Fresh, frozen.	Deep-fried.

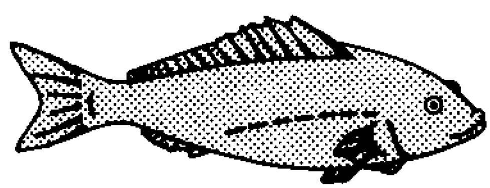
II-E: MARKET FORMS OF FRESH AND FROZEN FISH

Fresh and frozen fish are marketed in various forms or cuts. Knowing these forms and their special uses helps in choosing which kind to buy. The following are known market forms:



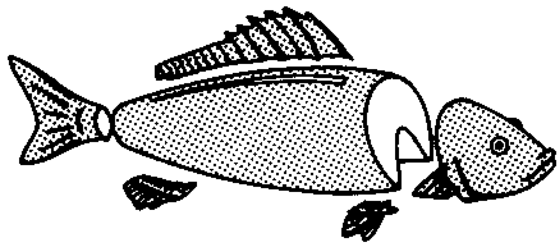
Whole

Fish as they come from the water. Before cooking, the fish must be scaled and eviscerated -- usually the head, tail, and fins are removed. The fish may then be cooked, filleted, or cut into steaks or chunks.



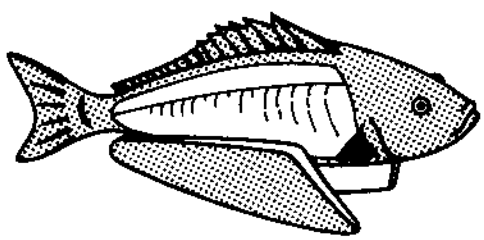
Drawn

Whole fish with insides removed. Generally scaled before cooking, and usually the head, tail, and fins removed. Ask your dealer to do this.



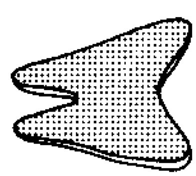
Dressed

Fish with scales and entrails removed; usually the head, tail, and fins are also removed. The fish may then be cooked, filleted, or cut into steaks or chunks. Small dressed fish are called pandressed and are ready to cook as purchased.



Fillets

Fillets are the sides of the fish cut length-wise away from the backbone. They are ready to cook as purchased. A fillet cut from one side of a fish is called a single fillet. This is the type most generally available on the market. The fillets may or may not include the skin. Only two fillets can be cut from one fish.



The two sides of the fish cut length-wise away from the backbone and held together by the uncut flesh and skin of the belly are called butterfly fillets.

Steaks

Steaks are cross section slices from large dressed fish cut 5/8 to 1 inch thick. A cross section of the backbone is the only bone in a steak. They are ready to cook as purchased.

Chunks

Chunks are pieces of the cross sections from large dressed fish. A cross section of the backbone is the only bone in a chunk. They are ready to cook as purchased.

Raw Breaded Fish Portions

Portions are cut from frozen fish blocks, coated with a batter, breaded, packaged, and frozen. Raw breaded fish portions weigh more than 1 1/2 ounces, are at least 3/8 inch thick, and must contain not less than 75 percent fish. They are ready to cook as purchased.

Fried Fish Portions and Sticks

In the 1950's, an entirely new line of frozen food products entered the consumer market and was tremendously successful. Today's homemaker has a selection of food in easy-to-prepare forms that were unknown 20 years ago. Frozen convenience seafoods have become popular throughout the nation, with breaded fish portions and sticks leading the field.

As an example of how frozen fish portions and sticks have caught on in the United States, statistics compiled by the Bureau of Commercial Fisheries show that, since the mid '50s, the combined production of fish portions and sticks rose to over 270 million pounds in 1968. This figure continues to grow as additional drive-ins, restaurants, schools, institutions, and homemakers are introduced to these convenience seafoods.

Fish portions and sticks are generally made of cod, haddock, or pollock and come in frozen, raw, or partially-cooked forms. Fish portions can be obtained either breaded or unbreaded. They come in a variety of sizes and shapes, carefully defined by FDA standards of identity. The cut pieces are dipped into a batter and coated with breading. Most fish sticks and some portions are then partially cooked. Partially-cooked fish portions and sticks take only minutes to prepare. Uncooked portions and sticks take slightly longer. For best results, follow the directions on the package for cooking time and temperature.

Fish portions range in size from 1 1/2 to more than 5 ounces and come in square, round, and rectangular shapes. Generally speaking, one 8 or 10 ounce package of fish portions will serve two. Raw breaded fish portions are at least 3/8 inch thick and contain not less than 75 percent fish. Partially cooked fish portions are at least 3/8 inch thick and contain not less than 65 percent fish.

Frozen fried fish sticks are 3 to 4 inches long and weigh up to 1 1/2 ounces. They are at least 3/8 inch thick and contain at least 60 percent fish. An 8-ounce package will usually serve two persons.

Frozen fried battered fish portions come in 2-ounce and 3-ounce portions. They must contain at least 50 percent fish and not more than 50 percent batter. Fried breaded fish come in 2-ounce, 3-ounce, and 4-ounce portions and contain at least 65 percent fish.

II-F: CONSUMER INSPECTION AND BUYING

Buying Fresh Fish

The following chart is a general guide for buying fresh fish.

FRESH FISH BUYING GUIDE

		Fresh	Reject
General Appearance: (lustre and bleaching)		Bright, with metallic lustre. Very little, if any, bleaching.	Bloom completely gone. Color faded or bleached.
Eyes		Bright, translucent, usually full but in some cases may be slightly sunken and somewhat dull.	Dull and sunken. May be cloudy, pink, white or opaque.
Gills	a. Color	Bright red to slightly pinkish red.	Brownish red to brown or gray. Frequently covered with thick, bacterial mucus.
	b. Odor	Fresh odor characteristic of species to faint sour odor.	Medium to strong sour odor.
Odor	a. Poke End	Fresh to very faint sour odor.	Medium to strong sour odor.
	b. At Neck when deheading.	No odor to very slight odor.	Sour or putrid

	Fresh	Reject
Consistency of Fish	Firm and elastic to the touch. Occasionally may be slightly soft.	Generally soft and flabby, separating from bones.
Belly Cavity	Flesh adheres firmly to rib bones.	Rib bones free or almost free from flesh.
Vent	Normal in shape and color.	Protruding and may be discolored.

Buying Frozen Fish

Frozen fish must be handled properly if it is to reach the consumer in good condition. It will not deteriorate while it is deep frozen, but changes in temperature during transporting or handling may result in deterioration of quality.

A check on the following points will help assure that the product has been correctly handled.

A. Flesh should be solidly frozen when received.

B. The flesh should have a firm, glossy appearance with no evidence of drying-out, i.e. no white spots, papery corners or edges, dark spots, discoloration, or fading of red or pink flesh.

C. If wrapped, cut fish shows signs of frost inside the transparent wrap, either the fish has been stored for a long time or the contents have thawed and refrozen.

D. Check carefully to see that the container is intact, with no torn or crushed edges.

E. Avoid packages which have been stacked above the load line or frost line of the store's display freezer.

F. Avoid packages with "drip" or ice on the package, an indication that the contents have thawed and refrozen.

G. Check cello-wrap packages for discoloration.

H. If you purchase products of questionable quality inadvertently, return them to the store at once.

Inspection, Standards, and Grade Marks

Frozen fish portions and sticks lend themselves to the advantages of inspection and grading. However, not all these products on the market are inspected and graded. Inspected products may be labeled "Packed Under Federal Inspection", either as a mark or statement. Fish portions and sticks may also bear "U.S. Grade" marks. See Part II-E for a discussion of the standards connected with these inspections and grades.

Portions and sticks are graded on a number of factors that affect the quality of the products. The standards are set by the National Marine Fisheries Service, taking into account consumer needs and industry capabilities. In the frozen state, the portions and sticks are checked for condition of package, ease of separation, broken or damaged pieces, and uniformity of weight and size. Cooked samples are checked for color, texture coating, defects, blemishes, flavor, and odor.

II-G: HOW MUCH TO BUY

The amount of fish to buy per serving varies with the recipe to be used, the size of the serving, and the amount of bone in the fish. Count about 3 ounces of cooked, boneless fish as a serving, a little less for small children and a little more for adolescent boys and men. The following table can help you decide how much fish, purchased fresh, frozen, or canned, to buy:

FINFISH SERVING GUIDE

Form	Amt. per person	Amt. for 100
Whole	3/4 pound	90 pounds
Dressed or pan-dressed	1/2 pound	45 pounds
Fillets or steaks	1/3 pound	30 pounds
Portions	1/3 pound	30 pounds
Sticks	1/4 pound	25 pounds
Canned	1/6 pound	15 pounds

II-H: NOW THAT YOU'VE CAUGHT THAT FISH... WHAT ARE YOU GOING TO DO WITH IT?

Illustrations courtesy Texas A&M University Sea Grant Program

Preparations

Preparations for any fishing trip, short or long, should include a few necessary items that will help the fisherman keep the fish he catches as fresh tasting as the day they were caught -- whether they are eaten a day, a week, a month, or six months later. At a minimum, these items include a knife, an ice chest, and plenty of crushed ice. In addition, scaling or skinning tools and even packaging materials may come in handy. Having this equipment on hand, knowing the parts of the fish (Figure II-1) and following the simple procedures described here, a fish can be easily and quickly prepared for cooking or freezing.

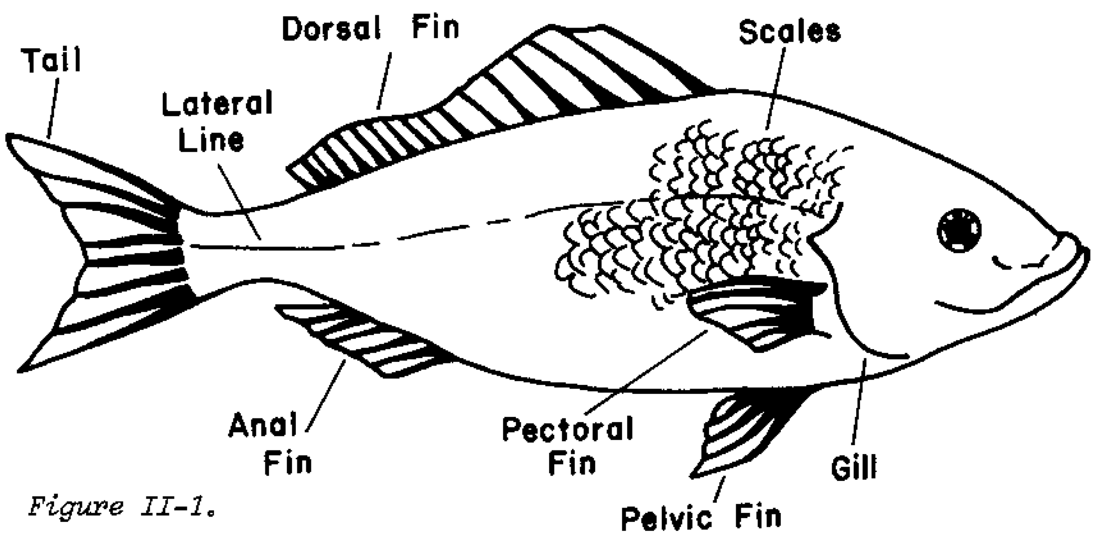


Figure II-1.

Remember that the way a fish is handled, from the time it is pulled from the water until it appears on the dinner table, is important in preserving good taste and high quality. Ideally, a fish should be removed from the hook or net and gilled, gutted, and iced as soon as possible.

Do's and Don'ts of Fish Handling

Here are some do's and don'ts of fish handling that can affect its taste and storage life. By keeping these suggestions in mind, the fisherman can keep the fresh-caught quality that makes the eating as good as the fishing.

Do's:

- Do gut, gill, and ice a fish as soon as possible.
- Do wash the gutted fish in lake water, creek water, saltwater, or tap water to remove as much slime, mud, and blood as possible before icing.
- Do wrap fish in damp paper or a damp cloth and store in a shady, well ventilated area if ice is not available. This will keep the flesh moist and cool.
- Do allow for proper bleeding by either removing the head or cutting the tail and positioning the fish in the ice chest so the blood can drain out. Blood remaining in the tissue can speed up the rancidity that develops in fish in frozen storage.
- Do ice fish generously before transporting it home. Pack the belly cavity with ice and provide adequate ice between fish and the sides of the ice chest. Make a "false bottom" in the ice chest so your fish will not be floating in bloody, melted ice water when you get home.

Don'ts

- Don't let a fish flop around in the bottom of a boat or on a pier. This will bruise the flesh and speed up biochemical changes (rigor mortis) that may produce an undesirable taste.
- Don't keep fish on a crowded stringer and/or in shallow, muddy, warm water.
- Don't leave the gills and guts in a fish for very long after the fish has died.

Most marinas, fishing piers, state parks, etc., have facilities for cleaning fish, and unless you have adequate space at home, it is probably best to make use of these facilities.

The methods of cleaning a fish are as varied as the individual fisherman. Basically, the cleaning process involves gilling and gutting, scaling or skinning, and filleting -- not necessarily in that order. Depending on the final use intended for the fish, only one or two of these procedures might be necessary.

Gilling and Gutting

The gills and guts of a fish should be removed as soon as possible since they contain the highest concentration of bacteria that may cause rapid spoilage. The guts also can cause an off-taste in the flesh because of the enzymes in the fish's intestines. After the fish has died, these enzymes digest the walls of the intestinal tract, creating what is commonly known as "belly burn". This is particularly true in a fish that was feeding when caught.

One good way to gill and gut a fish is:

. . Cut into the area under the chin that joins the bottom of the two gill openings; then cut the belly cavity open back to the anal fin (Figure II-2).

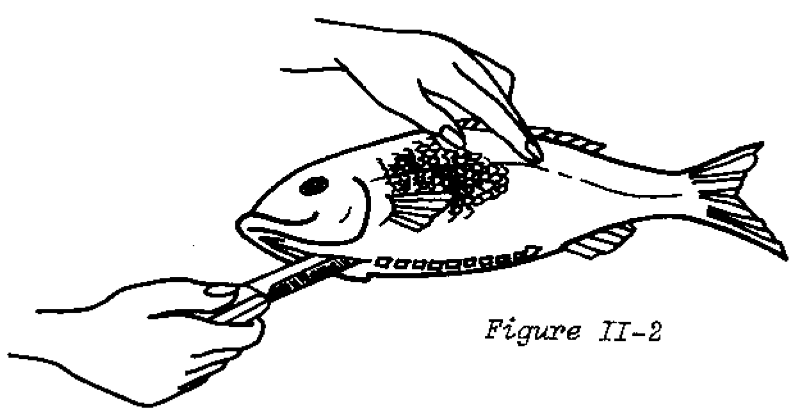


Figure II-2

. . Carefully avoid cutting the intestinal tract. If the intestinal contents are spilled onto the flesh of the fish, wash thoroughly.

. . Remove any visible body fat, as it will turn rancid in storage.

. . The kidneys (the dark red mass along the backbone) and inner abdominal lining (either black or a silvery color) should be brushed out under running water (Figures II-3, II-4).

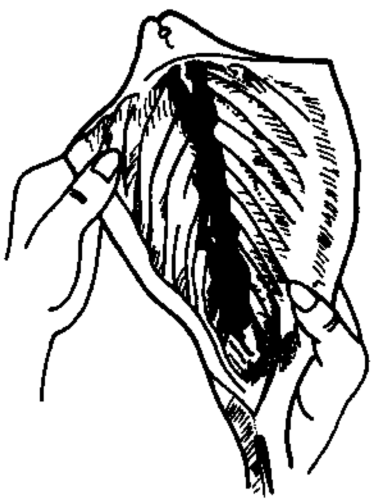


Figure II-3

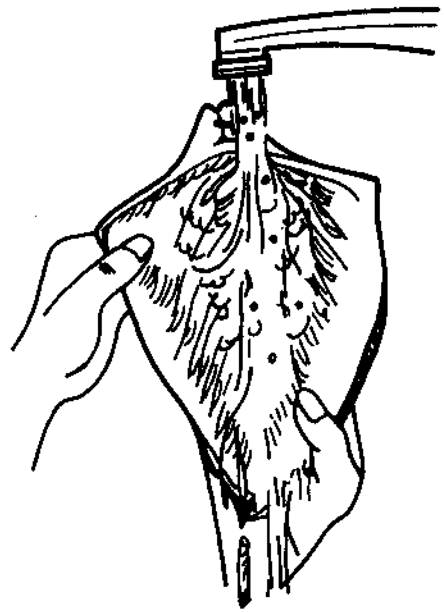


Figure II-4

Scaling and Fin Removal

Scaling only (skin left on) is suited for small fish that are hard to skin, or for fish that are to be baked, barbecued or pan dressed.

Scaling is done with a commercial scaler, the back of a knife blade, a tablespoon or the edge of a soft drink can. Use a scraping motion against the grain of the scales, starting at the tail and working toward the head. Fins should be removed by cutting into the flesh (about 3/4 inch) along each side of the fin (Figure II-5).

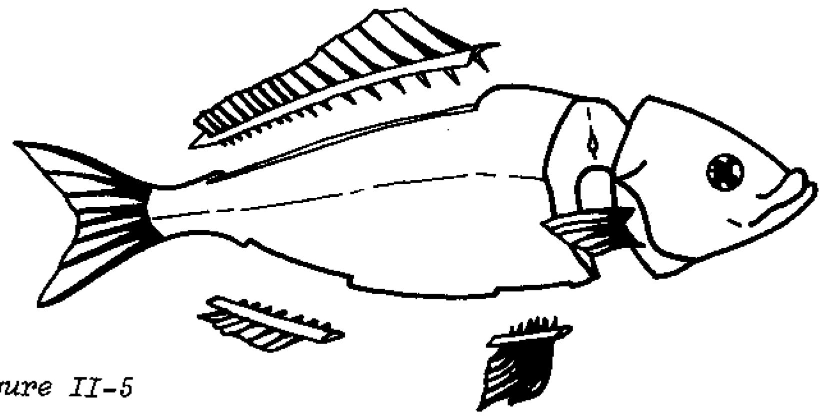


Figure II-5

Pull the fin away from the tail and toward the head with either skinning pliers or household pliers. This is also a good time to dehead the fish if it is to be done. A fish prepared this way is "pan dressed". Fins left on a fish can puncture packaging material and cause freezer burn (dehydration).

Skinning

A large portion of the fat found in fish is located directly under the skin. Removing this layer of fat by skinning the fish will reduce the chances of rancidity developing while the fish is frozen. A fish can be skinned without first being scaled, and skinning is almost always part of preparing a fish like catfish, which has no scales.

To skin a scaleless fish, cut the skin only (not the flesh) along the top of the fish and around each of the dorsal and anal fins. Peel the skin away from the flesh with skinning pliers, household pliers, or your fingers -- if using your fingers, extra grip can be added by dipping them in table salt.

Catfish can be skinned by cutting the skin around the head or by gripping the skin on top of the bone-like knot directly under the pectoral (side) fin and pulling it toward the tail (Figure II-6).

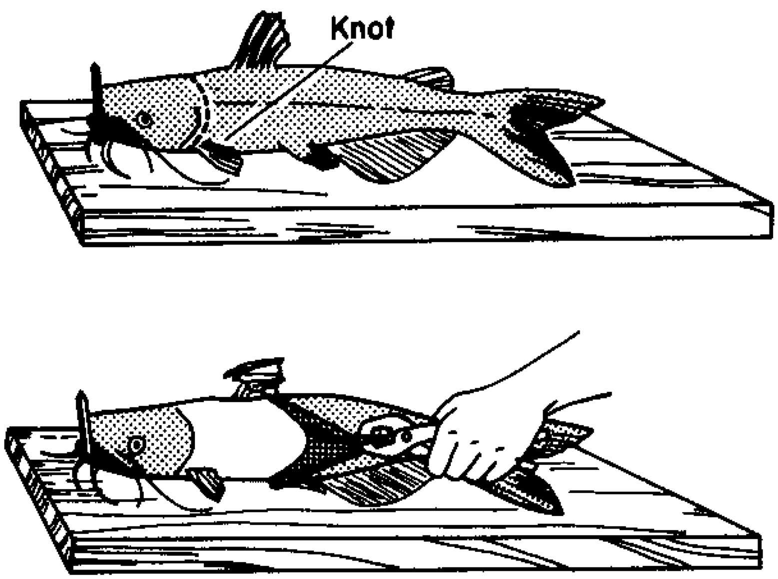


Figure II-6

The fish can be held by hand for skinning, but it is usually easier to hang it from a tree limb or to hook its lower jaw on a spike mounted on a skinning board. Skinning pliers are recommended for skinning catfish.

Filleting

Filleting is an easy way to clean a fish and produce a boneless portion of meat -- which saves freezing time and space. Fish can be filleted with head, skin, and scales still on and sometimes without removing the guts, although, as mentioned earlier, it is advisable to remove the guts as soon as possible. Filleting can be done with a conventional filleting knife (long, narrow, flexible blade) or a household electric knife.

The filleting process is as follows:

. . Starting at the pectoral fin just behind the head, cut into the flesh at a 45° angle toward the head until you hit the backbone.

. . Turn the knife and follow the backbone all the way to the tail, staying as close to the backbone as possible without cutting it (Figure II-7). Some resistance will be noticed as several rib bones must be cut.

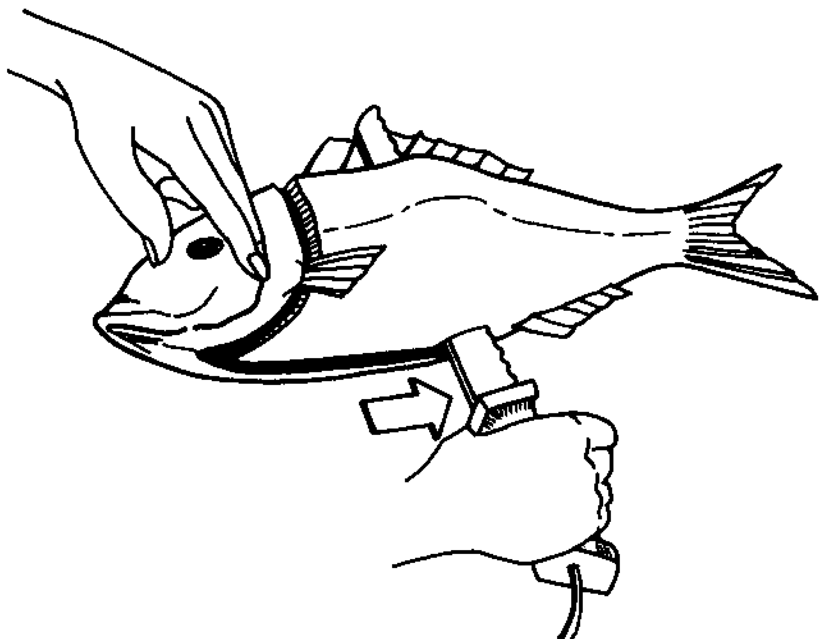


Figure II-7

. . Do not cut through the flesh at the tail as this makes it difficult to remove the skin on the fillet.

. . Lay the fillet back from the fish so it is lying on the cutting board with the flesh side up (Figure II-8).

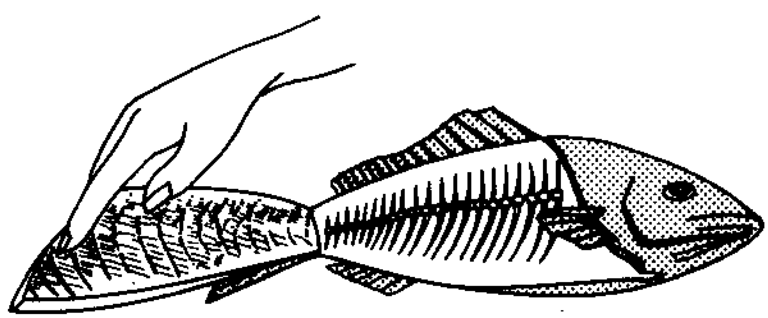


Figure II-8

. . Starting at the tail where the skin is still attached, run the knife between the flesh and the skin back toward the head-end of the fillet (Figure II-9). By keeping the fillet flat and running the knife close to the skin, little meat is wasted.

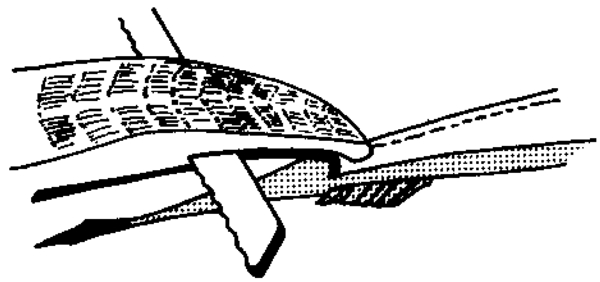


Figure II-9

The rib bones may be removed for a completely bone-free fillet. In larger fish, a dark strip of meat can be seen running down the center of the fillet on the skin side. If possible, remove this dark meat.

Always clean the cutting board and utensils with soap and water before and after use. A solution of household bleach (one tablespoon bleach per gallon of water) should be used as disinfectant in addition to soap and water. The bleach solution will help eliminate the unpleasant smells associated with cleaning fish.

Your fish is now ready for cooking or storage. See Part V-C for information on home freezing.

PART III: SPECIAL SPECIES OF MARINE FOOD PRODUCTS

III-A: FINFISH: SARDINES, SALMON, CANNED TUNA, EEL, AND ANCHOVY

Sardines, salmon, and tuna are given special attention here because they are among the most widely eaten varieties of fish. Eels and anchovies are considered separately because they are a much overlooked source of excellent seafood.

Sardines

Characteristics: Maine sardines are the immature young of the Atlantic herring. They have elongated bodies and are greenish blue with a silvery cast on the sides and belly. The herring has a deeply forked tail and has a single dorsal fin directly over the small ventral fin. Scales of herring are large and loosely attached. Herring reach about four inches in length by the end of the year.

Definition: What is a sardine? The word sardine is not the name of just one species of fish but rather a collective name that represents a variety of tiny, soft-boned fish. The name sardine probably comes from the fact that similar, tiny fish called French sardines were first found and caught in great abundance around the island of Sardinia in the Mediterranean. Caught and enjoyed by Atlantic coastal Indians long before the first white settlers arrived, these tasty little fish are still being caught in the same coves and inlets used by the Indians of long ago.

Uses of Sardines: Sardines are a valuable source of high protein needed for building and repairing body tissues. They contain iron needed for healthy, red blood. Sardines provide useful amounts of thiamine, niacin, and riboflavin. Maine sardines are packed in various types of oil as well as mustard and tomato sauces. Packed in flat 4-ounce cans, they are ready to eat at the zip of a can opener, pull tab, or key.

Salmon

Species of Salmon:

Pink (*Oncorhynchus gorbuscha*) is the smallest, weighing an average of four pounds. It has a good red flesh and a delicate flavor. It may be sold fresh or canned. Fresh pink salmon is abundant during July, August, and September.

Sockeye (*O. nerka*) is the next largest, weighing approximately seven pounds. The flesh is deep red and is usually not available fresh.

Coho (*O. kisutch*) is generally classified as the next largest, weighing approximately nine pounds. The flesh is medium red. May be purchased fresh, frozen and canned. Fresh Coho is abundant from July to November.

King (*O. tshawytscha*) is the largest of all the salmon. It is accepted as the best eating of the salmon and usually commands the highest prices. It is obtainable fresh in the early spring or summer, and the year round in smoked or frozen form.

Canned Tuna

There are four kinds of tuna canned commercially in the United States. They include Albacore, Yellowfin, Skipjack, and Bluefin. The most prized tuna are the Albacore, which have a very light color and firm texture. By law, canned Albacore tuna is the only one that can be commercially labeled as "white tuna". The second most popular species is the Yellowfin, which has the same firm texture as Albacore but is slightly darker in color. In the grocery store, canned tuna labeled as "light" will contain Yellowfin. As the supplies of these favored species have dwindled, canners have begun to use the Skipjack tuna as well. This species is smaller, darker, and somewhat stronger flavored than the other two. The fourth type is called Bluefin tuna, and actually refers to several species of tuna which are grouped under this collective name. Bluefin tuna are similar to Skipjack in color and flavor, but can be much larger (some weigh over 1,000 pounds). The tuna caught in the mid-Atlantic region are usually those from the Bluefin family. Canned tuna is prepared in the following forms:

A. *Solid* or *solid packs* consist of loins to which no free pieces are added. A piece may be added if necessary to fill a can.
B. *Chunk, chunks, chunk style* consist of a mixture of pieces of tuna in which the original muscle structure is retained. The pieces may vary in size but not less than 50 percent (by weight) shall be retained on a ½ inch-mesh screen.
C. *Flake* or *flakes* consist of a mixture of pieces of tuna in which more than 50 percent of the weight of the pressed contents of the container will pass through a ½ inch-mesh screen, but in which the muscular structure of the flesh is retained.
D. *Grated* consists of a mixture of particles of tuna that have been reduced to uniform size, that will pass through a ½ inch-mesh screen, and in which the particles are discrete and do not comprise a paste.

Any of the above forms of canned tuna may be smoked.
All canned tuna falls within one of the following color designations:

A. White - limited to the Albacore.
B. Light - includes any tuna not darker than Munsell value 5.3.
C. Dark - includes all tuna darker than Munsell value 5.3.
D. Blended - applied only to a mixture of tuna flakes of which not less than 20 percent by weight meet the color standard for either white tuna or light tuna and the remainder fall within the color standard for dark tuna.

Canned tuna is packed in one of the following optional media.

A. any edible vegetable oil
B. olive oil (When solid pack tuna is packed in olive oil, the designation "Tonno" may also appear.)
C. water

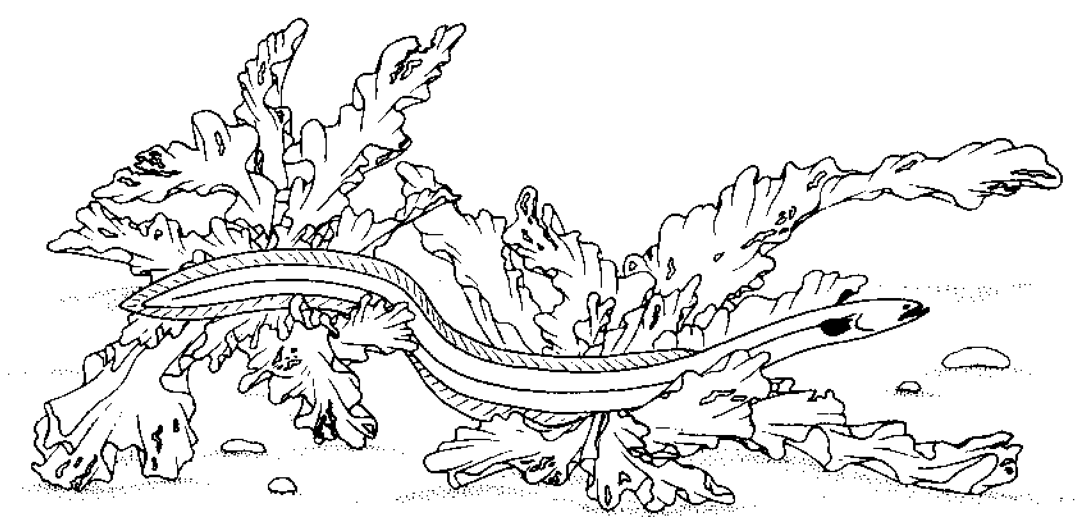
Canned tuna may be seasoned or flavored with one or more of the following:

A. salt
B. purified monosodium glutamate
C. hydrolyzed protein
D. spices, spice oils or spice extracts
E. vegetable broth (not to exceed 5 percent of the volume capacity of the container). The broth can be made from beans, cabbage, carrots, celery, garlic, onions, parsley, peas, potatoes, green bell peppers, red bell peppers, spinach, and tomatoes.
F. garlic

Eels

Eels are snake-like fish found in estuarine waters as well as the fresh waters of major rivers and tributaries. The American eel (*Anguilla rostrata*) averages 7 to 8 pounds and 36 inches in length, and is found in abundance from Greenland to the Gulf of Mexico. Eels are caught in V-shaped weirs in streams.

Eels traditionally have not been a part of the seafood diets of Americans. However, Europeans have long considered them a delicacy. They are sold fresh, smoked, pickled, and canned.



American Eel

Preparation: Live eels must be killed, cleaned and cooked. One method used in killing eels and also removing the slime layer is to sprinkle them with salt and add just enough water to cover them. Let them soak in this solution for two to three hours before removing and then wash them thoroughly with clean water. Soak them again, but this time for a half hour only and in fresh cold water. Following this soaking, scrub them with a steel brush to remove the last traces of salt and slime. Following this procedure the eels should be skinned and gutted. The best method of skinning the eel is to drive a nail through the eel's head into a wooden post or board. Using a sharp knife, cut through the skin three inches behind the head all the way around. Care should be exercised to avoid the gall bladder which is located behind the head. Fold the skin back and peel it off with pliers.

The next step is the gutting process. Insert a knife into the vent and cut along the belly line toward the head, stopping at the gills. Cut toward the tail two inches past the vent. Remove the kidneys and, if possible, pull out the large vein along the backbone. Wash the gut cavity, making sure to remove all traces of blood.

Freezing: Eels can be frozen, however, they do not keep well in home freezers due to their high fat content. If you do attempt to freeze eels, package them well. This will protect other foods in the freezer against off odors and flavors which could develop in eels stored inadequately or stored for too long a period.

Cooking Eels:

A. Fried - Cut cleaned meat in three-inch lengths. Roll in crumbs, dip in slightly beaten egg diluted with two tablespoons of water, roll again in crumbs. Fry in deep fat at 375°F for three to five minutes.

B. Baked - 2 pounds of eel in two inch lengths
1/4 cup olive oil
1 clove garlic, coarsely chopped
a pinch of thyme leaves
juice of 1/2 lemon

Sprinkle blended salt and pepper over pieces of eel. Heat the olive oil in a baking dish. Add garlic and thyme. Place the eel in this hot mixture, squeeze a little lemon juice over it, and bake in a moderate oven (375°F) for 25 to 30 minutes.

Anchovy

The strong flavored seafood product known as anchovy is made from several different small, fatty, pelagic fishes including herring, sardine, and anchovy families, but most often small fish called sprats (*Clupea sprattus L.*). The fish are cured with a combination of salt and spices and allowed to undergo a complicated maturation process which gives them their characteristic flavor. Anchovies are generally packed in one of two ways; either in bulk barrels or directly into retail cans. Those packed in barrels are later repacked into small containers in the form of skinless, boneless anchovies.

Barrel anchovies are packed into wooden barrels; about 95 kilogram to each barrel. To these are added a mixture of salt, sugar, spices and a preservative, usually benzoic acid. Whole sprats are mixed thoroughly on special tables with the salt-sugar-spice mixture, then poured into clean barrels with the same mixture in the bottom. Once full, the rest of the salt-sugar-spice mixture is poured over the top. After 1-2 days a brine is formed from the liquid extracted from the fish. At this point, the barrels are tightly sealed and put aside, and the curing process begins. The curing process depends upon the condition of the raw fish and the temperature at which the barrels are held. In some countries, the barrels are kept cold, while in others, such as Spain and North West Africa, the barrels are actually placed in the sun. A ripe anchovy is one with a soft and smooth consistency and one from which the backbone can be easily removed. Generally, one person is responsible for determining when the anchovies are ripe. He does so by continually sampling until they finish curing. Most of these experts sample by biting through the anchovy just behind the head.

When the barrel anchovy is ripe, it is cut into fillets and packed into small rectangular cans. The final product is then covered with a sauce of salt, sugar and spices, and the can is sealed and labeled.

'Direct made' anchovies are packed whole into small rectangular cans, and the same salt-sugar-spice combination is added to the cans.

When all the salt and sugar is dissolved, about two days later, the cans are topped up with brine and sealed. Curing is done at temperatures between 12-15°C and the cans are turned over every two weeks. When the cure is complete, the cans are placed in cold storage and are ready to eat.

As the anchovies ripen, several by-product compounds diffuse out of the fish and into the brine. Since this diffusion of by-products occurs in the retail can of direct made anchovies, they tend to be stronger in flavor. Some of these flavors are left behind in barrel-cured anchovies and are further diluted and masked by packing into cans with new brine and sauce. Another difference to consider is that directly packed anchovies are still whole and have to be filleted by the consumer if so desired. Many anchovy eaters consider it part of the experience and some eat the fish whole.

III-B: ROE

The female gonads of fish develop during the annual spawning cycle to edible proportions in a few species. Roe can be frozen, salted, smoked, canned or fried. For instance, fresh cod roe are available around March in the Northeast, although they can be frozen, refrigerated, or canned to make them available year round. They are also considered a delicacy when smoked. Salmon roe can be as large as 35 percent of the fish's total weight, and are generally smoked. The roe of sturgeon are salt-pickled and sold as the premium priced caviars. Salmon roe are also used for this purpose in some places.

In the mid-Atlantic region, good quality edible roe can be obtained from herring, mullet, rockfish and shad. One of the more common methods of preparation is to remove the egg sacs (or skeins) from the fish whole, wash it carefully, and then simply pan fry it in a small amount of grease or oil. Roe prepared in this manner are frequently eaten as a breakfast dish.

Fish roe are an excellent source of protein, but tend to be high in both fat and cholesterol. It should be kept in mind that the roe of a few species of marine fish are very poisonous (see Part V-F). So sport fishermen should be very careful about eating the roe from their catch.

III-C: CAVIAR

Caviar is a product made from fish eggs which has been enjoyed as a delicacy for centuries. Although caviar can be made from eggs of many fish, including salmon, mullet, herring, steelhead, rock fish, and shad, the most highly prized is the eggs of sturgeon caught in the Volga River of the Soviet Union. Only sturgeon yield the top grade black caviar which has large, firm grains. Lesser grade caviars range in color from yellow to red to dark grey, and are characterized by smaller grain size and a looser consistency.

Caviar is produced through a special salt pickling procedure in which a controlled process of maturation encourages the development of the characteristic flavor. Commercial production of caviar begins by collecting the roe in special basins where it is washed and mixed with salt (44 grams of salt per kilogram of roe). The salted roe is packed into jars or cans, kept in ice and sawdust, and shipped at temperatures just above freezing.

The U.S.S.R. is the leading producer of caviar, producing about 5,000 tons annually or about 90 percent of the world supply. The Soviet processors utilize four species of sturgeon which abound in the Caspian Sea and process them in a large plant in Astrakhan. Iran, which also borders the Caspian Sea, is the second largest producer, providing only 5 percent of the world supply. Attempts have been made in Western European countries to produce a substitute caviar from the roe of lumpfish (or lumpsucker, *Cyclopterus lumpus*), which has eggs comparable with, but even larger than those of the sturgeon.

Caviar exported to the U.S. is preserved with salt, so the salt content is quite high. It also contains a relatively high fat content (about 15 percent) and has one of the highest cholesterol contents of any fishery product, about 300 milligrams per 100 grams.

Caviar should always be refrigerated. It generally remains acceptable for about a month. Caviar should never be frozen.

Caviar can be produced at home from the species mentioned above by using the following procedure:

A. Begin with eggs that are less than twenty-four hours old and show no signs of spoilage (particularly an ammonia odor).

B. Gently remove the individual eggs from the egg sacs and place in a bowl, being careful to remove pieces of membrane, blood, and bits of intestine or black skin.

C. For every two cups of cleaned eggs, stir ½ cup of salt with two cups of cold water in a large bowl until the salt is dissolved.

D. Pour the eggs slowly into the salt solution. Gently stir the eggs to allow contact with the brine and allow them to sit 30 minutes.

E. Pour the caviar into a strainer and rinse with cold water.

F. Transfer the finished caviar into a container which can be sealed tightly and store in the refrigerator.

Your homemade caviar should stay acceptable in the refrigerator for several weeks. It should be served chilled by nesting the serving bowl in a larger bowl filled with crushed ice. Caviar is most often served with unsalted crackers or toast spread with sweet butter or sour cream.

III-D: TURTLES

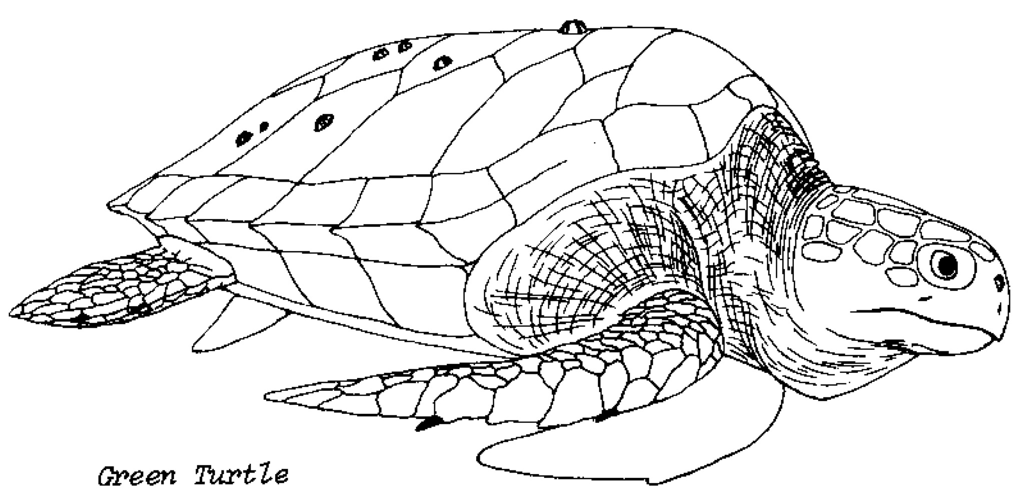
Due to excessive harvesting of nesting females and their eggs, sea turtles are an endangered species and should NOT be harvested.

Characteristics

There are seven species of sea turtles found in the tropical and subtropical waters of the world. Only three species have been of commercial value. They are commonly called the green turtle, hawksbill turtle, and loggerhead turtle. The remaining four species are not used due to their scarcity or, in the case of the ridley turtle, small size.

Sea turtles rarely leave the water except to lay their eggs. When first hatched the turtles are only inches long. Once mature the average weight range is 100 pounds (ridleys) to 1,000 pounds (leatherbacks) with a carapace (shell) length of 2 to 7 feet.

Freshwater turtles, terrapins (i.e., edible, more or less aquatic, hardshelled turtle), and tortoises (i.e., terrestrial turtles) are composed of many different species. Some of these species are eaten locally, but only a small percentage of the catch is marketed.



Green Turtle

Important Species

Green turtles, hawksbill turtles, and loggerhead turtles are the three sea turtles which have been of commercial importance. In most areas, there is a closed season for taking turtles and their eggs. Some countries have banned the taking of eggs or nesting females at any time. Also, due to dwindling numbers, most sea turtles have been or are now listed as endangered species. Therefore, prior to harvesting any turtles, check with the local extension agent or the Wildlife and Fisheries office.

The following fresh water turtles and terrapins are marketed in the United States: snapping turtle, diamond back terrapin, pond slider, red-bellied turtle, spring softshell, Florida softshell, and the Chinese softshell. Just as the sea turtles are endangered, some freshwater turtles are listed as endangered species at times, or there may be closed seasons in some areas. These limitations should be investigated prior to collecting turtles.

Fishing Methods

For commercial purposes, turtles are usually collected in stationary nets in which they become entangled during the night. The nets are checked early each morning, hopefully before sharks attack and ruin the catch and the nets.

There are basically three methods for harvesting freshwater turtles. The method used is determined by the habits of the turtles.

The first method, employed during hibernation, uses a large hook to probe in areas where turtles may be hibernating. Fishermen and trappers harvest large numbers of snapper during the winter months.

Terrapins are usually taken by the second method. A net is placed around a log, rock, or any object which the fisherman knows is a place where turtles bask in the sun. One end is left open for the turtles to climb onto the object. Then either the turtles overcrowd and push one another into the net, or the fisherman surprises the turtles, causing them to jump into the awaiting net.

The third method also utilizes a net. Seine nets are sometimes used, but the most effective is a baited net, which should be checked every 12 hours to prevent drowning. Softshell turtles are usually caught in this manner.

Market Forms

Turtles are harvested primarily for their meat which can be purchased and eaten fresh as steaks, or in turtle soup or curry. The meat and soup may also be purchased canned.

Other products obtained largely from sea turtles are turtle oil, which is used in soaps, face creams, and cosmetic lotions, and turtle leather. The leather is produced from the skin of the neck and forequarters and is used for shoes and handbags, replacing alligator and crocodile hides. Turtle shells obtained from the hawsksbill, a sea turtle, are used for jewelry and inlaying on such objects as knife handles and toilet accessories.

III-E: SEAWEED

Characteristics

There are two kinds of marine plants: grasses and algae. Stationary or fixed algae, as opposed to grasses and free floating algae, are of commercial importance. Green, brown, red, and blue green algae are the four varieties of fixed (attached) algae. In commercial utilization of algae, considerations should be given to light, temperature, size, life span, supply, and harvesting methods.

Light: Different amounts of light are necessary for each of the four varieties to grow. For this reason, the algae grow at various depths along the coast line: green in shallow water, brown at intermediate depths, and red the deepest (up to 100 fathoms). The depth of growth depends on clarity of water and amount of sun the area is exposed to everyday (latitude).

Temperature: The four algae also require various temperatures. Brown algae is found primarily in cold water and red algae, though found in colder regions, flourishes in tropical waters.

Size: The green and blue green algae are very small and difficult to harvest. The larger red and brown algae are used commercially most often, due to economy of harvesting. Kelp is a term used for the larger brown algae.

Life Span: There are annual, biennial, and perennial seaweeds. The life span of each alga determines how often and intensively the algae may be harvested.

Supply: The supply of seaweed must be located sufficiently close to a processing plant to keep transportation costs within economical limits. The type of seaweed available is determined mainly by latitude and temperature of the waters.

Harvesting Methods: The harvesting methods and frequency of harvest are determined by the size, location, and life span of the seaweed. Other than kelp, most species of algae are hand-harvested by divers or men using rakes with handles 15 to 20 feet long.

Market Forms

Seaweed is the raw material for many different products. It is used in food, fertilizer, and chemicals.

Food: As a food, seaweed is not widely accepted in the Western countries, but is used extensively in the Orient, especially Japan. Seaweed is high in minerals and vitamins and is used in soups, salads, and vegetable dishes. Seaweed is purchased dried, either in sheets or tangles, and may be used in a dry state or restored to a fresh state by soaking. The most popular forms are kombu (kelp), nori, wakame, and hijiki.

Fertilizer: Due to a high content of potassium and trace elements, seaweed is used for fertilizer. Additions are made to the seaweed to produce a complete fertilizer which is widely used.

Chemicals: A wide variety of chemicals may be produced from seaweed; potassium chloride, iodine, organic solvents, and phycocolloids, to name a few. Of these chemicals, phycocolloids are produced most often due to the economical feasibility. There are many kinds of phycocolloids which may be manufactured from seaweed, but agar, algin, and carrageenan are the only ones of commercial value (see marine colloids).

Nutrition

Sea plants are generally high in nutritive value and are among the most nutritious plants available to us. As with all plants, the nutritive content of different species of algae varies from plant to plant; the following information, however, is generally true of edible algae:

Vitamins: Generally marine algae contain good supplies of vitamins E and A. They also are sources of vitamins C, B_{12}, B_1, pantothentic acid, niacin, folic acid, and folinic acid. The vitamin concentrations in marine algae vary with the season of the year.

Minerals: Marine algae contain the minerals found in sea water and some even tend to be good sources of iron and calcium. Iodine concentrations tend to be fairly high.

Protein: Like other marine food products, the protein found in marine algae generally is highly digestible. The proportion of protein in seaweed can account for up to 25 percent of its dry weight.

Carbohydrates: Seaweed compare favorably with oats in carbohydrate (and protein) value. Marine algae contain carbohydrates in the form of polysaccharides. While not biologically available at first eating, the human body can acquire the capability to digest this "gel" after a conditioning period of about one week.

Fats and Oils: Concentrations of fats and oils in sea vegetables range from 1 to 8 percent, and in general, calories and cholesterol content are extremely low.

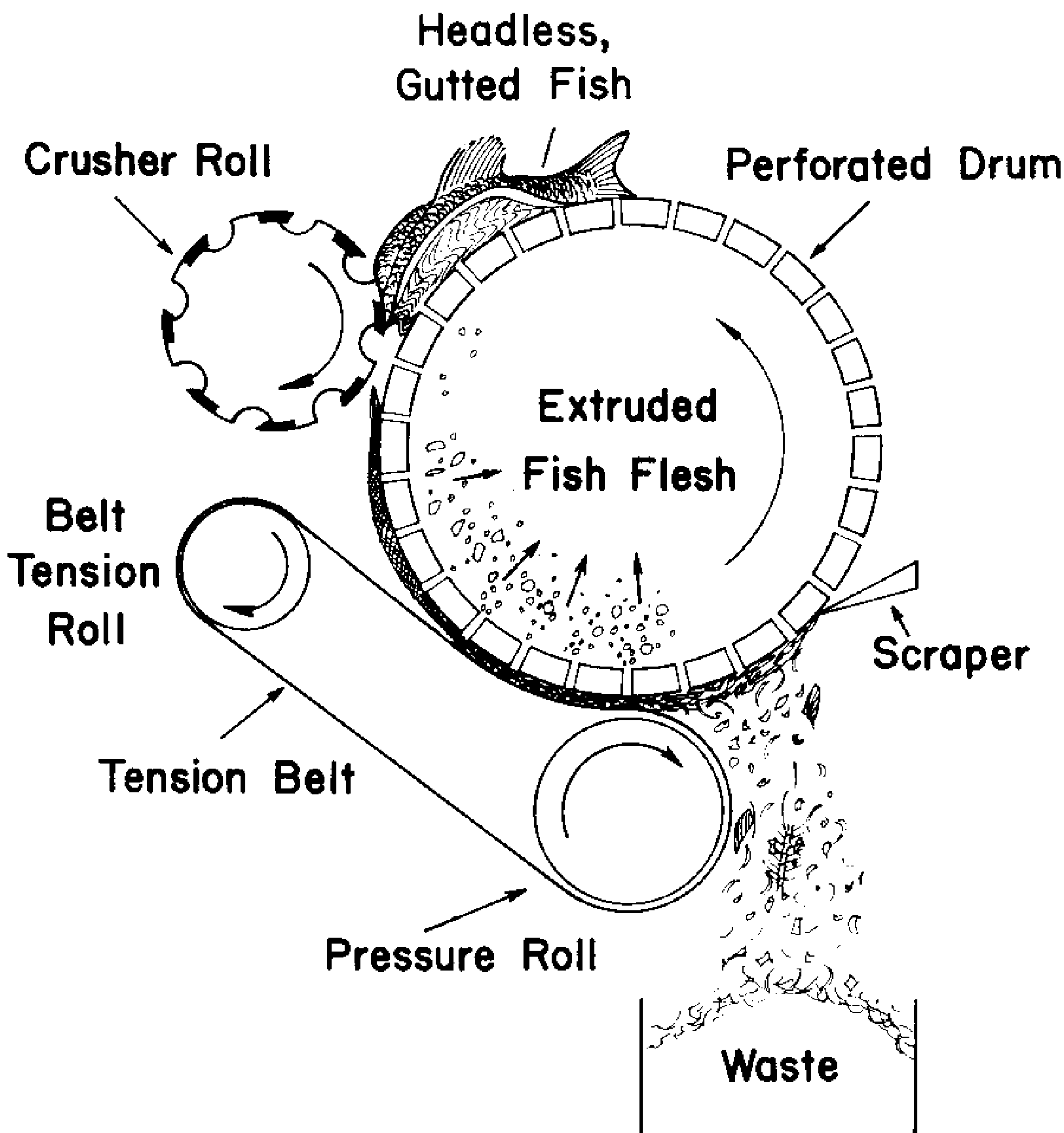
PART IV: MANUFACTURED FISHERY PRODUCTS

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 ½ 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 envionmental 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, fluccutation 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 pentobarbitol by slowing its movement into the bloodstream. Thus, hypothetically, much smaller and safer doses of pentobarbitol 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.

Strepogenin, 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 caecae 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 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

V-A: COMMON SEAFOOD SPECIES OF VIRGINIA

Table V-1. Common Finfish Species of Virginia

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

*Never eat the eggs, skin, or viscera of the puffers. Those parts are poisonous. Eat only the meat of the tail.

Table V-2. Common Molluscan Species of Virginia

Molluscs	Season Harvested Locally	Uses
Conch (Whelk)	All year	Chowder, Specialty dishes
Moon snail	All year	Chowder
Periwinkle	May be collected all year	Steamed, roasted, chowder
Blue mussel	Mostly north of Virginia	Steamed, in tomato sauce
Surf clam	All year	Clam chowder, minced
Ocean quahog (Mahogany)	All year	Chowder, clam strips
Hard clam	All year	Steamed, raw, chowder, baked
Soft shell clam (manninose)	All year - mostly north of Virginia	Steamed
Razor clams	All year	Steamed, chowder
Rangia (brackish water clam)	Not harvested yet - edible all year	Relaying or depuration necessary to alleviate muddy taste. Used for chowder.
Manilla clam (Cobicula)	Not harvested yet - edible all year	
Atlantic (Eastern) oyster	Fall, Winter, Spring - best quality	Fried, raw, stewed, baked
Sea scallop	All year	Fried, raw, stewed, baked
Squid	All year, mostly Fall, Winter, Spring	Fried, stuffed, specialty dishes

Table V-3. Common Crustacean Species of Virginia

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

*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

*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 <u>prohibited</u> 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.

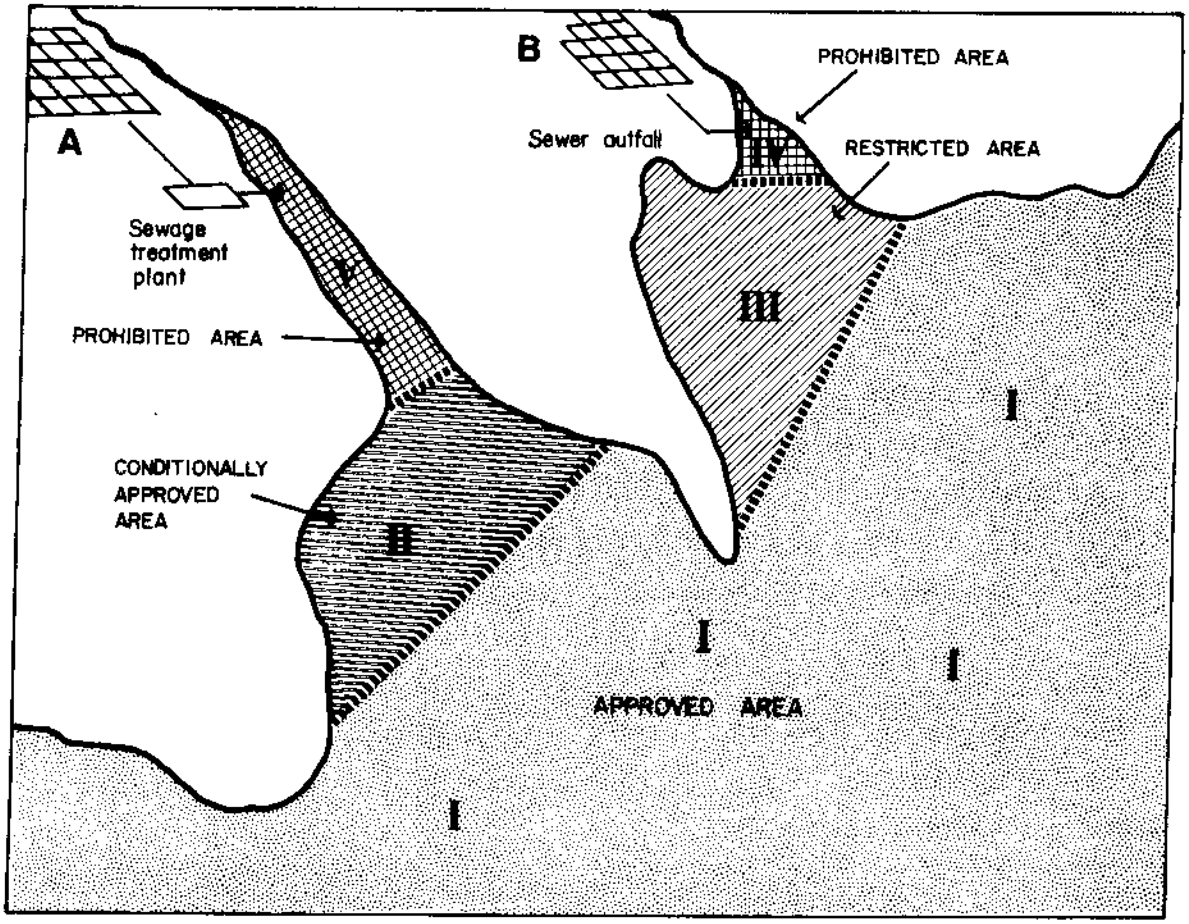


Figure V-1. Shellfish Gathering Areas

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

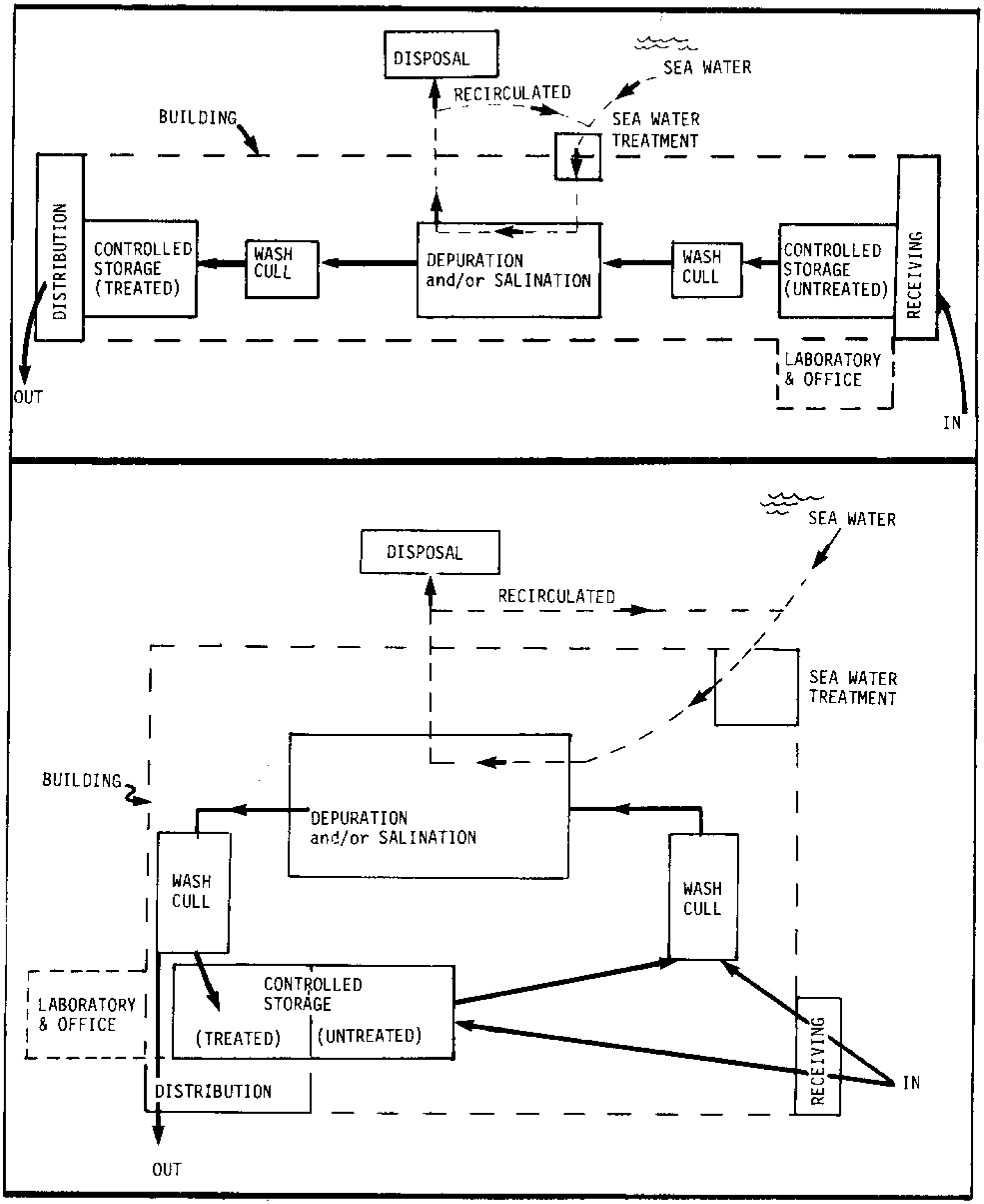


Figure V-2. Depuration and salination plant layouts the shellfish; however, optimum water parameters for maximum shellfish activity may be mechanically controlled or artificially produced so that depuration can occur in a relatively short span of time. Water parameters which may be controlled or produced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

Food and Drug Administration. 1979. Training Course and Information Manual, Shellfish Purification. U.S. Department of Health, Education, and Welfare. Washington, DC.

National Marine Fisheries Service. 1977. Water Quality and Molluscan Shellfish: An Overview of the Problems and the Nature of Appropriate Federal Laws. U.S. Department of Commerce. Washington, DC.

Public Health Service. 1966. Depuration Plant Design. U.S. Department of Health, Education, and Welfare. Washington, DC.

V-C: HOME FREEZING OF SEAFOODS

Home freezing is not only an excellent method for preserving seafoods, 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 seafoods 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 seafood 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

Material	Permeability Water	Permeability Air	Tightness of fit	Strength	Cost
Polyvinylidene Chloride (saran)	Low	Very Low	Very Good	Medium Low	Low
Polyvinyl Chloride P.V.C.	Low	Very Low	Very Good	Medium	Low
Polyester Bags and Sleeves	Very Low	Low	Good	Very High	Low
Ice Glaze	Low	Low	Excellent	Very Low	Low
Polyethylene Wrap and Bags	Medium	High	Poor	High	Low
Aluminum Foil	Low	Low	Fair	Very Low	High
Cellophane	Very High	Medium	Fair	Low	Low
Waxed Paper and Cartons	Very High	High	Poor	Adequate	Low

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.

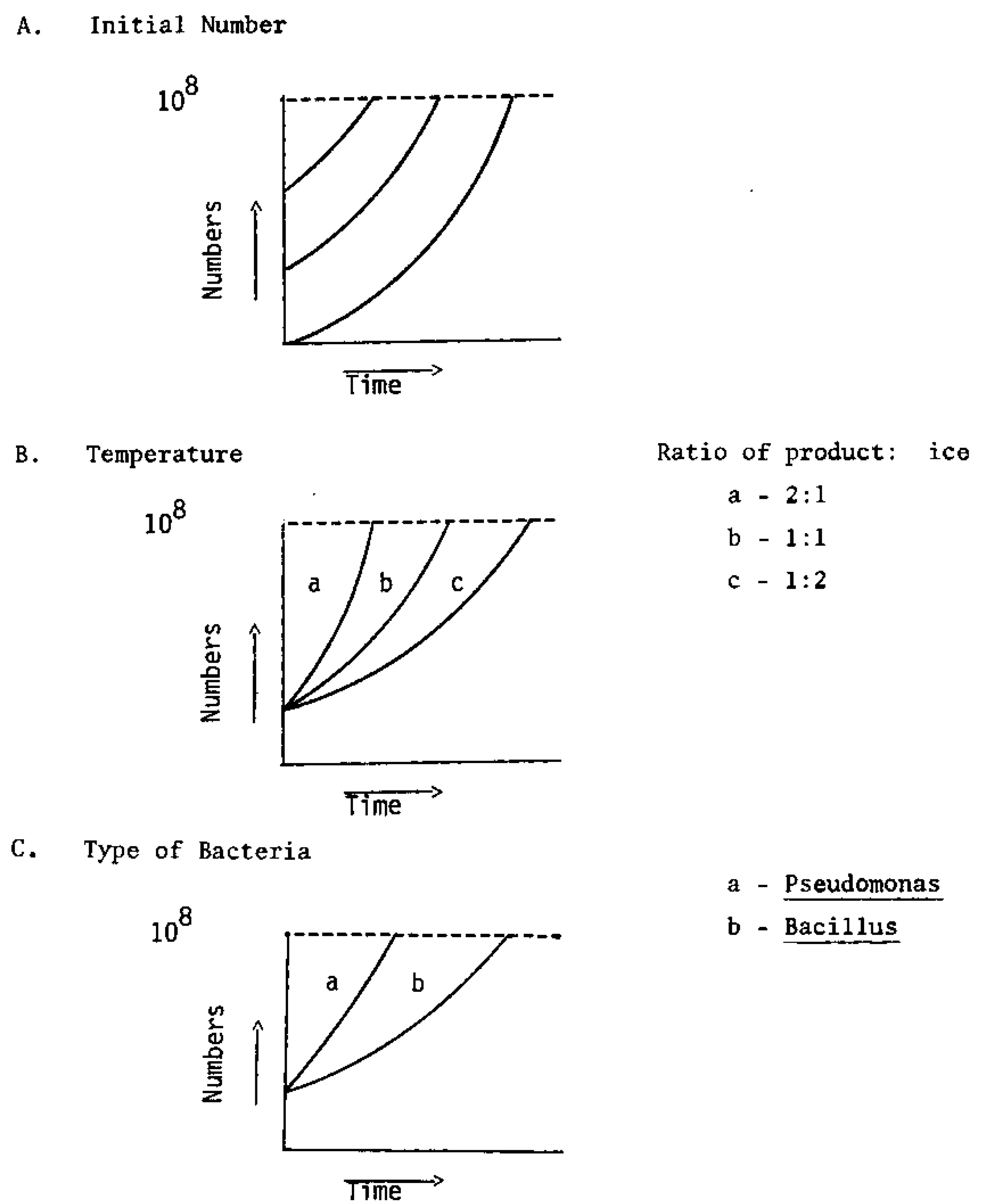


Figure V-3. Factors that affect the rate of bacterial spoilage

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.

	Storage Temperature		
Type of Fish	50°F - 68°F	32°F - 36°F	-22°F
Ungutted small fatty fish; e.g. sprats and herring	1 day	5-7 days	9 mos. - 2 yrs.
Ungutted small white fish; e.g. blue whiting, argentines	1 day	5-7 days	2 yrs.
Gutted fatty fish; e.g. herring, mackerel	1 day	7-10 days	9 mos. - 2 yrs.
Gutted white fish; e.g. cod, haddock	1 day	10-16 days	2 yrs. +

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

Keay, N. J. and Hardy, R. 1978. Fish as Food. Process Biochemistry 13:2.

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.

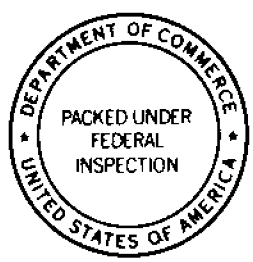
Grade C means fairly good quality. Grade C products are just as wholesome and are generally as nutritious as higher grades. Grade C products have a definite value as a thrifty buy for use where appearance is not an important factor. Consumers today will not find products labeled Grade B or Grade C in 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

V-F: TOXIC OR POISONOUS SEAFOOD

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 Artic 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 histadmine-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 accompained 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 evaucation 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 Tetraodontoidea, 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 particulary 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, Plamyra, 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 chryserydros*)

Surmullet (*Upeneus arge*)
Seabass, Grouper
Seabass
Trunkfish (*Lactoria cornutus*)
Trunkfish (*Lactophrys trigonus*)

Porgie
Squaretail
Porgie (*Pagrus pagrus*)
Filefish
Triggerfish

Anchovy
Squirrelfish
Oceanic Bonito
Wrasse (*Epibulus insidiator*)
Wrasse (*Julis gaimardi*)

Snapper (*Aprion virescens*)
Snapper (*Gnatodentex 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 microrhinos*)
Seabass (*Plectropomus oligacanthus*)
Seabass (*Plectropomus truncatus*)
Seabass (*Variola louti*)

<u>Medical Aspects</u>: 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 accompained 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, intuvation 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 developments 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, particulary 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 subsistance 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.

PART VI: SEAFOOD PREPARATION

VI-A: HOW TO SMOKE FISH

Curing by exposure to smoke is one means of temporarily preserving fish, and of producing an appetizing flavor.

The best fish to smoke are those with high fat content, such as carp, catfish, salmon, smelt, herring, whitefish, eel and trout. There are only four steps in preparing your catch: cleaning, brining, drying, and smoking.

The first step is cleaning the fish. Depending on the species, fish may be gutted and beheaded, halved, filleted, or skinned and cut into pieces. Small fish may be smoked in the round (without cleaning). Fresh fish may also be cleaned and frozen for later smoking.

After cleaning, you are ready for step two, brining the fish. Brining means steeping the fish in a solution of salt, water and spices. This process is essential before smoking; it firms the fish by removing moisture. Here are two brine recipes for hot smoked fish:

<u>I</u>

1 gal. water
1 lb. salt
1/2 lb. sugar
1/3 cup lemon juice
1/2 tbs. onion powder
1/4 tbs. garlic powder
1/2 tbs. seafood seasoning

(This is enough brine for 20 lbs. of fish.)

<u>II</u>

6 gal. water
4 lb. salt
1 1/2 lbs. sugar
1 1/2 oz. saltpeter
3 oz. whole cloves (optional)
1 oz. bay leaves (optional)

<u>Directions</u>: Mix ingredients well. Submerge fish in brine and refrigerate 12 hours. Remove fish from brine and freshen under running water for 10 minutes.

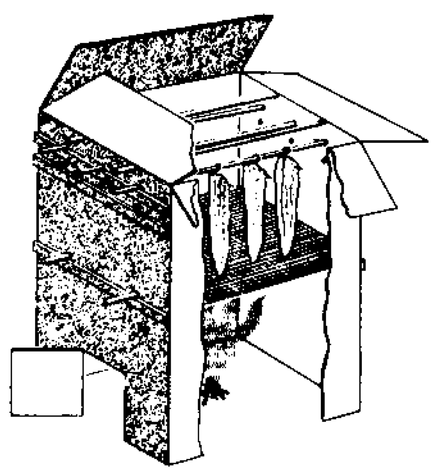
Now you are ready for step three, drying the fish. Pat the fish dry with a cloth, then place them in the refrigerator to drain for one to three hours. Drying increases keeping quality and promotes development of the "pellicile", a glossy finish of dissolved proteins on the fish which gives them the desired appearance.

The last step is the actual smoking of the fish. There are both hot and cool smoking techniques.

Cool-smoked fish require a heavier brine and a smokehouse temperature not over 90°F, in which the fish are cooked one to five days. Cool smoking is seldom done, except to preserve fish for long periods.

Hot-smoked (kippered) fish require a smoker temperature of 150 to 200°F, but a shorter cooking time of four to five hours. Hot-smoked fish are perishable and should be refrigerated.

For either process you will need a smokehouse. Your smokehouse may be designed from a large cardboard box, a metal drum, a wooden barrel, or an old refrigerator. The cardboard box is perhaps easiest to obtain; it should be 30 inches square and 48 inches high. Refer to the following diagram and building instructions.



Smokehouse

Directions:

A. Remove one end of box to form bottom of smokehouse.

B. Unfasten flaps at opposite end so they fold back and serve as a cover.

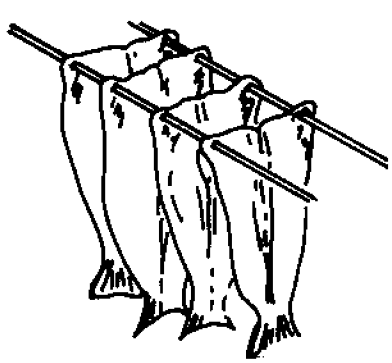
C. Strengthen box, if necessary, by tacking 3/4 inch strips of wood on outside of box -- vertically at corners and horizontally across sides.

D. Cut a door 10 inches wide and 12 inches high in bottom center of one side. Make one vertical and one horizontal cut, so uncut side serves as hinge.

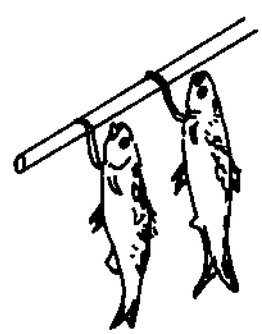
E. Suspend several rods or sticks (iron or wood) across top of box. Cut holes through box, so rods rest on wooden strips. A rack of coarse wire mesh (heavy 1/2" or 1/4" iron or steel) may replace rods.

F. Arrange fish on rods or rack so they do not touch. Fish may be hung on "S" shaped hooks, strung through gills by rods, split and nailed to rods, or simply laid on rack. Refer to the diagrams which follow for illustrated methods. Use regular nails, 8 or 10 gauge steel wires, coat hanger wires, S-shaped iron hooks, and/or round wooden sticks.

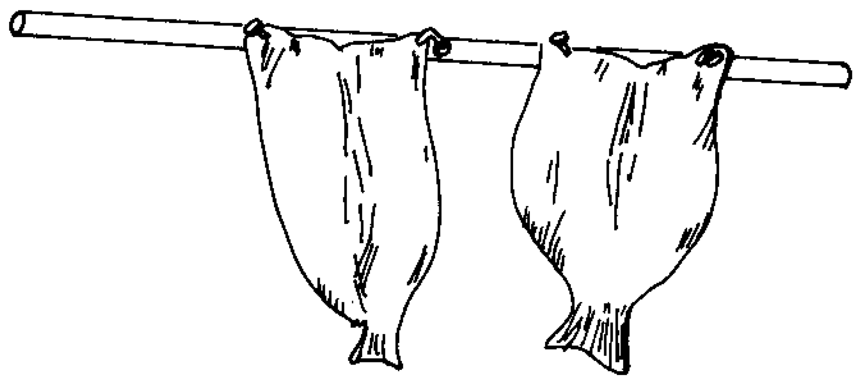
G. Build fire on level ground with nonresinous (hickory, oak, maple, apple) wood chips or sawdust to produce light, constant volume of smoke. Never use wood containing pitch, such as pine. Liquid smoke is also less satisfactory.



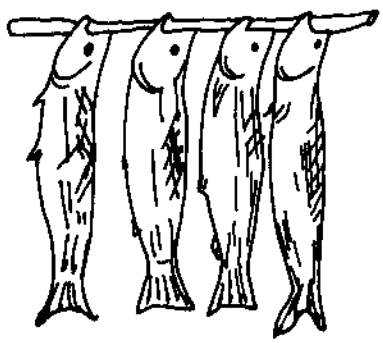
Split fish hung on two 1/4 inch rods



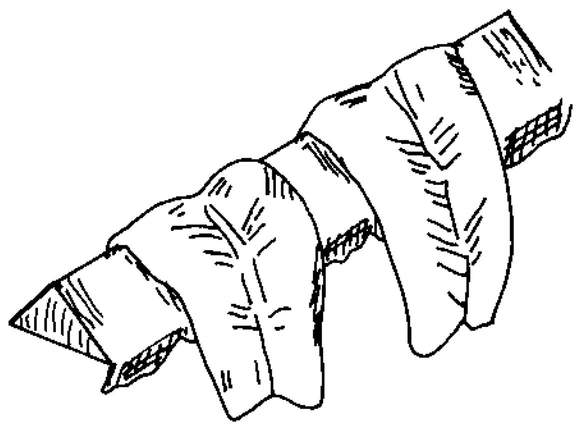
Small whole fish hung on "S"-shaped hooks



Split fish nailed to wooden strips or large sticks



Whole fish strung on wooden dowels



Fillets hung over wooden dowels, or whole fish flat on wire mesh screens

H. Center smokehouse over smouldering fire and close flaps. Danger of fire is minimized if ventilation is controlled to promote smoke rather than flames.

I. Monitor fish temperatures by inserting meat thermometer into fleshiest part of fish. Maintain fish temperature of about 180°F for kippered fish. (Temperatures exceeding 200°F cause excessive drying of fish.)

J. Smoke four to five hours.

Fish are ready for serving. Fish not eaten immediately can be stored in the refrigerator or freezer for later use. Smoking fish is fun, economical, and delicious.

VI-B: CANNING TUNA

Tuna is a low acid food and, when improperly processed, there is a danger of botulism poisoning. Botulism poisoning, one of the most severe food poisonings known, is caused by a toxin produced by the bacterium, Clostridium botulinum. This organism often is found in mud samples taken from seafood producing waters.

Two things should be done to avoid botulism poisoning. First, keep hands, equipment, and the working area clean to minimize the possibility of contamination. Second, always follow the processing instruction carefully and use the pressure canner instead of a boiling water bath or the oven. This is because it takes higher-than-boiling temperatures to completely destroy or inactivate Clostridium botulinum, and the pressure canner alone can attain sufficient heat.

Before you start, there are a few things you should check to insure the safe use of your pressure canner. First, make sure the pressure gauge on the canner is accurate. It should be checked for accuracy once a year. Have the proper amount of water in the pressure canner. Process at either 10 or 15 pounds pressure. Begin counting the processing time after the correct pressure is reached. If you are doubtful as to whether your fish was properly processed, reprocess for the entire period; or refrigerate the fish and eat within 3 to 5 days; or freeze in tightly sealed containers. Re-read the directions on how to use the pressure canner and on canning fish.

There are different methods of canning tuna using either raw or precooked tuna. There are two reasons canned tuna sold commercially are precooked prior to canning. First, precooking removes much of the body oil of tuna; that oil causes the meat to be somewhat bitter. Second, precooking improves the appearance, flavor, and texture of the product. After precooking, tuna meat is packed in oil (cottonseed, soy, or vegetable), water, or oil and water.

Tuna may be precooked by pressure cooking at 240°F at 10 pounds pressure for 2 hours. It may be steamed for 2 to 4 hours; or baked in a slow-to-moderate oven (250 - 350°F) for 1 to 4 hours, depending on the size of the fish, until cooked through. If cooking in the oven, the meat thermometer inserted into the center of the fish should register at 165 to 175°F when cooking is complete. Cool fish to room temperature, then store overnight, or 12 to 24 hours, in a cool room or refrigerator to firm the meat.

Before or during the packing of the precooked meat into jars, inspect for two possible defects. One is called "greening," characterized by grey or grey-green coloring of meat. It usually is accompanied by an unpleasant, urine-like odor. "Green" meat is not harmful but is unappealing and is best discarded. The other defect is called "honeycombing," which develops after the precooking step. It is characterized by pitted, spongy-looking meat, generally localized near the head of the fish. Since the defect is a result of fish decomposition, any tuna exhibiting honeycombing should be discarded. Off-odors usually accompany the honeycombing.

Before canning, the fish should be skinned and cut into chunks small enough to fit jars. Half-pint and pint jars with wide mouths are recommended. Pack fish pieces into jars, leaving 1/2- to 1-inch space at top. Add 1/2 to 1 teaspoon salt to pint jars; 1/4 to 1/2 teaspoon salt to half-pint jars. Add 4 to 6 tablespoons of hot oil, boiling water, or equal amounts of oil and water to each pint; 2 to 4 tablespoons to each 1/2 pint.

Seal jars and process at 15 pounds pressure for 80 minutes. If using 10 pounds of pressure, process half-pint containers for 90 minutes and pint jars for 100 minutes. Allow jars to cool and store in a cool, dark place.

Tuna may be canned raw without precooking. The dry pack method calls for cut pieces of raw tuna to be packed into half-pint jars to within 1/4 inch of the rim. One-half teaspoon of salt is added to the jars which are then processed at 10 pounds pressure for 1 hour and 50 minutes (80 minutes at 15 pounds pressure).

The brine pack method, similar to the dry pack method, calls for soaking cut pieces of tuna for 1 hour in a brine made of 3/4 cup salt mixed with one gallon of water. The fish should be completely submerged in the brine. After soaking, the fish is drained for several minutes and packed into jars to within 1/4 inch of the rim. No water or salt is added. Half-pint jars are then processed at 10 pounds pressure for 1 hour and 50 minutes (80 minutes at 15 pounds pressure). One gallon of brine is enough for about 25 pounds of cleaned fish. Only use the brine once.

Whether the tuna is bought in a store or canned at home, one danger you should be aware of is scombroid poison. This substance is produced in scombroid fishes when naturally occurring spoilage bacteria in the meat convert the amino acid histidine in the fish protein into a biologically active amine poison, saurine. The saurine is produced when fish are left in the sun or at room temperature for several hours.

The incidence of scombroid poisoning is rare and generally not fatal, but the poisoning resembles a severe allergy with such symptoms as headaches, dizziness, nausea, and vomiting. Tuna containing the toxin in such high quantities as to bring on illness is said to taste "sharp and peppery." The toxin is relatively heat-stable and not completely destroyed or inactivated during the canning process. In order to avoid scombroid poisoning, fish should be processed immediately after capture, and should be discarded if left in the sun for more than two hours.

In the past, some large tuna had higher levels of mercury than that allowed by the government, and consequently were rejected for consumption. However, in recent years, it has been demonstrated that the limit set by the government was too low, and the government has since increased it. Most tuna, except, perhaps, very large ones exceeding 250 pounds, fall into the acceptable range and can be consumed without the danger of mercury contamination.

VI-C: SPICED AND PICKLED SEAFOODS

Pickling with vinegar and spices is an ancient form of food preservation, going back to prehistoric times. Stevenson (1899) believes that it probably antedates even pickling with salt. It is mentioned frequently in the writings of the Greeks and Romans, as witnessed by the citations of Smidth (1873) and Radcliffe (1921) in their excellent accounts of the fisheries of the ancients. Certain of these fishery products prepared with vinegar and spices were considered great delicacies, selling at such high prices that they were reserved for the banquet tables of the rich. One dish popular in Spain and in Central and South America today is "escabeche". It is prepared by frying fish in oil with bay leaves and spices, then marinating in vinegar and oil. This dish can be traced directly to the Romans, who in turn had it from the Greeks.

Pickling with vinegar was used extensively down through the Middle Ages, especially for fish that were fat and did not cure well by the very crude salting methods of the time. While the pickled product did not keep so long, it was more appetizing than the dried and salted products of the period. Vinegar-pickled fish played a very important part in the food economy of the north European people down through the seventeenth century.

Brine-salted fish is often called "pickled", but this is a misnomer, if the name as applied to other food products is considered. Pickled foods are fermented in the process of manufacture with the formation of organic acids. If the amount of organic acids formed is not sufficient, more acid may be added in the form of vinegar; or vinegar may be used in the original cure instead of depending on the natural formation of acid. Therefore, only fish preserved with vinegar or vinegar and spices should be considered pickled.

Preservation Action of Ingredients

Vinegar differs from salt as a preservative agent in that it does not preserve by osmosis, extracting water from the food, but enters into chemical combination with the product, reducing or inhibiting bacterial activity. The spices used may also have some slight value as a preservative; in fact through the Middle Ages pepper and other spices were valued as preservatives rather than condiments. Foods of this period were often very highly spiced, and it is probable that spoilage was masked rather than inhibited. The preservative action of vinegar is probably due to the fact that the growth of spoilage molds are inhibited and that of bacteria greatly retarded, if the product has a low pH, that is, if the medium has an acid reaction. The active principle in vinegar is the acetic acid. According to Tressler (1923) an acid content of 15 percent is required to entirely prohibit bacterial action. Since commercial vinegars average 6 percent acetic acid content, and stronger vinegars reduced to this level are as low as 3 percent when used in food preservation, fish products pickled in vinegar are only temporarily preserved. However, vinegars containing 3 percent acetic acid will preserve fish for months if the product is held in chill storage.

Requirements for Ingredients

Fish used in the vinegar-spice cure must, of course, be of the best quality. Equally important, however, is the quality of the various accessory ingredients in obtaining a finished product of the highest grade. The flavor, texture, color, and to some extent, the keeping quality are affected by the water, salt, sugar, vinegar, spices, herbs, and other miscellaneous ingredients.

The water must be potable and approved under all sanitary and health codes. Pond or shallow-well water should not be used. "Hard" waters are unsuitable, especially those with a high iron, calcium, or magnesium content. If the water supply is hard, the water must be filtered or softened with a softener. Brines should be boiled and filtered before use.

The vinegar should be clear without foreign odors or flavors, and should have a guaranteed acetic-acid content. Cider or other fruit vinegars should not be used because their acid contents are extremely variable and the fruit esters in the vinegar might give the pickled fish an "off flavor". Distilled vinegar is recommended. Acetic acid diluted to the desired strength may be used. A 120 grain (2 1/2 percent) malt vinegar is favored by some commercial packers. Vinegar should be titrated regularly to determine whether it has the required acid content. Wine may be used as a flavoring agent, as in a spiced wine sauce added to the pickled fish, but wine or wine vinegar should not be used in the original pickle cure.

The quality of the salt is also important. A high grade of purity is required. European curers prefer a Liverpool fishery salt. The salt must be as free as possible from calcium and magnesium compounds, as these impurities give a bitter flavor to the cured product. A coarse, half-ground salt will pit the surface of the pickled fish. A finely ground cooking salt, guaranteed to contain less than one percent impurities and preferably mined, is recommended.

Experienced packers of spiced fish prefer a good grade of cane sugar. Some use is made of corn sugar but the quantity must be adjusted to the standard formula to obtain uniform results. It is not a completely satisfactory substitute at present.

Spices should be bought whole and on the basis of chemical and microscopic examination. Buying specifications should require that the spices be fresh and of a high grade of purity. Spices should not be purchased ground as they may be readily adulterated with other plant material. Mixtures of whole spices may be composed of old or inferior spices. As a rule the curer should buy fresh whole spices, singly, and make up his own mixture. Spices should not be held much more than a year.

Essential spice oils should meet the requirements of the United States Pharmacopoeia. Both spices and oils should be bought only from well-known, reputable firms specializing in these products. "Bargain" spices are usually ruinous to quality products.

Quick Pickling Procedure for Fish

Clean fish and soak in brine (2 1/2 pound salt per gallon of water) for 30 minutes. Cut fish into bite size chunks approximately 1" x 2".

Pickling Mixture:

1 1/2 quarts vinegar (5%) to 1 quart water	2 cloves garlic
1/2 cup salt	2 medium onions, sliced
1 teaspoon each of mustard seed, peppercorns, bay leaf and cloves	

Method I.

Pack fish into jars and cover with pickling mixture. Place in refrigerator at least one week. After 1-2 weeks, fish are ready to eat.

Method II - Alternate method.

Bring pickling mixture to a boil and add fish. Cook for 5 minutes and pack fish into jars, covering with boiling mixture. Cool, then store in refrigerator.

A different product will result from each method.

Herring

Herring is the most important pickled fish product. Some of the more common pickled-herring products are appetitsild, Bismarck herring, cut spiced herring, gabbelbissen, gaffelbiter, Kaiser Friedrich herring, potted herring, rollmops, Russian sardines, gewurz herring, delicatessild, sur-sild, and smorgaas-sild. The names indicate that most of the spiced herring products prepared in the United States are of foreign origin. The composition of the sauce is the principal point of difference among many of these products. Kaiser Friedrich herring, for instance, are Bismarck herring in mustard sauce, while rollmops are Bismarck-herring fillets rolled around a piece of dill pickle. Bismarck herring are boned, with sides still joined, and packed in vinegar and spices.

Spiced herring packed in the United States is prepared entirely from fish cured during the fishing season, held in storage, and made into spiced-herring products as the market requires. Herring may be specially cured for this purpose, although Scotch-cured or Labrador salt herring may be substituted. Herring not specially cured for spicing is reported to have a shorter period of preservation and to be darker in color, lacking in flavor, and tougher and more fibrous in texture.

One of the most common methods for home preparation of salt herring is to pickle it with vinegar and spices. At one time salt herring were used extensively for commercial vinegar-pickled herring, but such raw material is used today only when the stock of specially cured herring is exhausted or unavailable.

Most of the specially cured herring are prepared from alewives or river herring (*Pomolobus pseudoharengus*) in the Chesapeake Bay area. A variety of curing methods are used, of which the following is typical. The herring are cut or dressed as described in the salting of alewives. The cut herring are cleaned thoroughly with special attention to removal of the kidney, which is the dark streak along the backbone. The fish are rinsed in fresh water and placed in a curing tank where they are covered with a brine testing 80° to 90° by a salinometer, and containing 120-grain distilled vinegar amounting to an acidity of about 2.5 percent. The fish are left in this brine until the salt has struck through or completely penetrated the flesh. The fish, however, must be removed before the skin starts to wrinkle or lose color. The length of cure depends on the judgment of the curer and varies with the temperature, freshness, and size of the fish. The average length of cure is reported to be 5 days. Various sources give curing times varying from 3 to 7 days.

When the herring are sufficiently cured, they are packed in barrels. These barrels are often second-hand, previously used for soda fountain syrup. As a rule, no attempt is made to pack the herring in regular layers. They are simply shoveled in until the barrel will hold no more. The barrels are headed, filled with a salt-vinegar brine testing 70° salinometer, and shipped to marketing centers such as Chicago or New York for final manufacture. There the herring are repacked in kegs which are then filled with a solution of distilled vinegar diluted with water to a 3 percent acidity, and containing sufficient salt to test 35° salinometer. Before the fish are repacked, they may be cut into fillets or the backbone may be removed from the otherwise whole fish. The kegs are then put into cold storage at 34°F to be held until required.

The final process of manufacture begins by soaking the herring in a tank of cold water for 8 to 10 hours. They are then removed from the tank, drained, and placed in a solution of vinegar, salt, and water for 72 hours. The solution is made in the proportion of 1 gallon of 6 percent white distilled vinegar to 1 gallon of water and 1 pound of salt. The fish should be well covered with the solution. They are then made into cut spiced herring, rollmops, or Bismarck herring.

Cut Spiced Herring I

The vinegar-salt-cured herring are cut across the body in pieces 1 to 2 inches long. The sliced herring are then packed in 8-ounce tumblers or in 16- or 32-ounce glass jars, with whole mixed spices. The amount of spices added to each container is approximately one teaspoon to an 8-ounce tumbler, 2 teaspoons to a 16-ounce jar, and 1 tablespoon to a 32-ounce jar. A slice or two of onion, a slice of lemon or a strip of canned pimiento, and a bay leaf or two may be placed around the sides, depending on the preference of the individual packer. Each container is then filled with vinegar diluted to 2.5 percent acidity, containing 1/2 pound of sugar, 1/4 pound of salt, 10 drops oil of cloves, 10 drops oil of allspice, and 10 drops oil of cardamon per gallon of solution. The spice oils usually are added to the sugar before dissolving it in solution to distribute the spice flavor more evenly.

The amount and variety of spice flavors may be altered to suit the taste of the packer or his market. The formula given is typical but is not claimed to be standard. The jars are vacuum-sealed, wiped clean, labeled, and packed one or two dozen jars to the fiberboard carton. The length of preservation depends on the care in manufacture and the temperature of the storage. If held under refrigeration at 40°F, this product should remain in good condition for at least 6 months. Exposure to light causes the herring to deteriorate more rapidly even under refrigeration, as in a refrigerated show case.

Cut Spiced Herring II

The cut pieces of herring are packed in wooden tubs holding 10 or 20 pounds, or in kegs holding 100 pounds if they are to be repacked in individual glass containers. A few spices, a bay leaf or two, and several slices of onion are placed in the bottom of the container, then a layer of cut herring is placed, then another layer of spices and onion. This is repeated until the tub or keg is filled. The fish are covered with vinegar diluted with water in which the sugar is dissolved. The containers are then stored at 40°F to cure for 10 days. At the end of this time if the fish are to be repacked, they are removed from storage and packed in 8-, 16-, and 32-ounce glass jars. The vinegar used in curing may be strained and re-used, but some packers prefer to use fresh vinegar diluted to 3 percent acidity. A few of the spices, bay leaves, and a little chopped onion are placed in each jar.

The quantities given in the formula below are sufficient for 10 pounds of cleaned herring. Whole spices are used in all recipes, unless otherwise specified.

10 lb. salt herring	1/2 oz. cloves
2 oz. mustard seed	2 1/2 oz. sugar
1 oz. bay leaves	4 oz. onions, sliced
1 oz. allspice	2 qt. water
1 oz. black peppers	2 qt. vinegar (6 percent acidity)
1 oz. white peppers	1 oz. red (chili) peppers

There are other recipes for the preparation of cut spiced herring. Cut spiced herring in tubs usually go to delicatessen shops or other wholesale outlets.

Rollmops

The vinegar-cured fillets are wrapped around a piece of dill pickle or a pickled onion. The rolls are fastened with wooden toothpicks, cured several days in a spiced-vinegar sauce, then packed in glass containers, generally of the same sizes as those used for cut spiced herring. Anderson (1925) made a comprehensive study of the packing of rollmops. The formula given here is the one recommended by him:

10 lb. salt herring	1/16 oz. cracked cinnamon
4 oz. chopped onions	1/4 oz. mustard seed
2 1/2 oz. sugar	1/16 oz. cracked ginger
1/4 oz. whole cloves	1/16 oz. crushed cardamon
1/4 oz. chili peppers	2 qt. distilled vinegar (5 percent acidity)
1/8 oz. bay leaves	1/8 oz. whole white peppers
1/8 oz. whole black peppers	8 qt. dill pickles
1/4 oz. whole allspice	
1/16 oz. powdered nutmeg	

Put the bay leaves and chili peppers in a small cloth bag so they can be easily separated for later use. Place this bag together with the balance of the spices and 3/4 quart of vinegar into a covered receptacle. Bring to a boil and allow to simmer for 1 1/2 to 2 hours. Violent boiling causes loss of the volatile acetic acid. A simple way to avoid it is to put the spices in a common fruit jar and place in boiling water for 2 hours. Allow to stand 1 to 2 weeks after boiling to insure still greater extraction of the spicing materials. Remove the chili peppers and bay leaves which are to be used for decorative purposes. Strain the pickle through a cloth bag to remove the spices. Slightly less than three-fourths of a quart of pickle will be obtained.

Preparation of the fish: Remove heads and scale and wash. Split into two fillets and trim. Freshen two and one-half hours in running water, then drain. Ten pounds of medium size herring should give about 6 pounds drained weight.

Preliminary vinegar-cure: Pack the fillets skin down in a stone crock. Cover with one and one-fourth quarts of vinegar. If necessary, put a light weight on top to keep the fillets well covered. Allow to cure in a cool place for 40-48 hours. Remove and drain. The vinegar should now test about 2 percent acid and show a salinometer reading of about 30°. The fish has absorbed much of the acid and has lost some salt.

Packing: Cut each dill pickle lengthwise into four parts, then each of these across the center, making eight pieces in all.

Roll the fillets around a piece of pickle and fasten with a fresh clove. A clove serves the purpose just as well as a toothpick and adds to the attractiveness of the pack.

Place one teaspoonful of mixed, used spices on the bottom of the jar, then pack the fish. With a medium sized herring, three rolls will pack nicely into a No. 306 jar (six fluid ounces capacity), if placed on end. Decorate around the sides with a couple of chili peppers and a bay leaf. Add sufficient pickle to fill from 25 to 35 cc. (this is about equivalent to two level tablespoonfuls). The net weight should be five and one-half ounces or over. Seal the jars immediately after packing. Vacuum sealing is preferable.

Store in a cool place. Cold storage at about 35°F is advisable to insure longest preservation.

If vinegar-salt cured herring are used, the preparation and preliminary vinegar-cure steps are unnecessary. It is believed that a better product will be obtained if the vinegar-salt cured herring are used. Test packs, by the writer, of Anderson's formula indicate that the spice-vinegar sauce should be diluted to 3 percent acidity, that the rollmops should be cured in the spice sauce for 10 days, then repacked in jars with a few spices, and the jars should be filled with fresh 3-percent vinegar with 2 tablespoons sugar and 1 tablespoon salt to the quart. Store at 34° to 40°F.

Herring in Sour Cream Sauce

Mild-cure salt (Holland style) herring are filleted, and milts are saved for later use. The fillets are soaked in cold water for two hours. The milts are rubbed through a fine sieve. The fillets are drained of surplus moisture. The vinegar, wine, and spices are boiled together for a few minutes, then cooled. After removing the spices, the vinegar-wine mixture is stirred into the sour cream, sweet cream, and milts. The fillets are packed in a container with sliced onions, then covered with the sauce. They are allowed to marinate in a cool place one week. The fish are then packed in glass jars, which are then filled with the sauce.

- 1 gal. keg Holland style herring
- 1 pt. white wine, dry
- 1 pt. sour cream
- 1 pt. sweet cream
- 1/2 pt. distilled vinegar
- 1/2 oz. mixed spices
- 2 cups onions, sliced thin

Herring in Wine Sauce

Wine sauce formulas are similar to the standard spice sauce formulas for herring, except that the amount of vinegar is reduced one-half or three-fourths and wine is added. A dry white wine or burgundy-type red wine should be used. Sweet wines are not suitable. A sample wine sauce

- 1 qt. white wine
- 1 pt. white, distilled vinegar
- 4 oz. chopped onions
- 2 1/2 oz. sugar
- 1/4 oz. mustard seed
- 1/4 oz. whole cloves
- 1/4 oz. chili peppers
- 1/8 oz. whole black peppers
- 1/8 oz. whole white peppers
- 1/4 oz. whole allspice
- 1/16 oz. ground nutmeg
- 1/16 oz. cracked cinnamon
- 1/16 oz. cracked ginger
- 1/16 oz. crushed cardamon
- 1/8 oz. bay leaves

First the vinegar and wine are poured into a large, covered jar, and the onions, sugar, and spices are added. The jar is placed in a pan of boiling water for two hours, then allowed to stand overnight. The sauce is then strained to remove the spices.

If vinegar-salt cured herring are used, the herring fillets are cut into pieces of suitable size, rinsed in fresh water, drained, and packed in glass jars with a few fresh spices such as bay leaves, chili peppers, and a slice of lemon. The jars are filled with wine sauce and sealed. The amount of sauce above is enough for about 10 pounds of fish.

If ordinary salt herring are used, they are filleted and freshened in water. The drained fillets are packed in a stoneware crock, covered with 1 quart distilled vinegar of 3 percent acidity (for 10 lb. herring) and allowed to stand 48 hours. The fillets are then cut into cubes and packed in jars, which are filled with wine sauce.

Mackerel

Fillets: This formula, developed for mackerel, may be used for other fish as well. It has been obtained from German sources. Clean and wash the fish thoroughly, then cut into fillets, removing the backbone. Divide the fillets into 2-inch lengths and dredge in fine salt. Pick up the fillets with as much salt as will cling to the flesh and pack in a crock or tub. Let the fish stand for one to two hours, then rinse in fresh water. Cook the vinegar, water, and other ingredients slowly and gently for 10 minutes, counting from the moment the liquid begins to boil. Add the fish and cook slowly for 10 minutes longer, counting from the moment the liquid again begins to boil. Remove the fish and allow the pieces to drain, then pack them in sterilized jars, adding some chopped onion, a bay leaf, a few spices, and a slice of lemon to each jar. Strain the spice vinegar sauce and bring to a boil. Fill the containers with hot sauce and seal immediately. Store in a cool dry place.

10 lb. mackerel fillets	2 oz. sugar
2 qt. distilled vinegar	1 tbs. allspice
3 pt. water	1 tbs. cloves
2 cups chopped onion	1 tbs. black peppers
clove garlic, chopped	1 tbs. bay leaves
1 tbs. crushed nutmeg	

Pickled Eels

This dish is a favorite in northern Europe, from the British Isles to Sweden. Clean and skin the eels and cut them into pieces about 3/4 inch thick. Wash and drain the pieces, then dredge in fine salt and allow to stand from 30 minutes to 1 hour. Rinse off the salt, wipe the pieces dry, and rub them with a cut clove of garlic. Brush the eel pieces with melted butter and broil until both sides are lightly browned. As an alternative, pieces may be sauted in olive oil or other good vegetable oil. Place the pieces of cooked eel on absorbent paper. When the pieces are cool, pack them in layers in a crock with a scattering of sliced onion, allspice, bay leaves, mustard seed, whole cloves, peppers, and mace between the layers of fish. Weight the mixture down to keep it compressed. Cover the fish with a cold vinegar sauce made of vinegar, water, onions, and a few bay leaves cooked for 15 to 20 minutes. After standing for 48 hours in a cool place, pack the eels in glass tumblers with a thin slice of lemon, a bay leaf, a slice of onion, and a few fresh whole spices for decoration. Fill the tumblers with sauce used in curing, which has been filtered. Seal the containers immediately. Store in a cool, dry place. This article remains in good condition for a considerable period of time.

Oysters

In the eighteenth and nineteenth centuries, pickled oysters were prepared commercially over most of the Atlantic Coast area. According to Stevenson (1899), pickled oysters were consumed extensively around New York during the Christmas holidays. They are not nearly so popular now and are usually prepared only for special orders. Some pickled oysters are prepared in Virginia for local consumption. Various formulae are available, some from traditional colonial sources, others found in French or other continental cookbooks. Two typical formulae are given here:

Virginia Pickled Oysters I: Open one gallon of oysters, saving the liquor. Strain the liquor and add enough salted water to make 3 pints. Simmer the mixture gently over a low flame. When the liquor is near the boiling point, add the oysters a few at a time, cooking until the "fringe" curls. Remove the oysters from the liquor and set aside to cool. Make a sauce of vinegar, white wine, bay leaves, onion, garlic, parsley, fennel, thyme, cloves, black pepper, allspice, cinnamon, and mace. Add this sauce to the oyster liquor and simmer 30 to 45 minutes. When it is cool, pack the oysters in glass jars with a bay leaf, a slice of lemon, and a few fresh spices in each jar. Strain the liquor and, when it is cool, pour it into jars, seal immediately, and store in a cool, dark place. The oysters are ready for use in 10 to 14 days.

- 1 gal. shucked oysters
- 3 pt. oyster liquor
- 1 pt. distilled vinegar
- 1 pt. dry white wine
- 2 tbs. ground onion
- 2 cloves garlic, crushed
- 1 tbs. chopped parsley stems
- 2 tbs. crushed bay leaves
- 1 tbs. crushed fennel
- 1 tbs. crushed allspice
- 1 tbs. crushed black peppers
- 1 tbs. crushed cloves
- 1 tbs. crushed stick cinnamon
- 1/4 tbs. crushed mace
- 1/4 tbs. crushed thyme

Pickled Oysters II: Blanch one gallon of freshly opened oysters until the fringe curls. Remove the oysters and set them out to cool. Bring the liquor used in blanching to the boiling point, then set aside to cool. At the same time cook the vinegar and spices together slowly, then strain out the pieces. Combine the oyster liquor and spiced vinegar. Pack the oysters in glass tumblers with a bay leaf and a thin slice of lemon in each. When the sauce is cool, strain it and pour over oysters until the containers are filled. Seal the tumblers immediately and store in a cool, dark place.

- 1 gal. shucked oysters
- 2 qt. oyster liquor
- 1 qt. vinegar
- 1/2 oz. whole cloves
- 1/2 oz. whole allspice
- 1/2 oz. whole black peppers
- 1 blade mace

Mussels

This formula may also be used in pickling clams and oysters. Scrub the shells well and steam just enough to open the shells. Save the liquor or nectar. Remove the meats from the shells, cutting out the byssus or beard. Cool meats and nectar separately. When cool, pack the meats in sterilized glass jars with a bay leaf or two, a few whole cloves, and a thin slice of lemon to each jar.

Strain the liquor obtained in steaming the shellfish. To each quart of liquor add one-half pint distilled vinegar, one-half tablespoon each of allspice, cloves, and red peppers, with one-quarter teaspoon of cracked whole mace. Some recipes call for white wine or wine vinegar instead of distilled vinegar. The amount of wine or vinegar is a matter of personal taste. Simmer for 45 minutes. When the sauce is cool, pour into the jars, and seal. Store in a cool, dark place. This product will be ready for use in about two weeks. Pickled mussels and oysters turn dark if exposed to the light.

Shrimp

Pickled shrimp is a regional speciality of the New Orleans area but is sold in fish markets from Key West to Washington, D.C. There are no standard recipes but those given here are believed to be typical.

Pickled or Spiced Shrimp Formula I: Peel the green shrimp and wash them well. Make a brine of 1 gallon water, 1/2 cup salt, 1 pint distilled vinegar, 1 tablespoon red peppers, 1/2 tablespoon cloves, 1/2 tablespoon allspice, 1/2 tablespoon mustard seed, and 6 bay leaves. Simmer the brine slowly for a half hour, then bring to a boil, and add the shrimp. After 5 minutes, counting from the time the brine again begins to boil, remove the shrimp from the brine and allow to cool. Pack in sterilized jars with a bay leaf, a few fresh spices, and a slice of lemon in each jar. Fill the jars with a solution made in the proportions of 2 pints of water, 1 pint of 5 percent distilled vinegar, and 1 tablespoon sugar. Seal the jars tightly and store in a cool, dark place. These pickled shrimp keep longer than those prepared by the second method which, however, requires less labor and is cheaper.

Pickled or Spiced Shrimp Formula II: Take 5 pounds of fresh, green headless shrimp. Wash them well but do not remove the shells. Put celery tops, salt, parsley, thyme, bay leaves, vinegar, and spices into the water. When this has boiled about 45 minutes, add the shrimp. Let boil 10 minutes, then set the pot aside and allow the shrimp to cool in the liquor. Drain and pack in small cartons with some of the spices. This product remains in good condition only a very short time unless held under refrigeration.

5 lb. shrimp	1 tbs. allspice
1 gal. water	1 tbs. bay leaves
1 pt. distilled vinegar	1 tbs. red (chili) peppers
2 cups salt	1 tbs. black peppers
1 bunch celery tops	1/2 tbs. cloves
1 small bunch parsley	1 blade mace

REFERENCES

Anderson, Clarence L. 1925. Preserved pickled herring. University of Washington Publication in Fisheries, vol. 1, no. 1, p. 1-64.

Hoffman, Herbert. n.d. Lehrbuch der Fischverwertung fur die Fischindustrie. (Eighth revised edition, Lehrbuch der Fischbereitung. Wilhelm Dunker.) 197 p. Stettin.

Jacobsen, Eduard. 1926. Handbuch fur die Konserven Industrie, Donserven Favriken und den Donserven Grossbetreib. Bd. 2, 1459 p. Paul Parey, Berlin.

Jarvis, Norman D. 1943. Home preservation of fishery products. Salting, smoking, and other methods of curing fish at home. U.S. Department of the Interior, Fish and Wildlife Service, Fishery Leaflet 18, 26 p.

Radcliff, William. 1921. Fishing from the earliest times. 478 p. William Clowes and Sons, Ltd., London.

Smidth, J. K. 1876. Historical observations on the condition of the fisheries among the ancient Greeks and Romans, and on their mode of salting and pickling fish. United States Commission of Fish and Fisheries, Report of the Commissioner for 1873-4 and 1874-5, Part III, App. A, P. 3-20.

Stevenson, Charles H. 1899. The preservation of fishery products for fish. U.S. Commission of Fish and Fisheries, U.S. Fish Commission Bulletin for 1898, p. 335-563.

Tressler, Donald K. 1923. Marine products of commerce. 762 p. Reinhold Publishing Corporation, New York.

The next time you come home with a sizable catch of fish, you might want to preserve them in an entirely different manner. You probably never considered salting fish, but the procedure is simple and easy. Our earliest records of food preservation practices include using salt for preserving fish. Salt has long been used both as the primary preserving ingredient and in combination with other methods such as drying and smoking.

In recent years, salting as a technique for preserving fish has become less popular because of development of quick freezing preservation methods. Frozen fish have much the same flavor as fresh fish, while salted fish have a distinct flavor derived from the salting process.

Salting is usually done by one of two methods; brine salting or dry salting. In the brine salting process, the fish are salted and layered in a container and held in the brine liquor that seeps from the salted fish. In the dry salting method, the brine liquor that escapes from the fish is allowed to drain away. Although commercial salting of fish has declined significantly in this country, a small quantity of fish is still salted. Most of it is exported to the Caribbean, South America, and southern Europe.

Why Salt Slows Down Spoilage

Common salt or sodium chloride, if present in sufficient quantities, will slow down the processes that occur in fish during spoilage. Spoilage is brought about by two causes: (1) autolysis, the deterioration of the bodily tissues after death by enzymes which are part of the biological makeup of the fish; (2) deterioration due to bacteria already present in the fish, which grow rapidly under favorable conditions and produce enzymes which break down the fish tissues. Usually the quantity of bacteria in the body of a fish is small, but more bacteria are often introduced through handling, cleaning, washing, etc. Most of the enzymes and bacteria are destroyed or rendered inactive in a concentrated solution of salt.

As salt is being absorbed into the fish, the bacteria and the enzymes are still active, and their growth and activity continues until a certain level of salt concentration is reached. At that level, bacterial growth and activity are arrested and spoilage prevented. The presence of more than 6 percent salt in solution in the tissue of the fish retards both autolytic and bacterial decomposition. If the uptake of salt is slow, the fish can become spoiled before this level is reached.

Factors Affecting Salting Process

Several factors affect the rate of salt absorption into the fish. These include; (1) the purity of the salt; (2) the thickness of the fish; (3) freshness and fat content of the fish; (4) the temperature; and (5) the care and cleaniness exercised in handling the fish.

(1) If a solution of pure sodium chloride is used, fish do not acquire the bitter taste commonly associated with salted fish; but they become soggy and yellow. Fish salted with pure sodium chloride are most like fresh fish when freshened (soaked with water before preparing), but most commercially salted fish are prepared in salt containing such impurities as calcium and magnesium salts and sulfates. These impurities give the fish a firmer white flesh which has proved to be more marketable. They also give the fish a sharp bitter taste characteristically associated with salted fish.

If these impurities are present in sufficient quantities, the fish may spoil because the absorption of salt is inhibited.

(2) The thickness of the flesh of the fish can also affect the penetration of salt. If fish are salted whole or round (beheaded and eviscerated), the enzymes contained in the fish's body may cause the fish to spoil before salt is taken into the flesh in sufficient quantities to arrest spoilage. Since most of the enzymes causing autolysis are in

the blood and organs of the fish, whole fish are more susceptible to spoilage. Eviscerated fish should be thoroughly cleaned to minimize possible spoilage.

(3) Likewise, if the fish is not fresh when it is salted, the enzymes and bacteria may have caused the flesh to deteriorate to such a degree that the rate of salt absorption is slower than the decomposition of the fish.

The fat content in fish significantly affects the salting process. Fatty fish do not absorb salt as readily as lean fish, and bacterial growth may not be slowed quickly enough to prevent spoilage.

(4) Spoilage can also be enhanced or retarded by the temperature during salting. At very high temperatures, bacterial growth may be so rapid that the fish become spoiled before they absorb enough salt. Even after fish are salted, they deteriorate much more rapidly at high temperatures than at cool ones. Heavily cured fish (those which were cured in a concentrated solution) may be preserved at high temperatures for only a few days but can be held at lower temperatures much longer.

(5) If the fish are not handled and stored properly under sanitary conditions, the bacterial count of the fish during the salting process may be quite high. Also rough handling can tear and bruise the flesh of the fish and consequently shorten the amount of time the fish can be held before spoilage occurs.

Changes Due to Salt Absorption

Salt preserves fish by extracting water from the tissues and replacing it with salt. This absorption occurs until the concentration of salt in the fish tissues is the same as the concentration in the solution surrounding the fish, or until it reaches an upper limit of about 20 percent. Once the concentration of salt in the fish rises above 9 percent, irreversible changes take place in the muscle proteins. At this point, the fish is said to be "struck through". The inner flesh loses much of its translucent appearance and stickiness.

Select Fish Carefully

Before beginning the salting process, it is important to understand the characteristics of the fish you wish to salt. The fish with a high fat content should probably be salted by the brine method rather than the dry-salting method, since the brine method gives a more consistent distribution of salt. Fatty fish do not absorb salt as readily and are more likely to spoil.

Once the fish are salted, fat tissues are susceptible to rancidity due to oxidation, so fatty fish need to be kept in cold storage or in a manner that prevents them from oxidizing. Such handling is more successful (or easier) with the brine method.

It is difficult to classify fish accurately based upon fat content which varies considerably from one fish to another within the same species. Also, the statistics are based upon a relatively small number of samples. The following lists can serve as a general guide.

Fish have been categorized as lean if the percentage of fat is less than 2.5 percent, moderate if between 2.5 percent and 6.5 percent, and fat if over 6.5 percent. Exceptions for species within a common name have been noted.

Fat Content of Fish

Some FAT fish are: Atlantic herring, Atlantic mackerel, butterfish, chinook salmon, freshwater eels, lake trout, Pacific herring, rainbow trout, sablefish, shad, sockeye salmon, and whitefish.

Some MODERATELY FAT fish are: albacore, bluefin tuna, bluefish, brook trout, carp (*Barbus*), carp (*Cyprinus*), chub, chum salmon, coho salmon, conger eels, Dolly Varden trout, Indian carp, lake herring, mackerel (*Auxis*), mackerel (*Scomber*), mackerel (*Scombermorus*), mullet, Pacific mackerel, pink salmon, sardines, scup, smelt, and swordfish.

Some LEAN fish are: bigeye tuna, carp (*Cirrhina*), cod, croaker, fimbriated herring, flounder, grouper, haddock, hake, halibut, Indian mackerel, perch, pike, pollock, pompano or permi, porgies, rockfish, snake eels, snapper, soles, whiting, and yellowfin tuna.

Salt Purity is Important

For salting, use the purest salt with the finest grain available. Salt which is virtually chemically pure (less than 1 percent impurities) results in fish with a milder, more pleasant flavor, which do not need prolonged freshening. The finer the salt, the more rapidly the brine forms, thus the more rapidly the flesh is penetrated with salt. Standard curing salt is available from salt companies, butcher supply firms, and, often, rural feed stores.

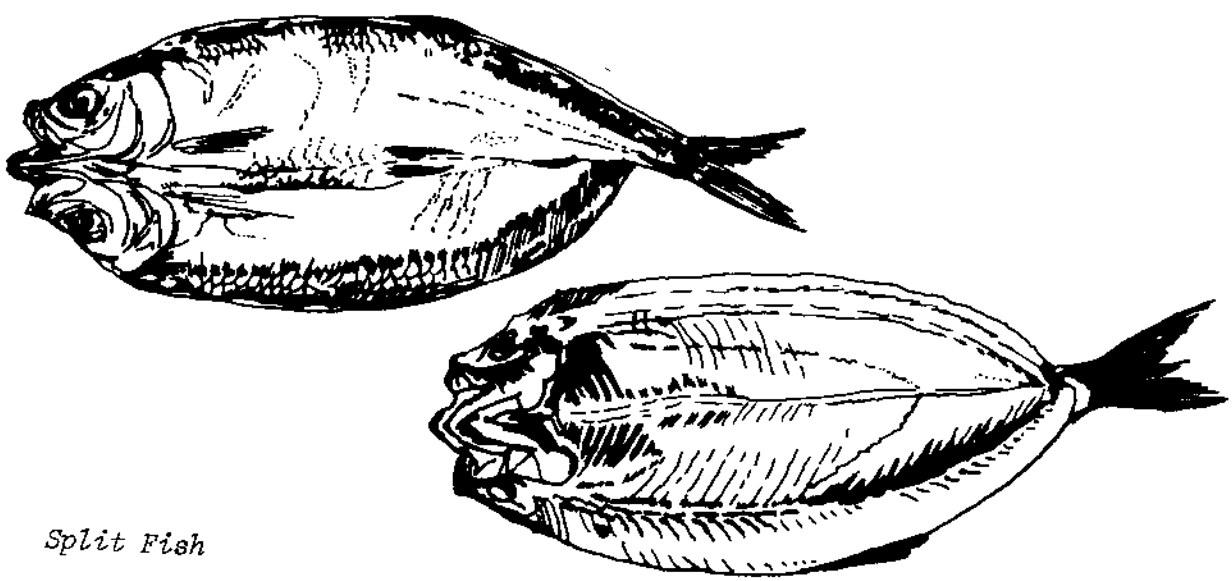
For home preparation, the brine method or gaspe is becoming more popular.

The Heavy Cure Method

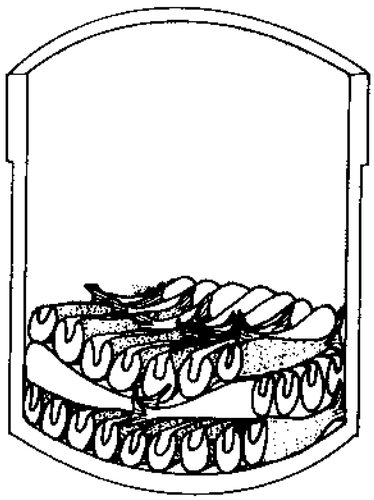
Most small or medium sized fish are prepared for brining in the same manner: they are scaled, beheaded, eviscerated, and split along the backbone. To facilitate penetration by the brine, the fish can be scored at 1-2 inch intervals along the length. When scoring the flesh, the skin should not be cut. Large fish can be filleted and thick-skinned; spiny or large-scaled fish should be skinned before brining.

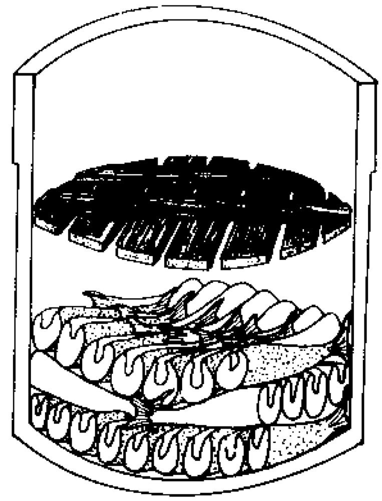
The prepared fish should be washed thoroughly in fresh water and then soaked in a brine of 1/2 cup of salt in one gallon of water for 30-60 minutes. This will draw any blood from the fish and cut any remaining skin slime.

After the fish are drained for 5-10 minutes, they should be dredged (or coated) with salt. The fish are now ready to be placed in the container in layers.



Split Fish





A good container for brining is a stoneware crock. Put a layer of salt in the bottom, then a layer of fish skin side down (or backs down if whole). Add a thin layer of salt and another layer of fish at right angles to the preceding layer. Do not let the fish in a single layer overlap any more than is necessary. Stagger the layers so that the fish are distributed as evenly as possible. Place the top layer of the fish skin side up (or backs up) and add a generous amount of salt.

The amount of salt used for the entire salting should be between a quarter to a third the weight of the fish. This amount is dependent upon the purity of the salt, the size of the grain, the temperature (warm weather requires more salt), and the size and fat content of the fish.

Put a loose wooden cover on the top layer and a weight on top of that to compress the fish and force out the brine. Small fish will generally be completely brined in about 48 hours, while larger, fatter fish may take 10-14 days.

When brining is completed, scrub the fish in a fresh full-brine solution (one quart of salt for each gallon of water) with a stiff brush. Then repack in the crock, with a light sprinkling of salt between layers. Make sure the layers are well pressed.

Fill the crock with a fresh full-brine solution and store in a cool, dark place. The fish will keep like this for about 9 months, if the brine is closely watched. At any sign of fermentation, the fish should be washed and repacked.

Light Cure

The procedure for a light cure is the same, but it can be used only for fresh (less than 48 hours old), lean fish and only in cool temperatures. The amount of salt used for a light cure or gaspe is generally in the proportion of 1 to 10. This may vary, as in a heavy cure, depending on the temperature, the type of fish, and other factors. After the fish are cured, they should be removed from the brine, put in a container, and stored in the refrigerator. They can be kept chilled for a short period of time or they may be dried and chilled.

Light-cured fish are yellow when removed from the brine; when dried, they have amber-colored translucent flesh and taste somewhat like cheese. Light-cured fish cannot be kept nearly as long as heavily cured fish.

Curing Herring

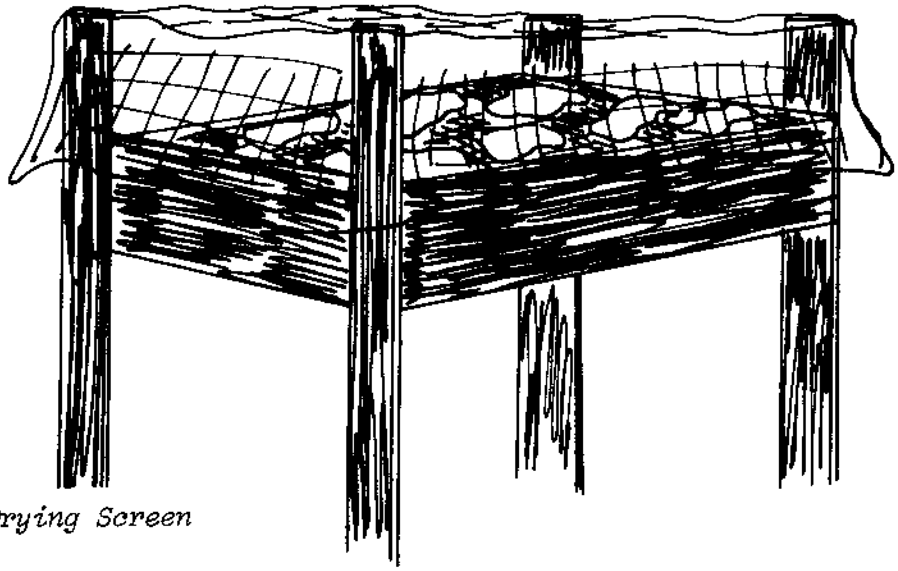
Herring are handled differently. They should be brined immediately after being caught (not held on ice). They can be brined whole, gibbed, or thoroughly cleaned.

Traditionally they are gibbed. In this process, the herring is held with its back to the palm, the head between the thumb and forefinger, leaving the throat clear. A short bladed knife is inserted under the gill cover. With the edge of the blade toward the stomach, a sharp twist upward and outward removes the throat, pectoral fins, gills, and main gut in one operation. Since the strong taste associated with whole or gibbed fish has become less popular today, it is preferable to clean the fish thoroughly, removing all the viscera and the head.

Thoroughly scrub the herring in a brine solution to remove scales and leach out the blood, then drain. Layer the herring in the crock with their backs down, except the top layer which should be backs up. The brine solution of the herring should be replaced every two months.

Dry Salting

The dry-salting process requires more care and effort than the brine method. And though fish (particularly fat fish) are more likely to spoil during the dry-salting process once the fish are "struck through", drying decreases the likelihood of spoilage. This is the traditional



Drying Screen

method for curing cod in the New England area and North Atlantic. Dry-salted cod, cusk, haddock, and mackerel can be bought in many parts of the country in wooden boxes or tubs.

Fish to be dry-salted should be bled immediately when caught. Cut the throat and remove the gills, and ice the fish; when ready to salt, clean the fish and cut it along the backbone so the flesh lies flat. Clean the fish thoroughly, inside and out, removing all traces of black skin, blood, etc. Wash in a brine of one cup of salt for each gallon of water. Scrub the fish to be sure it's clean and then drain well. Remove as much moisture as possible.

Using the finest salt available, dredge the fish in salt. Put a layer of salt in the bottom of the container to be used. The container should drain well, to allow the brine to flow away from the fish and not remain trapped in the bottom. The fish should be placed skin side down with salt spread between each layer of fish. The top layer should be placed skin side up and then thoroughly salted. The usual proportion of salt is 25-33 percent of the weight of the fish. More or less may be needed depending upon the temperature, the salt used, and the condition of the fish. A top with a weight on it can facilitate the flow of brine from the fish.

Usually the fish should be left for about 48 hours to a week, depending upon the humidity and the temperature. Under warm and dry conditions, the time could be shorter.

Once the fish are "struck through" they should be removed from the salt and scrubbed well with a brine solution so that no salt remains on the surface. Drain the fish well. They are now ready to be dried.

Drying should be done in the shade (sunlight will discolor the fish) in an area with free-flowing air circulation. A hardware-cloth screen raised on legs a few feet off the ground can be used. The fish should be placed skinside down on the screen. Prop cheesecloth over the fish so flies do not spoil them. They should be turned several times the first day.

The screens must be brought indoors at night for the moisture could allow mold to grow on the fish. If the weather turns bad and the fish can't be taken outside, the fish should be salted lightly. This salt should be brushed off when they are again put out of doors.

Rapid drying produces a superior product with a clear colored flesh. The best way to tell when the fish have dried sufficiently is to pinch the thick section of the flesh. If your fingers don't leave an impression, the fish are ready for packing.

Dry salted fish are usually wrapped in wax paper and packed in wooden boxes or tubs. If these are unavailable at home, you can wrap the fish and place them in the freezer. Even in wooden containers with airtight lids, they should be kept in a cool, dry place.

For the majority of recipes, dry salted fish should be freshened by soaking in fresh water from one half hour to twelve hours before preparing. Salted fish which have been freshened can be used in nearly any standard recipe calling for fish or fillets.

VI-E: TIPS FOR COOKING AND SERVING

How To Cook Fish

Fish are delicious -- if cooked properly. We cook fish to develop their flavor, to soften the small amount of connective tissue present, and to make the protein easier to digest. Cooking fish at too high a temperature or for too long a time toughens them, dries them out, and destroys their fine flavor.

How can you tell when fish are cooked? Raw fish have a watery, translucent look. During the cooking process the watery juices become milky colored, giving the flesh an opaque, whitish tint. This color change is unmistakable. When the flesh has taken on this opaque whitish tint to the center of the thickest part, fish are completely cooked. At this point the flesh will easily separate into flakes, and if there are bones present, the flesh will come away from them readily.

Most cooked fish tend to break up easily, so handle fish as little and as gently as possible during and after cooking to preserve their appearance.

Baking: Baking is a form of dry heat cooking and is one of the easiest ways to cook fish. But "bake fish easy" is the most important guide to follow in fish cookery. Fish like a preheated, moderate oven set at 350°F for a relatively short period of time. This keeps the moistness and flavor in the fish, prevents drying, and keeps the fish tender and palatable. Fish not baked in a sauce or with a topping are basted with melted fat or oil to keep the surface moist.

Can fish be baked from the frozen state? Yes, provided the cooking time is increased to allow for thawing during the baking process and provided the recipe does not call for special handling such as stuffing or rolling.

Broiling: Broiling, like baking, is a dry heat method of cookery but in broiling the heat is direct, intense, and comes from only one source. Thin foods tend to dry out under the broiler, so when planning to use this method, choose pan-dressed fish, fillets, or steaks which are about 1 inch thick in preference to the thinner ones. If frozen, the fish should be thawed. Baste fish well with melted fat or oil or a basting sauce before placing them under the broiler. Baste again while broiling to keep the fish moist.

Follow the range manufacturer's directions for the operation of the broiler and preheating. The length of time it takes to broil fish depends on the thickness and the distance they are placed from the heat. As a general guide, have the surface of the fish about 3 to 4 inches from the source of heat and place thicker cuts farther from the heat than thin ones.

Cooking time will usually range from 10 to 15 minutes to reach the "fish flake easily" stage. As a rule, the fish do not need to be turned because the heat of the pan will cook the underside adequately. Turn the thicker pieces, such as pan-dressed fish, when half the allotted cooking time is up. Baste again with fat or sauce. Always serve broiled fish sizzling hot.

Charcoal Broiling: Charcoal broiling is a dry heat method of cooking over hot coals and in recent years has become a popular form of recreation. Fish, because they cook so quickly, are a natural for this method of cookery.

Pan-dressed fish, fillets, and steaks are all suitable for charcoal broiling. If frozen, the fish should be thawed in advance. Because fish flake easily as their cooking nears completion, use of a well-greased, long-handled, hinged wire grill is recommended.

Since charcoal broiling is a dry heat cooking method, thicker cuts of fish are preferable as they tend to dry out less during the process than thin ones. Also, baste the fish generously with a sauce that contains some fat before and while cooking to keep the fish juicy and flavorful.

Fish are usually cooked about 4 inches from moderately hot coals for 10 to 20 minutes, depending on the thickenss of the fish.

Smoking (for flavor only): Smoking fish for flavor is a simple technique that requires a minimum of effort and equipment, and the fish smoked in this manner can be used in various recipes from appetizers to salads and casseroles. It is not a method of preserving fish, however. Items needed for smoking are a hooded or covered grill, (either gas, electric, or charcoal), briquets, one pound of hickory or other hardwood chips (if a charcoal grill is to be used), water, salt, oil, and fish. The best smoked fish is produced from "fat" fish like bluefish, mullet, mackerel, herring, and shad to name a few; however, other species can be used.

A. Soak the chips in two quarts of water until the fire is ready (or at least as long as the fish marinate).
B. Marinate the fish in a brine of one cup of salt dissolved in one gallon of water for the length of time in the table below.
C. Start the fire using fewer briquets than for an average broiling fire. Adjust the temperature on gas or electric grills according to the table. When the coals have burned to a red color, spread evenly over the bottom of the grill.
D. Cover the charcoal with one third of the wet chips. This not only produces the smoke but also lowers the temperature of the fire.
E. Grease the grill generously and keep oil handy for basting.
F. Drain and dry the fish and place it on the grill skin side down.
G. Baste the fish at the start and as needed during cooking to prevent the fish from drying out.
H. Cover the grill with the hood.
I. Smoke the fish for the amount of time indicated in the table below.
J. Add the remainder of the chips as they are needed to produce smoke.
K. Fish are done when they turn a golden brown and flake easily when tested with a fork.

TIMETABLE FOR SMOKING FISH

Size and Shape	How Long to Marinate in Brine	Cook at (°F)	How Long
Fillets or steaks (1/2 inch thick)	30 min	150°-175°	1 hr
		200°	30 min
		250°	20 min
Fillets or steaks (3/4 inch thick)	45 min	150-175°	1 hr + 30 min
		200°	30-45 min
		250°	30 min
Fillets or steaks (1 1/2 inch thick)	1 hr	150-175°	2 hr
		200°	1 hr + 15 min
		250°	45-50 min

Frying: Frying is a method of cooking food in fat. For frying, choose a fat that may be heated to a high temperature without danger of smoking. This is necessary because a smoking fat begins to decompose and will give the food an unpleasant flavor. Vegetable oils and fats are preferable to fats of animal origin.

The temperature of the fat is extremely important. Too high heat will brown the outside of the fish before the centers are cooked. Too low heat will give a pale, greasy, and fat-soaked product. The most satisfactory frying temperature for fish is 350°F.

Frozen fish must be thawed before frying. Separate the pieces and cut to uniform size.

After frying, drain the fish immediately on absorbent paper to remove excess fat. Keep the fish warm in a low oven until all pieces are cooked, then serve immediately.

Deep-fat frying: Deep fat frying is a term applied to cooking in a deep layer of fat. It is a quick method of cooking and is an excellent way to cook tender foods and precooked foods.

For deep-fat frying you need a heavy, deep saucepan or French fryer with straight sides, a fry basket to fit the fryer, a deep-fat frying thermometer, or an electric fryer with automatic temperature control.

Use enough fat to float the fish but do not fill the fryer more than half full. You must allow room for the fish and for the bubbling fat.

The fish may be dipped in a liquid and coated with a breading, or dipped in batter. The coating will keep the fish moist during frying and will give them a delicious crispness.

Place only one layer of fish at a time in the fry basket and allow enough room so that the pieces do not touch. This prevents the temperature of the fat from dropping suddenly and assures thorough cooking and even browning. When the fat has heated to the proper temperature, lower the basket into the fryer slowly to prevent excessive bubbling. If the fat is at the right temperature when the fish are added, a crust forms almost immediately, holding in the juices and at the same time preventing the fat from soaking in. Fry until the fish are golden brown and flake easily, usually about 3 to 5 minutes.

Oven-frying: Oven-frying is not actually a true frying method but a hot oven method. Oven-fried fish resembles fried fish. This method of cooking fish was developed by Evelene Spencer, a former Bureau Home Economist, and is sometimes referred to as the Spencer method.

For oven-frying, the fish are cut into serving-size portions, dipped in salted milk, and coated with toasted, fine, dry crumbs. The fish are then placed on a shallow, well greased baking pan. A little melted fat or oil is poured over the fish, which are baked in an extremely hot oven (550°F). Nice features of oven-frying are that the fish don't require turning, basting, or careful watching, and that the cooking time is short, usually 10 to 15 minutes. The crumb coating and the high temperature prevent flavorful juices from escaping and give an attractive, brown crust.

Pan-frying: Pan-frying is a term applied to cooking in a small amount of fat in a frying pan. Of all the ways of cooking fish, pan-frying is probably the most frequently used -- and most frequently abused -- method. When well controlled, it is an excellent way of cooking pan-dressed fish, fillets, and steaks.

The general procedure is to dip the fish in a liquid and then coat them with a breading. Heat about 1/8 inch of fat in the bottom of a heavy frying pan. For pans with a temperature control, the right temperature is 350°F. Place one layer of breaded fish in the hot fat, taking care not to overload the pan and thus cool the fat. Fry until brown on one side, then turn and brown the other side. Cooking time will vary with the thickness of the fish. In general, allow about 8 to 10 minutes.

Poaching: Poaching is a method of cooking in a simmering liquid. In poaching, the fish are placed in a single layer in a shallow, wide pan, such as a large frying pan, and covered lightly with liquid. The liquid used in poaching may be lightly salted water, water seasoned with spices and herbs, milk, or a mixture of white wine and water, to name just a few. As with other methods of fish cookery, it is important not to overcook the fish. Simmer the fish in the liquid in a covered pan just until the fish flakes easily, usually 5 to 10 minutes. Because the poaching liquid contains flavorful juices, the liquid is often reduced and thickened to make a sauce for the fish.

Poaching is a favorite method of cooking fish -- and with good reason. As an entree, poached fish can be served simply with a sauce or used as the main ingredient of a casserole or other combination dish. Chilled and flaked, poached fish makes a delicious salad.

Steaming: Steaming is a method of cooking fish by means of the steam generated from boiling water. When cooked over moisture in a tightly covered pan, the fish retain their natural juices and flavors. A steam cooker is ideal, but any deep pan with a tight cover is satisfactory. If a steaming rack is not available, anything may be used that prevents the fish from touching the water. The water used for steaming may be plain, or seasoned with various spices, herbs, or wine. When the water boils rapidly, the fish are placed on the rack, the pan is covered tightly, and the fish are steamed for 5 to 10 minutes or until they flake easily when tested with a fork. Steamed fish may be served in the same way as poached fish.

TIMETABLE FOR COOKING FISH

METHOD OF COOKING	MARKET FORM	AMOUNT FOR 6	COOKING TEMPERATURE	APPROXIMATE COOKING TIME [minutes]
Baking	Dressed	3 pounds	350° F.	45 to 60
	Pan-dressed	3 pounds	350° F.	25 to 30
	Fillets or steaks	2 pounds	350° F.	20 to 25
	Frozen fried fish portions	12 portions (2½ to 3 ounces each)	400° F.	15 to 20
	Frozen fried fish sticks	24 sticks (¾ to 1¼ ounces each)	400° F.	15 to 20
Broiling	Pan-dressed	3 pounds		10 to 16 (turning once)
	Fillets or steaks	2 pounds		10 to 15
	Frozen fried fish portions	12 portions (2½ to 3 ounces each)		10 to 15
	Frozen fried fish sticks	24 sticks (¾ to 1¼ ounces each)		10 to 15
Charcoal Broiling	Pan-dressed	3 pounds	Moderate	10 to 16 (turning once)
	Fillets or steaks	2 pounds	Moderate	10 to 16 (turning once)
	Frozen fried fish portions	12 portions (2½ to 3 ounces each)	Moderate	8 to 10 (turning once)
	Frozen fried fish sticks	24 sticks (¾ to 1¼ ounces each)	Moderate	8 to 10 (turning once)
Deep-Fat Frying	Pan-dressed	3 pounds	350° F.	3 to 5
	Fillets or steaks	2 pounds	350° F.	3 to 5
	Frozen raw breaded fish portions	12 portions (2½ to 3 ounces each)	350° F.	3 to 5
Oven-Frying	Pan-dressed	3 pounds	500° F.	15 to 20
	Fillets or steaks	2 pounds	500° F.	10 to 15
Pan-Frying	Pan-dressed	3 pounds	Moderate	8 to 10 (turning once)
	Fillets or steaks	2 pounds	Moderate	8 to 10 (turning once)
	Frozen raw breaded or frozen fried fish portions	12 portions (2½ to 3 ounces each)	Moderate	8 to 10 (turning once)
	Frozen fried fish sticks	24 sticks (¾ to 1¼ ounces each)		8 to 10 (turning once)
Poaching	Fillets or steaks	2 pounds	Simmer	5 to 10
Steaming	Fillets or steaks	1½ pounds	Boil	5 to 10

VI-F: BASIC SHELLFISH RECIPES

Boiled Blue Crabs

24 live, hard-shell, blue crabs
6 quarts boiling water
1/3 cup salt

Place crabs in boiling water. Cover and return to boiling point. Simmer for 15 minutes. Drain. Serve hot or cold. Serves 6.

Fried Soft-Shell Blue Crabs

12 soft-shell blue crabs
1/4 cup milk
3/4 cup flour
2 eggs, beaten
2 teaspoons salt
3/4 cup dry bread crumbs

Dress crabs by cutting off the face just back of the eyes. Remove the apron; remove the spongy parts (the gills, stomach, and intestines) under the points of the body covering. Rinse in cold water; drain. Combine egg, milk, and salt. Combine flour and crumbs. Dip crabs in egg mixture and roll in flour-and-crumb mixture.

Pan-Fried: Place crabs in a heavy frying pan which contains about 1/8 inch of fat, hot but not smoking. Fry at moderate heat. When crabs are brown on one side, turn carefully and brown the other side. Cooking time approximately 8 to 10 minutes. Drain on absorbent paper. Serves 6.

Deep-Fat Fried: Fry in a basket in deep fat, 375°F for 3 to 4 minutes or until brown. Drain on absorbent paper. Serves 6.

NOTE: A commercial breading may be used. Follow the directions on the package.

Baked Crab Meat in Shells

- 1 pound crab meat
- 1/4 cup butter or other fat, melted
- 1/2 cup milk
- 1/2 teaspoon salt
- 1/4 cup grated cheese
- 1/2 cup chopped onion
- 2 tablespoons flour
- 1/2 cup tomato sauce
- Dash pepper
- 1/2 cup soft bread crumbs

Remove any shell or cartilage from crab meat. Cook onion in butter until tender. Blend in flour. Add milk gradually and cook until thick, stirring constantly. Add tomato sauce, seasonings, and crab meat. Place in 6 well-greased, individual shells or 5-ounce custard cups. Combine cheese and crumbs; sprinkle over top of each shell. Bake in a moderate oven, 350°F for 20 to 25 minutes or until brown. Serves 6.

Stuffed Crab (Brennan's)

- 1 medium-sized onion, chopped fine
- 1/2 cup shallots (green onions) chopped fine
- 1 stick butter
- 2 cups coarse bread crumbs, dampened with oyster water or fish stock
- 1/2 teaspoon salt
- 1/2 teaspoon black pepper
- Dash cayenne
- 1/2 pound crabmeat
- 1 tablespoon chopped parsley
- 2 bay leaves
- 1/2 cup buttered bread crumbs

In a medium-sized skillet, saute onion and shallots in butter. Add dampened bread crumbs and cook 3-5 minutes. Add bay leaves, salt, pepper, cayenne, crabmeat, and parsley; mix thoroughly, and heat through. Remove from heat and remove bay leaves. Pack stuffing into 4 crab shells and cover with buttered bread crumbs. Bake in shallow baking dish 15-20 minutes at 350°F. Serves 4.

Crab Meat Salad

- 1 pound crab meat
- 2 tablespoons chopped onion
- 2 tablespoons chopped sweet pickle
- 1/2 teaspoon salt
- Lettuce
- 1/2 cup mayonnaise or salad dressing
- 1 cup chopped celery
- 2 hard-cooked, eggs, chopped
- Dash pepper

Remove any shell or cartilage from crab meat, being careful not to break the meat into small pieces. Combine all ingredients except lettuce. Chill. Serve on lettuce. Serves 6.

Alaska King Crab Ole

1 pound Alaska king crab	1 pound avocados
1/2 cup capers	1/2 ripe olives (sliced)
3/4 cup lemon juice	1/4 cup lime juice
1 cup olive oil	1 1/2 tablespoon cilantro

Thaw and flake crab meat. Peel and dice avocados. Combine juices, oil and cilantro; blend well. Pour over remaining ingredients and toss; chill well. Serve as an appetizer with tortilla chips. Serves 8 appetizer portions.

Alaska King Crab Salad in Cucumber Boat

8 ounce Alaska king crab	1 large cucumber
1 1/2 tablespoons lemon juice	1/4 cup mayonnaise
1/2 teaspoon dill weed	1 tablespoon minced onion
Salt and pepper to taste	

Thaw crab. Cut cucumber lengthwise. Scoop out and discard seeds. Continue to scrape halves, reserving all pulp. Mix crab meat with cucumber, mayonnaise, lemon juice, dill weed, minced onion, and salt and pepper. Chill. Adjust seasoning and mound crab mixture in cucumber boats. Serve on a sea of greens. Serves 2.

Alaska King Crab Seafoam Salad Spread

4 ounce Alaska king crab	1 ounce roast beef
1 ounce gherkins (dill)	1 cup whipped cream
2 teaspoon horseradish	

Thaw crab and flake. Cut roast beef julienne. Mince gherkins. Blend horseradish with whipped cream. Combine all ingredients. Season to taste. Serve either as luncheon salad or as sandwich spread. Serves 1.

Deviled King Crab en Casserole

9 pound Alaska king crab	1 gallon white sauce (medium)
4 tablespoons prepared mustard	Salt and pepper to taste
1 quart bread crumbs	butter as needed

Thaw crab and flake. Add mustard, salt and pepper to white sauce. Adjust seasoning and blend in king crab meat. Pour mixture into individual casseroles or shallow hotel pan. Sprinkle liberally with bread crumbs and dot with butter. Place in moderate oven until top is nicely browned and crab is heated through. Serves 48.

Alaska King Crab Legs au Bleu

5 - 6 ounces Alaska king crab (whole legs)
Blue cheese
Dry vermouth

Thaw crab meat. Place in shallow oven-proof dish. Pour vermouth over crab and marinate 20 minutes, turning occasionally. Sprinkle the crumbled blue cheese over crab. Place under broiler until cheese melts and crab is heated through, about 4-5 minutes. Baste once with the vermouth marinade. Serves 1.

BOILED LOBSTER

Live Whole Lobsters

2 live lobsters (1 pound each)
3 tablespoons salt
3 quarts boiling water
Melted butter

Plunge lobsters head first into boiling salted water. Cover and return to boiling point. Simmer for 20 minutes. Drain. Place lobster on its back. With a sharp knife cut in half lengthwise. Remove the stomach, which is just back of the head, and the intestinal vein, which runs from the stomach to the tip of the tail. Do not discard the green liver and coral roe; they are delicious. Crack claws. Serve with butter. Serves 2.

For the recipes requiring cooked lobster meat, cool lobsters and remove meat. Two live lobsters, 1 pound each, yield approximately 1/2 pound cooked lobster meat.

Spiny Lobster Tails

6 frozen spiny lobster tails (5 to 8 ounces each)
1/3 cup salt
2 quarts boiling water
Melted butter

Place lobster tails in boiling salted water. Cover and return to boiling point. Simmer for 10 to 15 minutes, depending on size of lobster tails. Drain. Cut in half lengthwise. Serve with butter. Serves 6.

For the recipes requiring cooked lobster meat, cool spiny lobster tails and remove meat. One and one-half pounds frozen spiny lobster tails yield approximately 3/4 pound cooked meat.

BROILED LOBSTERS

Live Whole Lobsters

2 live lobsters (1 pound each)	1 tablespoon butter, or margarine, melted
1/4 teaspoon salt	Dash white pepper
Dash paprika	1/4 cup butter or margarine, melted
1 tablespoon lemon juice	

Place lobster on its back; insert a sharp knife between body shell and tail segment, cutting down to sever the spinal cord. Cut in half lengthwise. Remove the stomach, which is just back of the head, and the intestinal vein, which runs from the stomach to the tip of the tail. Do not discard the green liver and coral roe; they are delicious. Crack claws. Lay lobsters open as flat as possible on a broiler pan. Brush lobster meat with butter. Sprinkle with salt, pepper, and paprika. Broil about 4 inches from source of heat for 12 to 15 minutes or until lightly browned. Combine butter and lemon juice; serve with lobsters. Serves 2.

Spiny Lobster Tails

6 frozen spiny lobster tails (5 to 8 ounces each)	1/3 cup butter or margarine, melted
1/2 teaspoon salt	Dash white pepper
Dash paprika	3/4 cup butter or margarine, melted
3 tablespoons lemon juice	

Thaw lobster tails. Cut in half lengthwise. Lay lobster tails open as flat as possible on a broiler pan. Brush lobster meat with butter. Sprinkle with salt, pepper, and paprika. Broil about 4 inches from source of heat for 10 to 15 minutes, depending on size of lobster tails. Combine butter and lemon juice; serve with lobster tails. Serves 6.

HOW TO BOIL SHRIMP

Boiling is the basic method of cooking raw shrimp. The shrimp may be boiled, then peeled; or they may be peeled, then boiled. The order is largely a matter of personal preference; about the only difference is in the amount of salt used in the boiling water.

Either way, 1 1/2 pounds of raw shrimp yield about 3/4 pound of cooked, peeled, and cleaned shrimp, ready to eat immediately or to be chilled for later use in any of the recipes that call for cooked shrimp.

To boil before peeling:

1 1/2 pounds shrimp
1/4 cup salt
1 quart water

Wash shrimp. Place in boiling salted water. Cover and return to boiling point. Simmer 5 minutes. Drain. Peel. Remove sand veins. Wash. Chill. Yields 3/4 pound cooked shrimp.

To boil after peeling:

1 1/2 pounds shrimp
2 tablespoons salt
1 quart water

Peel shrimp. Make a shallow cut lengthwise down the back of each shrimp. Wash. Place in boiling salted water. Cover and return to boiling point. Simmer 5 minutes. Drain. Remove any particles of sand veins remaining. Chill. Yields 3/4 pound cooked shrimp.

Shrimp Salad

3/4 pound cooked shrimp
1 tablespoon grated onion
1/2 teaspoon salt
1/4 cup mayonnaise or salad dressing
2 tablespoons chopped sweet pickle
Dash pepper
Lettuce

Cut large shrimp in half. Combine all ingredients, except lettuce; chill. Serve on lettuce. Serves 6.

Fried Oysters

1 quart select oysters
2 tablespoons milk
1/8 teaspoon pepper
2 eggs, broken
1 teaspoon salt
1 cup bread crumbs, cracker crumbs, or cornmeal

Drain oysters. Mix eggs, milk, and seasonings. Dip oysters in egg mixture and roll in crumbs. Fry in hot fat; when brown on one side turn and brown other side. Cooking time about 5 minutes. Drain on absorbent paper. Serve immediately with slices of lemon or Tartar sauce. Serves 6.

Oyster Stew

1 pint oysters
1 quart milk
1/8 teaspoon pepper
4 tablespoons butter
1 1/2 teaspoons salt
Paprika

Melt butter, add drained oysters, and cook 3 minutes or until edges curl. Add milk, salt, and pepper, and bring almost to boiling point. Serve at once. Garnish with paprika. Serves 6.

Steamed Clams

6 pounds shell clams ("steamers")
1/2 cup boiling water
Butter or margarine

Wash clams thoroughly. Place in a steamer, add water, and cover. Steam for 5 to 10 minutes or until clams open. Serve hot in the shell with melted butter. Serves 6.

Clams Oregano (for two dozen cherry stone clams)

2 tablespoons olive oil
1 medium onion
1 teaspoon basil
2 teaspoons lemon juice
1 cup fresh bread crumbs
2 tablespoons butter
1 clove garlic
1 tablespoon oregano
1/2 cup chopped parsley

Saute onion and garlic in olive oil and butter. Combine remaining ingredients. Spread on clams, bake 10 minutes in 350°F oven or freeze.

New England Clam Chowder

1 pint clams
1/4 cup chopped onion
1 cup diced potatoes
Dash pepper
Parsley
1/4 cup chopped bacon or salt pork
1 cup clam liquor and water
1/2 teaspoon salt
2 cups milk

Drain clams and save liquor. Chop. Fry bacon until lightly brown. Add onion and cook until tender. Add liquor, potatoes, seasonings, and clams. Cook about 15 minutes or until potatoes are tender. Add milk; heat. Garnish with chopped parsley sprinkled over the top. Serves 6.

Manhattan Clam Chowder

1 pint clams
1/2 cup chopped onion
1 cup chopped celery
1 cup diced potatoes
1 teaspoon salt
2 cups tomato juice
1/4 cup chopped bacon or salt pork
1/2 cup chopped green pepper
1 cup clam liquor and water
1/4 teaspoon thyme
Dash cayenne

Drain clams and save liquor. Chop. Fry bacon until lightly brown. Add onion, green pepper, and celery; cook until tender. Add liquor, potatoes, seasonings, and clams. Cook about 15 minutes or until potatoes are tender. Add tomato juice; heat. Serves 6.

Broiled Scallops

1 1/2 pounds scallops, fresh or frozen
1/2 teaspoon salt
Dash paprika
3/4 cup butter or margarine, melted
1/3 cup butter or margarine, melted
Dash white pepper
2 tablespoons chopped parsley
3 tablespoons lemon juice

Thaw frozen scallops. Remove any shell particles and wash. Cut large scallops in half. Place on a greased broiler pan. Combine butter, salt, pepper, and paprika. Brush scallops with seasoned butter. Broil about 3 inches from source of heat for 3 to 4 minutes. Turn carefully. Brush other side with seasoned butter and broil 3 to 4 minutes longer. Sprinkle with parsley. Combine butter and lemon juice; serve with scallops. Serves 6.

Fried Scallops

2 pounds scallops, fresh or frozen
1 tablespoon milk
Dash pepper
1/2 cup dry bread crumbs
1 egg, beaten
1 teaspoon salt
1/2 cup flour

Thaw frozen scallops. Remove any shell particles and wash. Cut large scallops in half. Combine egg, milk, and seasonings. Combine flour and crumbs. Dip scallops in egg mixture and roll in flour-and-crumb mixture.

NOTE: A commercial breading may be used. Follow the directions on the package.

Pan-Fried: Place scallops in a heavy frying pan which contains about 1/8 inch of fat, hot but not smoking. Fry at moderate heat. When scallops are brown on one side, turn carefully and brown the other side. Cooking time approximately 4 to 6 minutes. Drain on absorbent paper. Serves 6.

Deep-Fat Fried: Fry scallops in a basket in deep fat, 350°F for 2 to 3 minutes or until brown. Drain on absorbent paper. Serves 6.

California Abalone Steak

Tenderize abalone -- using light strokes, pound slices (3/8" thick) with the smooth end of a mallet until the meat is limp and velvety, a state which has been compared to a limp pancake. Dip into flour, then into lightly beaten egg, and then into cracker meal. Pan-fry quickly in butter (45 to 55 seconds TOTAL time), turning once; overcooking toughens abalone.

Breaded Abalone

Dredge slices of abalone in flour, then dip them in eggs beaten with water, and roll them in crumbs. Saute in butter as in the recipe above.

Fried Abalone

Slice and tenderize abalone and cut into thin strips. Heat fat or oil in a deep fryer to 370°. Dip the pieces of abalone into beer batter for frying and fry until delicately browned. Salt and pepper to taste.

Abalone Chowder

This is made in the same way you make clam chowder, except abalone is cooked in chicken broth until tender and then ground. The ground abalone is added to the potatoes while they are cooking.

Keys Conch Steak

Tenderize conch -- pound with a sharp edged instrument (edge of plate) or parboil and pound until flesh is tender. Dip into batter and deep-fry in fat or oil heated to 390°.

Fried Conch

1 conch sliced
1 cup cracker meal
2 eggs, slightly beaten
salt and pepper
fat for deep frying

Dip slices into cracker meal, then into eggs, then into meal again. Season well and deep-fry in fat heated to 390°. Serves 2.

Conch Chowder

24 conchs
1/2 pound butter
4 cups water
6 large carrots diced
2 green peppers, diced
8 potatoes diced
3 onions, diced
4 cups canned tomatoes
2 bay leaves
1/2 cup flour
1/4 cup salad oil
salt and pepper

Grind conchs in a food grinder. Simmer the pieces in the butter until tender. Mix water, vegetables, and bay leaves in a large kettle and simmer until vegetables are tender. Add conch meat and butter to the kettle and continue to simmer. Brown flour in the oil, stir the roux into the chowder, and simmer until thickened. Season to taste. Serves 6.

VI-G: BASIC FINFISH RECIPES

Broiled Fillets or Steaks

2 pounds fish fillets or steaks, fresh or frozen
2 tablespoons melted fat or oil
1/2 teaspoon paprika
2 tablespoons lemon juice
1 teaspoon salt
Dash pepper

Thaw fish if frozen. Cut fish into 6 portions. Place fish in a single layer, skin side down, on a well-greased baking pan, 15 by 10 by 1 inches. Combine remaining ingredients and mix well. Pour sauce over fish. Broil about 4 inches from source of heat for 10 to 15 minutes or until fish flake easily when tested with a fork. Baste once during broiling with sauce in pan. Makes 6 servings.

Broiled Pan-Dressed Fish

3 pounds pan-dressed fish, fresh or frozen
1/4 cup melted fat or oil
1/4 cup lemon juice
1 1/2 teaspoons salt
3/4 teaspoon paprika
Dash pepper

Thaw fish if frozen. Cut fish into 6 portions. Place fish in a single layer, skin side down, on a well-greased baking pan, 15 by 10 by 1 inches. Combine remaining ingredients and mix well. Brush fish inside and out with sauce. Broil about 4 inches from source of heat for 5 to 8 minutes. Turn carefully and baste with sauce. Broil 5 to 8 minutes longer or until fish flake easily when tested with a fork. Makes 6 servings.

Baked Stuffed Fish

1 dressed fish (3 pounds fresh or frozen)
Salt
2 tablespoons melted fat or oil
Pepper
Bread stuffing

Thaw fish if frozen. Clean, wash, and dry fish. Sprinkle inside with salt and pepper. Place fish on a well-greased bake and serve platter, 18 by 13 inches. Stuff fish loosely. Brush fish with fat.

Bake in a moderate oven, 350°F for 45 to 60 minutes or until fish flakes easily when tested with a fork. Makes 6 servings.

Bread Stuffing

1/2 cup chopped celery
1/4 cup chopped onion
1/4 cup butter or margarine, melted
1 quart dry bread cubes
Dash pepper
1 egg, beaten
1/2 teaspoon sage
1/2 teaspoon salt
1/4 teaspoon thyme

Cook celery and onion in butter until tender. Combine all ingredients and mix well. Makes 3 cups stuffing.

Fried Pan-Dressed Fish

3 pounds pan-dressed fish, fresh or frozen
1/4 cup milk
1 egg, beaten
1 teaspoon salt
Dash pepper
1 1/2 cups dry bread, cereal or cracker crumbs
Fat for frying

Thaw fish if frozen. Clean, wash, and dry fish. Combine milk, egg, salt, and pepper. Dip fish in milk and roll in crumbs. Place fish in a single layer in hot fat, in a 10-inch frying pan. Fry at a moderate heat for 4 to 5 minutes or until brown. Turn carefully. Fry 4 to 5 minutes longer or until fish are brown and flake easily when tested with a fork. Drain on absorbent paper. Makes 6 servings.

Barbecued Fillets or Steaks

2 pounds fish fillets or steaks, fresh or frozen
1/4 cup chopped onion
2 tablespoons chopped green pepper
1 clove garlic, finely chopped
2 tablespoons melted fat or oil
1/4 teaspoon pepper
1 can (8 ounces) tomato sauce
2 tablespoons lemon juice
1 tablespoon Worcestershire sauce
1 tablespoon sugar
2 teaspoons salt

Thaw fish if frozen. Cook onion, green pepper, and garlic in fat until tender. Add remaining ingredients and simmer for 5 minutes, stirring occasionally. Cool. Cut fish into 6 portions. Place fish in a single layer in a shallow baking dish. Pour sauce over fish and let stand for 30 minutes, turning once. Remove fish, reserving sauce for basting. Place fish in well-greased, hinged, wire grills. Cook about 4 inches from moderately hot coals for 5 to 8 minutes. Baste with sauce.

Turn. Cook for 5 to 8 minutes longer or until fish flake easily when tested with a fork. Makes 6 servings.

Deep-Fat Fried Fillets or Steaks

- 2 pounds fish fillets or steaks, fresh or frozen
- 1/4 cup milk
- 1 egg beaten
- 1 teaspoon salt
- Dash pepper
- 1 1/2 cups dry bread, cereal, or cracker crumbs
- Fat for frying

Thaw fish if frozen. Cut fish into 6 portions. Combine milk, egg, salt, and pepper. Dip fish in milk and roll in crumbs. Place in a single layer in a frying basket. Fry in deep fat, 350°F for 3 to 5 minutes or until fish are brown and flake easily when tested with a fork. Drain on absorbent paper. Makes 6 servings.

NOTE: A commercial breading may be used. Follow the directions on the package.

Oven-Fried Fillets or Steaks

- 2 pounds fish fillets or steaks, fresh or frozen
- 1 teaspoon salt
- 1/4 cup melted fat or oil
- 1/2 cup milk
- 1 1/2 cups cereal crumbs or toasted dry bread crumbs

Thaw fish if frozen. Cut fish into 6 portions. Combine milk and salt. Dip fish in milk and roll in crumbs. Place fish in a single layer, skin side down, on a well-greased baking pan, 15 by 10 by 1 inches. Pour fat over fish. Bake in an extremely hot oven, 500°F for 10 to 15 minutes or until fish are brown and flake easily when tested with a fork. Makes 6 servings.

Poached Fish with Egg Sauce

- 2 pounds fish fillets or steaks, fresh or frozen
- 2 cups boiling water
- 1/4 cup lemon juice
- 1 small onion, thinly sliced
- 1 teaspoon salt
- 3 peppercorns
- 2 sprigs parsley
- 1 bay leaf
- Egg sauce
- Paprika

Thaw fish if frozen. Remove skin and bones from fish. Cut fish into 6 portions. Place fish in a well-greased 10-inch frying pan. Add remaining ingredients. Cover and simmer for 5 to 10 minutes or until fish flake easily when tested with a fork. Carefully remove fish to a hot platter. Pour Egg Sauce over the fish. Sprinkle with paprika. Makes 6 servings.

Egg Sauce:

1/4 cup butter or margarine
2 tablespoons flour
3/4 teaspoon powdered mustard
1/2 teaspoon salt
Dash pepper
1 1/4 cups milk
2 hard-cooked eggs, chopped
1 tablespoon chopped parsley

Melt butter. Stir in flour and seasonings. Add milk gradually and cook until thick and smooth, stirring constantly. Add eggs and parsley. Heat. Makes 1 1/2 cups sauce.

Steamed Fish

1 1/2 pounds fish fillets, steaks, or pan-dressed fish, fresh or frozen
1 1/2 teaspoons salt
1 quart boiling water

Thaw fish if frozen. Place fish in a well-greased steamer insert pan. Sprinkle fish with salt. Cover and cook over boiling water for 5 to 10 minutes or until fish flake easily when tested with a fork. Cool. Remove skin and bones. Makes 2 cups cooked fish.

VI-H: RECIPES BEYOND THE BASICS

Smoked Fish Spread

- 1 1/2 pounds smoked fish
- 2 teaspoons minced onion
- 2 teaspoons finely chopped celery
- 1 clove garlic, minced
- 2 tablespoons finely chopped sweet pickle
- 1 1/4 cup mayonnaise
- 1 tablespoon mustard (creole or brown mustard adds some zip!)
- Dash Worcestershire sauce
- 2 tablespoons chopped parsley

Mix all ingredients together, place in mold and chill at least 1 hour. Garnish and serve with crackers or bread. Makes 3 1/2 cups.

Fish Timbales

- 1 cup bread crumbs
- 2 cups flaked poached fish (save liquid)
- 1 teaspoon grated onion
- 1/4 teaspoon white pepper
- 3 eggs, separated
- 3/4 cup heavy cream
- 1/4 cup white wine
- 1 teaspoon salt
- nutmeg

Butter 6 ramekins. Soak crumbs in cream for 10 minutes. Add fish, wine and seasoning and mix well in a blender. Add the yolks and beat until smooth. Fold stiffly beaten whites into fish mixture and pour into ramekins (fill them). Place in bain-marie, cover with foil and bake for 30 minutes at 350°. Remove from oven, cool 5 minutes, unmold, and serve with the following sauce.

- 3 tablespoons butter
- 3 tablespoons flour
- 1 cup poaching liquid

Make roux with butter and flour. Add liquid and stir until thick. Add catsup or tomato paste just to color and 3/4 cup cooked shrimp.

Coulibiac

- Brioche dough (or pastry dough)
- 1 1-pound can sockeye salmon (seasoned with 1/8 teaspoon dry dill weed)
- 2 hard cooked eggs
- Egg wash (1 egg and 1 teaspoon water)
- 1/2 pound mushrooms, sliced
- 1/4 pound butter
- 2 tablespoons lemon juice

2 cups cooked rice with 1 cup chopped parsley added
salt
cayenne pepper
black pepper

Roll dough into 1/4" thick rectangle. Place on parchment lined pan. Begin layering the ingredients (centered lengthwise, off center crosswise) in the following order:

3/4 of the rice mixture
all of the salmon
mushrooms
rest of rice
eggs
cayenne and black pepper

Pour butter over all. Pull short lengthwise side up, trim crosswise ends if necessary and pull up, pull long lengthwise side up and over and seal all around top. Use excess dough for decorations. Paint pastry with egg wash. Cook at 375° until pastry is done.

Pompano En Papillote

2 pound pompano fillets or other fish fillets, fresh or frozen
1 can (6 1/2-7 oz.) crabmeat, drained, flaked, and cartilage removed
1/4 pound cooked, peeled and deveined shrimp, fresh or frozen
3 cups water
1 teaspoon salt
2 lemon slices
1 bay leaf
1/8 teaspoon dried thyme leaves, crushed
Parchment or brown paper
2 tablespoons cooking oil
1/2 cup chopped green onion
1 clove garlic, minced
2 tablespoons margarine or butter
3 tablespoons flour
1/4 teaspoon salt
2 slightly beaten egg yolks
3 tablespoons dry white wine

Thaw fish if frozen. Chop shrimp. In 10-inch frying pan bring water, 1 teaspoon salt, lemon, bay leaf, and thyme to a boil. Add fish, cover, and simmer for about 10 minutes or until fish flakes easily when tested with fork. Carefully remove fish. Cut 6 pieces parchment or brown paper into heart shapes about 10x12 inches each. Brush paper with oil. Place one fillet on half of each heart. In saucepan melt margarine. Add onion and garlic and cook until tender. Blend in flour and 1/4 teaspoon salt. Add reserved stock. Cook, stirring constantly, until thickened. Gradually stir small amount of hot mixture into egg yolks; add to remaining sauce, stirring constantly. Heat just until mixture thickens. Stir in wine, crabmeat, and shrimp. Heat. Spoon about 1/2 cup sauce over each fillet. Fold other half of each paper heart over fillet to form individual cases. Seal, starting at top of heart, by turning edges up and folding, twisting tip of heart to hold case closed. Place cases in shallow baking pan. Bake in hot oven, 400°F, for 10-15 minutes. To serve, cut cases open with large X design on top; fold back each segment. Makes 6 servings.

Atlantic City Flamed Sea Bass

- 2 pounds sea bass fillets or other fish fillets, fresh or frozen
- 2/3 cup margarine or butter, melted
- 1 teaspoon paprika
- 1 bunch parsley
- 2 tablespoons fennel seeds
- 1/2 cup brandy

Thaw fish if frozen. Divide into serving size portions. Place fish in a well-greased baking dish, 12 by 12 inches, with the skin side down. Combine margarine and paprika; brush fish with sauce. Reserve remaining sauce for serving with fish. Bake fish in moderate oven, 350°F, for 15-20 minutes or until fish flakes easily when tested with fork. Cover serving platter with parsley, sprinkle fennel seeds over parsley. Place fish on top of parsley. Pour reserved margarine mixture over fish. Heat brandy and flame; pour over fish. Makes 6 servings.

Stuffed Flounder

- 4 flounders, medium size
- 1 1/2 pounds shrimp, peeled and deveined
- 1/2 pound crab meat, fresh or canned
- 1/2 cup chopped celery
- 1 cup chopped onions
- 4 cloves garlic, minced
- 1/2 cup cooking oil
- 3 stale buns soaked in water
- 4 eggs
- 1/2 cup cracker meal or bread crumbs
- 1/2 cup green onion tops and parsley, chopped
- salt, pepper and cayenne

Boil shrimp. Put oil, celery, onions and garlic in heavy pot. Cook over medium heat in uncovered pot, until onions are wilted. Chop shrimp, and add to onion mixture. Then add crabmeat, soaked buns and 2 unbeaten eggs. Mix well. Add 2 egg whites and mix. Then add 2 egg yolks, cracker meal or bread crumbs, green onion tops and parsley. Season generously with salt, black pepper and cayenne.

Split flounders lengthwise, removing bones, or make butterfly fillets. Stuff with the prepared mixture. Brush egg yolk across tops of fish and broil 10 minutes on one side. Turn over and broil 10 minutes on other side. Serve piping hot with drawn or garlic butter. Serves 4.

Garlic Butter:

1 pound butter
5 cloves garlic
1/2 lemon

Melt butter, add garlic and lemon juice and heat for about 3 minutes.

Trout Almondine

4 pounds fresh trout, cleaned
1 egg
1/2 pint milk
1 5-ounce can almonds
1/2 cup cold water
1/4 cup chopped parsley
1/2 teaspoon corn starch
1 cup all-purpose flour
Salt, pepper and cayenne
Cooking oil

Beat egg and milk together, set aside. Split trout lengthwise. Season generously with salt, pepper, and cayenne. Dip in egg and milk mixture, then roll in white flour. Put 1/2 inch cooking oil in heavy pot over high heat. Fry trout in uncovered pot. When trout is golden brown on both sides, set it aside. Grind almonds and put in heavy skillet until almonds are brown. Drain off 2/3 of the butter. Dissolve corn starch in 1/2 cup cold water and add to the fried almonds. Season with salt, pepper and cayenne to taste. Pour this mixture over fried trout. Garnish top with parsley. Serves 4.

Cocktail Quiche

1/2 cup mayonnaise
2 beaten eggs
1 2/3 cups flaked crabmeat
1/3 cup sliced green onion
2 tablespoons flour
1/2 cup milk
8 ounces Swiss cheese
Sliced pastry for 9 inch quiche pan or cream cheese pastry for miniature muffin tins

Combine mayonnaise, flour, egg and milk. Mix until blended. Stir in crabmeat, cheese and green onion. Pour into pastry lined pan. Bake at 350°F for 40-45 minutes.

Coquilles St. Jacques

1 cup dry white wine
3/4 cup water
1 bay leaf
1 tablespoon lemon juice
2 tablespoons butter
Fresh bread crumbs
3 whole shallots
1 pound scallops
1/4 pound mushrooms, finely sliced
1 tablespoon chopped parsley
2 egg yolks
4 tablespoons cream
4 tablespoons butter
4 tablespoons flour

Simmer scallops and mushrooms in mixture of wine, 3/4 cup of water, lemon juice, bay leaf, parsley and shallots for 5 minutes. Remove and strain, reserving liquid. Make a medium white sauce with 4 tablespoons butter, 4 tablespoons flour, and 1 3/4 cups poaching liquid. Stir 2 egg yolks into 4 tablespoons cream and add to the sauce. Season to taste. Place scallops in shells and spoon sauce over. Add mushrooms around edges. Sprinkle with bread crumbs, dot with butter and heat in a 450° oven until lightly browned. Serve at once.

Pilgrims Clam Pie

- 3 dozen shell clams or 3 cans (8 oz. each) minced clams
- 1 1/2 cups water
- 1/4 cup margarine or butter
- 1/2 cup sliced fresh mushrooms
- 2 tablespoons minced onion
- 1/4 cup all-purpose flour
- 1/8 teaspoon liquid hot pepper
- 1/4 teaspoon dry mustard
- 1/4 teaspoon salt
- 1/8 teaspoon white pepper
- 1 cup reserved clam liquor
- 1 cup half and half
- 1 tablespoon lemon juice
- 2 tablespoons chopped parsley
- 2 tablespoons chopped pimiento
- Pastry for a 9 inch pie
- 1 egg, beaten

Wash clam shells thoroughly. Place clams in a large pot with water. Bring to a boil and simmer for 8-10 minutes or until clams open. Remove clams from shell and cut into fourths. Reserve 1 cup of clam liquor. (Or: if using canned clams, drain and reserve 1 cup of liquor). In a skillet melt margarine, add mushrooms and onion, and cook until tender. Stir in flour, mustard, liquid, hot pepper, salt, and pepper. Gradually add clam liquor and half and half. Cook, stirring constantly, until thick. Stir in lemon juice, parsley, pimiento, and clams. Pour mixture into a 9-inch round deep dish pie plate (about 2 inches deep). Roll out pastry dough and place on top of mixture in pie plate; secure dough to the rim of the pie plate by crimping. Vent pastry. Brush with beaten egg. Bake in a hot oven, 375°F, for 25-30 minutes or until pastry is browned. Makes 6 servings.

Squid Sauce for Pasta or Rice

- 1 pound squid
- 4 tablespoons olive oil
- 1 large onion
- 4 anchovy fillets, mashed
- 1 teaspoon parsley, chopped
- 1-2 cloves garlic, minced
- 1 tablespoon freshly grated parmesan cheese
- 1/3 cup dry red wine
- 1 cup peeled tomatoes, crushed (fresh or canned Italian)
- 1 teaspoon oregano
- 1 tablespoon fresh chopped basil (1 teaspoon dry)
- Salt
- Freshly ground pepper

Clean squid, removing eyes, beak, skin and intestines, wash well. Slit mantle and chop (along with tentacles if desired) into small pieces. Heat olive oil in skillet until haze forms over the top. Add onion and anchovies and brown lightly. Add squid pieces and cook over medium heat about 10 minutes. Add garlic, pepper, oregano, and basil. Cook 30 minutes longer. Add tomatoes and parmesan. Cover and simmer about 30 minutes. Add salt and wine. Replace cover and simmer 2-3 minutes. Serve over pasta or rice.

Squid Tempura

1/2 pound squid, cut into rings	8 baby onions
8 prawns, shelled, with the tail left on	8 slices potato
1 green pepper, cut into rings	1 cup flour
8 large mushrooms	2 eggs
8 slices eggplant	water
	oil for frying

Sift flour. Add water to eggs to make 2 cups. Pour the liquid on the flour, mixing with swift and as few strokes as possible to avoid the development of gluten. Pat the ingredients dry with paper towel, then coat with the batter. Cook them in oil heated to 350°F. Serve with soy sauce and lemon wedges. Grated white radish and ginger root may be added to soy sauce for piquant taste. Makes 3-4 servings.

Squid in Tomato Sauce

2 pounds squid	1/4 cup water
1 cup sliced onion	1 tablespoon flour
1 clove garlic, minced	1 teaspoon salt
2 tablespoons cooking oil	Cooked rice or spaghetti (or other pasta)
1 can (1 pound) tomatoes	
1/2 teaspoon basil	

Clean squid, cut into 1/2-inch rings. Cook onion and garlic in oil until onion is limp, not brown. Add tomatoes and basil, simmer for 5 minutes. Add squid rings. Cover, simmer 10 minutes or until squid is cooked. Blend water, flour, and salt. Stir into sauce, cook, stirring constantly until thickened. Serve on cooked rice, spaghetti, or your choice of pasta. Makes 4 to 6 servings.

Oysters Rockefeller

1 pint oysters, select or counts, fresh or frozen
1/4 cup margarine or butter
1/4 cup chopped celery
1/4 cup chopped green onion
2 tablespoons chopped parsley
1 package (10 oz.) frozen chopped spinach
1 tablespoon anisette
1/4 teaspoon salt
Rock salt
18 baking shells
1/4 cup dry bread crumbs
1 tablespoon melted margarine or butter

Thaw oysters if frozen. In small saucepan melt 1/4 cup of margarine. Add celery, green onion, and parsley. Cover and cook 5 minutes or until tender. Combine cooked vegetables with spinach in blender container. Add anisette and salt. Chop vegetables in blender until almost pureed, stopping once or twice to push vegetables into knife blades. (Vegetables may be run through a food mill.) Make a layer of rock salt in pie tins. Place small baking shells or ramekins on top. (The rock salt is used mainly to hold shells upright; however, it also helps to keep oysters hot to serve.) Place the oysters in the shells or ramekins. Top each oyster with spinach mixture. Combine bread crumbs and 1 tablespoon melted margarine; sprinkle over oysters. Bake in a very hot oven, 450°F, for 10 minutes. Serve immediately in pie tins. Makes 6 appetizer servings of 3 oysters each.

Oysters Bienville

1 bunch green onions, finely chopped
1/4 pound butter
3 tablespoons flour
1 pint chicken or fish boullion or broth
1 can chopped mushrooms
1/4 cup cheddar cheese
1/8 teaspoon paprika
3 egg yolks
3 ounces white wine
1/2 cup evaporated milk
Salt, pepper and hot pepper sauce to taste
1/2 pound shrimp, finely chopped
1 teaspoon oregano

This recipe, used as a casserole dish, will serve 4-6 persons. It can also be used as a sauce to cover approximately 4 dozen oysters on the half-shell.

Sauce:

Mix shrimp, mushrooms and 1 1/2 ounces of wine together. Set aside. Brown onions in butter; add flour and stir over low flame until mixture is a light brown. Add chicken or fish boullion or broth which has been heated, slowly stirring all the while. Add shrimp, mushrooms and wine mixture until sauce is smooth and begins to thicken. Set aside to cool slightly.

Beat egg yolks well, but not too long, with 1 1/2 ounces of wine and the evaporated milk. Slowly pour the warm sauce into this egg-wine-milk mixture, and stir constantly so it will stay smooth and not curdle. (Add liquor from pre-baked oyster shells and season to taste). Replace the whole mixture on the fire and cook over low heat for 10-15 minutes until thick, stirring constantly to prevent lumping or scorching. If too thin, add flour or cornstarch to thicken. Pour into four separate casseroles or ramekins and place 10 to 12 oysters in the middle of the mixture; cover with more sauce. Sprinkle well with cheddar cheese, place in 400°F oven and bake until golden brown.

CAUTION: Make sure oysters are placed between layers of sauce, as they will get extremely hard if cooked on the bottom.

Shrimp in Lobster Sauce

- 1 pound raw shrimp, peeled, deveined and washed
- 1 tablespoon sherry
- 2 tablespoons fermented black beans, chopped
- 1 teaspoon garlic, finely minced
- 1/4 pound lean pork, finely chopped
- 1 tablespoon soy sauce
- 1/2 teaspoon salt
- 1/4 teaspoon sugar
- 1 scallion, finely minced
- 2 tablespoons corn starch
- 1 1/2 cups chicken stock
- 1 egg
- 5 tablespoons oil

Mix soy sauce and sugar in a small bowl. Mix corn starch with stock. Add a little oil to pan and heat. Add shrimp and cook just until done. Add sherry and turn out onto plate. Add a little more oil to pan and heat. Add garlic, then pork and stir fry. Then add one item at a time: beans, soy mixture, corn starch/stock, shrimp and finally egg to thicken.

Creole Bouillabaisse

- 1 pound red drum fillets or other fish fillets, fresh or frozen
- 1 pound sea trout fillets or other fish fillets, fresh or frozen
- 1/2 pound raw shrimp, peeled, deveined, fresh or frozen
- 1 pint oysters, fresh or frozen
- 1 can (6 1/2 oz.) crabmeat, drained, cartilage removed
- 1/4 cup all-purpose flour
- 1 cup chopped onion
- 1/2 cup chopped celery
- 1 clove garlic, minced
- 5 cups water
- 1 can (1 lb.) tomatoes, undrained cut up
- 1/2 cup dry white wine
- 2 tablespoons chopped parsley
- 1 tablespoon lemon juice
- 1 bay leaf

- 2 tablespoons butter or margarine
- 2 tablespoons olive oil
- 1/2 teaspoon salt
- 1/4 teaspoon saffron
- 1/4 teaspoon cayenne pepper

Thaw fish if frozen. Remove skin and bones from fish. Cut each fish into 6 or 8 portions. In a 4 to 5 quart dutch oven, melt margarine. Add olive oil and blend in flour. Cook, stirring constantly, until light brown in color. Add onion, celery, and garlic. Cook, stirring constantly, until vegetables begin to brown. Gradually stir in water. Add tomatoes, wine, parsley, lemon juice, bay leaf, salt, saffron, cayenne pepper, and about 1/4 of the fish. Bring to a boil and simmer for 20 minutes. Add remaining fish and cook 5-8 minutes longer. Add shrimp, oysters, and crabmeat. Cook another 3 minutes or until all the seafood is done. Makes 8 servings.

Pickled Rock Shrimp

- 2 pounds cooked, peeled and deveined rock shrimp or other shrimp, fresh or frozen
- 1/2 cup salad oil
- 1/2 cup lime juice
- 1/2 cup sliced onion
- 6 lemon slices
- 1 tablespoon capers with liquid
- 1 tablespoon chopped parsley
- 1/2 teaspoon salt
- 1/2 teaspoon dried dill weed
- 1/8 teaspoon liquid hot pepper

Thaw shrimp if frozen. Combine remaining ingredients. Pour marinade over shrimp; toss lightly. Cover and chill several hours, stirring occasionally. Drain. Makes 60 to 70 hors d'oeuvres.

NOTE: This may be served over salad greens as an appetizer, makes 12 to 15 appetizer servings.

Paella or Saffron Rice with Seafood and Chicken

- 1 live lobster (1 1/2-2 pounds)
- 6 medium-sized raw shrimp in their shell
- 6 small hard-shelled clams
- 6 mussels
- 3 chorizos, or substitute 1/2 pound garlic-seasoned smoked pork sausage
- 1 chicken (1 1/2-2 pounds), cut into 12 serving pieces
- 2 teaspoons salt
- 1 large tomato, peeled, seeded and finely chopped
- 3 cups raw medium or long grain regular milled rice or imported short grain rice
- 1/4 teaspoon ground saffron or saffron threads pulverized with a mortar and pestle or with back of spoon
- 6 cups boiling water

Freshly ground black pepper
1/2 cup olive oil
2 ounces lean boneless pork, cut into 1/4-inch cubes
1/2 cup finely chopped onion
1 teaspoon finely chopped garlic
1 medium-size sweet red or green pepper, seeded, deribbed, cut into strips 1 1/2 inchs long and 1/4 inch wide
1/2 cup fresh peas (1/2 lb.) or 1/2 cup thoroughly defrosted frozen peas
2 lemons, cut lengthwise into 6 wedges each

With a cleaver or large, heavy knife, chop off the tail section of the lobster at the point where it joins the body and twist or cut off the large claws. Remove and discard the gelatinous sac (stomach) in the head and the long intestinal vein attached to it. Without removing the shell, cut the tail crosswise into 1-inch thick slices and split the body of the lobster in half lengthwise, then crosswise in quarters; set aside.

Shell the shrimp, leaving the tails intact. With a small sharp knife, devein the shrimp by making a shallow incision down their backs and lifting out the intestinal vein with the point of the knife. Scrub the clams and mussels thoroughly with a stiff brush or soapless steel-mesh scouring pad under cold running water and remove the black, ropelike tufts from the mussels. Set the shrimp, clams and mussels aside on separate plates.

Place the sausages in an 8-10 inch skillet and prick them in two or three places with the point of a small sharp knife. Add enough cold water to cover them completely and bring to a boil over high heat. Reduce the heat to low and simmer uncovered for 5 minutes. Drain on paper towels and slice them into 1/4-inch rounds.

Pat the chicken dry with paper towels and season with 1 teaspoon salt and a few grindings of pepper. In a heavy skillet (10-12 inch), heat 1/4 cup olive oil over high heat until a light haze forms above it. Add the chicken skin side down, and brown it well, turning the pieces with tongs and regulating the heat so they color evenly without burning. As the pieces become a rich golden brown, remove them to a plate.

Add the lobster to the skillet. Turning the pieces frequently, cook over high heat for 2-5 minutes or until the shell begins to turn pink. Set the lobster aside on a separate plate and add the sausage to the pan. Brown the slices quickly on both sides, then spread them on paper towels to drain.

To make the sofrito, discard all the fat remaining in the skillet and in its place add the remaining 1/4 cup olive oil. Heat until a light haze forms above it, add the pork and brown it quickly on all sides over high heat. Add the onions, garlic, pepper strips and tomato. Stirring constantly, cook briskly until most of the liquid in the pan evaporates and the mixture is thick enough to hold its shape lightly in a spoon. Set the sofrito aside.

About a half hour before you plan to serve the paella, preheat the oven to 400°F. In a 14-inch paella pan or a skillet or casserole at least 11-inches in diameter and 2-2 1/2 inches deep, combine the sofrito, rice, the remaining teaspoon of salt and the saffron. Pour in the boiling water and, stirring constantly, bring to a boil over high heat. Remove the pan from the heat immediately. (Taste the liquid for seasoning and add more salt if necessary.) Arrange the chicken, lobster, sausage, shrimp, clams and mussels on top of the rice and scatter the peas at random over the whole. Set the pan on the floor of the oven and bake uncovered for 25-30 minutes until all the liquid has been absorbed by the rice and the grains are tender but not too soft. At no point should the paella be stirred after it goes in the oven.

When the paella is done, remove it from the oven and drape a kitchen towel loosely over the top. Let it stand for 5-8 minutes. Then garnish the paella with the lemon wedges and serve at the table directly from the pan.

Japanese Broil

8 small eels or large eels cut into 1 1/2- to 2-inch lengths
Salt
8 skewers

1 cup soy sauce (use Japanese soy sauce, not Chinese)
1 tablespoon sake wine, white cooking wine or sherry
4 tablespoons sugar

Mix soy sauce, wine and sugar well and boil for 2 minutes. Thread eels onto skewers and season them with salt. Broil over a charcoal fire for 20 minutes, brushing with sauce frequently and turning when first side is browned; or eels can be cooked in the oven without skewers. Serve hot with or over rice. Makes 4 servings.

Seafood Gumbo

1 pound okra, sliced
1/4 cup shortening
2 tablespoons flour
1 onion, chopped
1 bunch green onion, chopped
1/2 cup celery, chopped
1 can (10 1/2 oz.) tomatoes
2 sprigs parsley chopped
1 bay leaf
1 sprig thyme
2 quarts water
salt and pepper
1 pound shrimp, cleaned
1/2 pound crab meat, or 1 dozen crabs
1 teaspoon filé, if desired

Fry okra in 2 tablespoons of shortening until it ceases to "rope", about 30-45 minutes. In another saucepan, make roux with remaining shortening and flour. Add onions and tomatoes, parsley, bay leaf, thyme and water. Simmer for 30 minutes. Season. Add peeled, deveined and washed shrimp, and crab meat (or crabs), and simmer for 30 minutes longer. Remove from heat. If desired, stir in filé just before serving (never cook filé). Gumbo is better cooked early in the day and refrigerated for several hours. Reheat and serve with cooked rice.

NOTE: If live, hard-shell crabs are used, scald and clean them, removing the spongy substance and the "sandbag" on the under part. Break off and crack the claws, and cut the body in half.

Turtle Soup (Soupe a la Tortue)

2 pounds turtle meat
1 tablespoon shortening
1 tablespoon butter
2 tablespoons flour (browned)
2 tomatoes
1 large onion
1 sprig of thyme
2 sprigs parsley
1 bay leaf
1 clove garlic, finely minced
1 square inch ham
1 dozen cloves, tied in muslin
6 allspice, finely mashed
2 quarts water
2 hard boiled eggs
1 glass sherry or white wine
Salt and cayenne to taste

Clean the turtle by washing thoroughly in cold water. Then put the meat into a saucepan and parboil for ten minutes. Carefully save this stock of water. Chop onion very finely, and cut the ham into fine pieces. Cut the turtle meat into one-inch pieces, mash the allspice very finely, and mince the parsley, thyme, and bay leaf. Then brown the onions in the mixture of shortening and butter, and almost immediately add the turtle meat. Brown together for ten minutes and add the ham. As this continues to brown, add the cloves of garlic, thyme, bay leaf and allspice. Mix all together, stirring almost constantly to prevent burning. Then add the well-rubbed tablespoons of flour, stirring constantly. Scald and skin the tomatoes and chop them finely, and add to the turtle meat. When well browned, pour over three quarts of the water in which the turtle was parboiled, season with salt and pepper and cayenne to taste, and let it boil slowly for a full hour, stirring frequently. After one hour taste the soup and, if not sufficiently seasoned, add seasoning of salt, pepper and cayenne again.

Let it cook for about an hour longer until turtle is thoroughly tender. This may be ascertained by piercing it with a fork. Take it off the stove and strain through a colander into the tureen. Add the whites and yolks of two hard boiled eggs, chopped finely, and one glass of wine. Slice a lemon thinly and add to the soup and serve hot.

How to Serve Turtle Soup: Great care should be taken in serving the soup. Bear in mind that boiling the soup a second time, or warming it over, deprives it of much of its delicious flavor. To avoid this, fill two tureens with boiling water; let them stand a few minutes, then dry the insides thoroughly and place in a "bain-maria" or a hot-water bath. Fill the tureens with the soup and cover tightly. Bring them to the table, adding some dainty slices of lemon just before serving. If the meat is served, use only the most delicate portions.

Sushi Rolls (Seaweed stuffed with vinegared rice)

There are many different versions of this recipe, some more involved than others. The following version is somewhat "Americanized". Dried mushrooms and nori are available in specialty and ethnic food stores.

Vinegared Rice:

1/4 cup rice vinegar
3 tablespoons sugar
2 teaspoons salt
1 tablespoon sherry (or rice wine if available)
2 cups raw rice (washed until the water runs clear)

Mix vinegar, sugar, salt and sherry together. Wash and cook the rice with the equal amount of water. When the rice is done and still hot, place on a shallow platter, pouring the vinegar mixture over the rice and mixing with a few, swift strokes at the same time. Allow rice to cool.

Sushi:

6 cups vinegared rice (recipe above)
6 dried mushrooms
9 shrimp
2 eggs
6 sheets nori cut in half lengthwise
18 sprigs coriander or spinach leaves

Soak mushrooms in 1 cup warm water until soft (about 20 minutes). Squeeze lightly, remove stem, slice in 1/2 inch pieces, and cook in 2 tablespoons soy sauce, 1 tablespoon sugar and 1/2 cup of the soaking liquid. Parboil coriander or spinach for 30 seconds or so. Drain and cool. Skewer the raw cleaned shrimp lengthwise with a toothpick to prevent curling and cook in boiling water just until done. Drain and cool. Beat eggs one at a time and fry in approximately 2 teaspoons oil to make crepes. Cool and slice in 1/2 inch strips.

To assemble: Place a nori sheet flat. Spread a fistful of rice on, leaving 1 1/2-2 inches on far side. Lay egg slices on, then coriander or spinach, then mushrooms, then whole shrimp. Roll up tightly, pushing hard to eliminate air spaces (a bamboo mat will help). Refrigerate for 10 minutes. Slice in rounds and serve at room temperature with soy sauce.

Seaweed Salad

A few strands wakame
1 cucumber, sliced
crab meat
salt
vinegar
sugar

Use wakame (lobe-leafed undaria), which is a type of seaweed sold dried. Restore it to a fresh state by briefly soaking in warm water. After soaking, cut the hard stems off. Mix wakame with sliced cucumber and crab meat, add a mixture of salt, vinegar, and sugar to taste and serve in a porcelain bowl.

Seaweed Vegetarian Dish

Soak hijiki (spindle-shaped bladder leaf) in water for a few hours until soft. Fry in oil sliced carrots and/or onion. Add hijiki, soy sauce, and sugar at the end of frying.

Fillets in Nori Wrappers

2 pounds fish fillets (white, firm fish)
10 sheets dried nori
1/2 cup whole wheat flour
1/2 cup wheat germ
1 teaspoon red pepper or cayenne
2 to 3 eggs, beaten
peanut oil

Wash fish and pat dry with a clean towel. Cut fillets to about 2 inches by 4 inches.

Cut nori sheets in fours. Wrap the nori around the fillets.

Combine the flour, wheat germ, and red pepper. Paint each wrapper with beaten egg and roll in the flour mixture. Coat about 6 to 8 at a time and fry in hot peanut oil until they become a rich golden brown. Then turn and fry the other side.

Serve hot. Makes 4 to 6 servings.

Carrot Cake with Nori Flakes

Varying amounts of nori can be used in this recipe. Doubling the seaweed will produce an extra-nutty, rich taste.

1/2 cup melted butter
1 sheet dried nori
1 cup finely grated raw carrot
1 1/4 cups whole wheat flour
2 eggs
1/2 cup honey
2 teaspoons baking powder
1/2 cup fresh lemon juice

Preheat oven to 350°F. Melt the butter in a saucepan. Tear the nori into pieces about the size of peas, and add to the melted butter to hydrate (about 5 minutes). Combine all ingredients. Mix well. Pour into well-buttered 5-cup mold or bread pan. Bake 1 hour. Let cool 10 minutes before removing from pan. Cool completely before serving. Makes 6 servings.

VI-I: SAUCES

Cocktail Sauce

1/2 cup catsup
1 tablespoon horseradish
1/2 teaspoon celery salt
6 tablespoons lemon juice
3 drops hot pepper sauce
1/4 teaspoon salt

Blend all ingredients and chill. Serves 6.

Tartar Sauce

1/2 cup mayonnaise
1 tablespoon pickles, minced
1 tablespoon olives, minced
1 tablespoon onion, minced
1 tablespoon parsley, minced

Mix thoroughly and chill.

Clam Dip

1 can (7 ounces) minced clams
2 packages (3 ounces each) cream cheese
1/4 teaspoon salt
2 teaspoons grated onion
Potato chips
1 teaspoon Worcestershire sauce
3 drops hot pepper sauce
2 teaspoons lemon juice
1 teaspoon chopped parsley

Drain clams. Save liquor. Soften cheese at room temperature. Combine all ingredients except potato chips and liquor; blend into a paste. Gradually add about 1/4 cup clam liquor and beat until consistency of whipped cream. Chill. Serve in a bowl surrounded by potato chips. Makes about 1 pint dip.

Crab Dip

1 cup mayonnaise
1/2 cup sour cream
1 tablespoon chopped parsley
8-12 ounces crab meat
1 tablespoon sherry
1 teaspoon lemon juice
salt and pepper

Combine all ingredients and chill. Makes 2 cups.

Remoulade Sauce

- 1/4 cup tarragon vinegar
- 2 tablespoons prepared brown mustard
- 1 tablespoon catsup
- 1 1/2 teaspoon paprika
- 1/2 teaspoon salt
- 1/4 teaspoon cayenne pepper
- 1/2 cup salad oil
- 1/4 cup chopped celery
- 1/4 cup chopped green onion
- 1 tablespoon chopped parsley

In small bowl combine vinegar, mustard, catsup, paprika, salt and cayenne. Slowly add salad oil, beating constantly (may also be done in blender). Stir in celery, green onion, and parsley. Allow to stand 3-4 hours to blend flavors. Makes 1 1/4 cup sauce.

Blender Hollandaise Sauce

- 3 egg yolks
- 2 tablespoons lemon juice
- dash cayenne pepper
- 1/2 cup margarine or butter

Place egg yolks, lemon juice and cayenne pepper in blender container. Cover; quickly turn blender on and off. Heat margarine until melted and almost boiling. Turn blender on high speed; slowly pour margarine in, blending until thick and fluffy, about 30 seconds. Heat over warm, not hot, water until ready to serve. Makes 1 cup.

Blender Bearnaise Sauce

- 1 tablespoon chopped green onion
- 2 teaspoons lemon juice
- 1/4 cup dry white wine
- 1/2 teaspoon dried tarragon leaves
- 1/4 teaspoon dried chervil leaves
- 3 egg yolks
- 1/8 teaspoon cayenne pepper
- 1/2 cup margarine or butter

In small saucepan combine green onion, lemon juice, white wine, tarragon, and chervil. Simmer until mixture is reduced to about 2 tablespoons. Cool. Place egg yolks, cayenne and herb mixture in blender container. Cover; quickly turn blender on and off. Heat margarine until melted and almost boiling. Turn blender on high speed; slowly pour margarine in, blending until thick and fluffy, about 30 seconds. Heat over warm, not hot, water until ready to serve. Makes 1 cup.

Mustard Sauce

1/4 cup margarine or butter
3 tablespoons all-purpose flour
1 1/2 tablespoons dry mustard
1/2 teaspoon salt
1/4 teaspoon liquid hot pepper sauce
2 cups half and half
1 egg yolk, beaten

In a saucepan melt margarine. Blend in flour, mustard, salt and liquid hot pepper. Gradually stir in half and half; cook until thickened, stirring constantly. Heat until thickened. Serve sauce over fish. Makes approximately 2 cups.

VI-J: GARNISHES

The importance of garnishes cannot be emphasized too much. No matter how nutritious and carefully prepared the food on a menu is, the visual appeal can be a determining factor in whether the food is eaten or not. Menus should be carefully planned to include garnishes that will be appealing to your eye as well as your appetite. Some of the more common garnishes are listed below to be used alone or in combination. For more substantial menu items, some tangy-sweet flavor combinations are suggested on the next page. All garnishes should be edible and should enhance the recipe they are used with.

Garnishes	Suggested Preparation
Artichoke Heart	Sliced
Basil Leaves, fresh	Whole or chopped
Beets	Cooked whole or sliced
Capers	Sprinkled sparingly
Carrots	Tops, sticks, curls, or shredded
Chives	Chopped
Cranberry sauce (jellied)	Cutouts
Cucumbers	Slices, sticks, basket
Dill	Sprigs or chopped
Grapes, green or purple	Plain or frosted
Green or red peppers	Sticks or rings
Hard-cooked eggs	Slices, wedges, deviled, or grated yolks
Kiwi fruit	Sliced
Lemons or limes	Slices, twists, wedges, curls
Lettuce, red leaf, Boston, bibb, Romaine	Leaves or shredded
Mint	Sprigs or chopped
Nut meats	Toasted whole, halved, slivered or chopped
Oranges, fresh or canned mandarin	Slices, twists, wedges
Paprika	Sprinkled sparingly
Parsley	Sprigs or chopped
Pickles	Whole, sliced, chopped, fans
Radishes	Whole, sliced or roses
Tomatoes, Cherry	Sliced
Water cress	Sprigs or chopped
Scallions	Shredded and curled from root end

- "Side-Boys" for seafood curry including kumquats, coconut, vegetable or fruit chutney, chopped peanuts, chopped onions, chopped raisins, etc.
- Broiled orange sections dipped in honey and shredded coconut
- Broiled peach halves sprinkled with oregano-seasoned bread crumbs
- Fruit and/or vegetable kabobs
- Cherry tomatoes filled with seasoned cottage cheese
- Golden broiled pineapple slices teamed with vivid spiced crab apples
- Grape or mint jelly in small pear halves
- Heated tomato halves topped with drained warm sauerkraut with caraway seeds
- Orange cups filled with cranberry sauce or lemon-cranberry relish
- Thin unpeeled orange slices topped with tiny plain or sugared grape clusters. Add mint or watercress sprigs.
- Whole tomatoes filled with cole slaw. Cut tomatoes almost through into sixths and spread open to give petal effect before adding cole slaw.

PART VII: COMPOSITION AND NUTRITION

VII-A: DARK MUSCLE AND WHITE MUSCLE

Fish muscle does not have a uniform color. Some muscles are white while others have a reddish or brown color. This dark color is usually observed just under the skin. The proportion of dark to white muscle differs continually from head to tail. The proportion also varies between species, increasing with the swimming activity of the fish and sometimes approaching 48 percent of the body weight. There are often differences in the chemical composition of dark and white muscles with respect to protein and lipid contents. The dark muscle has greater concentrations of hemoglobin and myoglobin than the white muscle.

The presence of dark muscle is related to the activity of the fish. Those fish that swim continuously throughout their lives usually have a larger proportion of dark muscle than those that often rest on the sea bottom. It appears that white muscle controls short spurts and darting movements, while dark muscle is used for slow, continuous movement.

When freezing fish, the dark muscle is sometimes removed in order to prolong the storage life of fish. The dark muscle spoils faster because it contains hematin compounds which can act as pro-oxidants. It has been observed that dark muscle oxidizes 100 times faster than white muscle. Therefore, consumers should be careful not to store dark muscle fish for long periods since adverse flavor changes may occur due to oxidation. The greater the content of dark muscle, the shorter the storage life.

VII-B: FISH AND SEAFOOD - COMPOSITION AND NUTRITIONAL ASPECTS

Throughout the ages, seafood has been one of man's chief sources of animal protein. Ancient Egyptians processed fish by sun-drying, salting, or both, in order to preserve a constant supply. Early Romans had fish ponds where they kept the animals until preparation time. Wherever man lives near water and is assured a supply of protein, there is no evidence of malnutrition due to the lack of protein.

Calories

Fishery products with no added sauces are low in calories. A 100-gram raw edible portion of a low-fat fish such as haddock or cod contains about 80 calories; a high-fat fish such as bluefish or mullet about 120 calories.

Protein

The amount of protein in a species of fish varies with feeding habits, age and sex of the fish, and fat and water contents of the flesh. On the average, the muscle of finfish contains 18 to 22 grams (g) of protein per 100 g of edible portion. Mollusks contain less protein and crustaceans more than the finfish. The protein content of the various muscles in the fish body is not always the same. For example, the white muscle of the albacore is higher in protein than the dark meat which contains more fatty tissue. The nutritive value of the protein in fish flesh is equal to or better than milk protein (casein). Unless fish is badly handled during processing or cooking, the nutritive quality of the protein does not change markedly.

There is scientific evidence that fish muscle is highly digestible. All of the essential amino acids needed for man's good protein nutrition are present in fish muscle. It is high in lysine and therefore is a good supplement to a cereal diet. All of man's protein requirements may be met by a diet with fish as its sole protein source.

Water

Average finfish and some shellfish contain 80 to 85 percent water, with the extreme values ranging from 53 to 90 percent. Mollusks contain more water than finfish or crustaceans. The amount of water in some animals varies with season. Before spawning, finfish is high in fat and low in water, and at other times the reverse ratio prevails.

Fat

The chemical composition of the lipid content of fish flesh differs from that of most other naturally-occurring oils and fats in: (1) having a greater variety of lipid compounds, (2) possessing larger quantities of fatty acids with chain lengths exceeding 18 carbons, (3) containing a much greater proportion of highly unsaturated fatty acids, and (4) having polyunsaturates, primarily at the W3 rather than W6 position. The lipid content of a species of fish varies with season, geographic origin, prevailing temperatures of the environment, physiological status of the animal (pre- or post-spawning), and available food. There is an inverse relationship between the water, protein, and fat contents of fish flesh. When the fat content is high, the moisture level and protein content are lower. The amounts and character of the fatty acids vary with the different organs and parts of the fish. For example, the liver oils contain different lipids than do the dark or the white meats.

These polyunsaturated fatty acids have important nutritional roles. Fish lipids contain 2 to 9 percent linoleic acid, which is needed for growth and for the maintenance of normal integrity. The linolenic acid of the W3 series not only supports growth, but also functions in the transport of lipoid material such as cholesterol.

The lipids may be divided into 2 parts: (1) saponifiables, which contain the mono-, di-, and tri-glycerides; (2) non-saponifiables, containing the fat-soluble vitamins, A, D, and E, steroids, and phospholipids. The variation in the amount of non-saponifiable material is small and somewhat constant. Changes in the amount of lipid content of fish flesh are mainly due to variation in the amount of triglycerides.

Ash

In the edible portion of fishery products the percent ash varies from 0.4 to 1.5 g per 100g. The amount present is clearly associated with the amount of skin and bones present in the samples of fish muscle. Small fish such as herring or smelt are often utilized whole and therefore their ash content approximates 3-4 g/100g. In processed fish the ash content is high, since salt is often used in the canning or drying procedures.

Ash in fish muscle contains nutritionally important minerals. Sodium and potassium play a significant role in cellular physiology. Values reported in literature range from 30 to 150 milligrams (mg) for sodium with an average of 60 mg/100g of fish muscle, and 250 to 500 mg with an average of 400 mg for potassium. Freshwater fish are somewhat lower in sodium than salt-water fish, 34-96 mg in salt-water fish and 38-84 mg/100g in freshwater fish. The corresponding figures for potassium are 240-400 mg in flesh of marine species and 133-440 mg/100g of freshwater fish. Some species from different areas show differences in sodium content; for example, whiting from the Atlantic Ocean contain 82 mg/100g compared to 65 mg/100g for the Pacific Ocean whiting. These elements also vary with size and season. Some fishery technologists postulate that the variation in sodium and potassium may be associated with life cycle (pre- or post-spawning). In crustaceans and mollusks, the sodium content in the flesh is higher, but the potassium tends to be lower than in the teleosts.

Values for calcium range for 5 to 200 mg/100g with an average of 30 mg/100g of fish flesh; for phosphorus 100 to 400 mg with an average of 220 mg. This variability may be related to a number of factors, such as the amount of calcium and phosphorus present in the water and/or food, and age, size, and sexual maturity of the animal. The levels of these minerals are much higher in whole fish; in fact, whole fish is a nutritionally excellent source of calcium. Crustaceans and mollusks tend to contain more calcium and less phosphorus in the muscle tissue than do the finfish.

Magnesium is another important dietary nutrient for it activates the enzyme system which functions in the metabolism of carbohydrates to produce energy. Fish is a good source of magnesium. The amount found in the flesh is associated with the amount in the food chain. It is not known whether the animal accumulates this element in its muscle or reaches a saturation point at which the magnesium content levels off.

Fish flesh contains most of the elements present in sea water.

Some are nutritionally important: iron, copper, iodine, fluorine, cobalt, zinc, chromium, and vanadium. The amount of each of these elements present in fish is determined by such variables as the amount present in the food chain, and the size and age of the animal. Also, certain species of fish have a tendency to accumulate more of some of the elements than others.

Iron and copper are important elements needed for good nutrition. They are needed by the body to synthesize hemoglobin. There is about one mg of iron (0.4-5 mg) per 100 g of fish flesh. Dark meat is richer in iron than white meat. Also, freshwater fish contain less iron than marine species. No information is available as to whether the iron in fish is biologically available. If it is, then fish flesh is a good source of iron. The amounts of copper in fish flesh range from 0.04 to 0.6 mg/100g with an average of 0.25 mg. Crustaceans and mollusks contain more iron and copper than finfish.

Seafood is the richest natural source of iodine, which is nutritionally important for the maintenance and function of the thyroid gland in the production of thyroxine. It is difficult to give an overall average amount that can be expected to be present in the flesh of fish. For marine species of finfish the values range from 16 to 318 micrograms (μg), for freshwater fish 1.7 to 40 μg/100g of flesh. Iodine seems to concentrate in the oil fraction of the fish. In fatty fish, the iodine is found to a greater extent in the skin than in the muscle. The reverse situation appears in the lean fish.

Fluorine is found in the skeleton rather than in the muscle of fish. Marine species have larger amounts of fluorine than freshwater species. Limited data are available. The values range from 0.5 to 1.0 mg per 100g of flesh. A small amount of this element is needed to prevent cavities in growing children, and to prevent brittleness in the bones of the aged.

Cobalt is a component of the molecular structure of vitamin B_{12}. Zinc is present in the cells of all living organisms and is especially plentiful in marine organisms. The element functions in many enzymatic systems and therefore has a predominant role in carbohydrate and protein metabolism. In finfish flesh the amount of zinc ranges from 0.7 to 30 mg/100g, the amount present in the environment playing a great role in the exact concentration. Shellfish tend to concentrate zinc in larger quantities than those needed by the organism (1.2-26.0 mg/100g).

A number of nutritionally important elements are found in trace amounts (more so in marine than in freshwater animals); for example, chromium and vanadium. In man, minute amounts of vanadium are found in the bony and fatty tissues. There is also some experimental evidence that vanadium interferes with the synthesis of cholesterol. Chromium functions in glucose and fat metabolism.

There are some elements that may be toxic to man if ingested in large amounts. Mercury is one. Mercury, per se, is not absorbed from the gut, but the mercury compound methylmercury is. Therefore, the Food and Drug Administration has set a guideline of 0.5 parts per million (ppm) for the allowable amount of mercury present in food. The presence of selenium has been shown to interfere with the absorption of methylmercury. Little is known about this relationship. Arsenic is another element that falls into this category. The amount of arsenic found in seafood flesh is closely associated with the amount present in the environment. Metallic arsenic is far more toxic than the organic form of the metal. It has been shown in animal studies that arsenic in shrimp is by far less toxic than the inorganic form. Cadmium is another metal that may be toxic to man. So little is actually known about these toxic metals that no clear conclusions can be drawn.

Vitamins

There are indications that the vitamin content in fish muscle varies with species, age, season, sexual maturity, and geographical areas. No extensive studies have been published on the vitamin content in the various species of fish flesh. There is an abundance of information on the fat-soluble vitamins A and D in fish liver oil.

Most of the vitamins A and D are found in the viscera, especially the liver; very little, if any, in the flesh. The vitamin A content of fish flesh ranges from 0 to 18,000 international units (IU) per gram of tissue. Cod, herring, and ocean perch contain negligible amounts of vitamin A in their flesh, even when the liver contains large amounts of the vitamin. However, lamprey, eel, shark, and conger eel contain more vitamin A in the flesh than in the viscera. White meat contains less vitamin A than dark flesh. In general, there is very little or no vitamin D in fish flesh. The content is somewhat dependent upon the species. For example, the flesh of yellow tail and flatfish contains very little vitamin D, while sardine and mackerel contain a higher level. Information on the vitamin E or K content in the muscle tissue is sparse. The gonads are rich in vitamin E, which may be connected with spawning activities. Potency varies from a high level before spawning to a low one after spawning.

Some important members of the water-soluble vitamins which exist in fish flesh include thiamine, riboflavin, pyridoxine, niacin, folic acid, pantothenic acid, vitamin B_{12}, and vitamin C. The distribution of these vitamins in the body of the marine animals is not like that of the fat-soluble vitamins which concentrate in the viscera. The water-soluble vitamins are more evenly dispersed throughout the body.

Thiamine (B_1) content in fish flesh ranges from 0 μg in carp and suckers to 660 μg in flounder, with an average of approximately 100 μg per 100g of fish muscle. The presence of thiaminase should be considered whenever certain fish such as carp, mackerel, or sardine are being fed to terrestrial animals. In this case, the fish should be thoroughly cooked to destroy the enzyme. No process except cooking will destroy its activity.

The amount of riboflavin (B_2) in fish is far more variable than the amount of thiamine. Riboflavin functions in the co-enzyme systems that participate in metabolism and growth of animals. This physiological activity is not as clearly documented in marine animals as in terrestrial animals. Dark meat contains more riboflavin than white meat. The amounts of this vitamin in the flesh of cod, haddock, mackerel, salmon, smelt, and tuna are comparable to those found in the meat of terrestrial animals, 50 to 980 μg/100g of muscle.

Again, the real function of pyridoxine (B_6) in fish has not been clarified as in mammalian organisms. It plays a vital role in general fat metabolism, that is, the conversion of carbohydrate and protein into fat. Whole fish is a good source of pyridoxine. The range of values is 100 to 1,200 μg per 100g of fish flesh. The fish-spoiling bacteria produce large amounts of vitamin B_6 during their activity, and consequently it is difficult to determine the real biochemical role of this vitamin in fish metabolism.

Fish muscle is a good source of niacin. The amounts range from 0.9 to 3.1 mg per 100g of tissue. The amount of niacin in the flesh appears to be associated with the degree of mobility exhibited by each species of fish. Those with greater locomotive power carry more niacin than species with poor locomotion.

Seafood contains significant amounts of vitamin B_{12}, especially the fatty fish and shellfish. The potency of the vitamin is higher in dark flesh fish, such as herring and sardine, than in white flesh, such as cod or flatfish. The amount in fish muscle ranges from 0, as in shark, to 1.9 μg/100g in Pacific herring. Since this vitamin is synthesized by microorganisms, fermented fish products are a rich source of vitamin B_{12}.

Very little is known about the physiological function of pantothenic acid in fish. Muscle tissue contains the least amount of pantothenic acid. The values range from 0 to 1,400 μg per 100g of tissue. The variation is quite small within species but considerable between species. The greatest concentration is found in the gonads; therefore it may be associated with the reproductive system. Like most of the other B-vitamins, the concentration is higher in dark meat than in white meat.

The edible portion of fish muscle is not always a rich source of folic acid. It is concentrated in the kidney, liver, and spleen. The values for a select number of fish range from 0 for grouper to 11 μg for mullet and Arctic cod per 100 g of muscle tissue. There is a negligible amount of vitamin C in the edible portion of fish. Most of it is found in the vital organs of the animal.

REFERENCES

Borgstrom, George. 1961. Fish as Food. Volumes I and II. Academic Press Inc., New York.

Heen, Eirik and Kreuzer, Rudolf. 1962. Fish in Nutrition. Fishing News (Books) Ltd. London.

Love, R. M. 1957. The Biochemical Composition of Fish. In The Physiology of Fish, Margaret E. Brown, Editor. Academic Press Inc., New York.

VII-C: SEAFOOD COMPOSITION TABLES

The tables that follow are the result of extensive analyses by researchers for the National Marine Fisheries Service. In each table, the left-hand column lists the individual species analyzed. The other columns list the compositional milligrams per hundred grams. Dashes represent information that is not available.

The charts are composed of groups containing three figures. In each group, the first figure is the mean (average) followed by the standard error. The second figure is the range of values found, from lowest to highest. The third figure is the number of analyses made for that particular species. Thus, in the first table we find that haddock contains 79% moisture (plus or minus 0.2 g), with individuals ranging from 78 to 80.7% in 20 analyses.

TABLE VII-1: PROXIMATE COMPOSITION, CALCIUM, AND PHOSPHORUS CONTENT OF THE EDIBLE PORTIONS OF RAW FINFISH

Fresh finfish	Proximates				Minerals	
	Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Ca mg%	P mg%
Catfish (Cultured)	*77.4±0.1	20.5±0.7	1.53±0.09	0.65±0.32	64±8	228±14
Ictalurus punctatus	**74.5-80.7	17.0-23.9	1.10-1.94	0.09-2.31	20-90	130-240
	***10	10	10	8	9	9
Catfish (Wild)	79.4±0.2	18.2±0.3	1.19±0.02	0.96±0.11	27±2	214±8
Ictalurus punctatus	77.9-80.0	16.3-19.7	1.09-1.25	0.51-1.51	19-37	158-298
	10	10	10	9	9	15
Cod (Icelandic)	81.4±0.2	18.1±0.2	1.20±0.02	0.10±0.02	22±1	192±7
Gadus morhua	79.0-83.1	16.7-19.6	1.01-1.36	0.01-0.26	18-30	150-240
	22	20	20	20	16	15
Cod (Inshore-Domestic)	80.1±0.3	19.6±0.3	1.26±0.04	0.12±0.02	42±5	222±6
Gadus morhua	76.8-83.3	16.3-21.8	0.96-1.84	0.00-0.30	19-80	180-270
	23	24	20	20	16	18
Flounder, Yellowtail	76.5±0.3	22.3±0.4	1.21±0.04	0.37±0.06	27±2	203±12
Limanda ferruginea	74.1-78.7	18.8-25.5	1.05-1.76	0.05-1.16	20-40	170-300
	20	20	20	19	14	12
Haddock (inshore)	79.0±0.2	20.4±0.3	1.50±0.05	0.11±0.01	62±7	211±13
Melanogrammus aeglefinus	78.0-80.7	16.7-22.6	1.12-1.87	0.03-0.23	20-90	150-350
	20	20	21	20	11	20
Hake, Pacific	80.1±0.2	18.4±0.4	1.25±0.04	0.69±0.10	28±3	176±5
Merluccius productus	78.7-81.1	16.2-22.4	1.00-1.59	0.20-1.50	20-50	150-200
	18	18	18	17	17	15
Halibut, Pacific	77.5±0.4	20.1±0.3	1.27±0.02	1.22±0.23	47±6	221±8
Hippoglossus stenolepsis	76.6-80.9	18.1-22.9	1.14-1.49	0.43-3.90	20-78	160-260
	23	21	21	19	13	16
Perch, Ocean	77.3±0.3	21.7±0.3	1.45±0.03	0.81±0.11	141±7	223±6
Sebastes marinus	75.8-80.2	19.6-24.8	1.18-1.71	0.10-1.44	80-190	160-270
	21	19	22	17	21	23
Pollock	77.7±0.2	20.9±0.2	1.47±0.06	0.15±0.03	87±12	228±10
Pollachius virens	75.8-80.6	19.2-22.5	1.12-2.01	0.0-0.51	30-150	160-300
	22	23	20	20	11	16
Rockfish, Pacific	79.7±0.2	19.8±0.3	1.26±0.03	0.53±0.10	39±5	214±7
Sebastes sp.	78.0-81.3	18.0-22.6	1.07-1.42	0.03-1.58	20-90	160-250
	22	22	20	19	9	12
Snapper, Red	76.0±0.2	22.4±0.1	1.31±0.02	0.41±0.08	28±4	210±8
Lutjanus blackfordii	73.8-77.7	20.9-23.6	1.16-1.55	0.09-1.36	20-50	160-240
	24	23	20	21	15	19
Whiting	78.7±0.4	17.8±0.2	1.26±0.03	2.43±0.22	72±6	221±11
Merluccius bilinearis	75.6-80.9	16.3-19.5	1.00-1.53	0.78-4.76	50-100	150-290
	22	25	21	20	11	13

*Mean and standard error of the mean.
**Range.
***Number of analyses.

TABLE VII-2: PROXIMATE COMPOSITION, CALCIUM, AND PHOSPHORUS CONTENT OF THE EDIBLE PORTIONS OF CANNED FINFISH

Canned finfish	Proximates				Minerals	
	Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Ca mg%	P mg%
Salmon, Sockeye *Oncorhynchus nerka*	*71.3±0.2 **69.3-72.5 ***16	21.0±0.2 19.3-22.1 20	2.35±0.11 1.55-3.03 17	6.04±0.13 5.20-7.08 16	22±1 19-28 9	273±10 180-340 17
Tuna, Yellowfin (canned in oil) *Thunnus albacares*	59.9±0.4 57.9-62.2 14	22.9±0.5 19.3-24.3 12	1.91±0.05 1.51-2.11 12	15.2±0.4 13.0-17.7 11	37±7 20-67 7	224±5 190-260 15
Tuna, Yellowfin (canned in brine) *Thunnus albacares*	74.8±0.4 73.1-76.5 8	24.0±0.2 23.3-24.8 8	1.48±0.12 1.14-1.92 8	0.81±0.08 0.43-1.04 8	33±9 20-50 3	195±12 180-230 4

*Mean and standard error of the mean.
**Range.
***Number of analyses.

TABLE VII-3: PROXIMATE COMPOSITION, CALCIUM, AND PHOSPHORUS CONTENT OF THE EDIBLE PORTIONS OF RAW CRUSTACEANS

Crustaceans	Proximates				Minerals	
	Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Ca mg%	P mg%
Crab, Blue	*77.4±0.3	19.8±0.1	2.06±0.04	1.02±0.07	102±12	272±10
Callinectes sapidus	**75.2-80.6	18.4-21.0	1.81-2.46	0.55-1.58	22-180	200-370
	***22	22	22	20	13	16
Crab, King (body)	79.2±0.3	18.3±0.2	1.60±0.05	0.38±0.02	42±3	212±10
Paralithodes camschatica	76.7-81.4	17.0-19.5	1.19-1.83	0.24-0.54	21-69	180-273
	16	16	16	16	24	25
Crab, King (leg)	76.8±0.07	20.1±0.5	1.81±0.06	0.40±0.03	55±4	228±10
Paralithodes camschatica	69.2-79.3	17.2-24.9	1.28-2.52	0.22-0.67	40-80	160-320
	17	18	18	18	12	18
Lobster, Spiny	75.6±0.3	23.1±0.2	1.71±0.02	0.33±0.03	47±4	237±11
Panulirus argus	74.2-79.0	22.0-25.6	1.51-1.96	0.17-0.55	20-80	150-320
	23	20	20	15	18	19
Shrimp, Alaskan	77.4±0.3	20.1±0.4	2.26±0.14	0.64±0.02	49±4	187±4
Mixed spp.	75.5-79.7	16.7-26.2	1.41-3.77	0.44-0.85	40-80	170-210
	20	22	19	20	14	12
Shrimp, Asian	84.0±0.4	15.2±0.4	0.77±0.03	0.42±0.17	68±5	181±10
Mixed spp.	81.0-87.3	13.1-18.8	0.53-0.96	0.12-3.00	30-90	130-230
	20	20	21	16	14	10
Shrimp, Brown	76.2±0.1	21.4±0.2	1.63±0.01	0.14±0.01	59±2	248±5
Penaeus aztecus	75.2-76.5	17.2-23.3	1.54-1.72	0.05-0.28	40-80	220-290
	20	23	20	20	19	18
Shrimp, Maine	81.5±0.5	17.1±0.4	1.30±0.06	0.39±0.05	54±4	177±9
Pandalus borealis	77.9-86.0	13.5-20.2	0.93-1.86	0.12-0.82	40-80	150-270
	19	23	20	19	11	14
Shrimp, Mexican	80.4±0.3	18.1±0.3	1.40±0.04	0.18±0.03	95±2	176±4
Mixed spp.	78.5-82.5	16.5-20.6	1.14-1.68	0.06-0.55	70-120	150-210
	22	23	20	18	14	18
Shrimp, White (Gulf)	77.4±0.2	20.6±0.1	1.41±0.02	0.20±0.02	50±1	233±9
Penaeus setiferus	76.4-78.7	19.5-21.6	1.26-1.57	0.05-0.40	40-60	150-290
	20	21	20	20	20	17
Shrimp, White	76.2±0.2	22.0±0.2	1.90±0.05	0.17±0.02	64±3	281±11
(South Atlantic)	75.3-79.5	20.9-23.5	1.86-2.03	0.06-0.26	50-90	160-350
Penaeus setiferus	22	20	20	15	17	17

*Mean and standard error of the mean.
**Range.
***Number of analyses.

TABLE VII-4: PROXIMATE COMPOSITION, CALCIUM, AND PHOSPHORUS CONTENT OF THE EDIBLE PORTIONS OF RAW MOLLUSCA

Mollusca	Proximates				Minerals	
	Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Ca mg%	P mg%
Clams (Hard Shell) *Marcenaria mercenaria*	*91.8±0.1 **90.8-92.5 ***20	4.41±0.17 3.20-6.24 19	1.97±0.02 1.79-2.16 20	0.21±0.02 0.10-0.42 20	65±3 20-91 31	69±3 50-130 26
Clams (Soft Shell) *Mya arenaria*	83.3±0.9 76.6-90.8 20	9.51±0.43 5.48-11.68 20	1.19±0.09 0.62-1.99 17	1.27±0.16 0.42-2.64 20	53±3 17-73 27	152±6 110-206 24
Clams (Surf) *Spisula solidissima*	79.4±0.2 78.2-80.9 20	15.6±0.1 14.6-16.7 20	2.29±0.10 1.10-3.05 20	0.34±0.06 0.10-0.87 20	41±3 17-80 31	194±5 110-265 36
Oysters (Long Island) *Crassostrea virginica*	85.4±0.2 82.5-86.6 20	7.86±0.23 6.65-10.28 20	1.11±0.02 0.93-1.28 20	1.13±0.07 0.75-1.89 20	52±3 30-70 20	145±6 110-240 20
Oysters (Maryland & Virginia) *Crassostrea virginica*	88.3±0.2 87.0-90.0 21	5.77±0.24 4.48-7.86 20	0.65±0.02 0.55-0.83 20	1.06±0.08 0.56-1.97 19	36±4 20-70 17	121±5 100-140 7
Scallops (Bay) *Pecten sp.*	78.8±0.7 76.4-87.8 20	14.1±0.1 12.9-14.8 19	1.42±0.02 1.25-1.59 20	0.20±0.03 0.09-0.43 20	32±5 20-80 16	207±5 180-250 17
Scallops (Calico) *Argopecten gibbus*	77.8±0.4 76.8-83.6 20	16.9±0.1 15.9-18.5 20	1.79±0.01 1.71-1.89 20	0.21±0.02 0.11-0.31 19	32±2 20-60 19	215±5 160-270 20
Scallops (Sea) *Placopecten magellanicus*	78.2±0.2 77.2-79.7 21	18.2±0.1 17.1-19.0 20	1.50±0.02 1.38-1.84 20	0.17±0.02 0.02-0.32 20	22±1 20-30 15	234±16 150-320 16

*Mean and standard error of the mean.
**Range.
***Number of analyses.

TABLE VII-5: COMPOSITION OF THE EDIBLE PORTIONS OF RAW (FRESH OR FROZEN) CRUSTACEA, FINFISH, AND MOLLUSKS, I. PROTEIN, FAT, MOISTURE, ASH, CARBOHYDRATE, ENERGY, AND CHOLESTEROL

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Abalone *Haliotis kamtschatkana*	*14.9±0.2 **10.4-18.2 ***4	0.5±0.1 0.3-0.7 3	76.9±2.9 72.6-82.4 3	1.8±0.6 1.0-3.0 3	---	---	---
Albacore *Thunnus alalunga*	24.2±0.5 19.1-27.6 18	5.4±0.9 0.7-18.2 19	70.2±1.0 62.3-78.6 17	1.3±0.1 1.2-2.4 18	0.2 --- 1	134±17 107-185 5	---
Amberjacks *Seriola* spp.	21.1±0.7 20.1-22.5 3	1.6±0.4 0.8-3.1 5	75.2±1.2 73.4-77.5 3	1.2 1.1-1.3 2	---	96 --- 1	---
Anchovies *Engraulidae* spp.	20.2±0.7 18.4-21.8 4	2.4±0.8 0.5-3.8 4	76.0±1.1 73.4-81.0 4	1.8±0.1 1.5-2.1 4	---	93±5.3 73-103 3	---
Anchovy, striped *Anchoa hepsetus*	17.4±0.2 16.2-18.9 21	2.8±0.2 1.6-4.6 21	76.6±0.3 74.2-78.1 21	3.3±0.1 2.6-4.1 21	---	---	---
Barracouta *Thyrsites atun*	22.0±0.1 21.9-22.1 3	4.8±1.2 2.6-6.7 3	71.0±0.9 69.5-72.6 3	1.6±0.2 1.3-1.8 3	0.7 --- 1	132 --- 1	---
Barracudas *Sphyraenidae* spp.	19.8±0.2 18.4-22.1 39	3.2±0.4 0.2-10.3 43	75.8±0.4 69.1-79.5 40	1.7±0.1 1.1-2.5 40	1.1±0.3 0.1-2.2 6	94±3.1 77-110 9	---
Basses *Percichthyidae* spp.	18.1±0.3 16.6-18.9 11	3.0±0.6 0.1-6.7 9	77.4±0.7 74.5-81.1 11	1.4±0.2 1.0-2.9 11	---	113±11.0 92-129 3	---
Basses *Serranidae* spp.	18.6±0.3 17.3-20.1 7	1.6±0.4 .1-3.0 7	78.6±0.3 77.3-79.6 7	1.1±0.1 0.9-1.2 7	---	---	---
Bluefishes *Pomatomidae* spp.	21.0±0.4 20.4-21.6 3	3.8±0.8 2.1-4.8 3	74.7±1.7 69.0-81.4 6	1.3±0.1 1.1-1.5 4	---	---	---
Bonita *Sarda* spp.	24.7±1.6 22.6-29.3 4	4.5±2.0 1.5-10.2 4	71.3±1.9 66.3-74.8 4	1.5±0.1 1.4-1.7 4	---	---	---
Bream *Pagellus* spp.	17.9±1.0 16.4-20.7 4	1.6±0.4 0.5-2.3 5	74.8±3.5 61.3-80.2 5	1.5±0.4 1.4-1.6 5	---	82.3±4.6 70-92 4	---
Bream, lg-eyed *Monotaxes grandoculis*	18.4±0.6 17.1-19.0 3	1.0±0.4 0.6-1.8 3	78.2±0.6 77.0-79.2 3	1.2±0.2 0.8-1.4 3	1.6 --- 1	90.5 89-92 2	---
Burbot *Lota lota*	18.0±0.7 16.8-19.2 3	0.8±0.2 0.6-1.2 3	80.3±0.2 80.1-80.6 3	1.3±0.3 1.0-1.9 3	---	---	---
Butterfishes *Stromateidae* spp.	17.7±0.4 15.0-20.7 13	7.2±1.9 0.9-24.5 13	74.3±1.7 56.5-80.4 13	1.4±0.4 0.9-2.5 13	1.3±0.6 0.3-2.6 4	95 95-95 2	---
Carp *Barbus* spp.	20.6 16.0-25.2 2	2.7 2.3-3.1 2	74.7 70.3-79.1 2	1.4 1.2-1.5 2	---	---	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Carp *Cirrhina mrigala*	18.9±0.2 18.1-19.6 10	0.9±0.5 0.2-4.0 8	78.0±0.4 75.0-79.8 10	1.4±2.1 1.0-1.6 8	1.4±0.2 0.6-2.0 7	86.7±0.9 84.0-90.0 7	---
Carp *Cyrpinus carpio*	18.0±0.2 17.4-19.3 9	6.2±1.2 3.3-14.8 9	75.6±1.1 66.2-79.8 14	1.1±0.03 1.0-1.2 7	---	---	---
Carp, Indian *Labeo* spp.	16.8±0.4 14.3-19.1 12	4.6±2.9 0.5-24.5 8	79.7±0.8 72.5-82.1 12	1.3±0.1 0.9-1.4 8	0.4±0.1 0.3-0.4 2	---	---
Catfishes, air-breathing *Claridae* spp.	17.3±0.8 15.0-19.7 5	2.5±1.0 0.4-4.8 5	77.6±0.7 76.3-79.9 5	1.4±0.2 1.1-2.1 5	0.2 0.1-0.3 2	103±12.7 78-117 3	---
Catfishes, freshwater *Ictaluridae* spp.	17.6±0.8 15.4-22.8 10	3.2±1.8 0.3-11.0 10	77.8±1.2 68.0-82.6 14	1.1±0.1 0.9-1.7 10	---	---	---
Catfishes, sea *Ariidae* spp.	18.3±0.9 12.7-21.2 9	1.2±0.3 0.2-2.9 8	78.3±0.6 75.1-81.1 9	1.3±0.1 0.9-1.6 9	0.5±0.1 0.4-0.6 3	84.2±3.0 74-90 5	---
Chubs, sea *Kyphosidae* spp.	21.1 --- 1	4.2 2.0-6.3 2	76.0 75.9-76.0 2	1.3 1.1-1.4 2	---	102 --- 1	---
Chubs, Utah *Gila atraria*	15.5 --- 1	4.8 --- 1	79.3 --- 1	1.0 --- 1	---	---	---
Cisco, longjar, trout *Coregonus alpenae*	15.5±0.8 13.3-16.9 4	12.5±3.1 7.6-21.5 4	71.2±2.8 63.8-77.2 4	1.5±0.4 1.0-2.7 4	---	---	---
Clam Miscellaneous spp.	11.7±0.4 7.6-19.0 21	1.4±0.2 0.3-4.8 19	83.0±0.7 73.7-87.9 16	1.8±0.2 0.8-3.9 11	---	---	---
Clam, short neck *Venerupis semi decusata*	12.8±0.2 12.2-13.6 5	0.8±0.04 0.7-0.9 5	84.9 --- 1	---	---	---	---
Clam, soft shell *Mya arenaria*	11.2±0.06 9.7-15.6 10	2.0 1.4-2.5 2	84.8±1.0 78.5-87.8 8	1.7 --- 1	1.7 --- 1	89 --- 1	---
Cod, Atlantic *Gadus morhua*	17.9±0.4 16.5-20.7 9	0.3±0.1 0.1-0.8 8	81.1±0.4 78.2-82.6 10	1.1±0.3 1.0-1.2 7	---	---	---
Cods *Gadus* spp.	18.8±0.7 17.7-21.4 5	0.5±0.2 0.1-1.0 5	79.2±1.0 75.5-81.4 5	1.5±0.2 1.1-2.1 5	---	86.0±5.6 79.0-97.0 3	---
Congers, pike *Muraenesocidae* spp.	18.4±0.7 16.9-21.5 6	0.9±0.2 0.2-1.5 5	78.9±0.6 77.3-80.3 6	1.3±0.2 0.6-2.0 6	0.8 --- 1	85±4.0 80-93 3	---
Crab Miscellaneous spp.	15.8±1.4 7.2-22.4 10	3.1±1.3 0.1-12.5 9	76.1±1.8 61.0-84.7 12	2.5±0.5 1.4-6.2 9	---	---	---
Crab, blue *Callinectes sapidus*	16.1±0.5 11.9-19.2 18	1.0±0.1 0.4-1.5 18	81.2±0.6 77.4-86.7 17	1.6±0.1 1.3-1.8 15	1.25 0.5-2.0 2	81.5 77-86 2	84 70-98 2

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Crab, Dungeness *Cancer magister*	17.2±0.7 14.3-23.4 12	1.4±0.1 0.7-2.2 14	80.5±0.3 78.5-82.3 13	1.4±0.1 1.2-1.9 11	---	85±4.6 77-97 4	57.5 52-63 2
Crab, deep sea *Neptunnis* spp.	16.5±0.5 12.8-18.8 12	0.5 --- 1	78.4±0.6 75.9-81.4 12	1.45 0.6-2.3 2	0.3 --- 1	---	---
Crab, King *Paralithodes camtschatica*	17.2±0.7 14.6-19.0 7	0.7±0.2 0.2-1.4 6	80.7±0.6 80.1-82.8 6	1.6±0.2 1.3-2.2 5	---	---	---
Crab, samaon *Scylla serrata*	14.9±0.4 11.8-20.1 22	2.9±1.1 0.7-4.0 3	80.3±0.5 75.1-83.9 22	1.8±0.1 1.5-1.9 4	0.6 --- 1	---	---
Crayfish Miscellaneous spp.	18.7±0.9 17.0-19.6 3	1.7 --- 1	76.3±0.2 72.4-80.1 3	1.1 --- 1	---	---	---
Croakers *Sciaenidae* spp.	19.0±1.4 14.1-29.1 9	1.9±0.4 0.4-4.9 10	78.5±1.1 72.0 9	1.3±0.1 0.9-1.8 9	---	103 --- 1	---
Dolphin *Coryphaena equisetis*	19.0±0.4 18.5-19.8 3	1.6±0.8 0.7-3.2 3	75.4 --- 2	1.5 --- 2	---	94.3±6.6 85-107 3	---
Dories *Zeidae* spp.	18.4 18.3-18.4 2	1.05 0.9-1.2 2	78.1±0.7 77.0-79.3 3	1.3±0.03 1.2-1.3 3	---	80.0 --- 1	---
Drum *Sciaenidae* spp.	19.2±0.3 18.1-20.1 6	1.5±0.2 0.9-1.9 4	76.9±1.1 69.7-80.2 8	1.6±0.2 0.9-2.4 8	---	91.0 --- 1	---
Drum, freshwater *Aplodinotus grunniens*	17.4±0.2 15.9-18.4 11	5.5±0.7 1.0-8.4 11	76.7±1.0 73.9-82.7 10	1.1±0.02 1.0-1.1 10	---	---	---
Eel, conger *Congridae* spp.	16.4 --- 2	4.5 --- 2	77.6±1.0 76.3-79.5 3	1.2±0.2 1.0-1.5 3	---	110.5 99-122 2	---
Eels, freshwater *Anguillidae* spp.	18.0 --- 2	17.3±2.6 12.7-21.5 3	65.0±1.8 62.2-70.1 4	1.3 --- 2	---	246 237-255 2	---
Eels, snake *Ophichthidae* spp.	17.7±0.4 15.3-20.2 18	0.9±0.2 0.1-3.1 18	78.8±0.5 74.0-81.1 17	1.3±0.1 0.2-2.6 18	0.6±0.2 0.3-2.4 10	81.4±3.3 73-104 11	
Flatheads *Percophididae* spp.	19.0±0.5 17.6-20.0 4	1.1±0.3 0.2-1.8 4	80.2±2.9 78.4-83.0 5	1.3±0.2 1.0-1.9 5	---	87±2.9 82-95 4	---
Flounder, winter *Pseudopleuronectes americanus*	17.4±2.3 16.0-19.9 6	0.8±0.5 0.2-3.0 6	79.5±0.9 75.4-81.0 6	1.3±0.0 1.2-1.3 5	---	---	---
Flounders *Bothidae* spp.	19.0±0.6 17.3-20.8 7	0.9±0.2 .1-2.5 11	78.1±0.7 76.0-80.1 7	1.7±0.2 1.3-2.3 4	0.6 0.4-0.8 2	84.3±5.4 78-95 3	---
Flounders *Pleuronectidae* spp.	17.3±0.3 14.0-20.3 22	1.0±0.2 0.1-2.9 21	80.8±0.4 76.8-84.1 20	1.3±0.1 1.1-2.3 15	1.3 --- 1	87.7±3.4 81-92 3	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Flyingfish and halfbeaks *Exocoetidae* spp.	20.1±0.9 17.1-23.5 7	1.1±0.2 0.2-1.4 7	77.5±0.7 75.2-80.3 8	1.2±0.1 0.6-1.6 8	0.4 --- 1	92.3±3.2 83-97 4	---
Goatfish, dwarf *Upeneus parvus*	19.8±0.2 19.7-21.5 14	4.0±0.5 1.6-7.0 14	75.2±0.6 71.7-78.4 15	1.8±0.1 1.6-2.5 15	---	---	---
Goatfishes *Mullidae* spp.	20.1±0.7 16.9-22.9 9	2.0±0.5 0.4-4.7 9	76.3±0.6 74.5-78.1 6	1.7±0.5 0.6-4.0 6	---	106.3±5.0 99-120 4	---
Gobies *Gobiidae* spp.	17.4±0.6 15.4-20.5 11	1.1±0.3 0.1-2.7 11	79.3±0.5 76.5-81.8 11	1.8±0.2 1.0-2.9 11	0.3 --- 1	75±0.6 74-76 3	---
Goosefishes *Lophiidae* spp.	13.2±1.0 10.6-15.2 4	1.2±0.5 0.3-2.5 4	83.6±0.4 82.9-84.2 3	1.6±0.2 1.2-2.0 3	---	62.7±2.3 58-65 3	---
Groupers *Serranidae* spp.	19.2±0.3 16.4-20.8 12	0.8±0.2 0.2-2.3 13	78.6±0.3 76.0-79.8 13	1.3±0.1 0.9-1.8 13	1.0 --- 1	87.4±2.3 83.0-94.0 5	---
Grunts *Pomadasyidae*	19.2±0.4 17.7-21.1 9	0.9±0.3 0.2-2.7 9	77.9±0.5 75.6-79.8 9	1.8±0.3 1.1-3.5 9	2.2 --- 1	87.3±2.3 80-92 6	---
Haddock *Melanogrammus aeglefinus*	18.3±0.3 15.4-19.6 13	0.5±0.2 0.1-1.2 5	80.3±0.3 79.1-81.7 11	1.1±0.1 1.0-1.2 3	---	79 --- 1	66.3±13.0 45.0-90.0 3
Hakes *Merluccius* spp.	16.3±0.3 15.4-16.9 4	1.2±0.5 0.6-2.7 4	81.1±1.0 78.5-83.1 4	1.2±0.1 1.0-1.5 4	---	86 --- 1	---
Halibut, Atlantic *Hippoglossus hippoglossus*	17.7±1.3 12.6-20.1 5	2.4±0.9 0.7-5.2 5	78.1±0.7 76.5-82.9 9	1.1 --- 1	---	126 --- 1	60 --- 1
Halibut, Pacific *Hippoglossus Stenolepis*	21.1±0.1 20.3-22.0 12	1.1±0.2 0.6-3.6 13	77.9±0.1 77.3-78.7 16	1.4±0.0 1.2-1.4 12	---	---	---
Herring, Atlantic *Clupea harengus*	18.2±0.8 15.2-21.9 7	15.7±1.9 2.4-29.1 17	60.1±2.5 52.6-78.0 11	1.7 --- 1	---	---	---
Herring, fimbriated *Sardinella fimbriata*	20.0±0.4 18.3-21.8 7	2.0±0.5 0.4-3.6 6	76.1±0.8 71.3-78.1 8	2.0±0.2 1.3-3.4 8	1.7 0.6-2.7 2	102.3±8.9 88-128 4	---
Herring, lake, trout *Coregonus artedii*	18.8±0.9 15.6-20.8 6	3.3±1.04 1.5-7.2 6	77.6±1.1 62.6-81.3 18	1.4±0.2 1.0-2.8 8	---	---	---
Herring, Pacific *Clupea harengus pallasi*	14.6±1.7 9.4-16.5 4	11.1±1.6 8.0-12.8 3	71.5 69.0-73.9 2	3.8±0.9 2.5-3.3 7	---	---	---
Jack mackerel *Trachurus trachurus*	19.7 --- 1	6.8±4.3 1.5-15.3 3	76.7 --- 1	1.2 --- 1	---	---	---
Jacks *Caranx* spp.	19.9±0.4 16.6-22.0 14	1.2±0.5 0.1-6.1 12	76.5±0.5 71.5-79.8 16	1.5±0.1 1.0-2.7 15	0.6±0.4 0.2-1.4 3	96.6±45 84-135 10	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Kingfishes *Menticirrhus* spp.	17.2±0.3 16.5-17.9 5	3.1±1.1 0.7-6.1 5	78.4±1.2 75.3-81.7 5	1.1±0.1 1.1-1.3 5	---	---	---
Leatherjacket *Scomeroides lysan*	19.9±0.3 19.3-20.7 4	1.3±0.4 0.1-1.8 4	77.1±0.4 76.4-77.7 4	1.6±0.1 1.3-1.8 4	0.3 --- 1	109 88-130 2	---
Lincod *Ophiodon elongatus*	17.5±0.4 16.7-18.1 3	0.7±0.2 0.5-1.0 3	80.2 79.2-81.1 2	1.2±0.0 1.2-1.2 3	---	99 81-117 2	---
Lizardfish *Saurida tumbil*	19.3±0.3 17.4-23.5 17	1.13±0.1 0.1-1.8 18	78.2±0.3 76.3-80.2 17	1.7±0.1 1.4-2.2 17	---	---	---
Lizardfish *Saurida undosquamis*	19.4±0.2 18.4-20.9 13	2.3±0.2 0.5-3.4 13	77.0±0.3 75.6-79.2 13	1.8±0.1 1.5-2.2 12	0.9 --- 1	88 ---	---
Lobster *Panulirus* spp.	19.6±0.8 16.2-21.6 7	1.3±0.2 0.6-1.9 6	76.0±1.1 71.5-81.2 10	2.4±0.6 1.2-3.4 4	0.8 --- 1	95 92-98 2	260 170-350 2
Mackerel *Scomber* spp.	22.0±0.3 13.5-25.3 44	5.3±0.7 0.3-18.1 42	71.7±0.6 61.4-77.7 45	1.5±0.04 1.1-2.4 43	0.3 --- 1	114±3.6 108-124 4	---
Mackerel *Scombermorus* spp.	18.9±0.5 15.9-22.4 16	3.7±1.4 0.2-14.4 13	74.9±1.4 63.0-82.1 15	1.3±0.1 0.9-1.6 15	2.8±0.1 2.6-3.0 3	103.4±17.3 80-172 5	---
Mackerel *Auxis* spp.	24.8 23.7-25.8 2	3.2±1.2 0.7-7.2 5	71.2 70.2-72.2 2	1.4 1.3-1.5 2	---	---	---
Mackerel, Atlantic *Scomber scomberus*	19.1±0.6 15.1-23.1 17	16.3±2.1 0.7-24.0 17	64.0±1.9 49.3-78.6 15	1.5±0.1 1.0-3.0 15	---	169±30.7 84-230 4	80 --- 1
Mackerel, Indian *Rastrelliger* spp.	19.1±0.7 16.6-21.4 9	2.0±0.4 0.5-4.1 14	76.4±0.8 73.3-79.3 9	1.5±0.1 1.1-2.2 9	2.1±0.2 1.8-2.5 3	97.7-3.8 92-105 3	---
Mackerel, Pacific *Pneumatophorus japonicus*	21.2 --- 1	4.6±2.5 1.6-9.5 3	72.3 --- 1	2.4 --- 1	---	---	---
Mojarras *Gerreidae* spp.	18.6±0.6 17.7-19.6 3	1.3 1.2-1.3 2	78.5±0.2 --- 3	1.6±0.3 --- 3	---	84 --- 1	---
Mullet *Mugil* spp.	19.2±0.7 12.3-22.6 14	3.3±0.5 0.4-5.9 11	75.3±1.1 69.3-86.0 15	1.4±0.1 0.9-2.1 13	2.2 1.9-2.4 2	128.4±13.4 103-124 5	---
Mullet, striped *Mugil cephalus*	19.4±0.4 17.9-21.8 11	5.5±1.3 0.2-14.8 12	73.7±1.4 64.5-80.2 11	1.3±0.1 1.0-1.8 10	---	143±13.7 102-219 8	---
Mullet, red *Mullus barbatus*	19.0±0.4 16.8-23.0 19	5.0±0.7 0.8-10.8 19	75.3±0.8 68.4-79.9 19	1.7±0.1 1.3-2.1 18	---	---	---
Needlefishes *Belonidae* spp.	23.2±1.8 20.6-26.6 3	1.1±0.5 0.3-2.1 3	74.9±2.3 70.4-78.0 3	1.6±0.1 1.4-1.8 3	---	84.5 78-91 2	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo- hydrate	Energy	Choles- terol
	grams per 100 grams					cal/100g	mg/100g
Ocean perch, Pacific *Sebastes alutus*	18.1±0.6 17.2-19.2 3	1.4±0.1 1.2-1.5 3	79.1±0.4 78.4-79.8 3	1.2±0.03 1.1-1.2 3	---	---	---
Oysters *Ostreidae* spp.	7.8±0.5 5.0-14.3 22	1.5±0.1 0.7-2.6 21	84.8±0.9 76.0-93.0 26	1.8±0.1 1.1-2.7 19	4.2±0.3 2.3-6.5 20	78.5±5.7 54-92 6	262±52.9 112-470 6
Oyster, blue point *Crassostrea virginica*	6.9±0.3 5.6-10.0 24	1.5±0.1 0.7-2.4 24	85.7±0.5 77.4-90.2 40	1.5±0.1 0.7-2.9 23	3.3±0.2 1.9-4.7 18	---	47.5 37-58 2
Parrotfishes *Scaridae* spp.	19.7±0.7 18.9-21.0 3	0.9±0.5 0.4-2.0 3	78.7±1.4 75.8-80.2 3	1.3±0.1 1.1-1.5 3	---	105 --- 1	---
Perch, yellow *Perca flavescens*	19.0±0.3 17.3-19.9 9	0.9±0.1 0.5-1.2 8	79.1±0.3 78.3-80.2 6	1.4±0.3 0.6-3.3 8	---	---	---
Perches *Serranidae* spp.	18.0 --- 1	1.0±0.4 0.3-1.5 3	81.1±0.5 80.4-82.0 3	1.2 1.1-1.2 2	---	83 --- 1	---
Pikes *Esocidae* spp.	19.0 18.2-19.7 2	1.2 1.2-1.2 2	77.9±1.8 72.5-80.2 4	1.2 1.1-1.3 2	---	---	---
Pilchards *Sardinops* spp.	16.7±0.6 14.7-19.4 7	2.0±0.7 0.3-5.2 7	76.7±0.6 74.5-78.9 7	3.7±0.6 1.1-4.9 7	---	87.3±10.3 70-117 4	---
Pilchard *Sardina caerulea*	19.2±0.2 16.9-21.4 30	8.0±1.1 0.3-21.4 32	71.4±1.1 59.7-79.7 30	1.8±0.3 1.3-2.7 4	---	---	---
Pollack, coalfish *Pollachius virens*	18.6±0.3 17.4-19.3 7	0.5±0.1 0.2-1.0 7	79.2±0.7 77.4-81.6 6	1.6±0.1 1.3-2.0 6	---	---	---
Pollack, walleye *Theragra chalcogramma*	17.4 16.8-18.0 2	0.9 0.7-1.0 2	82.5 --- 1	1.1 --- 1	---	---	---
Pomfrets *Bramidae* spp.	18.9±0.6 16.2-21.6 10	1.1±0.3 0.6-1.4 3	76.5±1.1 70.6-80.3 10	1.3±0.2 0.4-2.2 7	2.8 1.3-2.3 2	93.3±4.1 84-101 4	---
Pompano *Trachinotus* spp.	19.3±0.4 17.6-21.0 8	1.4±0.4 0.2-4.0 8	77.3±0.6 75.3-80.4 8	1.2±0.1 0.4-1.5 8	2.8 --- 1	86.2±3.4 83-99 5	---
Porgies *Dentex* spp.	19.9±0.5 18.7-21.4 5	1.8±0.5 1.0-3.5 5	77.4±0.7 76.4-80.0 5	1.6±0.2 1.3-2.1 5	---	94.7±5.2 86-104 3	---
Porgies *Sparus* spp.	20.8±0.4 19.0-22.8 8	1.8±0.5 0.2-4.9 10	75.3±0.5 73.6-77.4 8	1.5±0.2 1.3-2.5 8	1.1 0.7-1.5 2	100.7±3.5 90-115 6	
Porgies *Pagrus* spp.	20.3±0.2 19.9-20.5 3	1.2±0.5 0.6-2.2 3	77.1±0.2 76.9-77.5 3	1.5±0.2 --- 3	---	102 --- 1	---
Porgy *Box boops*	19.0±0.8 17.3-20.9 4	6.3±1.3 4.5-10.1 4	73.5±1.5 69.3-76.5 4	1.9±0.2 1.4-2.4 4	---	128.8±13.8 113-170 4	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Prawns *Miscellaneous spp.*	16.8±1.1 8.9-23.2 19	1.2±0.2 0.3-3.1 17	75.3±1.0 67.5-80.6 20	2.7±0.3 1.6-5.2 14	---	---	---
Puffer *Sphoeroides* spp.	23.2 --- 1	0.7 --- 1	74.2 --- 1	1.1 1.0-1.2 2	---	---	---
Redfish *Sebastes marinus*	18.0±0.1 17.9-18.1 7	1.3±0.2 0.6-2.2 7	79.4±0.2 78.8-79.6 6	1.1±0.0 1.1-1.1 6	---	---	---
Rockfishes *Sebastes* spp.	18.8±0.3 17.2-20.8 13	1.2±0.2 0.2-2.4 14	78.3±0.5 75.1-80.0 12	1.2±0.02 1.1-1.3 11	---	---	---
Sablefish *Anoplopoma fimbria*	13.3 12.9-13.6 2	14.0 12.8-15.2 2	71.5 --- 1	1.0 --- 1	---	---	---
Salmon, Chinook *Oncorhynchus tshawytscha*	16.2±0.4 13.4-17.6 10	11.5±2.4 2.2-19.0 8	67.6±2.2 61.3-79.9 10	0.9±0.02 0.9-1.0 10	---	---	---
Salmon, chum *Oncorhynchus keta*	20.7±0.7 18.4-24.5 9	4.3±0.6 1.3-4.8 11	73.8±1.4 68.9-78.3 8	1.5±0.1 1.2-1.7 8	---	---	---
Salmon, coho *Oncorhynchus kisutch*	21.5±0.1 20.5-22.0 14	5.7±0.5 3.1-9.0 14	72.7±0.5 70.3-75.3 13	1.2±0.01 1.1-1.3 13	---	---	---
Salmon, pink *Oncorhynchus gorbuscha*	19.4±0.2 17.2-20.6 22	5.3±0.4 2.0-9.4 36	74.0±0.5 69.0-78.3 33	1.2±0.02 1.1-1.4 21	---	---	65 --- 1
Salmon, sockeye *Oncorhynchus nerka*	20.9±0.5 17.9-22.7 13	7.5±1.2 1.6-19.2 16	72.8±1.4 65.6-80.3 14	1.2±0.02 1.1-1.3 12	---	---	---
Sandlanches *Ammodytes lancedatus*	17.9 --- 1	1.5 --- 1	78.0 --- 1	2.8 --- 1	---	87.0 --- 1	---
Sardine *Sardinella eba*	19.0 --- 1	3.7 --- 1	77.1 --- 1	2.6 --- 1	---	---	---
Sardine, gilt *Sardinella aurita*	20.5±0.2 17.3-22.3 49	3.8±0.3 0.4-20.0 125	74.8±0.3 65.9-79.9 50	2.1±0.1 1.4-2.9 49	---	---	---
Sardine, Indian *Sardinella longiceps*	19.3±0.7 17.7-21.0 4	2.9±0.6 1.9-4.6 4	75.7±0.1 75.3-76.0 4	1.5±0.1 1.3-1.6 4	0.7 0.1-1.3 2	103±6.0 91-110 3	---
Scad *Decapterus* spp.	21.8±1.5 19.2-24.4 3	2.4±0.7 1.0-4.9 5	75.4 74.2-76.6 2	1.5 1.1-1.8 2	1.2 --- 1	109 101-117 2	---
Scallop *Pectinidae* spp.	17.2±0.7 15.2-20.1 7	0.7±0.2 0.3-1.6 7	79.2±0.8 74.6-85.6 11	1.7±0.1 1.3-1.8 6	---	---	---
Scallop, Atlantic Bay *Pecten irradians*	15.4±0.2 13.4-17.0 24	0.5±0.03 0.3-0.9 24	80.7±0.4 74.6-83.7 24	1.4±0.04 1.1-1.7 24	1.7±0.2 1.4-1.9 3	---	105.7±35.2 60-175

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Scallop, calico *Aequipecten gibbus*	15.9±0.2 15.6-16.4 4	0.6±0.06 0.5-0.7 4	79.8±0.4 78.8-80.4 4	1.5±0.03 1.4-1.5 4	---	---	---
Scup *Stenotomus chrysops*	18.8±0.1 18.4-19.1 5	3.7±0.8 1.2-5.9 5	75.5±0.6 73.6-77.0 5	1.2±0.1 1.1-1.4 5	---	---	---
Shad *Alosa sapidissima*	18.5±0.5 15.7-20.0 9	8.3±1.7 1.7-15.2 9	71.4±1.4 64.6-77.0 9	1.5±0.1 1.2-1.9 9	---	---	---
Shad *Clupeidae* spp.	17.4±0.7 15.1-21.5 8	12.0±3.6 1.2-23.1 6	70.2±2.6 58.0-78.3 8	2.1±0.4 1.2-4.2 8	---	87 --- 1	---
Sharks *Mixed* spp.	22.7±0.8 14.9-27.1 18	0.5±0.2 0.1-2.9 14	76.3±0.5 72.0-76.9 17	1.3±0.1 1.0-2.0 17	---	101±4.3 --- 4	---
Shrimp Miscellaneous spp.	20.5±0.71 16.2-22.7 16	1.1±0.2 0.1-3.2 19	76.2±0.7 69.6-84.8 26	2.6±0.5 1.3-6.8 14	2.2 --- 2	88.3±9.7 69-99 3	159.5±13.8 138-200 4
Skates *Rajidae* spp.	20.3 19.0-21.5 2	0.2 --- 1	78.0±0.9 76.4-79.6 3	1.3 1.1-1.4 2	---	80 --- 1	---
Skipjack *Euthynnus pelamis*	25.5±0.4 23.8-26.6 8	3.4±0.6 0.3-7.4 14	70.0±0.4 68.6-71.1 6	1.5±0.1 1.3-1.7 7	---	---	---
Smelts *Osmeridae* spp.	16.6±0.6 14.3-18.8 9	3.9±0.7 2.3-6.7 9	79.0±0.4 76.8-80.2 8	1.5±0.2 1.1-2.3 6	---	---	---
Snappers *Lutjanidae* spp.	19.2±0.4 16.7-21.9 16	2.0±0.5 0.4-7.4 16	77.9±0.5 72.7-81.9 19	1.3±0.1 1.0-1.7 15	0.7±0.2 .2-1.3 4	99.5±5.2 82-146 12	---
Snooks *Centropomidae* spp.	18.5±1.1 13.7-20.6 6	0.9±0.2 0.3-1.9 6	78.3±0.7 77.0-82.0 8	1.2±0.1 1.0-1.5 8	0.6 0.2-0.6 2	82.5 79-86 2	---
Soles *Limanda* spp.	18.0±0.4 17.0-19.2 6	1.0±0.2 0.1-1.3 6	81.1±0.3 80.0-82.7 8	1.3±0.1 1.1-1.5 4	---	---	---
Sole *Soleidae*	18.7±1.3 16.6-21.2 3	1.07±0.5 0.2-1.7 3	78.4±1.2 75.0-80.1 4	1.7±0.2 1.3-2.1 4	---	82.5 80-85 2	---
Sole, Dover *Microstomus pacificus*	15.0±0.3 13.9-16.6 7	0.8±0.1 0.6-1.2 6	83.7±0.3 82.6-84.4 6	1.1±0.0 1.1-1.1 4	---	---	---
Sole, English *Parophys ventulus*	17.1±0.4 16.4-18.5 5	1.4±0.1 1.2-1.8 5	81.2±0.2 80.7-81.8 4	1.2±0.0 1.2-1.3 5	---	---	---
Sole, Petrole *Eopsetta jordani*	17.4±0.8 14.8-19.4 6	2.4±0.9 0.9-6.7 6	78.5±1.0 74.8-81.0 5	1.8±0.5 1.2-3.8 5	---	85.0 --- 1	---
Spot *Leiostomus xanthurus*	17.9 --- 1	3.1 --- 1	77.5 --- 1	1.1 --- 1	---	---	---

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Sprat *Clupea sprattus*	16.9 16.7-17.1 2	6.7 1.8-11.6 2	69.2±1.2 66.8-71.0 3	1.9±0.1 1.8-2.0 3	---	176 --- 1	---
Squawfish, northern *Ptychocheilus oregonensis*	17.0±0.4 15.6-18.0 7	2.5±0.2 1.8-3.1 7	79.3±0.2 78.8-80.1 7	1.1±0.02 1.0-1.1 7	---	---	---
Squid *Loliginidae* spp.	15.3±1.1 11.9-18.4 6	1.0±0.2 0.5-1.4 6	79.3±1.6 74.2-84.0 6	1.8±0.3 1.0-3.1 7	3.0 --- 1	89 80-98 2	---
Surgeonfish *Acipenseridae* spp.	18.7±0.5 17.4-20.9 6	1.3±0.5 0.4-3.8 6	80.3±1.9 74.4-89.0 6	1.0±0.2 0.3-1.4 5	1.3 1.3-1.3 2	92.2±6.9 81-119 5	---
Swordfish *Xiphias gladius*	19.5±0.4 18.6-20.8 6	4.1±0.7 2.0-6.4 6	76.2±0.4 74.7-77.5 6	1.3±0.1 1.0-1.9 6	0.7 --- 1	100 87-113 2	---
Trouts *Salmonidae* spp.	16.1±1.1 12.4-19.0 5	11.0±1.1 8.7-14.0 5	71.3±1.8 64.0-76.3 6	1.3±0.2 1.0-2.0 5	---	---	---
Trout, brook *Salvelinus fontinalis*	17.5 13.7-21.2 2	4.5 3.4-5.5 2	74.5±1.2 71.5-77.2 4	2.7 2.0-3.3 2	---	---	---
Trout, Dolly Varden *Salvelinus malma*	19.9 --- 1	6.5 --- 1	73.1 --- 1	1.2 --- 1	---	---	---
Trout, Lake *Salvelinus namaycush*	16.4±0.9 11.3-20.0 9	14.9±2.7 9.1-36.0 10	69.3±2.1 52.5-79.0 11	1.2±0.3 0.5-3.3 8	---	---	---
Trout, rainbow *Salmo gairdneri*	22.0 --- 1	11.7 --- 1	72.0 66.3-77.7 2	1.3 --- 1	---	---	---
Tuna, big eye *Thunnus obesus*	22.5 --- 1	1.3±0.3 0.6-2.0 4	73.1 --- 1	1.3 --- 1	---	98 --- 1	---
Tuna, bluefin *Thunnus thynnus*	24.7±0.3 23.3-27.5 13	3.9±0.6 1.2-8.0 13	70.4±0.4 67.7-72.6 13	1.3±0.02 1.2-1.4 12	---	122±3.2 114-129 5	---
Tuna, yellowfin *Thunnus albacares*	24.3±0.2 22.9-25.8 26	2.2±0.5 0.1-9.5 25	73.2±0.5 67.3-77.1 27	1.5±0.03 1.3-1.9 25	---	---	---
Tunny, little *Euthynnus alletteratus*	22.8±0.1 22.0-25.4 48	5.7±0.8 0.7-20.2 48	69.8±0.7 59.0-74.4 47	1.6±0.02 1.2-2.1 48	---	---	---
Turbot *Rhombus maximus*	16.4 --- 2	2.9 --- 2	78.3 --- 2	1.0 --- 2	---	94 74-114 2	----

(TABLE VII-5 CONTINUED)

	Protein	Fat	Moisture	Ash	Carbo-hydrate	Energy	Choles-terol
	grams per 100 grams					cal/100g	mg/100g
Walleye *Stizostedion vitreum*	19.3±0.2 18.8-19.8 4	1.5±0.3 0.8-1.9 4	79.3±0.6 78.2-80.0 3	1.2±0.03 1.1-1.2 3	---	---	---
Weakfish *Cynoscion regalis*	18.7±0.6 15.7-20.0 7	3.2±0.4 1.4-4.3 7	76.6±0.7 74.6-79.6 7	1.19±0.03 1.1-1.3 7	---	---	---
Whitefish, lake, trout *Coregonus clupeaformus*	18.0±0.3 15.1-19.8 16	7.6±1.2 1.7-18.5 17	73.4±1.3 62.6-79.0 14	1.3±0.1 1.0-3.1 15	---	---	---
Whiting *Merluccius bilinearis*	16.1±0.3 15.2-16.7 6	1.2±0.3 0.2-2.0 6	80.7±0.5 79.3-82.4 5	1.2±0.02 1.1-1.2 5	---	87.7±11.8 73-111 3	75 --- 1

*Standard error of the mean.
**Range.
***This number of averager used to compute the overall average.

TABLE VII-6: COMPOSITION OF THE EDIBLE PORTION OF RAW (FRESH OR FROZEN) CRUSTACEANS, FINFISH, AND MOLLUSKS, II. SODIUM, POTASSIUM, CALCIUM, PHOSPHORUS, CHLORINE, AND MAGNESIUM

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Abalone Haliotidae spp.	---	---	*27±6 **21-34 ***2	---	---	112±62 50-175 2
Amberjacks and Yellowtails *Seriola* spp.	76±12 52-90 3	438±158 280-597 2	22±6 6-35 5	162±40 102-253 3	20 --- 1	35±2 30-40 3
Anchovies Engraulidae spp.	115±23 70-147 3	356±51 267-511 5	194±46 20-480 9	239±18 188-349 8	138±55 30-214 3	41±12 29-54 2
Barracudas Sphryaenidae spp.	89±43 46-132 2	252±48 155-307 3	40±7 22-70 8	328±60 156-598 8	230 --- 1	31±4 27-35 2
Basses, sea Serranidae spp.	71±8 30-112 11	332±37 138-580 13	48±7 7-140 17	205±12 150-375 20	105±15 90-135 3	24±6 10-40 4
Basses, temperate Percichthyidae spp.	---	---	71±61 10-132 2	---	---	---
Brills Bothidae spp.	---	---	30±0 30-30 2	204±0 204-204 2	---	---
Butterfishes Stromateidae spp.	94±7 81-106 3	346±52 203-434 4	96±39 17-314 8	300±43 159-506 8	---	---
Butterflyfishes Chaetodontidae spp.	104±3 101-108 2	263±47 216-310 2	37±11 12-57 4	140±8 116-153 4	120 --- 1	---
Caesios Caesionidae spp. (in Lutjanidae)	59 --- 1	391±127 264-519 2	35±1 34-36 4	274±97 165-565 4	---	---
Carps Cyprinidae spp.	59±6 43-105 11	295±18 174-435 17	52±6 12-182 45	318±16 165-605 54	37±10 30-45 4	---
Catfish, air-breathing Clariidae spp.	59±2 55-63 2	309±86 147-440 3	35±6 18-51 5	231±46 116-375 5	130 --- 1	33 --- 1
Catfishes, sea Ariidae spp.	79±24 55-103 2	322±109 109-468 3	71±26 14-98 9	208±27 148-440 10	110 --- 1	34 --- 1
Cavefishes Amblyopsidae spp.	---	---	550 --- 1	350 --- 1	---	---
Characins Characidae spp.	---	---	173 --- 1	266 --- 1	---	---
Cichlids Cichlidae spp.	52 --- 1	454 --- 1	68±23 37-112 3	173±90 39-344 3	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Clams, mactra Mactridae spp.	---	---	42 --- 1	325 --- 1	---	---
Clams, razor Solenidae spp.		143 1	60 1	204±6 198-210 2	---	---
Clams, tellin Tellinidae spp.	262 --- 1	164 --- 1	121 --- 1	83 --- 1	---	---
Clams (species unknown)	190±10 180-200 2	137±56 35-228 3	99±9 59-144 14	156±19 90-350 14	---	43±11 20-70 4
Cockles Cardiidae spp.	200 --- 1	197 --- 1	167±51 116-217 2	93±15 78-122 3	---	---
Cods Gadidae spp.	82±1 60-180 10	364±17 270-465 11	16±2 9-20 7	212±31 9-240 8	228±173 55-400 2	23±3 20-25 2
Crabs, blue *Callinectes sapidus*	---	188 --- 1	94±11 71-133 5	152±30 38-205 5	---	30±5 12-38 5
Crabs, deep sea *Neptunnis* spp.	---	134 --- 1	174±10 20-202 3	---	---	---
Crabs, Johan *Cancer borealis*	276 --- 1	279 --- 1	96 --- 1	12 --- 1	---	45 --- 1
Crabs, king *Paralithodes camtschatica*	---	55 --- 1	160 --- 1	---	---	---
Crabs, Samoan *Scylla serrata*	---	---	118±45 53-290 5	209±65 130-402 4	---	---
Crabs, Tanner *Chionoecetes tanneri*	120 --- 1	520 --- 1	140 --- 1	220 --- 1	---	130 --- 1
Crabs, Miscellaneous spp.	262±78 95-453 4	233±63 111-322 3	94±22 29-120 4	233±40 171-350 4	117 --- 1	48 --- 1
Crayfish Miscellaneous spp.	121±61 60-182 2	302±35 239-500 7	39±5 16-58 8	239±36 101-560 11	280 --- 1	60±20 40-80 2
Croaker Sciaenidae spp.	109±27 70-160 3	259±45 180-336 3	42±8 18-89 8	232±43 125-444 8	178±68 110-246 2	30 --- 1
Cusk *Brosme brosme*	---	---	20 --- 1	220 --- 1	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Cusk eels and brotulas Ophidiidae spp.	---	---	66 --- 1	345±200 145-545 2	110 --- 1	---
Cutlassfishes Trichiuridae spp.	94 --- 1	330 --- 1	75±47 13-214 4	301±90 160-542 4	100 --- 1	25 --- 1
Cuttlefish Misscellaneous spp.	---	239±35 204-273 2	27 --- 1	143 --- 1	---	---
Dace Cyprinidae spp.	---	270 --- 1	---	---	---	---
Dagol *Chorinemus toloo*	---	---	16 --- 1	424±26 398-449 2	750 --- 1	---
Damselfishes Pomacentridae spp.	---	---	---	728 --- 1	140 --- 1	---
Dolphins Coryphaenidae spp.	170±72 98-242 2	370 --- 1	15 --- 1	143 --- 1	---	---
Dories Zeidae spp.	60 --- 1	241±90 151-330 2	40 --- 1	181±51 130-231 2	70 --- 1	20 --- 1
Drepanes Drepanidae spp.	88 --- 1	373 --- 1	57±18 30-90 3	183±27 149-235 3	---	---
Drums Sciaenidae spp.	67±5 51-84 7	273±8 226-301 8	37±12 16-57 3	113±88 25-200 2	---	24 --- 1
Eels, conger Congridae spp.	50 --- 1	241±41 200-282 2	71±31 20-50 4	270±40 180-390 5	100 --- 1	20 --- 1
Eels, freshwater Anguillidae spp.	79±3 76-81 2	362±118 214-712 4	62±25 15-188 4	293±52 196-501 5	64±7 40-80 5	22±4 16-30 3
Eels, moray Muraenidae spp.	25 --- 1	165 --- 1	41±22 19-63 2	251±141 83-532 3	57±33 24-90 2	15 --- 1
Eels, pike conger Muraenesocidae spp.	88 --- 1	490 --- 1	70±43 27-112 2	243±38 205-280 2	---	---
Eels, snake Ophichthidae spp.	62±24 38-86 2	358±44 314-401 2	43±8 14-140 20	274±27 95-509 21	95 --- 1	34 --- 1
Eels, spiny Notacanthidae spp.	50 --- 1	270 --- 1	34±10 22-55 3	248±74 174-322 2	223 --- 1	27 --- 1
Eels, swamp Flutidae spp.	116 --- 1	172 --- 1	40±10 30-50 2	126±33 93-158 2	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Featherbacks *Nctopterus* spp.	40±6 34-45 2	190±71 119-260 2	73±18 40-180 7	317±39 161-450 8	106 --- 1	32 --- 1
Flatheads Percophididae spp.	66±26 40-91 2	291±101 190-392 2	44±13 18-79 4	204±28 174-260 3	---	19±9 10-27 2
Flounders, left eye Bothidae spp.	100±32 54-160 3	220 --- 1	63 --- 1	313±66 185-401 3	235±5 230-240 2	44 --- 1
Flounders, right eye Pleuronectidae spp.	61±7 35-99 12	316±22 157-394 11	27±3 17-36 6	182±29 116-250 4	---	24±5 10-31 4
Flyingfishes and halfbacks Exocoetidae spp.	85±14 70-112 3	407±81 250-516 3	94±37 30-229 5	260±72 140-614 6	90 --- 1	20 --- 1
Gillrakers Chirocentridae spp.	---	---	22 1	1,150 1	---	---
Goatfishes Mullidae spp.	59±8 40-74 4	316±5 311-320 2	72±17 23-97 4	246±33 170-340 6	143±3 140-150 3	30 --- 1
Gobies Gobiidae spp.	92±30 50-150 3	294±58 250-360 3	92±47 15-370 7	324±47 151-554 9	178±72 106-250 2	28 --- 1
Goosefishes Lophiidae spp.	---	297 --- 1	13±6 7-19 2	334±132 180-597 3	370 --- 1	---
Greenlings Hexagrammidae spp.	58±2 52-62 8	411±17 352-478 7	34±12 12-55 3	173±8 165-180 2	---	18 --- 1
Grunts Pomadasyidae spp.	71±1 70-72 2	230±30 200-260 2	55±27 9-268 9	194±21 110-285 8	500 --- 1	10 --- 1
Guitarfishes Rhinobatidae spp.	---	---	11±2 9-12 2	257 --- 1	---	24 --- 1
Gurnards, flying Dactylopteridae spp.	80 --- 1	300±14 260-320 4	65±20 22-104 4	179±27 130-222 3	---	21±1 20-22 2
Haddock *Melanogrammus aeglefinnus*	57±2 49-67 8	342±26 299-434 5	19±3 10-30 5	208±46 164-318 9	---	24 --- 1
Hagfishes Myxinidae spp.	136 --- 1	114 --- 1	4 --- 1	160 --- 1	141 --- 1	26 --- 1
Halibut Pleuronectidae spp.	64±3 36-112 46	398±8 318-475 34	23±8 13-30 4	216±14 192-253 4	88 --- 1	23 --- 1
Herrings Clupeidae spp.	103±15 49-183 10	348±47 25-512 10	142±35 21-460 17	324±21 134-742 42	173±42 108-291 4	38±8 30-46 2

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Jacks Carangidae spp.	68±8 54-89 4	431±44 340-550 4	45±8 16-93 11	237±37 150-565 10	---	34±4 30-37 2
Kingfishes *Menticirrhus* spp.	85±2 83-87 2	250 --- 1	---	---	---	---
Lampreys Petromyzontidae spp.	---	183 --- 1	10 --- 1	---	---	---
Lings *Molva* spp.	---	---	20 --- 1	200 --- 1	---	---
Lizardfishes Synodontidae spp.	70 --- 1	390±124 266-513 2	30±9 13-49 4	291±56 201-445 4	110 --- 1	29 --- 1
Loaches *Misgurnus anguillicaudatus*	---	496 --- 1	28 --- 1	402 --- 1	---	---
Longaray Ambassidae spp.	---	---	67 --- 1	150 --- 1	---	---
Lumpfishes and snailfishes Cyclopteridae spp.	69 --- 1	485 --- 1	56 --- 1	203 --- 1	33 --- 1	---
Mackerels Scombridae spp.	90±14 30-252 15	320±27 136-471 16	58±11 5-343 35	267±25 148-778 33	105±39 35-170 3	30±3 25-40 4
Minnows Cyprinidae spp.	---	---	140 --- 1	180 --- 1	---	---
Mojarras Gerreidae spp.	107 --- 1	404 --- 1	65±34 6-122 3	231±40 191-312 3	---	---
Mullet Mugilidae spp.	73±6 52-100 7	303±11 259-356 7	40±8 11-99 16	258±21 140-436 19	131±21 120-152 2	29±2 25-33 5
Mussels Mytilidae spp	91±30 11-140 4	327±107 121-480 3	105±30 71-164 3	145±15 102-170 4	---	---
Needlefishes Belonidae spp.	79 --- 1	397±1 396-397 2	72±26 21-98 3	251±50 121-362 4	140 --- 1	---
Nemipterids Nemipteridae spp.	88 --- 1	500 --- 1	57±27 15-135 4	198±12 173-210 3	---	28 --- 1
Octopuses Mixed spp.	363 --- 1	232 --- 1	28±8 12-39 3	109±25 66-151 3	---	---
Oysters Ostreidae spp.	160±78 73-618 4	248±111 90-570 4	98±16 39-210 14	153±14 76-265 14	42 --- 1	32±7 12-230 6
Parrotfishes Scaridae spp.	---	---	54±18 36-90 3	167±23 143-213 3	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Perches Percidae spp.	63±3 50-80 3	264±13 210-324 12	30±0 30-30 2	168±29 110-230 4	---	20±0 20-20 2
Perches, climbing Anabantidae spp.	43±7 35-64 4	323±50 195-438 4	68±22 13-131 5	228±38 159-390 7	101±5 96-106 2	34±2 32-35 2
Periwinkles Littorinidae spp.	---	102 --- 1	---	---	---	---
Pickerels Esocidae spp.	---	---	---	---	606 --- 1	---
Pikes Esocidae spp.	52 --- 1	329±50 174-590 7	---	---	227 --- 1	175±27 148-202 2
Plaice Pleuronectidae spp.	91±8 83-98 2	312±18 277-333 3	20 --- 1	220 --- 1	---	25 --- 1
Promfrets Bramidae spp.	---	517 --- 1	132±109 23-240 2	---	223±83 140-305 2	---
Porgies Sparidae spp.	77±6 40-110 12	291±29 156-488 13	44±6 15-123 20	291±25 117-580 27	119±13 90-190 8	27±3 20-31 3
Puffers Tetraodontidae spp.	---	347 --- 1	18 --- 1	138 --- 1	---	---
Rays, eagle Myliobatidae spp.	---	---	---	179 --- 1	275 --- 1	---
Rays, electric Torpedinidae spp.	---	---	---	---	671 --- 1	---
Rays, stringray Dasyatidae spp.	156±23 133-179 2	294±58 236-352 2	19±3 9-25 7	129±11 99-170 7	---	38 38 1
Roaches Cyprinidae spp	---	270 --- 1	---	---	---	---
Sablefishes Anoplopomatidae spp.	56 --- 1	358 --- 1	77 --- 1	187 --- 1	---	---
Salmon, Australian Arripidae spp.	57±6 50-60 3	240±6 230-250 3	37±3 30-40 3	183±29 150-240 3	---	27±3 20-30 3
Sanddab Citharichthys spp.	397 --- 1	220 --- 1	25 --- 1	110 --- 1	---	44 --- 1
Sandfishes Trichodontidae spp.	---	---	61 --- 1	184 --- 1	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Sandlances Ammodytidae spp.	---	377 --- 1	---	---	---	---
Sardines Clupeidae spp.	90±6 60-128 10	218±73 25-420 5	134±19 28-380 21	350±28 39-580 27	138±7 115-164 6	---
Sauries Scomberesocidae spp.	60 --- 1	---	22±0 22-22 2	190±0 190-190 2	---	50 --- 1
Sawfishes Pristidae spp.	---	---	54 --- 1	238 --- 1	---	---
Scad and mackerel Carangidae spp.	71±7 53-94 5	487±127 360-614 2	46±8 12-71 9	279±63 115-680 10	86±29 28-120 3	24±8 20-37 3
Scallops Pectinidae spp.	182±19 163-200 2	278±58 162-340 3	78±38 40-115 2	270±38 210-340 3	---	30±10 20-40 2
Scorpionfishes Scorpaenidae spp.	65±2 45-94 32	366±12 269-432 19	18±3 15-20 2	229±64 60-327 4	75±5 70-80 2	---
Sculpins Cottidae spp.	55 --- 1	332 --- 1	---	---	---	---
Sea chubs Kyphosidae spp.	50 --- 1	268±42 226-310 2	38±2 36-40 2	335±79 227-488 3	240 --- 1	20 --- 1
Sea Cucumbers Mixed species	---	---	---	67 --- 1	14 --- 1	---
Searobins Triglidae spp.	---	---	---	---	296 --- 1	---
Seatrout Sciaenidae spp.	59±0 59-60 3	305±12 280-317 3	40 --- 1	120 --- 1	---	---
Shad Clupeidae spp.	69±15 54-98 3	274±56 162-330 3	108±16 22-127 6	203±28 39-323 11	216±40 140-276 3	41 --- 1
Sharks, dogfish Squalidae spp.	100 --- 1	223±49 174-272 2	13±3 7-16 3	253±27 176-300 4	---	20 --- 1
Sharks, hammerhead Sphyrnidae spp.	---	---	20±5 15-25 2	163±45 118-208 2	---	20 --- 1
Sharks, mackerel Lamnidae spp.	---	---	13 --- 1	161±54 107-214 2	150 --- 1	---
Sharks, requiem Carcharhinidae spp.	70 --- 1	290 --- 1	34±8 5-59 7	204±58 150-309 9	150 --- 1	27±17 10-44 2

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Sharks, sand tiger Odontaspididae spp.	79 --- 1	549 --- 1	68±48 9-164 3	211±26 141-288 5	140 --- 1	---
Sharks, thresher Alopiidae spp.	---	---	---	349 --- 1	120 --- 1	---
Sheathfishes Siluridae spp.	---	---	49 --- 1	152 --- 1	---	---
Shrimps and Prawns Mixed species	132±22 45-220 7	248±40 118-410 8	142±18 16-550 45	239±21 127-912 44	---	54±11 23-111 7
Siganids Seganoidae spp.	76 --- 1	450 --- 1	41±0 41-41 2	122±0 122-122 2	---	---
Silversides Atherinidae spp.	---	---	---	105 --- 1	---	---
Skates Rajidae spp.	97±7 90-103 2	303±42 250-387 3	67±3 64-70 2	199±50 131-296 3	210 --- 1	30 ---
Smelts Osmeridae spp.	156±25 80-214 5	---	317±200 50-750 3	245±55 190-680 3	112±13 86-137 4	24 --- 1
Snails Mixed species	91±18 68-146 4	179 --- 1	---	---	---	---
Snake mackerels Gempylidae spp.	101±21 80-122 2	360 --- 1	70 --- 1	270 --- 1	---	59±19 40-78 2
Snappers Lutjanidae spp.	78±10 33-150 11	285±27 125-373 9	32±5 14-65 10	248±42 120-527 10	220 --- 1	24±4 20-28 2
Snooks Centropomidae spp.	71±3 66-80 4	308±63 193-477 4	33±6 14-54 8	191±31 89-400 10	---	25±5 20-30 2
Slimys and Soapies Leinognathidae spp.	146±16 130-162 2	344±65 218-437 3	42±6 19-52 6	272±79 148-554 5	---	---
Soles Pleuronectidae spp.	85±4 56-163 27	344±12 253-475 20	21±6 12-32 3	249±98 105-436 3	---	31 --- 1
Soles Soleidae spp.	80 --- 1	220±28 168-262 3	29±7 18-47 4	271±27 230-349 4	80 --- 1	25±3 20-30 3
Spadefishes Ephippidae spp.	94±4 90-98 2	331±39 292-370 2	61±9 37-74 4	223±20 191-280 4	---	40 --- 1
Squids Mixed species	176 --- 1	275±20 246-313 3	50±11 10-109 8	221±41 153-420 6	---	20 --- 1
Squirellfishes Holocentridae spp.	70 --- 1	---	---	---	---	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Stargazers Uranoscopidae spp.	---	---	---	---	357 --- 1	---
Sturgeons Acipenseridae spp.	---	---	---	---	466 --- 1	---
Suckers Catostomidae spp.	53±1 50-59 8	313±9 292-344 7	15 --- 1	165 --- 1	---	---
Sunfishes Centrarchidae spp.	116 --- 1	---	---	---	---	38 --- 1
Surgeonfishes Acanthuridae spp.	91±31 60-122 2	327±111 192-546 3	38±12 21-45 4	324±90 169-503 4	---	---
Swordfishes Xipiidae spp.	102 --- 1	342 --- 1	13 --- 1	228 --- 1	130 --- 1	---
Tarpons Elopidae spp.	82±0 82-82 2	426±66 360-491 2	66±9 54-92 4	211±28 113-263 5	---	---
Therapons Theraponidae spp.	83 --- 1	345±129 216-474 2	48±4 40-59 4	280±78 193-435 3	---	---
Threadfins Polynemidae spp.	---	---	67±25 10-117 6	214±33 148-398 7	---	---
Tilefishes Branchiostegidae spp.	---	---	40 --- 1	217 --- 1	---	---
Tonguefishes Cynoglossidae spp.	---	489 --- 1	29 --- 1	164 --- 1	---	---
Triggerfishes Balistidae spp.	50±20 30-70 2	265±75 190-340 2	35±5 30-40 2	130±0 130-130 2	---	25±5 20-30 2
Trout, cisco Salmonidae spp.	108±29 38-320 9	329±19 280-358 4	12 --- 1	206±54 152-260 2	---	17 --- 1
Trout, grayling *Thymallus arcticus*	---	---	---	142±41 101-182 2	---	---
Trout, salmon Salmonidae spp.	56±2 24-127 88	340±92 139-500 80	82±21 8-249 18	268±17 125-360 18	29 --- 1	52±11 15-99 10
Trouts Salmonidae spp.	43±8 26-77 6	395±30 227-555 13	23±8 12-38 3	221±23 152-315 8	100 --- 1	29±3 26-32 2
Trout, whitefish Salmonidae spp.	52±1 52-53 3	307±10 297-317 2	---	310 --- 1	351 --- 1	---

(TABLE VII-6 CONTINUED)

	mg/100g					
	Na	K	Ca	P	Cl	Mg
Tunas Scombridae spp.	66±5 31-188 44	363±7 252-518 42	30±8 6-93 12	348±44 190-760 17	162±39 35-280 5	50 --- 1
Turbot Pleuronectidae spp.	68 --- 1	---	49 --- 1	203 --- 1	---	---
Viperfish Charliodontidae spp.	150 --- 1	250 --- 1	51±8 43-58 2	118 --- 1	112 --- 1	29±0 25-32 2
Weevers Trachinidae spp.	---	213 --- 1	---	423 --- 1	50 --- 1	---
Whale, sperm *Phyester macrocephalus*	---	360 --- 1	---	---	---	---
Whelks Mixed species	---	89±51 38-140 2	34 --- 1	58 --- 1	---	---
Whiting Sillaginidae spp.	84±34 50-118 2	326±66 260-457 3	45±11 16-71 5	169±12 130-253 5	---	21±1 20-21 2
Wrasses Labridae spp.	50 --- 1	390±32 358-422 2	---	432±69 388-615 3	83±12 50-100 4	---

*Standard error of the mean.
**Range.
***The number of averages used.

TABLE VII-7: COMPOSITION OF THE EDIBLE PORTION OF RAW (FRESH OR FROZEN) CRUSTACEANS, FINFISH, AND MOLLUSKS. VITAMINS: A, D, E, CHOLINE, ASCORBIC ACID, INOSITOL, and BIOTIN

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (µg)	Biotin (µg)
	per 100 g						
Abalone *Haliotidae spp.*	61 1						
Amberjack and yellowtail *Seriola spp.*	*11±11 **0-22 ***2	27±27 0-53 2	0.2±0 0.1-0.2 5	59 1	2.0±0.4 1.0-2.8 4		
Anchovies *Engraulidae spp.*	635 1						
Barracudas *Sphyraenidae spp.*	51±7 40-62 3						
Basses, sea *Serranidae spp.*	129±36 61-184 3						
Breams and porgies *Sparidae spp.*	53±31 7-144 4			31±4 18-39 3	2.9±0.5 0.4-1.7 4		
Butterfishes *Stromateidae spp.*	182 1						
Carp *Cyprinidae spp.*	262±127 29-1,020 8		630 1	2.0±0.4 0.6-3.1 6	18.5±6.9 0-160 24	8,894±823 7,585-11,000 4	
Catfishes, airbreathing *Clariidae spp.*	633 1						
Catfishes, freshwater *Ictaluridae spp.*		500 1			9.3±1.9 6.0-12.5 4	6,620 1	
Catfishes, sea *Ariidae spp.*	96 1				7.8±3.9 0-11.7 3		
Characins *Characidae spp.*					0±0 0-0 2		
Cichlids *Cichlidae spp.*	58±41 17-99 2				1.0 1		
Clams, mactra *Mactridae spp.*	33 1						
Clams, razor *Solenidae spp.*	64±47 17-110 2						
Clams, Veneridae *Veneridae spp.*	1,124±237 887-1,360 2				14.2±1.1 13.1-15.2 2		
Clams *Miscellaneous species*	370±172 11-1,317 7	4.4±4.4 0-8.8 2	0.5±0.2 0-0.9 4	58±0 58-58 2	11.2±3.6 2.0-30.0 7		2.3 1

(TABLE VII-7 CONTINUED)

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (μg)	Biotin (μg)
	per 100 g						
Codfish *Gadidae spp.*	25 1		0.2±0 0.2-0.2 2				1.2±0.7 0.2-2.6 3
Crabs *Mixed species*	5,115±3,755 1,360-8,870 2				7.7±5.4 2.2-13.1 2		
Cusk *Brosme brosme*							2.5±2.0 0.5-4.5 2
Cusk eels and brotulas *Ophidiidae spp.*							0.1 1
Cuttlefishes *Miscellaneous species*					2.3±0.7 0.9-5.3 6		
Dace *Cyprinidae spp.*					1.0 1		
Dolphins *Coryphaenidae spp.*	179±154 26-333 2						
Drums *Sciaenidae spp.*	199±155 31-508 3				10.2±3.9 2.5-14.1 3		
Eels, conger *Congridae spp.*					1.0 1		
Eels, freshwater *Anguillidae spp.*	3,295±764 1,500-5,700 6	200 1			1.0±0.8 0.2-1.7 2		
Eels, snake *Ophichthidae spp.*	17 1						
Eels, swamp *Flutidae spp.*	62±19 43-81 2						
Flounders, lefteye *Bothidae spp.*	335±182 114-695 3	43 1	140 1		1.0 1	7,519±609 6,015-8,520 4	
Flounders, righteye *Pleuronectidae spp.*	48±13 34-73 3	60 1	0.4 1		1.0±1.0 0.0-2.0 2		1.2 1
Goatfishes *Mullidae spp.*	104 1						
Gobies *Gobiidae spp.*	891 1				0.5±0 0.5-0.5 2		
Greenlings *Hexagrammidae spp.*	0 1						
Grunts *Pomadasyidae spp.*	136 1						

(TABLE VII-7 CONTINUED)

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (µg)	Biotin (µg)
	per 100 g						
Gurnards, flying *Dactylopteridae*	59 1				0.0 1		
Haddock *Melanogrammus aeglefinus*	50 1				0.0 1		2.6±2.3 0.2-4.8 2
Hake *Gadidae spp.*					1.0 1		
Halibut *Pleuronectidae spp.*	440 1	44 1			0.0 1	8,350±5,407 1,400-19,000 3	8.1±1.5 6.6-9.5 2
Herrings *Clupeidae spp.*	814±620 10-4,531 7	1,627 1			9.0±3.8 0.0-27.7 9	9,590 1	
Jacks *Carangidae spp.*	125±53 72-177 2				3.3 1		
Lampreys *Petromyzontidae spp.*	30,060±6,584 9,060-44,300 6	260±140 120-400 2					
Lings *Molva spp.*							1.1±0.1 1.0-1.2 2
Lizardfishes *Synodontidae spp.*					3.0 1		 2
Lobsters and crayfishes *Mixed species*	17 1				3.0±0.9 0.0-5.0 6		5.0±0.2 4.8-5.2 2
Mackerels *Scrombridae spp.*	107±40 0-711 17	1,036±273 143-2,000 6		11.1±4.4 2.5-29.2 6	3.0 1	8,060 1	
Milkfishes *Chanidae spp.*	537±137 400-673 2						
Minnows *Cyprinidae spp.*	79 1						
Mojarras *Gerreidae spp.*	62 1						
Mussel *Mytilidae spp.*	1,226±1,193 33-2,418 2		0.5±0 0.4-0.6 3		4.1±1.4 1.1-9.0 6		
Octopuses *Mixed species*					0 1		

(TABLE VII-7 CONTINUED)

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (μg)	Biotin (μg)
	per 100 g						
Oysters *Ostreidae spp.*	273±36 170-366 5	40 1			10.7±5.4 0-38.1 7		41±31 10-72 2
Perches *Percidae spp.*					1.2±0.0 1.1-1.2 2		
Perches, climbing *Anabantidae spp.*	218 1						
Plaice *Pleuronectidae spp.*							90 1
Pollock *Gadidae spp.*	32 1						3.7±2.4 1.3-6.1 2
Pompanos *Carangidae spp.*	5.1 1				0.0 1		
Sardines and pilchards *Clupeidae spp.*	156±51 50-303 5	2,310±873 532-5,400 5					
Sauries *Scomberesocidae spp.*	1,551±1,493 58-3,044 2				2.0 1		
Sawfish *Pristidae spp.*					0.0 1		
Scad and mackerels *Carangidae spp.*	60±33 11-122 3		0.4 1		1.4±0.6 0.8-2.0 2		
Scallops *Pectinidae spp.*	0 1				3.0 1		0.3 1
Sea chubs *Kyphosidae spp.*	19 1						
Sea cucumbers *Mixed species*					0.0 1		
Sea robins *Triglidae spp.*					1.0 1		
Shad *Clupeidae spp.*	138 1						
Sharks, dogfish *Squalidae spp.*	797±211 114-1,600 8	15 1					

(TABLE VII-7 CONTINUED)

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (μg)	Biotin (μg)
	per 100 g						
Sharks *Miscellaneous species*			270.0 1		0.0 1		
Sheathfishes *Siluridae spp.*	67 1						
Shrimp and prawns *Mixed species*	108±35 20-297 8	150±0 150-150 2			1.5±0.6 0.0-3.0 5	542±319 4-2,400 7	1.0 1
Silversides *Atherinidae spp.*					1.0 1		
Smelts *Osmeridae spp.*	96 1				1.4±1.4 0.0-2.8 2		
Snails *Mixed species*	83 1				15.0 1		
Snappers *Lutjanidae spp.*	187 1				0.3 1		
Snooks *Centropomidae spp.*					0.0 1		
Soapies *Leiognathidae spp.*	33 1						
Soles *Pleuronectidae spp.*	39 1						
Spadefishes *Ephippidae spp.*	98 1						
Squid *Mixed species*					4.9 1		
Surfperches *Embiotocidae spp.*	62±17 45-79 2						
Surgeonfishes *Acanthuridae spp.*					1.3 1		
Therapons *Theraponidae spp.*	29 1						

(TABLE VII-7 CONTINUED)

	A (I.U.)	D (I.U.)	E (mg)	Choline (mg)	Ascorbic acid (mg)	Inositol (µg)	Biotin (µg)
				per 100 g			
Threadfins *Polynemidae spp.*	172 1			8.0±0.0 8.0-8.0 2			
Tilefishes *Branchiostegidae spp.*	17 1					6,350 1	
Trout, salmon *Salmonidae spp.*	173±49 3-600 17	360±107 30-1,200 12			7.1±1.9 1.3-9.0 4	19 1	3.7±1.4 0.9-5.3 3
Trout, trout *Salmonidae spp.*	41±28 13-69 2			87 1	1.1±1.1 0.0-2.2 2		
Tuna *Scombridae spp.*	129±66 0-963 14	1,125±307 700-2,000 4		37 1	2.6±1.2 0.0-10.7 9		1.5 1
Turbon *Turbanidae spp.*	233 1				2.0 1		
Turbots *Pleuronectidae spp.*	39 1						
Whales *Physeter macrocephalus*	267 1						
Whitings *Sillaginidae spp.*	54±54 0-107 2						
Wrasses *Labridae spp.*	48 1						

* Average of the means.

** Range of the means.

*** Number of mean values.

TABLE VII-8: COMPOSITION OF THE EDIBLE PORTION OF RAW (FRESH OR FROZEN CRUSTACEANS, FINFISH, AND MOLLUSKS. VITAMINS: THIAMIN, RIBOFLAVIN, NIACIN, PYRIDOXINE, FOLIC ACID, B_{12}, AND PANTOTHENIC ACID

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Eels, moray	10	30	3.1			0.3±0.2	
Muraenidae spp.						0.1-0.4	
	1	1	1			2	
Eels, pike conger	60	90	2.7			0.2	
Muraenesocidae spp.							
	1	1	1			1	
Eels, snake	41±7	120	1.3±0.5			1.5±0.5	
Ophichthidae spp.	30-53		0.5-2.3			1.0-2.6	
	3	1	3			3	
Eels, spiny	60						
Motacanthidae spp.							
	1						
Eels, swamp	85±45	135±85	2.2±0.4				
Flutidae spp.	40-130	50-220	1.8-2.5				
	2	2	2				
Featherbacks	85±35	55±15	3.3±2.6			3.4	
Notopterus spp.	50-120	40-70	0.4-8.5				
	2	2	3			1	
Flatheads	20±1	60±30	4.7±0.4				240
Percophididae spp.	19-20	30-90	4.3-5.0				
	2	2	2				1
Flounders, lefteye	85±15	73±27	5.3±0.4	130		1.3	900
Bothidae spp.	70-100	46-100	5.0-5.7				
	2	2	2	1		1	1
Flounders, righteye	103±31	84±23	2.3±0.4	191±24	5±0	5.4±4.6	863±240
Pleuronectidae spp.	30-400	40-335	0.8-3.8	137-250	5-5	0.8-10	245-1,700
	11	12	9	4	2	2	6
Flyingfishes	17±7	56±10	3.9±0.6		2.8	1.0±0.4	
Exocoetidae spp.	4-26	40-80	3.0-5.6			0.3-1.3	
	3	4	4		1	3	
Gars				900			
Lepisosteidae spp.							
				1			
Goatfishes	36±6	59±21	1.5±0.1	1.7			
Mulidae spp.	25-43	38-80	1.4-1.6				
	3	2	2	1			
Greenlings	72±15	49±8		540	7.4±0	13.2±4.8	188±3
Hexagrammidae spp.	43-105	38-73			7.4-7.4	3.6-18.0	185-190
	4	4		1	2	3	2
Grunts	77±23	226±126	4.2±0.9	200	7.0±3.5	0.4±0.3	270±0
Pomadasyidae spp.	18-200	32-900	2.0-8.6		3.5-10.5	0.1-0.7	270-270
	7	7	7	1	2	2	2
Gurnards, flying	85±75	75±5	2.8±0.7	480	1.8	0.3	225
Dactylopteridae spp.	10-160	70-80	2.1-3.4				
	2	2	2	1	1	1	1
Haddock	39±5	69±11	3.6±0.1	231±16	0.8	1.3±0.1	145±17
Melanogrammus aeglefinus	9-100	12-210	2.4-4.3	122-300		0.5-3.5	49-380
	19	24	20	11	1	19	20

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Clams *Miscellaneous species*	49±12 2-139 14	238±47 12-780 16	1.3±0.2 0.2-2.3 9	75±42 0-350 8	25.1±6.5 2.7-58.0 7	9.8±2.5 0.2-62.3 34	531±91 440-622 2
Codfishes *Gadidae spp.*	71±9 18-150 17	121±23 11-325 16	2.5±0.4 0.2-6.7 14	221±25 170-288 4	5.0±1.6 1.8-6.7 3	0.6±0.2 0.1-2 11	163±20 96-400 14
Cornet *Fistulariidae spp.*						0 1	
Crabs *Mixed species*	85±20 10-140 6	382±280 60-940 3	2.5±0.2 2.3-2.7 2				
Croakers *Sciaenidae spp.*	85±26 40-160 4	98±19 60-150 4	3.2±0.9 1.7-5.5 4	0.2 1		2.5 1	
Cusk *Brosme brosme*	38±6 32-51 3	303±160 94-940 5	2.7±0.2 2.3-3.0 3	304±30 274-333 2		1.0 1	261±44 273-310 3
Cusk eels and brotulas *Ophidiidae spp.*	175 1	35±3 32-37 2	1.8±0.4 1.4-2.2 2		2.0 1	0.6±0.3 0.3-0.9 2	115 1
Cuttlefishes *Miscellaneous species*	96±59 9-210 3	480±430 50-910 2	2.1±0.8 1.2-2.9 2				
Dolphins *Coryphaenidae spp.*	20 1	70 1	6.1 1			0.1 1	
Dories *Zeidae spp.*				952 1		0 1	
Drepanes *Drepanidae spp.*	29±2 27-30 2	111±30 81-140 2	3.2±0.4 2.8-3.7 2				
Drums *Sciaenidae spp.*	63±14 20-130 9	131±46 31-530 10	3.1±0.7 0.5-8.9 11			2.4±1.5 0.2-5.3 3	
Eels, arrowtooth *Dysommidae spp.*				230 1			150 1
Eels, conger *Congridae spp.*	60 1	40±0 40-40 2	4.3±0.8 3.5-5.0 2			3 1	240 1
Eels, freshwater *Anguillidae spp.*	191±31 144-280 4	335±51 190-520 6	2.3±0.5 1.4-3.5 4	254±15 230-300 5	11.6±1.6 10.0-13.1 2	1.0±0 1.0-1.0 3	141±6 125-150 4

(TABLE VII-8 CONTINUED)

	Thiamin (µg)	Riboflavin (µg)	Niacin (mg)	Pyridoxine (µg)	Folic acid (µg)	B_{12} (µg)	Pantothenic acid (µg)
				per 100 gm			
Butterflyfishes	33±4	45±26	4.5±0.1				
Chaetodontidae spp.	25-40	19-70	4.4-4.6				
	3	2	3				
Caesios	24±4	24±4	3.8±0.6	190		2.3±0.8	
Caesionidae spp.	20-28	20-27	3.2-4.3			1.5-3.1	
	2	2	2	1		2	
Carps	114±32	81±23	3.0±0.7	71±60	70±68	3.2±1.2	150
Cyprinidae spp.	5-448	10-180	1.3-11	11-130	2.8-138	0.1-9	
	20	7	16	2	2	8	1
Catfishes, airbrething	44±23	36±5	1.7±0.6		13.6±1.7	3.5±0.1	460
Claridae spp.	8-110	31-40	0.5-3.2		12.0-15.3	3.4-3.7	
	4	2	4		2	4	1
Catfishes, freshwater	0		1.8±0.5		3.1±1.2	3.7±0.4	464±4
Ictaluridae spp.			1.0-2.5		1.9-4.3	2.2-4.6	460-468
	1		3		2	7	2
Catfishes, sea	61±8	115±22	2.4±0.6	370	82.5±67.5	2.4±0.2	570
Ariidae spp.	40-80	80-197	0.5-4.5		15-150	2.2-2.5	
	4	5	6	1	2	2	1
Characins	30±12	87±19	3.7±1.4			1.6	
Characidae spp.	10-50	50-100	1.7-6.3				
	3	3	3			1	
Chimaeras					2.7		310
Chimaeridae spp.							
					1		1
Cichlids	30±0	85±35	2.3±0.8	320		2.9±0.2	
Cichlidae spp.	30-30	50-120	1.5-3.1			2.7-3.0	
	2	2	2	1		2	
Clams, akshels	2	200	1.5		17	13.6±6.4	790
Arcidae spp.						7.2-20	
	1	1	1		1	2	1
Clams, freshwater					17	12.1	360
Corbiculidae spp.							
					1	1	1
Clams, mactra	72±52	114±16				0.4±0.2	
Mactridae spp.	20-128	98-130				0.2-0.7	
	2	2				3	
Clams, razor	95±5	355±155	1.6±0.1			8.6	
Solenidae spp.	90-100	180-490	1.5-1.6				
	2	2	2			1	
Clams, softshell	21±19	180±29	1.9±0.4	88±9		71.5±22.4	293±17
Myacidae spp.	1-79	95-219	1.2-2.5	77-106		7.1-105.0	260-311
	4	4	3	3		4	3
Clams, Tellin	10	20	2.2	70	10.9		
Tellindae spp.							
	1	1	1	1	1		
Clams	100±33	381±147	2.9±0.6			3.9±1.7	
Veneridae spp.	10-240	20-940	1.1-5.0			2.2-5.6	
	7	7	6			2	

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Abalone *Haliotidae spp.*	* 210±30 **180-240 ***2	85±27 56-140 3	1.4±0.1 1.2-1.6 3	0.6 1		0.7 1	2,300±0 2,300-2,300 2
Amberjacks and yellowtails *Seriola spp.*	115±33 27-180 4	84±17 40-120 4	8.3±8 6.8-10 4		3.5±0.3 3.2-3.7 2	4.2±1.4 1.3-5.6 3	598±3 595-600 2
Anchovies *Engraulidae spp.*	19±7 8-37 4	104±24 79-152 3	3.1±0.4 2.3-3.5 3	181±27 144-260 4	12.3 1	6.3±0 6.3-6.3 2	
Augar shells *Terebralia sulcatua*					21.1 1	12.6 1	60 1
Barracudas *Sphyraenidae spp.*	92±21 44-134 4	70±11 27-90 5	4.1±0.6 2.4-5.9 5	350±101 150-470 3	11.9 1	1.4±0.4 0.2-1.8 4	
Basses, sea *Serranidae spp.*	79±13 20-170 14	114±33 35-374 13	2.4±0.4 1.1-4.3 12	300 1	8.8 1	5.0±2.4 0.3-9.1 4	7,530 1
Basses, temperate *Percichthyidae spp.*	100 1	52 1	2.4 1				
Bigeyes *Scombropidae spp.*				400 1			
Billfishes *Istiophoridae spp.*	100 1	60 1	4.5 1				
Bluefishes *Pomatomidae spp.*	135±15 120-150 2	120±30 90-150 2	1.9±0 1.9-1.9 2				
Bombay duck *Harpadon nochereus*	30±10 20-40 2	70±20 50-90 2	5.7±5.1 0.6-10.7 2	970 1			
Breams and porgies *Sparidae spp.*	77±18 10-190 15	96±21 20-250 15	5.4±6 1.5-7.8 12	460±0 460-460 2	1.6±1.2 0.4-4 3	1.8±0.4 0.1-2.8 7	213±8 205-220 2
Burbot *Gadidae spp.*	388±27 306-455 6	141±1 140-142 2	1.6±0 1.6-1.6 2				
Butterfishes *Stromateidae spp.*	163±1 163-164 2	223±109 90-550 4	4.8±1.2 2.6-8.1 4	450 1		2.3±0 2.3-2.3 2	

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Hake *Gadidae spp.*	89±27 39-132 3	75±5 70-80 2	1.6±0.6 1.0-2.2 2	875 1			
Halibut *Pleuronectidae spp.*	83±11 40-180 13	80±11 44-185 15	7.5±1.0 2.8-142 11	400±15 347-430 5	2.6±0.3 2.0-2.9 3	0.8±0.1 0.7-1.0 6	303±50 111-595 11
Herring *Clupeidae spp.*	46±8 6-170 27	261±39 50-1,000 26	3.8±0.4 0.6-9.6 25	310±43 160-450 6	10.3±2.9 1.7-14.0 4	11.4±4.3 1.4-34.0 9	2,427±1,415 970-9,500 6
Jacks *Caringidae spp.*	59±17 15-122 5	60±10 25-81 5	5.7±0.5 3.9-7.1 5	670 1		7.5±1.6 5.9-9.1 2	
Lampreys *Petromyzontidae spp.*	339±256 46-850 3	520±93 427-612 2	4.7 1	195±25 170-220 2	25.5±1.7 23.6-29.0 3	4.1±0.3 3.8-4.4 2	425±145 280-570 2
Lings *Molva spp.*		80 1	2.5±0.2 2.3-2.7 2	265±44 221-309 2		1±0.5 0.5-1.9 3	320 1
Lizardfishes *Synodontidae spp.*	92±12 80-104 2	39±11 28-50 2	2.9±0.5 2.4-3.4 2				
Lobsters and crayfishes *Miscellaneous species*	99±24 7-165 7	64±10 10-130 10	2.3±0.3 1.2-4.3 8	210 1	0.6±0 0.6-0.6 2	1.6±0.6 0.5-2.7 4	410±0 410-410 2
Longarays *Ambasidae spp.*	11 1	39 1	1.5 1				
Mackerels *Scombridae spp.*	90±11 10-237 31	263±49 27-940 30	12.4±2.0 2.7-58.0 27	654±76 270-1,000 10		4.2±1.2 0.4-16.2 14	444±82 160-850 8
Milkfishes *Chanidae spp.*	57±44 13-100 2	77±23 54-100 2	6.1±0.3 5.8-6.4 2	420 1	15.9 1	3.4±0 3.4-3.4 2	
Minnows *Cyprinidae spp.*	30 1	100 1	3.5 1	130 1			
Mojarras *Gerreidae spp.*	51±21 30-92 3	85±3 80-90 3	5.0±0.3 4.5-5.3 3	360 1	21.4 1	2.4±0.5 1.9-3.4 3	
Mussels *Mytilidae spp.*		150±30 120-180 2	1.6±0.4 1.2-2.0 2	98±92 6-190 2	41.8 1	10.2 1	
Needlefishes *Belonidae spp.*	4 1	39±2 37-40 2	0.9±0 0.9-0.9 2	655±85 570-740 2		1.9±0 1.9-1.9 2	

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Ocean perches *Sebastes marinus*		110 1	2.0 1				360 1
Octopuses *Mixed species*	67±26 20-140 5	73±14 40-110 5	3.2±1.2 1.3-5.3 3	360 1			
Oysters *Ostreidae spp.*	153±11 9-300 36	188±15 16-340 29	1.8±0.2 0.7-7.1 34	166±25 30-320 18	84.4±77.8 3.7-240 3	17.2±2.6 11.5-33.0 9	365±2 184-5 22
Parrotfishes *Scaridae spp.*	29±24 5-53 2	57±6 50-70 3	1.4±0 1.4-1.5 3	180 1		0.6 1	
Perches *Percidae spp.*	187±63 60-250 3	119±46 28-170 3	1.9±0.2 1.4-2.3 4				
Perches, climbing *Anabantidae spp.*	39±12 19-99 6	274±49 190-361 3	2.4±0.7 0.8-3.7 4	200 1	2.7±1.3 1.0-5.2 3		
Pikes *Esocidae spp.*				135±17 115-150 2			
Plaice *Pleuronectidae spp.*	137±32 105-200 3	163±33 130-195 2	4.0 1	217±14 182-250 4		1.4±0.4 1.0-2.2 3	800± 800- 2
Pollock *Gadidae spp.*	82±18 45-160 6	122±18 80-200 7	2.6±0.6 1.6-2.9 4	238±60 60-473 6	65 1	2.1±0.5 1.0-3.5 5	274± 140- 5
Pomfrets *Bramidae spp.*	120±70 50-190 2	190±110 80-300 2	0.6±0.2 0.4-0.8 2				
Pompanos *Carangidae spp.*	254±154 90-562 3	91±17 60-118 3	4.7±1.5 3.0-8.1 3				
Rays, stingray *Dasyatidae spp.*	50±10 36-80 4	44±5 30-50 4	3.5±0.6 2.5-4.6 4			0.1 1	
Rockfishes *Scorpaenidae spp.*	96±18 29-153 7	150 1	3.0 1	143±88 55-230 2	4.7±4.3 0.4-9 2	1.0 1	177± 80- 3
Sandfishes *Trichodontidae spp.*	100 1	50 1			7.8±0 7.8-7.8 2		630± 630- 2
Sardines and pilchards *Clupeidae spp.*	19±8 1-90 10	107±38 30-387 9	6.3±1.0 2.4-10 9	424±231 150-882 3	2 1	5.6±2.3 1.1-17.0 7	1,030± 1,000- [illegible]
Sauries *Scomberesocidae spp.*	50±1 48-54 5	112±11 87-132 5	6.0 1	660 1	6.4 1		85 [illegible]

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Sawfishes *Pristidae spp.*	140 1	190 1	4.1 1				
Scad and mackerel *Carangidae spp.*	139±19 26-180 8	141±13 77-190 7	6.0±1.3 1.5-11.0 7	406±98 300-700 4	4.3±2.4 1.9-6.6 2	5.3±1.4 0.2-12.7 11	350±0 350-350 2
Scallops *Pectinidae spp.*	85±45 40-130 2	83±18 65-100 2	1.3±0.1 1.2-1.4 2			8.9±7.6 1.2-24.0 3	138±6 132-143 2
Scorpionfishes *Scorpaenidae spp.*				55 1		7.6±4.4 3.2-12.0 2	80 1
Sculpins *Cottidae spp.*			3.2 1			6.1 1	100 1
Sea cucumber *Mixed species*	53±18 35-70 2	90±0 90-90 2	0.5 1			1.4±0.3 0.5-2.0 4	
Sea robins *Triglidae spp.*	90 1						
Shad *Clupeidae spp.*	46±35 10-150 4	240-0 240-240 2	8.4 1				608 1
Shark, dogfish *Squalidae spp.*	52±8 40-66 3	264±155 80-573 3	2.9±1.2 1.0-5.2 3		3.2 1	1.8±0 1.8-1.8 2	747±57 690-860 3
Sharks, hammerhead *Sphyrnidae spp.*	14 1	81 1	3.2 1				
Sharks, mackerel *Lamnidae spp.*	105±25 80-130 2	91±10 81-100 2	9.5±2.5 7.0-12.1 2			3.0±0.4 2.6-3.4 2	330 1
Sharks, sand tiger *Odontaspididae spp.*	20 1	30 1	4.4 1				
Sharks *Miscellaneous species*	40±16 5-110 6	57±15 19-110 6	4.0±0.9 0.9-6.6 6			0.4±0.2 0-0.7 3	
Sheathfishes *Siluridae spp.*	10 1	40 1	1.4 1				
Shiners *Cyprinidae spp.*						1.4 1	
Shrimp and prawns *Mixed species*	41±6 10-143 28	76±11 13-190 26	2.7±0.3 0.7-4.9 17	66±13 16-125 10	5.2±2.2 3.0-7.4 2	3.8±1.0 0.9-8.1 7	278±16 165-372 15

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Siganids *Seganoidae spp.*	203±43 160-245 2	129±2 127-130 2	4.8±0.4 4.4-5.1 2	140 1		0.1 1	
Silversides *Atherinidae spp.*	88±71 10-230 3	65±15 50-80 2	2.9±1.6 1.3-4.5 2				
Sleepers *Eleotridae spp.*	26 1						
Smelts *Osmeridae spp.*	54±26 10-130 4	143±33 43-360 8	1.9±0.4 1.3-3.0 4	120 1	5.0±1.3 3.7-6.3 2	1.8±1.6 0.2-3.4 2	919±281 638-1,200 2
Snails *Mixed species*	56±54 2-110 2	169±111 58-280 2	1.5±0.2 1.3-1.6 2	120 1	31.8 1	26.7±7.1 9.0-77.0 10	
Snappers *Lutjanidae spp.*	88±18 46-170 6	81±17 38-131 5	3.6±0.6 2.5-5.2 5	100±100 0-200 2			
Snooks *Centropomidae spp.*	134±47 48-350 8	150±59 48-440 7	1.4±0.4 0.7-3.1 8		65.0 1	3.4±0 3.4-3.4 2	
Soapies *Leiognathidae spp.*	43±16 13-70 4	39.3±0.8 37-40 4	2.1±0.1 1.9-2.5 4	170 1	23.6 1	3.6±0 3.6-3.6 2	
Soles *Pleuronectidae spp.*	62±5 38-88 10	48±2 37-57 7	1.1 1	1,045 1	3.0±0.1 2.9-3.1 2	0.1 1	420±197 155-805 3
Soles *Soleidae spp.*	72 1						
Spadefishes *Ephippidae spp.*	66±46 20-158 3	157±7 150-170 3	5.2±0.1 5.0-5.3 3			2.6±0 2.6-2.6 2	
Squid *Mixed species*	43±19 8-150 7	218±104 50-836 7	2.6±0.5 1.2-4.7 7	623±360 70-1,300 3	12.5 1	4.5±2.9 1.3-13.0 4	680 1
Suckers *Catostomidae spp.*	15±11 4-36 3	50 1	1.3±0.1 1.1-2.0 7				464 1
Sunfishes *Centrarchidae spp.*			0.5 1				512 1
Surgeonfishes *Acanthuridae spp.*	29±2 27-30 2	28±2 26-30 2	3.8±0 3.8-3.8 2		10 1	1.1±0.5 0.6-1.6 2	320 1
Tarpons *Elopidae spp.*	54±21 16-90 4	52±5 39-60 4	3.6±0.7 1.6-5.1 5				

(TABLE VII-8 CONTINUED)

	Thiamin (μg)	Riboflavin (μg)	Niacin (mg)	Pyridoxine (μg)	Folic acid (μg)	B_{12} (μg)	Pantothenic acid (μg)
				per 100 gm			
Therapons *Theraponidae spp.*	23±2.5 20-28 3	71±5 63-81 3		600 1		4.9±2.2 2.7-9.2 3	
Threadfins *Polynemidae spp.*	25±5 19-40 4	93±26 50-160 4	2.6±0.6 1.5-4.6 5		70 1		
Tilefishes *Branchiostegidae spp.*	80 1	111 1	2.8 1	45 1			
Tonguefishes *Cynoglossidae spp.*	50 1	150 1	3.3 1				
Trout, salmon *Salmonidae spp.*	130±15 30-348 23	143±13 46-231 26	7.2±0.2 5.6-8.8 15	745±54 590-975 6	3.9±0.4 2.2-4.8 6	1.7±0.5 0.1-5.0 13	988±144 490-2,080 15
Trout, trout *Salmonidae spp.*	80±9 10-140 12	109±17 10-210 15	4.2±0.6 2.5-7.8 9	690±0 690-690 2		3.3±0.8 1.0-5.0 6	1,843±77 1,630-2,000 5
Trout, whitefish *Salmonidae spp.*	88±5 27-126 26	120±0 120-120 3	2.8±0.2 0.6-4.6 15				
Tunas *Scombridae spp.*	120±21 10-434 22	164±31 13-660 28	9.7±1.1 0-23.4 21	647±72 190-920 10	2.1±0.7 0.6-3.2 4	6.2±2.5 0.2-47.0 19	917±313 186-3,280 9
Turbons *Turbanidae spp.*	60 1	60 1	3.0 1	1,700 1	7.3±0 7.3-7.3 2	0.3 1	305±45 260-350 2
Turbots *Pleuronectidae spp.*	46±14 18-60 3	86±28 40-137 3	1.1±0.4 0.6-1.5 2			1.3±0.3 1.0-1.5 2	250±0 250-250 3
Whiting *Sallaginidae spp.*	36±15 21-50 2	80±20 60-100 2	6.1±0.7 5.4-6.9 2				
Wolffishes *Anarhihadidae spp.*				350 1		2.0 1	570 1
Wrasses *Labridae spp.*				80 1		3.0±2.3 0.7-5.3 2	

*Average of the means.

**Range of the means.

***Number of mean values.

APPENDIX

THE CHEMICAL COMPOSITION OF FISH

A knowledge of the chemical composition of fish is important in determining their nutritional properties, uses, and storage stabilities, as well as in the development of new fisheries technologies. Chemical analysis reveals that the actual composition varies widely in response to environmental and genetic factors, and, indeed, even within the body of a single fish. However, the general makeup is comparable between the species and it presents some unique and interesting considerations.

The chemical nature, significance, and critical factors for the following components of fish will be discussed: protein, lipid, non-protein nitrogenous compounds, pigments, and vitamins.

PROTEIN

The protein content of fish varies from 15 - 24%. Shellfish usually have less muscle protein than finfish; they range from 22% for crustaceans to about 9% for gastropods. In all cases, this is a high value protein. Eighty-seven to 98% of the protein utilized, the protein efficiency ratio (PER), is greater than that of eggs or casein. The relative ease of digestion may be due to the low connective tissue content or to the relative shortness of the muscle fiber.

The amino acid composition of fish protein is similar to that of other animal proteins. All of the essential amino acids are present. The lysine content is high, making fish a good supplement to cereal protein. The lysine content may be about 30% greater than that found in beef and about eight times that in bread. The histidine level is also high, especially in the red meat fish. Bacterial decarboxylation of histidine and the subsequent formation of histamine in scombroid fishes may create food poisoning problems.

Tryptophan and methionine are characteristically low, with methionine (or cysteine) being the limiting amino acid. However, cysteine is still four times more abundant in fish protein than in casein.

The three general classes of proteins found in fish are the sarcoplasmic proteins, the myofibrillar proteins, and the connective tissue proteins. Sarcoplasmic protein or myogen makes up 20 to 30% of the total protein content. This fraction is composed chiefly of enzymes, most of which resemble those found in mammalian sarcoplasm. Two enzymes which are unique to fish are thiaminase and anserinase. The remaining sarcoplasmic fraction, about 0.5%, consists of the colored hemocyanin proteins and cytochrome c. These are usually present in low concentrations, especially in the white-fleshed fish. In some seafoods, however, the oxygen-carrying pigments create discoloration problems, especially during processing. Oxidative changes in myoglobin are responsible for such defects as the greening of tuna. Chemical changes in the copper hemocyanin of crab may cause the canned product to have a blue or blue-black discoloration.

Myofibrillar proteins comprise 65 to 75% of the protein content. They control the fibrousness, plasticity, and gel-forming ability of the flesh. Components of the myofibrillar proteins are actin, myosin, tropomyosin, and troponin. Myosins may be used to distinguish between different species on the basis of oligomer appearance in the ultracentrifuge.

The connective tissue (3 to 5% of the total protein) contains collagen and elastin. It is found in the skin of the fish and in the myocommata, which are thin connective tissue layers separating compartments or myostomes of fish flesh. The connective tissue denatures and dissolves at a relatively low temperature, 30°C, thus explaining the formation of flakes of flesh when fish are cooked. The small amount of connective tissue actually present also contributes to the tenderness of fish flesh. The scales of fish are scleroproteins of the keratin group.

The protein content of fish flesh is influenced by several factors. Chief among these are the fat and water content. There is an inverse relationship between the amount of fat and the amount of water. The sum of these two components is always constant in a given species. With some species (e.g., herring), the sum is so reliable that a determination of the water content alone is sufficient in deriving the fat content.

Protein content also varies inversely with water content. An extreme of this relationship is seen in "jellied" fish such as plaice. Jellied fish suffer protein emanciation in the flesh because the gonads, which have priority over muscle, have an increased need for protein. The reverse situation is "chalkiness" in halibut, resulting from higher-than-normal protein content. The degree of hydration influences the dollar value, so protein content is usually expressed on a dry weight basis.

Differences in protein content and composition of red meat and white meat are minor but consistent and are identical in all species studied so far. The amino acid content of red meat protein is closer to that of land animals. Glycine, leucine, phenylalanine, and arginine are higher in red meat, while lysine, aspartic acid, and glutamic acid dominate in white meat. White flesh has a higher protein content, because it contains less oil than dark flesh.

The sexual stage influences protein makeup. During depletion, catheptic enzymes preferentially destroy the protein for a food source and to supply building materials to gonads and eggs or sperm. The albumins are destroyed first, then α and β globulins, but never the σ fraction. Muscle protein may actually increase in the early stages of depletion while the liver glycogen is being utilized for energy. Contractile tissue breaks down more easily than collagens, so the actual collagen content appears to increase, along with a relative increase in the concentration of hydroxyproline and hydroxylysine. There is actually an increase in the absolute quantity of collagen during spawning. It is necessary to give increased strength to the body walls, so they can hold the accumulated eggs or sperm.

Amino acid content shows a response to environmental temperature. The hydroxyproline content increases as the water temperature increases. The denaturation temperature of protein is higher in fish from warmer waters.

Even within the same species or genus, variation in protein content will exist. For example, chum salmon always have more protein (21.5%) than pink salmon (19%). It was once believed that female fish contained a higher percentage of protein than males, but now differences due to sex appear to be minor and coincidental at best.

Shellfish protein varies greatly with season, especially during spawning time. Fat and protein contents both build up just before spawning, then drop off afterwards. Protein also increases in spring and summer, when more food becomes available, then drops in late fall.

Crustacean protein is often bound to carbohydrate, thus existing as a glycoprotein. Crustacean protein suits human requirements for essential amino acids, but contains less tyrosine, arginine, and methionine than mammalian protein.

During processing, fish protein undergoes changes that are both detrimental and beneficial. The most obvious beneficial effect of heat processing is an increased digestibility, resulting from the cleavage of peptide bonds and the destruction of connective tissue. The deteriorative changes are more complex.

Freezing is a common preservation method. No change in texture will occur if the product is frozen and thawed out in less than 24 hours. Under less ideal conditions, deterioration will occur. With a loss of selective permeability on freezing, the myofibrillar protein gel loses its capacity to hold moisture. The resultant drip loss makes a dry product. Freezerburn can cause a tough, chewy, or rubbery product.

The temperature of freezing is an important consideration. Maximum ice crystal formation is between 0.8° and -5°C. A slow freezing rate causes the most damage to the actomyosin system because of the longer time taken to pass through this zone of maximum crystallization. Below -5°C, the rate at which fish toughens and becomes inextractable declines as the temperature drops. Below -30°C, changes take about one year to become apparent. Fluctuations in storage temperature have a more severe deteriorative effect than the actual temperature.

Several theories have been proposed to explain the nature of these reactions. The most widely accepted is that the toughness and water loss are due to an increased number and strength of actin-myosin bonds between the myofibrillar proteins. The cause of these altered binding characteristics is a concentration of solutes, especially hygroscopic salts like trimethylamine oxide and lactate, in the remaining unfrozen portion. This facilitates a pH change, protein dehydration, and crystallization of the solutes. No real benefit has been proven to freezing either post or prerigor.

Canning is a carefully controlled process that doesn't affect the amino acid composition of fish. However, the protein may be less available for absorption due to Maillard type reactions or the formation of other indigestible bonds. The presence of copper in crab blood and iron in crab meat will accelerate such browning.

Drying may also decrease the physiological availability of amino acids due to the formation of enzyme-resistant linkages. The loss in nutritive value is primarily due to unavailability of lysine.

Lipids

Fish contain a great variety of unique lipids. They are present in the liver and viscera as fat deposits, and in the muscle tissue, skin, and roe to a smaller extent. Lipids make up from 0.1 to 22% of the fish.

Fish lipids differ from other naturally occurring fats and oils in having a greater proportion of unsaturated fatty acids; having large quantities of fatty acids with chain lengths greater than 18 carbon atoms; having polyunsaturates, mostly at the $\omega 3$ rather than the $\omega 6$ position; and in general possessing a greater variety of lipid compounds.

The origin of oil in fish is marine plant life, crustacea, and plankton that are able to convert ingested dienoic acids to tetra, penta, and hexaenoic forms. The odd number fatty acid chains in marine lipids come from phytoplankton, while the branched chain fatty acids are supplied by zooplankton. The degree of unsaturation varies with the diet. Diatoms provide an abundant supply of hexa-, penta-, and tetraeonic acids, while plankton have mostly hexa- and pentaeonic acids.

Several classes of lipids are found in fish. Hydrocarbons may be present in quantities ranging from 0.1 to 90% of marine oils. These include a wide variety of saturated and unsaturated straight and branched chain hydrocarbons. Two common branched chains are squalene and pristane; paraffins are straight chain hydrocarbons. High percentages of hydrocarbons are found in elasmobranchs; shark oil may be 90% squalene.

Triglycerides (e.g., triolein, palmitodiolein) are the principal source of fatty acids in fish lipids. Of the fatty acids found on these triglycerides, only 15 to 40% are saturated. The chief one is palmitic. The remainder are polyenoic acids. They have a cis configuration with no conjugated double bonds; most are straight chain and even-numbered. The polyenoic acids are preferentially bound at the two-position on the glycerol backbone. The C_{20-22} series is the most common. Common unsaturated fatty acids include palmitoleic, oleic, and linoleic.

Wax esters are also found in fish oils. They serve as an energy source and consist of a fatty acid and a fatty alcohol, usually with a low degree of unsaturation. They are found in sea anemone, crustaceans, and dolphins, as well as many species of fish.

Phospholipids make up the fat in body organs and cells, while most of the depot fats are triglycerides. Fish phospholipids are mainly lecithin and phosphatidyl ethanolamine. The polyunsaturated fatty acid is on the two-position of the glycerol backbone. Phospholipids are usually more unsaturated than triglycerides.

Differences are found in the content and composition of fish lipids, depending on many factors. Fish liver and egg oils differ from body oils in having a higher degree of unsaturation.

Large differences in oil content exist among species. Species are classified as fat when they contain 12 to 26% oil (e.g., salmon, tuna, herring), as semifat when they contain 2 to 10% oil (e.g., swordfish, halibut, mackerel), or as lean when they contain 0.1 to 1% oil (e.g., haddock, cod, sole, plaice).

The section of the fish sampled must be identified. For example, oil from the ventral area of Pacific herring has more than twice the amount of 20:1 and 22:1 acids than oil from the dorsal area of the same. The dark muscle of fish has a consistently higher oil content than the white muscle.

During sexual maturation and the following reproduction, extensive lipid depletion occurs as lipid is used for energy and for gonad growth. Selective mobilization, which influences the composition of the remaining fats and oils, is observed. Smaller lipid molecules are more readily utilized when depot fat is metabolized. The unsaturated oils are used preferentially. Phospholipids are not used because they have a structural function in cell walls. An increase is seen in free fatty acid concentration in the blood.

Environmental temperature plays a critical role in lipid composition. At lower temperatures, the lipids are more unsaturated. This is necessary to keep the melting point below that of the water, so that the fish can maintain flexibility and motility. A reduction in chain length in response to a drop in environmental temperature also helps the fish adapt to surrounding conditions.

Marine fish oils have a more complex composition than freshwater fish oils. They have more C_{18}, C_{20}, and C_{22} series fatty acids and a higher bromine content. The freshwater fish fatty acids have more C_{18} and palmitic unsaturated acids. Elasmobranch lipids differ from teleost lipids. The liver oil has a higher content of saturated fatty acids and unsaturated fatty acids with 18 carbon atoms.

The high degree of unsaturation in fish oils causes many problems with rancidity. Two types of deteriorative changes are common: hydrolytic rancidity and oxidation rancidity. Hydrolytic rancidity yields free fatty acids from the breakdown of triglycerides. The reaction usually precedes only to a monoglyceride plus two free fatty acids, unless an enzyme or other catalyst is present. If an alkaline catalyst such as sodium hydroxide is used, soaps will be formed. The significance of free fatty acid formation is threefold. First, free fatty acids speed up oxidative deterioration. Second, they interfere with commercial processing by poisoning any catalysts used. Finally, the hydrolyzed fat probably has poor color, off-flavor, and low stability. All of these factors will lower the sales value of the oil.

Oxidative rancidity is more detrimental than hydrolytic rancidity. The product may have a strong, disagreeable odor and flavor, due to the union of unsaturated compounds of the glycerides with oxygen to produce reactive molecules and rancid flavors. This type of rancidity gives highly unsaturated hydroperoxides which are very unstable and break down into flavorous compounds. Care must be taken to protect the unstable oil from catalysts like light, heat, and oxygen. Destruction of vitamins A, D, E, and K occurs with oxidative rancidity.

General characteristics of oxidized fish oil include increased specific gravity, index of refraction, viscosity, acid value, and saponification value. The iodine value and ether insoluble bromides are lower. A fishy flavor is prevalent and may be associated with the presence of rancidity products such as hydroperoxides, formaldehyde, and volatile bases including trimethylamine and trimethylamine oxide. The fishy flavor may also be due to the breakdown of oxidized, highly unsaturated fatty acids. The color of the oil becomes brown or deep red, which may be due to interaction with protein, trimethylamine, or oxidized fatty acids. These reactions are accelerated by basic compounds.

The oxidative process occurs in two steps. During the induction period, oxygen is absorbed at a moderate rate. The main reaction is peroxide formation, but the chain reaction for oxidative rancidity is initiated. Oxygen is added at or near the double bond to give the highly reactive peroxides, which propagate the reaction by decomposing or reacting with one another. The products are acids, carbonyls, and condensation products, all of which produce off-odors and flavors.

The rate of these reactions increases with increased amounts of the following: degree of unsaturation, isolation of the double bond, temperature, light, and prooxidant metals such as copper and iron. This last factor necessitates the use of good quality stainless steel or tinplated metal when processing fish oils.

Practical measures must be taken during the harvesting of fish to prevent the initiation of rancidity reactions. Whole fish should be iced immediately; fillets should be ice-glazed to keep oxygen out. A carbon dioxide or nitrogen atmosphere may be helpful. A salt cure is sometimes applied to promote preservation, but the purity of the salt must be considered, since contaminants such as magnesium chloride are prooxidants. Refined oils should be stored below -30°C.

Antioxidants play an important role in preservation of fish and fish oils. They prevent or control rancidity through interference with the initiation or propagation steps by reacting with the initial free radical or one formed in the early stages. The intermediate formed is not capable of continuing the chain. The best antioxidants are aromatic phenols and amines. Those in common use include BHA, BHT, and TBHQ. Two natural antioxidants are lecithin and the tocopherols.

Synergists are often employed to enhance the effectiveness of the antioxidants. Their mode of action is to chelate metals which act as prooxidants. Phosphoric acid, citric acid, ascorbic acid, and ascorbyl palmitate function as synergists.

Nonprotein Nitrogenous Compounds

Nonprotein nitrogenous compounds are often volatile and malodorous, or have decomposition products which are. Thus they must be carefully controlled during fish storage. Nonprotein nitrogenous (NPN) compounds make up 9.2 to 18% of the total nitrogen in teleosts and 33 to 38% of the total nitrogen in elasmobranchs. The compounds include:

A. volatile bases; e.g., ammonium, mono-, di-, and trimethylamine
B. trimethylammonium bases; e.g., trimethylamine oxide, betaine
C. guanidine derivatives; e.g., creatine, arginine
D. imidazole derivatives; e.g., histidine
E. other miscellaneous compounds; e.g., urea, free amino acids, purines.

Nonprotein nitrogen compounds are important flavor components of fish. The free amino acids have the most significant impact on taste, with the most influential being glutamic acid, glycine, alanine, valine, and methionine. Their potency is greatest when they are combined with adenosine monophosphate (AMP), adenosine triphosphate (ATP), or inosine monophosphate (IMP). Other implicated compounds include trimethylamine oxide, histidine, and glycine betaine.

Some NPN compounds have osmoregulatory functions in the living fish. Specifically, these compounds are ammonia, urea, creatine, and trimethylamine oxide.

The most significant practical role NPN compounds play is that of a freshness indicator. The relative contents of fixed and volatile nitrogen bases are a good indication of the freshness of fish. In the living fish, equilibrium exists between trimethylamine oxide and trimethylamine. After death there is an increased content of di- and trimethylamine as a consequence of the reduction of the oxide to free base. The base is the principal compound responsible for the characteristic rotten fish odor.

In dark-fleshed fish, about 21% of the total nitrogen exists in forms other than protein. The content of NPN is directly correlated with the degree of motility or, equivalently, the amount of red muscle. Red muscle contains the most free arginine and histidine. Seasonal changes are seen in the dark flesh. Monoamino nitrogen may drop in winter and increase in summer. Since the flavor is not usually as good in summer, it may be related to diamine content or arginine and histidine content.

Histidine may be converted to histamine by bacterial decarboxylation and autolytic changes. Histamine has often been implicated as the causative agent in fish-related food poisonings.

The content of NPN in white-fleshed fish is markedly lower than in dark-fleshed fish. White-fleshed fish contain creatine, creatinine, trimethylamine oxide, anserine, and free amino acids. The amino acids detected include small amounts of arginine and histidine. Free cysteine is common in freshwater fish. These free amino acids, along with imidazole compounds, contribute to the sweet taste of white-fleshed fish. Among white-fleshed fish, trimethylamine oxide is found primarily in marine species.

In elasmobranchs, urea is the predominant nitrogenous compound. It is a muscle constituent and is also found in the blood where it acts as a freezing point depressant. The overall function of urea is its responsibility for osmotic regulation. Urea may be converted to ammonia during storage. The presence of ammonia is an indication of spoilage. Trimethylamine oxide is present in large amounts in elasmobranchs.

In invertebrates, free α-amino nitrogen accounts for 40% of the NPN. Crustaceans contain compounds similar to those present in dark-fleshed fish. The free amino acids include glycine, proline, arginine, glutamic acid, and alanine. In mollusks, amino acid nitrogen accounts for 52 to 63% of the NPN. Trimethylamine oxide is not present. In squid, scallops, and octopus, the main compounds are glycine, alanine, and hypoxanthine, respectively. All groups exhibit rapid ammonia formation.

Pigments

The colors of fish change in response to their background, during courtship, and in moments of excitement. Pigment-containing cells called chromatophores control these changes. Chromatophores are classified according to the pigment they contain:

A. melanophores - brown or black pigment

B. erythrophores - red pigment

C. xanthophores - yellow pigment

D. leucophores - white pigment

E. iridophores - iridescent or reflecting pigment.

Chromatophores may contain more than one pigment.

The brown and black pigments are produced by melanins, highly polymerized compounds derived from tyrosine. In some species, the intensity of the brown or black color is dependent on tyrosinase activity. For example, in some goldfish species, the tyrosinase activity will determine whether the fish is white, gray, or black. However, no generalization can be made for all species concerning tyrosinase level and color.

Carotenoids are the basis for the yellow and red pigments found in xanthophores and erythrophores. As members of the terpene group, they are highly unsaturated hydrocarbons consisting of a chain of carbon atoms with a ring structure at one or both ends. They are water insoluble, but are soluble in organic solvents.

Pteridines are present in both colored and uncolored forms in chromatophores. They have a variety of hues and may appear red, yellowish, blue, or violet fluorescent. Pteridines are related to purines and flavins; they have both a pyrimidine and associated pyrazine rings. They are water soluble.

Purines, especially guanine, are responsible for white or silvery colors. They are accumulated in leucophores and iridophores where they are stacked in reflecting layers or platelets of crystals.

Pigments from fish scales and skin have a number of industrial uses. Guanine crystals are purified from the skin and scales of herring and are manufactured into pearl essence. Products such as artificial pearl beads, buttons, jewelry, and ash trays are dipped into or sprayed with pearl essence to obtain an iridescent sheen.

Ground-up crustacean shells, which contain the astaxanthin pigment, are included in the diet of cultivated salmonids. The ingested pigment helps produce the desirable pink-colored flesh in these species when they are raised in captivity.

Vitamins

Fish oils are the richest known sources of vitamins A and D.

Soupfin shark liver may contain as much as 50,000 IU/g of vitamin A and swordfish liver can contain 25,000 IU/g of vitamin D. Fish flesh may also be a good source of some of the water soluble vitamins.

Vitamin A is present in fish oils predominantly as the xanthophyll form; the oils are almost devoid of β-carotene. Fish do not synthesize vitamin A. They may obtain it in several ways:

A. preformed vitamin A from ingested zooplankton
B. a noncarotenoid percursor of vitamin A ingested in copepods
C. astaxanthin precursor of vitamin A ingested from copepods and shrimp.

This fat soluble vitamin is found in the fat of viscera, muscles, membranes, and liver oils. The flesh of lean fish is almost devoid of vitamin A. For example, 100 grams of cod fillet contains only about 50 IU of vitamin A.

The amount of vitamin A found in the fish liver is dependent upon a number of factors. Large fish appear to store more of the vitamin than smaller fish. Some species show different levels of retention between the sexes. The sexual stage of the fish appears to be important. Immature fish have very little, if any, stored vitamin A but pregnant females have large stocks. Seasonal variation in food availability influences the amount of vitamin A being stored. As the summer season advances, the level will drop off because diatoms and copepods become scarce.

Dehydrocholesterol is metabolized into vitamin D_3, which is the most common form of vitamin D in fish. It is supplied by solar irradiation of plankton containing the provitamin. Liver oil or meat from fatty or semifatty fish is the richest source of vitamin D. It is not deposited in the visceral oils to as great an extent as vitamin A. Very little vitamin D can be found in the flesh of lean fish.

Vitamin E occurs in fish as an α-tocopherol. Shark liver oil contains about 100 μg/g which appears to be an excellent supply. However, the potency of this vitamin E is difficult to determine, since the liver oils contain vitamin E antagonists such as highly unsaturated fatty acids. There appears to be an inverse relationship between the rate of autoxidation of fish oils and their α-tocopherol content.

The presence of the antihemorrhagic factor, vitamin K, has been reported in fish. Fish meal may be a good source, but little work has been done concerning this vitamin in fish.

Fish are a good source of thiamin. Thiaminase may be present, but since it is heat labile, it is destroyed upon cooking.

Fish also are an excellent source of niacin (especially in swordfish) and vitamin B_{12} (especially in clams and oysters).

Vitamin C is found only in very small amounts in fish.

REFERENCES

Aurand, L. W. and A. E. Woods. 1973. Food Chemistry. The Avi Publishing Company, Inc., Westport, Connecticut.

Borgstrom, G. (Ed.). Fish as Food. Academic Press, New York and London.
(a) 1961. Vol. I. Production, Biochemistry, and Microbiology.
(b) 1962. Vol. II. Nutrition, Sanitation, and Utilization.

Connell, J. J. 1964. Symposia on Foods: Proteins and Some Effects on Them by Processing. The Avi Publishing Company, Inc., Westport, Connecticut.

Hoar, W. S. and D. J. Randall (Ed.). 1969. Fish Physiology. Vol. III. Reproduction and Growth, Bioluminescence, Pigments and Poisons. Academic Press, New York and London.

Kreuzer, R. (Ed.). 1965. The Technology of Fish Utilization. Fishing News (Books), Ltd., London.

Love, R. M. 1970. The Chemical Biology of Fishes. Academic Press, London and New York.

Stansby, M. E. (Ed.). 1967. Fish Oils - Their Chemistry, Technology, Stability, Nutritional Properties, and Uses. The Avi Publishing Company, Inc., Westport, Connecticut.

Stansby, M. E. 1976. Industrial Fisheries Technology. Robert E. Krieger Publishing Co., Inc., New York.

Glossary

Autolytic Enzyme: A bacterial enzyme located in the cell wall. It causes disintegration of the cell following injury or death.

Adductor muscle: A muscle that draws a part of the body toward the median axis. For example, the muscle that a clam uses to close its valves.

Biologically Available: Existing in a form that can be utilized by the body.

Bivalved: Having two valves, as the two "shells" of a clam.

Brackish: Water which is a combination of fresh water and salt water.

Buoy: A float moored in water as a warning of danger or as a marker.

Carapace: A hard outer covering such as the fused plates of a turtle.

Chlorination: The addition of chlorine to water to reduce contamination by microbes.

Coliform: Term used to describe a group of bacteria which have similar physical, growth, and biochemical characteristics. Used as an indicator of sanitary quality; however, due to a lack of specificity in characterizing and enumerating individual members within the group, its value as an indicator has been questioned.

Controlled Purification: The process of removing contamination from whole live shellfish acquired while growing in polluted areas.

Crustacean: A category of animals having jointed feet and mandibles, two pairs of antennae, and segmented bodies with a protective covering. Examples are crabs and lobsters.

Depuration: The process by which shellfish cleanse themselves of microbiological contaminants in a controlled process water environment.

Effluent: The outflow of a sewer.

Enzyme: An extremely complex protein molecule which is able to initiate or control the rate of certain biological processes. There are many different types of enzymes in the body, which control digestion, food uptake by cells, cell metabolism, muscle activity, and many other functions.

Estuary: An inlet or arm of the sea, especially the wide mouth of a river, where the tide of the sea meets the current of the river.

Exoskeleton: The external supportive covering of certain animals that lack backbones and internal skeletons.

Fatty acid: Long carbon chain molecules with an organic acid at one end and hydrogen atoms attached to the remaining carbon atoms. Three essential fatty acids (linoleic, linolenic, and arachidonic acid) are not synthesized by humans and must be obtained from diet.

Fecal: Of sediment or feces.

Fecal coliform: Coliform organism capable of growth at elevated temperature (44.5°C). More specific indicator of sanitary quality than coliform, as it is a more precise indicator of fecal contamination.

Gills: The respiratory organs of water-breathing animals.

Lipid: Organic compounds often containing elements other than carbon, hydrogen, and oxygen -- particularly phosphorus and nitrogen. These compounds are insoluble in water. They include fats and waxes.

Mantle: An enveloping layer, such as the external body wall lining the shell of many invertebrates.

Mariculture: Artificial cultivation of marine (saltwater) organisms.

Metabolism: The physical and chemical processes by which foodstuffs are synthesized into complex elements, complex substances are transformed into simple ones, and energy is made available for use by the organism.

Milts: The secretions of the testis of fishes.

Mollusca: A category of animals that includes snails, slugs, octupuses, squids, clams, mussels and oysters. Mollusks are characterized by a shell-secreting organ, a mantle, and a radula (a food-rasping organ located in the forward area of the mouth).

Molting: Shedding an outer covering as part of a periodic process of growth.

Most Probable Number (MPN): A statistical estimate of the number of bacteria per unit volume.

Munsell value: A numerical representation of color based on a standardized color scale.

Oxidation: A chemical reaction that increases the oxygen content of a compound.

Pasteurization: A process of heat treatment of food to destroy all organisms dangerous to health. Pasteurized food is normally heated at between 70° and 100°C (160°-212°F).

Pathogenic: Capable of causing disease.

Plankton: Passively floating or weakly moving aquatic plants and animals, usually microscopic.

Polyunsaturates: Fats containing fatty acids having more than one unsaturated bond. An unsaturated bond is a chemical structure into which additional hydrogen can be incorporated. In general, polyunsaturated fats tend to be liquids of vegetative origin.

Radionuclide: Any element which has a radioactive emission.

Rancidity: An oxidative deterioration in food fat whereby a typical off-odor and/or flavor is produced.

Regeneration: The replacement by an organism of tissues or organs which have been lost or severely injured.

Relaying: The moving of commercial size shellfish from waters not classified as approved to waters classified as approved, conditionally approved, or restricted for the purpose of natural purification; by relaying shellfish they will purify themselves through depuration.

Retort: Any closed vessel or other equipment used for the thermal sterilization of foods.

Salinity: A salty quality or state.

Spawning: Producing or depositing eggs or discharging sperm. Applied to aquatic animals.

Teleost: A class of finfish, to which most of the world's fish belong.

Titration: A method of analyzing the composition of a solution by adding known amounts of a standardized solution until a given reaction (color change, precipitation, or conductivity change) is produced.

Transplanting: The moving of shellfish from one area to another area.

Turbidity: Muddy or cloudy state due to amount of free floating sediment in the water.

Viscera: The organs within the cavities of the body of an organism.

Weir: A fence placed in a stream to catch or retain fish.

Bibliography

Beard, James, *James Beard's Fish Cookery*, Warner Paperback Library, New York, 1974.

Booth's Fish & Seafood Cook Book, The Pillsbury Company, 1970.

Brody, Julius, *Fishery By-Products Technology*, The Avi Publishing Company, Inc., Westport, Connecticut, 1965.

Burtis, Jean, Ellen H. Nagy, and Rose G. Kerr, *How to Cook Lobsters*, Test Kitchen Series No. 11, Fish and Wildlife Service, 1964.

Burtis, Jean and Rose G. Kerr, *How to Cook Shrimp*, Test Kitchen Series No. 7, Fish and Wildlife Service, 1964.

Crocker, Denton W. and David W. Barr, *Crayfishes of Ontario*, University of Toronto Press, Buffalo, 1971.

Firth, Frank E., Ed., *The Encyclopedia of Marine Resources*, Van Nostrand Reinhold Company, New York, 1969.

Fish and Shellfish for your Table, The North Carolina Agricultural Extension Service, Circular 465, Raleigh, 1965.

Fresh and Frozen Fish Buying Manual, U.S. Department of the Interior, Circular 20, Washington, D.C., 1961.

Goodwin, Harold L. and Joe A. Hanson, *The Aquaculture of Freshwater Prawns*, The Oceanic Institute, Hawaii, 1975.

Gorman, Brian, "Unlocking the Ocean's Medicine Chest," *A Review of the National Seagrant Program*, vol. 7 Texas A&M University, Texas, 1976-77.

Gray, Don L., *The Commercial Crawfish Industry of South Louisiana*, Center for Wetland Resources, Louisiana State University, Baton Rouge, 1974.

How to Eye and Buy Seafood, National Marine Fisheries Service, Washington, D.C., 1970.

Jarvis, Norman D., *Spiced and Pickled Seafoods*, revision of U.S. Fish and Wildlife Service, Research Report 18, pp. 146-164.

Keller, Dorothy M., Paula W. Lemmon, and Rose G. Kerr, *How to Cook Scallops*, Test Kitchen Series No. 13, Fish and Wildlife Service, 1959.

Kerr, Rose G. and Jean Burtis, *How to Cook Oysters*, Test Kitchen Series No. 3, Fish and Wildlife Service, 1964.

Knight, Jacqueline E., *The Cook's Fish Guide*, E. P. Dutton and Company, Inc., New York, 1973.

Lapedes, Daniel H., Ed., *McGraw-Hill Dictionary of Life Sciences*, McGraw-Hill Book Company, New York, 1976.

Let's Cook Fish! Fishery Market Development Series No. 8, United States Department of the Interior, Washington, D.C., 1976.

Madlener, Judith C. *The Seavegetable Book*, Clarkson N. Potter, Inc., Publishers, New York, 1977.

McClane, A. J., *The Encyclopedia of Fish Cookery*, Holt, Reinhart, and Winston, New York, 1977.

Nickleson II, Ranzell, and Don W. Steinbach. *Now that you've caught that fish. . . what are you going to do with it?* Texas A&M Seagrant Program, 1976.

Osterhaug, Kathryn L. and Rose G. Kerr, *How to Cook Clams*, Test Kitchen Series No. 8, Fish and Wildlife Service, 1964.

Protection Through Inspection, U.S. Department of Commerce, Washington, D.C., 1974.

Rebel, Thomas P., Ed., *Sea Turtles*, University of Miami Press, Gainesville, 1974.

Robey, Dorothy M. and Rose G. Kerr, *How to Cook Crabs*, Test Kitchen Series No. 10, Fish and Wildlife Service, 1964.

Seafood Data Bank, National Marine Fisheries Service, Washington, D.C., 1974.

Seafood Information Packet, Maryland Seafood Marketing Authority, Annapolis.

Sidwell, Virginia D., et al., Chemical and nutritive values of several fresh and canned finfish, crustaceans and mollusks. Part I: Proximate composition, calcium, and phosphorus, MFR Paper 1022, *Marine Fisheries Review*, December, 1973, pp. 16-19.

Sidwell, Virginia D., et al., Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. I. Protein, fat, moisture, ash, carbohydrate, energy value, and cholesterol, MFR Paper 1043, *Marine Fisheries Review*, March, 1974, pp. 21-35.

Sidwell, Virginia D., et al., Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. II. Macroelements: sodium potassium, chlorine, calcium, phosphorus, and magnesium, MFR Paper 1228, *Marine Fisheries Review*, January, 1977, pp. 1-11.

Sidwell, Virginia D., et al., Composition of edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. IV. Vitamins, MFR Paper 1355, *Marine Fisheries Review*, December, 1978, pp. 1-16.

Stansby, Maurice E., *Industrial Fishery Technology*, Reinhold Publishing Corporation, New York, 1963.

Tips of Cooking Fish and Shellfish, U.S. Department of the Interior, Washington, D.C., 1958.

Tressler, Donald K. and James McW. Lemon, *Marine Products of Commerce*, Reinhold Publishing Corporation, New York, 1951.

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