VSGCP-H-88-001 C3

SEAFOOD PRODUCTS RESOURCE GUIDE

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$20.00

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GENERAL LIFE CYCLE OF FINFISH AND SHELLFISH

Most mature finfish and shellfish congregate during their particular spawning season and extrude eggs and sperm into the water. Fertilized eggs develop during what is called the incubation period. Many species lay eggs that are buoyant while others have sinking eggs. After incubation, the eggs hatch into small larval forms, which may look little like the adult of the species. Many newly hatched finfish larvae have a yolk sac that provides nourishment for the first few days but later they subsist on minute plankton in the water. The larvae may undergo metamorphosis several times before transforming into tiny replicas of the adult. As young finfish, called fry, grow larger they take on the behavior and feeding habits of adult fish.

Of importance in this simple description is the observation that eggs and larvae are extremely vulnerable to environmental factors such as currents, storms and sudden temperature changes. Additionally, fish larvae become part of the zooplankton (animal plankton) that larger fish feed on. To compensate for the high level of mortality, mature females may spawn hundreds or thousands of eggs at one time.

The survival of all finfish and shellfish depends on the ocean's primary producers. Phytoplankton (plant plankton) do not consume food but have the ability to transform carbon dioxide and nutrients in the water into plant tissue, using the energy of sunlight. Planktonic plants serve as food for zooplankton, which include fish larvae. These, in turn, are eaten by filter-feeding finfish and shellfish, as well as by mollusks. Plankton-eating fish are consumed by carnivorous fish, which are eaten by even larger carnivorous fish. This feeding relationship is called the food chain or web, and is made possible by the presence of primary producers. Fish may occupy different levels of the chain at different stages in their life.

The abundance of plankton in a given area depends on environmental conditions. Since their abundance affects the rest of the food chain, this partially explains the seasonal, and sometimes yearly, fluctuations in the availability of finfish and shellfish in the marketplace.

[A single fish species may be known by different names in different areas, therefore both the single scientific name and, sometimes, the many common names are given for each species. A scientific name consists of two names: the first is generic and belongs to a group of closely related organisms, and the second is specific, belonging to a particular species. These names are called the genus and species, respectively, and are generally Latin terms. For instance, the scientific name for human beings is <u>Homo</u> <u>sapiens</u>.]

FINFISH

The term "fish" is loosely applied to practically any animal living in water, and its usage is commonly intended to include both finfish and shellfish, though stricter usage limits the definition to exclusively finfish. In general, finfish are cold-blooded vertebrate animals living in water, and having gills for breathing, rudimentary limbs represented by fins, and usually scales.

There are more than 20,000 known living species of finfish, which constitute close to 50% of all the living vertebrate species on earth. Fish are a very important food source and, historically, have been sought by man for food and sport for at least 7,000 years.

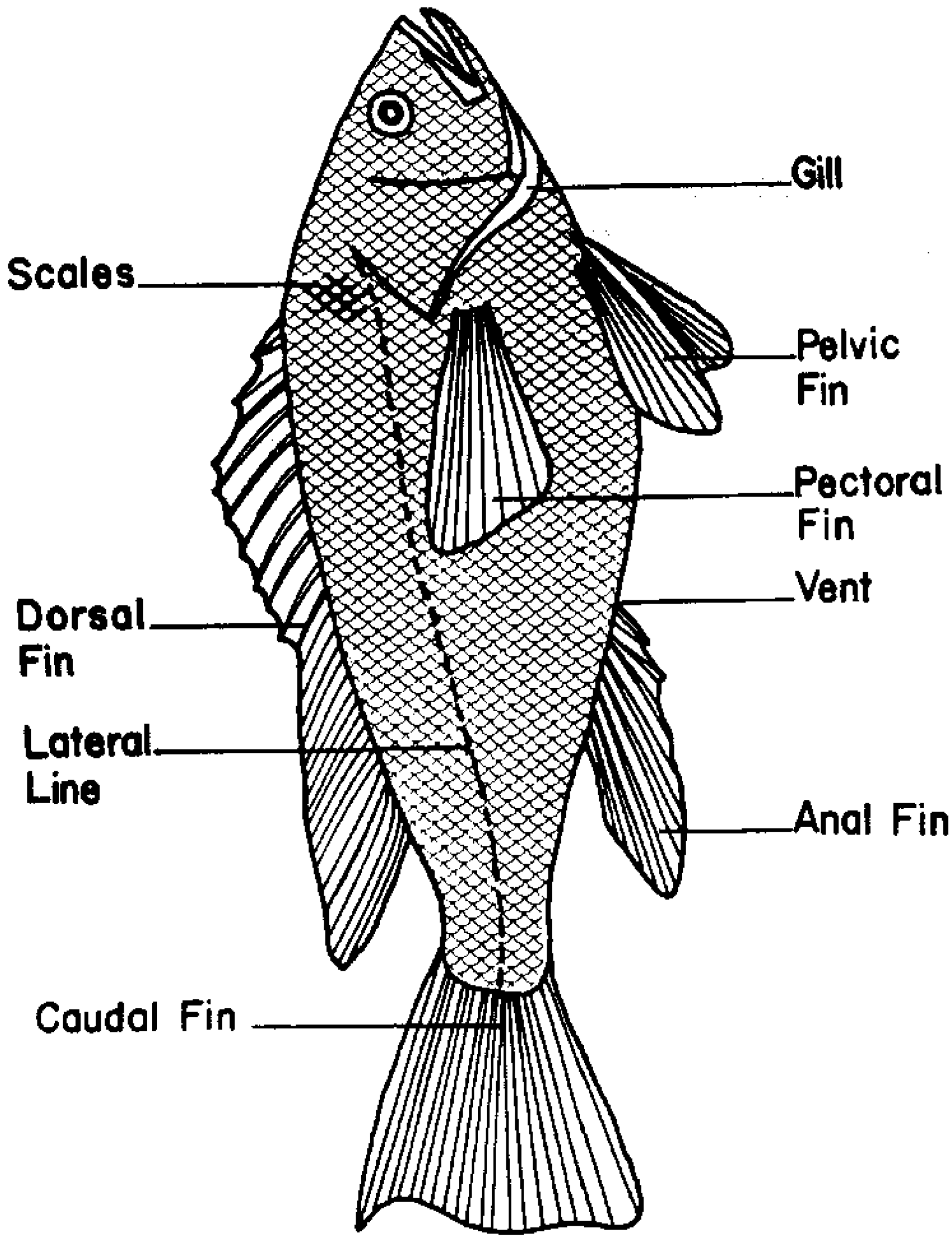
Finfish species vary in size, shape, color, and numerous other physical characteristics; however, certain features are generally shared by all. The overall structure of a fish is comprised of a head, mid-body (trunk), and tail. Common features of the head include the eyes, nostrils, mouth, gill openings and gill covers. Barbels are present in some fish and function as sensory structures.

Fins are supported by the skeleton and are composed of two groups, unpaired and paired. The unpaired fins are the dorsal, anal, and caudal (tail); the paired fins are the pectorals and ventrals (pelvics). Fins are stiffened by structures called rays, which may be soft and flexible or rigid and spine-like. A variety of fin modifications have evolved in some species including feelers (sea robin), sucking devices (lumpfish), lures (monkfish), and reproductive structure (male sharks).

Most fish have a covering of scales, although in some species the scales are reduced (eels), modified (sturgeons), or absent (freshwater catfish). A primitive type of scale is the toothlike scale of sharks, which has an overall structure similar to a tooth and consists of a basal plate, that is buried in the skin, and a raised exposed portion. It is these scales that make possible the use of dried shark skin as an abrasive similar to sandpaper.

The typical bony scales of most finfish are thin and generally circular in shape. They are characterized by concentric ridges that represent growth increments, somewhat like the growth rings seen in a cross section of tree. The ridges aid biologists in determining the age and life history of fish.

Another structure common to most finfish is the lateral line, which detects vibrations in the water just as our ears detect vibrations in the air. Fish are extremely sensitive to vibrations and pressure changes which allows them to avoid obstacles, to maintain position in a school -- and to detect predators or prey. The sense organs that detect pressure stimuli are set in canals running beneath the skin, and the canal running along the sides of fish is marked by the lateral line.



PARTS OF A FISH

The internal anatomy of finfish, as with most vertebrate animals, includes vital organs such as the heart, liver, spleen, kidney, stomach, intestines and gonads. Additionally, most fish have an air bladder which functions in buoyancy control and sound reception and production. Also called the gas bladder or swim bladder, this structure is simply a gas-filled sac, typically housed in the upper part of the body cavity. By adjusting the amount of air in the bladder, fish can remain suspended in water.

Fish also must make an adjustment to live in saltwater while retaining less salt in their blood and tissues than in the surrounding environment. They do this by a process called osmoregulation, which is the controlling of osmotic pressure within an organism. Water has the tendency to pass through the skin of fish to the sea, where a higher salt concentration exists. To prevent excessive water loss, osmotic concentration is regulated by the kidney, gills and, to some extent, by the skin. For instance, to curtail water loss, marine fish excrete a very concentrated urine. Freshwater fish have the opposite problem and excrete a highly diluted urine.

Of importance to humans are the swimming muscles of fish, the part commonly eaten. On either side of the backbone, the musculature consists of a series of muscle segments or myomeres, separated by connective tissue. The segments are arranged in a -shaped course across the body (also described as the letter W tipped at a 90° angle) and are divided into upper and lower halves by a groove (horizontal septum) running along the mid body of the fish.

Just under the skin is a layer of dark muscles, which are reddish or brown. These muscles are used in substained swimming activity, while white muscles are used for sudden bursts of swift swimming, as in escape or in the capture of prey. Fish species vary in their proportion of dark to white muscle. Active fish which swim almost continuously, such as tuna and mackerel, have a much greater proportion of dark meat than sedentary fish such as flounder and cod.

The body form of a fish is also related to swimming activity, as well as overall way of life. Tuna and other fast-swimming fish have an extremely streamlined body, also known as fusiform. Some fish, such as scup and butterfish, are compressed laterally, while eels and ocean pout have a tubular shape. There are numerous finfish shapes, but for simplicity, fish are often classified as round fish, those that are basically fusiform in shape, or as flat fish, which are typified by the flounders.

Mouth size and type of teeth are associated with a fish's feeding habits. For instance, sharks have large mouths and sharp teeth to enable them to eat large prey, while fish which feed on mollusks have strong, flattened teeth for crushing shells. A few fish feed relatively low on the food chain by filtering plankton from the water with a sieve-like structure. These fish include menhaden and shad, and they swim with their mouths wide open to collect food.

Most finfish reproduce by spawning (depositing) vast quantities of eggs and sperm into the water. The eggs are fertilized after they are laid -- and are generally less than one-fifth of an inch in diameter. Whether free floating or sinking, the eggs are at the mercy of predators and adverse water conditions. The high numbers of eggs produced is necessary because of high mortality rates. Conversely, sharks bear live young and need considerably fewer eggs since the added protection lowers the mortality rate.

Many fish have adopted the behavior of schooling because it provides certain survival benefits. Swimming in schools provides defense against predators and an efficient warning system. For instance, even though only a few fish may see a predator, their movements will be recognized by other fish in the school. Another advantage of group swimming is that it seems to be more energy efficient than solitary swimming. Although exceptions exist, fish generally school by species and size. This behavior is of obvious importance to fishermen.

While some fish species travel little during their lifetime, other carry out extensive migrations, often covering hundreds of miles each year. There are several reasons for migrating, such as to avoid extreme seasonal temperature changes or to travel to spawning grounds. Meteorological factors may affect fish migration and behavior to the extreme that in some years a particular fish may be abundant while in others it may be scarce. Hurricanes and slight changes in the Gulf Stream have been proposed as explanations for some abundance/scarcity cycles.

Whether seasonal travelers or year-round inhabitants, most fish species live in a particular water environment, either salt, fresh, or brackish. Overlap does occur and may even be a necessary part of the life history of some species. For instance, salmon, shad, and striped bass are anadromous fish; they are born in freshwater, mature in saltwater, and return to freshwater to spawn. Conversely, eels are catadromous fish and live in freshwater but return to saltwater to spawn.

Like all living plants and animals, fish are classified according to biological characteristics. There are two major classes of finfish that are of particular importance as food -- Elasmobranchii and Osteichthyes.

Class Elasmobranchii (formerly Chondrichthyes) consists of sharks, skates, and rays and are characterized by having a skeleton made of cartilage, not bone. Of importance to seafood users is that these fish retain high levels of urea and smaller amounts of other nitrogenous compounds in their blood for osmoregulatory purposes. The retention of these substances raises the osmotic content of their blood to that of the surrounding sea water so that a balance exists. Once the fish dies, the urea breaks into ammonia. Therefore, it is necessary to bleed sharks immediately after capture.

Fish in Class Osteichthyes have bony skeletons and make up the majority of finfish eaten by humans. There are approximately 20,000 known living species of bony fish and only about 600 species of cartilagenous fish.

BLACK SEA BASS (Centropristes striatus)

Other names: sea bass, often confused with blackfish and tautog, which are both members of the wrasse family, and with striped bass and white perch.

Three closely related species, the bank sea bass, the southern sea bass and the rock sea bass are often marketed as black sea bass.

Like many fish which inhabit rocky bottoms the color of the black sea bass varies. They are generally smoky gray, dusky brown, or bluish black in color, and the exposed bases of their scales are paler than the margins, giving the appearance of being longitudinally barred with light dots. Black sea bass are small, stout-bodied fish averaging 1-1/2 to 3 pounds and rarely exceeding 5 pounds. All black sea bass begin life as females and then change into males at the age of 2 to 5 years. They should be handled with care because of their sharp, stiff dorsal spines.

Black sea bass range from Cape Code to northern Florida but are most abundant off the Middle Atlantic states. Substantial quantities are caught incidentally to several commercial fisheries, particularly the spring Nantucket Sound trap fishery for Loligo (long-fin) squid and the winter trawl fisheries off Virginia and North Carolina. Unlike striped bass, they live strictly in saltwater. Black sea bass congregate each spring in bays, sounds and along the inland waterway where they forage for mussels, crabs, shrimp and small fish. When the water cools in the fall, they move back offshore to the deeper waters of the continental shelf.

Sometimes a black sea bass' swim bladder is pushed into its mouth when lifted from deep water. This does not affect shelf-life but may be asthetically unappealing when fish are marketed whole.

BLUE FISH (Pomatomus saltatrix)

Other names: blue, snapper, chopper blues

Named for their color, bluefish are bluish green with silvery underside. They range from 3 to 15 pounds, though a few fish over 30 pounds have been recorded. Bluefish mature in two years and reach 3 pounds in 3 years. Young fish about 6 to 8 inches long are called snappers and are frequently pan fried.

Bluefish are distributed worldwide in temperate shelf waters, excluding the eastern Pacific. Off the U.S., they range from Maine to Texas and are caught commercially from Cape Cod to Florida. Bluefish journey into the northern extent of their range only in the warmer months. Offshore stocks move inshore beginning mid-winter in Florida and proceed northward. In the mid-Atlantic, schools of blues enter the Chesapeake Bay in early spring. The major run is early April to June with a secondary run in late fall.

These fish travel in schools throughout the water column and feed predominately on schooling fish such as menhaden, herring and mackerel. Bluefish have voracious appetites and are noted to be frenzied eaters, as evidenced by the trail of blood and mangled fish left behind after a feeding binge.

Renowned for their fighting ability, bluefish are a favorite game fish. In fact, sport catches outweigh commercial landings. Most of the commercial catch is taken incidentally. Bluefish are not usually directly sought after by commercial fishermen because of depressed prices during seasonal gluts. Since this fish has a high oil content, fishermen should gut, bleed, and ice bluefish as soon as it is caught. A word of caution for those not familiar with landing live bluefish -- they have very sharp teeth and can clamp down on unwary fingers.

In the marketplace, "Boston bluefish" is an occasionally used name for pollock but is not to be confused with the true bluefish.

BUTTERFISH (Peprilus triacanthus)

Other names: dollarfish, silver dollar, harvestfish

There are several genera in the butterfish family but Peprilus triacanthus is the most common commercial species. This shiny fish has a bluish back and silvery sides and belly. The fish gets its name from its normally high fat content; its meat is mostly dark with an excellent flavor. Its body is very thin and deep with scales that are small and easily rubbed off. Butterfish are small fish; adults range from 6 to 10 inches long and 1/8 to 1 pound. The larger sizes command higher prices.

Butterfish range from Nova Scotia to North Carolina. They travel in loose schools and are often found throughout the water column. They are known to feed on small finfish, squid and crustaceans.

CROAKER (Micropogonias undulatus)

Other names: Atlantic croaker, drum, golden croaker, hardhead

The name croaker and drum are descriptive of the noise the fish makes by vibrating strong muscles against its swim bladder, which acts as a resonation chamber much like a drum. The upper body of the croaker is covered with small dark spots, which extend up into the first dorsal fin. The lower third of the body is white, the tail is slightly rounded and the lateral line continues onto the tailfin, sometimes to the end. A row of little barbels border each side of the lower jaw. The body of the fish is silvery green or gray with a silvery white underside. Its sides are often covered with brown wavy bands. During spawning season they become a distinct bronze or yellow color, hence the name golden croaker. At maturity, 3-4 years, croakers reach between 1 to 1-1/2 feet long and 4 to 5 pounds, but the average size is 1/2 to 2 pounds.

Croaker can be found along the Atlantic coast from Massachusetts to Florida and into the Gulf of Mexico around to Texas. Large concentrations of croaker can be found in the Chesapeake Bay and the Mississippi River delta. It inhabits the Chesapeake Bay from March to October over sandy or grassy shallows then moves out into deeper water, up to 240 feet, in the winter. Spawning occurs from late August to December.

EEL (<u>Auquilla</u> <u>rostrata</u>)

Other names: American eel, silver eel, freshwater eel

Eels have a misleading snake-like appearance but actually are true fish possessing gills and very small scales. They have a pointed snout and a relatively large mouth. Their color varies including olive green, dark brown, gray, and black; all have a yellowish belly. Their upper body color can change to conform with the color of the sea bottom. Fully grown female eels are 2 to 3-1/2 feet long, while males are smaller.

The American eel is found in coastal streams, river, ponds, lakes and estuaries from Greenland to the Gulf of Mexico. It is bottom dwelling, nocturnal in habit and feeds on invertebrates and small finfish. They are plentiful from the Cheasapeake Bay north to Long Island, with the Delaware River estuary system serving as a prime fishing area.

This species has a peculiar life history, spending most of its life in fresh or brackish water but returning to the sea to spawn. This living pattern is referred to as catadromous and is the opposite of the anadromous life style of shad and salmon.

Mature adult female eels, usually 8 to 10 years old, will cease feeding. Their eyes become larger to help with navigation; the upper body color changes to silvery-black, and their belly turns silver at which stage they become known as silver eels. They leave their inshore habitats in late fall to meet swarms of males at brackish river mouths and migrate to the Saragasso Sea, southeast of Bermuda. Male eels spend their lives in salt and brackish waters near the coast. [The European eel (Anguilla anguilla) also spawn here and follow the currents back to Europe.] Spawning in midwinter, females are capable of, laying up to 20 million eggs before presumably dying. The hatched larvae, called leptocephali, look very little like adult eels and are transparent and ribbon like.

The larvae drift with the currents in a one-year journey which brings them to the North American coastline in spring. By this time they have metamorphosed into an adult form but are totally transparent. They are known as glass eels at this stage and are about 3 inches long. As these young eels migrate to freshwater they acquire the pigmentation of adults and are called elvers. Female elvers travel into freshwater rivers, ponds, and lakes; while males prefer to live in brackish coastal streams and estuaries.

Currently, a small number of part-time fishermen harvest eels, primarily using baited wire pots. Most of our commercial catch is exported to Europe or sold to local smokers, with smaller eels marketed locally as bait.

Eel meat has a very firm texture, high fat content, and a full flavor. It is grayish in the uncooked state but turns white when cooked.

FLOUNDER

Flounder are easily distinguished from other fish because of their flat shape. They are members of a group of fish known at flatfish, which also includes sole. Sole and flounder are different biological classifications of flatfish according to body shape. Flounders are rounded in shape, while sole are more elliptical and deeper bodied.

The only true sole living in Eastern waters is the hogchoker, which is delicious, but so small that it has no commercial value. Then what is gray sole and lemon sole? They are flounder species that have been given the name "sole" for marketing purposes; these alternate names supposedly sound more glamorous. For instance, witch flounder is gastronomically more appealing when called gray sole. The only true sole sometimes seen in local markets and restaurants is the Dover sole, which, imported from Europe, is relatively expensive.

Flounder and sole begin their lives with a body shape that is typical of most finfish. When about 1/2 inch long, their body begins to flatten as they grow. Their skull twists, and one eye moves over to join the other. Within a short time, both eyes are situated close together on the same side, and the fish swims horizontally with its eyeless side facing the bottom.

Flounder are well adapted for their bottom-dwelling lifestyle. Their top coloration is generally mottled brown to camouflage the fish from predators swimming above. They have the ability to change color and their pattern of mottling to blend in with different bottom types. Their eyeless side is white, and to predators swimming below the white form blends in with the whitish cast of light from the water's surface.

To catch their food, they often bury themselves in the sand, except for their eyes, and wait for prey to come by. When prey is spotted, they dash off the bottom in rapid pursuit.

Flounder do not school and are found over a wide area. They range from inshore bays and estuaries to the continental shelf and slope. They are very important commercially and are landed primarily by trawling along the bottom.

WINTER FLOUNDER (*Pseudopleuronectes americanus*)

Other names: called blackbacks when 3-1/2 pounds and under and lemon sole when over 3-1/2 pounds.

Winter flounder are the most common shallow water flatfish in North America. They support a large sport fishery as well as one of the most important commercial flounder fisheries in the United States.

Winter flounder have a small mouth and straight lateral line. The tail area on the eyeless side of some individuals, especially larger ones, is yellow; hence the name "lemon sole". There are two populations of winter flounder, varying in size of individual fish. The coastal population averages 1 to 2 pounds while flounder inhabiting Georges Bank average 4 to 6 pounds and can reach 8 pounds.

This species ranges from Labrador to Georges but is most common from New England to New Jersey. The coastal population can be found from the tideline to depths of 100 feet, although some fish have been known to run up into brackish water in river mouths to breed. Winter flounder carry out a seasonal migration which is more distinct south of New York. They inhabit shallow water in the winter then move to slightly deeper waters in the summer to avoid high temperatures. They spawn while inshore.

YELLOWTAIL FLOUNDER (*Limanda ferruginea*)

Like winter flounder, yellowtail flounder also support one of the largest fisheries in the United States. Yellowtail flounder are named for their tail which has a yellowish hue. The margins of their fins are also tinged with yellow, and their top side is spotted with irregular rusty red spots. Yellowtail flounder have small mouths and average 1 to 1-1/2 pounds. Their pointed snouts and arched lateral lines distinguish them from winter flounder.

This species ranges from Newfoundland to Chesapeake Bay; however it is most abundant off New England. Yellowtail flounder predominately inhabit waters from 90 to 240 feet deep. Harvests have been declining as a result of overfishing, and biologists predict yellowtail catches will continue to decline.

GRAY SOLE (Glyptocephalus cynoglossus)

Gray sole, known to biologists as witch flounder, are thin bodied with a small mouth and a straight lateral line. The eye side is dark gray or brownish. Gray sole can reach 5 pounds but most are 1 to 2 pounds. This species inhabits both sides of the Atlantic Ocean, ranging off America from Newfoundland to North Carolina. It is more common north of Cape Cod. Gray sole, moderate-deep water fish, are seldom caught shallower than 50 feet, and the best catches are in water 300 to 900 feet deep. Gray sole command a higher price than other native flounder species, partly because of their thin body and hence lower yield, and also because of their popularity.

DAB (Hippoglossoides plattessoides)

Other names: American dab, American plaice, Canadian plaice

It is right-sided, large mouthed and has a nearly straight lateral line. Dab usually range from 1 to 3 pounds but can reach 14 pounds. American dab inhabit cold waters on both sides of the Atlantic. Off North America, they range from Labrador to Rhode Island and are most plentiful on the Grand Banks. They live in depths from very shallow to over 2,000 feet. The meat is very white but tends to be less moist than other local flounder species.

SUMMER FLOUNDER (Paralichthys dentatus)

Other name: fluke

Summer flounder are left-sided with a large mouth and an arched lateral line. Their top side is marked with many regularly placed, dark, eye-like spots which can change shades. Summer flounder are one of the larger flounders, reaching 30 pounds. Ordinarily they grow to 15 pounds, with the average landed size at 2 to 5 pounds.

This species ranges from Maine to Florida and is most abundant from Cape Cod to North Carolina. During the summer, fluke are found inshore from estuarine waters to depths of no more than 100 feet. During the cooler months, they move offshore to depths of 150 to 500 feet. This migration pattern necessitates an inshore summer fishery and offshore winter fishery.

Summer flounder are an important commercial flounder to the west and south of Rhode Island. In the Mid-Atlantic region, sport landings of summer flounders exceed commercial landings.

GROUPER GENERA (Epinephelus and Mycteroperca in the U. S.)

Grouper lead an unusual and somewhat schizophrenic life. Like shrimp, groupers are females at birth but experience a sex change later in life. Before they die, most will have been both a mother and a father. These fish are masters of disguise, able to successfully blend into their surroundings. Groupers are heavy-bodies fish with large mouths.

There are numerous grouper species inhabiting temperate and tropical waters worldwide. U.S. fishermen harvest about 12 million pounds a year, mainly off the Gulf and southern Atlantic states. These include the black, red, Nassau, and yellowfin groupers and the jewfish. Fresh grouper from outside the United States, many of which are not grouper at all, are arriving in the market.

More than 70 species of grouper are found in the warmer waters of the U.S., but most commercial landings are comprised of two species: red grouper, Epinephelus morio and black grouper Mycteroperca bonaci.

Red grouper are the most abundant of the groupers sold on the U.S. market. Despite its name, the red grouper is brown with some mottling but redder than a black grouper. Though they can reach 40 pounds, few reds larger than 20 pounds make it to market, and most weigh under 10 pounds. Groupers are voracious; marine biologists have discovered new species by analyzing their stomach contents. These are exceptionally hardy fish that can survive out of water for long periods. Aquaculturists think they have considerable potential because they an live in a crowded environment.

Black grouper, which live in deeper water, are less prone to parasites than red grouper and are about twice the size of reds. Younger fish are found closer to shore, older ones farther out to sea. These fish are usually between 10 to 20 pounds when caught by hook and line.

Other groupers also appear on the market such as the highly regarded yellowfin grouper, M. venenosa, called "the Cadillac of groupers" by some for its nice white meat. Jewfish, E. itajara, are mammoth groupers, the largest landed reaching 700 pounds. Sometimes called spotted or giant sea bass, most jewfish landed weigh about 50 pounds. Warsaw groupers, E. nigritus, can weigh 300 pounds and are sometimes sold as jewfish. Warsaws cause some confusion in grouper terminology as they are sometimes mistakenly called black grouper because they are very dark. Nassau grouper, E. striatus, are noted for their fine taste and texture. In reality not even the most sophisticated palates can always tell the difference between the species.

HAKE

Red hake, squirrel hake (Urophycis chuss) Cod (Gadidae) Family
White hake (U. tenuis)

Other names: ling (red hake), scrod, whitefish

Hake and whiting are two names often used interchangeably for the many species of this fish found throughout the world's oceans. Silver hake is called whiting. Hake are members of the cod family but their bodies are more slender, softer, smaller and have long feeler-like ventral fins and only two dorsal fins. White hake and red hake make up the majority of hake landings.

White and red hake are hard to tell apart and are often not distinguished when marketed. A good telltale sign is the upper jaw bone, which extends to the rear edge of the eye in white hake, but only to the rear edge of the pupil in red hake. If the filamentous part of the first dorsal fin is undamaged, it is much longer in red hake and measures 3 to 5 times the length of the fins. White hake are generally larger and can attain 40 pounds; however most are under 8 pounds. Red hake average 1 to 3 pounds. There is also a slight coloration difference; red hake tend to be more reddish while white hake have a purplish hue.

These two fish are fairly similar in distribution and habit. Both occur from Newfoundland to Virginia and are bottom dwellers and sluggish swimmers. Red hake are found from the tidemark to depths of 1,000 feet, while white hake extend farther out to depths of 3,000 feet. Larger fish leave the coastline for the summer to seek cool, deeper water. Hake feed on small crustaceans, squid and small finfish. They use ventral feelers to locate food.

Hake is sold primarily for food, though some red hake is used for industrial processing and has been found suitable as a base for surimi-based products. Sometimes hake is filleted and sold under the general term "scrod" or "whitefish".

Hake does not keep well so it must be carefully handled and processed soon after being caught. It should be noted hake is among the least expensive of white fish.

MACKEREL (Scomber scombrus)

Other names: Atlantic mackerel, Boston mackerel, tinkers

Mackerel are distinguished by their brilliant color pattern. The upper half of their body is iridescent blue-green with vertical black wavy band, and the lower half and belly are silvery white. The iridescence fades soon after death but the color pattern remains as the distinguishing characteristic. Mackerel have a fusiform shape and deeply forked tail. Their scales are small and smooth, giving a velvety feel to the skin. Atlantic mackerel average 14 to 18 inches long and 1 to 2-1/2 pounds in weight and reach their prime when they are fattest, which is at the end of summer and during the fall. Smaller mackerel called "tinker" mackerel are harvested in early spring. They generally weigh not more than a pound and measure 6 to 10 inches. As these mackerel are not spawners, they are in prime condition when caught.

These species inhabit both sides of the North Atlantic, and on the American side range from the Gulf of Saint Lawrence to North Carolina. There are two major spawning groups, a southern group that spawns off the Mid-Atlantic Bight in April and May and a northern group which spawns in the Gulf of St. Lawrence in June and July. Both groups winter off Nova Scotia. Like their relatives the tunas, they are pelagic and travel in swift-moving schools of similar size fish.

Mackerel eat small finfish, squid and pelagic crustaceans. They feed little over the winter and eat most greedily after spawning. A 14-inch fish will weigh about 1 pound in the spring and 1-1/4 pounds in the fall. Atlantic mackerel are oily fish, high in omega-3 fatty acids that are believed to reduce serum cholesterol.

MONKFISH (Lophius americanus)

Other names: goosefish, anglerfish, monktail, lotte

Monkfish are unlike finfish in appearance and are by far one of the ugliest. They have an enormous head with tiny eyes and huge tooth-filled mouth. The body narrows into a fleshy tail. Its body, designed for hugging the sea bottom, is quite flat, and the skin, lacking scales, is thin, pliable and slippery. They are dark mottled brown above and muddy white below.

Monkfish are in the family of anglerfish, which are characterized my having on the top of their head a small antenna (dorsal fin) which terminates in an irregular-shaped flap of skin. Members of this family "fish" for their food by swinging this appendage to lure small finfish within seizing distance. When the prey is close, the monkfish thrusts itself forward with its pectoral fins, which are modified footlike structures, and swallows the smaller fish. Monkfish can reach 4 feet long and 50 pounds, but the average commercial catch measures about 2 feet and weights 7 to 15 pounds.

The American monkfish occurs from Newfoundland to North Carolina and inhabits bottom waters in a wide range of depths. Its appetite is remarkably large and it eats finfish, invertebrates and an occasional sea bird. Monkfish is mainly a commercial fish, landed as an incidental catch of the bottom trawl fishery, being caught while dredging for scallops or dragging for flounder. Fisherman cut off the huge head and belly section at sea and bring in only the meaty tail. Processors skin the tails and cut two cylindrical shaped fillets off a single center bone.

Monkfish are highly esteemed in Europe, especially in France where they are called "lotte" and commonly used in bouillabaisse. The meat is white, lean and very firm. When cooked, its texture is somewhat similar to cooked lobster tail meat. As it also is reputed to taste somewhat like lobster, it is often called "poor man's lobster".

PERCH

OCEAN PERCH (Sebastes marinus)

Other names: redfish, rockfish

Ocean Perch are bright red, pink or orange in color, causing their large, black eyes to stand out in contrast. They look somewhat like red snapper and have been mislabeled as such. Ocean perch average 8 to 16 inches long and 1/2 to 2 pounds, rarely exceeding 5 pounds.

Ocean perch are close relatives to Pacific ocean perch (Pacific rockfish) but inhabit the North Atlantic Ocean. They range from southern Labrador to southern New England and are typically found close to the ocean floor in cold, deep offshore waters. Ocean perch are slow growers and are unusual in that they bear their young life.

YELLOW PERCH (Perca flavescens)

Other names: Lake Perch

In North America, yellow perch are found from Nova Scotia to South Carolina, north to central Canada and westward almost to Great Slave Lake and east to Quebec. They are one of the most abundant fishes in the Great Lakes and have been subject to a large commercial fishery, particularly on Lake Erie. The average fish caught weighs about 1/2 pound.

SNAPPERS

RED SNAPPER (Lutjanus campechanus)

Named for its color, red snappers are a brilliant rose-red that fades toward the belly, orange-yellow trim along the edges of the fins and red eyes. The red eyes distinguish it from the silk snapper, which has yellow eyes but is otherwise identical. The real red snapper occurs from North Carolina to Brazil. Today more red snapper are taken by Florida sports fishermen by hook and line than the commercial fleet, although Florida is still the main United States producer. They may weigh as much as 40 pounds but are commonly marketed from 2 to 6 pounds. The majority of this fish is sold to restaurants.

B-LINE SNAPPERS

The true red snapper is not to be confused with B-line snappers. B-line is not an indicator of quality but a reflection of consumer demand as B-line species fill the gap between the supply of the expensive red snapper and the larger consumer demand. B-line snapper are at times knowingly substituted for the red snapper. In fact almost any fish with red skin has been, at one time or other, sold as red snapper. True red snapper is always sold fresh with its distinctive red skin on, while many other snapper or perch come skinless. Snappers are available from just about any tropical country in the world but chances are if it hasn't been caught in the Gulf of Mexico or off Florida, it isn't red snapper.

Red snapper has several close relatives that are available. The red snapper is only one member of the family Lutjanidae which includes 250 snappers, many of which are marketed as "red snapper". The more important of these snappers are Caribbean, yellowtail, lane, mangrove or gray, mutton (looks like red snapper and comes very close to tasting like it for less money), silk and vermillion. Their meat is slightly darker than that of red snapper, and does not command as high a price. These lesser know snappers are popular near where they are landed, but few get shipped north. Genuine red snapper command the highest price.

SALMON

Most native salmon in the United States come from the Pacific Coast, where five species of -- coho or silver, king or chinook, sockeye or red, pink and chum or keta -- are harvested for the fresh, frozen, smoked and canned markets. A different species, the Atlantic or Eastern salmon, inhabits the East Coast and is relatively scarce. The Pacific coho and Chinook salmon have been successfully transplanted into a few areas in the northeast.

Salmon are anadromous fish, living in saltwater and returning to their natal freshwater stream or river to spawn. They stop feeding and begin to deteriorate rapidly: their flesh turns from pink to yellow; the skin darkens and males develop hooked noses. Far upstream the females dig their nests called reds in the gravelly bottom and lay their eggs; the male fertilizes them at once then the female fans gravel over them to protect them from predators. The alevin emerge in a matter of weeks nourished by their yolk sacs, then by the small organisms which exist, in part, on the rotting adult salmon in the river. From fry they grow into smolt about the size of a little finger and head out to sea to start the cycle over again.

How long they spend in fresh water before heading out to sea depends on the species. Pinks and chum spend only a few months in fresh water, while kings, sockeyes and cohos may linger as long as two years before swimming downstream. Their sea time varies, too. Pink salmon will return in two years, while the king salmon may stay in the sea as long as seven years.

How salmon find their way back from distances up to 3,000 miles to their natal streams, pinpointing the exact river, tributary and pool from which it left perhaps five or six years before as a fish the size of a minnow remains a mystery. One theory holds that the salmon's keen sense of smell leads it back to its natal stream.

Salmon are considered prime eating when they are fattest, which is just before they enter freshwater.

ATLANTIC SALMON (Salmo salar)

Other names: Norwegian or Icelandic or Nova Scotian salmon

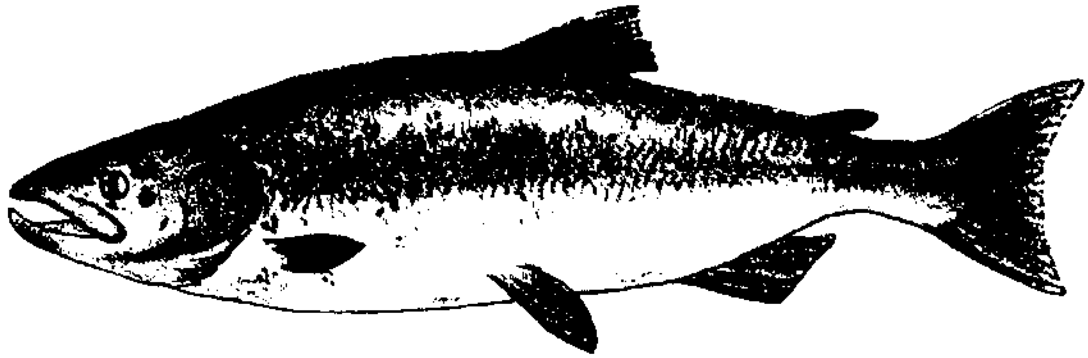
When in the sea, Atlantic salmon are silvery with a darker back. Their upper body, head and fins are marked with small black crosses and spots. They have a small head, and a small, fleshy adipose fin between their dorsal fin and tail.

Atlantic salmon inhabit coastal water on both sides of the North Atlantic. At one time they occurred along our coast from Labrador to New York. However, man-made obstructions and pollution hindered their spawning success, and overfishing further reduced their numbers.

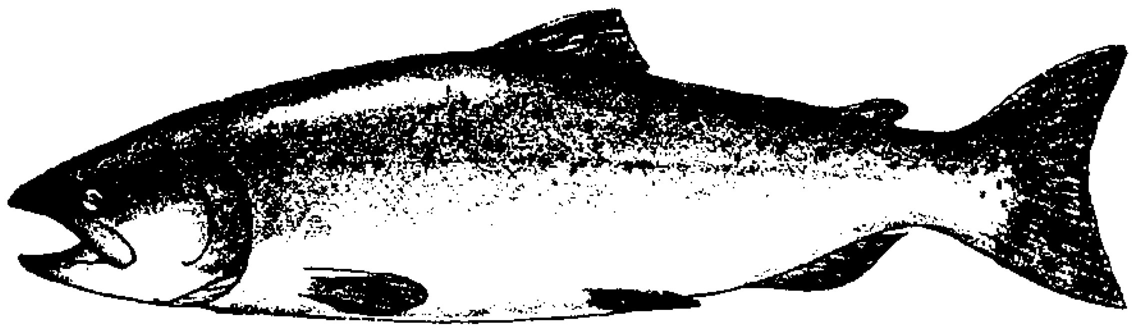
In the 1960s and 1970s, restoration efforts in New England were increased. Passage facilities were made, and hatchery grown fish released into appointed rivers. To date, the success of these programs has been slow but steadily improving.

The spawning migration of Atlantic salmon begins in spring or early summer when mature fish enter the freshwater stream of their origin. As they make their way upstream, they loose their silvery sheen and take on a dull brownish or reddish hue. Males are more colorful than females and become mottled and spotted with red or orange. The jaws of the males elongate, and their lower jaw becomes hooked so that only the tips of the two jaws come together. Both sexes feed little while on their spawning run, and their body condition slowly deteriorates. Atlantic salmon differ in life history from Pacific species in that they may survive to spawn three or four times.

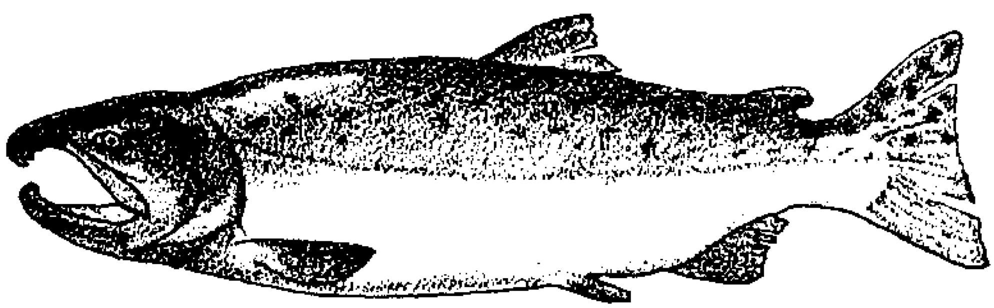
Fresh Atlantic salmon in Eastern markets originates in part from Canada and Maine but most of the Atlantic salmon marketed in the world is farm-raised in Norway. Canada and Maine are now farming Atlantic



ATLANTIC SALMON



CHINOOK SALMON



COHO SALMON

Salmon. These aquaculture operations can supply fresh fish during winter and spring when wild fish are not available. Farming now produces the bulk of the Atlantic salmon in our markets year-round but is marketed heavily when wild salmon is scarce. The Atlantic salmon may also be marketed by the country of origin: Norwegian or Icelandic or Nova Scotian salmon for example.

Atlantic salmon has pink to red flesh and a delicate taste. Sexually immature Atlantic salmon returning early to spawn are called "grilse".

PACIFIC SALMON

COHO (SILVER) SALMON (Oncorhynchus kisutch)

Other names: silver salmon, medium red salmon, silversides, sexually immature cohos and kings returning early to spawn are called "jacks"

Coho salmon are not native to the East Coast but naturally inhabit the Pacific Coast. However, to build a new sport fishery, coho were successfully introduced into the Great Lakes, the North River in Massachusetts, and the Lamprey River in New Hampshire. This species is artificially propagated and hatchery reared; then juvenile fish are released into designated areas. Since these fish are accessible to sport fishermen while in freshwater, they are not of optimal eating quality though they certainly are edible. There is no commercial fishery for the transplanted populations.

Commonly penraised to one to two pounds, cohos are marketed as "baby salmon or yearling salmon".

Coho follow an anadromous life history somewhat similar to Atlantic salmon. Unlike most other salmon, the coho migrates within a relatively small area. They range from California to northern Alaska. While in saltwater, cohos are bright silver. During their spawning migration in freshwater they change to bright red with black back and head, and the jaws of males elongate and become hooked. Unlike Atlantic salmon, all Pacific salmon die after spawning.

CHINOOK or KING (O. tshawytscha)

Other names: spring salmon, blackmouth or tyee salmon.

The chinook are the largest, least abundant and therefore the most expensive of the Pacific salmon. Kings average 10 to 30 pounds. The Yukon spawning run, over 2,000 miles, is the longest stream migration by any salmon species. Troll caught king salmon from the ocean are considered superior and command the best prices. Caught from southeast Alaska to California in summer and fall, the king salmon has firm red flesh, except for a white fleshed subspecies known as white king salmon, which has a limited market in areas where it is caught and known. Kings are often marketed by their river of origin or their flesh color: red kings for red colored flesh and white kings for white colored flesh.

SOCKEYE OR RED SALMON (*O. nerka*)

Other names: blueback salmon, Quinault salmon

Sockeye or Red salmon are named for their deep red flesh. They range from 4 to 7 pounds and are relatively oily, containing 10 to 20 percent fat depending on where and when it was caught.

About half the total sockeye production is canned and a large percentage exported, primarily to the United Kingdom. It has a deep-red, firm flesh that retains its color when cooked or processed. Long considered the most valuable of canned salmon, it has in recent years gained considerable popularity in the fresh and frozen state approaching that of the king salmon. Like the king, it is similarly named after its river origin.

PINK (*O. gorbuscha*)

Other names: humpback salmon or humpie

The pink is the smallest of the Pacific salmon, averaging about 3 pounds. It is occasionally called "humpback salmon" or "humpies", referring to the pronounced hump that develops shortly before spawning.

Although pinks range as far north as Norton Sound and as far south as California, they account for more than half of Alaska's total salmon landings. The pink runs of certain areas tend to be very heavy in alternate years.

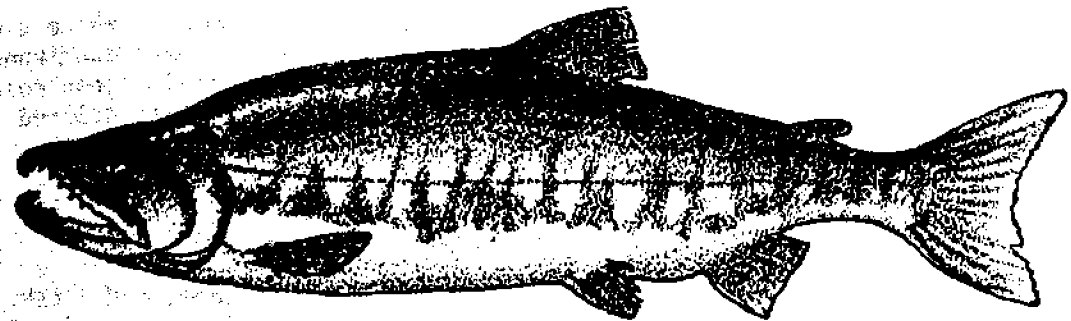
The flesh is lighter and has less oil content than that of other salmon species. Most pink salmon is canned because the flesh is soft and deteriorates relatively quickly, but it is gathering a consumer following for fresh and frozen forms.

CHUM (*O. keta*)

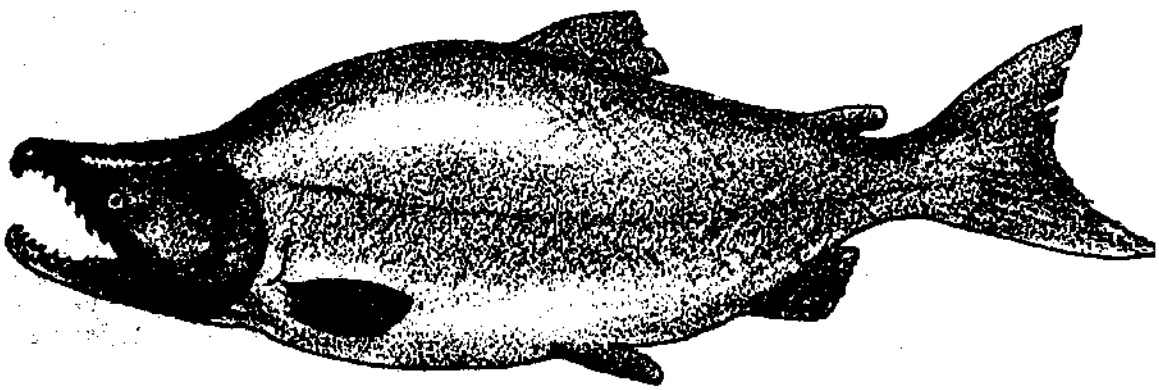
Other names: keta, silverbrites, dog salmon

The chum has firm, pink to red flesh and moderate oil content. The average weight is 9 to 10 pounds and is almost always net caught.

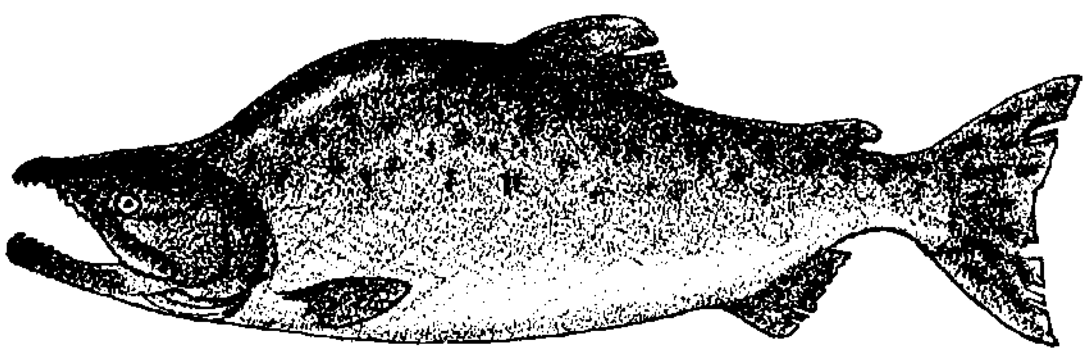
The big chum runs are largely in the more remote regions of Alaska where harvests have been difficult. The chum often has been used by natives to feed their sled dogs, hence the name "dog salmon".



CHUM SALMON



SOCKEYE SALMON



PINK SALMON

Not all chums are silver bright when they are caught and many have begun to darken. The best grade of chum is called silverbright and varies from "semibrites", "arks", "falls" or "calicos". Grading is subjective and color categories vary between buyer and supplier and according to demand. There is little if any meat quality difference between a dark or silverbrite chum salmon.

SCUP (Stenotomus chrysops)

Other names: porgy

Scup are dull silvery and iridescent with a white belly, and their sides and back are flecked with blue and marked with 12 to 15 indistinct longitudinal stripes. Scup have a deep body which is flattened sidewise. Their scales are large and firmly attached. Adults average 14 to 16 inches and 1 to 2 pounds but may reach 18 inches and 4 pounds. Larger fish usually command a higher price.

They generally range from southern New England to North Carolina. During the warmer months, scup stay fairly close to shore, typically within 6 miles of the coastline. They live close to the bottom and concentrate over areas of smooth to rocky bottom. This results in a congregation in some areas and complete absence in other nearby areas. Scup feed on small bottom-dwelling invertebrates and young finfish. Traveling in schools, they migrate offshore and southward in the fall.

SEA TROUT (Cynoscion regalis)

Other names: weakfish, gray sea trout, squeteague, yellowfin

Sea trout are colorful, slim bodied fish. They are dark olive green above and burnished with purple, blue, gold, green, or copper tints. Above their arched lateral line are many small black, dark green, or bronze spots, which appear to form irregular lines. Their belly is white or silvery, and their fins are tinged with yellow. Sea trout are further distinguished by two large teeth projecting from their upper jaw.

Members of the drum family, the males make a drumming noise by rapidly contracting abdominal muscles that resonate against the air bladder. The drumming can be heard by boaters, and during the spawning season, from May to October, the noise grows even louder.

A 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. The average is 1 to 7 pounds.

Sea trout usually travel in small schools and can be found along the east coast from Florida to Massachusetts, occasionally straying northward to the Bay of Fundy. Sea trout are most important commercially off the Mid-Atlantic states. During the summer they live in shallow shore waters, usually over sandy bottoms and move south to offshore waters in the autumn. Small fish are their chief food source.

Sea trout are called weakfish because they have weak mouth tissues that are easily torn by hooks. The flesh is also very soft or tender, which requires that it be handled gently.

SHAD (Alosa sapidissima)

Other names: American shad, white shad

Shad, the largest of our herring, may reach 12 pounds. Adult females average 3-1/2 to 7 pounds, while males are slightly smaller. Shad are dark bluish or greenish above with white or silvery lower sides and belly. Behind their gill cover is a dark spot, usually with 1 or 2 longitudinal rows of dusky spots behind it. Shad have a deep body, sharp saw-edged belly, and large, loosely attached scales. Unlike their southern relative the hickory shad (Alosa mediocris), the tip of their lower jaw is entirely enclosed within the tip of the upper jaw when their mouth is closed.

Although American shad occur from Newfoundland to Florida, they are most abundant from Connecticut to North Carolina. They also have been transplanted successfully to the Pacific Coast. Shad are often near the surface in spring, summer, and fall. They winter in the Mid-Atlantic region offshore. Shad school at sea and migrate to their native freshwater streams in late winter, spring and early summer to spawn. Adults return to saltwater while the newly hatched fry remain in freshwater until fall. As adults, they feed primarily on plankton though they do take small finfish on occasion.

Formerly abundant, shad have significantly decreased in number because of dam construction, overfishing, and pollution. Currently, an active sport fishery exists south of New Hampshire. Where allowed, shad are harvested commercially, primarily with gillnet, poundnet and haul seine, in rivers or near mouths of rivers.

Shad roe, considered a prime delicacy, commands a high price. it is typically sold in natural pairs. The meat of shad is delicious but difficult to process into a boneless form because of the complicated skeletal structure, with its three parallel rows of bones running from head to tail perpendicular to the backbone. The meat is light colored, oily, and soft textured.

SHARK

Sharks are more closely related to skates and rays than other finfish, because they do not have true bones in their body but instead a skeleton composed of cartilage. Another difference from typical finfish is that sharks lack an air-filled swim bladder, therefore must keep swimming to keep from sinking. Additionally, they have 5 or more gill openings, an uneven tail, and tooth-like scales.

More primitive than bony fish, sharks, are among the oldest animals on earth and have changed very little since their origin more than 300 million years ago.

Sharks can be caught on baited longlines and hook-and-line. Trawl, gillnet, and other gear take sharks, though it is usually as a by-catch. As the demand for shark meat increases, more directed fishing may take place. Sharks are caught year-round but are landed most often during warmer months.

Sharks destined for the dinner table must be handled properly by bleeding the fish immediately after catching. The blood of sharks contains a relatively high concentration of urea for osmoregulatory purposes, and urea breaks down into ammonia after a sharks death. Do <u>not</u> use shark meat that smells strongly of ammonia. However, if only a very faint ammonia smell is present the meat can still be used by following this procedure: the meat may be soaked in a weak solution of lemon juice or vinegar for at least 4 hours (refrigerated) before final preparation. For each pound of shark, add 1/2 teaspoon lemon juice or 1 tablespoon vinegar to enough cold water to cover the fish. This acidic solution neutralizes any ammonia that may be present.

The meat of some shark species, such as Mako, is similar to swordfish in taste and texture, while others have white, mild tasting meat. In general larger individuals within a species will have coarser textured meat.

MAKO SHARK (*Isurus oxyrinchus*)

Other names: Atlantic mako, sharp-nosed mackerel shark

Most of the Mako, the most popular shark in Eastern markets, is similar in color, taste, and texture to swordfish. Both are retailed in steaked form; however, mako is generally priced lower. How does one verify that swordfish purchases are really swordfish? One test is to feel the skin. The skin of swordfish will feel smooth, while running against the grain of shark skin will feel rough, like sandpaper. Additionally, the light meat of swordfish steaks will have definite eye-like whorls which are not present in shark steaks, and in shark, the connective tissue between the meat and the skin is thicker.

Freshly caught mako shark are deep blue-gray above, changing along the sides to snowy white belly. Soon after death, these colors change to dark slate gray above and pale dirty gray below. Mako can reach 12 feet and 1,000 pounds, but most are 5 to 8 feet long.

Mako sharks inhabit oceanic tropical and warm temperature waters in the Atlantic, Mediterranean and Caribbean. In the Pacific and Indian Oceans, the Pacific mako or bonito shark (Isurus glaucus) is found. Off the East Coast, the Atlantic mako is most abundant in warmer areas but moves northward to southern New England in the summer. One of the most active and swiftest swimming of all sharks, the mako has the amazing habit of leaping out of the water when hooked. Its fighting ability makes this shark a superb game fish.

SPINY DOGFISH (Squalus acanthias)

The spiny dogfish is traditionally known as "rock salmon" in Great Britain and is used there in fish and chips. Germany and France import just the belly flaps of this shark. There it is smoked and considered a delicacy. Most of the dogfish caught in the United States is exported to these countries. What little is sold domestically is marketed as "grayfish" or simply "shark". In the early 1980s, dogfish was promoted in the Mid-Atlantic region.

This fish is named for its weapon of defense. Along the front of each dorsal fin is a long spine which stands more or less upright when the shark curls its body into a bow. Spiny dogfish are small, slender bodied fish; most are 2 to 3-1/2 feet long and 5 to 10 pounds. They are slate gray above, sometimes tinged with brown, with grayish white sides and a white belly. On each side here is a row of small, white spots which fade with age.

Spiny dogfish inhabit temperate and subarctic waters including both sides of the North Atlantic and North Pacific. They are abundant off the East Coast in spring, summer and fall but spend their winters offshore in deeper waters and/or south. Dogfish travel in large schools, are bottom feeders and do not have the sharp teeth found in most other sharks. Yet, many fishermen consider spiny dogfish a nuisance that can cause considerable damage to nets.

SMOOTH DOGFISH (Mustelus canis)

The smooth dogfish, which is about the same size as the spiny dogfish, is one of the most abundant sharks along the East Coast. In the shallow waters of the Delaware Bay, where it is found in great numbers during the summer, more smooth dogfish are caught than all other sharks together. Since their migrations are temperature dependent, smooth dogfish will leave the area for warmer waters in fall.

Instead of possessing the ferocious jaws that sharks are generally famous for, smooth dogfish have many low, flat pavement-like teeth that crush and grind more than they actually bite or tear. Their diets consists chiefly of crustaceans. In terms of abundance the smooth dogfish is second only to the spiny dogfish. The tasty smooth dogfish is caught and sold pooled with the spiny dogfish.

Because smooth dogfish are usually caught close to beaches and around sand bars, they are often erroneously called "sand sharks". But true sand sharks (Odontaspis taurus) have much sharper teeth and are 4 to 6 feet long and weigh considerably more than dogfish. All sizes of sand shark are edible, though generally this fish is not as delicious as some other shark species.

SPOT (Leiostomus xanthurus)

The spot is a small, well-known member of the croaker family that derives its name from the black spot directly behind the gills. Its body is short and deep, and the body coloration is usually bluish-gray with gold or bronze reflections above and a silvery cast below. It has 12 to 15 yellowish oblique bars on the side which become indistinct with age. Like croakers, the male spot makes a drumming sound using the swimbladder. Spot are usually smaller and rounder than croaker and average only half a pound.

Able to tolerate a wide range of temperatures and salinities, spots are found along the Atlantic coast from Massachusetts to Texas, but are most common south of New Jersey. They can be found in the Chesapeake Bay and its tributaries in early spring. The rivers serve as nurseries until October when the spot leave the Bay. They sometimes occur in large schools, from the shallows of coastal marshes to at least 670 feet, and occasionally they are extremely abundant in deepwater.

STRIPED BASS (Morone saxatilis)

Other names: striper, rockfish

Striped bass are dark olive to bluish above, paling on the sides into a silvery white on the belly. They are stout-bodied fish and have large scales and 7 to 8 dark longitudinal stripes on both sides. Striped bass grow to become large fish with record landings of 100 pounds, but larger fish are disappearing. Where allowed, the normal market size is 24 inches. Striped bass fillets should be purchased skin on to avoid substitutes.

On the Atlantic Coast, striped bass inhabit inshore and estuarine waters from Canada to the Gulf of Mexico. They are anadromous, moving into freshwater rivers to spawn. The main spawning areas are the estuaries of the Hudson River and Chesapeake Bay. Stripers migrate south with the coming of winter. They are pelagic schooling fish and feed on finfish and invertebrates. Commercial fishing for striped bass is not allowed in all states. Much of the commercially marketed fish is supplied by sport fishermen who may hold their catch before selling to a dealer, thus the quality of fish reaching the consumer can vary a great deal.

Striped bass have a high tolerance for polluted water and the flesh seems to absorb some of the pollutants. For example, fish taken from water with oil waste may taste slightly of oil.

The supply of striped bass has drastically declined in recent years, probably because of a combination of declining water quality in the spawning areas, overfishing and natural phenomenon. Concerned states along the Atlantic Coast have joined efforts to formulate an interstate management plan that will alleviate fishing pressure until stocks are replenished.

SWORDFISH (Xiphias gladius)

Other name: billfish

Swordfish are named for their long upper jaw and snout which form a flat, double edge, sword-like structure. This sword can be as much as one-third the total length of the fish. Swordfish have long, sleek, scaleless bodies which are thickest in the shoulder region and taper towards the tail. Their eyes are relatively large and said to be deep blue. Swordfish lack pectoral fins and adults are toothless. They are dark purplish, bluish or black above with silvery white sides and belly. The average commercial catch consists of fish from 50 to 400 pounds.

There is only one species of swordfish and it occurs worldwide in tropical and temperature waters. Swordfish are pelagic and are fast, powerful swimmers.

Both sport and commercial fishermen seek this fish, which is especially attractive because of a high exvessel price. Off the east coast of the United States they are commercially harvested with long lines and to a lesser extent by the traditional method of harpooning while it is basking near the surface of the water. The fish has a distinctive flavor and firm flesh.

TILEFISH (Lopholatius chamaeleonticeps)

Other names: golden bass, golden snapper

Tilefish are olive green or dark tan above, changing to yellow or rose on the lower sides. The back and upper sides are dotted with brilliant yellow spots, and the belly is white. Tilefish are further characterized by a fleshy protuberance on their back just in from the the dorsal fin, which looks like a miniature rudder balanced on its head. Although they can reach 50 pounds, this fish is usually marketed at 4 to 8 pounds. Their diet consists mostly of crabs and other crustaceans. Tilefish have unusually firm, yet tender flesh, which is best compared to lobster or scallop meat.

Tilefish occur from Nova Scotia to the Gulf of Mexico and are most abundant from Nantucket to Delaware Bay. They are known to occupy a narrow band of the ocean floor on the upper part of the continental slope where a belt of warm water is found. A significant commercial fishery exists, especially off the Mid-Atlantic Coast.

TUNA

Tuna belong to a large family of fish called Scombridae, which includes mackerel and bonito. Members of this family are similar in that they have streamlined bodies, travel in schools and are among the fastest swimmers of all fish.

Tuna inhabit tropical and temperate waters worldwide. Several species arrive off our coast in spring and travel south during the fall.

Japan and the United States are the world's leading harvesters and consumers of tuna, with Americans eating almost a third of all the tuna caught in the world. While Japanese prefer fresh tuna, Americans consume more canned tuna that any other fish. (It is estimated that almost 25% of all seafood consumed in the United States is canned tuna.)

Canned tuna is classified according to the color and size of the pieces of meat. Only albacore can be labeled as white meat. Other tuna species are labeled as light meat and are priced less. The size of the canned pieces of meat also affect the product's price. From largest to smallest piece size, and from most to least expensive, the product forms are fancy or solid pack, chunk, and flaked or grated.

Americans are just beginning to realize that tuna doesn't have to be canned to be good. The physical appearance of fresh tuna is quite unlike the canned product. The color of fresh tuna is red with brownish darker sections. When cooked, the meat turns brown and actually looks similar to cooked steak. Fresh tuna is rich in oil and very firm textures. It is relative expensive and is wholesaled in two basic grades -- shashimi and fry. The former commands the highest price since special handling is required for use in the raw tuna trade.

BLUEFIN TUNA (Thunnus thynnus)

The bluefin tuna is the most common tuna occurring off the mid-Atlantic. It is dark steel blue with silvery-gray sides and belly. It is so large, reaching weights of more than 1000 pounds, that it is sometimes called horse mackerel. Correspondingly, this fish can attain high speeds, with sudden bursts exceeding 50 mph. Because of its high metabolic rate, bluefin tuna maintain a body temperature warmer than the surrounding water.

The meat of bluefin has a stronger flavor that many other tuna, but this doesn't bother the Japanese who consider bluefin a favorite. Most of the U.S. harvest is exported to Japan, and the rest is primarily marketed in New York, New England and Mid-Atlantic cities. Although often a large fish, most of the commercial landings are smaller fish from 15 to 80 pounds.

YELLOWFIN TUNA (Thunnus albacares)

Yellowfin tuna are characterized by their yellowish orals and anal fins and yellow coloring on their sides. Otherwise they are blue-gray above with a light belly. Yellowfin usually are from 30 to 100 pounds though they may reach 300 pounds. Yellowfin tuna is a very important commercial fish in the Pacific Ocean, however, only a small amount is landed in Mid-Atlantic ports.

Yellowfin are taken by surface longline and pole-and-line, but most are taken by multi-million dollar superseiners that roam the high seas for months catching as much as 1,000 tons of tuna in a single good set. Most is frozen in brine and later canned. Fresh yellowfin is taken close to shore by small boats fishing short trips of a few days.

ALBACORE (Thunnus alalunga)

Albacore, the only tuna that can be labeled "white meat" in the can, also has expanded its popularity to the fresh market, largely because of efforts of fishermen who lost their market when all but one tuna cannery on the West Coast shut down in 1985. Albacore are found in temperate to tropical waters around the world; in California they are landed throughout the year by offshore trollers and longliners but are more abundant during the summer. Slightly half of the worldwide catch is taken in the Atlantic.

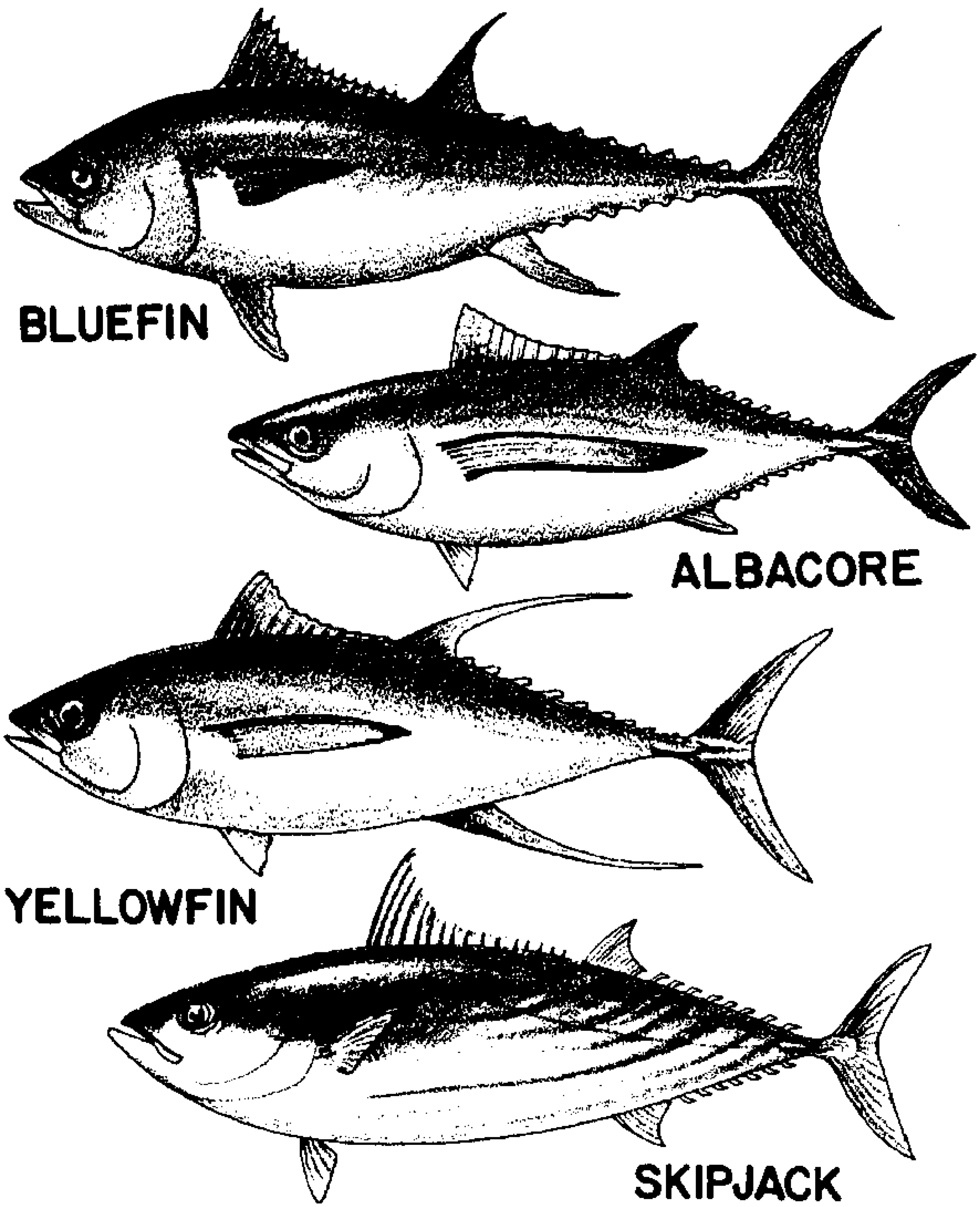
WHITING (Merluccius bilinearis)

Other names: Atlantic whiting, silver hake, winter trout

Hake and whiting are names often used interchangeable for the many species of this fish. Whiting are distant relatives of the cod family but are much smaller, averaging only 14 inches long and under 2 pounds. One abundant whiting is also referred to as winter trout or more properly silver hake because of their silvery iridescent color. They are slender streamlined fish with soft-rayed fins, the upper of which are transparent. The long body has small scales, a relatively small tail, and a lateral line running the length of the fish. The whiting has a flat-topped head, large eyes and a large mouth with 2 or mores rows of sharp teeth. They are gray, mottled with brown above, and silvery iridescent on their lower sides and belly. Whiting differ from other hake by lacking a chin barbel and having ventral fins which are not altered into long feelers.

This species inhabits continental shelf waters from Newfoundland to North Carolina but is most important commercially from Maine to New Jersey. They may live in water as deep as 3,000 feet during the winter months and seem to prefer warmer water than other members of the cod family. Whiting are bottom dwellers by day and move toward the surface at night to feed. They do not school often but will swim together at times. Like sea trout, whiting are tender and must be packed and handled carefully to avoid crushing.

Whiting are sometimes called "frostfish" because sudden cold snaps may freeze large quantities of this fish and wash them ashore before they migrate into deeper waters.



TUNAS

FREQUENTLY ASKED QUESTIONS ABOUT FINFISH

Q. What are the red lines often found on the white side of a flounder?
A. Although it is hard to determine without actually seeing the lines first hand, it could be bruising caused from mishandling.

Q. What is Monkfish and what does it taste like?
A. Monkfish is a deep water fish often referred to as "Poor Man's Lobster", Bellyfish, Lotte, Allmoutn, Uglyfish and Lawyer Fish. It is a mild-flavored, white meat fish that is firm in texture. It is an excellent fish for stews and to grill outdoors in a kabob recipe. Because the Monkfish feeds on lobster, many feel it tastes like lobster. When prepared with lemon and butter, it can taste similar to lobster.

Q. What part of the Monkfish is edible?
A. When a Monkfish is caught, only the tail is kept because the fish is mostly head and mouth. Harvesters discard the unneeded or inedible parts of the fish at sea. Only the tail is eaten. When preparing Monkfish for cooking, make sure all pieces are of same general thickness to prevent overcooking of the smaller pieces.

Q. What kind of fish is called "scrod"?
A. The name comes from a Middle Dutch word "Schrode" meaning a strip or shred. In New England, scrod may be immature cod or haddock weighing 1½ to 2½ pounds. Sometimes the term is applied to cusk of about the same weight, or to pollock weighing 1½ to 4 pounds. When fishermen use the word, they are usually referring to gutted small haddock.

Q. Which is the better buy? Whole fish or filleted fish?
A. When filleting fish, the yield from the whole fish generally averages out to 50%. Some fish like flounder will average a 60% yield. When looking at prices, if whole fish sells for 99¢ a pound and filleted fish for $1.69 a pound, fillets are the better buy--if you intend to fillet the fish for cooking anyway. There is something to be said about buying the whole fish and having it filleted, through, because you can check the overall quality and freshness of the fish.

Q. How nutritious is a fish's skin? Do I lose many nutrients if I skin a fillet?
A. Fish skin is mainly made up of a protein called collagen. It is not considered a high quality protein, but nevertheless a protein. The loss of nutrients from skinning a fillet is specific. The high lipid fat containing fish would lose some of the fish oils when the skin was removed.

Q. I got a good buy on flounder fillets. Is there a good way to preserve them?

A. There are many good ways to freeze fish, but one of the quickest and easiest is to place the number of fillets you need for a meal on a polyvinyl chloride wrap and using the "drug store" method, fold down two edges, squeeze out all of the air and then fold over the other two edges and seal. Overwrap this package with foil, freezer paper or any other paper, seal and label with the contents and date. Polyvinyl chloride is a clear plastic warp that is both moisture-proof and vapor-proof. It should, however, be overwrapped because it is not strong at freezer temperature.

Q. When is the season for pufferfish?

A. Pufferfish is harvested in late summer off the coast of Long Island.

Q. How long should I cook fish?

A. Fish is done when the flesh becomes opaque and flakes easily with a fork. A rule of thumb is that you should allow 10 minutes of cooking time per inch of thickness. For fish still frozen, allow 20 minutes per inch of thickness.

Q. How can I tell when the fish is fresh?

A. When buying fish your sense of smell is most important. We all enjoy the smells of the ocean and bay. Fresh fish should smell like the water where they were caught. Fishy smells indicate less than top quality. If buying whole fish, look for bright, non-sunken eyes and shiny, resilient skin that springs back after you poke it. The gills should be clean and red and not sticky.

Q. Is it safe to prepare sushi and sashimi dishes at home?

A. As with shellfish the ingredients for sashimi must be taken from pollution-free waters and/or purchased from a reputable source. One should know how to choose fresh fish. Although saltwater fish can be infected with harmless human parasites, freshwater species should not be used for sashimi because of the possibility of diseases related to uncooked fish. This has a parallel in eating improperly cooked pork. Freezing fish for 24 hours is recommended to reduce the risk of producing an unsafe sashimi product.

Q. What is the best way to thaw frozen, cooked seafood? Can it be thawed the same way as fresh, raw seafood?

A. Thaw frozen, cooked seafood under refrigeration as you would raw seafood. Do not thaw at room temperature. Raw seafood can be thawed quickly under cold running water. Make sure it is packaged in a water proof package.

Q. Some of my customers have told me that they are on low sodium diets and have asked if they can eat fish from salt water?

A. Yes. Marine species contain a mechanism known as an osmoregulator. This mechanism limits the intrusion of salt into the species, with the end result that fish from marine waters, on the average, have no higher salt content than those from fresh water.

Q. I want to make a bouillabaisse for a large dinner party. What do you suggest I put in it besides a lot of expensive seafoods like shrimp, lobster and crabmeat?

A. An excellent flavor extender is Monkfish, a firm-fleshed fish that is mild in flavor. It will hold up very well in a bouillabaisse and is relatively inexpensive. Mussels are also an inexpensive extender to help keep down the cost of the seafood stew.

Q. I once ate a tilefish from the Pacific that tasted very bitter. Was it bad?

A. What you ate was actually an "ocean whitefish" which is the Pacific species of tilefish. The ocean whitefish occasionally has harmless but very bitter flavor. The unpleasant flavor is believed to be caused by a change in the diet of the ocean whitefish when they come into shallow water.

Q. Should I parboil Monkfish before I use it in a baked or broiled recipe?

A. No. Although many recipes tell you to parboil Monkfish, it is not necessary. Just make sure the Monkfish you are about to cook is of relatively similar size and thickness so that it bakes, broils or fries evenly. Parboiling it can actually overcook it.

Q. Is fresh fish safe to eat if it has a strong ammonia odor before or after cooking?

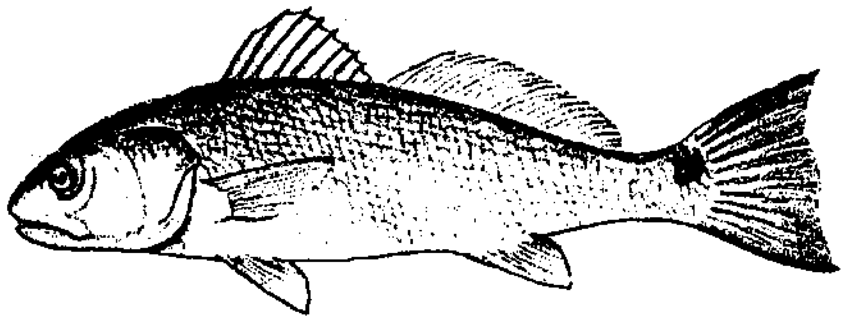
A. Reject and do not prepare or eat fresh fish that has a medium to strong sour odor. Finfish should have a fresh clean sea breeze smell.

Q. What is the storage time for fresh finfish (dressed or filleted)?

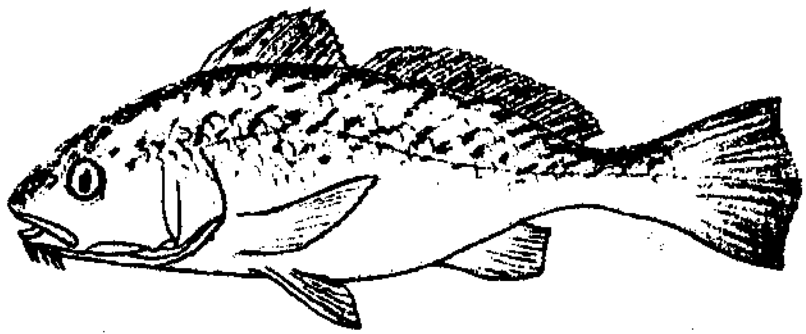
A. Finfish (cooked - 2 to 3 days in refrigerator and uncooked 1 to 2 days).

FINFISH SPECIES CHART

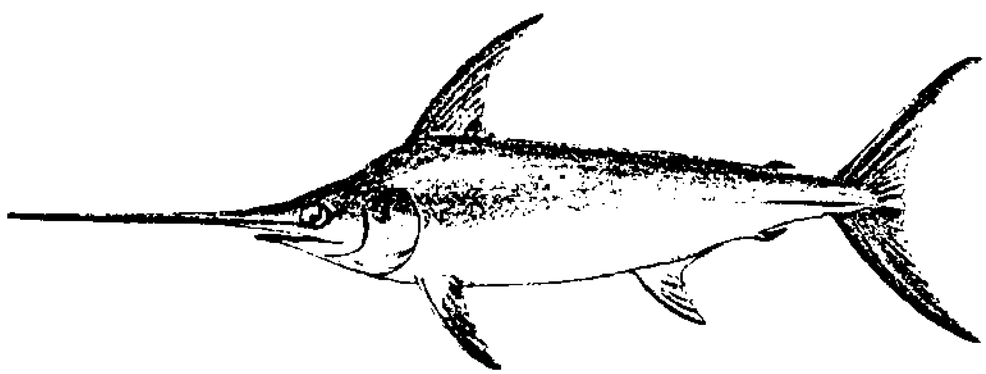
SPECIES	OTHER/NAMES	AVAILABLE	F/L	RANGE	MKT FORMS
Black Sea Bass	Sea Bass Blackfish Tautog	Spring To Fall	L	Cape Cod to N. Florida	Drawn Dressed Fillets
Bluefish	Blue, Snapper Chopper Blues	Spring Thru Late Fall	F	Worldwide	Fresh, Whole, Drawn, Fillets
Butterfish	Dollarfish Silver Dollar Harvestfish	Spring Thru Early Winter	F	Nova Scotia to North Carolina	Fresh Whole, Drawn Dressed Smoked
Catfish	Bullhead Blue Channel	Year Round	L	Freshwater Farmed	Fresh/Frozen Dressed Fillets Breaded
-Ocean Catfish	Wolffish		L	Eastern N. Atlantic	Frozen Fillets Breaded
Cod	Codfish	Year Round	L	North Atlantic	Fresh/Frozen Drawn, Dressed Steaks, Fillets Breaded Precooked Salted
Croaker	Atlantic Croaker Drum Golden Croaker Hardhead	Spring Thru Fall	L	Atlantic Coast Gulf of Mexico	Fresh, Drawn Lg. Fillets
Eel	American Eel Silver Eel Freshwater Eel	Year Round	F	Greenland to Gulf of Mexico	Live, Limited: Gutted Fillets Whole, Smoked Frozen
Flounder	Sole Winter Flounder: Blackback/Lemon Sole, Yellowtail Gray Sole/Witch Flounder Dab Summer Flounder/Fluke	Year Round	L	Atlantic Ocean Gulf of Mexico	Fresh/Frozen Whole Fillets: W or W/Out Skin Dressed/Pan Dr. Breaded, Stuffed Precooked



RED DRUM

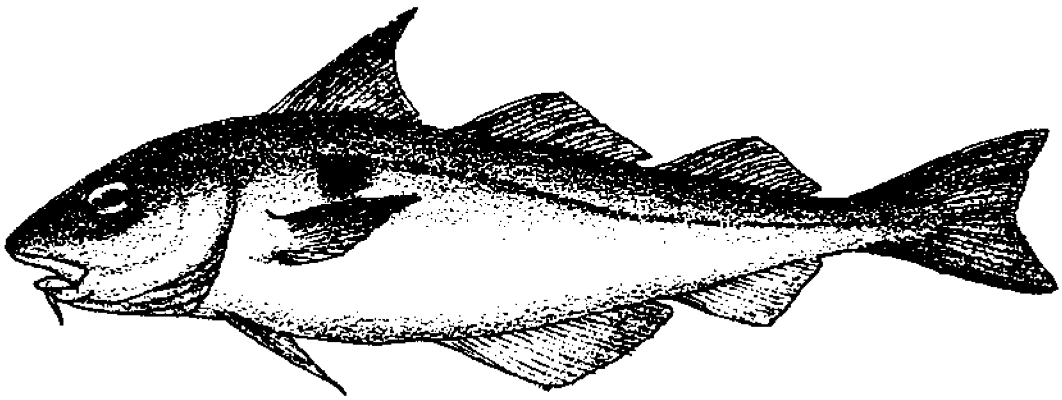


CROAKER

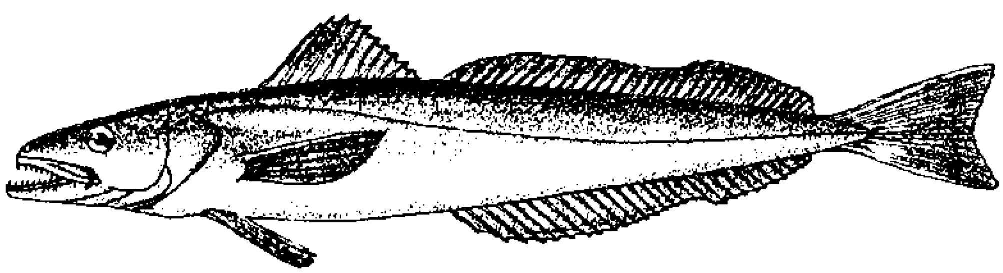


SWORDFISH

ATLANTIC COD



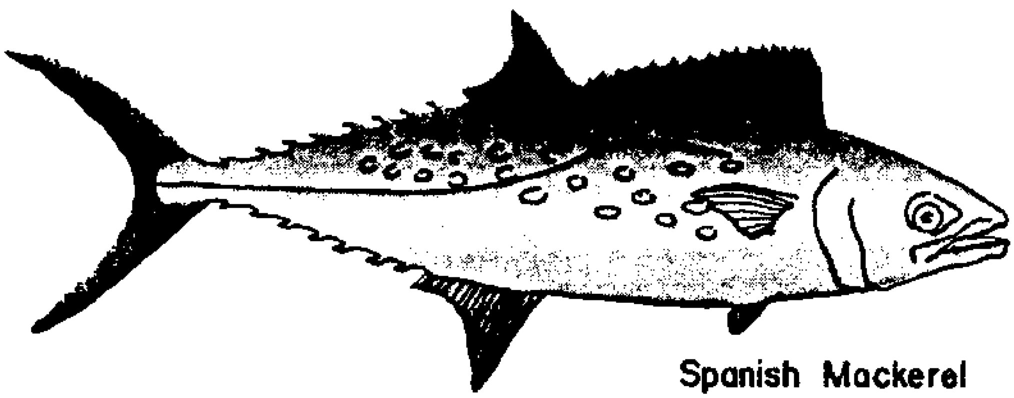
HADDOCK



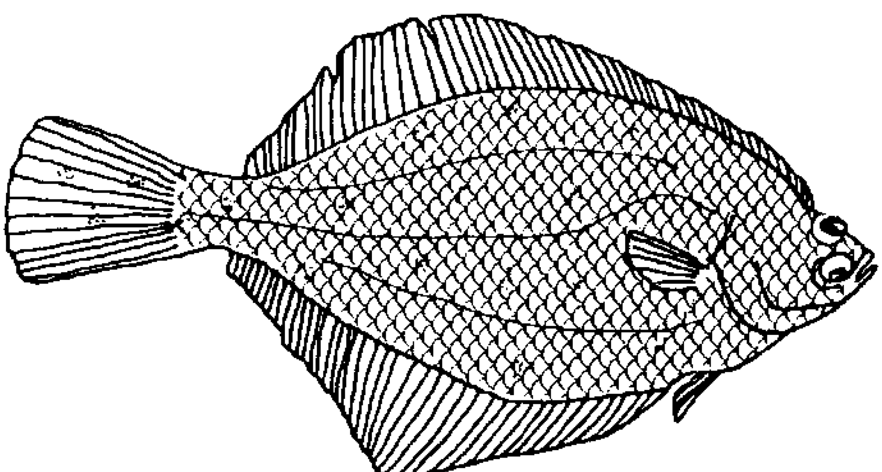
WHITING (SILVER HAKE)

Red, Black Yellowfin Jewfish Warsaw Nassau Speckled Hind, Gag, Scamp		L	South Atlantic Gulf of Mexico	Fresh/Frozen Whole Steaks Fillets
Scrod (baby)	Year Round	L	North Atlantic	Fresh/Frozen Whole, Drawn, Fillets, Salted, Smoked, Breaded Precooked
White Red Hake/Ling Squirrel, Whitefish, Scrod	Year Round	L	Newfoundland to Virginia	Fresh/Frozen Drawn, Dressed Fillets, Salted Corned
	Year Round	L	North Atlantic North Pacific	Fresh/Frozen Steaks, Chunks, Fillets, Smoked, Breaded
Togue	Year Round	F	Northern Freshwater	Fresh/Frozen Whole, Drawn Fillets, Steaks
American M. Blue M.	Late Winter To Early Fall	F	Northeast	Whole Fresh/Frozen
		F	South Atlantic to Gulf/Mexico	Fresh/Frozen Whole, Drawn Fillets
Cero Kingfish		F	South Atlantic to Gulf/Mexico	Fresh/Frozen Drawn, Steaks Fillets
Dolphin Dolphinfish	Summer in Mid Atlantic	L	Worldwide Tropical and Subtropical Waters FL and Hawaii	Fillets
Goosefish Anglerfish Monktail, Lotte	Year Round	L	Newfoundland to N. Carolina	Fresh Skinless Tails/Fillets

Atlantic Mackerel



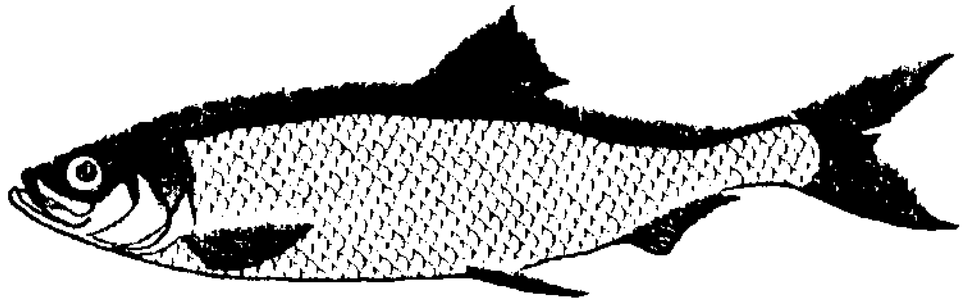
Spanish Mackerel



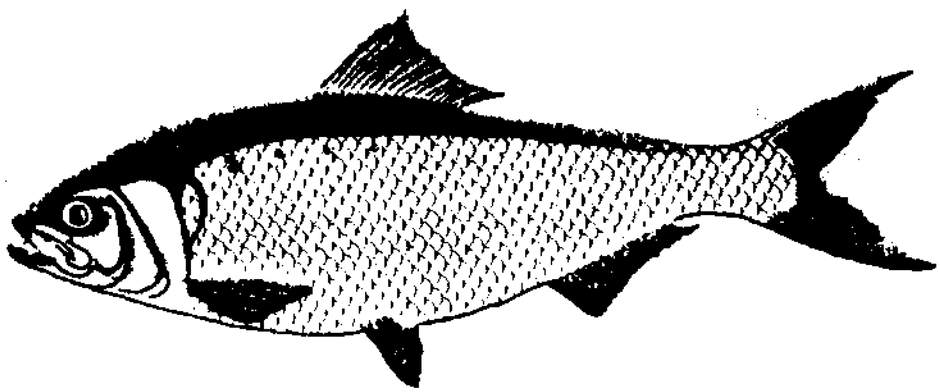
Winter Flounder

Ocean Perch	Redfish Rosefish Rockfish	Year Round	L	Newfoundland to Southern Northeast	Fresh/Frozen Fillets, Breaded
-Yellow	Lake Perch		L	Freshwaters	Fresh/Frozen Fillets, Breaded Fresh/Frozen Whole Pan-Dressed Fillets
Orange Roughy		Year Round	L	New Zealand	Frozen Skinless Fillets
Pollock	Boston Bluefish	Year Round	L	North Atlantic	Frozen/Fresh Drawn, Dressed Fillets, Steaks Salted, Smoked Breaded
Rainbow Trout		Year Round	L	Farms-Us Denmark Japan	Frozen/Frozen Dressed Boned
Red Snapper			L	Gulf/Mexico	Fresh Southern Drawn
				Atlantic Coast	Dressed Fillets W/Skin
Salmon -Atlantic	Norwegian	Year Round	F	Farms-US Denmark Japan	Fresh/Frozen Dressed Boned
Red Snapper			L	Gulf/Mexico	Fresh Southern Drawn
				Atlantic Coast	Dressed Fillets W/Skin
Salmon -Atlantic	Norwegian	Year Round	F	Farms-US Norway	Fresh/Frozen Dressed

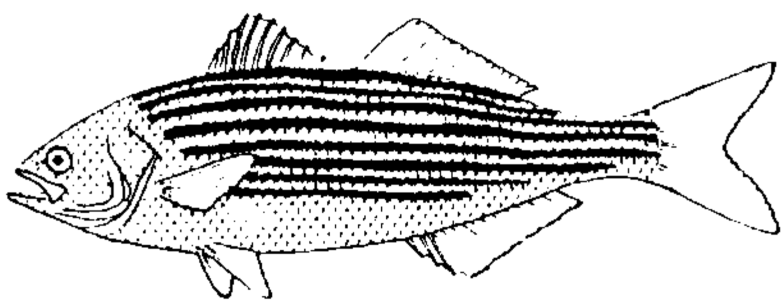
-Coho -Chinook -Chum -Pink -Sockeye	Silver King Keta Humpback Red	Spring to Fall	F	N. California Alaska	Fillets Steaks, Canned Smoked
Scup	Porgy		L	Middle Atlantic Cost	Fresh Whole Pan-Dressed
Sea Herring	Atlantic/Pacific Pacific		F	North Atlantic	Whole Chunks, Fresh, Salted Pickled, Smoked
Sea Trout	Weakfish Gray Sea Trout Squeteaque Yellowfin	Apr. to Dec.	L	Middle to Southern Atlantic	Fresh/Frozen Whole, Drawn, Pan Dressed Fillets
-Spotted Trout	Speckled Tr		L	Middle, South Atlantic Gulf of Mexico	See Sea Trout
-White	Sand Trout		L	Gulf of Mexico	Fresh/Frozen Whole Fillets
Shad	Buck Shad Roe Shad	Spring to Fall	F	Coastal Rivers Maine to FL & Cal to Wash	Fresh/Frozen Drawn Fillets, Boned Shad Roe: Fresh/Frozen Canned
Shark -Mako	Atlantic Mako Sharp-Nosed- Mackerel Shark	Year Round	L	Middle and South Atlantic (Warm Waters)	Steaks, Chunks Small Sharks-
-Spiny Dog Fish			F	North Atlantic North Pacific (Cold Waters)	Fillets



Atlantic Herring



American Shad



Striped Sea Bass

Smelts	Whitebait Surfsmelt Grunton Silverside Jacksmelt Bay Smelt Eulachon or Columbia River Smelt	Fall Thru Spring	F/L	North Atlantic Pacific Columbia River Bays From Mex. to Canada Great Lakes	Fresh/Frozen Whole Dressed Breaded
Sole	Rox Petrale Sand Grey or Lemon Over or Eng.	Year Round	L	Pacific Coast North Atlantic	Fresh/Frozen Whole, Fillets Breaded Stuffed
Spot	Goody Lafayette	Apr. to Dec.	L	Middle and South Atlantic	Fresh/Frozen Whole Pan-Dressed
Striped Bass	Rock, Rock Bass Rock Fish		L	Middle Atlantic	Fresh/Frozen Whole, Drawn Steaks, Fillets
Swordfish	Billfish	Late Spring Thru Fall	L	Worldwide Atlantic Coast	Fresh/Frozen Dressed Steaks
Tilefish	Golden Bass Golden Snapper	Year Round	L	Atlantic Coast Gulf of Mexico	Fresh, Drawn Fillets
Tuna		Year Round		Tropical and Temperate Waters Worldwide	
-Albacore			F	Pacific and Atlantic Coast	Fresh Steaks Canned
-Bluefin			F	Pacific and Atlantic Coast	Fresh Steaks Canned
-Little	False Albacore		F	Atlantic and Worldwide	
-Skipjack	Striped Tuna		F	Southern Waters	
-Yellowfin			F	Pacific and Atlantic Coast	Canned

Whitefish			F	Great Lakes Minnesota Canada	Fresh/Frozen Whole, Drawn, Dressed Fillet Smoked
Whiting	Silver Hake Frostfish	Year Round	L	New England	Fresh/Frozen Drawn, Skinned Breaded
	Oceanic Bonito				

CHAPTER TWO

SHELLFISH

SHELLFISH

Shellfish are invertebrate animals, that is, unlike finfish, they do not have backbones. To support their soft bodies, most have an external skeleton in the form of a calcareous or chitinous shell. The majority of the shellfish we eat are from two different phyla or groupings, namely mollusks and arthropods. Mollusks include clams, oysters, mussels, scallops, whelks, squid, and octopus; while lobsters, crabs, and shrimp are in the arthropod group.

Mollusks are soft-bodied animals that have a structure unlike any other group of animals. This structure is the mantle, which is a sheet of tissue lining the inside of the shell. The mantle forms the shell as the animal grows. Growth spurts leave line-like marks on the shells of many species, and these growth marks are often used by scientists to determine the animal's age. The shell consists of several calcareous layers and an outer covering or periostracum. The latter is composed of a horny organic material and protects the inner shell layers from erosion. The shell is the main distinguishing feature of most molluscan species, and varies in shape, size, sculpturing, and color.

The most popular class of mollusks is the bivalves, which includes clams, mussels, oysters, and scallops. As the name implies, the exoskeleton of bivalve mollusks consists of two valves or shells, which are hinged on one side. Generally, the two shells are convex and fairly similar. They are attached dorsally by an elastic ligament. To prevent lateral slipping, the shells, beneath the ligament, are interlocked by teethlike ridges and opposing sockets and grooves. The shells are held together by one or two adductor muscles. Scars on the inner surface of the valves indicate where these muscles were attached. When the adductor muscles relax, the ligament causes the valves to open. In most species the shells can shut firmly, completely enclosing the animal.

The mantle encloses the soft body in a fleshy case when the shell is shut. The edge of the mantle bears three folds, each with a special function. There is a sensory fold, a muscular fold, and an outer shell-secreting fold. When a foreign particle, such as a grain of sand, lodges between the shell and the mantle, a pearl is formed.

The gills of bivalves are adapted for both food collecting and gas exchange. They function as sieves and strain microscopic food from the water. This type of food gathering is known as filter feeding. Water is circulated through the body cavity my means of an incurrent and excurrent siphon. The mantle joins to form these tubes. The siphons are fused below their openings and are commonly called the "neck."

Clams are burrowing bivalves and are equipped with a tongue-shaped muscular foot adapted for this purpose. Non-burrowing bivalves have a reduced foot and have evolved different adaptations for other living areas. Mussels live attached to rocks, piers, or other hard surfaces by means of a bundle of tough threads which are commonly called the "beard." Oysters also remain adhered to bottom surfaces but attach by means of cementation. Cementation occurs by initially secreting an adhesive fluid which is reinforced through normal shell secretion. The result is dissimilar shells; the lower attached shell being larger, heavier, and more convex. Scallops live on the surface but remain unattached and free swimming. Scallops swim by ejecting water from the mantle cavity by rapidly opening and closing their shells. Their single adductor muscle is well developed for this purpose.

Whelks, moon snails, and periwinkles are grouped within a different class of mollusks called gastropods. These shellfish are characterized by having a single spiral-shaped shell, with an opening by the largest whorl. The opening is protected by a lid-like horny disc called the operculum. Gastropods creep slowly along the bottom with a large, muscular foot which protrudes out through the opening. They are not filter feeders but feed by means of a rasping mouth structure called the radula.

The highest class of mollusks is the cephalopods or "head-footed" animals, which includes squid, cuttlefish, and octopus. Surrounding the head of these animals are tentacles and/or arms, which are a modification of the muscular foot of their ancestors. In evolving, the shell of cephalopods became reduced and is now found within the body in the form of a small, slender plastic-like structure. The mantle, which encases the body, is thick and muscular. Cephalopods are active predators, and their mouths are armed with a bird-like beak. They are free swimming and can move rapidly by expelling water from the mantle cavity.

The arthropod phylum (jointed-legged animals) is the largest grouping of animals as it contains the insect class. We are more concerned with the crustacean class which contains the illustrious lobster, crab, and shrimp.

Crustaceans have a jointed, armor-like chitinous exoskeleton and segmented appendages. The body of these animals is composed of a head, thorax, and abdomen. In most, the head and thorax are covered by a hood-shaped shell piece called the carapace. The abdomen ends in a flattened telson (tail fan) in shrimp and lobsters but is reduced and folded underneath in crabs.

Shrimp are adapted for swimming and have slender legs and a thin, flexible exoskeleton. Crabs and lobsters have heavier legs and are better adapted for crawling. Interestingly, lobsters move backwards, while crabs move sideways. In order to grow, arthropods must shed their restrictive shell and form a new larger one by a process called molting. All generally are predacious and have chewing jaws or mandibles.

The arthropod and mollusk phyla contain most of the shellfish we commonly eat, but some countries savor the roe of a shellfish in the echinoderm phylum. Echinoderms are a group of spiny-skinned animals which appropriately includes sea urchins. Urchins have a calcareous sphere-shaped exoskeleton with movable spiny outgrowths. They are scavenging feeders and possess a toothed mouth which is directed against the substratum.

ABALONE

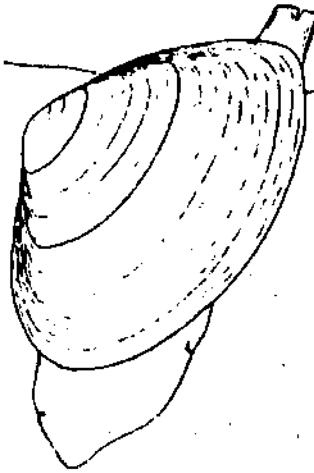
This large univalve mollusk resembles a human ear in shape, thus its generic name Haliotis comes from two Greek words meaning "sea ear." A univalve's shell protects the animal's body yet permits the muscular foot to maneuver along the bottom or cling with great suction. Other univalves such as conch, whelk and limpet are utilized as food but none has the culinary status of an abalone. Many species of abalone occur in various parts of the world; wherever they are found the resource has been thoroughly exploited. The inner shell with its opalescent greens and blues or iridescent pinks, and pearl has long been a source of jewelry.

There are about 100 species of abalone in the world's seas, of which eight occur along our Pacific Coast. The most popular are black abalone (H. cracherodii) and red abalone and the largest (H. rufescens) grows to a foot in length and may weight 8 pounds. While the average is half this size, the shell contains a very substantial amount of meat. Abalone are scarce and likely to become even more so because of fishing pressure and predators. In California wild abalone is carefully managed and efforts to farm abalone are underway. Because of the high value of abalone, it is a prime target for substitutions. Giant squid and cuttlefish are among the unlikely items that have apparently been used to fool the consumer.

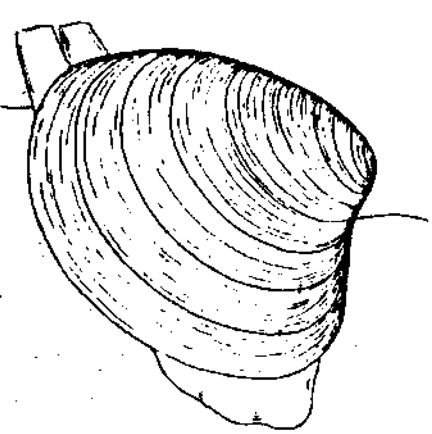
Abalone are strict vegetarians, feeding with tiny rasplike teeth but only on seaweed. They are not filter feeders such as the bivalves, and as a result the abalone is immune to red tides and does not build up concentrations of bacteria in polluted water.

Shucked abalone is marketed whole or cut into steaks. White to ivory colored, it has a chewy texture which can be tenderized by pounding. Abalone requires very little cooking time and is excellent raw.

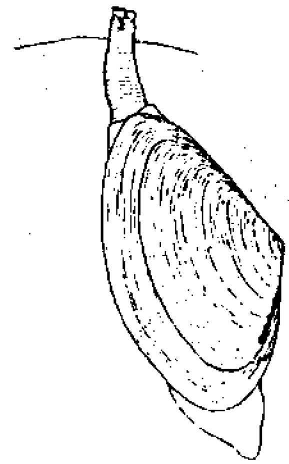
Californians eat more abalone than any other group of people in the U.S. In the East, for those willing to pay the price, abalone is available fresh, frozen and canned. The abalone served in restaurants is primarily from Chili, Mexico, and Australia.



SURF CLAM



OCEAN QUAHOG



SOFT-SHELL CLAM

ABALONE

CLAMS

Clams are burrowing 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. 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.

SURF CLAM (*Spisula solidissima*)

Other names: skimmer, hen clam, sea clam, giant clam, bar clam

Surf clams are more oval or triangular than round and grow to 8 inches across. The outside of their whitish shells has a protective brown covering which retards erosion. Surf Clams prefer gravel or coarser substrates from subtidal areas to 120 feet deep. They range from the Gulf of St. Lawrence to South Carolina, but the center of the fishery is in the Mid-Atlantic region. Overfishing of this species peaked in the 1970s, but since then state and federal management has stabilized landings.

OCEAN QUAHOG (*Arctica islandica*)

Other names: mahogany clam, mahogany quahog, black quahog, black clam.

Ocean quahogs resemble common quahog or hard shell clams with few exceptions. They have extremely brittle shells, which have a black or dark brown skin-like outer coverings (periostracum). In addition they lack a purplish mark on the inside of their shells. Adult ocean quahogs measure from 3 to 6 inches across and weigh an average of 1/2 pound each. The meat of ocean quahogs is darker, tougher, and stronger in flavor and aroma than most clam species.

Ocean quahogs are found in European waters and along our coast from Canada to North Carolina, usually in depths from 100 to 250 feet deep.

Compared to bay quahogs, surf clams, and soft shell clams, ocean quahog are an underutilized resource. Declining surf clam populations have caused a growth in the ocean quahog fishery, and today there is a commerical fishery extending from Maine to New Jersey. A small fishery exists in Maine for littleneck-size ocean quahogs that are sold live for the raw clam market.

HARD CLAM (Mercenaria mercenaria)

Other names: hard shell clam, bay quahog, quahog in New England

Hard clams have heavy, rounded, white shells, which measure up to 5 inches across and can be completely closed. The inside of each shell is distinguished by a purplish mark and two adductor muscle scars. "Quahog", the name used in New England, is of Indian derivation.

Hard clams live in the substrate of relatively shallow waters and inhabit sheltered bays and coves from Canada to Texas, however, they are found only sporadically north of Cape Cod.

This species supports a substantial recreational and commercial fishery. Recreational fishermen gather hard clams with rakes and hoes, or simply by feeling for clams by probing the bottom with their feet and toes.

There is a minimum legal size that varies from state to state. Long Island leads the country in commercial landing of hard clams, although reportedly, numbers are declining.

Hard clams are marketed according to size and usually sold in three categories:

o Little Necks (named after Little Neck Bay on Long Island, once the center of the half-shell trade) or "necks" range from the minimum legal size which can vary from state to state to 2-1/4 inches across and yield approximately 450 to 600 clams per bushel. They are the tenderest and most expensive, and typically are served raw on the half-shell or steamed.

o Cherrystones or "cherries" are medium sized and medium priced. They range from 2-1/4 to 3 inches across and yield about 300 to 400 shellfish per bushel. Cherrystones are eaten raw on the half-shell and as baked clam appetizers.

o Chowders, sometimes simply referred to as quahogs, are over 3 inches across and yield an average of 125 to 180 clams per bushel. They are the toughest and least expensive, which runs contrary to the general rule of thumb that the largest shellfish is the most expensive. As their names implies, chowders are minced and canned for use in chowders and other dishes or cut into strips for breading.

SOFT-SHELL CLAM (Mya arenaria)

Other names: manninose, long clam, long neck clam, squirt clam, sandgaper, old maid, steamer, ipswich clam, belly clam

Soft shell clams are distinguished by their thin, elongated, white shells and their long siphons. The siphons cannot be fully retracted within the shell and are commonly called the "neck." Soft shell clams grow to 5 inches across but are usually harvested before reaching this size. A minimum legal harvest exists and may vary by state.

This clam inhabits fine sand or sandy mud substrates from the intertidal zone to about 30 feet. On tidal flats, it is the clam that squirts at you. The soft shell clam is found from Labrador to North Carolina and in a number of scattered locations on the Pacific Coast.

GEODUCK CLAM (pronounced "gooey duck") (*Panope generosa*)

The largest North American clam is found only in the Pacific Northwest and Southeastern Alaska. It may weigh several pounds and have a neck 7 inches long or longer. Even the mantle bulges out of the shell, which is always far too small to contain the entire clam. These clams are harvested in a variety of ways, depending on species, habitat, and local law.

RAZOR CLAMS (*Ensis directus*)

Other names: jackknife clam

The razor clam does not have a typical clam shape but is long and thin with squared ends. Its shape is similar to an old-fashioned straight razor. This calm is approximately 6 times longer than it is wide and can grow to 10 inches in length. The shells are covered with a thin, yellowish-brown periostracum.

Razor clams inhabit lower intertidal areas down to 120 feet and can be found from Labrador to Georgia. They burrow deeply into a very fine sand or sandy mud bottoms and often live in colonies. Razor clams are difficult to harvest as they burrow quickly and hold on persistently with their foot, which when extended is nearly as long as the shell. Although not found in retail markets very often, their creamy colored meat has a unique sweet taste and chewy texture.

CONCH (*Strombidae*) and WHELKS (*Buccinidae*)

Other Names: periwinkle, scungilli

Although "whelk" and "conch" are often used interchangeable, they acutally are gastropod shellfish from different biological families and geographic locations. Whelks typically inhabit temperate water , while the edible pink or green conches (*Strombus gigas*) occur in southern latitudes and in this country are abundant only off the Florida Keys. Conch shells have a bright pink interior. The whelk has darker meat and a stronger flavor, which is preferred by the Italian market.

No commerical harvest of conch exists today in the United States. Florida has what's left of the resource and is considering putting conch off limits even to scuba divers. Primarily, Queen conch is imported from Belize, followed by Caribbean countries, Honduras, Haiti, and Mexico. Whelks on the other hand are available from the East Coast, primarily the New England states, on a year round basis frozen and from spring through fall, fresh. As the temperatures drop they are harvested farther south.

Whelks have a thick-walled, spiral-shaped shell which grows to 9 inches in height. The outside of the shell is dull white, tan or yellowish gray, and the inside usually is yellow. It is believed that, like quahogs, the shell was used as a sort of money by American Indians. Whelks feed on bivalve mollusks such as clams, mussels, and oysters. They are inactive during the winter and by late fall burrow into the bottom where they remain until spring.

Whelks are commercially harvested using baited traps similar to those used for lobster but are mainly a by-catch of the flounder and fluke fisheries.

As with whelks, the edible part of a conch is the foot, which is removed form the shell by breaking the shell where the muscle is attached. Insert a knift into the hole to cut the muscle from the shell. The horny clawlike operculum must be removed and the large muscle needs to be skinned. The entire meat is edible, although you may wish to discard the spongy viscera which is noticable after slicing the meat in half. Whelk and conch have a chewy texture and should be tenderized by pounding, grinding, marinating or cooking under pressure.

CRABS

BLUE CRAB (Callinectes sapidus)

"Savory beautiful swimmer" is the translation of the scientific name of this species. Blue crabs are capable of swimming, and their last pair of legs are paddle shaped for this purpose. They are bluish or brownish green above, creamy white below, and the topside of their claws is blue. Sex is easily distinguished because the tips of the claws of female crabs are bright red.

The female carries her eggs in a mass, called "sponge" on her underside. In about 2 weeks they hatch into free swimming larva called zoea. After several moltings they become adults. Blue crab are further noted by their carapace, which is drawn out on each side to a spike. Fully grown crabs measure 5 to 7 inches across and 1/4 to 1 pound a piece. Male blue crab, sometimes called "jimmy" crab, have a higher meat yield than female.

Blue crabs are found from Massachusetts to northern South America but are most important commercially from Delaware to Florida, especially in the Chesapeake Bay area. A significant fishery for this species also exists in the Mediterraean. Blue crabs can extend offshore to at least 120 feet deep, however, they are predominately shallow water crabs, especially common in bays and estuaries, and sometimes range into freshwater rivers. For the winter, female crabs migrate into deeper water where they semi-hibernate buried in the mud. Blue crabs are particularly aggressive and snap viciously when caught.

Soft shell crabs are taken in molting season which occurs during warm months. The crab houses which handle these crabs are known in the trade as "shanties" or "shedding houses". Fishermen can distinguish "peelers" (crabs which are just about to molt) and place them in boxes, called busters box, or floats until they shed. Peelers are characterized by a thin white line on their paddle legs which turns to pink and then red as motling nears. The molting process takes only a couple of hours. The crab suddenly expands in size by one third as though it were a rubber balloon, and after having "busted" out of the shell, the crabs must be removed from water so that shell hardening is suspended. The trick is to remove the crabs when the shells are hard enough to provide a firm skin for safe shipment, yet are soft enough for consumption. A molting crab is in danger of being eaten by nearby hard crabs. Soft shell crabs that have become leathery are called "paper shells" or "buckrams". The entire cleaned soft shell crab is eaten.

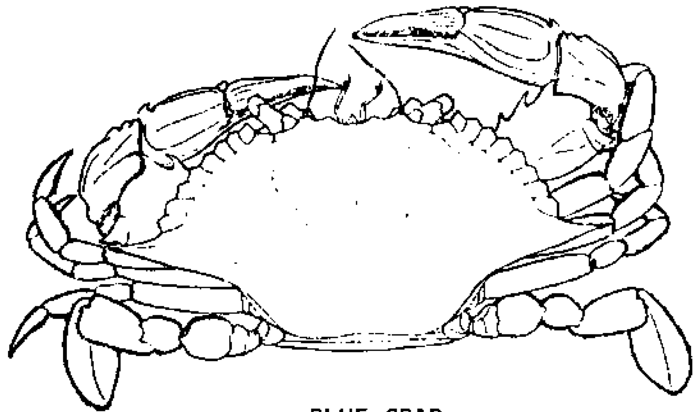
Hard shell crabs turn red during cooking. The cooked meat is white and is sold fresh or pasteurized. Pasteurizing extends refrigerated shelf life to 6 months.

RED CRAB (Geryon quinquedens)

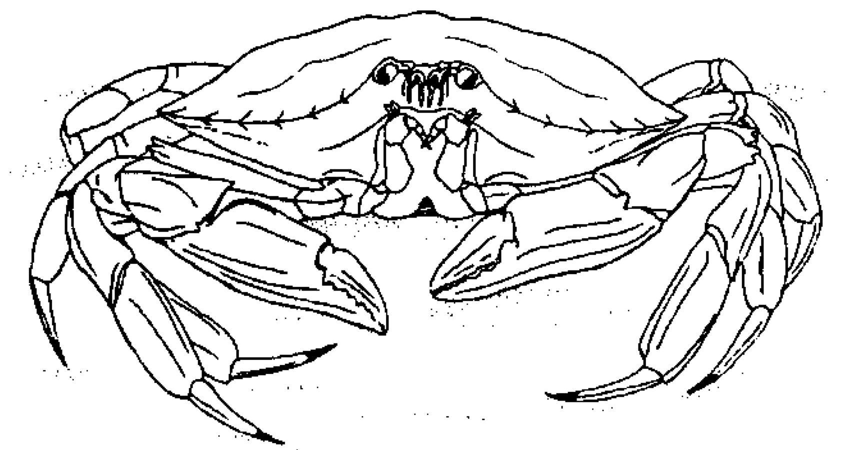
Red Crab are bright red when pulled from the deep dark waters along the edge of the continental shelf from Nova Scotia to Cuba at depths of up to 7,000 feet. The ride to the surface from those depths takes its toll. Until recently, most of the red crab landed in the Northeast have been caught by offshore lobstermen laying traps in deep underwater canyons.

Now specially designed crab pots and live tanks, combined with the latest processing technology, allows fishermen and processors to maintain a reliable supply. Red crab run on the small side -- males to 2-1/4 pounds and females to 1-1/4 pounds -- but the yield is very high at 23%. The meat is removed in a manner similar to blue crab.

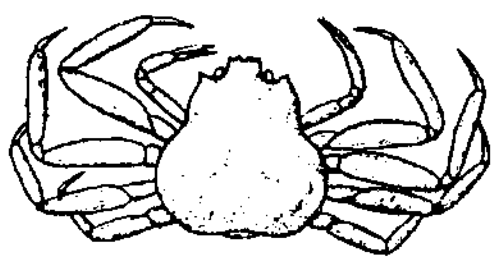
In the Mid-Atlantic region it is sold live or fully cooked as red crab, or "Big Red" crabs, but because the largest red crab processor in the Northeast markets red crab under the "Cape Cod" brand, numerous wholesalers have now started selling red crab as Cape Cod crab. Actually the crabs are neither caught nor processed near Cape Cod.



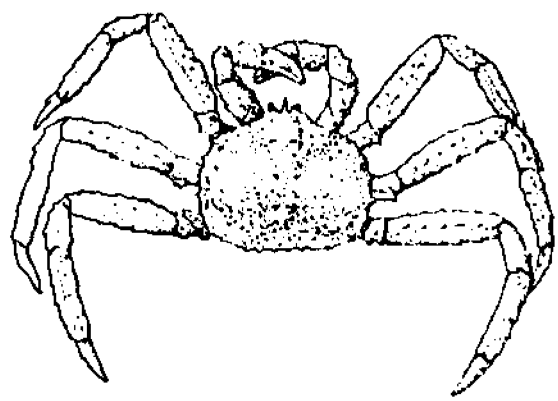
BLUE CRAB



ROCK CRAB



TANNER CRAB



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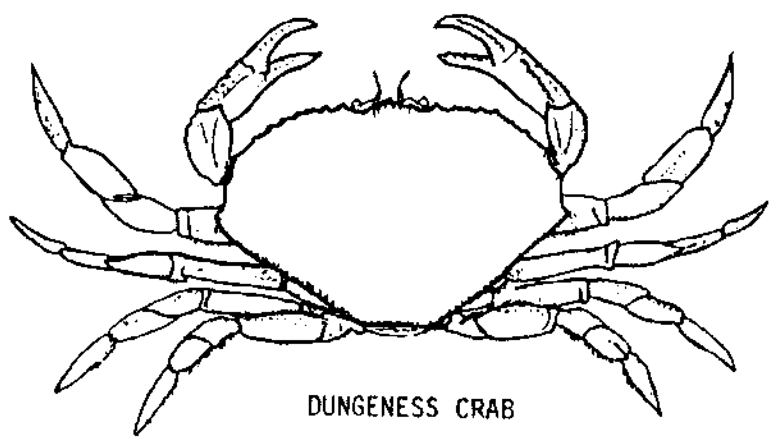
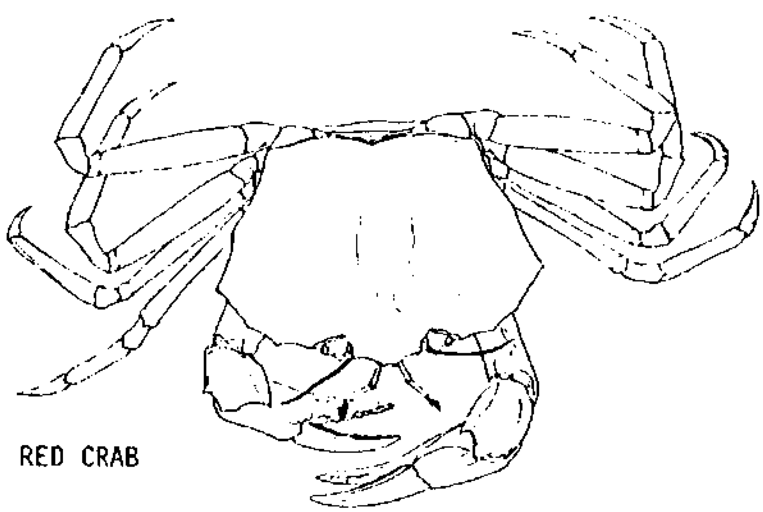


DUNGENESS CRAB



RED CRAB

An unrelated species of snow crab caught by Japanese and Korean fishermen in the North Pacific is frequently marketed as "red crab" or "red snow crab". This imported crab is priced well under true red crab, and it's culinary quality is notably inferior to true red crab.

DUNGENESS CRAB (Cancer magister)

Dungeness crab is California's most popular crab. It ranges from Alaska to southern California and is named for a small fishing village where commercial fishing for it began.

Dungeness crabs have a body somewhat like rock and Jonah crabs but grow larger, up to 10 inches across the carapace and weighing 3 1/2 pounds. Their shell is light reddish brown and turns bright red when cooked.

Only male crabs measuring at least 6 1/4 inches across the carapace are harvested. They are cooked immediately after they are caught then distributed ready to use. Inshore crabs, especially those from the San Franciso area, are known as bay crabs and are smaller than the ocean variety.

JONAH CRABS (Cancer borealis)

Jonah crabs are closely related to the rock crab, and the two are often not differentiated in the marketplace. Jonahs grow larger than rock crabs and have more pronounced claws, thicker legs, and a rough shell. In addition, the tooth-edged part of the shell is jagged, not smooth or granulated as in rock crabs. Jonah crabs are brick red to purplish above and yellowish below. Fully grown crabs measure from 6 to 7 inches across and average about one pound.

Jonah crabs extend into deeper waters than rock crabs and range from the coastline to the upper continental slope at depths of 100 to 1,300 feet, with larger crabs tending to inhabit deeper and colder waters. This species occurs from Nova Scotia to Florida but is most abundant off New England and the Mid-Atlantic states.

Most of the Jonah crab harvest is a by-catch of the offshore lobster fishery. Since lobsters are of more value to fishermen, Jonah crabs are bought in more when the lobster catch is down. However, this trend is changing, and a growing directed fishery with special crab pots now exists.

Jonah crabs are becoming more interesting to fishermen as the claws are large enough to be sold like stone crab claws which are very popular in Florida. Because of this, large Jonah crabs will command a higher exvessel price than rock crabs or small Jonah crabs.

ROCK CRABS (*Cancer irroratus*)

Rock crabs have smooth, reddish-ivory colored shells which are heavily speckled with purple or red dots. The edge of the toothed part of the shell is smooth or granulated, not jagged like that of the closely related Jonah crab. Fully grown rock crabs measure 4 to 5 inches across the carapace and weight 8 to 10 ounces each.

This species is one of the most common shallow water crabs in New England. Rock crabs can be found most easily by looking in crevices, in jetties, under rocks and in tide pools. They range from Labrador to South Carolina and are in greatest abundance from Maine to New York. Rock crabs inhabit water from the intertidal zone to 200 feet deep. They are intertidal north of Cape Cod and are found in progressively deeper water southward. Generally, however, rock crabs inhabit shallower waters than Jonah crabs.

A few small directed fisheries for rock crab exist, but this species is obtained primarily as a by-catch of other fisheries. Off New England, it is a by-catch of the inshore lobster fishery. In the Mid-Atlantic region, rock crabs are incidentally caught in sea bass traps and pound nets. Male rock crabs migrate closer to shore during late fall and winter, and are subject to the Chesapeake Bay blue crab dredge fishery.

STONE CRAB (*Memippe mercenaria*)

The stone crab is found along the Gulf Coast of Florida and north to the Carolinas. It is commercially abundant primarily off Florida's Gulf Coast where it is fished in baited pots. Only the claws are eaten. The name is derived from the very hard shell, which requires hammering to crack it before the meat can be removed.

Stone crabs are purplish or reddish brown and grow to 5 inches across the carapace. They are recognized by their black pinchers which contrast with the cream-colored, red-tinged claw and knuckle.

Fishermen remove the claws and return the clawless crabs to the sea. The lack of claws does not inhibit the crab's feeding as these powerful pinchers are defensive weapons only, as many a careless hand can testify. In about 18 months, new claws are completely grown back but never reach the original size. Florida law prohibits the possession of whole stone crabs.

GOLDEN CRAB (*Geryon fenneri*)

Other names: Empress, Golden Gulf Crab, Gold Empress Crab

The newly identified golden crab is found in deep water in the Gulf of Mexico and western Atlantic. It differs from the commercial red crab in that it is larger and has a distinct cream, buff-colored shell which remains buff colored when cooked. Like the red crab and other Geryon sp. crabs it is a nonswimmer with distinct sexes. The males are much larger and further distinguished by their unique narrower shaped ventral apron. Growth rates of the red crab are thought to be slow. A similar growth rate is expected for all Geryon species.

The average male harvested in experimental crab pots was about 6 inches wide (carapace width) and weighed about 2.5 pounds. The female was about 5 inches wide and weighted about 1 pound. These sizes are substantially larger than the average commercial size red crabs harvested in New England. The yield is nearly twice that of blue crabs. Golden crab is a good source of protein with low fat.

A fledgling golden crab fishery exists on the Florida Gulf Coast. The hand-picked crabs are available in claws and graded meat both fresh and pasteurized. Golden crab is available in up-grade seafood stores and chain restaurants.

In taste tests the golden crab compares favorable with most traditional crab meats. It is delicate, white and has a distinct appealing crab flavor. The golden crab does not have true lump meat that is common in swimming crabs but larger pieces and section can be recovered from the body and legs. Consumers may need some advice on picking. Although the basic process is similar for most crabs, the merus leg is more pliable and could present difficulty. Proper trimming to provide a wide opening on the end of the merus will facilitate removal.

[Source: Initial Developement of a Deep-Sea Crab Fishery in the Gulf of Mexico Sea Grant Report - SGR-61 by W. Steve Otwell, Jeffrey Bellairs, Donald Sweat]

SNOW CRABS (genus Chionoecetes)

Other names: tanner crab, queen crab

Snow crab refers to several closely related species of spider crabs but only two C.bairdi and C. opilio are of importance to the commercial fishery. The U.S. Food and Drug Administration has officially designated these species and the C. tanneri and angulatus as snow crab for marketing and labeling purposes. The larger bairdi is caught in the North Pacific, while the smaller opilio is caught in the Pacific, Bering Sea and North Atlantic as far south at Casco Bay, Maine. Atlantic catches are primarily by Canadian fishermen whose opilio is marketed as queen crab. Tanner crab are roughly half the size of king crab. The largest bairdi may exceed 5 pounds and have a leg span of 3 feet. These crabs have long, slender legs and rounded body, and adult male crabs are larger than females.

Snow crabs are caught in pots, and only adult males are kept. Floating plants as well as shore-based processing plants receive the crabs for either canning or freezing.

ALASKAN KING CRAB

FDA allows only certain species to be called king crab: Paralithodes camtschatica (red), P. platypus (blue), P. brevipes (brown)

Paralithodes camtschatica are the giants of all crabs. The largest specimens measure six feet across the legs and body and weigh up to 25 pounds although most weigh about 10 pounds. Despite its size, only 25 percent of the king crab is edible.

They are distinguished by their rough, reddish shell and long, spine-covered legs. At first glance, it appears as though they have only 4 pairs of legs. The fifth pair is small, bent upward, and often inserted under the carapace.

King crabs are found in very cold waters on both sides of the North Pacific. They move into relatively shallow waters in winter and early spring for molting and spawning; in the summer and fall they migrate to deep, offshore feeding areas. They are caught off Alaska in baited pots. To conserve, only the large male crabs are kept. King crabs are held alive in circulating sea water until processed.

King crabs supported a lucrative fishery until the early 1980s when it drastically decreased in numbers. The decline has lead to increased prices and more imports, and has contributed to the marketing success of imitation crab products in America.

PEA CRABS (Pinnotheres ostreum)

Other names: chowder crabs, oyster crabs

The maximum width of these tiny, pale-pink crabs is only about a half inch. At an early stage in their lives both males and females invade the shells of oysters, mussels or other bivalves, and feed on the same foods as the bivalve. In their protected environment they remain permanently soft shelled and lose the ability to make any but minor and sluggish movements. The females remain in the shell or gills of the bivalve but the males emerge in their first year and swim about to enter another bivalve and mate. After mating, the male dies but the female may live for as long as three years. When the female spawns, the eggs give a pinkish cast to the flesh of their host. The pea crab or its eggs are not harmful to the bivalve. It is safe to eat the crab, the eggs and the host, in fact it is considered a delicacy.

CRAWFISH or CRAYFISH

Louisiana commercial species:
Red Swamp crawfish (*Procambarus clarkii*)
White River crawfish (*P. blandingi acutus*)

California commercial species: *Several species of Pacifasticus crayfish*

The Atchafalaya Basin of southern Louisiana is the greatest crawfish producing area in the world. During peak season, February through May, hundreds of fishermen run strings of baited crawfish traps and harvest tons of wild red swamp and White River Crawfish.

A live red swamp crawfish is red to nearly black in color while a White River crawfish is light to dark brown. The claws of the White River crawfish are much longer and slimmer. Both species turn bright red when boiled, and their meat tastes the same.

To eat crawfish, break the head and tail apart and suck the flavorful juices from the head. Lift off the carapace and curl your thumbnail down the remaining shell. It will come up with a yellow mass called the "fat", which is a liver-like organ. Peel and, if desired, devein the tail for eating. Crack the claws and suck out the meat and juices. It takes about 7 pounds of live crawfish to yield one pound of peeled tail meats.

Red swamp crawfish is the species most often selected for cultivation in pond farms. This practice began in the early 1960s to ensure a supply of crawfish when the natural conditions of the Atchafalaya Basin failed. Farming also made crawfish available November through June, while Atchafalaya Basin production is primarily in April and May. Rice farmers of southwest Louisiana were among the first to raise crawfish because their fields were already diked for annual flooding. In other words the farmers rotate crops of rice and crawfish. Crawfish are also farmed in highly managed open ponds and in minimally managed wooded or swampland ponds.

Female crawfish begin laying eggs in late summer with peak spawning occurring in September. The female carries her eggs attached to her abdomen for about 15 days, and because they resemble berries, she is said to be "in berry". Once hatched, the young crawfish attach themselves to the appendages on the underside of the mother and remain there for about four weeks or until they can fend for themselves. Three or four months later, many of the young are of edible size. The natural life span of most Louisiana crawfish is from one to three year.

Several species of the slower growing Pacifasticus crawfish are harvested in the lakes and rivers of California and Oregon. Although these species are marketed on a much smaller scale, they are available in commerical quantities in the summer.

LOBSTER

LOBSTER (Homarus americanus)

Other names: American lobster, northern lobster, Maine lobster

The American lobster is prized worldwide and, despite declining numbers, is one of New England's most valuable fishery products. It usually takes 5 to 8 years for a lobster to weigh one pound, and the most common market size is 1 to 5 pounds. The chitinous shell of the American lobster is commonly dark-greenish black, greenish blue, or reddish brown. It turns bright red only after cooking.

Its two large claws distinguish it from the spiny or rock lobster Panulirus argus, which is abundant off the Florida Coast. The crusher claw is the heavier of the two, while the lighter is the ripper claw. They can easily wound a careless finger of a lobsterman. For these reasons, the claws are usually immobilized by inserting a peg in the joint of the claw or by placing a rubber band around each claw.

Behind the claws are 4 pairs of smaller and thinner walking legs. The legs and claws originate underneath a main body section known as the thorax, which is covered by a large shell or carapace. The next body section is the abdomen, followed by the tail fan. The thorax is commonly called the body, and the abdomen and tail fan are generally referred to as the tail.

Underneath the abdomen are five pairs of swimmerets which are similar except for the pair closest to the thorax. The first pair is used in reproduction and provides an easy way to distinguish sex. The first pair of swimmerets on a male lobster is hard and grooved while a female's pair is soft and feathery.

To grow, a lobster must molt. It takes about 12 days after shedding for a new shell to gain normal hardness. Lobsters are able to regenerate some of their body parts when lost or damaged, and produce a completely normal part in 3 molts. Unlike soft shell blue crab, soft shell lobster is not considered a delicacy.

Molting may occur during any season. Lobsters mate shortly after the female has molted. Fertilized eggs are held underneath the female's tail where they remain for 10 to 12 months before hatching. The fertilized eggs look like small black berries, hence, females holding eggs are said to be "berried". Newly hatched lobsters spend their early lives as planktonic larvae. By their fourth mold they settle to the bottom and carry out a lifestyle similar to adults.

This species ranges from Labrador to North Carolina and is most abundant off Maine, Nova Scotia, and Newfoundland. Lobsters are caught, summer through fall, both inshore and offshore with baited pots in depths from a few feet to over 1,000 feet along the continental shelf. Biologists believe that two distinct populations exist, an inshore and an offshore group. South of Long Island most lobsters tend to inhabit deeper offshore waters.

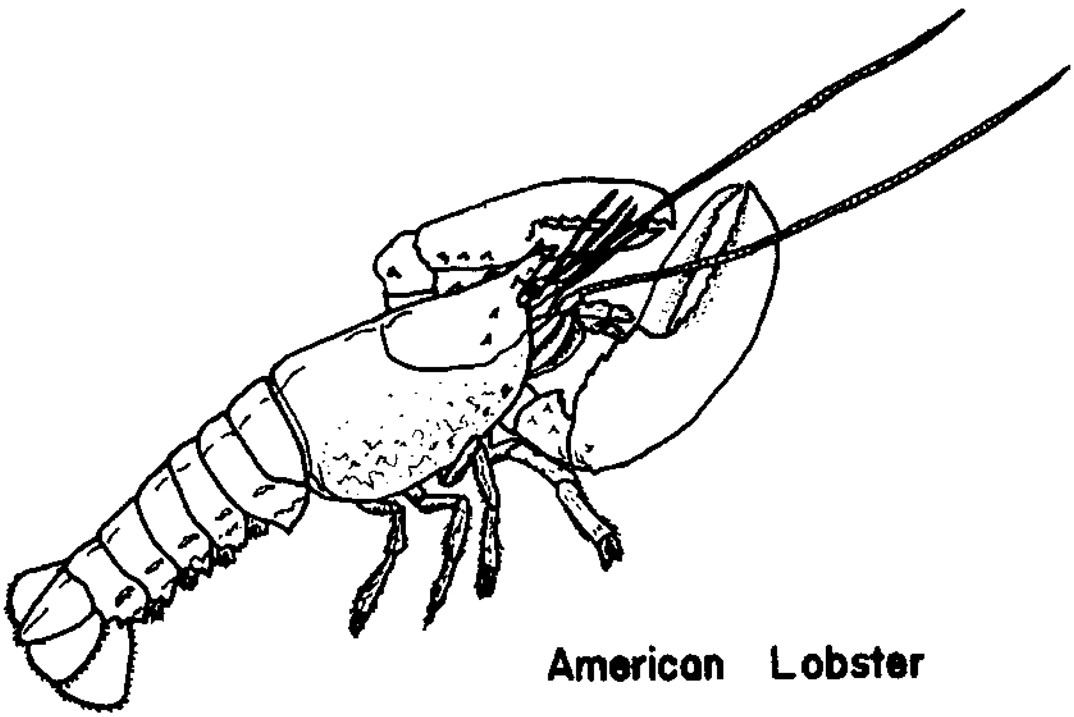
Lobsters are bottom dwellers and inhabit many types of bottom, though areas with ledges and boulders are preferred. They are more active at night and can swim by swiftly snapping their tail down and under. Lobsters feed on slow moving shellfish, some seaweeds and small finfish. Despite popular belief, lobsters are not scavengers. They are attracted to decaying fish used as bait in traps but generally will not eat it.

In this country, a commercial fishery for lobster began about 1840, when lobsters were plentiful, cheap and commonly used as bait for cod and striped bass. In some areas they were even used as hog feed. Now both commercial and family fishing for lobsters are extremely popular and strictly regulated by both state and federal governments. Restrictions exist concerning pot construction, fishing times, minimum legal sizes, and many other factors. These laws often vary from state to state.

Grading:
- under 1 pound = chicken
- 1 to 2 pounds = selects
- larger = jumbos
- lobster with one claw = culls
- lobster with no claws = bullets

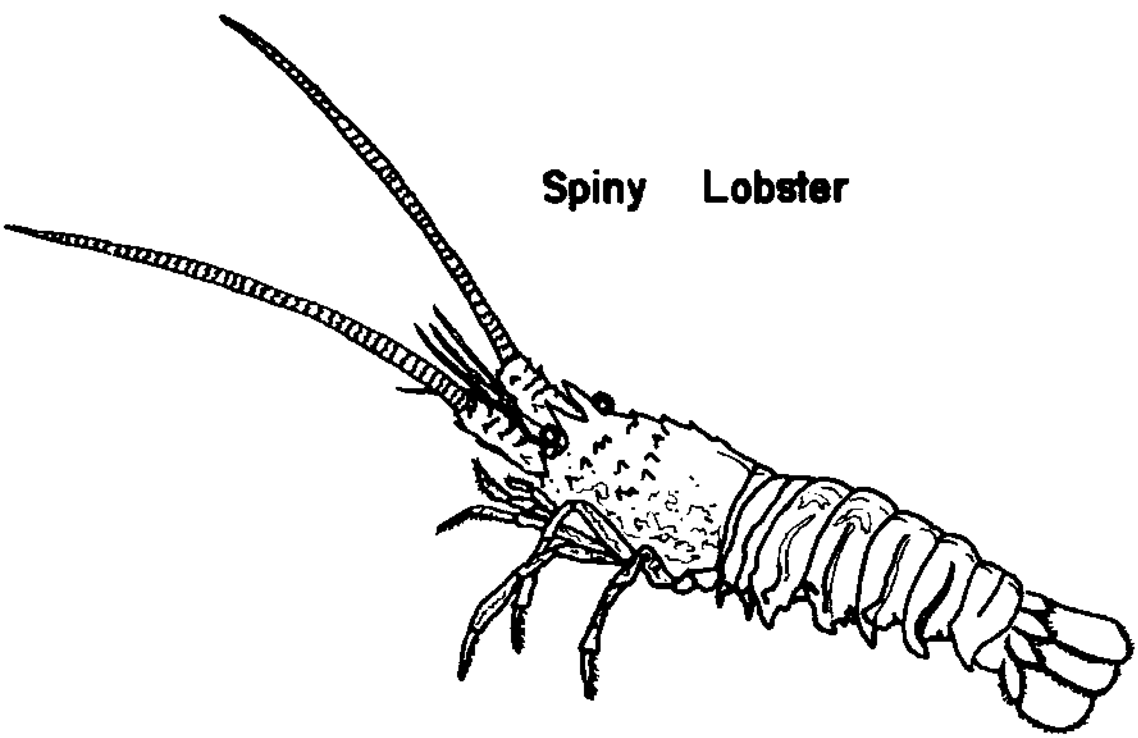
Almost all American lobsters are sold alive. Despite rumor, size is not an indication of toughness and larger lobsters are still tender and sweet. In addition to the meat, the tomalley and coral can be eaten. The tomalley, actually the lobster's liver, is the green-colored mass found within the body section. The coral is the interal roe of female lobsters. It is also found within the body section and is red or orange when cooked. Both can be eaten directly from a cooked lobster or used in preparing other recipes.

A general rule for boiling lobster is to plunge the lobster into boiling salted water and once the water returns to a boil allow to cook 12 minutes for a one pound lobster, adding 2 or 3 minutes for each additional pound.



American Lobster

Spiny Lobster



SPINY LOBSTER (*Panulirus argus* and *P. interruptus*)

Other names: rock lobster, Florida lobster, crawfish, crayfish, and lobster tails

Spiny or rock lobsters, actually sea crawfish, are easy to differentiate from American lobsters since the former do not have claws. They are classified into two broad groups: cold water and warm water lobsters.

Cold water lobsters are considered to be tastier and firmer, and are more expensive. The United States is supplied frozen, cooked and uncooked cold water lobster tails from Australia, South Africa, and New Zealand.

All domestically produced spiny lobsters are warm water varieties. Atlantic spiny lobsters (*Panulirus argus*) are found from the Carolinas to the Gulf of Mexico and also off Hawaii and California (*P. interruptus*). The domestic supply is primarily from Florida waters, and is supplemented with imports mainly from the Bahamas and Brazil.

LANGOSTINOS

Langostinos are small, lobster-like, clawless crustaceans that inhabit Pacific waters off South America. A few species inhabit the tropical Atlantic but in far less abundance than the Pacific species. These shellfish are cooked, peeled, pasteurized, vacuum packed, and frozen. They are available in the frozen seafood section of most supermarkets and seafood stores. Langostino meat tastes similar to lobster but is much less expensive.

LOBSTERETTE

Other names: Norway lobster, Dublin Bay prawn, Danish lobster, langoustine and scampi

"Lobsterette" is a general term for lobster species in the family *Nephropidae*. They are smaller than the American lobster and have long slender claws. Lobsterettes from Europe are exported. They are used mainly in the restaurant trade.

MUSSELS *Mytilus edulis*

Mussels have smooth, dark bluish shells which are elongated and somewhat pear shaped. The inside of the shells is pearly violet or white, and actually quite beautiful. Mussels average 2 to 4 inches in length and live in colonies or beds in very shallow waters, predominantly in the rocky intertidal zone. They are distributed worldwide in most polar and temperate waters. Off North America, they occur from Canada to North Carolina (commercially just to New Jersey) and have been transplanted to the Pacific Coast.

Mussels are able to attach themselves to almost anything with a tough bundle of brown fibers extending from the shell called byssal threads or byssus, more commonly known as the beard. The beard aids in withstanding currents and storms. They do not bury into the substrate like clams, so mussels tend to accumulate much less sand inside their shells.

Don't be alarmed if a tiny crab is present within a mussel. The tiny pea crab sometimes called chowder crab, is perfectly edible and may be eaten along with the mussel in one bite or eaten separately to savor its own flavor.

As demand increases, wild populations must be supplemented by aquaculture so that depletion of national beds does not occur. Demand surpassed supply in Europe a long time ago, and their mussel culture has been going on for 300 years. Mussel popularity and the need for aquaculture are much more recent in the United States; however successful commercial farms already exist in Maine, Rhode Island and Washington.

Mussels are cultured on ropes or long-lines secured between buoys and by bottom methods. The rope method yields a superior product but labor costs are its prime detraction. Bottom culture methods give an excellent high quality product and is mechanized, making it a financially more desirable method for farmers. Cultured mussels have certain advantages over wild mussels; in particular, less sand and pearl, uniform size, fuller meats and cleaner, shinier, thinner, more uniform shells.

Of all shellfish, mussels are the most efficient and indiscriminate feeders consuming virtually everything in the 10 to 15 gallons of water they filter each day. Hence, they are very susceptible to pollution and paralytic shellfish poisoning. In all mussel farming countries, strict monitoring is required to detect the periodic impact of natural and man-made pollutants. In the more developed farming areas, mussels are routinely run through licensed purification plants.

Green-lipped mussels (_Perna canaliculus_) from New Zealand are available in selected markets.

OCTOPUS

Octopus, like squid and cuttlefish, is actually a shellfish. With more than 140 species, they are found in nearly all the seas of the world with the exception of the polar icecaps. They live from tidal shallows up to depths of 1,000 feet and more. The species _Octopus_ _vulgaris_ inhabits the Atlantic Ocean and our Eastern Coast. In size, octopus vary from tiny 1/2-inch species to giants which can reach 28 feet from the top of its head to the tip of its tentacles. Despite horror movie images of monstrous animals, the common market size of octopus is 1 to 3 pounds. It has a flexible, nearly globular body with eight long arms covered with suction cups. Octopus get about by "walking" on the sea bottom, free swimming or propelling themselves in short bursts by means of jet action from their funnels. Like squid, octopus shoot clouds of black ink into the water to confuse their attackers and possibly to attract or merely locate other octopuses.

The octopus, which hunts for food by night and hides from his natural enemies by day, consumes a luxurious diet that includes lobster, crab, abalone, and scallops. It lives in caves and crevices. Octopus feed by hiding and grasping passing prey with their tentacles. Their powerful parrotlike beaks can crush the shells of mollusks and crustaceans. THe salivary gland of an octopus contains a powerful poison which paralyzes its victims before they're actually killed by bites from its beak.

The female octopus lays her eggs inshore, attaching them to rocks, pebbles or vegetation. The male fertilizes the eggs with sperm released from a specialized arm. The female broods over her eggs, frequently holding them in the membranous expansions of her arms and syringing them with jets of water from her funnel. After they hatch, octopus babies, which look like miniatures of their parents, drift in the planktonic state before descending to the bottom where they will spend the rest of their lives. After spawning, the male and female die.

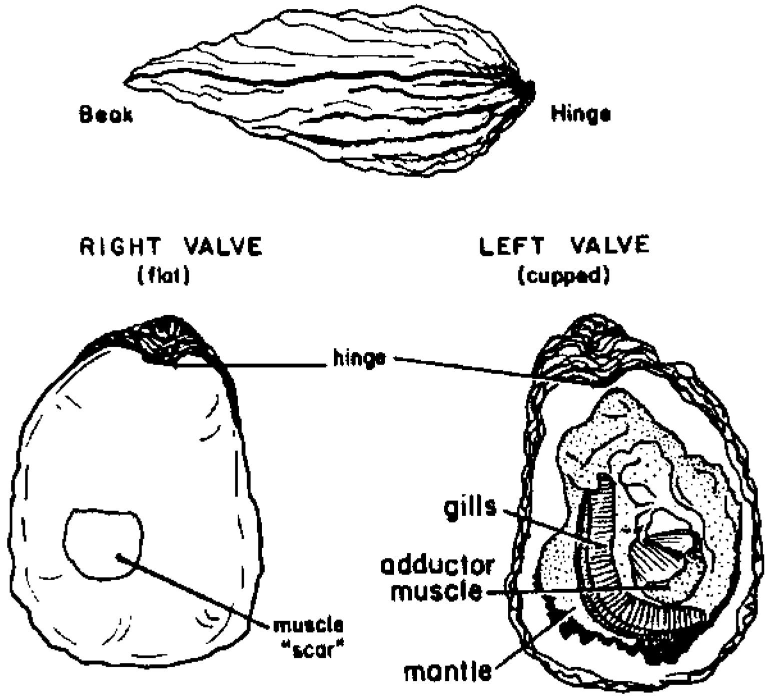
The meat of octopus is white, lean and mild flavored. Its texture is extremely firm and may be softened by pounding with a mallet. Because of its image problem octopus is often marketed in the U.S. using foreign names: pulpo (Spanish) Poulpe (French), and tako (Japanese).

An octopus fishery exists off our Pacific Coast (_Octopus dofleini_). The Atlantic species is harvested primarily off northwest Africa on the Sahara Bank.

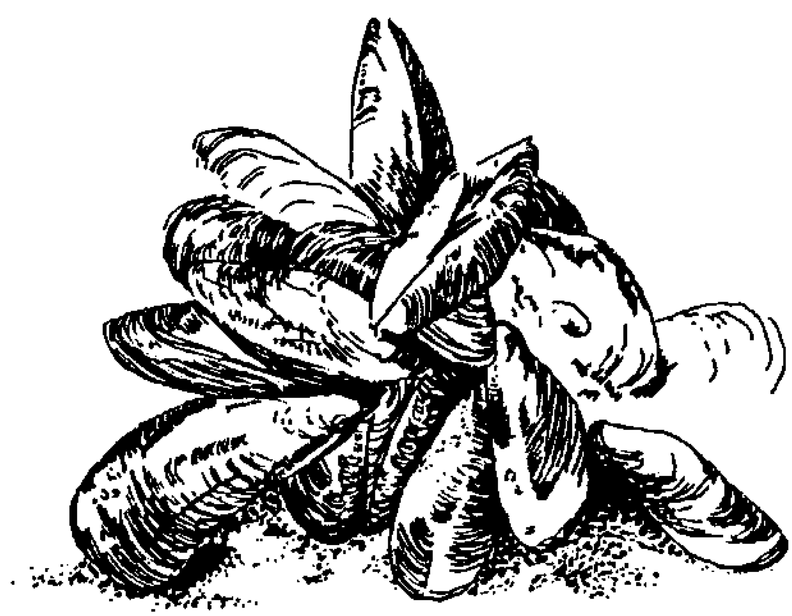
OYSTERS

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 restaurantas as oysters on the half shell.

Many more oysters are "shucked" or removed from the shell before shipment. The meats are then washed. On the East and Pacific coasts they are placed in a bubbler or blower which churns the meats in fresh



OYSTER



Blue Mussels

water by means of air blown in from the bottom of the tank. This agitation dislodges sand and silt from within the oysters. Most Gulf coast plants simply rinse the oysters with a spray. Meats are then graded for size, sealed in glass or metal containers, and shipped fresh in curshed 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 pre-cooked foods in the market. Breaded, deep fat-fried, packed, 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 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, thereofre, 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.

EASTERN ATLANTIC OYSTERS (Crassostrea virginica)

Other names: Eastern, Atlantic or American oyster

Americans eat more oysters than any other people in the world. The eastern or Atlantic oyster ranges from the Gulf of Saint Lawrence to the Gulf of Mexico and is found on hard rock or semi-hard mud bottoms. It is more abundant south of Cape Cod with most of the production occurring in the Gulf coastal states. C. virginica accounts for the majority of oyster production in the U.S.

Unlike most other seafood, the taste of oysters varies greatly depending on the type of algae fed upon and the salinity in the area they are harvested. Oyster connoiseurs take pride in distinguishing the different tastes that result from the various regions of harvest. To distinguish the oysters, both the Atlantic and Pacific oyster, frequently take on the name of their harvesting region. Names familiar on the east and Gulf coasts are Chesapeake, Blue Point, Long Island, Chincoteague, Gulf and Louisiana. On restaurant menus, oysters are often referred to by their origin.

Oysters are easily recognized by their rough, irregular-shaped shells, which are dissimilar in size. The upper shell is flatish and the lower is concave, thus providing space for the soft body of the oyster. The opening and closing of the shell is regulated by one adductor muscle, which is capable of closing the shells completely. Oysters are found chiefly in shallow water of bays and estuaries especially where the salinity is reduced by river outflows. When young, they attach themselves to a hard surface by means of a slimy secretion and remain sedentary for the rest of their lives.

The American oyster has declined in numbers for several reasons including pollution, storms, shoreline development, natural predators, Dermo and MSX (diseases fatal to oysters). Oyster production peaked in 1908 with 152 million pounds whereas 35 million pounds wre harvested in 1986. To supplement natural populations, oysters are cultured in many areas along the Atlantic Coast. The American oyster is the most commercially important oyster in the United States and mariculture programs produce most commercial oysters. (C. virginica spat from New York are being grown in northern California.)

A brackish area is strewn with oyster shells or other artificial attachment material, and the young oysters called "spat" are introduced to the area and attach themselves to the shell. When the spat reach a breadth of about an inch, they are taken up as "seed" oysters and introduced into saltier commercial beds where, under optimum conditions, the spat will grow to harvest size in about one year. The average life span is about 5 to 7 years. Mariculture operations attempt to keep natural predators, such as the oyster drill, starfish and boring sponge, away from the growing oysters. Adult oysters average 3 to 6 inches in length.

The color of meat varies with the color of algae that the oyster feeds upon. The typical color of fresh shucked oyster meats is cream, tan, or gray; however, with diet change this can deviate to green, red, or brown. The latter are perfectly safe to eat; in fact Europeans prefer green oysters. The green color may be chlorophyll from green plants the oysters had been eating or it may be from high concentrations of copper in the water. Sometimes the oyster is red, or the liquor in which it is packed is red. The red color comes from a dinoflagellate or algae which has been in the oyster's food. The red pigment is water soluble, and appears when the oyster is cut during shucking or frozen after shucking.

The red pigment will be destroyed when the oyster is heated to only 120 degrees for a few minutes. Both the Food and Drug Administration and the U.S. Army Quartermaster Corp certify that this red color is a seasonal occurrence in 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 North Atlantic waters; red tide has never been reported in the Middle Atlantic.

Brown spots are caused by a normal biochemical reaction that sometimes develops in southern oysters. Oyster meats can also be pinkish from the eggs of pea crabs. This tiny crab lives in the gills of the oyster and feed on the same food. Pea crabs do not harm the oyster or its edibility. The crabs themselves are tasty and considered a real delicacy by many oyster lovers.

Oysters are harvested year round but catches are heaviest in October, November, and December. Contrary to popular belief all oysters are edible during their spawning season or the months without an "R", although their flavor may not be as good in summer as it is in fall and winter. Summer is the spawning season when oysters tend to be less meaty and relatively watery or "milky". The northern C. virginica are at their best in the fall and winter months, while Gulf C. virginica are firm and ripe from December onward. Oysters are harvested using dredges and tongs.

PACIFIC KING OYSTER (Crassostrea gigas)

Other names: Japanese oyster.

The Pacific oyster, a transplant from Japan, is found along the West Coast from British Columbia to North California. It is the second most common oyster in the United States and production is increasing while production of the Eastern oyster is decreasing. It has a very large shell. Having a greater tolerance to very salty waters, it is often bedded far from the influence of rivers. Its natural habitat is the intertidal region.

C. gigas does not breed easily in the cold water of the northwest so most are bred in hatcheries in Washington state. In the past most of the seed oysters were imported from Japan, but shortages and price fluctuation led to the development of oyster hatcheries in the U.S. The oysters are farmed in northern California, Oregon and Washington and harvested after 2-3 years of growth. The current trend is to harvest smaller oysters, especially when they are destined for eastern markets. C. gigas is distributed nationally, usually by shipping by air, and it is not unusual to find them in East Coast supermakrets, especially during times of shortages of Eastern oysters.

C. gigas can be differentiated from C. virginica by their larger size, dark mantle (referred to as the flavor edge by producers) and white color. It is often recommended that thorough cooking provides the best tasting oyster. Pacific oysters can be precooked by dropping them into boiling water and simmering for five minutes. After pre-cooking they are ready for use in typical recipes.

WESTERN OR OLYMPIA OYSTER (*Ostrea lurida*)

The oyster native to the Pacific Coast waters is the small one known as the Olympia. It rarely reaches 2 inches in length and is regarded as a real delicacy. It is not harvested in a volume to be marketed on more than a local level.

BELON OYSTER (*Ostrea edulis*)

The European or Belon oyster has been successfully transplanted to the Casco Bay area of Maine and is also cultured in Maine and New Hampshire and on the Pacific Coast. This oyster has flatter shells and a more rounded shape, while the meat is darker and has a distinct black edge around it. This oyster is more expensive than our native species.

Standard of Identity for Size (Number in one gallon)

Eastern	Pacific
Extra Large (counts) Not more than 160 oysters	
Large (extra selects) More than 160 but not more than 210 oysters	Large Not more than 64 oysters
Medium (selects) More than 210 but not more than 300 oysters	Medium More than 64 but not more than 96 oysters
Small (standard) More than 300 but not more than 500 oysters	Small More than 96 but not more than 144 oysters
Very Small More than 500 oysters	Extra Small More than 144 oysters

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Comparison of characteristics of Eastern and Pacific Oysters

	Eastern	Pacific
Color of liquor	clear	milky
Color	creamy to tan	white with black mantle
Cooking	light	thoroughly

PERIWINKLE - (Littorina littorea)

Other names: winkles, sea snail.

Periwinkles are small, marine, snail-like mollusks found in large numbers along the shoreline of the northern Atlantic. This same periwinkle was found originally in the European Atlantic but has spread around the eastern coast of North America from Canada during the past two centuries and now occurs as far south as Delaware Bay. There are nearly 300 species known throughout the world but relatively few of these reach edible sizes. They are relatives of the whelks but are considerably smaller, only growing to about 1 inch in diameter and height. Their spiral-shaped shell is black, olive, gray, or brown. They cling to rocks and piers, and feed on diatom and the thick film of algae covering the tidal areas. Because they have modified gills for breathing, they are able to live from the lowest tide level to the highest. They live in colonies from Nova Scotia to Delaware Bay. A different edible species, the Gulf periwinkle, Littorina irrorata, is prevalent from Maryland to the Gulf of Mexico, but occasionally is found as far north as Massachusetts.

Periwinkles are a common food in Europe but are not harvested commercially to any great extent in this country. They appear with most regularity in some ethnic markets, with the bulk of the landings being sold through New York's Fulton Fish Market.

SCALLOPS

Scallops are bivalve mollusks with scallop-edged, fan-shaped shells. The shells are further characterized by radiating ribs or grooves and concentric growth rings. The latter are used in determining a scallop's age. Near the hinge, where the two valves meet, the shell is flared out on each side forming small "wings" or "ears". Just inside each valve along the edge of the mantle is a row of short sensory tentacles and a row of small blue eyes. The shells are opened and closed by a single, oversized adductor muscle which is sometimes called the "eye".

Unlike clams, oysters and mussles, scallops are not commonly eaten whole in the U.S., and only the marshmallow-shaped muscle is retained in the shucking process. In Europe the muscle with the orange-pink roe attached is considered a delicacy, and this market form is now being served in some gourmet restaurants in the U.S. The vertically striated muscle meat is known for its firm texture and sweet taste. The color of the muscle varies including white, cream, tan, light pink, orange or bluish but most often they are creamy white.

Scallops usually rest on the ocean bottom but are capable of swimming in a jerky zig-zag motion. Using their well developed adductor muscle they rapidly open and close their shells expelling a jet of water, which causes the animal to move.

Scallops are primarily harvested by dredging and are shucked soon after capture. They cannot hold their shells firmly closed, therefore, once out of the water, they cannot live long due to moisture loss from the body. Prior to marketing, shucked scallops are sometimes plumped by soaking in water or a phosphate solution. This soaking process increases volume by about one-third and whitens the meat color but is also said to deplete flavor. A phosphate preservative is advantageous when freezing scallops as it helps inhibit moisture loss and oxidative changes during frozen storage.

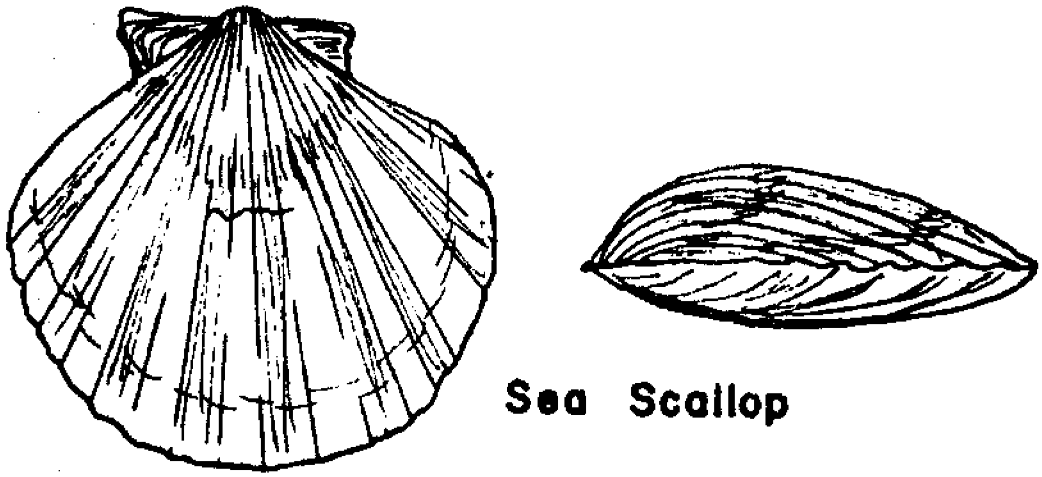
When purchasing scallops at any point in the marketing chain, labels should clearly indicate the species and its origin. Most states have labeling laws to protect purchasers.

Scallops have a patron saint, the apostle Saint James wore a scallop shell as his personal emblem, hence the name coquille Saint Jacques (St. James' shell). This French term has become a common name for a variety of creamy scallop dishes.

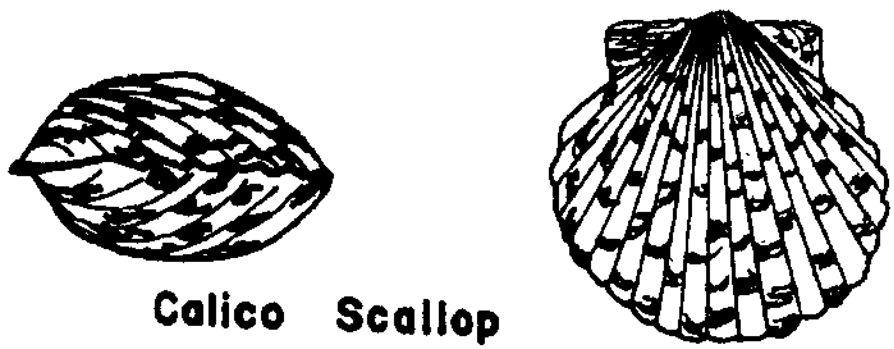
SEA SCALLOP (Plactopecten magellanicus)

Sea scallops have flattish, saucer-shaped shells which are finely ribbed and grow to 8 inches across. The upper shell is reddish brown or tan, sometimes rayed with white, and the lower valve is pinkish white. The inside of both shells is glossy white and marked by a prominent muscle scar. The marketed muscle meats average 1 to 3 inches across.

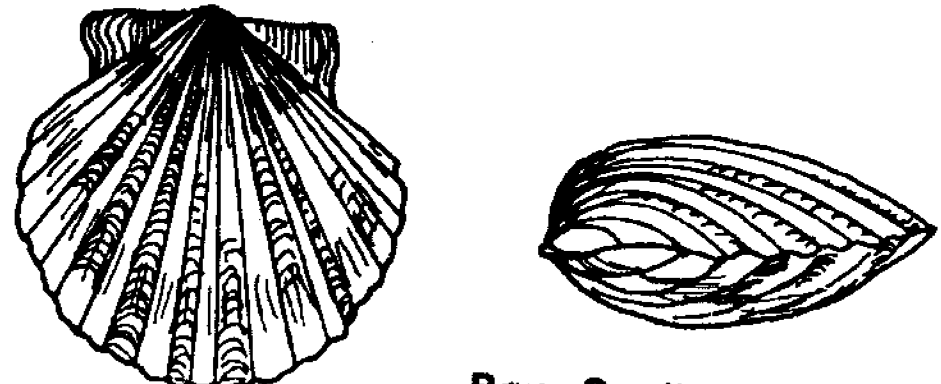
This scallop inhabits deeper waters from 12 to 900 feet on firm sand or gravel bottoms from Labrador to New Jersey. The most important sea scallop beds are located on Georges Bank. On board fishing vessels, the catch is shucked, bagged, and stored on ice until the vessel returns to port. Sea scallops are the most commercially important scallop in the U.S. with the major port being New Bedford, Maassachusetts. Sea scallops are also an important fishery in Canada.



Sea Scallop



Calico Scallop



Bay Scallop

BAY SCALLOP (*Argopecten irradians*)

Bay scallops have deeply ribbed shells and grow to 4 inches across. Their shells are mottled and vary in color including brown, white, tan, orange, reddish, or even purplish. Marketed muscle meats average 1/2 to 3/4 inches across.

As the name implies, this scallop inhabits protected bays and shallow flats and is commonly found among eel grass. It ranges from New England to North Carolina and is most abundant from Cape Cod to Long Island. Its shallow water habitat makes bay scallops easily accessible to the recreational shellfish gatherer. Besides being caught by man, bay scallops are preyed upon by starfish, crabs and snails.

The limited harvesting season for bay scallops is for conservation purposes. Scallops reproduce only once in their 1 1/2 to 2-year lifetime; thus it is beneficial to refrain from harvesting those scallops which have not yet spawned. Their reproductive period is during the summer months. At this time, a great deal of energy is directed to the reproductive process, and normal growth stops. After spawning, growth resumes and a line-like mark is left on the shell, denoting growth cessation.

This interesting life history forms the basis for resource management laws pertaining to this species. Harvesting bay scallops is not permitted during the reproductive period, and only those scallops with a well defined growth line (ring) may be legally harvested.

CALICO SCALLOP (*Argopecten gibbys*)

Other names: bay or cape scallop

The Calico scallop is a fast maturing species that can grow to commercial size in about 6 months. It inhabits deep waters from North Carolina to Brazil. It is named for the mottled or calico appearance of its shells. The markings are usually red or maroon on a white or yellow background. The calico scallop is slightly smaller than the bay scallop and has an average shell height of 1-1/2 to 2-1/3 inches.

The calico's small size prevents economical shucking by hand, instead they are usually mechanically steamed open and shucked. This procedure produces a partially cooked, whitish, dry outer edge which hand shucked scallops do not have. As a result, the muscle meat requires a very short cooking time to prevent overcooking.

Abundant from the Carolinas to the Gulf of Mexico, these scallops are often sold as bay or cape scallops.

ICELANDIC SCALLOPS (Chalmys islandica)

Icelandic scallops in the shell are easily recognizable by their unequal wings. Their shell is pale orange, reddish brown, or pinkish and is prominently ribbed. They are smaller than sea scallops and reach a shell height of 4 inches.

Icelandic scallops inhabit cold waters from the Artic Ocean to Casco Bay, Maine. Recently, dense beds of this species have been found off Chatham, Massachusetts in about 200 feet of water. Small quantities of Icelandics are now available in the Northeast market year round.

SEA URCHINS (Strongylocentrus droedachiensis)

Other names: sea eggs

The sea urchin takes its name from an old English meaning of urchin: Hedgehog. This spiny, spherical delicacy, eaten solely for its gonads or sex organs, euphemistically and inaccurately is marketed as sea urchin "roe" or as uni, its Japanese name. The gonads appear as a mass of yellow orange colored grannules. Unripe roe is brown and overripe is red. The roe of males has a finer texture, while that of females is more egg-like; both are eaten. The roe is divided into five segments and is located just inside the shell on the side opposite the mouth.

The sea urchin is a marine animal that looks like a large pin cushion 1-1/2 to 10 inches in diameter. It can cause a painful injury if stepped on with a bare foot. Although the short-spined edible varieties can be picked up in tidal pools by hand if held gently, it is advisable to wear gardening gloves to collect them. Gathering roe-bearing urchins is highly seasonal and dependent on water temperatures. Most are collected in the Pacific Ocean and Atlantic Ocean from the Arctic to New Jersey. It is shipped during the winter months from Maine, the site of a small fishery.

Urchins cannot be frozen and too much vibration during transport can reduce them from a valuable product to a useless mush. Due to their perishability, urchins are largely a cold weather item and reach their peak abundance at New York's Fulton Market around Christmas. Prices depend on the percentage of roe to the total weight of the animal. Higher roe content means higher prices.

The largest sea urchin fishery in the U.S. is Southern California's for red sea urchins (S. franciscanus).

The demand for the cream to orange-colored urchin, male or female, gonads always exceeds the supply. The French call them oursins, in Chile they're called herizos, while the natives of the West Indies eat them under the name of sea eggs. In fact they were sold so abundantly in the streets of Barbados that laws have been enacted to prevent their extinction.

To eat an urchin is simple. Merely cut around the mouth side of the shell with scissors or knife and shake out the viscera. Underneath and attached to the top side of the shell you'll find five branched roe in both male and female. Scoop out the roe with a spoon and eat with a squirt of lemon.

SHRIMP

The name "Shrimp" comes from an Old English word meaning puny person. Larger shrimp are sometimes called prawn but that term also is used in reference to freshwater shrimp. No precise standard exists for the term. The term "scampi" is used by American restauranteurs to describe shrimp cooked in butter and garlic, yet it also refers to a number of small lobster-like shellfish inhabitating European waters.

There are approximately 300 hundred species of shrimp found throughout the world but they can be divided into two categories: tropical and northern. They range from less than an inch to nearly 12 inches in length. In the United States, 95 percent of the catch taken off the Gulf and Southern Atlantic coasts is tropical shrimp. Tropical shrimp are classified by the color of their shells: brown, white, or pink.

Tropical shrimp spawn offshore; the eggs develop into larva which are quickly carried by currents to inshore estuaries, where most species will spend three to four months of rapid growth before migrating offshore as mature shrimp. Few tropical shrimp survive nets and predators longer than a year.

Advances in aquaculture in both South American and the Far East have allowed shrimp suppliers to meet an overall increase in world market demand. Shrimp supplies should continue to increase in the forseeable future as shrimp farming technology improves in developing countries around the world.

In some areas, protected estuaries or huge shallow coastal ponds with good sources of water are simply diked off to farm shrimp. Post larval or juvenile shrimp are used to seed the ponds. The larvae feed on naturally occurring diatoms plus get supplemental feedings. In many cases shrimp grow to market size in three to four months but little more than a third of the shrimp planted usually survive. If all goes according to plan, a farmer might harvest as much as 400 pounds from a 2-1/2 acre pond.

This success gave rise to an explosion of shrimp farms. Today the shrimp farming industry in some areas has a shortage of post-larval shrimp to stock the proliferation of ponds. Prices for wild seed stock has increased dramatically. But shrimp farms that have invested in technology probably will survive the many problems. At these farms, shrimp are raised under closely-monitored, simulated oceanic conditions to provide an optimum breeding environment. The shrimp are fed diatoms and other natural foods along with artificial food stocks developed in the lab. Some shrimp farming operations have invested in expensive computerized hatcheries in an attempt to breed high quality brood stocks of the most desirable species.

Successful shrimp farms are also operated in the U.S., Southeast Asia and South and Central America.

BROWN SHRIMP (Penaeus aztecus)

Brown shrimp account for the largest portion of the domestic shrimp catch. The main domestic fishery takes place in the Gulf of Mexico from Alabama to the Mexican border, although brown shrimp have been found as far north as Martha's Vineyard, Massachusetts. Browns are a fast growing shrimp, and the warmer the water, the faster their growth; they are fully mature at one year.

The Japanese hold brown shrimp in high culinary esteem because of its full flavor, which is a result of its higher iodine content. Depending on what they are feeding on at the time, the same species of brown shrimp may have either a pronounced or mild flavor. The shells of brown shrimp are usually a brownish grey although when cooked they are indistinguishable from whites or pinks. Browns caught in deeper water tend to be more reddish brown in color.

WHITE SHRIMP (Penaeus setiferus)

Numerous species of shrimp belonging to the commercially important warmwater penaeid family are sold in the U.S. under the general classification of "whites". Depending on their origin, some whites are whiter than others. The shells of most whites are greyish-green with patches of green, red and blue near their legs and tail. In the wild, white shrimp are found south from North Carolina to the Texas-Mexico border, but the primary commercial fishery takes place in the summer and early fall in the bays along the Louisiana coast. In most years, whites account for about 20% of the total U.S. tropical shrimp harvest.

White shrimp comprise the major portion of the U.S. shell-on shrimp (also known as green shrimp) market. It is generally assumed most Americans prefer the somewhat bland flavor of white shrimp. Wild and farmed (P. vannamei and P. stylirostris) whites are imported from a number of Central and South American countries as well as Thailand and Pakistan. China farms and exports whites (P. indicus and P. merguiensis).

PINK SHRIMP (Panaeus duorarum)

The domestic pink shrimp fishery, concentrated on the Tortugas shelf off Florida's southwest coast, is about half the size of the Gulf white shrimp fishery. Pinks are found in tropical waters throughout the world but the primary production comes from the Gulf of Mexico (P. duorarum) and the coast of Brazil (P. braziliensis).

The color of pink shrimp varies with age, diet and locality, but offshore, most pinks range from a pale pink to a deep rose.

The primary domestic pink fishery occurs on winter nights when the shrimp concentrate to spawn. Domestic pink production is down substantially from its historical level, primarily because of habitat destruction. Pink supplies may continue to decline as there are few efforts to farm this species extensively.

FRESHWATER PRAWNS (Macrobrachium rosenbergii)

Other names: blue prawn, giant prawn, Malaysian prawn, Macrobrachium prawn

Freshwater prawn, a large, fast-growing shrimp that is fished and farmed in many Asian countries flourishes in fresh and brackish waters. Their tails are thicker and shorter than the penaeid species but their taste is quite comparable to other tropical shrimp.

Freshwater prawn are now farmed to a limited extent in Hawaii and an Idaho company is using geothermal water to grow these shrimp for the live market. Live, these prawns command the highest price of any shrimp, an indication of their high culinary standing.

ROYAL RED SHRIMP

Royal reds are a warmwater panaeid species caught well offshore in the South Atlantic and Gulf. Their color is deep pink, much like the color of cooked shrimp; it hardly changes color when it is cooked. These deep water shrimp have more fat; are shorter and have a shorter shelf life than other shrimp from this region. Their flavor is rather like lobster. Royal reds are best when fresh as freezing encourages the shell to stick firmly to the meat. Peel frozen shrimp before cooking.

Argentine red shrimp, a coldwater species, is currently the most widely imported red shrimp.

TIGER PRAWNS (Penaeusital monodon)

Widely farmed in the Far East, tiger prawns were once targeted only at the Japanese market. However, the mushrooming production of tiger prawns in the Philippines, Taiwan and Indonesia is rapidly outstripping the Japanese market. Two kinds of these prawns, white tigers and black tigers, are currently being exported to the U.S. Tigers get their name from their striped shell, but when cooked they turn a deep red color.

NORTHERN SHRIMP

Other Names: Artic prawn

The most common northern shrimp are the two pink species, Pandalus borealis and P. jordani. Pandalus borealis are found in the cold waters across the top of the North Atlantic, including under the ice pack. Especially sensitive to water temperature fluctuations, the abundance of populations at the edges of their range can show huge variances. Jordani is slightly smaller in size and ranges along the Pacific coast from Alaska to California.

Northern shrimp are a slow-growing species that look similar to tropical shrimp species except are much smaller in size. They can be recognized by their large black eyes and relatively low price. Certain times of the year an enzymatic reaction occurs causing the head to become dark, however, this does not effect the taste of the shrimp. Since they are hermaphrodites, a high percentage of the shrimp at any given time are laden with eggs.

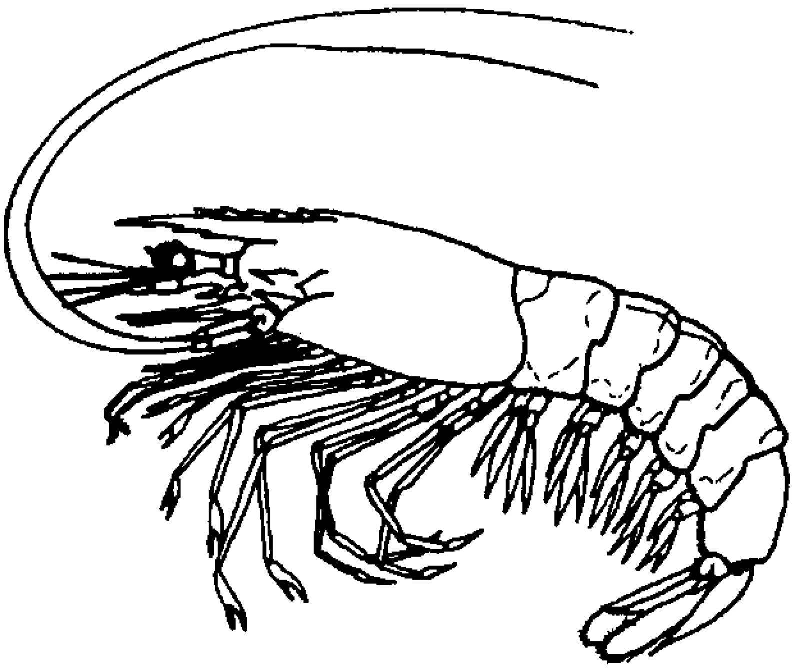
Norway and Greenland are the biggest producers of northern shrimp, but a fishery exists in Maine and northern Massachusetts. Northern shrimp, found on muddy and sandy bottoms in water from 150 to 900 feet deep, are harvested by trawling.

The shrimp are cooked and peeled when processed and are marketed canned or frozen.

ROCK SHRIMP (Sicyonia brevirostris)

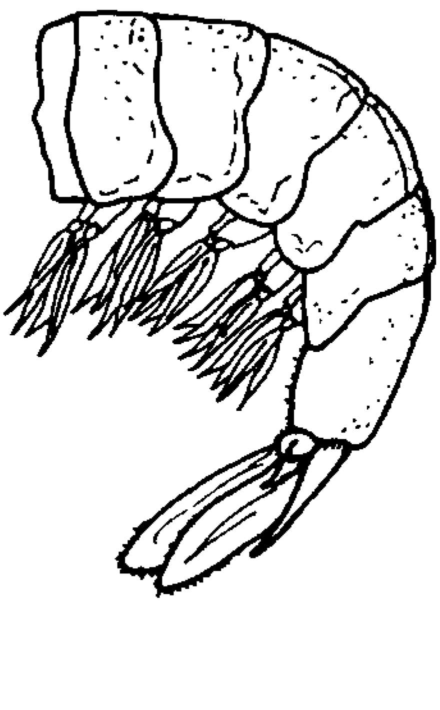
The rock Shrimp, which ranges from Norfolk, Virginia to the Gulf of Mexico, tends to be brownish on the dorsal surface and pale on the sides; the underside and appendages are variously colored with red or purple and are the approximate size of shrimp. This deep water cousin of white and brown shrimp is caught only at night and far offshore. The meat is very firm and more lobster-like and lower priced than other shrimp.

A fairly recent introduction to the American market, this species has always been caught abundantly in Florida and Mexican waters during



WHOLE SHRIMP

Normal Shrimp



Black Spotting

regular shrimping operations. Until 1970, however, it was invariably discarded because of its tough shell, from which it gets its name. Since a peeling machine was designed that could handle this operation, the demand has increased.

Most rock shrimp are marketed raw or frozen. They freeze exceptionally well, so don't hesitate to buy them frozen. You may notice an odor, however, which is present even when the shrimp are quite fresh. A reasonable amount of smell is to be expected, but avoid purchasing rock shrimp that have an exceptionally strong, sour odor, especially if the meat is mushy and discolored. Look for shrimp that have good firm white flesh with little odor.

2 pounds of tails = 1 pound cooked meat;
1 pound of tails = 1 1/2 to 2 cups cooked meat

BLACK SPOT

Shrimp are susceptible to a defect called black spot. This brown or black spotting may be visually objectionable but is not harmful to the health of the consumer. It is not caused by excessive levels of spoilage bacteria, rather it 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 to 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 bisulfitre, 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 re-using the dip, and careful washing and icing after frozen shrimp are thawed.

Seafood Extension specialists say 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 adversely affected, the shrimp should not be eaten. The black spot is not, of itself, a quality defect and will not harm the consumer.

SQUID

Other names: calamari, calamare, inkfish

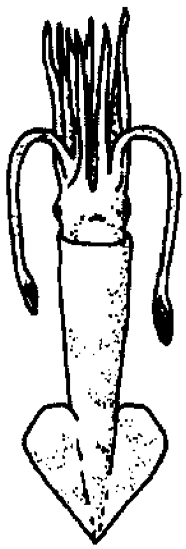
Squid is a close relative of the octopus and cuttlefish and a more distant relative of the clam, mussel, scallop, and oyster. Instead of having a protective external shell, the squid has a compact internal shell called the pen or quill. This singular slender chitinous pen, which runs within the dorsal side of the body cavity or mantle, is all that remains of the shell. Also within the mantle is an ink sac which is used in defense. The sac contains a blackish brown fluid or ink, which can be ejected to the outside through a siphon to form an inky cloud that aids the squid's escape.

The mantle is a hollow cone or cigar-shaped piece of flesh which is open at one end. Popping out of the opening is a head with two large black eyes. Ten appendages arranged in five pairs surround the head. Four pairs are known as arms and are short and heavy, and the remaining pair is lighter, twice as long and called tentacles. These appendages are equipped with suction cups which are used to seize and hold prey. For simplicity, in most cookbooks all ten appendages are referred to as tentacles.

Two slightly lobed fins are located near the terminal end of the mantle on the dorsal side. Squid can propel themselves by moving these fins, but for quick movement they use jet-like propulsion, which is accomplished by shooting water out through the siphon with great force, resulting in quick motion in the opposite direction.

Live squid are typically a milky, translucent color. However, as a defense mechanism they have the ability to change color or blend with their background. Fresh squid have creamy colored skin with reddish brown spots. Pinkening of the skin is an initial indication of aging.

Squid are schooling, pelagic, predatory animals that prey on small finfish and crustaceans. There are approximately 350 species of squid worldwide. This class of shellfish is considered to be one of the world's most underutilized fish resources. Oriental and Mediterranean peoples have been eating squid for centuries, but it is predominately ethnic groups which consume most of the squid in the U.S. However, this trend is changing as Americans are becoming aware of squid as a delicious food.



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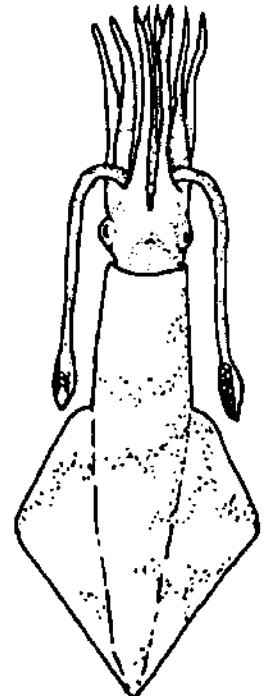

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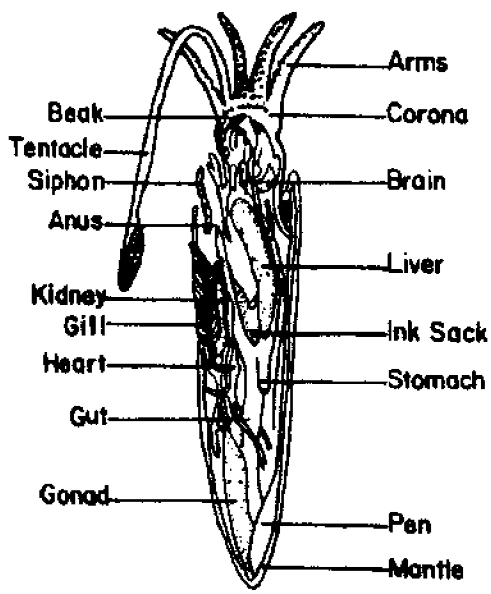


SQUID

The firm, white meat of squid consists mostly of fine muscle fibers with few connective tissues and little fat. Therefore, it has firmer texture than chicken or beef. After cleaning, the yield of edible meat (mantle, fins, tentacles, and arms) is between 60 to 80 percent.

If cooked improperly, squid will become tough and rubbery. It is best to cook squid quickly (under one minute) or to cook it over 30 minutes using a slow moist cooking method. The meat is quite mild flavored, almost to the point of being bland, and takes on the flavors of the ingredients it is cooked with. The ink of squid can be used in many dishes to add flavor, aroma and color.

In United States waters, most of the squid harvest consists of three species ranging in mantle lengths from 4 to 12 inches.

CALIFORNIA SQUID (Loligo opalescens)

Other names: Monterey squid, Opal squid, San Pedro squid, calamari grande

It is the smallest squid (10 to 12 inches across) marketed and appears frozen on the East Coast. They are harvested in winter months when they move inshore to spawn. Traditionally, this species accounts for the bulk of the domestic catch of loligo squid, but stocks have been rapidly disappearing.

NORTH ATLANTIC LOLIGO OR LONG-FINNED SQUID (loligo pealii)

Other names: winter squid, Boston squid, bone squid, trap squid

Atlantic long-finned squid ranges from Nova Scotia to Venezuela and occurs commonly from Massachusetts to North Carolina. It has a broad pen and long fins that equal half the mantle length. The long-finned squid is generally smaller and has thinner mantle walls than the short-finned squid. It is tender unless overcooked and is regarded in the East as the superior squid.

NORTH ATLANTIC OR SHORT-FINNED SQUID (Illex illecebrosus)

Other names: summer squid, bait squid

The short-finned or summer squid commonly occurs from the Maritime Provinces to New Jersey. It has a slender pen, and its fins are one-third the length of the mantle. The short-finned squid attains a larger size, has a thicker mantle wall, and usually sells for less than the long-finned squid. Illex can be quite tough and is easy to overcook making it tougher. This squid was once harvested almost exclusively for use as bait or animal food but is now marketed as a food item, which has found consumer acceptance equal to the long-finned squid.

FREQUENTLY ASKED QUESTIONS ABOUT SHELLFISH

Q. Can I freeze fresh crabmeat?

A. We suggest the crabmeat be put in a semi-prepared form such as crabcakes, casserole or soup before freezing. Freezing fresh crabmeat toughens the meat, dries it out and quality is lost in the product when frozen in the can. Store prepared dishes in the freezer for 3-6 months, remember the longer it is stored the more it will toughen and dry out. Plan to use it soon for optimum quality.

Q. Can I freeze live soft crabs?

A. A soft crab is a hard shell crab that has just shed its shell in order to grow. The "soft" crab stage is only temporary and is harvested before the shell hardens. It can be frozen successfully by using the following procedures of "dressing" the soft crab:

1. Cut off the face, cutting behind the eyes with a pair of scissors.
2. Cut off the opposite end the same way as the face.
3. Lift the top paper like shell on both sides and snip out the lungs.
4. Wash the soft crab and individually wrap it in an air-tight freezer wrap. Store in the freezer three months. If you don't freeze them, eat the soft crab within two days. Once the soft crab has been dressed, the entire crab may be eaten.

Q. Does fresh picked crabmeat contain salt?

A. According to the Maryland Department of Health and Hygiene, Maryland licensed crab processors must, by law, use only water to steam the crabs for fresh or pasteurized picked crabmeat. If there are any additives, processors must indicate them on the can. In the case of steamed crabs sold by the bushel, seasonings such as salt and seafood seasoning, may have been added. There are no "additive" regulations regarding the "crab by the bushel trade". Therefore, if you are on a sodium restricted diet, steam your own crabs or purchase fresh picked meat to be safe.

Q. How long can I keep pasteurized crabmeat, steamed crabs and fresh crabmeat?

A. Pasteurized crabmeat has been processed in a controlled atmosphere that enables the consumer to store it in the refrigerator (not freezer) for approximately six months. Once it has been opened, it has the same shelf life as fresh crabmeat. Steamed crabs may be kept in the refrigerator for 5-7 days. Make sure to keep them in an air tight plastic bag. They should be refrigerated as soon as possible after steaming. The longer they remain at room temperature, the more bacterial growth will occur. Fresh crabmeat will keep 3-5 days in the refrigerator. The best way to store it is by surrounding the crabmeat with ice. Clean out your vegetable or meat keeper and store the crabmeat in it with lots of ice.

Q. Can I cook dead crabs?

A. No. We suggest only cooking live crabs. Once the crab has died, bacterial growth occurs. This rule is the same for lobsters and other "live" shellfish.

Q. Can I send steamed crabs or crabmeat to relatives who live out of state?

A. Several crab processors have the ability to ship steamed crabs and pasteurized crabmeat to almost any destination in the United States. Certain processors do have minimum order stipulations. For more information, contact the Maryland office of Seafood Marketing at (301) 269-3461.

Q. Where do soft crabs come from?

A. A hard crab must molt or shed its shell in order to grow. When it molts, it is in the soft state that is commonly recognized as a "soft shell crab". Commercial soft crabs must be removed from the shedding tank within a very short time before they begin to harden again.

Q. How should I handle crab vegetable soup after it has been cooked?

A. Fill your sink with cold water, place the pot of soup in the sink and stir for 10 minutes to speed up cooling. Fill small containers (pints or quarts) with soup and refrigerate immediately. Do not put whole pot of soup with lid intact in the refrigerator because this could cause spoilage.

Q. How can I tell when crabmeat becomes spoiled?

A. Crabmeat becomes sticky, has an ammonia odor and is yellowish in color when it spoils. Crabmeat should remain fresh for three to five days after it is purchased. Store in the coldest part of your refrigerator.

Q. How long can I store live crabs and what is the best method to do so?

A. Live crabs will remain alive for approximately 6-8 hours if:

1. The crabs purchased were refrigerated and you continue to refrigerate them at home. Perishability will be high if the crab is not refrigerated one you get it home. 2. They were not refrigerated when you purchased them, or if you caught them and

kept them in a shaded cool, airy container such as a crab bushel basket outside. In either case, some will die and some will live a lot longer than 8 hours. Before steaming the crabs, if you "chill" them in the refrigerator, the cold temperature renders them inactive and easier to put in the steamer and also helps keep the legs and claws on during cooking. If you have ever tried to put them in a pot at room temperature, you know how active they can be.

Q. How long can I keep steamed crabs?

A. Steamed crabs may be kept in the refrigerator for three to five days. They should be refrigerated as soon as possible after steaming. Make sure to store them in airtight plastic bags.

Q. Can you pasteurize crab meat at home?

A. No. Pasteurization requires special monitoring of the internal temperature of cans not possible with home canning equipment.

Q. Can I make oyster stuffing ahead of time and put it in the turkey the day before I plan on roasting the turkey?

A. Absolutely not. All turkeys and poultry should be stuffed immediately before putting into the oven. The cold temperature needed to limit bacterial growth cannot adequately penetrate the interior cavity of a turkey. Therefore, make your dressing and stuff the turkey at the last moment.

Q. What's a good recipe I can make ahead and serve my guests without much trouble?

A. Marinated Oysters - just serve with crackers

2 pints standard oysters, with liquor
1 cup white vinegar
1/4 cup sugar
2 tsps. tarragon
3 T. pickling spice
1/4 cup sherry
crackers

In a large saucepan, simmer oysters in liquor until curled. Set aside. Combine remaining ingredients in a small sauce pan and cook over medium heat for 10 minutes. Drain oysters thoroughly and transfer to a bowl. Strain sauce and pour liquid over oysters. Cover and refrigerate for at least 3 hours. Serve with crackers.

Q. What color should shucked oysters be when purchased?

A. The most commonly found colors of fresh shucked oysters may be described as creamy, gray, brownish, pale yellow, red, green, or a combination of these colors. Oysters turn many colors for a variety of reasons -- what the oyster has eaten and rapid change in temperature to name a few.

Q. I'm confused by some terms. For oysters, do the terms "standard" and "select" refer to size or quality?

A. In oysters, "standards" and "selects" are measures of size. Standard oysters should count 220 to 240 shucked oysters to the gallon. A gallon of select oysters should contain 200 to 220. This means that select oysters are larger in size than standard oysters, but there is absolutely no difference in the quality of the oyster itself.

Q. How long can I store shucked oysters in the refrigerator?

A. Fresh shucked oysters have about a 7-10 day refrigerated storage life. Make sure to put them in the coldest part of the refrigerator.

Q. What is the small crab-like animal found in some raw oysters?

A. It's actually a pea-crab which lives in the gills of the oyster and feeds on the same foods that the oyster is filtering for itself. It is a delicacy in it's own right and is put in many stews.

Q. Is it safe to eat oysters during the months without "R's"?

A. Yes. Fresh oysters properly refrigerated are wholesome and nutritious throughout the year. They spoil rapidly at high temperatures, however. The belief that oysters are unsafe to eat in May through August arose in earlier days when refrigeration was less prevalent.

Q. Can I freeze fresh shucked oysters? How about oysters in the shell?

A. Shucked oysters freeze very well. Put the oysters in a rigid plastic container, make sure all the oysters are immersed in liquor to prevent freezer burn, leave 1/2 inch head space and freeze. You may have to add water to completely cover the oysters. Label the contents of the package, date and freeze. Even though shucked frozen oysters have a 3-6 months storage life, plan to use them as soon as you can. Shell oysters may also be frozen. Place the oysters in a freezer bag, exhaust air and seal. Lable and date contents, freeze. These oysters are best used in soups and stews or cooked dishes. Storage life is about 3 months.

Q. What should I look for in purchasing fresh shucked oysters?

A. Fresh shucked oysters should be plump and a creamy white to gray in color. The liquor should be clear, not excessively cloudy. Oysters turn many different colors for different reasons: rapid change in temperature, or what the oysters have eaten. The color of fresh oysters may be described as creamy, gray, brownish, pale yellow, red, green or a combination of these colors. They are safe for consumption.

Q. Are raw oysters an aphrodisiac?

A. Oysters do contain cholesterol, the basic building blocks of male and female sex hormones. But the human body produces enough cholesterol to satisfy our total needs. The additional cholesterol from oysters will not affect sexual behavior or act as a love potion.

Q. How long can I refrigerate oysters in the shell?

A. About 5-7 days. When you store fresh oysters in the shell in the refrigerator, leave the grit and dirt on them. This helps insulate and keep the oysters moist. Make sure they have air, do not put them in a sealed plastic bag because they need to breathe. Put them in a burlap bag or cover them with a damp towel. When ready to shuck, run under cold water, and scrub with a stiff brush.

Q. If an oyster's shell is not tightly closed, can I still eat it?

A. An oyster will open its shell in order to breathe. If you want to make sure it is still alive and safe to eat, tap it with a knife or run it under cold water. If the oyster fails to close its shell, discard it as it is probably dead. Sometimes refrigerated storage will cause gaping so don't be alarmed if the oyster shells are not tightly closed - give it the "tap" test.

Q. Are oysters fattening?

A. Eastern oysters in the raw are very low in calories, only 19 per ounce. If you bread them, fry them and then add tartar sauce, the calories will increase many fold, so watch how you prepare them. Oysters contain protein, calcium, phosphorus, iron, zinc, potassium, Vitamin A and thiamin.

Q. Are oysters, which develop a pink or red color when they are frozen, safe to eat?

A. Yes. The red color is probably due to algae or other plant material in the oyster's food. The color disappears when the oyster is cooked.

Q. What can I do to be sure that the clams I'm serving are safe to eat?

A. Obtain shellfish from a reputable source and eat only shellfish that have been thoroughly cooked.

Q. I have trouble opening clams. Is there an easy way?

A. Shucking clams with a knife is, indeed, a difficult task. There are, however, a couple of things that will facilitate opening the shells. If you have the time and the room in your freezer, bag the clams and freeze overnight. Before using, remove clams from the freezer and run them under cold water. The clams will open enough for a knife to be inserted. Another method that will work if you're careful is to place the clams in a conventional or microwave oven and steam them until they open. Be careful not to cook the meats, however, if you want to have a raw product.

Q. How many one-pound lobsters are needed for a pound of lobster meat?

A. Five, on the average.

Q. I have seen rock shrimp advertised. What is it?

A. Rock shrimp are a relative of the commonly retailed shrimp. Its flavor has been characterized as a combination of lobster and shrimp. It is a southern species that comes from the Gulf states as well as Georgia and South Carolina. It is a highly perishable product and therefore should be marketed frozen. Rock shrimp have a very hard exterior shell which approximates 50% of the weight of the headless shrimp. Care must be taken in cooking rock shrimp because it cooks much more rapidly than regular shrimp.

Q. How long can lobster live out of water?

A. Several days if kept in a cool, moist environment. The lobsters is a gillbreather, and moisture is essential to survival.

Q. It is true that all shellfish are high in cholesterol?

A. Recent, more accurate laboratory methods have shown that shellfish are not as high in cholesterol as once thought. With the new data, shellfish ranging from 40 to 100 milligrams per serving are comparable to chicken, lean beef, and finfish in the amount of cholesterol they contain. For example: The new value for cooked shrimp (100 grams) will be about 90 mg. of cholesterol. The only popular "fish food" that remains rich in cholestrol is fish roe or eggs. But few can afford a steady diet of caviar.

Q. When I stuff squid for baking, the stuffing comes out during cooking. What am I doing wrong?

A. You are probably over-stuffing the squid. During cooking, the squid will shrink. Understuff or stuff the squid loosely to prevent the stuffing from squeezing out during cooking.

Q. How much seafood should I buy?

A. The amount of fish or shellfish to purchase varies according to portion size, the type of recipe, and the market for the fish product. On the average, allow approximately 3 ounces of cooked, boneless fish per serving.

Q. Whenever I cook squid, it becomes tough and rubbery. What am I doing wrong?

A. If not cooked properly, squid can be very tough. It you are deep frying, do so very quickly. Make sure your oil temperature is 350° and that you don't overload the fryer. If you are stewing squid, do so for at least an hour. Taste for tenderness. Squid seems to have a tough period where if you don't either cook it very quickly or stew it for a long period of time, it will become tough. If baking squid, always baste frequently to keep it moist and tender.

Q. Are the tentacles of a squid edible?

A. Yes, the "prime-parts" of a squid are the ink, tentacles, cleaned body wings, and arms. Discard the pen or quill, head and interior of the body.

Q. Is it true that shark meat is being substituted for scallops in some areas?

A. This rumor surfaces every few years. Shark meat and scallops are not at all alike. The have completely different textures and flavors. Because of the texture of the "eye" or adductor muscle, shark meat cannot be substituted for scallops.

Q. What is the proper method for freezing, thawing clams and oysters in the shell?

A. Freezing clams and oysters -- Allow clams to stand in cool water or a weak salt solution for about half an hour to remove grit. Hard clams should be placed in a freezer bag and may then be frozen in the shell at 0°F for 3 to 4 months. Soft shelled clams do not freeze well. DO NOT refreeze shellfish. Thaw shellfish in refrigerator.

Q. What is the best way to keep lobster alive until you're ready to cook them?

A. Keep lobster moist and refrigerated by wrapping in newspaper and protecting with a cardboard box. Use within 2 days. What if it died before it was cooked? It it was alive when you bought it on Friday and it died on Saturday -- it is OK to cook Saturday evening or Sunday at the latest, since it was refrigerated the entire time.

Q. How many people will a bushel of Maryland Steamed crabs feed?

A. Generally speaking, a bushel of number 1 or "Jimmy" crabs will hold about 60-70 crabs depending on how big the crabs are at that time of year. If there are 60-70 crabs, they will feed about 10-12 people depending upon what else is served on the menu. If you have all kinds of food, for example, salads, hot dogs, chicken, etc., you'll probably need half as many crabs. If you just served steamed crabs, clams, corn and beverages, buy the whole bushel.

Q. Why can't I store cooked crabs in the same basket they came in when I purchased them live?

A. Live crabs, like most other animals, contain bacteria which can easily be transmitted. Cooked crabs that have been properly cooked will be, for all practical purposes, bacteria free, the bacteria having been killed by cooking. Therefore, the cooked crab is in a state ready to eat directly from the shell; should these cooked crabs some in contact with uncooked crabs, cross contamination could occur.

Q. Can I freeze steamed crabs?

A. The Maryland Office of Seafood Marketing does not recommend freezing steamed crabs because of the potential for bacterial growth. The digested food the crab has eaten and the wastes in the interior take a long time to freeze in home freezers and therefore increase the risk of bacterial growth. We suggest that crab be cleaned; remove the shell, legs, intestines, claws and fat. Only the meat containing parts or "body" and claws of the crab should be frozen and is best used for soups or casseroles.

Q. What can I do with leftover steamed crabs?

A. Pick the meat out of them as soon as possible. The leftover meat can be used in any traditional recipe calling for crabmeat. If you decide to freeze the meat, the crabmeat should be put in a semi-prepared form such as crab cakes, casseroles or soup, then frozen. Insulate the crab product with freezer wrap, label and freeze. Store prepared dishes in the freezer for three to six months. Remember the longer it is stored the more it will toughen and dry out. Plan to use it quickly for optimal quality.

Q. How can I be assured that oysters purchased in the market are safe and wholesome to consume?

A. The waters covering all charted oyster beds are periodically sampled by state health agencies to determine the purity of the water. No oysters are allowed to be harvested from waters that do not meet the strict criteria. Oysters harvested from approved waters are again tested at the processor level. Oysters are finally tested at the market level to assure wholesomeness.

CHAPTER THREE

ASSOCIATED PRODUCTS

ASSOCIATED PRODUCTS

ANCHOVIES

There are 16 species of anchovy in American waters but there are many more of these small and fatty species worldwide. These pelagic, silvery fish with big eyes are more commonly used as bait than as food in the U.S. Few people take the time today to catch anchovies and enjoy them fresh. Anchovies travel in densely packed schools and frequently mingle with silversides and young herring. When cooked and served together these fish are called "whitebait", a common name for very tiny fish. Anchovies are marketed in salted form, canned, smoked, dried, in butters, cream and paste. Their distinctive, rich flavor is widely used as a garnish for other foods.

Anchovies are generally packed in one of two ways; either in bulk barrels or directly into retail cans. The natural white, fresh anchovy is packed in barrels with a salt-sugar-spice mixture and allowed to ripen for about 4 months until the flesh is cured to a deep red. They are later repacked and sealed in small containers as skinless, boneless anchovies. "Direct made" anchovies are packed whole into small rectangular cans. The final product is then covered with the same curing mixture used in the barrels and sealed. They have a tendency to be stonger in flavor. The anchovy product familiar to most Americans is the canned boneless fillet packed in oil.

CAVIAR

True caviar is the salted roe of sturgeon and is probably the most expensive food in the world. At one time, any fish roe that was salted and dyed black was called caviar, but, in 1966, the FDA defined caviar as exclusively salted sturgeon roe. Salted roe from other fish has to be designated on the label; for example, "salmon caviar".

Caviar has had an interesting history in America. When it was most plentiful, there was little demand by Americans. In the late 1800s in San Francisco, caviar was served free at bars as a ploy to get customers to drink more. At this time, the United States had a thriving caviar business exporting to Europe and Russia.

The East Coast industry was established in 1873 along the Delaware River, and shortly afterwards a fishery began in the West, principally in the Columbia River. A slow growing fish, sturgeon were quickly brought to near extinction. Today, despite pollution and other interferences by man, sturgeon species are making a slow recovery under strict fishery management.

The collapse of the U.S. caviar industry at the turn of the century set the stage for the costly rise to fame of Russian caviar. The

Caspian and Black Seas became the major world sources of caviar and, having access to these water, the Russians and Iranians became the major world suppliers.

The most important products are from three sturgeon species: the beluga, osetra (osietr) and sevruga. The giant beluga sturgeon may weigh 2,500 pounds and yield as much as 350 pounds of roe. It produces the largest and most valuable berries (industry term for individual eggs) which currently retail for up to $400 a pound. Beluga caviar ranges in color from blackish gray to light gray. The osetra sturgeon is also large and produces gray to golden-brown berries. The sevruga is a much smaller sturgeon which yields small, grayish black eggs.

Soviet and Iranian sturgeon resources are slowly dwindling as a result of pollution, dam construction (sturgeon are anadromous), and overfishing. This has given spark to the rebirth of the American caviar business.

Of the several species of sturgeon in the United States, five are currently harvested on a small commerical basis. These are: the white and green sturgeon of the West Coast, the Atlantic sturgeon of the East Coast, the lake sturgeon of the Great Lakes, and the shovelnose sturgeon (sometimes erroneously called Mississippi paddlefish) of the Mississippi Valley. Paddlefish are in the same biological order of fish as sturgeons, are extremely similar, and occur in the Mississippi area. Their eggs are marketed as a caviar substitute, or probably as true sturgeon caviar because of their similarity to the eggs of American sturgeon species. American caviar is generally much less expensive than imported Russian caviar and is roughly one-third the cost of beluga caviar.

Caviar comes from freshly killed sturgeon. The fish are cut open and the two sacs (sometimes called skeins) of roe are carefully removed and placed on a mesh screen. The mesh is just large enough for the eggs to fall through. The sacs are split open, and the eggs drop below leaving the thin membrane and other debris behind. The eggs are salted by soaking in a brine solution, and then packed into kegs or tins. Retail containers are small, airtight jars or tins.

The amount of salt added to the eggs affects the price and perishability of the resulting caviar. The most expensive caviar is packed malossol style, meaning little salt. The less salt the more desirable the product, but also the more perishable. Malassol caviar contains 3% to 5% salt and is sold fresh. Pasteurized caviar contains more salt, is less expensive and does not require refrigeration until opened. One other style of caviar is pausnaya, meaning pressed caviar; damaged or less firm eggs are used to produce what looks like caviar marmalade.

When buying caviar, look for whole, uncrushed, firm berries that are well coated with their own glistening fat. Conscientious dealers will periodically turn the containers so that the fat remains well distributed to prevent drying. Turning also alleviates the pressure on the bottom eggs.

Store fresh caviar in a cold refrigerator. A temperature of 26° to 30° F is optimal (the salt prevents freezing at these temperatures). Fresh caviar can be kept for up to six months but is freshest when just purchased. Once the container is open, use within a few hours for the best results. Pasteurized caviar does not require refrigeration until opened and can be stored unopened for a few months. Never freeze sturgeon caviar which can occur if stored below 26°F, as the eggs will burst.

The flavor of sturgeon caviar is faintly salty and nut-like. It should not be too salty and never taste fishy. To relish its flavor, caviar is served very plainly on a piece of thin toast or unsalted cracker, with or without butter. It may be lightly sprinkled with finely chopped egg, onion, or chives, and/or topped with sour cream or a dash of lemon juice. Although chefs have tried to incorporate caviar into many dishes, its flavor is masked when mixed with other ingredients, and its texture changes when cooked. Caviar is a good source of protein but is also high in fat, cholesterol, and sodium.

Since the cost of sturgeon caviar excludes most individuals from experiencing it, substitute caviars are produced from the roe of several types of fish. The eggs are often dyed with a vegetable dye to attain the gray to black color of true caviar. Otherwise they are sold undyed. In fact, red and yellow (golden) caviar are marketed. Caviar substitutes are much more affordable and are gaining popularity in the United States. Many do not resemble sturgeon caviar in taste but have a distinct enjoyable flavor of their own. A brief review of the more important ones follows.

Salmon caviar is also called red caviar because of the natural color of the eggs. It is produced on the Pacific Coast from where a large amount is exported to the Japanese, the biggest consumers of salmon eggs. Unlike sturgeon caviar, salmon caviar can be frozen.

Whitefish caviar is produced in Canada from the roe of lake whitefish. It is priced similar to salmon caviar and also can be frozen. Whitefish caviar is often marketed as "golden caviar".

Lumpfish is native to the Northeast and is used to make a very inexpensive caviar. It is popular in Denmark where is is lightly salted. American lumpfish caviar tends to be overpreserved and not as good. The natural color of the eggs is dark green when they are fully developed (yellow when they are not); therefore lumpfish roe is typically dyed.

ROE

Although roe properly refers to the ovaries of female fish, the term is also used to describe the testes of male fish (white or soft roe), the coral of lobsters and scallops, the male and female gonads of sea urchins, and the berries of crabs. The gonads of all fish develop during the spawning season of the particular species.

Finfish ovaries exist in pairs and consist of two egg-filled sacs, which are lobe shaped and connected at one end by a thick blood vessel. Each sac is covered by two membranes: a paper-thin, transparent inner membrane, which is edible; and an inedible, thicker, loose-fitting outer membrane.

The best eating roe is fully developed but not overripe. "Green" or underripe roe has very compact eggs and tends to be firm or rubbery, with little flavor. On the other hand, overripe roe is watery and also somewhat tasteless. Over ripeness is indicated when the eggs are ready to separate from the membrane.

Marketed roe will have the inedible outer membrane removed. The eggs should be visible and of uniform color. The sacs should be clean of blood and debris and should have no disagreeable odor. Roe should not have a mushy texture or appear clouded, dried or shriveled. Fresh roe can be refrigerated for a couple of days but is best when freshest. It can be frozen but does not keep very well because of its high fat content.

The roe of numerous fish can be taken, but not all fish have ovaries that are large enough to make them worth keeping. In the Mid-Atlantic region, good quality edible roe can be obtained from herring, mullet, shad and rockfish. One of the favorites, shad roe, is considered a prime delicacy and commands a high price. It is typically sold in natural pairs. Roe from pufferfish, however, is toxic.

To prepare roe for cooking, separate the two sacs where they are joined but be careful of losing eggs out the cut end. Handle roe with care to avoid rupturing the membrane. The most popular preparation consists of lightly flouring and sauteing in butter. Roe can be used in a variety of recipes but be leary of recipes which call for prepoaching. Although this serves to firm the roe, so that it can be cooked whole using after-cooking methods without breaking apart, the precooking must be very brief to avoid overcooking in the final stages. If overcooked, roe is dry and chewy. As an alternated to cooking, roe may be smoked, salted, or pickled.

Fish roe is a good source of protein but is also high in fat and cholesterol.

CANNED PRODUCTS

Many types of seafood are commercially canned, however, tuna and salmon are by far the biggest sellers in the U.S. In addition to finfish and shellfish, specialty items such as spreads, smoked fish, chowders and sauces are canned. Canned products account for approximately 37 percent of the seafood consumed in this country.

Canned fish is packed in oil, brine, water, or various sauces. Clams, oysters, and mussels are steamed for easy removal and to firm the meats. Shrimp are peeled and blanched in boiling brine prior to packing. Crabs are boiled or steamed, and the meat picked and usually dipped and/or packed in a citric brine to prevent discoloration. Tiny elvers (eels) are canned and considered a delicacy in many cultures. Squid and octopus can be found on grocers, shelves in a variety of sauces.

CANNED TUNA

About a quarter of all seafood that Americans eat is canned tuna, and this represents almost a third of the world's tuna catch. The price and grade of canned tuna is depends on the species, the parts of the tuna used and the style of packing.

The most prized tuna are the albacore, which have a very light color and firm texture. By law, canned albacore is the only species that can be labeled as "white meat". Yellowfin, bluefin and skipjack must be labeled as light meat. Most yellowfin are taken by superseiners that roam the seas for months, catching as much as 1,000 tons of tuna in a single good set. Most yellowfin tuna caught by superseiners is frozen in brine and later canned. The yellowfin has the same firm texture as albacore but is slightly darker in color. As these supplies have dwindled, canners have begun to use the skipjack tuna, which is smaller, darker, and somewhat stronger flavored than the other two. Bluefin tuna 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. Tuna caught in the Mid-Atlantic region are usually from the bluefin family.

Tuna, sardines, herring, and anchovies are precooked before packing. Precooking removes a portion of the natural oil content, loosens the meat from the bones, and is needed to obtain the proper texture in the final canned products. The loins, which are four large, light-colored muscles that extend along the side of the backbone, are the only part of the tuna that is canned for human consumption. The dark meat is used for the production of animal feeds.

Canned tuna is prepared in four forms:

1) Solid or solid packs, the most expensive, consist of loins to which

no free pieces are added, although a piece may be added if necessary to fill a can.

2) Chunk, chunks, chunk style, the most popular form, consist of a mixture of pieces of tuna in which the original muscle structure is retained.

3) Flake or flakes are a mixture of pieces in which the muscular structure of the flesh is retained.

4) Grated tuna consists of a mixture of particles of tuna that have been reduced to uniform size in which the particles are discrete and do not comprise a paste. This is the least expensive form.

Canned tuna is available in several can sizes ranging from a 4-ounce snack can to a 4-pound food service can. The most popular size is the 6-7 net ounces of tuna.

CANNED SALMON

Salmon ranks second to tuna in popularity of canned seafoods. Several species of Pacific salmon are sold canned. Salmon, mackerel, and shad are typically packed raw.

The abundant pink salmon (Oncorhychus gorbuscha) is still used primarily for canned product. As pinks have a somewhat softer and finer flesh and lower oil content than most salmon species, they require more careful handling and thus are still mostly canned. The flesh color ranges from light peach to deep pink. The flavor is distinctively delicate. Pink salmon is usually priced lower than all canned products except chum.

Large quantities of chum or keta are marketed fresh in the fall when they are the only Pacific salmon still landed in quantity, but the bulk of the production is either frozen or canned. The flesh is usually lacking in red color (it may at times appear gray). The fat content, in relation to the other species, is low.

As much as half the total Alaska production of sockeye (O. nerka) or red salmon may be canned, but fresh and frozen demand is making this fish too expensive for the canned market. The firm deep orange-red flesh has a small flake and a considerable amount of oil.

Only a very small amount of king salmon or chinook (O. tshawytscha), the largest and most expensive of the Pacific salmon, is canned in Alaska. Accepted as the best "eating" of the salmon, it is rich in oil and is commonly sold in several grades according to color which varies from deep red to white. The canned flesh readily separates into very large flakes. The fish canned are those that generally fail to meet quality standards for fresh or frozen markets.

FROGLEGS

The major market source of froglegs in the U.S. is frozen legs from Asian countries and India, a fact that raises concerns for the consumer. Frogs consume close to their own body weight each day in insects. The voracious appetite of frogs help farmers in underdeveloped countries to control predation. But heavy frog harvesting in these countries has resulted in insects breeding out of control and forcing farmers to use pesticides such as DDT (which is banned in the U.S.) to save their crops. This use of pesticides can contaminate the frogs, making them unsafe for human consumption.

In 1985 Asian bullfrogs (Rana hexadactyla) and the Indian bullfrog (R. tigrina) were put on the "regulated species" list because of concern over declining numbers. Bangladesh and India have enacted conservation measures to stabilize the species.

Few fresh froglegs are produced in the U.S. Most of those available are caught in Florida and Louisiana but the cost of domestic froglegs is very high. It is possible that aquaculture techniques will restore fresh frog supplies.

Three species of frog are caught for consumption in the United States. The green Frog (R. clamitans). American bullfrog (R. catesbeiana), Northern leopard frog (R. pipiens). The American bullfrog is about 8 inches long and is found all over North America. The Northern leopard frog is bright green with large irregular, black white-margined blotches on its back; its legs are barred and its belly very pale.

Only the hind legs are eaten and are always marketed skinned. When cooked the meat is snowy white and very delicately flavored. THe species selected is not too significant.

MENHADEN (Brevoortia tyrannus)

Other names: pogy, mossbunker, fatback, bunker, shad

Menhaden differ from their herring relatives by the size of their head, which is scaleless and very large, about one-third the total length of the body. Another distinguishing feature is that their scale margins are nearly vertical and edged with comb-like teeth. Their mouth is relatively large and toothless. Like herring, their body is flattened sidewise and their belly saw-edged.

Adult menhaden average 12 to 15 inches long and 10 to 16 ounces. They are dark blue, green, blue-gray, or blue-brown above. Their sides and belly are silvery with a strong yellow or brassy luster. A conspicuous dusky spot is found on each side behind the gill cover and is followed by smaller dark spots.

Menhaden inhabit inner shelf water from Maine to Florida. They are seasonal migrators and are found in the northern portion of their range only during warmer months. It is exclusively the older and larger fish that make this long journey, only to return south again when the water cools. Menhaden travel in a large, dense school which darken the water's surface like the shadow of a cloud. They remain near the surface when the water is calm. Because of their dense schooling behavior and near surface occurrence, aircraft are used to spot menhaden for the commercial fisherman. Menhaden are filter feeders and use their gill rakers like a seive to strain microscopic plants and crustacean out of the water.

Atlantic menhaden and the closely related Gulf menhaden (B. patronus) are almost the most abundant fish along the Atlantic Coast and support one of the largest and most important fisheries in the United States. Although they are rarely eaten directly as food in this country, menhaden have many uses. One of the oldest industries in the U.S. is the processing of menhaden into fertilizer. Today, menhaden are processed into fish meal, oil, and protein solubles. These products are used in a variety of secondary products including paints, pharmaceuticals, cosmetics, lubricants, and animal feed. Unprocessed menhaden are used as bait and, in some less developed countries, as food. The value of this fish may increase as the demand for protein increases in the world.

SARDINES

Sardines is not the name of any particular fish but rather a collective term for a number of small, soft-boned species in the herring family. This may include young Pacific (Sardinops sagax) or Atlantic herring (Clupea harengus), blueback herring, pilchards, or sprat (which are sold as bristling sardine). 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 a single dorsal fin directly over the small ventral fin. Scales of herring are large and loosely attached. Herring reach about 4 inches in length by the end of the first year.

The name sardine probably comes from the fact that similar, tiny fish called French sardines (Sardina pilchardus) were first found and caught in great abundance around the islands of Sardinia in the Mediterranean. Most of the world sardine production is Sardina pilchardus, which are called sardines when young and pilchards when mature.

During the period 1930 to 1936, U.S. Pacific sardine landings reached a billion and a half pounds annually. For various reasons this catch declined rapidly and for all practical purposes is extinct.

Today, American production is largely from the coast of Maine (600,000 cases in 1984) but imports now account for more than 60 percent of the U.S. sardine market. Canada's major sardine fishery is in the Bay of Fundy.

Sardines are marketed fresh or lightly salted in some countries, notably Portugal, Spain and Italy, but the world trade is based on canned products. These little fish are mechanically scaled aboard the boats, then washed, brined, and briefly steam-cooked at the canneries. After air-drying, the sardines are graded by size and packed into cans manually. Before sealing, a sauce or oil is injected by machine, and the can is sterilized in high pressure steam ovens. Some sardines are fried or smoked before being packed and others are skinned and boned to be sold as "fillets of sardine". There are some differences in texture and flavor between the various fishes and often extreme variations in the quality of the pack.

Though surveys by the Maine Sardine Council show sardine eaters are an aging market, signs indicate this may be changing as a result of renewed interest in healthful diet and lifestyle. One reason is that sardines are a very healthful food. They are high in calcium, a nutrient necessary in combating osteoporesis, a degenerative bone disease that strikes 25 percent of American women over 60. It also has Omega-3 fatty acids which have been linked to low blood cholesterol levels and a low incidence of heart disease in humans.

Though not easy to find, some frozen sardines are available, which when properly handled and prepared, have a quality nearing fresh. Fresh sardines are traditionally cooked over charcoal.

SEAWEED

Seaweeds are commonly harvested as sources of food, fertilizer, and chemicals. Although chemical production is the chief use of seaweeds in the U.S., in Oriental countries seaweeds are an important food source and are cultivated to fill the demand.

Sea vegetables grow in a variety of habitats, but the number and size of species is generally larger in northern waters. They grow anchored in sand, mud, gravel, or attached to rocks, shells, wood, pilings, or coral. The type of sea bottom helps determine the variety of species found and the extent to which they flourish. Northern rocky shores are best for foraging because they support the greatest variety of species. As rocky coves disappear along the coasts in favor of beaches and shallow bays, seaweeds found between the tide marks become fewer. The large kelp disappear in favor of the sea lettuces and other green algae. Father south, around North Carolina, the silt from river deltas cause stunting of the intertidal algae. Subtidal vegetation, is however, lush and species are large. Here the brown and greens give way to the red algae.

Marine plants are divided into two groups, grasses and algae. The latter group contains the commercially important plants. Algae range in size from microscopic phytoplankton (plant plankton) to large, tree-like kelps which may reach 150 to 200 feet in length. Algae are classified by color into blue-green, green, red, and brown varieties. "Seaweed" is a term for marine algae exclusive of microscopic forms. The largest seaweeds are certain species of brown algae commonly called kelp.

Marine algae are necessary to sustain animal life in the ocean. Like land plants they contain the green pigment chlorophyll which enables them to convert the sun's energy into starches and sugars. Therefore, algae are at the base of the ocean's food web. Algae also produce oxygen and provide a habitat for many marine organisms.

Because seaweeds are dependent on sunlight they are found near the surface or in relatively shallow water along the coastline. Here they can be gathered by hand; however, commercial harvesters work out of small boats and scrape seaweed off rocks using long handled rakes. Off California, kelp beds are mechanically harvested. Commercially harvested seaweed is typically dried and bundled in bales.

As a food, seaweed is not widely accepted in the Western countries, but is used extensively in the Orient, especially Japan.

Sometimes called sea vegetables, seaweeds can be collected while at the shore or purchased in health food stores, Oriental markets and some groceries stores. They are typically sold in dried sheets or tangles. The most popular forms are hijiki (Hizikia), kombu (Laminaria), nori (Porphyra), wakame (Undaria), and irish moss (Chondrus crispus).

Hijiki have fine small brown tapering leaves which grow on lateral branches breaking from main branches. It is used as a fresh vegetable and is often combined with other ingredients or rice. Fresh plants are included in soups and dried plants are prepared as tea.

Kombu plants are dark brown with a leathery texture. The blade can be 2-1/2 to 10 yards long, 3 to 6 inches wide, with a wedge-shaped midsection and margins slightly ruffled. It is typically boiled and eaten as a vegetable or used to make soup stock.

Nori is Japan's most treasured seaweed. The plant is light pink when young, dark purple when older. The plants are about 10 inches tall. It has long, narrow wavy-edged blades tapering at each end when young and widening or becoming slightly heart-shaped as mature plants. It has a gelatinous texture. Also called laver, this algae is pressed, sun-dried, toasted, and sold in the form of paper-thin dark purple or green sheets. Its most popular use is in the making of sushi rolls.

Wakame has a natural gel ingredient called algin. The medium to dark brown plants are 2 to 4 feet long with many winglike protrusions 12 to 16 inches wide. It is used in miso soups, meat and bean curd dishes as well as a vegetable sidedish.

Irish moss is a small, red-purple to greenish to white algae, 2 to 4 inches in height forming loose to dense clumps. It is harvested in the Northeast as a commercial source of carrageen, a compound that acts as a stabilizer and emulsifier in many products. It can also be used directly in salads, soups, breads, and other dishes.

Food value is just one of the many uses for seaweeds. They are also used in the production of chemicals, as an animal feed, agricultural fertilizer, and as packing material for live crabs and lobsters.

The most important seaweed-related industry in the United States is the production of chemicals. During World War I, seaweed was used to produce potassium chloride and iodine. Today seaweed is used to produce phycocolloids (seaweed colloids), which are used as thickeners, coagulents, moisture retainers, antibiotic carriers, and bulking agents.

Three types of phycocolloids are commercially important in the U.S.: algin, agar, and carrageen. Algin is produced from the giant kelp found off California. Agar is manufactured from red algae and is used primarily as a solid culture medium in bacteriology and as an ingredient in bakery icings. Carrageen is produced from red algae, primarily from Irish moss. Phycocolloids are used in many products we use daily, such as cosmetics, ice cream, chocolate milk, aspirin, chewing gum, toothpaste, pie fillings, paints, dental molds, and several other products.

Freshly picked seaweed should be soaked in fresh water to remove some of its saltiness. The length of soaking depends on how much salt you wish to remove. The water should be changed several times a day. When preparing kelp, its outer skin should be removed with a vegetable peeler. Seaweed can be used fresh or can be dried for later use. Dry seaweed in an oven or hang it for air drying, them pack in jars. If not to be used in the dried form, reconstitute by soaking in water prior to use.

SNAILS OR LES ESCARGOTS

Snails can be terrestrial, freshwater or marine. The land variety, which is the most commonly eaten, is a vegetarian. L'escargot is the common name for a land gastropod mollusk. In France the <u>vineyard snail</u> is the most popular to meet demands; the <u>petit-gris</u> of southern France is also used. The edible snails of France have a single shell, are tan and white in color and 1 to 2 inches in diameter. L'escargot is similar to sea snails or periwinkles and may be cooked in the same manner.

Throughout the summer snails gorge themselves, then in a stuffed and lazy condition they hibernate during the winter. In the fall, wild snails are gathered in their dormant stage and either eaten fresh (in France) or canned for year round enjoyment. Snails are also farmed in mesh enclosures that are densely foliated or are cultivated in covered containers under controlled conditions.

The job of cleaning snails is an unfamiliar one in the U.S. because we use the frozen or canned variety, just as most restaurants in France do.

The snails in our retail markets rarely measure more than 1 inch or 1-1/2 inches in diameter; but tropical snails grow to 6 inches and may weigh more than a pound.

How to prepare:
Soak the snails until they come out of their shells. Those that do not open are thrown away. Place them in salted water or court bouillon. After you have brought this to a boil, remove them from their shells and rinse with a little cold water or white wine. Wash the shells, and then follow the recipe for canned snails.

TURTLES, TORTOISE and TERRAPIN

Turtles are any of a large number of fresh or saltwater reptiles having a shell and hornybeak. There are about 225 species in the world, found at sea, in lakes, rivers, ponds, woodlands, fields and pastures. Turtles come in many different sizes and colors, and once the word turtle covered all of them. Loosely defined, a tortoise is a turtle that prefers the land and a terrapin is a variety of turtle that inhabits rivers and coastal swamps along the Eastern seaboard and the Gulf. Some reserve the term "turtle" solely for the sea turtle.

SEA TURTLES

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

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 small size.

The Green turtle (*Chelonia mydas*) is the most famous sea turtle. The meat, very highly praised by gourmets, led to excessive demands and eventual over-harvesting. The commercial fishery was centered around Key West. Today sea turtles are being commercially raised, especially in the Cayman Islands.

Sea turtles rarely leave the water except to lay their eggs. When first hatched the turtles are only a few inches long but are exact miniatures of the adult. When mature the logger head can weight 1,000 pounds and have a carapace 7 feet across.

DIAMONDBACK TERRAPIN (Malaclemys centrata concentrica-Shaw)

Terrapins can be found in the summer basking in the sun along the salt and brackish marshes of both the Chesapeake and Chincoteague Bays. Diamondback terrapins feed on small fish, shrimp, crabs and small clams. In the winter they hibernate in the mud below the waters of marsh streams and creeks.

Diamondback terrapins are easily recognized by the distinctive concentric plate markings on their carapace. The carapace can be pale greenish gray to dark brown to almost black. The belly plate is yellowish with dark mottled markings, though in some terrapin the plate is very dark. The head of the terrapin is gray with irregular stripes or spots. The legs are scaled and dark; the toes are broadly webbed. The streamlined shell and webbed feet make the terrapin a good diver and fast swimmer. Maturity is reached at about 7 years of age, although a better indicator of maturity is size. Males are generally smaller than females and reach maturity when they are 3.2 to 3.5 inches in length; females at 5.5 inches. The average size is 5 to 7 inches, though some have reached lengths of up to 9 inches. The male and female are quite similar. Besides size, there are two other recognizable differences. The male has a narrower head; the female's is wider and more triangular in shape. The male also has a noticeably more muscular tail.

Terrapins mate in the early spring, and egg laying takes place from May to July. The female comes ashore to lay her eggs, selecting a spot above the high water mark. She digs a jug shaped hole and lays a clutch of 3 to 7 eggs that have a pinkish cast. She carefully fills in the hole then moves back and forth across the area so that no clue is left as to where the eggs are laid. The young hatch in 90 days.

The diamond back terrapin has always had enthusiasts in the Eastern part of the country. It was eaten by the early coastal settlers. During this same period, turtle meat was being exported back to England, where it became an expensive item of exotica. By the middle of the eighteenth century the demand for turtle both here and abroad led quickly to the near extinction of several species, including the diamondback terrapin, and before the middle of the nineteenth century only the American rich could afford turtle meat. By 1920 the prices for terrapin had grown so high that even the wealthy found prices too much.

Fortunately, through legislation and controlled harvesting the species has been restored to a certain extent.

Several fresh water turtles are marketed in the United States. These are snapping turtle, pond slider, red-bellied turtle, spring softshell, Florida softshell, and the Chinese softshell.

Just as some sea turtles are listed as endangered species, some freshwater turtles are listed as endangered species at times, or there may be a closed season in some areas. These limitations should be investigated prior to collecting turtles.

CHAPTER FOUR

MINCE, SURIMI AND MARINE COLLLIDS

MINCED FISH

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

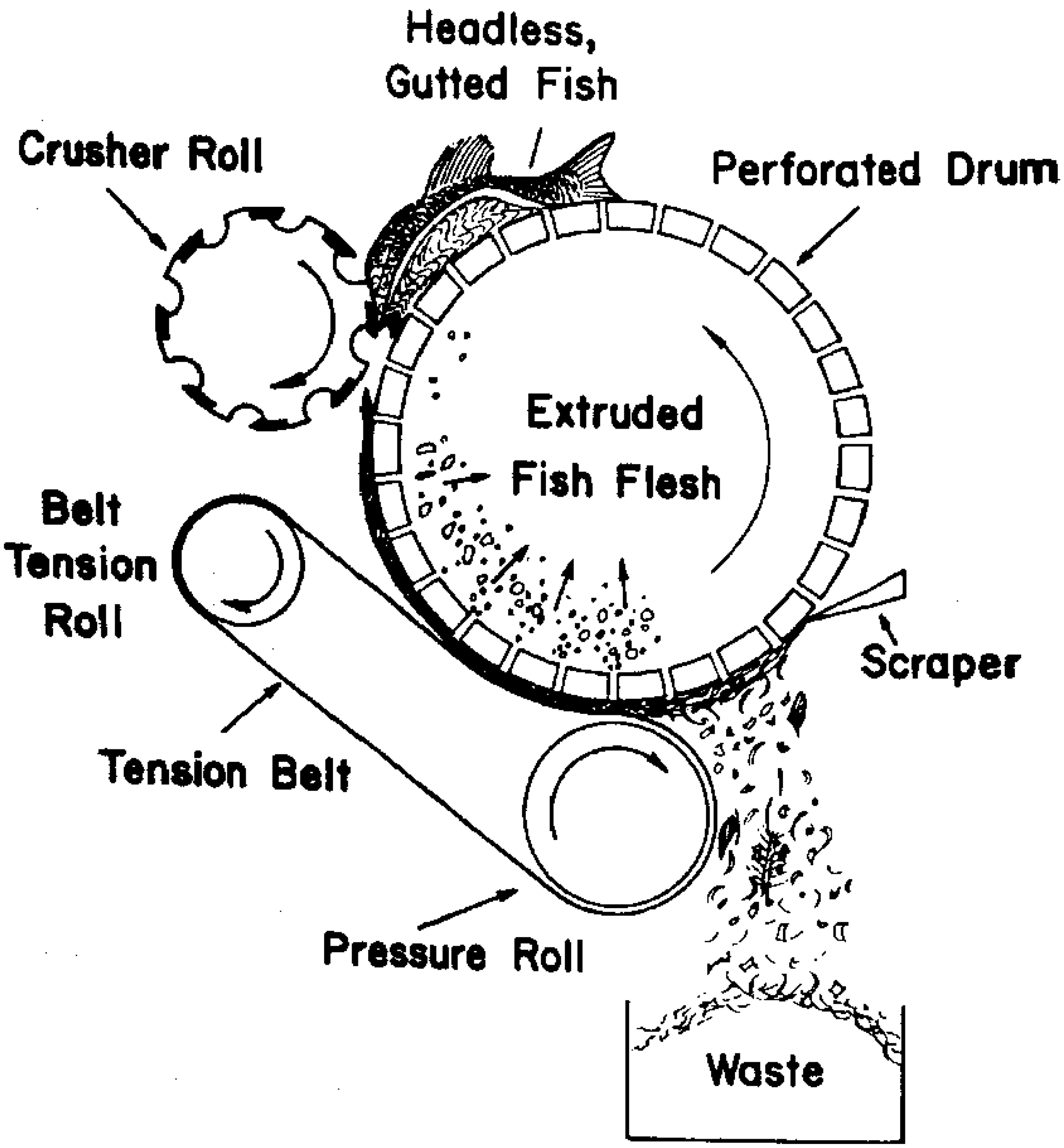
Minced fish, a product akin to a fish hamburger, is obtained by passing fish through a machine that by using extreme pressure, separates soft flesh from the rest of the carcass. The most popular design fo the deboning machine consists of a continuous rubber belt which presses against a large metal cylinder (or drum). The belt and the 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. Because of the pressure of the belt against the cylinder and the shearing action created by the different rates of rotation, the meat is pressed through holes in the cylinder.

The meat is then removed from the machine and the skin and bones are carried out 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. First, deboning machines have the potential to obtain from 50 to 200 percent more usable meat from a given fish than does conventional filleting. This would have significant economic effects as well as facilitating a more efficient use of our fishery resources. Along with higher yields comes lower waste, which has economic as well as environmental significance.

A second factor which makes the process attractive is that the machine will process species that, for reasons of size or anatomy, are not now filleted or used. For instance, small fish don't usually justify the labor involved in processing them, and some fish taste excellent but contain far too many bones to be eaten easily. These under-utilized species could be processed easily into deboned or minced fish. In addition to underutilized species, industrial fish, i.e., those that are currently used for fish meal and fish oil, can be used to make minced fish. But several difficulties must be overcome, including handling due to large catches, small size, and high oil content.

Food-grade waste materials are another source for minced fish. These materials include fish that are too big or too small to process normally, mechanically damaged fish, and bone racks left from filleted fish (Regenstein, 1985). Another advantage is that raw minced fish is extremely versatile and can be blended, stabilized, flavored, formed, used as a stuffing or extruded with numerous other possibilities. Currently there is an effort being made to have fish meat approved for use in meat and poultry hot dogs at a 15 percent addition level (Regenstein, 1985).



MECHANICAL FLESH SEPARATOR

To date, minced fish is still experimental in this country and only a few companies produce commercial products from it. One reason is the expense of the equipment required, and the industry is hesitant 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. For instance, the texture of minced fish 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 with whole fish. Finally, it has not been fully 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.

At Cornell University (Regenstein, 1985), several minced fish products and recipes have been developed and test marketed. A product called Special Sea Sauce, a spaghetti sauce with 30% fish meat was test marketed with limited success. Successful recipes using minced fish include fish tacos, fish chili's and fish curries. Regenstein (1985) says these minced fish products fit the consumer's need for nutritional foods without having an obvious fish character. But that "the next big hurdle is to make a good fish-based sausage, hamburger, meat pattie and/or fish frankfurter and most importantly to successfully introduce it into the market place."

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 other available.

ENGINEERED SEAFOOD PRODUCTS

An engineered seafood product is one that uses 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 artificial 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 and 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 and 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 snack foods are engineered 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, few have been 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 have become more common in this country as lower priced seafood substitutes. These products are better known as surimi-based products and are described in greater detail below.

SURIMI AND SURIMI-BASED PRODUCTS

Over the years, Americans have been exposed to a vast array of new food products, from cool whip to kiwi fruit. In the seafood industry new species of fish or shellfish are being introduced to consumers in different markets or regions. For example, Orange Roughy has made its way from New Zealand to U.S. markets. Recently a number of processed seafood products have appeared in the supermarket. These new seafood products resemble natural seafoods and go by a variety of market names: Sea Stix, Sea Legs, King Krab, Ocean Magic, and Delicasea, to name only a few. Not only are these new products available in the supermarket, many restaurants have added them to their menus.

When you talk with someone about these new products the term surimi usually finds its way into the conversation. Naturally the next question is, "What is surimi?" Surimi is the term given to a Japanese technology developed almost 900 years ago for preserving fresh fish. Surimi is mechanically deboned fish flesh that has been washed with water and mixed with sugar and/or sorbitol for a good frozen shelf life.

According to the FDA, "Surimi is an intermediate processed seafood product used in the formulation/fabrication of a variety of finished seafood products. It is normally traded in 10 kg. frozen blocks which are individually wrapped in waxed cardboard boxes. Surimi is minced fish meat (usually pollock) which has been washed to remove fat and undesirable matters (such as blood, pigments, and odorous substances), and mixed with cryoprotectants (such as sugar and/or sorbitol) for a good frozen shelf life. In formulating finished seafood products, surimi is thawed and blended with other ingredients and additives such as natural shellfish meat, and/or shellfish flavoring, salt, water, and starch and/or egg white; and processed by heat for making fibrous, flake, chunk, and composite-molded consumer products. The finished products are marketed frozen or unfrozen and may be breaded." (Martin, 1985).

Surimi products are generally wholesome and nutritious, although the washing process and the dilution with starches and water result in a product deficient in certain nutrients compared to the original fish from which it was made and also to the seafood it imitates. Table 1 contains a comparison of the nutrient composition of surimi and surimi-based products. Water soluable vitamins and proteins are lost in the production of the surimi. Sodium is added during processing and for flavor purposes. The sodium content varies depending on the manufacturer and averages approximately 780 mg/100 gm in the finished surimi-based product. Since these products require little preparation they should be compared to cooked seafoods rather than raw seafoods (Dudek, 1984).

TABLE 1. NUTRIENT QUALITY OF SURIMI AND SURIMI PRODUCTS (Dudek, 1984)

Nutrient	Surimi	Surimi Products	Shrimp Boiled	King Crab Legs, Boiled	Pollock Broiled	Scallops Microwaves Cooked	Casein
Protein (% USRDA/100g)	34±2	28±2	38	33	30	33	
P.E.R.*	3.25	3.11	2.99	3.09	2.97	-0.78	2.50
Thiamin (% USRDA/100g)	2	2	2	3	2	2	
Riboflavin (% USRDA/100g)	2	2	2	2	2	2	
Niacin (% USRDA/100g)	2	2	11	5	6	4	
Cholesterol (mg/100g)	30±3	26±9	156	43	44	26	
Calcium (% USRDA/100g)	2	2	6	6	2	2	
Iron (% USRDA/100g)	2	2	5	3	2	4	
Potassium (mg/100g)	78±58	94±11	162	135	261	277	
Sodium (mg/100g)	143±28	780±153	169	560	111	94	

* Protein Efficiency Ratio

Summary of Nutrient Quality

1. First there is variation in the nutrient content of seafoods. In general, shrimp is a better source of protein, niacin, calcium and iron than Alaskan king crab legs, scallops or pollock.
2. Secondly, surimi products are excellent sources of quality proteins.
3. Thirdly, the nutrient content of surimi products is similar to the nutrient profile of pollock, the white fish from which it is prepared, although some loss of niacin and potassium were observed.*

Nevertheless, manufacturers maintain that surimi products are a good buy. Consumers get more food and nutrients out of a dollar's worth of surimi products, they say, than from a dollar's worth of the real thing, because surimi foods are generally considerably cheaper (costing from $2.99 to $5.50 a pound) and more consistent in quality that natural seafood. Other advantages are its excellent quality and portion control as well as its ease in packaging. Surimi-based products or imitation seafood must be kept frozen; unfrozen, they have a refrigerated shelf-life of about three weeks (Maritimes, 1983).

The surimi produced for American markets is usually made from Alaskan Pollock (Theragra charcogramma), a species of the cod family that is more plentiful and cheaper than cod. Other species of fish being investigated for their potential use in surimi and surimi-based products include: freshwater catfish, red hake, menhaden, silver hake and croaker. For their domestic market, the Japanese use a variety of species such as shark, sea eel and lizard fish.

The amount of natural crabmeat added when producing the surimi product varies with the manufacturer and can range from 0-35 percent. Snow crab is the species typically used in addition to crab flavors or crab extracts.

Surimi-based products are not only an economical substitute for real seafood, they also can be made without seasonal quality variations. Consumers can buy brand name products and know they are getting quality and consistency (Ryan, 1984). When talking to consumer's about surimi-based products the following recipes are suggested; Crab and Zucchini Casserole, Brandied Crab and Seafood Pasta Salad.

CRAB AND ZUCCHINI CASSEROLE

1 lb. crab meat or sea legs
2 medium zucchini, sliced
1/2 cup chopped onion
2 cloves garlic, crushed
1/2 cup butter
1/8 tsp. pepper
1 tsp. basil
1 1/2 cups shredded Swiss Cheese
1 cup soft bread crumbs
3 medium tomatoes

Cook zucchini, onion, and garlic in butter about 5 minutes until tender. Add seasonings, crab meat, Swiss cheese and bread crumbs. Chop tomatoes, removing seeds. Add tomatoes to first mixture and toss lightly. Place in a glass casserole dish and put in a 375° oven for 30 to 35 minutes or until heated through. Makes 6 servings
Preparation Time: 1 hour.

BRANDIED CRAB

1 pound Maryland backfin crabmeat, cartilage removed
2 tablespoons margarine
1/4 cup fresh parsley, finely chopped
2 tablespoons brandy
1/8 teaspoon salt
1/8 teaspoon white pepper
Pinch nutmeg
Pinch paprika
1 large fresh lemon
1 loaf french bread, sliced thin

In a large skillet or electric wok, melt margarine. Add parsley, brandy, salt, white pepper, nutmeg, paprika and the juice of one lemon. Heat until hot. Add crabmeat and toss lightly to heat and coat. Be careful not to break up lumps. Arrange two slices of bread side by side on each serving plate. Mound crabmeat evenly on each slice of bread. May also be served with crackers as an hors d'oeuvre. Yield: 4 servings.

SEAFOOD PASTA SALAD

1 bottle Italian Dressing
1 cup spiral noodles
1 cup spinach noodles
1 cup plain flat noodles
1 cup cauliflower flowerettes
1 cup broccoli flowerettes
1 cup celery, chopped on diagonal
1 pound seafood-surimi crab meat or flaked meat, cut in chunks if using leg style
1/2 cup green onion sliced
1/2 cup carrots, cut in rounds
1 cup zucchini, sliced thinly
1/2 cup fresh parsley, chopped

Cook pasta until done, rinse in cold water. Prepare vegetables in separate bowl. Add about 1 cup salad dressing to vegetables and toss. Marinate vegetables overnight or for as long as you can before serving. Toss vegetables with pasta and seafood. Arrange seafood pasta on a serving platter.

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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, floculation agents, and antibiotic carriers. As mentioned in the section concerning seaweeds, marine colloids are usually obtained from seaweed and are called phycoccolloids. Following are the four 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 in bacteriology. Another area of major use is an ingredient of bakery icings and glazes. Agar will form firm gels at 1 percent concentrations.

ALGIN

Algin is produced from brown algae, such as Macrocystis pyrifera. 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 (desserts, ice cream and ices, and beverage emulsions) and pharmaceuticals, and has many industrial applications because of 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. In foods, aginates are low viscosity emulsifiers.

CARRAGEENAN

Carrageenan (Irish Moss) is produced from red algae, such as Chrodus crispus, which grow from 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 a 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. The carrageenan reacts with the milk (protein) in these products.

FURCELLARAN

Fucellaran (Danish Agar) structurally resembles carrageenan and the red algae Furcellaria fastigiata is the principal source. Furcellaran is used in dessers and flans and forms firm gels without refrigeration.

Other seaweed extracts include iridophycan, fucordan, hypnean and laminaran. These colloids have not attained commercial prominence as yet because there aren't large enough quantities, they can't compete with other well established colloids, or there isn't enough known about them or how to manufacture them.

FISH PROTEIN CONCENTRATE

The Protein Advisor Group to the United Nations defined fish protein concentrate as follows (Finch, 1977):

> "Fish protein concentrate (FPC) is a stable product suitable for human consumption, prepared from whole fish or other aquatic animals or parts thereof. Protein concentration is increased by the removal of water and in certain cases, of oil, bones and other materials. Traditionally, dried or traditionally-preserved products do not fall within this guideline."

There are three types of FPC; Type A, B, and C. Type A is a solvent-extracted, fine, free-flowing grayish powder with high nutritive values. All types of FPC are not intended for direct consumption, but rather as a protein supplement to various foods. Type A FPC can be used in most foods at a 5-10 percent level without reducing the acceptability of familiar foods (Finch, 1977).

Types B and C contain more fat and are less defined and would therefore add a flavor to food in which it is added. Research investigating possible raw materials, production methods and uses of FPC began in the 1960s and continued into the 1970s quite extensively but ended because of marketing and economic problems and because of a lack of congressional support. There has been no demand in the U.S. for present forms of FPC which cannot be better met by alternative products (Finch, 1977).

Presently, whole raw fish, usually hake, herring or menhaden, are ground and used in the production of FPC. Research has shown 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 was investigated.

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 that extracts most of the water and lipids (fats), thus dehydrating the fish. Depending on the 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.

A number of researchers have investigated the possibility of enzymatically digesting solvent-extracted FPC to improve the functional characteristics of the product (Pigott, 1982). Research is continuing on different enzyme processes and uses such as formulated foods and animal feeds.

The future for FPC is not as exciting as was once thought. Fishing problems, manufacturing problems, market and economical problems and lack of funding have slowed interest and research in FPC.

CHAPTER FIVE

FISHING IN THE MID-ATLANTIC

FISHING IN MID-ATLANTIC WATERS

Fishermen of the Mid Atlantic waters are fiercely independent, competitive businessmen, who have devoted their greatest asset, themselves, to the industry. As fishing resources become stressed by the dense population of the Mid Atlantic states, these men and women must exhibit a versatility unsurpassed by fishermen in most other regions.

The Mid Atlantic is a fisheries transition zone and commercial fishermen of the area must be versatile enough to fish the seasons or to supplement their income with an "on land" occupation. Winters of the Mid Atlantic states turn this region into a Northern-like fishing area with Northern fishing gear. Warm waters during the summer and fall promote Florida and Gulf-type fishing methods and gear. As weather and seasons are never entirely predictable, the feast or famine syndrome of fisheries becomes more pronounced. A too cool spring can delay the blue crab season, to crabbers' consternation. Overly dry or rainy seasons can affect the saline balance of the estuary web, causing spawning areas to be less productive. To counter balance this myriad of factors, the Mid Atlantic fishermen utilize a wide variety of methods and gear to maximize their harvest.

Finfish and shellfish can be harvested by the mechanics of one of the following principles: trapping, spearing and hooking, netting, dredging or tonging, long lining, or hand harvesting. Within these methods, fishermen have designed their gear, by trial and error, to be most productive within their locale.

Although a change in gear is often slow in this occupation of tradition, competition causes even the most independent fishermen to observe the more successful competitor and to then adapt these methods.

TRAPS AND POTS

Crabs, lobster, turtles, eels, shrimp and sometimes fish are caught and held alive in basket-like gear called traps or pots. The backyard of a fisherman during the off season often tells you his occupation. Blue crab pots winter in a stack resembling a modern apartment of chicken wire, hog rings, plastic can lids, inner tube strips, and bleach-bottle buoys. The blue crab trap is a two-foot cube of wire mesh, consisting of two chambers with the lower chamber, weighted or braced, containing a cylinder for bait, usually menhaden. The crab enters one of two funnel shaped entrances to reach the bait, becomes scared at the entrapment and swims upward into the main chamber where it is held until the crab potter lifts the pot, by hand or hydraulic lifter, from the water and dumps its contents onto a culling table. Culling is the process where seafood is divided for sale into size and sex divisions and held in baskets, barrels or boxes.

Corrosion is the enemy of submerged metal, so zinc anodes are often added to delay electrolysis. Plastic coating over the metal is another method.

A crabber may fish 35 to 50 pots from a small boat, or a crew of up to five members may fish several hundred crab pots from a larger bay-built boat. Crab pots are set in various depths of water, attached with a line to an identifiable buoy, depending on the current migratory status of the wandering crab. Pots must be fished within a 12 to 48 hour cycle to avoid crabs injuring one another, due to their aggressive nature.

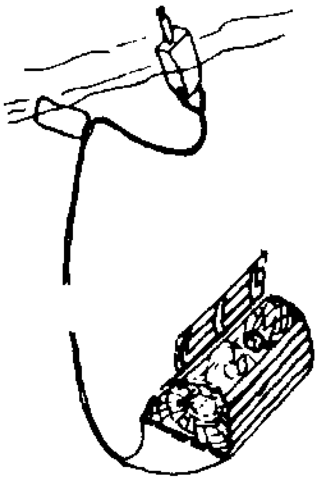
Peeler pots are used to catch crabs in the early molting stage so that they can shed into the soft stage for sale as the soft crab delicacy. The peeler pot is lighter in weight with smaller mesh to catch a crab 2 to 3 inches in length.

Eels are caught in pots that are designed from a 30-inch long cylinder of 1/4 to 1/2-inch square mesh, 8 to 10 inches in diameter. Two entrance funnels of canvas are sewn into place at one end and a trap bag is sewn into the opposite end. The eel pot is baited with horseshoe crab and dropped to the river bottom.

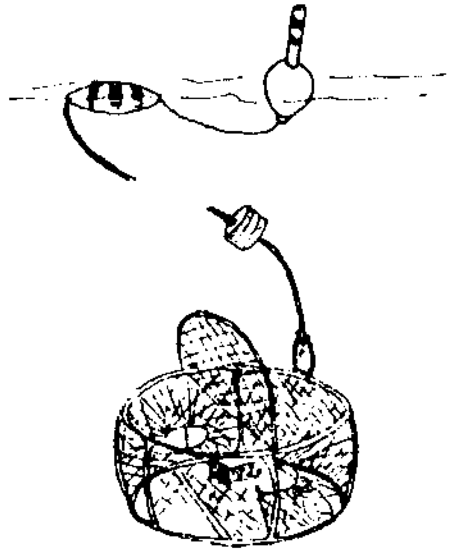
Lobster pots are set New England style as far south as Maryland's ocean. Oblong boxes of wood-lath slats, which are spaced to allow undersized lobsters to escape, have netting arranged in a funnel shape to allow entry but prevent escape. The pots are baited with fish, marked with a buoy and lowered to the bottom. Red crabs, rock crabs and Jonathan crabs are caught along with lobsters in the trap. This is called a by-catch.

The gill net serves as a netting trap for fish. The standing gill net is tied to stakes in shallow waters, rarely more than twelve feet deep. The size of the net mesh is dictated by current conservation restrictions on fishing but is generally 2 to 5 inches. It is checked every 4 to 6 hours and fish removed from the entanglement. As fish get caught, they cannot breathe and "drown", so they must be removed and iced to preserve a quality product.

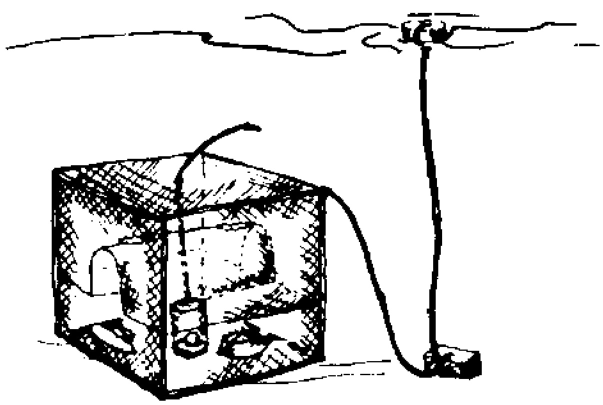
The pound net catches migrating fish in bay and inshore waters. A series of 20- to 30-foot poles are set in place and netting is attached with rings. A chain provides a bottom weight. The net is set in a design that becomes a constructed trap. A "lead" section of 4-inch mesh is 8 feet to 12 feet deep; a "heart" or "head" section of 3-inch mesh is set next; then a tunnel or pound section of 2-inch mesh. The three dimensional pound or tunnel section is the bag or holding section where fish remain penned until small skiffs enter the net and transfer the catch to larger boat



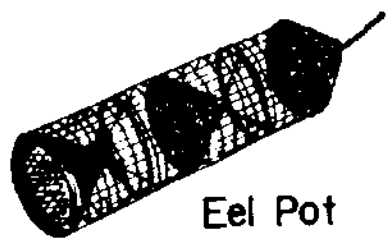
Atlantic Lobster
Pot



Dungeness Crab
Pot



Atlantic Hard Crab Pot



Eel Pot

POTS

NETS

Early fishermen designed nets to trap or capture free swimming fish. The most important or commonly used nets are encircling nets, trawls, and drift nets.

The purse seine is the most important of the encircling or surrounding nets. A wall of net, weighted at the bottom and with floats at the top, is set in a circular shape. Rings along the weighted bottom are threaded with a pursing cable that enables the fisherman to draw or close the bottom of the net entrapping the fish in a purse or pocket-like enclosure. The net is drawn to the boat and the fish are brailed or pumped aboard. A two-boat (East Coast) or a one-boat (West Coast) system of pursing is used to encircle the school of fish with net. Drum seining differs slightly in having a large drum onto which the net is spooled during hauling.

Demersal fish, such as cod and flounder, are most often caught by trawling. A trawl is a conical-shaped net which has a wide mouth and narrows to a sock-type end called the "cod end". Trawl operations are described by the method used to spread the net:

A.) Beam trawl, used in shrimp fisheries, has a long, tapering wooden beam to spread the mouth of the net. The net is secured to the beam and to "D" or "U" shaped runners. The end is not tapered.

B.) Otter trawl is opened by doors or boards which can be described as kite-like devices that open in a horizontal position. The trawl can be set and towed from one side of the boat (East Coast) or it can be shot over the stern and retrieved from the starboard side aft.

C.) Trawls can be identified from the area where they are set and retrieved. Stern trawlers operate nets from the rear or stern of the vessel while side trawlers are designed for nets to be set from the side of the boat.

D.) Mid-water trawling uses a square otter-like trawl to harvest fish that school in mid-depth water.

E.) Two boat or pair trawling describes the fishing of nets by two vessels.

F.) One boat trawling operation involves only one vessel.

LINEFISHING

Squid and swordfish are long-line hook fished in the off shore fisheries of the Mid-Atlantic coasts. For off shore fishing a large (over 40 feet) boat, with one or two large diesel engines, commonly is used. While some fishing continues commercially using pole-and-line gear, the long line and troll line gear is more common. Troll fishing adds the enticement of motion to the bait or lure being used. Simple trolling can consist of one line, but for efficiency, as many lines as possible are used. Out rigger or spreader poles are used to space or divide the lines. Fishing lines are attached by tag lines to the poles, while the other end is weighted with an 18- to 50-pound "cannon ball" weight. Lures or baited hooks are spaced approximately six feet apart, and the lines are fished as the boat moves at a speed dependent on the species of fish sought; the boat motion gives action to the lures.

Long lining uses a simple design of a main fishing line with a number of droppers (gangens or off shoots) to which baited hooks are attached. With this, fish may be caught on the bottom, at intermediate depths or near the surface, depending on where the long line is fished. Weights and floats position the line in the water. A few men can handle a large number of hooks fished over a wide area with this advanced design but simple gear.

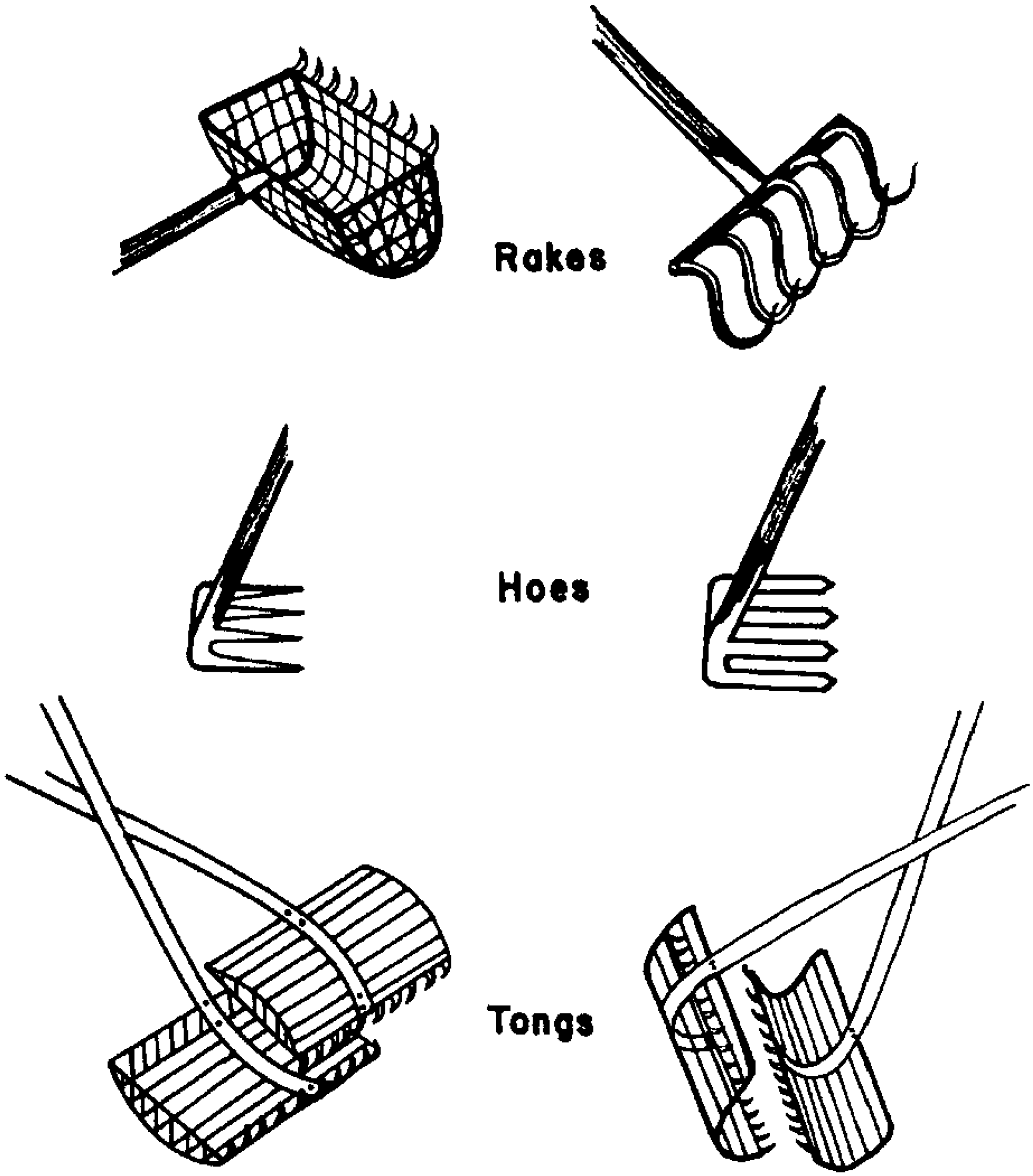
TONGS and DREDGES

A set of hand tongs can extend the arms of the oyster fisherman, so he can reach oysters in water depths of up to 25 feet. Oyster tongs are 3-foot metal rakes on a pair of flexible, white-pine shafts that are joined like the blade of scissors. Human strength and perseverance are necessary in this most taxing of harvest methods. In addition to oysters, the tonger will lift mud, stones, and sand to the surface. Where regulations permit their use, hydraulic systems are available for lifting oysters aboard.

Patent tongs, a mechanical version of the hand tong, are a pair of four-foot bars with 20 to 30 teeth that close mechanically to scrape the bottom for oysters when lifted hydraulically. The clam patent tong rig is similar to oyster tongs. Boats can be rigged to allow two patent-tong systems to operate at once. Usually a separate gas engine provides the power for the hydraulic patent tong system.

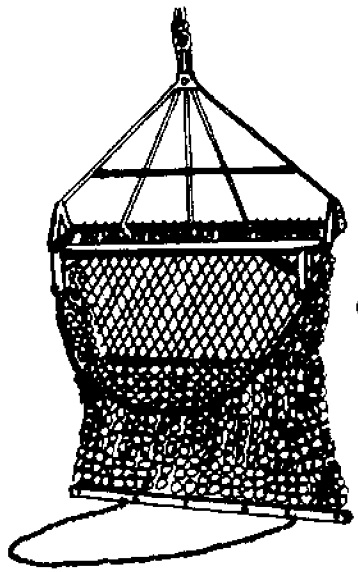
Oyster dredges or drags are an efficient method of oyster harvest. A metal scrape equipped with a tooth bar across the front dislodges the oysters and rolls them back into a chain mesh bag until they can be lifted into the boat. During the dredging operation, the boat is propelled by the wind through a sail or by a diesel or gas screw engine. State regulations determine the power source to limit the efficiency with which the product is harvested. Similar operations are involved in both the oyster and clam harvest.

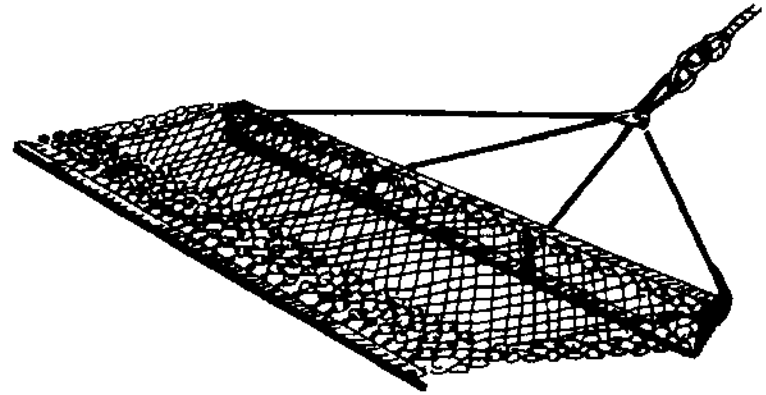
Soft shell crabs are dragged from the bottom by a scrape. A scrape is a triangular iron form two to five feet wide, with a cotton mesh bag about six feet long extending behind. From a small boat the crabber pulls the scrape across the bottom and lifts it into the boat to empty. Hard shell crabs may be caught with a scrape or a dredge. A dredge is a

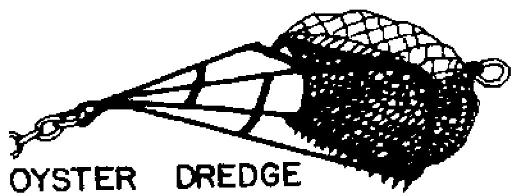


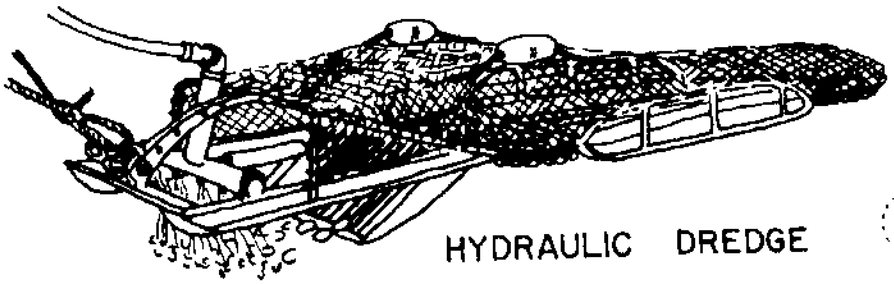
Hand Operated

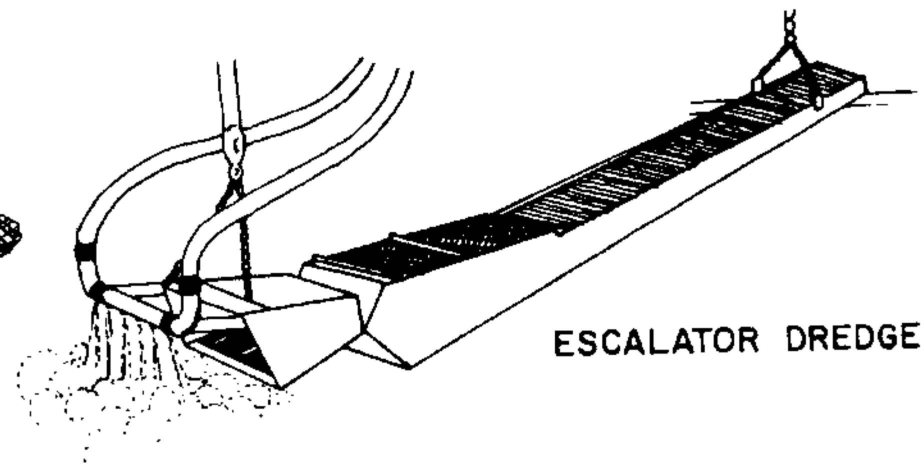
SHELLFISH GEAR


CHAIN DREDGE


BAR DREDGE


OYSTER DREDGE


HYDRAULIC DREDGE


ESCALATOR DREDGE

larger modified version of the scrape. Dredges are pulled by hand or mechanically, depending on the local or state regulation.

Scallops can be harvested from deep water by dredging. Several dredges are pulled behind a power boat in a modification of fishing trawler gear that uses dredges. These dredges can use a cutting bar with no teeth (bar dredges) or be used with a combination of a cutting bar and chain sweep called chain dredges. These dredges have a powerful mouth frame of steel with rings forming the under part of the bag. These dredges may be up to 16 feet wide, and an 11-foot dredge may weigh as much as 1,400 pounds when empty and 4,000 pounds when full.

Dredges used in the soft shell clam industry employ hydraulic or jet gear. With this equipment, clams are washed out of the bottom by high pressure water from a series of nozzles attached to the front of the tooth bars. The clams may be retained in a metal or netting cage, or a conveyor belt may be used to continuously bring the clams on board .

HARPOONING and SPEARFISHING

Like harpooning of whales in the Artic and Antartic, small scale harpooning of swordfish has become a traditional catch method. A four-inch long dart is attached by a rig line to a hand held pole, which can be 10 to 14 feet long depending on the height of the water of a boats stand. The harpoon is attached by a bib line to the boat and to a buoyed high flyer to anchor and buoy the speared fish. Small aircraft are used on the east coast to site the swordfish, but this may be illegal in other areas.

CHAPTER SIX

NUTRITIONAL ASPECTS

NUTRITIONAL ASPECTS AND IMPACTS OF SEAFOOD

The Science of Nutrition is a young science, having developed since the early 1900s. It is not a single science, but one that incorporates organic chemistry, biochemistry, epidemiology and food science, to name a few.

Since the 1960s, the relationship of nutrition to health has been the focal point of U.S. Senate hearings, the development of concensus statements and critical evaluations of epidemiological evidence.

To the surprise of many, seafood has surfaced as a food that is not only nutritious, but apparently able to reduce some of the risks associated with cardiovascular disease and cancer.

What do we know about the nutrient profile of seafood? We have some basic information, but we need to know much more.

I. <u>THE BASICS</u>

A. <u>General Information</u>
<u>The chemical composition</u> of seafood is similar to its animal counterparts. The main components are:
. moisture 66 to 84 percent.
. protein 15 to 24 percent.
. lipids 0.1 to 22 percent.
. minerals 0.8 to 2 percent.
The protein and fat content of fish is inversely related to its moisture content.

B. <u>Protein</u>
1. <u>General Information</u>
a. Chemically, all proteins are made up of four elements, carbon, oxygen, hydrogen and nitrogen. Dietary protein is required as a source of essential amino acids (those the body cannot manufacture) and of the nitrogen needed by the body to manufacture some of the non-essential amino acids and some other nitrogen-containing substances.

b. The protein content of seafood is excellent in quality. The protein efficiency ratio (PER) is greater than that of eggs or casein, the standards.

c. Seafood contains all nine of the essential amino acids:

histidine	phenylalanine
isoleucine	threonine
leucine	tryptophan
lysine	valine
methionine	

d. The <u>three classes of protein</u> found in fish are:

. Scaroplasmic protein (mogen)

- makes up 20 to 30 percent of the total protein content.
- composed mostly of enzymes. Two enzymes unique to fish are thiaminease and amarinase.
- remaining part consists of colored hemocyanin proteins and cytochrome c. These are found in low concentrations in white fleshed fish. Some of these oxygen-carrying pigments cause discoloration, especially during processing. Examples: greening of tuna and the blue or blue/black discoloration in canned crab.

. Myofibrillar proteins

- makes up 65 to 75 percent of total protein content.
- composed of the proteins actin, myosin, tropomyosin, and troponin.
- these proteins control the fibrousness, plasticity, and gel-forming ability of the flesh.

. Connective tissue proteins

- makes up 3 to 5 percent of total protein content.
- composed of collagen and elastin. These are found in the skin and in thin connective tissue layers separating compartments of fish flesh.
- connective tissue denatures and dissolves at 86 F (30 C) which explains the flaking of fish flesh when cooked.

e. Fish scales are scleroproteins of the keratin group

f. The protein content of fish flesh is inversely related to the:
1. fat content
2. water content

Examples of this extreme inverse relationship of water to protein are the "jellied" fish and halibut.

Jellied fish, such as plaice contains more water than protein. Halibut contains more protein than water.

g. The protein content of fish varies within the same species or genus. Example: chum salmon has more protein (21.5%) than pink salmon (19%).

h. The protein content of shellfish varies with the season and stage of spawning. The fat and protein content increases before spawning and decreases after spawning.

i. Crustacean protein is often linked to carbohydrate, thus existing as a glycoprotein. Like shellfish and finfish, crustacean protein meets human need for essential amino acids.

j. The amino acid content of fish protein is influenced by:

   1. Sexual stage. During the development of gonads and eggs or sperm, protein is destroyed by catheptic enzymes (a proteinase found in most cells that take part in self-digestion of tissues).
      During spawning, there is an increase in collagen due to the need to increase the strength of walls so they can hold accumulated eggs or sperm.
   2. Environmental temperatures. The hydroxpraline (an amino acid formed as a result of the decomposition of proteins, especially collagen) content increases as the water temperatures increases.
      The temperature at which a protein splits, called denaturation, is higher in fish from warmer waters.

C. Nonprotein Nitrogenous Compounds

Nonprotein nitrogenous compounds (NPN) are not classified as proteins, because they cannot be chemically precipitated as tissue proteins can. Nitrogenous compounds make up from 0.5 to 1 percent of the total weight of muscles.

The NPN compounds of importance in seafood are:

1. Volatile bases, e.g., ammonium, mono-, di-, and trimethylamine.
2. Trimethylammonium bases; e.g. trimethylamine oxide, betaine.

3. Guanidine derivatives; e.g. creatine, arginine.
4. Imidazole derivatives; e.g. histidine.
5. Miscellaneous compounds; e.g. urea, free amino acids, purines.

NPN Content in Seafood

- Dark fleshed fish: about 21% of the total nitrogen is in NPN. The amount is directly correlated to the degree of morbility, the amount of red muscle, and the season. Red muscle contains the most free arginine and histidine.

- White fleshed fish: contains much less NPN than dark fleshed fish. The NPN found in white fleshed fish includes creatine, creatinine, trimethylamine oxide, anserine and free amino acids. The free amino acids of cysteine, arginine and histidine along with imidazole contribute to the sweet taste of fresh fish.

- Elasmobranches: urea and trimethylamine oxide are present in large amounts in elasmo-branches. Urea is the primary NPN found in muscle and in the blood where it acts as a freezing point depressant. The overall function of urea is osmotic regulation. Urea can be converted to ammonia during storage. The presence of ammonia is a indication of spoilage.

- Crustaceans: contain compounds similar to those found in dark fleshed fish. Free amino acids present include glycine, proline, arginine, glutamic acid and alanine.
  - Mollusks do not contain trimethylanine oxide.
  - Squid contains mostly glycine, scallops mostly alanine and octopus mostly hypoxanthine. All groups exhibit rapid ammonia formation.

NPN compounds have the following functions in seafood:

- Flavor components: free amino acids, such as glutamic acid, glycine, alanine, valine, and methionine have a significant impact on the flavor of seafood. They are especially potent when combined with the energy releasing co-enzymes adenosine monophosphate (AMP), adenosine triphosphate (ATP) and inosine monophosphate (IMP).
- Osmoregulatory functions in the living fish. Ammonia, urea, creatine and trimethylamine oxide are involved in this function.
- Freshness indicator: in the living fish, trimethylamine oxide and trimethylamine are in equilibrium. After death, there is an increase in the amount of di- and trimethylamine due to the breakdown of the oxide to a free base. The base is the principal compound responsible for the characteristic rotten fish odor.

Spoilage indicators

- Ammonia odor is the result of conversion of urea to ammonia.
- Conversion of histidine to histamine by bacterial decarboxylation and autolylic changes. Histamine has been implicated as the causative agent in fish-related food poisonings.

D. Lipids

1. General Information

. Lipid is the chemical name for fats as well as being a group name for organic substances that have fatty qualities. The group includes fats, oils, waxes, and related compounds, such as cholesterol, sterols, phospholipids, lipoproteins, etc.

. Lipids are relatively insoluble in water, but do dissolve in solvents such as ether, choloform and benzene.

. All fats have a relationship to a fatty acid.

. All fatty acids and fats contain the basic elements of carbon, hydrogen and oxygen.

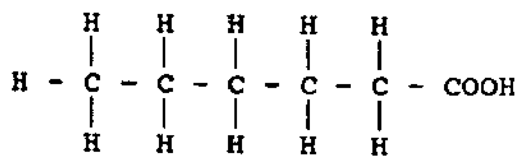
- The three essential fatty acids are arachidonic, linoleic and linolenic.

* Linoleic and linolenic are called essential fatty acids because the body cannot manufacture them and they must be supplied by the foods we eat. Arachonidic can be formed from linoleic.

* The fatty acids linoleic, linolenic and arachonidic are called nutritionally essential fatty acids because they are essential for the complete nutrition of humans. A lack of any of these fatty acids can result in the inflammation of the skin (dermatitis) and/or a failure to grown.

- Fatty acids are also classified according to their degree of saturation.

  * The basic structure of a fatty acid looks like this with a methyl group on one end (CH_3) and an acid or carboxyl group (COOH) at the other:



Methyl group   2 to 20 carbon chain   Carboxyl group

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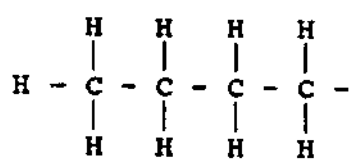
  * When each of the carbons is attached to 2 hydrogen atoms, the fatty acid is called <u>saturated</u>.



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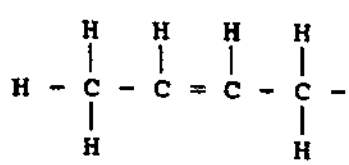
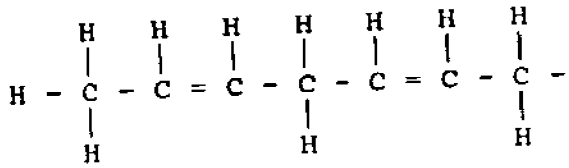
  * When two adjacent carbons are each attached to fewer than 2 hydrogen atoms, the fatty acids in called <u>unsaturated</u>.

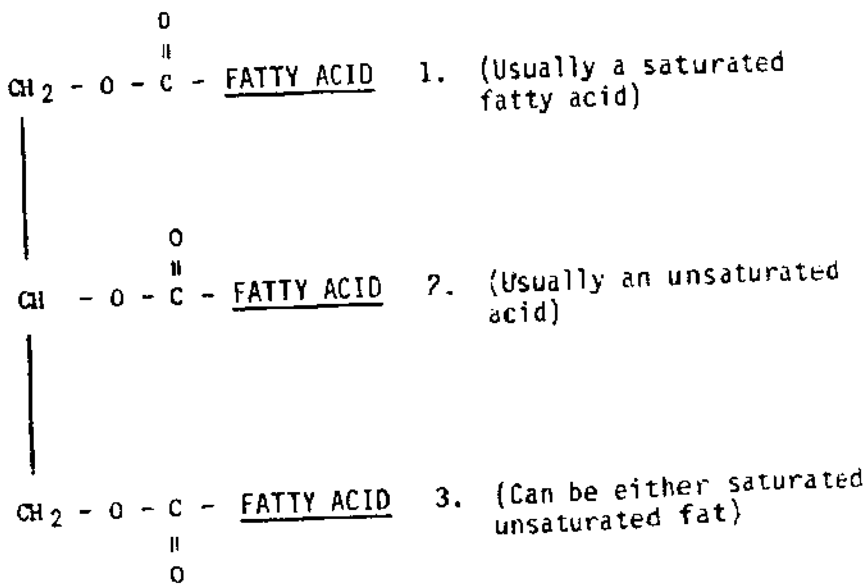


This is an example of a monounsaturated fat because only one hydrogen is missing from each of two carbons resulting in one double (=) bond.



This is an example of a polyunsaturated fat because it contains two or more double (=) bonds.

- Fatty acids are part of the structure of all <u>triglycerides</u>. The backbone of a triglyceride is a 3-carbon alcohol, glycerol. The fatty acids are attached to the glycerol at the carbons position.



Note: not all positions need be taken by a fatty acid molecule. If only one is in place, it is called a mono-glyceride, two a diglyceride. Most natural animal or vegetables fats are triglycerides.

The unsaturated fatty acids of current interest are:

Prostaglandins: a 20-carbon unsaturated fatty acid synthesized in the body from mainly arachidonic acid. Prostaglandins are hormone-like substances and are found in every cell of the body as well as in breast milk.

Eicosapentaenoic acid (EPA) is a 20-carbon chain polyunsatured fat of the omega 3 series (meaning that the first of 5 double bonds is found between carbons 3 and 4 starting with myethyl carbon.

Docosahexaneoic acid (DHA) is a 22-carbon chain polyunsaturated fat with 6 double bonds.

2. Lipids in Seafood

- Lipids make up from 0.1 to 22% of the fish. Lipids are found in liver and viscera as fat deposits and to a smaller extent in the muscle tissue, skin and roe.

- Fish lipids differ from other naturally occurring fats and oils in that they:
  1. have a greater proportion of unsaturated fatty acids.
  2. have larger quantities of fatty acids with chain lengths greater than 18 carbon atoms.
  3. have double bonds beginning at the omega (w)3 rather than the omega (w)6 position.
  4. possess a greater variety of lipid compounds.

LIPID CONTENT OF FISH AND ANIMAL PRODUCTS

FINFISH	TOTAL FAT gm/100gm	TOTAL W-3 gm/100gm	CHOLESTEROL mg/100gm	NON-CHOLESTEROL mg/100gm
LOW FAT e.g. bass, cod, flounder, hake, sole	1-5	.1-1.0	35-80	tr
MEDIUM FAT e.g. Atlantic salmon, lake trout, whitefish	5-10	.3-2.0	20-70	tr
HIGH FAT e.g. King mackerel, sablefish	10-16	.9-2.6	50-100	tr
SALMON ROE	15	---	340	tr
SHELLFISH				
CRUSTACEANS e.g. crab, lobster, shrimp	1-2.5	.2-5	60-160	tr-16
MOLLUSKS mussels, oysters, scallops, squid	1-3.3	.2-1.0	30-140	50-200

FINFISH	TOTAL FAT gm/100gm	TOTAL W-3 gm/100gm	CHOLESTEROL mg/100gm	NON-CHOLESTEROL mg/100gm
ANIMAL PRODUCTS				
LOW FAT e.g. egg white, milk, chicken w/o skin, low fat cheese	1-5	0-.1	0-80	0
MEDIUM FAT e.g. lean beef, turkey, veal	5-10	tr-.1	60-80	0
HIGH FAT e.g. beef, pork, cheese	10-32	.1-.7	70-100	0
EGGS	11	.1	550	tr

- The origin of oil in fish is marine plant life, crustacean and plankton. The degree of unsaturation varies with the diet of the fish.
- Several classes of lipids are found in fish.

- Hydrocarbons (compounds of only carbon and hydrogen elements) may be present in quantities ranging from 0.1 to 90 percent of marine oils. These include a variety of saturated and unsaturated straight (e.g., paraffins) and branched (e.g., squaline and prestane) chained hydrocarbons. Shark oil may be 90% squalene.
- Triglycerides (e.g., triolein, palmitodiolein) are the principle source of fatty acids in fish lipids. Triglycerides are found mostly in fat deposits of the fish. Only 15 to 40 percent of these fatty acids are saturated. Most of the triglycerides are straight chained, even-number in cis figuration. The C_{20-22} series is most common. Common unsaturated fatty acids found in fish lipids are palmitoleic, oleic and linoleic.

- Wax esters are also found in fish oils. They serve as a source of energy. Wax esters are more saturated than unsaturated. They are found in sea anemones, crustaceans, dolphins and many species of fish.
- Phospholipids are found in the body organs and cells. The two phospholipids found mostly in fish are lecithin and phosphatidye ethanolamine. Phospholipids are usually more unsaturated than triglycerides.

- Sterols are another lipid group.

  . Finfish - cholesterol is the only sterol commonly found in finfish. Many finfish have between 30 to 6 mg cholesterol/100 g. Fish roe contains large amounts of cholesterol.

  . Crustaceans - contain either cholesterol or a similar structured compound called non-cholesterol sterols or non-cholesterol marine sterols. Cholesterol ranges from 50 to 160 mg/100 g with non-cholesterol sterols estimated at up to 10 percent of the total sterol content.

. NOTE: Previously analysis measured total sterol content rather than cholesterol only. Since only cholesterol can now be measured separately, the cholesterol content of many shellfish is much lower than originally thought. As a result, a majority of shellfish are now of a low cholesterol diet.

. The content and composition of fish lipids vary depending on several factors.

  - Species
    *Salmon, tuna and herring are classified as fatty fish when they contain 12 to 26% oil.
    *Swordfish, halibut and mackerel are classified as semifatty fish when they contain from 2 to 10% oil.
    *Haddock, sole, cod and place are lean when they contain 0.1 to 1% oil.

  - Fish section
    . Pacific herring - oil from ventral area has more than twice the 20 and 22 carbon fatty acids with one double bond (20:1 and 22:1) than the dorsal area has.
    . Dark muscle fish have a higher oil content than white fish.
    . Liver oil of freshwater fish has a higher content of saturated and unsaturated fatty acids with 18 carbons.

- Sexual Maturation and Following Reproduction
  Fats are depleted because they are used for energy and gonad growth. Not all lipids are used so the composition of remaining fats and oils is affected. For example, unsaturated oils are usually used. Phospholipids are not because they are part of the cell wall. The concentration of free fatty acids in the blood in increased.

- Environmental Temperature
  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 mobility.
  A drop in the environmental temperature can trigger a reduction in the length of the carbon chain of a lipid. This helps the fish adjust to its environment.

- Marine vs. Freshwater Fish Oils
  Marine fish oils have more C_{18}, C_{20} and C_{22} series fatty acids and have a higher bromine content than freshwater fish.
  Freshwater fish fatty acids have more C_{18} and palmitic unsaturated acids than marine fish oils.

- Food Supply
  The foods consumed by fish affects the type of fat found in their flesh. This is of importance in light of 1) the research findings of the role of omega-3 fatty acids in coronary heart disease and cancer and 3) development of aquaculture and greater control of marine feeding.

4. Role of Omega 3 and Omega 6 Fatty Acids in Human Nutrition

- Background Information
  - The body cannot synthesize either omega 3 or omega 6 fatty acids.
  - Omega 6 fatty acids are found in liquid vegetable oils.
  - Omega 3 fatty acids are found in:
    a. seafood as a result of their consuming marine plants (phytoplankton and algae)
    b. green leafy vegetables which contain small amounts of linolenic acid (an omega-3 fatty acid). In the liver, linolenic acid is converted to eicosapentaenoic and docosahexaenoic fatty acids.

c. soybean and walnut oils

. Research Findings

. Cardio-vascular Diseases

General Information

a. Historically, the relationship of omega-3 fatty acids to circulatory disease was based on observations. In 1950, a Seattle cardiologist encouraged by reports of lowering blood cholesterol by fish oils advised his patients to consume fish as a main course three times a week. After following patients for 16 years, he found a four fold decrease in fatal heart attacks in controls compared to the diet group.
Strom and Jensen observed in 1951 a decrease in mortality for circulatory diseases in Norway during the second world war. They concluded that it was due to a reduction in dairy fat intake and an increase in fish.
In 1951 and 1954, medical records on Greenland Eskimos showed that they had a low incidence of cardiovascular disease. Several studies, using this population have been followed.

b. In Zutphen, The Netherlands, the dietary intake of 852 men free of coronary disease 1960 to 1980 was done. During the 20 year follow-up, 78 of the men died of coronary heart disease. Study revealed that death due to coronary heart disease was more than 50 percent lower among those men who consumed at least 30 g of fish per day.
Conclusion: consuming one to two fish dishes per week may help to prevent coronary heart disease.
Reference: Kromhout, D., E.B. Bosschieter, and C. Cor de Lezenne. 1985. The Inverse Relation Between Fish Consumption and 20 Year Mortality from Coronary Heart Disease. The New England Journal of Medicine 312: 1206.

c. Twenty patients with long standing high blood levels of triglycerides were put on three diets differing chiefly in the kind of fat they contained. The diets fed were (1 low-fat, (2 a fish (salmon oil) oil diet, (3 a polyunsaturated vegetable oil diet (mixed corn and safflower oils) and a low-cholesterol diet as the control diet. Results showed that the fish oil diet reduced the triglyceride blood levels markedly in these patients. Reduction was greater than that found in normal subjects. The vegetable oil diet results in an increase in plasma triglyceride

levels. Conclusion: fish oils and fish may be useful in treating persons with high triglyceride blood levels.
Reference: Phillipson, B.E., D. W. Rothrock, W. Conner, E. Harris, S. William, and D. R. Illingworth. 1985. Reduction of Plasma Lipids, Liproproteins and Apoproteins by Dietary Fish Oils in Patients with Hypertriglyceridemia. The England Journal of Medicine 312: 1210.

d. A comparison of 227 daily rations of food from Eskimons and one area of Greenland were compared with that of the Danes. The total fat consumption was similar but the Eskimos had lower saturated and higher unsaturated fat intakes dominated by omega-3 PUFA's. The influence of omega-3 and omega-6 on blood lipids were calculated. Conclusion reached was the omega-3 and omega-6 fatty acids affect the lipoproteins and plasma lipids differently. This finding counted the assumption that all polyunsaturated fat had the same affect on plasma lipid. This study also showed that these Eskimos had lower LDL, VLDL cholesterol and triglyceride levels and the men had higher HDL cholesterol levels.
Reference: Dyerberg, J. 1986. Linolenate Derived Polyunsaturated Fatty Acids and Prevention of Atherosclerosis. Nutrition Reviews 44: 125.

e. Other Related Findings:
- Increased bleeding times and decreased platelet aggregation found in human subjects as a result of increased intake of fish oils. The basis for these changes appears to be a change in the balance between two prostaglandin compounds (thromboxane A^2 and prostacylin) that influence platelet activity. Thromboxane A causes platelet aggregation and prostacyclin prevents aggregation. Severe bleeding not found to be a problem.
- Lowering blood pressure. A two week diet that included a daily intake of 8 ounces of canned mackerel was found to reduce blood pressure in 15 normal subjects. The role of omega-3 fatty acids in this reaction needs to be confirmed.

Breast Cancer
Animal studies have shown that the omega-3 fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) inhibits arachidonic acid metabolism by the cycloxygenase pathway thereby inhibiting tumor production. This has been found to be true for chemically induced and transplanted tumors. Research is continuing in this area.

Vitamins

General Information

Vitamins are divided into two groups:
- Fat Soluble - A, D, E, and K
- Water Soluble - C and B-Complex.

In humans, vitamins regulate metabolism, help convert fat and carbohydrates into energy and help in the forming of bones and teeth. Vitamins are not a source of energy. (See tables at end of this section).

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 melantins, highly polymerized compounds derive 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 groups, 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 salmoids. The ingested pigment helps produce the desirable pink-colored flesh in these species when they are raised in captivity.

FAT-SOLUBLE VITAMINS

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
VITAMIN A	Males 5,000 IU Females 4,500 IU	Liver, kidney, milk fat, fortified margarine, egg yolk, yellow and dark green leafy vegetables, apricots, cantaloupe, peaches. Fish liver oils.	Need for normal growth, development and maintenance of epithelial tissue. Essential for night vision. Essential for health of the eyes. Needed for normal bone development and tooth formation. Toxic in large quantities.
VITAMIN D	Sunlight and normal diet are usually adequate.	Vitamin D milk, irradiated foods, some in milk fat, liver, egg yolk, salmon, tuna, fish sardines. Sunlight converts 7-dehydro-cholesterol to chole-calciferol. Fish liver oil.	Essential for normal growth and development; important for formation of normal bones and teeth. Influences absorption and metabolism of phosphorus and calcium. Prevents and cures rickets and osteomalacia. Toxic in large quantities.
VITAMIN E	8 -T.E. females; 10 -T.E. males Amount needed is related to intake of PUFA.	Wheat germ, vegetable oils, green leafy vegetables, milk fat, egg yolk, nuts.	Is a strong antioxidant. As such may help prevent oxidation of unsaturated fatty acid and vitamin A in intestinal tract and body tissues. Protects red blood cells from hemolysis. Role in reproduction (in animals). Role in epithelial tissue maintenance and prostaglandin synthesis.
VITAMIN K	Not established.	Liver, soybean oil, other vegetable oils, green leafy vegetables, wheat bran. Synthesized in intestinal tract.	Aids in production of prothrombin, a compound required for normal clotting of blood. Toxic in large amounts.

WATER-SOLUBLE VITAMINS

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
THIAMIN	0.5 mg per 1000 kcalories; older person 1.0 mg per day.	Pork, liver, organ meats, legumes, whole grain and enriched cereals and breads, wheat germ, potatoes. Synthesized in intestinal tract.	Prevents beriberi. Essential for growth, normal appetite, digestion and healthy nerves.
RIBOFLAVIN	0.6 mg per 1000 kcalories. Older persons and when intake less than 2000 kcal, 1-2 mg per day.	Milk and dairy foods, organ meats, green leafy vegetables, enriched cereals and breads, eggs. Dark-fleshed fish.	Essential for growth. Essential for health of eyes. Prevents fissures at corners of mouth, around nose, ears, eye irritation, photophobia.
NIACIN	13-18 N.E. or 6.6 N.E. per 1000 kcal. (1 Niacin equivalent [NE] = 1 mg Niacin).	Liver, meat, poultry, many grains, eggs, peanuts, milk, legumes, enriched grains. Synthesized by intestinal bacteria. Mackerel, salmon, sardines, swordfish, tuna.	Helps to release energy from carbohydrates. Prevents pellagra, nervous depression, neuritis. Requirement related to the amino acid tryptophan.
VITAMIN B_6	2.2 mg males; 2.0 mg females.	Pork, glandular meats, cereal bran and germ, milk, egg yolk, oatmeal, and legumes. Synthesized by intestinal bacterial. Tuna, salmon.	Aids in the synthesis and breakdown of amino acids and in the synthesis of unsaturated fatty acids from essential fatty acids. Essential for conversion of tryptophan to niacin. Essential for normal growth.

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
FOLACIN	400 g.	Green leafy vegetables, organ meats (liver), lean beef, wheat, eggs, fish, dry beans, lentils, cowpeas, asparagus, broccoli, collards, yeast, Synthesized in intestinal tract.	Essential for normal development of red blood cells.
VITAMIN G_{12}	3 g.	Liver, kidney, milk and dairy foods, meat, eggs. Vegans require supplement.	Essential for normal red blood cell formation; role in metabolism of nervous tissue. Involved with folate metabolism. Related to certain anemias, especially pernicious anemia. Related to growth.
VITAMIN C	60 mg.	Puerto Rican cherry, citrus fruit, tomato, melon, peppers, greens, raw cabbage, guava, strawberries, pineapple, potato.	Essential for growth. Possibly functions as coenzyme in the metabolism of amino acids, particularly phenylalanine and tyrosine; facilitates conversion of folic acid to folinic acid and is essential for many hydroxylation reactions. Role in tooth and bone formation. Maintains intracellular cement substance with preservation of capillary integrity. Promotes healing of wounds and fractures; and reduces liability tin infections. Enhances absorption of iron. Essential for production of collagen, the basic substance of connective tissue. Related in some way to biosynthesis of steroid hormones. prevents scurvy.

MINERAL ELEMENTS IN HUMAN NUTRITION

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
CALCIUM	800 mg.	Milk and milk products, sardines, clams, oysters. kale, turnip greens, mustard greens, broccoli,	99% in bones and teeth. Ionic calcium in body fluids essential for ion transport across cell membranes. Calcium is also bound to protein, citrate or inorganic acids.
PHOSPHORUS	800 mg.	Cheese, egg yolk, milk, meat, poultry, whole-grain cereals, legumes, nuts. anchovies, snails, catfish, tuna canned in oil.	About 80% in inorganic phase of bones and teeth. Phosphorus is part of every cell and of highly important metabolites, including DNA, RNA, ATP (high energy compounds), and phospholipids. Important to pH regulation.
MAGNESIUM	350 mg for male, 300 mg for female.	Whole-grain cereals, nuts, meat, milk green vegetables, legumes, anchovies, snails, catfish, tuna canned in oil.	About 50% in bone. Remaining 50% is almost entirely inside body cells with only about 1% in extracellular fluid. Ionic Mg functions as an activator of many enzymes and must influence almost all processes.
SODIUM	1100-3300 mg.	Common table salt, seafoods,* animal foods, milk, eggs. Abundant in most foods except fruit.	30 to 45% in bone. Major cation of extracellular fluid and only a small amount is inside cell. Regulates body fluid osmolarity, pH and body fluid volume.

MINERAL ELEMENTS IN HUMAN NUTRITION

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
IRON	10 mg. for male, 18 mg for female.	Liver, meat, egg yolk, legumes, whole or enriched grains, dark green vegetables, dark molasses, <u>shrimp</u>, <u>oysters</u>, <u>dark meat fish</u>.	About 70% is in the hemoglobin; about 26% stored in liver, spleen and bone. Iron is a component of hemoglobin and myoglobin, important in oxygen transfer; also present in serum transferring and certain enzymes. Almost none in ionic form.
ZINC	15 mg.	Milk, liver herring, wheat gran (widely distributed). <u>Oysters</u>, <u>crustaceans</u>.	Present in most tissues, with higher amounts in liver, voluntary muscle and bone. Constituent of many enzymes and insulin; of importance in nucleic acid metabolism.
IODINE	150 g.	iodized table salt, <u>seafoods</u>, <u>hake</u>, <u>striped mullet</u>, <u>squid</u>, <u>haddock</u>, <u>herring</u>, <u>mackerel</u>, <u>clams</u>..	Constituent of thyroxine and related compounds synthesized by thyroid gland. Thyroxine functions in control of reactions involving cellular energy.
FLUORIDE	1.5-4.0 mg.	Drinking water (1 ppm. Fl), tea, coffee, rice, soybeans, spinach, gelatin, onions, lettuce, <u>mussels</u>, <u>sardines</u>, <u>salmon</u>, <u>herring</u>.	Present in bone. In optimal amounts in water and diet, reduces dental caries and may minimize bone loss.

NAME	DAILY RECOMMENDED ALLOWANCES FOR ADULTS	SOURCES	BIOLOGICAL ROLE
CHLORIDE	1700-5100 mg.	Common table salt, seafoods,* milk, meat, eggs.	Major anion of extracellular fluid, functioning in combination with sodium; serves as a buffer, enzyme activator; component of gastric hydrochloric acid. Mostly present in extracellular fluid; less than 15% inside cells.
POTASSIUM	1875-5625 mg.	Fruits, milk, meat, cereals, vegetables, legumes. <u>Finfish</u>, <u>mussels</u>, <u>scallops</u>, <u>clams</u>.	Major cation of intracellular fluid, with only small amounts of extracellular fluid. Functions in regulating pH and osmolarity, and cell membrane transfer. Ion is necessary for carbohydrate and protein metabolism

*Fresh caught seafood is low in calcium.

CHAPTER SEVEN

FACTORS AFFECTING PRODUCT QUALITY

FACTORS AFFECTING THE QUALITY OF FISH

Several factors contribute to the quality of a product before it reaches the consumer. These include species, where the fish was caught, how it was handled and processed. The consumer has no control over these factors. What follows is a review of factors the consumer does have some control over.

The spoilage of fresh fish is a very complex process. No single factor is solely responsible for quality deterioration, rather, it is the result of a number of interrelated changes. As soon as a fish dies chemical, oxidative and bacterial changes begin to take place.

CHEMICAL CHANGES

Chemical changes take place in the tissue of a dead fish because some enzymes remain active after death. After death, a fish loses its defenses against its own enzymes, including the digestive enzymes found in the gastrointestinal tract and the autolytic enzymes found in the tissues. As a result of the activity of these enzymes, it is possible to have spoilage in a completely sterile fish.

It should be stressed that 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 begins.

OXIDATIVE CHANGES

The taste and aroma of rancid fat are due to oxidative rancidity, which is due to the reaction of atmospheric oxygen with the unsaturated sites (double bonds) on fatty acids.

There is a wide variation in the fat content of fish species. Even within a single fish itself, there is a difference in the speed with which different portions undergo rancidity. A seasonal variation in susceptability to rancidity also has been shown.

BACTERIAL CHANGES

Bacterial spoilage is probably the most familiar type of spoilage. Bacteria are found on live fish in the surface slime, intestines, and gills. Once the fish dies, it loses its defense against those bacteria that cause the tissue to decompose. As a result, there is a breakdown of the tissue by the enzymes released by the bacteria thereby producing what is seen as spoilage.

Why are fish so perishable? Marine fish (salt water fish) have within their tissues low molecular weight nitrogenous compounds called osmoregulators, which help the live animal to counter the osmotic pressure created by the salt concentration in ocean water. If these osmoregulators were not present, the salt from the ocean environment would penetrate the animal's tissues, and if the animal could survive, the result would be a meat that was very salty in taste.

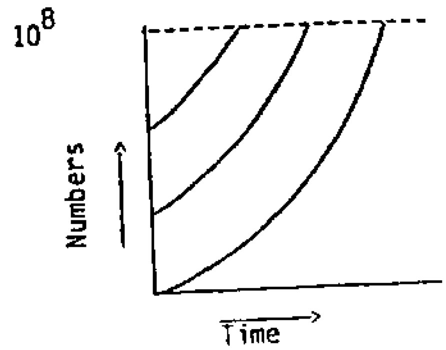
In terms of perishability, the presence of these osmoregulators provide a useable food source for bacteria which allows them to multiply rapidly, thereby making fish very perishable. Animals that do not have these low molecular weight osmoregulators are not as perishable because the bacteria must first breakdown large protein molecules to smaller units so that they can be used as a source of food.

Bacterial growth is slowed by refrigeration, but foods will eventually spoil even in the refrigerator. By reducing the temperature to below freezing, bacterial growth can, for all intents and purposes, be stopped.

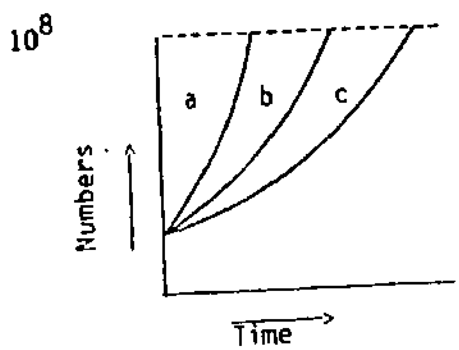
Prior to storage, whether a fish is going to be stored in the refrigerator for preparation within 24 hours or in the freezer for a longer period of time, all fish should be cleaned, including cutting the head off to remove the bacteria associated with the gills, gutting it to remove intestinal bacteria and digestive enzymes and then washing the cavity and the outside of the fish to remove as many additional bacteria as possible.

As shown in the following figure and table, the initial bacterial counts are critical with respect to expected shelf live of refrigerated and iced products and also can effect the quality of thawed frozen products.

A. Initial Number



B. Temperature



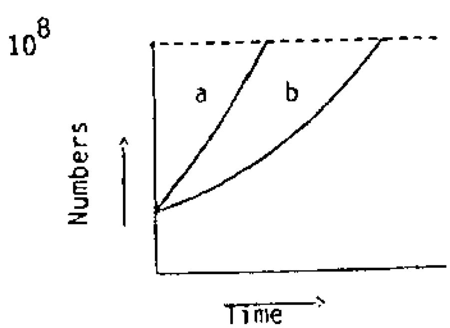
Ratio of product: ice

a - 2:1

b - 1:1

c - 1:2

C. Type of Bacteria



a - *Pseudomonas*

b - *Bacillus*

Factors that affect the rate of bacterial spoilage

SHELF LIFE OF VARIOUS PROCESSED AND UNPROCESSED FISH VS. TEMPERATURE OF STORAGE

Type of Fish	Storage Temperature		
	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.

PREVENTING SPOILAGE IN THE HOME

FRESH SEAFOOD

- Refrigerate in their original wrapper immediately/
- Best storage temperature range to maintain quality is 35 to 40°F.
- Do not hold fresh seafood in the refrigerator longer that two days before cooking.

FROZEN SEAFOOD

- Wrap fresh seafood as described in "How to Freeze Fish".
- Commercially frozen seafood and fish products should be placed in the freezer, in their moisture-vapor proof wrapper.
- A storage temperature of 0°F is needed to maintain the quality of frozen fish.
- Do not hold raw frozen seafood longer than 6 months. Use raw frozen fat seafood within 4 months.
- Label all packages placed in the freezer.

COOKED SEAFOOD

- Cooked seafood should be stored in the refrigerator or freezer.
- If stored in the refrigerator, they should be placed in a covered container. Use within 3 days.
- If frozen, package in moisture-vapor proof wrapping materials. Use within 3 months.

RANCIDITY

The high degree of unsaturation in fish oils causes rancidity. There are two types of rancidity.

1. Hydrolytic rancidity which yields free fatty acids from the breakdown of triglycerides. If an alkaline catalyst such as sodium hydroxide (NaOH) is used, soaps will be formed. The free fatty acids a.) speed up oxidative deterioration, b.) interfere with commercial processing by poisoning any catalyst used and c.) the resulting hydrolyzed fat probably has poor color, off-flavor, and low stability.

2. Oxidative rancidity results in a strong, disagreeable odor anc 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 rancid flavors. This type of rancidity gives highly unsaturated hydro peroxides which are very unstable and breakdown into flavorious compounds. Unstable oils must be protected from catalysts like light, heat, and oxygen. Oxidative rancidity results in the destruction of vitamins A, D, E and K.

The fishy flavor associated with rancidity is due to 1.) the presence of hydroperosides, formaldehyde and volatile bases including trimethylamine and trimethylamine oxide or 2.) the breakdown of oxidized, highly unsaturated fatty acids. The color of rancid oil can be brown or deep red due to the interaction with protein, trimethylamine, or oxidized fatty acid.

To prevent rancidity, the following measures should be taken during the harvesting of fish:

- Whole fish should be iced immediately.
- Fillets should be ice-glazed to keep oxygen out.
- Carbon dioxide or nitrogren atmosphere may be helpful.
- A salt cure is sometimes used 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.

<u>Antioxidants</u> 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 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.

<u>Synergists</u> are often employed to enhance the effectiveness of the antitoxidants. Their mode of action is to chelate metals which act as prooxidants. Phosphoric acid, citric acid, ascorbic acid, ad ascorbyl palmitate function as synergists.

REFERENCES: FACTORS AFFECTING THE QUALITY OF FOOD

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CHAPTER EIGHT

WATER QUALITY

WATER QUALITY

Molluscan shellfish -- oysters, clams, and mussels -- have been popular food items for centuries, and their harvesting is an important part of the seafood industry with a value of over $40 billion. The mollusks are harvested from coastal bays and estuaries along the eastern coast of the United States.

Commercial bivalves, including oysters, clams, mussels and scallops, maintain a steady flow of water through their gills for feeding, respiration, and the removal of waste products. Bivalves feed by pumping large volumes of water over the gills, which act like sieves. Particles become embedded in a mucous material, which is directed to the mouth by ciliary action where it is ingested, digested and waste is eliminated. The contents of the intestinal tract reflects the surrounding water.

Water quality, therefore, is an important factor in the survival and propogation of the animals. In addition, water quality will determine if the animals are safe to eat. The water must meet the mollusks needs for salinity, food, and temperature, and it must be relatively free of silting material.

Man's activities greatly impact water quality. Pollution can cause problems not only with safety but also can affect the survival of the shellfish, especially during certain phases of their life cycles. The sanitary quality of shellfish-growing waters is one of the main determinators in whether shellfish can be safely consumed. Other natural factors, such as the presence of paralytic shellfish poison, are of course important.

It is well documented that bivalves may be vehicles for food-poisoning organisms and toxins. Until the late 1940's *Salmonella typhi*, the causative of typhoid fever, was the organism of most concern. In recent years enteric viruses, particularly Hepatitis A and Norwalk virus, have been the agents of most concern. The majority of food poisonings related to shellfish have been caused by shellfish being harvested from polluted waters. Although, marine vibrios, *Aeromonas sp* , *Pleisomonas* and other marine bacteria have been responsible for sporadic outbreaks.

Public health concerns about contaminated shellfish was first expressed in the late 19th and early 20th centuries. In 1924, typhoid fever outbreaks, which were traced to contaminated shellfish alarmed the industry and public health officials, and the Surgeon General was asked to develop control measures to ensure safe shellfish. In accordance with this request, the Surgeon General called a meeting of representatives from state, municipal and federal agencies, as well as representatives from the industry. The conference developed resolutions for sanitation control of the oyster industry. These recommendations covered beds, plants, and shipping. The National Shellfish Sanitation Program (NSSP) was organized as a result of this conference.

The control of water quality is an important part of the program. Part I of the National Shellfish Sanitation Program's manual covers Sanitation of

Shellfish Growing Water. The second draft became available in June 1985. Sections covered in the manual include:

1. General Administrative Procedures
2. Laboratory Guidelines
3. Growing Area Surveys and Classifications
   a. Sanitary Surveys
   b. Classifications - approved, conditionally approved, restricted, and prohibited
   c. Control of marine biotoxins
4. Controlled Relaying
5. Control of Harvesting

Depuration is covered in Part II of the manual.

Shellfish growing area classification studies may be divided into two parts: the sanitary survey and the bacteriological survey.

The sanitary survey is often referred to as "Walking the Beach". It provides an overall view of pollution types, sources and volume. Hydrographic data on water flow and rainfall data are also important. Daniel Hunt, formerly of USFDA, compared the sanitary survey to the low power objective on a microscope in that it provides an overall view. The sanitary survey is the key to accurate classification of growing areas. The main part of the survey includes: evaluation of pollution sources, meteorological and hydrographic factors that affect distribution of pollutants. Sources of pollution include: malfunctioning septic tanks and package treatment units, municipal and industrial waste, and non-point source pollution (agricultural operations, storm water and urban run-off). Examples of meteorological and hydrographical data include: tidal amplitude and types, water depth, salinity, rainfall patterns and prevailing winds' effect on tides.

The bacteriological survey was compared to the high power objective in that it defines the level of viable sewage organisms in terms of indicator equivalents. Indicator organisms are used to assess sewage contamination and the possible presence of pathogens. They have been used since 1982, when Schardinger tested water for the organisms, now called Escherchia coli, instead of Salmonella typhi. It is physically and economically impossible to test water or food for the presence of all possible pathogens which might be present due to sewage contamination. Pathogens occur sporadically in sewage and the absence of one pathogen does not guarantee the absence of others. In addition, with respect to shellfish viral agents, those such as Hepatitis A and Norwalk, have been of primary concern. However, methodology to detect these pathogens is only now being developed. Therefore, indicators are used to detect the presence of sewage and by inference, the possible presence of pathogens.

There are certain criteria which determine the value of an indicator.

A. It should always be associated with feces and/or pathogens
B. It should be easy to grow and differentiate from non-fecal microorganisms
C. Its survival in water or food should reflect that of fecal pathogens

D. It should not be present as a natural contaminant
E. It should not multiply well in water

While single microorganisms or groups of microorganisms meet all the requirements of an ideal indicator, historically coliforms have been the most widely used indicators of sewage. Coliforms are defined as all aerobic or facultative anaerobic, Gram-negative nonspore forming rods that ferment lactose with the formation of acid and gas within 48 hours at 35°C. The term coliform was first coined in 1901 by British microbiologists to describe E. coli. It has no taxonomic validity. Organisms included in the coliform group include: the genera Escherichia, Enterobacter, Erwinia, Citrobacter, and Klebsiella. In addition certain oxidase positive marine bacteria such as Aeromonas species and Bacillus species may give positive coliform reactions.

Historically, the coliform standard was used to classify shellfish waters. Part I of the Manual of Operations of the National Shellfish Sanitation Program (NSSP) states that for approved waters "The coliform medium Most Probable Number (MPN) count of the water does not exceed 70 per 100 ml and not more than 10 percent of the samples ordinarily exceeds an MPN of 230 per 100 ml for a 5-tube dilution test (or 330 per 100 ml, where the 3-tube decimal dilution test is used) in those portions of the area most probably exposed to fecal contamination during the most unfavorably hydrographic and pollution conditions".

Put more simply - for an area to be approved for shellfish harvesting, the median coliform content should not exceed 70 per 100 ml during the worst conditions. The NSSP estimates that each person contributes 160,000,000,000 coliforms per day to municipal sewage. Therefore fecal material from one person has to be diluted in 8 million cubic feet of coliform free water to meet the standard. In more graphic terms this amount of water is the volume of water in a four and one-half foot deep cove one quarter of a square mile in area. The standard may seem excessively restrictive, but a large safety margin is built in because of the small sample size and relative small number of samples taken during a year.

The use of the coliform group as a fecal indicator was widely criticized because coliforms are ubiquitous in nature and are not limited to the fecal habitat. It is extremely difficult to relate coliform levels to sewage contamination when elevated numbers are caused by contamination from land and plant bacteria. To overcome this criticism the use of fecal coliforms was suggested. They may be defined as any Gram-negative facultative anaerobic nonsporeforming rod-shaped bacteria that ferment lactose containing media with the production of acid and gas at 44.5 or 45.5C. Again, the term fecal coliform has no taxonomic validity and, as defined, are not necessarily of fecal origin. Escherichia coli is considered to be the principal fecal coliform, often comprising 95-98 percent of the fecal coliform population. Some strains of Klebsiella and Enterobacter may produce positive fecal coliform reactions, especially during the summer in water along the Gulf of Mexico. The fecal coliform standard for shellfish harvesting waters is 14 per 100 ml of water and not more than 10 percent of the sample can exceed an MPN of 43 for a 5-tube MPN. This was determined by Hunt and Springer who examined the correlation between coliforms and fecal coliforms in samples taken along closure lines. Most states have adopted the fecal coliform standard.

GROWING AREA CLASSIFICATION

Shellfish growing areas are classified as approved, conditionally approved, restricted and prohibited. Approved, conditionally approves and restricted are classified on the basis of sanitary or marine biotoxin survey information. All waters not surveyed are designated as prohibited. A permanently closed safety zone is established adjacent to any sewage treatment plant out-fall, or other wastes. An area's status can be revised upward if supported by appropriated data.

APPROVED AREAS.

Growing areas may be designated as approved when the sanitary survey and marine biotoxin surveillance data indicates that fecal material, pathogenic microorganisms, poisonous and deleterious substances are not present in the area in dangerous concentrations. The areas must meet either the coliforms or fecal coliforms standard and the classification is based on a minimum of 15 samples. In general, sampling for specific chemical contaminants in shellfish is conducted only when a sanitary survey indicates that a problem might exist.

CONDITIONALLY APPROVED AREAS.

Growing areas that are subject to intermittent microbiological pollution may be classified as conditionally approved. This classification is used when the water is affected by a predictable pollution event such as performance standard for a waste treatment facility. Other events include seasonal population, non-point source pollution or sporadic use of a dock or harbor. The factors determining the periods of pollution must be know, predictable and fairly simple to manage. A written management plan is required for each area. The management plan includes evaluation of potential sources of pollution, performance standard for the sources of pollution, procedure for monitoring pollution sources, controls to prevent illegal harvesting, and alert systems for notifying the shellfish control authority for closing and reopening an area. The conditionally approved area must be evaluated at least yearly. A closed area safety zone should be placed between the conditionally approved area and pollution sources. The size of the zone is based on flow time through the safety area. The time should be twice the time needed for the notification process to become effective.

The use of conditionally approved areas allows for the harvesting of shellfish from areas that would otherwise be closed. A quick response time is essential for the process to work. Intermittent pollution has been a significant cause of shellfish bone disease around the world.

RESTRICTED AREAS.

An area may be classified as restricted when the sanitary survey indicates a limited degree of pollution. These areas may be used for harvesting shellfish for purifying or relaying. The levels of pollution must be such that the shellfish are safe after proper relaying or depuration.

Shellfish have the ability to cleanse themselves of certain contaminants when placed in clean water. The rate is dependent upon the species and environmental conditions. Commercially, two methods -- relaying and depuration -- are used for controlled purification.

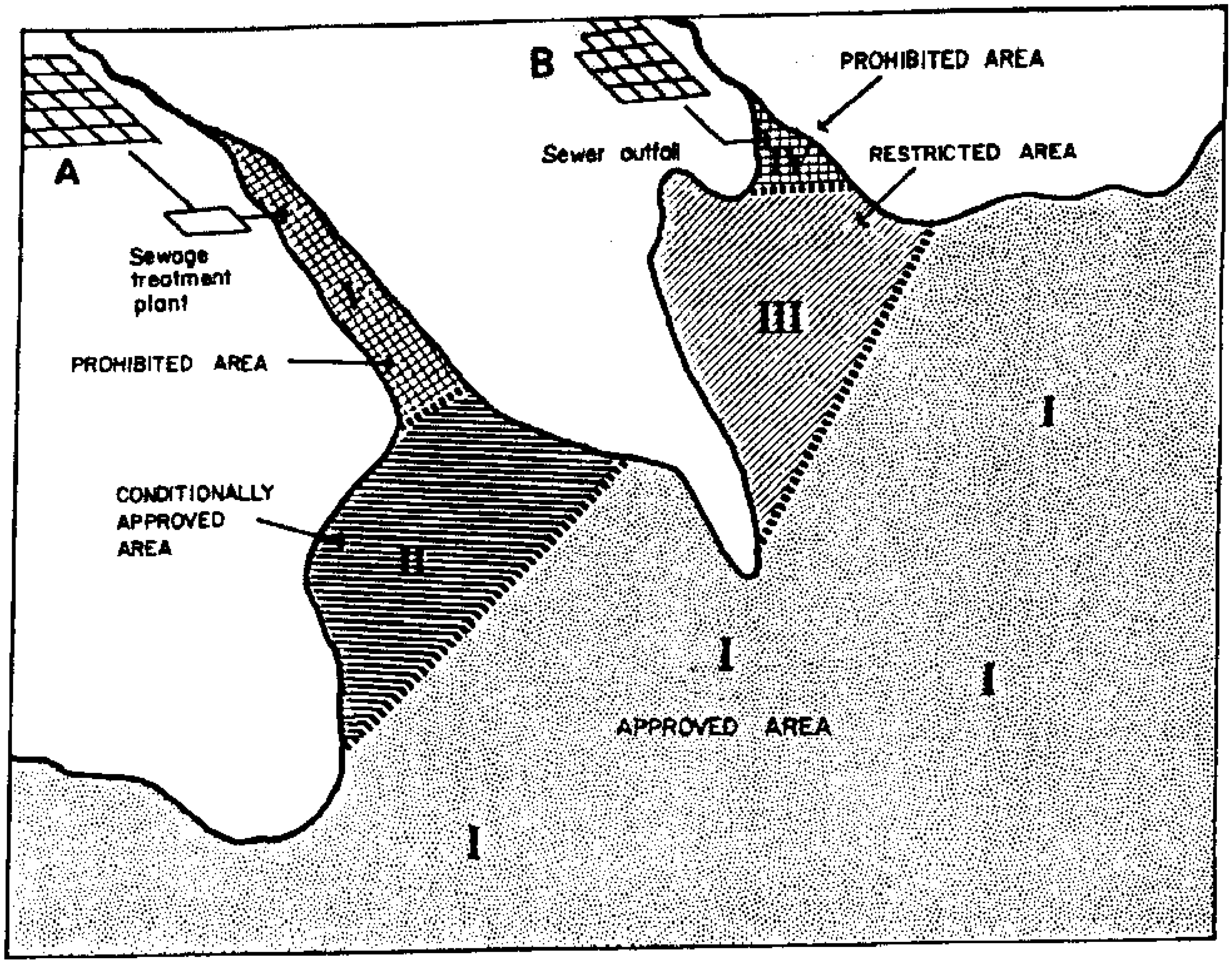
Relaying is simply transferring the shellstock from restricted areas to approved areas for natural purification. Shellfish must remain in the approved area for at least 14 days. Water temperature and salinity are critical factors and it is important to have conditions where the shellfish are pumping. The temperature should be above 45 to 50°F. Relaying will not remove heavy metals. However, in restricted areas the heavy metals from sewage should not be a problem.

Depuration is the other way shellfish are allowed to cleanse themselves commercially. The shellfish are harvested from restricted water and placed in plants designed for depuration, which occurs within 48 hours. The Food and Drug Administration has issued coliform and fecal coliform standards for restricted areas used as a source of shellstock for controlled purification. The standards state: "The total coliform median or geometric mean MPN)most probable number) of the water does not exceed 700 per 100 ml and not more than 10 percent of the samples exceed an MPN of 2,300 per 100 ml for a 5-tube decimal dilution test (or 3,300 per 100 ml for a 3-tube decimal dilution test); or "The fecal coliform median or geometric mean MPN of the water does not exceed 88 per 100 ml and not more than 10 percent of the samples exceed an MPN of 260 per ml for a 5-tube decimal dilution test (or 300 per 100 ml for a 3-tube decimal dilution test)". In comparison to some countries, these standards are rather strict. For example, in Australia all oysters are depurated. There is no restriction on the source of the shellfish. The standards are somewhat restrictive because of concern over depuration of viruses. Also at this level of contamination, heavy metals and other sewage related problems should not be a problem.

The Food and Drug Administration has also established microbiological indices for depurated products. For soft clams (*Mya arenaria*) the geometric means of the sample should be 50 fecal coliforms per 100 gram with no more than 10 percent having a geometric mean count of 130 fecal coliforms per 100 gram. The fecal coliform counts for hard clams (*Merceneria merceneria*) and oysters (*Crassostrea virginica*) should be 20 or less per 100 gram with no more than 10 percent having counts of 70 fecal coliforms per 100 gram.

PROHIBITED AREAS.

A shellfish growing area is classified as prohibited if there is no current sanitary survey or the monitoring studies indicated that fecal



SHELLFISH GATHERING AREAS

material, pathogenic organisms, poisonous or deleterious substances, marine biotoxins, or radionuclides may potentially be present in excessive concentrations. With respect to paralytic shellfish poison (PSP) the area is closed when the concentrations of PSP reaches 80 micrograms per 100 gram of edible raw shellfish or when neurotoxic shellfish poison is found in detectable levels. No shellfish are permitted to be harvested from prohibited areas.

Control of Areas due to Marine Biotoxins. In the latest edition of NSSP's Manual of Operations, there is a separate section for control of areas where shellfish harvesting is periodically influenced by the presence of paralytic shellfish poison or neurotoxic shellfish poison (formerly called ciguatera-like toxin). State shellfish control agencies are responsible for testing the shellfish whenever the growing areas are likely to be affected. The limits are 80 micrograms of PSP per 100 grams and/or detectable amounts of neurotoxic shellfish poison. These limits provide a fairly large safety factor. Epidemiological studies indicate that 200 to 600 micrograms of PSP will produce symptoms. Therefore, the limit of 80 micrograms per 100 gram should provide a safety factor.

Paralytic shellfish poisoning is caused by ingestion of mollusks which have ingested toxic. The toxin is not lethal to the mollusks but is toxic to higher organisms that eat the shellfish. The toxins accumulate mostly in the digestive tract, and symptoms usually develop within 30 minutes of ingestion. Paresthesia (described as tingling numbness or burning) is first felt about the mouth, lips and tongue, but it later spreads over the face, scalp and to the tip of fingers and toes. Coordination is affected and the victim may seem drunk. Incoherent speech is also a common symptom. The fatality rate is 1 to 10 percent. In fatal cases, death usually occurs within 12 hours due to respiratory failure and cardiovascular collapse.

Neurotoxic shellfish poisoning is associated with bloom of *Psychodiscus brevis* and produces symptoms similar to cigutera. It is more associated with Gulf coast areas. Neurotoxic shellfish poisoning is different than PSP.

Shellfish are defined as all edible species of oysters, clams, or mussels either shucked or in the shell. Some of the bivalves the Food and Drug Administration includes in their definition are:

Cockle, *Clinocardium nuttalli*, *Cardium corbis* (Pacific)
Geoduck, *Panope generosa*
Freshwater clam, *Rangia cuneata*
Soft shell clam, *Mya arenaria*
Hard (quahog) clam, *Mercenaria mercenaria* and *Mercenaria campechiensis*
Surf clam, *Spisula solidissima*
Mahogenay or Ocean quahog clam, *Artica islandica*
Gaper or Horse clam, *Tresus nuttalli* and *T. capax*
Razor clam, *Solen resaceus*, *Ensis Directus* (Atlantic)
Solen viridis, *Tagelus phebefus* and
Silliqua patula Pacific)

Bent-nose clam, Macoma nasuta
Piso Clam, Tivela stultorum
Butter clam, Saxidomusmus giganteus
Calico clam, Macrocallista maculata
Sunray venus, Macrocallista nimbosa
Pacific little neck clam, Protothaca tenerrima
and Protothaca staminea
Manila clam, Tapes semidecussata
Pacific (Japanese) oyster, Crassostrea gigas
Eastern oyster, Crassostrea virginica
Olympia or yaquina oyster, Ostrea lurida
European oyster, Ostera edulis
Blue or bay mussel, Mytilus edulis
California sea mussel, Mytilus californianus
Green lipped mussel, Perna canaliculus (New Zealand)

CHAPTER NINE

AQUACULTURE

MIDATLANTIC AQUACULTURE POTENTIAL

Aquaculture, or "fish-farming" as it is also known, offers an alternative to the traditional means of gathering seafood and that is through the harvest of fish and shellfish from a controlled environment. This approach to collecting aquatic animals is not unique and actually has been practiced for more than 5,000 years. Many early cultures, particularly the Orientals, Romans and Egyptians, constructed ponds and reared fish in a manner similar to the way we do today.

Properly defined, aquaculture is the farming and husbandry of aquatic organisms. It can be equated with traditional farming techniques of agriculture such as fertilization, manipulating proper stocking density (seed application rates), and improved growth and harvest through genetic manipulation.

A fish-farmer generally manages his crops by selecting the best environment for his crop, which can be a variety of ponds, tanks and pens or cages and then applies the proper amount of fertilizer, treats for noxious weeds, and attempts to control parasites and disease. At the same time, he must stock (seed) the proper number of fish to avoid exceeding the water's carrying capacity. Unlike land dwellers, most fish cannot breathe oxygen; their oxygen is dissolved in the water. There is only a certain amount of oxygen that water can hold in a dissolved state under normal conditions, and that level is directly related to temperature and the amount of organisms in the habitat. Therefore, the biggest difference between aquaculture and aqriculture is that crops are grown in the water instead of on the land.

Many species of both fresh and salt water fish and shellfish are raised commercially today throughout the world. However, despite the vast numbers of fish reared in aquaculture environments, most fish food products eaten in the United States are from wild harvests.

Farm raised products can be an answer to one of the more serious problems associated with world hunger today and that is dietary protein shortages, most particularly animal protein. In comparative efficiencies, fish are better converters of food to flesh than chicken (up to twice as efficient) and beef cattle (up to ten times as efficient). This fact is even more important when you consider that fish can take advantage of foods that are not commonly used by land animals.

In addition, because of their physiological nature (cold blooded), fish do not have to expend energy in an effort to maintain body heat as do mammals and birds. Thus more of their relative energy inputs (food) can be used in growth instead of maintenance. Thus fish require less food to live compared to land animals. In comparison, when fish are given the right kinds of environments (i.e., temperature, pond fertilization, oxygen levels and feeding) yields can equal 6,250 pounds per acre where beef cattle yield approximately 1,000 pounds per acre.

The two basic forms of aquaculture are intensive and extensive culture. Intensive culture simply means that the culturists or farmer must pay closer attention to their crop as most of the culture is undertaken in tanks or under very crowded conditions. Intensive culture requires considerable technical training and is usually labor intensive. More often than not, intensive culture is performed indoors under environmentally controlled conditions. On the other hand, extensive culture is usually less "intensively" managed and usually requires less expertise to produce a crop. Extensive culture is usually undertaken in ponds or in pens or cages placed in rivers or lakes.

The biggest advantage aquaculture has over wild harvest is quality control of the product. Aquaculture allows a continual supply of the product and can cater to the preferred product size. Most often the quality of the meat is much better as the product is delivered straight from the pond to the market and does not spend several hours in the hold of a vessel. Just as important is that there is rarely an off flavor or strong fishy flavor associated with farm raised fish or shellfish.

Another major advantage of aquaculture is in the control of disease. Obviously a fish farmer will want to keep his animals free of disease and parasites because of the potential economic losses, and this results in a more appealing product for the market.

There are a variety of species farmed in the United States today. These include trout, salmon, catfish, tilapia, striped bass and hybrids, crawfish, crabs, oysters, clams, prawns, shrimp, sturgeon, eels, lobsters, turtles, and a host of other fish and shellfish. Many of these species are very profitable and comprise a considerable portion of the total seafood eaten today in this country. Some of the species have been, until recently, accepted only on a regional basis (i.e. catfish and crawfish). However, many national restaurants and retail food markets have realized the potential of these products and have begun national promotion campaigns.

Aquaculture is widely practiced throughout the world, especially in the Orient, Asia and third world countries. In fact, the Untied States lags far behind other countries in aquaculture production. However, with the severe declines in natural stocks and the harvest restrictions being placed on wild harvest, aquaculture may become more important in the future. This is even more evident as the general public becomes more aware of the advantages of eating fish for health reasons. Just as important from an economic viewpoint is consumers' increasing demand for fresh fish. This increased demand will only further promote local aquaculture and reduce the large imports of seafood products into the United States today.

CHAPTER TEN

FOOD PRESERVATION

CANNING SEAFOOD

As with all other low acids foods, seafood must be canned using exclusively a pressure canner to prevent the danger of botulism poisoning. Processing seafood at 10 pounds pressure for a designated time period should destroy the Clostridium Botulinum organism. In addition to using the correct equipment and procedures, sanitary food handling methods are essential.

EQUIPMENT

JARS

It is very important that the jars used for canning are meant for canning. Other jars may break under pressure or fail to seal correctly.

Wide-mouth standard canning jars in either pint or half-pint sizes should be used. Adequate processing cannot be assured for jars larger than one pint.

Before using, all jars should be washed in hot soapy water and rinsed in hot water. There is no need to sterilize the jars before packing. This will be accomplished during the processing time.

All jars should be checked for cracks or nicks on the rim which will prevent proper sealing.

LIDS

Only a two-piece (lid and band) lid should be used. If the bands are free of dents, nicks or signs of corrosion, they may be re-used after being thoroughly washed. Lids should not be used more than once. New lids should be used yearly.

PRESSURE CANNER

A pressure canner consists of a heavy kettle with a lid which can be clamped or locked down to make a steam-tight seal. The canner lid has three important features:

- a safety valve
- a vent or petcock
- a pressure gauge, which can be either in the form of a dial gauge or a weighted gauge.

Each of these features has a major function in assuring the proper working order of the pressure canner.

Safety Valve is designed to pop should the pressure inside the canner reach a point to where the canner could explode. TO MAKE SURE THAT NEITHER THE SAFETY VALVE NOR THE PETCLCK BECOMES CLOGGED, A PIPECLEANER SHOULD BE PULLED THROUGH BOTH BEFORE USING THE CANNER.

Vent or Petcock allows steam to escape under a controlled pressure. The pressure inside the canner exceeds the boiling point of water. At ten pounds pressure, the temperature will reach 240°F, which is high enough to kill bacteria. The maintenance of this pressure requires the release of pressure via the petcock.

Dial Gauge or Weighted Gauge registers the amount of pressure in the canner. A dial gauge must be checked periodically for accuracy. An incorrect reading will result in either under- or over-processed food. If a dial gauge reads 5 pounds too high or too low, it must be replaced. Dial gauges can usually be checked by your county extension home economist.

Weighted Gauges do not require checking, but it is important to remember that the petcock on which it is placed not be clogged and that the gauge is placed for the needed amount of pressure.

To assure tight fit, the lid is equipped with a gasket. This gasket must be properly cared for and checked for cracks and other changes that can prevent it from providing a tight fit.

The kettle of the pressure canner must be equipped with a rack that will permit the circulation of steam around all sides of the jars and prevent the jars from hitting each other during the processing time.

GUIDELINES FOR OPERATING A PRESSURE CANNER

It is very important that before a pressure canner is used, that the canner manual be read carefully. What follows are guidelines that generally apply to all pressure canners.

1. Place the rack in the bottom of the canner.
2. Pour 2 to 3 inches of water in the bottom of the canner.
3. Place properly filled jars on the rack, making sure the jars do not touch.
4. Check the vent opening, the rim of the canner and rim of the lid to make sure they are clean.
5. Place the lid on the canner, following the manufacturer's directions.
6. Pressurize the canner. This is done by leaving the vent open, heating the canner until a steady flow of steam comes through the vent. The steam should be permitted to flow continuously for 10 minutes. At the end of the 10 minutes, the vent is closed or the weighted gauge is put in position. Check your manual to make sure you pressurize your canner properly.

7. Once ten pounds pressure has been reached, start counting the processing time. It should be mentioned that when using a weighted gauge, the time should be noted when the gauge begins to jiggle.
8. During the processing time the appropriate pressure must be maintained. This is done by controlling the heat under the canner. Ten pounds pressure must always be indicated on the dial gauge and the weighted gauge should jiggle two to four times per minute.
9. As soon as the processing time has been reached, turn off the heat. If using an electric range, the canner needs to be removed from the burner to avoid continued processing.
10. Allow the canner to cool at room temperature. Cooling the canner quickly can result in the liquid contents of the jars being forced out of the jars, or the jars breaking due to the "thermal shock".
11. Canners with dial gauges must read 0 pounds of pressure before attempting to remove the lid. Canners with a weighted gauge should be cooled at least one hour before attempting to remove the lid. If steam flows when the gauge is gently moved, the canner needs to be cooled a little longer.
12. Remove the lid. To avoid burns, life the lid up and away from you so that any remaining steam will not come in contact with your skin.
13. Remove the jars with a jar lifter and place them on a cooling rack. Allow space between the jars to permit adequate circulation. Do not place jars directly on a counter top or in a draft.
14. When cool, check the jars to make sure they have sealed. First remove the bands. The lid can be pressed to make sure they are curved down and do not move. The center of the cover can also be tapped with a spoon. A clear sound, as opposed to a clunk-type sound, should be heard.

CANNING INSTRUCTIONS

A review of several reliable references shows the need for giving the following precautions when canning fish at home.

1. Use only freshly caught, thoroughly bleed fish.
2. Fish must be gutted when they are caught and refrigerated or packed in ice until they are precooked or packed for canning.
3. To remove air from the tissue of the fish and from the packed jar, all jars should be exhausted before they are processed. Exhausting the jars is done as follows:
   a. Jars are packed according to directions, and the lid and band are properly placed, BUT the band is screwed down only until it cannot be pulled off.

b. Jars are placed on the rack in the bottom of the pressure canner. Hot water is poured around them until it reaches about halfway up the sides of the jars.
c. The lid is placed on the canner kettle BUT NOT SCREWED IN PLACE as for canning. The vent is left open.
d. The heat is turned on under the canner. When the water is boiling and steam flows through the vent, start counting the exhausting time. Between 10 to 20 minutes will be needed for the center of the filled jars to reach 170°F. One jar should be used as a test jar. Insert a pencil thermometer or meat thermometer into the center of the jar, but not all the way to the bottom, to determine the internal temperature.

4. After exhausting, all jar lids are tightened, the the jars are ready to be processed. During processing, 10 pounds pressure must be maintained throughout the processing time. Should the pressure drop, it must be brought back to the 10 pound level and the counting of the processing time must begin again. This is necessary due to the pH value of seafood being very close to neutral (pH 7) and the density of pack.

WHAT TO DO IF JARS DO NOT SEAL

Do not reprocess---quality is unsatisfactory.
Refrigerate and use within the next few days.
Pour contents of jar into appropriate freezer container, freeze, and use within 3 to 6 months.

SERVING HOME CANNED FISH

1. To assure the safety of any home canned fish, it must be boiled for 20 minutes to destroy any toxin. Boiling a seafood product can result in an undesirable change in texture. To prevent this, oven heating is recommended.

a. Preheat oven to 350°F.
b. Open jar and examine for signs of spoilage. See item 2 below for instructions.
c. Insert a meat thermometer upright into the jar so that the tip is as near the center of the jar as possible.
d. Cover the jar loosely with foil. Put jar on oven rack and heat until thermometer registers 180F. About 30 to 35 minutes will be needed. NOTE: The temperature, and not the time, is important.
e. Let the jar cool at room temperature for 30 minutes to allow the temperature within the jar to become uniform throughout.
f. Serve hot or refrigerate for later use.

2. Always examine home-canned seafood for spoilage before serving it. Bulging jar lids (one that is curved upward), spurting liquid, an "off" odor or mold are all indications that the food is not safe to eat. DO NOT TASTE. Destroy the spoiled food so it cannot be eaten by humans or animals. Sterilize the container and lid by boiling, then throw away sterilized lid.

CANNING SPECIFIC SPECIES

I. AMOUNT OF FRESH SEAFOOD NEEDED

SEAFOOD	AMOUNT	NUMBER OF JARS AMOUNT WILL TAKE
Tuna, Large Mackerel	25 pounds	12 1/2 pints
Salmon, Shad	25 pounds	12 pints
Other fish	35 pounds	12 pints
Crabs	25 pounds (12 to 15)	12 1/2 pints
Lobster	7-10	12 1/2 pints
Shrimp	10 pounds	12 1/2 pints
Clams, whole, raw shredded	6 quarts	12 1/2 pints
Clams, minced	12 quarts	12 1/2 pints

II. RECOMMENDED PROCESSING TIMES AT 10 POUNDS PRESSURE

FISH	ONE-HALF PINT MINUTES	OR	PINT JAR MINUTES
Tuna, King Mackerel, precooked	100		---
Tuna, raw	100		---
Tuna, brined	100		---
Salmon, Shad	---		110
Lake Trout, White fish, small Mackerel and other fish	---		100
Crabs	65		---
Lobster	70		---
Shrimp	35		---
Clams, whole and minced	70		---

TUNA AND KING MACKEREL

NOTE: Tuna can be packed precooked, raw or brined. Mackerel should be packed precooked. Precooking allows for a tighter pack and removes most of the body oils, which tend to be strong-flavored.

- Precooking is the preferred METHOD OF CANNING. Scrombroid poison can occur in canned tuna bought in the store or canned at home. The poison can be produced in scrombroid fishes when naturally occurring spoilage bacteria in the meat convert the amino acid, histidine, into biologically active amine poison, saurine. Saurine is produced when fish are left in the sun or at room temperature for several hours.
  Scrombroid poisoning is rare and generally not fatal. Poisoning resembles a severe allergy with such symptoms as headaches, dizziness, nausea and vomitting.
  The toxin is heat stable and not completely destroyed by the canning process.
  Scrombroid poisoning can be prevented by processing the fish immediately after capture and discarding any fish exposed to sunlight for more than two hours.

CANNING PRECOOKED TUNA

1. Remove viscera and wash fish in cold water. Allow blood to drain from stomach cavity.
2. Place tuna (cut in half crosswise if necessary) belly-down on a rack or metal tray placed in the bottom of a large baking pan.
3. Precook fish in one of the following ways.
   a. Bake at 350F for about 1 hour, or until an internal temperature of 165°F to 170°F is reached.
   b. Steam for 2 to 4 hours or until done.
4. Refrigerate fish overnight to firm the meat.
5. Peel off the skin with a knife, lightly scraping the surface to remove blood vessels and any discolored flesh.
   NOTE: Before packing precooked fish into jar, look for two possible defects: (1) a grey or grey-green color to the meat. It usually is accompanied by an unpleasant, urine-like odor. "Greening" is not harmful, but is unappealing and should be discarded. (2) "Honeycombing" is characterized by a pitted, spongy-looking meat, and an off-odor, generally localized near the head. The defect is due to decomposition and should be discarded.
6. Cut fish into quarters. Pull off and cut out all bones and fin bases. Scrape and cut out all dark flesh.
7. Cut quarters crosswise with a sharp knife into lengths suitable for jars.
8. Pack pieces into jars, pressing down gently to make a solid pack. Leave 1 inch head space.

9. Add 1/2 to 1 teaspoon salt (optional) to pint jars, 1/4 to 1/2 teaspoon to half pint jars.
10. Add 4 to 6 tablespoons of hot oil (cottonseed, soy or other vegetable oil), boiling water or equal amounts of oil and water to each pint; 2 to 4 tablespoons to each 1/2 pint.
11. Adjust lids and process half pints and pints for 100 minutes at 10 pounds pressure.
12. Allow jars to cool and store in a cool, dark place.

CANNING RAW TUNA

1. Remove viscera and wash fish in cold water. Allow blood to drain from stomach cavity.
2. Cut fish into quarters. Pull off and cut out all bone and fin bases. Scrape and cut out all dark flesh.
3. Cut quarters crosswise with a sharp knife into lengths suitable for jars.
4. Pack raw pieces into half-pint jars to within 1/4 inch of rim. Add 1/2 teaspoon salt (optional) to each jar.
5. Exhaust as directed.
6. Adjust lids and process at 10 pounds pressure for 110 minutes.

CANNING BRINED TUNA

1. Remove viscera and wash fish in cold water. Allow blood to drain from stomach cavity.
2. Cut fish into quarters. Pull off and cut out all bone and fin bases.
3. Cut quarters crosswise with a sharp knife into lengths suitable for jars.
4. Soak cut pieces of tuna for 1 hour in a brine made of 3/4 cup salt mixed with one gallon of water. Fish must be completely submerged in brine. This amount of brine is enough for about 25 pounds of clean fish. USE BRINE SOLUTION ONLY ONCE.
5. After soaking, drain fish for several minutes.
6. Pack pieces into half-pint jars to within 1/4 inch of rim. Do not add salt or water.
7. Exhaust as directed.
8. Process at 10 pound pressure for 100 minutes.

SALMON AND SHAD

1. Remove viscera, head, tail, fins, scales and thin belly flap.
2. Wash carefully to remove all blood.
3. Split fish lengthwise and cut into lengths to fit 1 pint jars.

4. Prepare a cold brine of 3/4 cup pickling salt dissolved in 1 gallon of water. This should be enough for about 25 pounds of fish.
5. Weight fish down in brine for 1 hour.
6. Drain pieces well (about 10 minutes). Do not rinse.
7. Fill jars solidly leaving little or no head space.
8. Exhaust as directed.
9. Adjust lids and process at 10 pounds pressure for 110 minutes.

LAKE TROUT, WHITEFISH, SMALL MACKEREL AND OTHER FISH

1. Remove viscera, head, tail, fins, scales and thin belly flap.
2. Wash carefully to remove all blood.
3. Split fish lengthwise and cut lengths to fit 1 pint jars.
4. Prepare a cold brine of 3/4 cup pickling salt dissolved in 1 gallon of water.
5. Weight fish down in brine for 1 hour.
6. Drain pieces well (about 10 kinutes). Do not rinse.
7. Fill jars solidly leaving little or no head space.
8. Exhaust as follows:
    a. Using a large kettle with a rack or bottom or a water bath canner, put filled jars <u>without lids</u> on rack.
    b. Pour fresh, hot brine of 1/3 <u>cup pickling</u> salt dissolve in 1 gallon of water around jars until it comes to 1 inch <u>above the top of the jars</u>. Boil briskly for 15 minutes.
    c. Remove jars and cover tops with a slotted spoon or similar utensil. Invert on a cake cooling rack and drain (about 3 minutes).
    d. Wipe rims of jars with clean, damp cloth.
    e. Put on lids and band.
9. Process at 10 pounds pressure for 100 minutes.

CRAB

1. Use only crabs that are fresh-caught and active.
2. Keep live crabs cool until ready to use. Plan to can crabs soon after caught.
3. Clean thoroughly. Remove back by forcing the edge of shell against a solid object and breaking crab in two by folding it like a book. Shake out viscera and thoroughly clean under cold, running, drinking water.
4. In a large enameled or stainless-steel pot, bring a brine solution--of 1 cup pickling salt, 1/4 cup lemon juice to each gallon of fresh water--to a boil.
5. Add cleaned crabs. Bring mixture back to a boil and boil hard for 15 minutes.

6. Cool crabs in cold water just until cool enough to handle. Remove meat. Lightly rinse under cold running water to remove any coagulated protein.
7. Rinse crab in cool acid brine of 1 cup lemon juice and 1 cup pickling salt in 1 gallon of water. Rinse a colander-full at a time. Leave in rinse 1 to 2 minutes. Drain well and squeeze out excess moisture with your hands. NOTE: This rinse prevents sulfur compounds found in shellfish from darkening the meat during processing.
8. Fill 1/2 pint jars. Add boiling water to cover meat, leaving 1/2 inch head space.
9. Exhaust as directed for 10 minutes.
10. Adjust lids and process at 10 pounds pressure for 65 minutes.

LOBSTER

1. Use only fresh-caught live lobsters.
2. In a large stainless-steel or enameled pot, bring to a boil 3 to 4 gallons of brine of 2 tablespoons pickling salt to each gallon of fresh drinking water.
3. Plunge live lobsters, head first, into brine. Bring back to a boil and cook until lobster shell turns red (about 20 minutes).
4. Dip in cold brine, made as above, until cool enough to handle.
5. Split and clean each lobster under cool, running drinking water.
6. Lightly spray pieces with drinking water to remove curds of coagulation protein. Press our excess.
7. Rinse lobster in cool acid brine of 1 cup lemon juice, 1 cup pickling salt in 1 gallon of water. Leave in rinse 1 to 2 minutes. Drain well and press out excess moisture with your hands.
8. Fill 1/2 pint jars alternating claw and tail meat in a manner to get a tight pack.
9. Cover meat with fresh boiling brine made up of 1 1/4 teaspoon salt to each quart of water. Leave 1/2 inch head space.
10. Exhaust as directed for 10 minutes.
11. Adjust lids and process at 120 pounds pressure for 70 minutes.

SHRIMP

1. Remove heads as soon as shrimp are caught.
2. Chill or pack in crushed ice until ready to use.
3. Peel off shells, take out sand vein. Wash quickly in fresh water and drain.
4. In a large enameled or stainless steel pot, prepare a brine of 2 cups pickling salt to each gallon of water.
5. Put shrimp in brine 20 to 30 minutes. Stir occasionally. Remove shrimp and drain thoroughly.

6. Cook shrimp in boiling acid brine of 1 cup lemon juice, 1 cup pickling salt in 1 gallon of water for 6 to 8 minutes after brine returns to a boil. (NOTE: Use a fresh brine mixture for each basket full of shrimp due to brine becoming cloudy because of diffused blood).
7. Drain and air dry.
8. Solidly pack, but do not crush, shrimp into 1/2 pint jar. Add enough boiling water to cover meat. Leave 1/2 inch head space.
9. Exhaust as directed for 10 minutes.
10. Adjust lids and process at 10 pounds pressure for 35 minutes.

CLAMS, WHOLE

1. Keep live clams cool until ready to can. To help remove sand, they can be held for 12 to 24 hours in enough of a mild brine (1/4 cup pickling salt for every gallon of drinking water) to cover the clams by 3 to 4 inches.
2. Pick over shells, using only those that are tightly closed. Scrub shells with a stiff brush.
3. Steam to open. Remove meat, saving juice, which can be strained through a cheesecloth and boiled down to 2/3 its original volume and used as jar liquid. Boiling water can be used instead of the juice.
4. When removing meat, remove the siphon/neck and the membrane holding it.
5. Wash meat in fresh brine of 3 tablespoons pickling salt to 1 gallon of water. NOTE: Brine will need to be changed frequently.
6. Cook clams in boiling brine of 2 tablespoons lemon juice or plain vinegar to 1 gallon of water for 2 minutes after brine returns to boiling. Drain. (NOTE: For best results, cook a half-full deep fry basket of clams at a time, using fresh brine each time.)
7. Pack 1/2 pint jars, leaving 3/4-inch head space. Cover with hot clam juice, leaving 1/2-inch head space.
8. Exhaust as directed for 10 minutes.
9. Adjust lids and process at 10 pounds pressure for 70 minutes.

MINCED CLAMS

Follow same steps as 1 through 5 for whole clams above.

6. Grind in a meat grinder.
7. Strain broth through a cheese cloth. Bring to a boil.
8. Pack minced clams in 1/2 pint jars leaving 3/4-inch head space. Cover with hot clam juice, leaving 1/2-inch head space.
9. Exhaust as directed for 10 minutes.
10. Adjust lids and process at 10 pounds for 70 minutes.

PICKLING FISH

INTRODUCTION

- A pickled fish is one that has been salted and brined.
- Fish preserved using this method cannot be stored at room temperature. It must be refrigerated.
- Heat Processing (canning) is not recommended because the finished product can become carmelized, soft-textured and bitter in flavor.

INGREDIENTS

Six ingredients are used in pickling fish.

FISH: Any good quality fresh or frozen fish can be pickled. The fat content and flesh of herring makes it especially suited for pickling. Other good choices include: smelt, small mackerel, small trout and perch. The selection of fish is more critical if chunk style pickling is desired. In this case, only thinned-skinned, small-boned varieties of fish should be used.

WATER: Only good quality drinking water should be used to make all brine and spice mixtures. Water high in iron, calcium an magnesium should be avoided. These can cause the fish to develop an off flavor or to become discolored. If only hard water is available, boil brines and filter it through several layers of filter paper, such as coffee filters, before using.

VINEGAR: Only distilled white, with a guaranteed 50 grain (5 percent) acidity should be used. Use the amount of vinegar recommended to help prevent bacterial development in the finished product. Other kinds of vinegars (wine or cider) will give some pickled fish an off color and flavor.

SALT: Use only canning or pickling salt. These are pure and do not contain iodine or anti-caking ingredients that can result in the development of off-flavors and undesirable color changes. For the same reasons, do not use sea salt.

SUGAR: For best results, use can or beet (table0 sugar. It is consistent in sweetness, unlike corn syrup.

SPICES: For best results, use only fresh and whole spices.

PREPARING THE FISH

Fillet Style

1. Fillet the fish and remove the skin.

2. Wash several times in clean, cold water. Drain.
   NOTE: If fillets are one inch or more thick, they should be sliced to pieces of about a 1/2 inch thick.
3. Brine (see below).

<u>Fillet Chunks</u>

1. Follow steps 1 and 2 for fillet style.
2. Cut each fillet into chunks of 1 1/2 to 2 inches in length.
3. Brine (see below).

<u>Chunk Style</u>

1. Remove scales, head, fins and tail.
2. Wash thoroughly in cold water to remove material that may be clinging to the surface of the belly.
3. Cut clean fish into chunks about 1 1/2 inches wide.
4. Brine (see below).

<u>Brining</u>

1. Prepare a brining solution of 2 1/2 cups of pickling or canning salt dissolved in 1 gallon of drinking water. This should be enough for 5 pounds of fish.
2. Put brine in container made of glass, or food-quality plastic (meaning those plastics meant to hold foods).
3. Put in prepared fish and refrigerate 48 hours.
4. Rinse fish in cold water and return to emptied and cleaned containers.
5. Cover with undiluted vinegar and refrigerate another 24 hours.
6. Remove fish from vinegar and pack in half-pint or pint jars with chopped onion at the bottom and on the top. Cover with one of the pickling solutions found below.
7. Cover jar with scalded lid and place in refrigerator for at least one week before using. Use within 6 to 8 weeks.

PICKLING THE FISH

Herring-Style Pickling Solution

Treats five pounds of fish

1 quart distilled vinegar
 (5% acetic acid)
5 1/2 cups sugar
4 tablespoons mixed pickling
 spice (tied in spice bag)
1 cup dry white wine

Combine the vinegar, sugar and spices in a large pan and bring to a boil. Allow it to cool to room temperature. Remove the spice bag. Add the white wine and pour over the packed fish.

Creamed Pickled Fish Variation

After fish have been in herring-style pickling solution described above for at least a week, pour the pickling solution from the jar into a container. For each pint of fish, place 2 ounces of cultured sour cream in a mixing bowl and add pickling solution until you have enough to refill the jar of fish.

Pour the cream sauce back into the jar and let it stand for 15 to 20 minutes before serving. The creamed fish should be eaten within a few days; if held longer, the cream sauce will separate and curdle.

Mustard Pickling Solution

Treats five pounds of fish

1 cup vegetable oil
3 cups distilled vinegar
 (5% acetic acid)
1/3 cup prepared mustard
1/2 cup sugar
1 teaspoon ground white pepper
1 teaspoon mixed pickling
 spice
3 bay leaves

Mix listed ingredients in a pan and bring to a boil. Allow mixture to cool to room temperature, then fill the jars of fish with the solution. Cover the jars with scalded lids and refrigerate. Let stand for one week before using. This product can be stored in the refrigerator for 6 to 8 weeks.

HOW TO SMOKE FISH

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

High-oil content fish are usually the best for smoking. These fish absorb smoke faster and have a better texture. Species that smoke well include:

carp	sablefish
catfish	salmon
eel	smelt
herring	sturgeon
mackerel	trout

Technically any fish can be smoked without the fear of food poisoning if these five basic steps are followed. CLEANING, SALTING OR BRINING, SMOKING, COOKING, AND STORAGE.

CLEANING

Depending on the species, fish may be gutted and beheaded, halved, filleted, or skinned and cut into pieces. Regardless of the species used, clean all fish thoroughly to remove slime, blood and harmful bacteria. KEEP FISH AS COOL AS POSSIBLE AT ALL TIMES BUT DO NOT FREEZE. If fish is being cut prior to smoking, make sure the pieces are of equal size to allow for uniform absorption.

As in all other food preservation methods, use only good quality fish. Smoking will not improve fish quality. Do not let fish stand for an extended period between cleaning and smoking.

SALTING OR BRINING

Salting preserves the smoked fish and firms it by removing moisture. Sometimes the brine consists of only salt and water and other times spices may be added to the solution.

Recipes vary in the concentration of the brine and the length of time the food is left in the brine. The salt used should be granulated, regular pickling or canning salt.

Here are two brine recipes for hot smoke fish. Both are enough for 20 pounds of fish.

I	II
1 gal water	6 gal water
1 lb salt	4 lb salt
1/2 lb sugar	1 1/2 lb sugar
1/3 c lemon juice	1 1/2 oz saltpeter
1/2 Tbsp onion powder	3 oz whole cloves (optional)
1/2 Tbsp seafood seasoning	1 oz bay leaves (optional)

1. Mix all ingredients well.
2. Submerge fish in brine and refrigerate for 12 hours.
3. Remove fish from brine and rinse under cold running water for 10 minutes.
4. Pat fish with a clean cloth and place in the refrigerator to drain for one to three hours. Drying increases the keeping quality and gives the smoke a better chance of being more evenly deposited on the surface of the fish.

SMOKING AND COOKING

Hot-smoking or barbecuing fish requires a smokehouse temperature between 200 and 250°F. The complete smoking process, requires six to eight hours.

A meat thermometer should be used to monitor the internal temperature of the fish. The internal temperature of the largest piece must reach 180°F, and the temperature maintained for 30 minutes. If the smokehouse temperature is not high enough to do this, you will need to complete the cooking in a kitchen oven.

After cooking, the fish should be ready-to-eat. Any smoked fish not eaten at this time MUST BE REFRIGERATED.
NOTE: There is a cool-smoking method which requires the use of a heavier brine and a smokehouse temperature that is not over 90°F. The cooking period is from one to five days. This method is seldom used.

STORAGE

Refrigerate all smoked fish in the refrigerator at a temperature below 40°F. This is very important since the salt content is not known and one can never be absolutely sure that the time and the recommended internal temperature of 180°F has been achieved.

Mold growth can be retarded if the fish is packed in a porous material such as a paper towel before refrigerating. This kind of wrapping prevents sweating that can take place if stored in a plastic bag.

For extended storage (more than one to two weeks) smoked fish should be frozen, using the recommended wrapping materials and procedures.

SMOKEHOUSES

Smokehouses can be made from a large cardboard box, a metal drum, or a wooden barrel.

CARDBOARD BOX

- Should measure 30 inches square and 48 inches high.
- Remove one end of the box to form the bottom of the smokehouse.
- To strengthen the box, tack 3/4 inch strips of wood on outside of box. Do this vertically at corners and horizontally across sides.
- 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 a hinge.
- Suspend several wooden or iron rods or sticks across the top of the box. Cut holes through box so rods rest on wooden strips on the outside of the box. Coarse wire mesh (1/2" or 1/4" iron or steel) can be used as a rack instead of the rods. This rack should be supported by a couple of wooden or iron rods.
- Arrange fish on rods or shelf 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. Use regular nails, 8 to 10 gauge steel wires, metal coat hanger wires, S-shaped iron hooks, and/or wooden sticks.
- Build fire on level ground using nonresinous (hickory, oak, maple, apple) woodchips or sawdust to produce a light, constant volume of smoke. Never use wood containing pitch, such as pine.
- Center smokehouse over smoldering fire and close flaps. Danger of fire is minimized if ventilation is controlled to promote smoke rather than flames.
- Monitor fish temperatures with a meat thermometer as described earlier.

BARREL SMOKEHOUSE

- Knock the ends out of a large barrel.
- Set it over a hole in the ground about 2 feet deep and a little narrower in width than the diameter of the barrel.
- Nail wooden strips inside the barrel on two sides, a few inches below the top. The smoke-sticks rest on these strips.
- Place a loosely fitting cover on top.
- Dig a hole adjacent to the bottom of the barrel connected with the pit, and fix it with a cover. The fire is fed through this hole and also serves as a draft when the lid is raised.

HOME FREEZING OF SEAFOOD

Home freezing of seafood is easy to do and economical too when year round family favorites or seasonal varieties are used.

The most important factor to remember is that freezing does not improve the quality of any food. Therefore, to get the best product, freeze only fresh, not previously frozen, seafood. The local fish dealer can provide this information.

How economical a variety and/or form is will depend on its availability and how many servings you will get from a pound of seafood.

From the time the seafood is purchased to the time it is put into the freezer it must be kept as cold as possible. A few hours at room temperature or in the trunk of a car on a warm day can result in spoilage.

PREPARING SEAFOOD FOR THE FREEZER

To conserve freezer space, and lessen the preparation time later, its best to freeze fish in the form it is going to be used, that is steaks, fillets or whole.

The cleaning and dressing of a fish should be done as follows:

- Wash fish. Remove scales by scraping the fish gently from the tail to the head with the dull edge of a knife.
- Remove entrails after cutting the entire length of the belly from the vent to the head.
- Remove the head by cutting above the collarbone. Break the backbone over the edge of the cutting board or table.
- Remove the dorsal or large back fin by cutting the flesh along each side, and pulling the fin out. Never trim the fins off with a shears or a knife because the bones of the fin will be left in the fish.
- Wash the fish thoroughly in cold running water. The fish is now dressed and can be cut into steaks, filleted or left whole for freezing.

WRAPPING MATERIALS

The wrapping materials used for freezing any food must be MOISTURE PROOF and ODOR PROOF. In addition, the kind of wrapping material used should allow for tight-fitting, air-tight package.

These characteristics are important because:

MOISTURE PROOF. Loss of water during storage in the freezer results in freezer burn. The loss of water can cause a

toughening of the meat and can promote oxidation. A product with freezer burn develops an off-flavor, odor, and color, but freezer burn does not mean the product is spoiled.
ODOR RESISTANT. The wrapping material should not allow the rapid passage of odor between the product and the atmosphere. Packaging materials vary in this quality.
TIGHTNESS OF FIT. A tight-fitting wrap is essential to prevent moisture loss inside the package. If a wrapping is loose fitting, moisture will evaporate from the fish and condense as ice crystals on the inside of the package. If the product is warmed slightly during defrosting or each time the freezer door is opened the moisture may move back to the surface of the fish. On freezing, the cycle begins again. If this cycle is repeated, a large quantity of moisture can be removed from the food, causing severe dehydration.

CHARACTERISTICS OF FREEZER PACKAGING MATERIALS

Material	Permeability Water	Air	Tightness of fit	Strength	Cost
Polyvinlidene 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

PRESERVING FISH QUALITY DURING FREEZING

Preserving the quality of seafood during freezing is best accomplished by making sure as much air is excluded from the surface of the fish as possible. This can be accomplished by:

- Dipping the seafood in a precooked and cooled solution of 5 percent starch. Use about 6 tablespoons of cornstarch per gallon of water. Be sure to rinse away the starch after the seafood has thawed and before cooking.

- Excluding as much air as possible from the package. Air not only causes oxidation, it also acts as an insulator, slowing the freezing process. The drug store wrap is recommended.

- Fish to be stored for periods longer than 3 months should be left either whole or in large pieces. This reduces the amount of dehydration.

- Label each package with the following vital information:
  - the name or type of seafood, e.g., haddock fillets.
  - the date frozen.
  - the weight or number of servings.
  - how it should be prepared.

USING THE FREEZER

To maintain quality and to avoid losses, seafood should be frozen as quickly as possible. Overloading the freezer with packages to be frozen must be avoided. Here are some factors to consider:

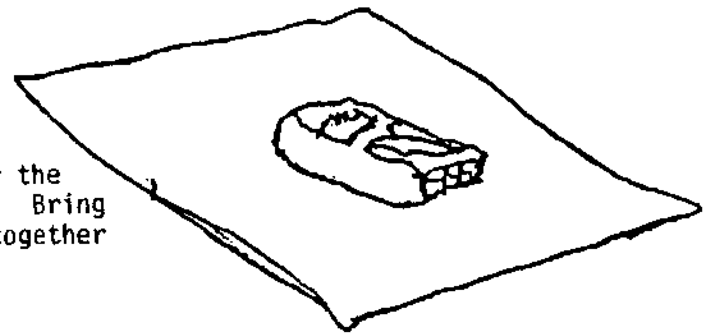
- Make sure your freezer is working properly. Set is at -4°F. If the thermostat can not be set at this temperature, recall how well other packages have held up in the freezer. If you have not had any losses, your freezer is probably working well. If packages have not stored well, the freezer needs to be repaired or replaced.

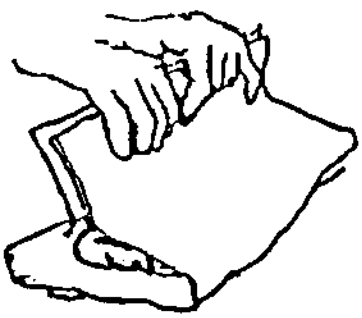
- Two or three hours before putting in packages to be frozen, set the thermostat at the coldest setting. This will help to prevent the thawing of other frozen packages when new packages are added.

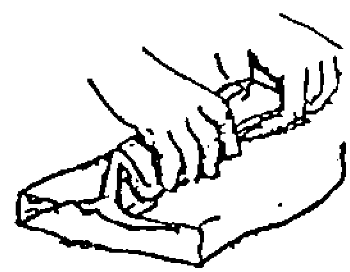
- Freeze no more than 2 to 3 pounds of seafood per cubic foot of freezer space. This will permit the packages to freeze in a period of 10 to 12 hours.

- To maintain quality and allow for as quick freezing as possible, place packages in the freezer as soon as they are ready. Slow freezing can result in the seafood remaining partially frozen

Place the meat near the center of the wrap. Bring edges of the wrap together over the meat

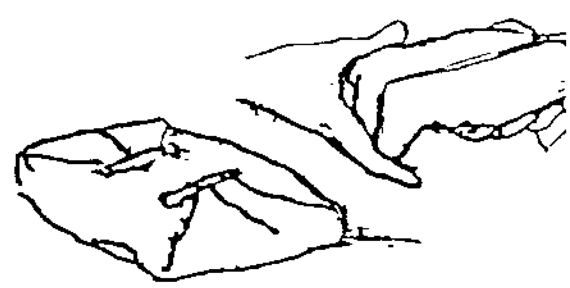






Fold the wrap over one, then fold again so the second fold is tight against the meat.

Make top folds even. Smooth the ends close to the meat and fold into triangles.



Fold the ends under the package away from the top fold. Seal with freezer tape and label with date, kind of meat, and number of servings or weight.

for a period of time. This can result in bacterial and enzymatic spoilage.

- For fast freezing, place packages in direct contact with the floor, walls or coils of the freezer until they are frozen. DO NOT STACK ONE PACKAGE ON TOP OF ANOTHER. ALLOW THE COLD AIR TO CIRCULATE AROUND THE PACKAGES. BE SURE THAT NEWLY ADDED PACKAGES ARE NOT PLACED ON TOP OF OR CLOSE TO ALREADY FROZEN PACKAGES.

STORAGE TIME

Most home-frozen seafood should not be stored over 6 months. Salmon, crab and shrimp should not be stored over 3 months. TWO TO THREE MONTHS OR LESS STORAGE TIME IS IDEAL FOR ALL SEAFOOD. A good rule to remember for a continuous supply of high quality frozen food is "FIRST IN, FIRST OUT."

CAUSES OF SPOILAGE

Rancidity. Rancidity appears to be directly related to the fat and oil content of seafood. Heat, light, oxygen and the presence of heavy metals, such as copper and iron enhance the development of rancidity.

Fish oils are considerably different from those found in other animals and plants. The oil in fish consists or long-chain fatty acids with many double bonds. As a result, fish oils are 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 can be classified into three categories according to their oil content:

LOW: those containing less than 5 percent oil such as halibut, cod, flounder, and red snapper.

MODERATE: those containing between 5 and 10 percent oil such as, mullet, croaker and salmon.

HIGH: those containing more than 10 percent oil such as herring, mackerel and lake trout.

The higher the oil content, the most susceptible the fish is to oxidation and, therefore, rancidity. Fish with a high oil content can become rancid in three months in a freezer unless precautions are taken. For example, the use of a glaze to which an antioxidant has been added will help. Recommended for use in the home are the antioxidants, ascorbic acid and citric acid. The fish should be soaked in a solution of 1 teaspoon crystalline ascorbic acid to 1 cup of water for about 1 to 2 minutes, then frozen and then dipped in the same solution to form a glaze. A second glazing is advisable. The fish may then be wrapped as previously described.

Moderately oily fish can become rancid in from 9 to 12 months.

There is also a variation in the rate at which fish becomes rancid. For example, King salmon has a fat content of about 15 percent. Pink salmon fat content is about 6 percent, but it becomes rancid more quickly than the King salmon. Herring is a fat fish which is difficult to store frozen in the home due to its susceptibility to rancidity.

Protein degradation. Protein degradation is due to autolytic and bacterial enzymes which are quite active at about 40°F. This spoilage is characterized by ammonia and amine-like odors often evident in spoiled meats and seafood. These enzymes are protein in nature, and activity decreases as the temperature is reduced. However, there are some enzymes that remain active to some degree even at 0°F. In fishery products, there is very little or no enzymatic degradation at 0°F to -10°F and these products remain stable for many months, all other factors being equal.

Browning discoloration. This reaction is also known as the browning reaction or Maillard reaction. It is particularly prevalent when white-fleshed fish is cut into steaks or fillets. Research has shown that this reaction is due to the combining of certain amino acids with reducing sugars. For example, pentose (5 carbon sugars) react readily with sulfur containing amino acids, i.e., methionine, cysteine, and cystine. The reaction is characterized by the presence of a brown color much like that of brown wrapping paper. This reaction can be also be inhibited by treatment with ascorbic acid.

USING HOME FROZEN SEAFOOD

Seafood should be thawed in the refrigerator and never by placing the frozen package in warm or hot water or at room temperature. A 1-pound package of frozen fish should thaw in the refrigerator in 18 to 24 hours. If quicker thawing is necessary, place the frozen packages 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.

Never re-freeze seafoods.

Some frozen seafood can be cooked without thawing. Breaded, frozen fish should be cooked when frozen. Frozen fillets can be cooked without thawing if additional cooking time is allowed. If the fillets are to be breaded or stuffed, they should be thawed before cooking. Do not stuff a whole fish and freeze it.

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CHAPTER ELEVEN

PARASITES
and
PATHOGENS

PARASITES

All marine and freshwater fish and shellfish are susceptible to the types of diseases and parasitism that affect land animals including man. Because of the vastness of the world's seas and oceans, with the consequent freedom of fish from close contact with each other, epidemics of disease in marine fish are rarely seen. A further contributing factor to controlling diseases in the sea is the probability that sick fish readily fall prey to predators. Yet, it is well known that fish suffer from viral, bacterial, fungal, protozoan and tumerous diseases.

Disease is of more consequence in freshwater than in marine fish. Epidemics in river fish are not uncommon, but outbreaks of microbial disease in farmed fish are more important economically; profitability demands high-density stocking of ponds, and in overcrowded conditions diseases spread rapidly with complete stocks of fish being condemned, lost or made unsuitable for food.

Parasites do not necessarily cause disease. A parasite lives in or on another animal from which it obtains its food and, if highly adapted, will cause little or no harm. In general, each type of parasite limits its attack to a particular kind of animal, called the host. Some parasites live in one host; while others require two or more hosts for different stages of their lives, the young and larvel form living in/on one animal and the adult in or on a different animal.

From our present limited knowledge, it appears that human health hazards associated with parasites of marine fish and shellfish may be conveniently divided into two categories: that concerned with infection by transmitted parasites; and that concerned with chemical alterations in seafoods resulting from the presence of parasites.

FUNGI

The only fungi which troubles the fish industry to any extent is Ichthyoponus Hoferei which causes an infected fish to feel greasy. The fungus particularly affects catfish, mackerel, and haddock. Sometimes there are numerous colonies in the flesh giving the fillets an off-white, peppered appearance and greasy feel. The fungus shows up most noticeably in smoked fillets.

PROTOZOA

No one has yet examined in detail whether the known protozoan parasites of marine fish are pathogenic to man, except that it was reported recently that, contrary to earlier reports, the ectoparasitic ciliate Ichthyopthirius multifiliis of freshwater and occasionally estuarine fishes is nonpathogenic to man. This situation, however, does not imply that the protozoan parasites of fish can't be transmitted to man. It merely indicates that no one has studied the situation intensively.

Similarly, there is no conclusive evidence that protozoan parasites of shellfish are infective to man. However, some preliminary information suggests that shellfish may serve as potential vehicles for the transmission of certain pathogenic amoebae to man. Specifically, it has been well established that certain free-living soil and freshwater amoebae belonging to the genera Acanthamoeba, Hartmannela, and Naegleria are pathogenic to man and other mammals. It was first demonstrated that species of Hartmannella will invade mollusks, freshwater snails in this case. It was subsequently reported that Hartmannella tahitiensis will act as a facultative parasite of the New Zealand oyster, Crassostrea commercialis, when it is placed under environmental stress. The point is that oysters under stress potentially could serve as vehicles for the transmission of Hartmannella and perhaps other pathogenic soil amoebae to man when they are eaten in the raw or inadequately cooked states. Since H. tahitiensis was discovered in oysters from commercial beds in Tahiti French Polynesia, where nonviral human meningoencephalitis is known to occur periodically, the question may be raised as to whether some of these cases could be due to this or some related amoebae. At present the nematode Angiostrongylus cantonensis is being exclusively incriminated as the etiologic agent.

Most of the protogen that infest fish live in the abdominal cavity but some invade the flesh. Species of fish most affected are hake, salmon, catfish, and blue whiting. In the past, one of the protozoa, Kudoa (Cholromyxum) thyrsites, has been very troublesome in hake caught in the south Atlantic. The parasite can be present in large numbers and, after the death of the fish, secretes a powerful enzyme which softens and liquifies the flesh during storage to such an extent that the fish are known as milky hake. Digestion of the fish takes place steadily even in ice and is accelerated with increase of temperature. It is particularly rapid during smoking when apparently normal fish develop the milky condition. Because the protozoan is microscopic in size, infestation in fish cannot be readily detected. Control can only be affected by rapid processing, freezing, and cold storage.

Another protozoan, Henneguya, causes similar spoilage in smoked salmon and is found in Canadian salmon.

CRUSTACEA

Crustacean parasites take a variety of shapes and sizes and are not of great commercial importance. Three types are more commonly encountered than others. The Lernaeocera or anchor worms, which are found firmly attached to the gills of fish, have slender irregular worm-shaped bodies about 25 mm (1 in) long and are reddish-brown in color. Secondly, Sphyrion Lumpi, which attaches itself to the outside of the fish, particularly redfish, is about 50 mm (2 in) in length, has a long slender neck and a flattened body composed largely of the brown-disc shaped reproductive organs. Thirdly, Sarcotoaces articus, the ink bag parasite of blue ling, develops in the flesh of the fish just below the skin. It is roughly pear-shaped, about 50 mm (2 in) in length, 25 mm (1 in) wide and blue-black in color. If accidentally cut during fileting, the watery fluid of the animal stains the flesh an inky color making it unsuitable for sale. Removal of the intact parasite renders the fish unsuitable for sale.

TREMATODES (Flukes or Flatworms)

Marine fish are well known as hosts for digenetic trematodes, both metacercariae and adults. Because of the accumulated knowledge of trematode life cycles and their modes of infection, one may assume there is little danger that adult trematodes can be transmitted from fish to man. However, there is ample evidence that certain species of trematodes that utilize fish as intermediate hosts can transmit these parasites to humans, resulting in serious diseases. Some of these are considered below.

One of the most popular marine fishes currently under culture throughout the world is the mullet, *Uigil cephalus*. It is known to serve as the second intermediate host for the number of species of heterophyid trematodes, i.e., the infective metacercariae of these trematodes are encysted in the fish's musculature. Specifically, the following heterophyids are known to be transmitted to mammals, including man, as the result of ingesting raw or inadequately cooked mullet: *Heterophyes heterophyes*, *Metagonimus yokogawai*, *M. minutus*, *Haplorchis yokogawai*, *H. pumilio*, *H. taichui*, *Centrocestus armatus*, *C. canius*, *C. formosanus*, *Cryptocotyle lingua*, *Stellantchasmus falcatus*, *S. amplicaecalis*, and *S. pseudocirratus*.

There is no need to review individually the biology and pathogenicity of each of these trematodes. The essential points are that these tremotodes, with diverse geographic distributions (Table 1), utilize either a freshwater or an estuarine gastropos (snail) as the first intermediate host. The larvae, taken in by ingestion of eggs,

TABLE 1

Species of Heterophyid Trematodes[a] Known to be Infective To Man -- And Their Geographic Distribution

Species	Known Distribution
Heterophyes heterophyes	Egypt, Japan, southern Korea, central and southern China, Formosa, Philippines
Spelotrema (=Heterophyes) brevicaeca	Philippines
Metagonimus yokogawai	China, Japan, Indonesia, Korea, Siberia, Rumania, Ukraine, Spain
Metagonimus minutus	Japan
Haplorchi yokogawai	Japan, Formosa, Hong Kong, southern China, Philippines, Hawaii
Haplorchis pumilio	Japan, Formosa, southern China, Philippines, Egypt, Tunisia, Israel
Haplorchis taichui	Japan, Formosa, southern China, Philippines, Egypt, Israel, India, Hawaii
Haplorchis microchis	Japan, Philippines
Centrocestus armatus	Japan, Hong Kong
Centrocestus caninus	Formosa, Philippines, southern China
Centrocestud formosanus	Formosa, Hawaii
Cryptocotyle lingua	Europe, North American, Japan, Siberia, Baltic area
Stellantchasmus falcatus	Formosa, Hawaii
Stellantchasmus pseudocirratus	Philippines, Indonesia, Israel, Hawaii
Stallantchasmus amplicaecalis	Formosa

[a]According to some scientists all of the members of the Heterophyidae are potential parasites of man.

will multiply to release cercariae, which will attach to the mullet or some other species of compatible fish in the estuary, and, after discarding their tails, penetrate and encyst as metacercariae in the fish's musculature. When these metacercariae are eaten by man, he becomes infected with the adult worms becoming established as intestinal parasites. The worms develop and live in the bile ducts for years, frequently causing cirrhosis. Chronically infested individuals are also at high risk of developing cancer of the biliary tract.

Human heterophyidiasis is by no means limited to the intestinal tract where the adult parasites actively destroy portions of the mucosal wall. Eggs deposited by adult worms can be carried by the blood and deposited in the myocardium, brian, spinal cord, and other tissues, where inflammatory reactions occur. When the inflammation is severe, deaths can result.

Although heterphyid trematodes are most abundant in the Far East (Table 1), they are by no means limited to these locations. Within the United States, several species are known to occur in Hawaii, and human infections do occur, especially among individuals of Filipino extraction. With the spread to the mainland, especially in Texas and Florida, of Tarebia granifera, one of the principal molluscan first intermediate hosts, and with the ability of various mammals, including cats and canines, to serve as reservoir hosts, the potential of human heterophydidiasis cannot be slighted.

Eating raw, partially cooked, or partially pickled fish is the primary mode of transmission. More than 80 species of fish, particularly cyprinids, have been found to be infected with infective metacercariae. Epicures in southern China are frequently infected as a result of their preference for raw ide (Ctenopharyngodon), which is commonly infected. It is estimated that more than 20 million people in Asia are infected. In southern China, human clonorchiasis rates can surpass 40 percent in some villages and in rural South Korea, recent surveys show no fewer than 11 percent of school children infected and a higher prevalence among adults.

Although domesticated dogs and cats and wild mammals are important reservoirs, the predominant problem in transmission is the contamination of snail-infested waters by egg-laden human feces. The persistent use of human feces as fertilizer makes control difficult, although efforts are directed at killing the eggs by storage of feces for one week prior to their use as fertilizer. Without question, transmission can be prevented by adequate cooking of fish, but eliminating the consumption of raw fish in these regions is impossible. The related species Opisthorchis viverrini infects 25-46 percent of village populations in northeast Thailand.

Heterophyes heterophyes and Metagonimus yokogawai are two other trematodes commonly found in the intestinal tract of humans and transmitted by ingestion of metacercariae-infected fish. Although human infections are well tolerated, these parasites can lead to visceral invasion and life-threatening disease, particularly in the Philippines. Besides the trematodes mentioned, several others are known to be transmissible from marine fish to man.

Spelotrema brevicaeca (Heterophyes brevicaeca) has been reported as a human parasite in the Philippines. This species also utilizes marine fish as its second intermediate host. The so-called salmon-poisoning flike, Nanophyetus salminocola, and the closely related N. schikhobalowi are two additional species transmissible to man by marine fish. The most common fish in both cases is the salmon. Nanophyetus salmincola, which occurs in the Pacific Northwest of the United States, is of particular interest since it serves as the vector for the rickettsial organism Neorickettsia helminthoeca, which causes "salmon poisoning" in dogs that have eaten entrails of salmon harboring the tematode.

Turning to shellfish, investigations have been made into the possible public-health implications of certain echinostome trematodes which utilize a number of estuarine pelecypod species as second intermediate hosts. The discussion here will be limited to members of the genus Himasthla.

Along the Atlantic Coast of North American, ranging from New Brunswick, Canada, to South Carolina, perhaps even farther south, there are three species of Himssthla: H. quissentensis, H. compacta, and H. littorinae. The first species utilizes the common mudflat snail, Nassarius obseletus, as the first intermediate host; H. compacta utilizes Hydrobia minuta; and H. littorinae utilizes Littorina obtusa. The cercariae of all three species can penetrate and encyst in a number of commercially important species of molluscan shellfish. In the case of H. quissetensis, which has been studied most, the soft-shell clam, Mya arenaria, is the favored second intermediate host. Normally, the definitive hosts are marine birds, especially the herring gull, which become infected through feeding on shellfish harboring metacercariae.

The public-health interests in Himasthla spp. stem from two sources: the possible susceptibility of man to these parasites; and undesirable chemical changes in shellfish meats resulting from the presence of the metacercariae. The first of these is discussed at this point.

A species of Himasthla, H. muehlensi, was described from a German who had eaten raw quahaug clams (cherry stones) in New York, and later, upon arrival in Germany, complained of gastrointestinal disturbances. The worms were passed after treatment with an anthelmintic. Since it is known that the definitive hosts of Himasthla spp. acquire their infections from ingesting shellfish harboring metacercariae, it is generally assumed that the German had become infected as the result of eating clams with metacercariae. The possibility exists that H. muehlensi may be a synonym of H. quissetensis. The question that remains without a definite answer is: Are the species of Himasthla infective to man under certain conditions?

As part of the discussion of the echinostome trematodes, it should be mentioned that the metacercariae of another species, Acanthoparyphium spinulosum, was found encrusted in the mantle of the American oyster occurring near Port Isabel, Texas. This echinostome can also be induced to develop to maturity in experimentally infected chicks. Specifically, the most adult worms (36%) were recovered from chicks fed on a normal diet with starch as the sole carbohydrate. On the other hand, the fewest worms (3%) were recovered from chicks fed a normal diet but with sucrose serving as the sole carbohydrate. Percentages of recovery were similar (23.5-25.5%) from chicks fed no vitamin A, no protein, and a commercial diet. It is also of interest to note that the metacercariae administered to chicks on the no-carbohydrate diet did not mature. It is noted that A. spinulosum will develop to some extent in laboratory rats.

The reason for this discussion is to emphasize that the host's nutritional state influences the establishment of parasitoses by trematodes and, undoubtedly, other categories of parasites as well. This point should be kept in mind since it is well known that "proteins from the sea" have been advocated for people of underdeveloped nations with chronic problems of unbalanced diets and malnutrition. Also, in affluent societies, where "complete" diets are the rule, infection with echinostomes of shellfish origin could become a problem.

No discussion of trematodes transmissible to man by shellfish would be complete without mention of the oriental lung flukes belonging to the genus Paragonimus. Although P. westermani is the most common and best known, it is not considered here since the metacercariae-harboring second intermediate hosts, Potamon rathbuni, Eriocheir japonicus, and others, are freshwater crabs. However, at least two other species, P. ohirai and P iloktsuenensis are transmitted by estuarine crabs in the Orient. A brief review of these, therefore, appears appropriate.

Paragonimus ohirai occurs in the lungs of humans and other mammals in Japan. These definitive hosts become infected by ingesting raw or poorly cooked crabs harboring metacercariae. The crab host is Sesarma intermedium or S. dehaani, both of which are found at the mouths of rivers. This parasite was first discovered in crabs collected at the mouth of the Japan's Kuma River.

Paragonimus iloktsuenensis occurs in China and Japan. Human hosts also become infected from eating parasitized estuarine crabs. In Japan, the crab host is Sesarma dehaani.

Although human paragonimiasis due to P. ohirai and P. iloktsuenensis are still limited to the Orient, the prospect of exporting pickled crabs from endemic areas is a potential problem.

In the 1930s and 1940s, Dr. N. Hataway, a Yale University physician, conducted a clinical and epidemiological study of the causes of a series of short-term (24-36 hours) but acute gastrointestinal disturbances in students who shared one common experience, that of having eaten raw clams, Mercenaria mercenaria, purchased from the New Haven, Connecticut market and presumably from the Connecticut coast. The symptoms, which include abdominal pain, diarrhea, vomiting, and ringing of the ears, have been recognized periodically since then. Bacteriological tests performed on samples of M. mercenaria and on victims failed to reveal any bacteria which could be responsible. On the other hand, a large percentage of the M. mercenaria specimens from the Connecticut coast harbored large numbers of encysted metacercariae of the trematode, Himasthly quissentensis. Subsequent feeding of isolated cysts to human volunteers failed to establish infections as determined by eggs in feces or the production of specific clinical symptoms. Thus, the mystery remained unresolved.

Because of the public-health implications, this author, while with the U.S. Public Health Service, continued to investigate this phenomenon. It was found that there is an accumulation of fatty acids in the clam tissues surrounding metacercariae. Preliminary studies indicated that the short-chain fatty acids were represented primarily by butyric acid. It has been suggested that the short-term gastroenteritis may be from ingesting sufficiently large quantities of this toxic fatty acid. Although studies are currently underway in our laboratory to test this hypothesis, it is of interest that toxicity resulting from rancidification associated with a variety of microorganisms is well known. For example, fats in foods have been shown to be hydrolyzed and oxidated by Pseudomonas, Alcalingenes, Clostridium, Micrococcus, Bacillus, Serratia, Achromobacter, and Proteus, among bacteria; by Geotrichum, Penicillium, Aspergillus Cladosporium, and Monilia, among molds; and by some yeasts, especially the film yeasts. In these instances, the invading organisms are capable of secreting lipases that are responsible for the degradation of naturally occurring fats to short-chain fatty acids.

The ability of Himasthla metacercariae to synthesize and secrete lipases or esterases has not been conclusively demonstrated; however, it has been shown that a similar degradation of neutral fats occurs in the oyster Crassostrea virginica parasitized by the sporocysts of Bucephalus and this is mediated by a lipase of parasite origin. At any rate, seafood problems of this nature have not been recognized and should be investigated in depth.

TAPEWORMS (Cestodes)

Tapeworms have life cycles similar to those of roundworms. The adult worms live solely in the gut of the host, while the larvae forms may be found in the flesh. Adult worms can vary greatly in size form a millimeter to many meters in length; they are flat and ribbon-like, consisting of many segments. The segments are smallest where they form at the head or scale of the worm, broadening and lengthening as the worm grows.

The tapeworm of greatest commercial importance is Grillotia Erinaceus, a common parasite of halibut and many other species of fish. The adult worms occur in skates and rays but are of little consequence since they are removed in the gutting process. The encysted larvae are found in the belly cavity and flaps of halibut. In heavily infested fish, they are scattered throughout the flesh as creamy white blobs of about 1-10 mm in length. In the past, infestation in halibut has been so heavy that port health inspectors now inspect all landings of halibut for this parasite.

Our knowledge of tapeworms transmissible to man via seafoods is rudimentary. Only three species of cestodes of this category are currently known: Diplogonoporus grandis, Diphyllobothrium latum (- Dibothricocephalus latus), and Diphyllobothrium glaciale (= D. pacificus).

A species of pseudophyllidean tapeworm was recovered from a Japanese and described as Krabbea grandis. It has since been transferred to the genus Diplogonoporus. The infective plerocercoid larva was reported to occur in marine teleosts. This parasite has not been reported again from man although it should be noted that the original classification was probably correct since a closely related species, Diplogonoporus brauni, is also known to infect man. Generally, members of Diplogonoporus are intestinal parasites of whales. The species reported from man most probably represent rare instances of the accidental parasitism.

The tapeworm Diphyllobothrium latum or the broad fish tapeworm is a common human parasite reaching up to 10 meters or more in length in the intestinal tract. This parasite is found in Northern Europe, Japan, and North America, where it has been reported, in particular, in the northern Midwest and adjacent Canadian regions. The complex life cycle (Fig. 1) requires a first intermediate host, the microcrustacean Cyclops, in which larvae from eggs deposited with feces from humans harboring the adult worm will develop into a stage (procercoid) infective for fish. The ingested crustacean carries the procercoid, which leaves the small intestine and invades the flesh, developing into a larger, infective plerocercoid. Upon ingestion of this second intermediate host the larvae develop into mature tapeworms.

The adult worms are a primary cause of vitamin B-12 deficiency leading to anemia, because of the parasite's preferential uptake of the vitamin from the host's ingested nutrients. Thus, the parasites are found in humans from countries where raw fish, fish products, and roe are a dietary stale and delicacy. It is estimated that five million cases occur in Europe, four million in Asia, and 100,000 in North America. In the U.S., the most prominently affected area is in the Great Lakes region, prompting some speculation that the tapeworm may have originally entered this country, accompanying immigrants from Scandinavian countries.

In 1980, there were 59 tapeworm cases reported in Pacific Coast states, more than three times the number (17) reported in 1979. It was evident that the primary source of the infective larvae was salmon which was being prepared raw for the Japanese delicacy, sushi. A possible reason for this upsurge may have been the large Alaskan salmon runs in 1980 that led to shipment of abundant, fresh, unprocessed salmon to markets. Anadromous salmon now constitute an additional health risk when consumed raw.

A related species, D. pacificum, is transmitted by marine fish, and most cases have occurred in Japan, Peru, and Chile coastal regions. The Latin American raw fish preparation ceviche is no doubt a major modality of exposure to infective larvae.

Although these tapeworms will mature in other mammals, it appears that D. latum endemicity in humans is dependent upon the human -- crustacean -- fish -- human cycle. Thus, the seemingly simple expedient of sanitary disposal of feces would eliminate the public health problem. Although this has led to marked decline in some Finnish foci, from 20-25 percent prevalence in 1952 down to 1.8 percent in 1972, social habits are hard to change and human infections will no doubt persist. Control can be effected by freezing to -18°C (-4.°F) for 24-48 hr or by consuming only cooked fish; heating to 56°C (133°F) for 5 minutes is sufficient to kill the infective larvae.

ROUNDWORMS (Nematodes)

Not many years ago a few parasitologists were categorically stating that parasites of marine origin were of no public-health importance. Today this statement must be considered invalid. This revision stems largely from recent findings relative to nematodes of the genus Anisakis.

Van Thiel and associates were the first to report a disease of man now designated as anisakiasis or eosinophilic phlegmonous enteritis. They reported that between 1955 and 1959 the patients in Rotterdam and Schiedan and one in Hilverson, all in Holland, had to undergo major surgery because of an acute gastrointestinal syndrome. Two patients died. The symptoms included sudden and violent abdominal colic and fever. By 1968 more than 200 cases had been reported there. In Japan, more than 500 cases were reported by 1980.

Examination of the intestinal tracts of victims revealed larval nematodes embedded in the mucosa, surrounded by phlegomonous infiltration of all layers of gastric and/or intestinal mass with eosinophilic leukocytes. The causative worm was tentatively identified as Eustoma rotundatum, although the designation Anisakis marina, first proposed by Van Thiel, is now commonly employed.

Since the initial report, several other investigations in Europe have described additional human cases of anisakiasis. A comparable disease has been reported in Japan, although the nematode species involved may be different. According to Van Thiel, anisakiasis was essentially unknown before 1955 apparently because before that the gutting and curing of herring occurred aboard ship at sea. In 1955, however, this practice was superseded by gutting and curing the iced fish after the ships reach port. This lapse in time allowed the larvae of Anisakis to penetrate from the viscera of the fish into the abdominal wall, where they remained when the viscera were removed. The larvae was later transmitted to man on the ingestion of slightly cured or lightly salted "green" herring. This alteration in fish processing, however, does not appear to be the only explanation for increased incidences of human anisakiasis. It has been pointed out, although not yet completely explained, that there was a tenfold increase of infection in herring from the North Sea between 1959 and 1965 and another increase during 1966. Van Thiel suggested that as the adult Anisakis in nature is a parasite of marine mammals, particularly the gray seal, the increase in number of seals along the Scottish coast, which is also the feeding ground of adult herring, may be responsible for the increased parasite density in herring.

Since human infections are acquired from eating fish harboring larval Anisakis, other species of marine fish were surveyed to determine their possible roles in transmission of the parasite. It was reported that mackeral, capelin, and salmon can also serve as intermediate hosts. In fact, it was suggested that raw or poorly cooked mackerel may be the major vehicle for human infections in the Orient.

It has been noted that the Japanese strain of anisakiasis is believed to be caused by one or more different species of Anisakis. Adults of Anisakis simplex were found in the bluewhite dolphin and blackfish caught off the coast of Japan, and it also was found what is believed to be the larvae of A. simplex in Alaska pollock, cod, salmon, herring, bonito, mackerel, horse mackerel, and squid. Adults of another species, A. phisteris, have been found in sperm whales in Japanese waters.

A great deal remains to be learned about Anisakis spp. and human anisakiasis. For example, there is no agreement on what role fish play in the life cycle of Anisakis spp. Earlier workers believed that fish serve as true intermediate hosts. Others have proposed that crustaceans serve as the true intermediate hosts, while fish, and even squid, serve as paratenic hosts, having acquired the larval nematodes along the food web.

The parasite is normally in the small intestine of marine mammals such as seals, dolphins, and porpoises (Fig. 2). It is thought that larvae hatched from discharged eggs are ingested by euphausiid crustaceans in which they become infective for fish. The fish and squid ingest the crustaceans, and the larvae continue to develop into infective forms in the gut wall, viscera, and musculature. The cycle is completed when marine mammals feed on the fish.

When humans accidentally ingest the larvae in fish, the worms burrow into the wall of the gastronintestinal tract, causing an acute abdominal emergency, simulating numerous other diseases and frequently leading to surgery. The resected tissue is commonly noted to have an eosinophilic abscess in which a worm fragment may be identified, although the diagnosis is not always established. Once Anisakis was established as the etiologic agent in Japan, reevaluation of surgical pathology specimens revealed many more cases. Thus, it would be expected that many cases remain undiagnosed etiologically.

A primary reason for this disease's recent appearance comes from changes in the processing of fish. Before refrigeration, fish caught at sea were immediately cleaned, eliminating most of the larval worms which initially reside in the intestinal wall and other abdominal viscera. Indeed, freshly caught fish examined for Anisakis larvae tend to have few larvae in the flesh and most in the viscera. But with the current practice of storing the catch on board ship and processing it back in port, the larvae have time to migrate into the fish's flesh.

In the Netherlands, the most important mode of transmission was from consumption of the delicacy, green herring; thus the name "herringworm" disease. In Japan, the raw fish dish, sashimi, is the usual mode of exposure. More than 160 species of marine teleosts have been found to be infected, including tuna, salmon, and mackerel -- all staples in the Japanese fish diet. In 1968, the Netherlands required all raw herring to be frozen at -20°C for at least 24 hours before distribution for consumption, thereby nearly eliminating the disease. However, the Japanese custom of eating raw fish as fresh as possible -- because of its better flavor -- has prevented similar proscriptions.

In the U.S., several surveys have shown the widespread occurrence and high prevalence of Anisakis larvae, Phocanema larvae, and other nematodes in fish commonly sold in markets. A recent sampling of Pacific Northwest salmon sold in supermarkets in Ann Arbor, Michigan, showed larval densities from 63-91 larvae/kg of salmon. These larvae were all alive and infective for rats, suggesting if the salmon were eaten raw, humans also could be infected. Fortunately, clinical cases have been infrequent. Between 1977 and 1980, four cases were documented in California. Three were due to Phocanema decipiens and the fourth to Anisakis type larvae (simplex). Raw salmon or raw red snapper was the apparent source of exposure. A recent case of Anisakis infection was reported in Pittsburgh. Twenty-three previous cases in North America have been primarily due to Phocanema spp.

The widespread occurrence of anisakids in fish in the U.S., in conjunction with the increasing appeal of ceviche, sushi, sashimi, and green herring, indicates a significant risk of exposure. Thus, attempts at prevention must be directed at the consumer as it is virtually impossible to eliminate the infection in fish. However, freezing fish to -20°C (-4°F) or lower for at least 24-48 hours should inactivate Anisakis larvae. On the other hand, cooking so that the core temperature of the fish reaches 60°C (140°F) for 1 min will ensure death of any larvae.

It is not clear, however, why human anisakiasis, although being recognized with increasing frequency, has not reached epidemic proportions among such ethnic groups as the Japanese, who are habitual eaters of raw fish. One answer may be faulty diagnosis by clinicians, and another theory is that severe symptoms occur only after penetration of an area of the stomach or intestine which had been sensitized by previous invasion by Anisakis larvae. These, however, are not complete answers.

Several other species of larval nematodes belonging to the family Anisakidae are known to occur in marine food flesh. Among these is Phocanema decipiens, the so-called codworm formerly known as Porrocaecum decipiens. This nematode's larvae occur in the flesh of cod, smelt, plaice, ocean pout, witch flounder, haddock, redfish, and other species of inshore marine fishes. Larvae of this species also have been reported in 18 species of Pacific fishes including the Pacific cod, Gadus macrocephalus, and Sebastodes alutus. Phocanema decipiens larvae are extremely common in some areas. For example, more than three-fourths of all larvae nematodes encountered in more than 15,000 fish from the Newfoundland fishing area were Phocanema. The occurrence of these relatively large brown worms presents a significant marketing problem as they render the fish unsightly. Furthermore, the occurrence of Phocanema larvae in smaller fish, such as smelt, permits transfer of the parasites to larger predatory species, such as cod. Hence, in more or less confined habitats, epizootics commonly occur.

In addition to Phocanema, larvae of species of Porrocaecum also commonly occur in marine fish. Their adult stages are parasitic in marine birds and can be distinguished from those of Phocanema spp. by the absence of interlabia, the occurrence of a shorter intestinal caecum, and the presence of the excretory pore at the base of the lips. When accidentally ingested by man in raw or inadequately cooked fish, Porrocaecum may also cause a gastrointestinal syndrome comparable to that caused by Anisakis spp. and Phocanema spp.

Another species of Porrocaecum, P. pectinis, occurs in scallops, Aequipecten irradians, and A. gibbus off the coasts of North Carolina, South Carolina, and Florida. On one cruise it was found that 2.38 percent of 400 bay scallop, specimens from the North Carolina coast harbored this nematode. This parasite is commonly found in the adductor muscle, causing it to take on a brownish color.

Another genus of anisakid nematodes, Contracaecum, is commonly encountered in the livers of cod and causes severe economic loss to cod fishermen because parasitized fish suffer losses of both total body weight and liver mass. The fish may even die.

Members of one genus of the Anisakidae, namely Anisakis, are known to be pathogenic to man, so the question may be raised as to whether Porrocaecum and Contracaecum may also be potentially pathogenic. Some scientists believe these larval anisakids are potential pathogens: "These worms (Phocanema, Anisakis, Contracaecum), if consumed alive in raw or inadequately cooked fish, can cause a dangerous parasitic syndrome in man." Furthermore, the potential danger isn't limited to Northern Europe and Japan; it has been reported in fish purchased in Connecticut, Maryland, and New York, with at least one lot originating from Canada. Also, at least one case of Porrocaecum infection is known from Tahiti, French Polynesia.

Since the early 1960s, parasitologists have been intrigued with unofficial reports of a new type of intestinal capillariasis in the Far East, especially in Southeast Asia and the Philippines. The etiologic agent was described as Capillaria philippinesis. The description was based on specimens recovered from a man in the Philippines who had died of symptoms including emaciation, cachexia, and intractable diarrhea. Although it was initially thought the infection had resulted from eating kilawan and papaet, foods containing the vital organs of various small mammals, Dr. John Cross of the Naval Medical Research Unit in Taiwan has found what is believed to be the infective larvae in marine fishes along the west coast of the Philippines, thus suggesting that human infections may be acquired from eating raw or poorly cooked fish.

Human intestinal capillariasis due to C. philippinesis is being recognized with increasing frequency.

Since this infection was recognized in 1962 in Northern Luzon, the Philippines, more than 1,700 cases occurred over the next six years, with a mortality rate of over 5 percent. This newly discovered parasite inhabits the intestinal tract, causing severe diarrhea and death attributed to fluid and electrolyte loss. Transmission occurs by ingestion of small freshwater fish. Hypseleotris, Eleotris, and Ambassis, a local habit among some villagers in Luzon and Mindanao and more recently in scattered sites in Thailand. The larvae are in the intestines of fish which have previously ingested embryonated eggs. The adult worms are most likely normal gut parasites of pisciverous birds, such as the black crown night heron, cattle egret, and yellow bittern. Human infection is thus accidental and not essential for the survival of the parasite. What ecological changes have led to this sudden human exposure are not known, but the incidence of human infection has declined significantly in recent years. Once diagnosed, these cases can be readily cured with an effective antihelminthic drug.

Finally, another nematode-caused disease of man, discovered relatively recently, may be associated with seafoods. The occurrence of eosinophilic meningoencephalitis has been reported in epidemic proportions in Ponape, Eastern Carolines, in the South Pacific and many additional cases have subsequently been reported from New Caledonia and Tahiti. It is now recognized that this disease, for the most part, is due to infection by the rat lungworm, Angiostrongylus cantonensis. Life-cycle studies showed that a mollusk, usually a terrestial species, serves as the intermediate host, and rats become infected in anature as the result of ingesting mollusks harboring third-stage larvae. A. cantonesis, however, can be passed through a series of paratenic hosts. Some of these, such as the freshwater prawn, Macrobrachium lar, and the land crab, Cardisoma hirtipes, acquire the larval nematodes from preying on molluscan intermediate hosts and, in turn, can serve as sources of infection to man if ingested raw or in inadequately pickled or cooked states.

It is pertinent to point out that tipalia, Tilapia mossambica, and the marine carangid fish, Trachurops crumenophthalmus, can serve as experimental paratenic hosts when fed third-stage larvae of A. cantonensis embedded in molluscan tissues. This finding may be of considerable epidemiologic significance in view of the report that the larvae of this nematode can survive for 27 hours in salinities up to 20%. Thus, these species of saltwater fish could possibly serve as sources of human infection.

Also of interest is the successful experimental infection of the American oyster, Crassostrea virginica, and of young, laboratory-reared, quahogs, Mercenaria mercenaria with A. cantonesis. Although infection of C. virginica has been denied by some reports. However, it was pointed out that, considering the experimental procedure, the negative results are not surprising. It has been demonstrated that oysters become infected only if the first-stage larvae are ingested (as the result of the pelecypod's natural pumping activity) and eventually penetrate the host's alimentary tract and come to rest in Leydid tissue. At any time, at least under laboratory conditions, certain species of marine fish and shellfish can respectively serve as paratenic and intermediate hosts for A. cantonesis.

Other Species

Numerous other species of tapeworms, flukes, and roundworms (Table 2) have been identified as causing infection and clinical disease in humans. In most cases, changes in individual food-related activities have been responsible for transmission of such parasites, which are normally found in wild animals. Of these organisms, U. S. residents, especially anglers, are probably familiar with the larvae of Clinostomum spp. and Eustrongylides spp. The former is a fluke whose infective metacercariae appear in the musculature of freshwater fish such as bass and perch. The larvae are large and yellowish in color and are commonly called "yellow grubs." These parasites normally mature in the oropharynx of fish-eating birds such as herons, and humans have been found to have developing worms in the oral cavity.

In a striking and vivid example of how accidental parasites may be acquired, the nematode Eustrongylides spp. caused disease in three fishermen in 1982. These individuals were fishing in Maryland and while waiting decided to satisfy their hunger by swallowing their bait, live minnows. Within 24 hours, each had crampy, abdominal pain. Two underwent surgery, during which roundworms were found in the abdominal cavity, having penetrated through the large intestine. These worms were identified as larvae of Eustrongylides spp. Normally the larvae (8-12 cm. long) in minnows are ingested by pisciverous birds, in whom the worms grow to adulthood in the intestine. The widespread nature of these worms was evidenced by a sampling of 67 minnows in a bait store in Baltimore; 48% were infected with Eustrongylides larvae.

Crustacean-Borne Parasites

In various regions of Asia, Africa, and Latin American, several species of the trematode Paragonimus cause extensive and severe disease in humans (Table 3). In all cases, the mode of transmission is the ingestion of crabs or crayfish that are infected with metacercariae. The life history of these parasites requires two intermediate hosts before humans and other canivores can become infected. The most prevalent of these parasites, P. westermani, is endemic in the Far East in humans and other carnivorous mammals. This parasite is normally found in the lungs, causing various pulmonary problems, although cerebral, intestinal, and cutaneous involvements are common, which lead to significant morbidity. The other species cause similar disease, although their prevalence of infection is typically low in those endemic regions because of the absence of eating the intermediate host crusteceans raw or partially pickled, as is common in the Orient. The infective metacercariae in crabs can withstand exposure to brine, soy sauce, and other commonly used condiments. The effective mode of prevention is to ensure thorough cooking by boiling or frying. Because all of these parasites are widely prevalent in the wild animal population, the most realistic approach to prevention is by proper cooking of the crustaceans.

Chance exposure to P. kellicotti, which is usually found in muskrats, raccoons, and other mammals in the eastern and midwestern U.S., occurred in a young man who ate a raw crayfish on a trip in Missouri. He developed severe pulmonary disease but was fortunately diagnosed by identification of characteristic parasite eggs in sputum and successfully treated. The potential for the occurrence of other cases is evident but has yet to be fully evaluated.

Molluscan-Borne Parasites

People in various parts of the world, either by preference or by economic necessity frequently consume aquatic and terrestrial snails and slugs that are raw or poorly cooked. These invertebrates also commonly contain infective parasites (Table 4) and act as intermediate hosts for worms normally found in rodents, particularly rats. The nematode

Angiostrongylus cantonensis lives as adults in the pulmonary arteries of rats and uses land snails and slugs as intermediate hosts. Human infection results from ingestion of the mollusk with larvae; the worms migrate to meninges of the brain, causing life threatening eosinophilic meningoencephalitis. The parasite, originally found in the Pacific region, has now been found in Africa and most recently in the Caribbean, especially Cuba. The related species A. costaricencis is limited to Central and South American, although it has been found in cotton rats in Texas. Human infections in Costa Rica resulted from ingesting infected slugs. The parasites migrate to the lymphatics and arteries along the intestinal tract, causing severe abdominal pain and inflammatory responses. The patients are usually children; thus, prevention by institution of health education programs would appear to be the most beneficial strategy.

In Southeast Asia, Echinostoma ilocanum is a trematode transmitted by metacercariae residing in aquatic snails commonly eaten raw. The adult worms live in the small intestine and cause tissue damage. The prevalence of infection in Asia is readily correlated with village inhabitants' dietary use of raw snails. In one site in northeast Thailand, 4% of 253 villagers were found to be infected. Prevention rests solely on the avoidance of eating raw snails.

Certain Foods Pose Significant Risk

It is readily apparent from this brief review that fish, squid, crabs, crayfish, and even snails as food items can constitute a significant risk of exposure to a multitude of helminthic parasites. The only requirement is that the aquatic food source be consumed raw or, at most, partially cooked. A definitive way to prevent infection is to cook food thoroughly; in most cases, temperatures of 60°C (140°F) for 1-5 minutes will uniformly kill infective larvae of these parasites. Freezing is somewhat effective, although different parasites have differing tolerances to low temperatures.

Many regions of the world include raw fish as a primary dietary delicacy, making alterations in health-oriented behavior difficult to achieve. Perhaps novel approaches need to be developed to find acceptable methods to render such food items safe with respect to infectious agents. One approach could be the use of external irradiation to inactivate or destroy potential pathogens. As most of the parasites discussed are usually found in a wide variety of domesticated and wild mammals, strategies to attempt eradication would be unproductive.

Furthermore, the worldwide programs of aquaculture and mariculture of fish and other important food items will necessitate improvements in realistic and cost-effective control measures that will be socially acceptable. Primary attention should be directed at control of the most important human parasites listed in Table 1. Many of the other parasites infect humans as chance encounters. These outbreaks require vigilance on the part of public health workers so that immediate recommendations can be made to reduce further exposures in the populations at greatest risk. Fortunately, these parasites do not multiply as do microorganisms such as viruses and bacteria; thus, the development of severe disease tends to be directly related to the numbers of infective larvae to which any individual is exposed. On the other hand, the unusual larval infections caused by *Anisakis* and *Eustrongylides* can cause disease with only a few organisms.

The most important fishborne parasites in the U.S. and Canada are listed in Table 5. The increasing use of various raw fish recipes in these countries necessitates an acceptance of significant health risk, although precise assessments are difficult to calculate. It is expected that periodic outbreaks of human disease as a result of these types of exposure will be increasingly reported.

Table 2 - Fishborne Parasites That Cause Occasional Human Infections

Diphylloborthrium spp. (other than D. latum and D. pacificum)
Clinostomum spp.
Heterophyids (other than H. heterophyes and M. yokogawai
Eustronglides spp.
Opisthorchids (other than C. (O.) sinensis and O. viverrini)

Table 3 - Crustacean-Borne Parasites Transmitted to Humans

Species	Location
Paragonimus westermani	Asia
P. mexicanus	Central America
P. aficanus	Africa
P. uterobilateralis	Africa

Table 4 - Molluscan-Borne Parasites Transmitted to Humans

Species	Location
Angiostrongylus cantonensis	Pacific Asia, Africa, Cuba
A. costaricencis	Central America, South America
Echinostoma ilocanum	Southeast Asia

Table 5 - Fishborne Parasites important as potential pathogens in humans in North America

Diphyllobothrium latum
Anisakis simplex
Phocanema spp.
Eustrongylides spp.

QUESTIONS AND ANSWERS
for Seafood Retailers

This fact sheet has been prepared in response to many questions from seafood retailers about parasites in fish products. Customers who fine parasites in fish they purchase need to have good answers for some obvious questions.

Your customers need to understand two key points: First, parasites are a natural occurrence. Second, although certain roundworms (nematodes) and tapeworms found in fish can infect people, thorough cooking of fish renders these parasites totally harmless.

Public health problems only arise when people eat raw or lightly preserved fish, such as sashimi or ceviche. When fish is to be prepared according to these recipes, it should first be completely frozen for at least 24 hours to kill any parasite that may be present.

Here are some of the most commonly asked questions about parasites.

1. What are those worms that I sometimes see in fish I catch or purchase:

   Fish, like all living organisms, can be infected with various parasites. Modern technology has allowed us to drastically reduce -- but not eliminate the parasites that occur in domesticated food animals and in people.

   Fish, of course, are wild animals, and people have little or no control over their environment. This makes it difficult to avoid an occasional encounter with a naturally occurring parasitic worm.

   The most commonly observed parasites in marine food fishes are roundworms called nematodes. Certain nematodes are common parasites of animals; other attack plants. Even more common are the microscopic, free-living nematodes that occur in soil everywhere.

   The nematodes seen most commonly in fish are often called *herring worms* or *cod worms*. Actually, a number of different species are involved, and it is difficult to distinguish between them. All are in the family *Anisakidae* and are properly referred to as *anisakid nematodes*.

   Other fish, especially freshwater and anadromous fish, may carry larvae of the tapeworm *Diphyllobvothrium*. These small, whitish, and somewhat flabby worms are especially common in salmon from Alaska.

2. How do fish get infected?

   In the case of both anisakid nematodes and Diphyllobothrium tapeworms, fish become infected when they eat small crustaceans that have themselves previously eaten parasite eggs or parasite larvae.

   In the fish, the worms may locate in the muscle or internal organs, where they develop into the stage that can infect people.

3. Will parasites hurt me if I accidentally eat one?

   Because nematodes are relatively uncommon in fish fillets and are easily destroyed by normal processing and cooking procedures, they rarely cause health problems. However, under some circumstances, swallowing a live nematode larvae can cause -- and has caused -- severe gastric upset called anisakiasis.

   These nematodes do not find people to be suitable hosts and do not live long in human digestive tracts. Nevertheless, infections have been reported to cause severe abdominal pain and intestinal upset for as long as 10 days.

   Tapeworms that occur in fish can infect people and other fish-eating mammals if they swallow living larvae. The tapeworms may live in the intestinal tract for several years, and eggs and tapeworm sections can be found in human feces.

   The infection is not fatal. Symptoms in infected individuals may vary from none to abdominal pain, weakness, loss of weight, and anemia.

4. How long do you have to cook fish to eliminate the possibility of parasite infection?

   According to most authorities, cooking fish to an internal temperature of 140°F (60°C) will kill all nematodes and fish tapeworms. This temperature is reached during normal cooking procedures.

5. How about pickling, salting, and smoking fish?

   Hot-smoked fish should be brought to at least 180°F (82°C) to prevent outgrowth of food-poisoning bacteria. If this is done, parasites should be no problem. The 140°F (60°C) temperature necessary to kill parasites would likely be achieved in any hot-smoking process.

Hard-salting (curing) fish before pickling is reported to kill any nematode or tapeworm present. However, pickling without salt curing first may not destroy some nematodes.

One researcher found 4% acetic acid and 6% brines would not kill anisakid after 26 days in a herring brine solution with equal volumes of brine and fish. It's reasonable to expect that pickled herring will be eaten as soon as 2 weeks after preparation.

6. How about raw and lightly marinated recipes? Are they safe?

   Considering recent research on the subject, advise your customers against raw or lightly marinated recipes unless they are sure that the fish is free of parasite larvae. While it's true that only a small percentage of fish are infected with larvae, they may be present but hard to detect.

   In countries where raw fish dishes are traditional, it's a common practice to freeze the fish before preparation. Researchers indicate that complete freezing at normal freezer temperatures (0 to 10°F, -18 to -12°C) for 24 hours is 100% effective, but they caution that large fish take more time than small fish to reach that temperature -- perhaps 4 to 5 days in inefficient freezers.

7. Why don't fish processors remove parasites from fish fillets before they sell them?

   They do remove most of them during the filleting process. (This process removes the parasites in the gut and belly walls of the fish, where most parasites occur.) When they can see larvae in the edible portion, they remove them or withhold the fish from sale.

   However, even examining fillets by transmitted light (candling) is less than 70% effective under the best of circumstances. Larvae more than 1/4-inch deep in the flesh or in dark tissue may not be detected.

   In a 1981 lawsuit against an Oregon grocery chain, the court held that the store had no obligation to eliminate all nematodes before sale. While no store knowingly sells a parasite-infested fish, it is impossible to insure that the product is free of them.

   Parasite infestation is common in fish just as insect infestation is common in fruits and vegetables. If we want to eat fish, we have to expect a certain incidence of parasites to occur.

8. What should retailers tell people about parasites when they ask?

First, tell people that parasites are unlikely to be a serious health problem. Consumers can't have fish in their diet without accepting the fact that nematodes or tapeworms may be present.

The danger to people is far less than that presented by "unseen" pathogenic bacteria likely to be present in all foods.

However, don't try to hide the fact that certain parasites can be harmful if swallowed alive. Suggest these steps:

- Cook all fish until it flakes and loses its translucent (raw) texture (over 140°F, or 60°C, is recommended).

- Use only frozen marine fish for raw fish dishes. Freezing to 0°F center temperatures (-18°C) for 24 hours is adequate. Remember, 4 or 5 days may be required in inefficient home freezers.

9. What else is known about parasites in fish?

Not nearly enough, according to most researchers. But enough is known to be confident that there is no reason to become overly concerned.

Some additional points that are useful to know:

- Older fish (usually the larger ones) tend to have a greater infestation rate than younger fish. They've had longer exposure to parasite sources.

- The life cycles of parasites aren't understood well enough that experts can predict when and where they will occur in fish -- or how long larvae might live in a human host.

- Good handling practices on board boats and in processing plants help to minimize some types of nematode infestation.

  Industry practices have been much improved over the past 30 years.

- While certain types of parasites seem to have been found everywhere, they are significant seasonal, geographic, and species variations.

- Fish infected with nematodes and tapeworms are not "sick." In most cases, infestations are a normal part of the fish's life. The fish is acting as an intermediate host for these parasites, which have a very complicated life history.

SEAFOOD-BORNE BACTERIAL PATHOGENS OF MARINE ORIGIN

Seafood - borne diseases are frequently divided into three categories based on the major source of the responsible agent; 1. agents naturally present in the environment; 2. agents derived from pollution of the aquatic environment; and 3. agents from workers, and processing and food service environments. This review will focus on seafood-borne pathogens of marine origin; specifically members of the family Vibrioacae and *Clostridum botulinum* type E.

Vibrios associated with food-borne illness

Historically, *Vibrio cholerae* 01 has been the *Vibrio* of most concern with respect to public health, all other species and serotypes were referred to as non-agglutinable or non-cholera *Vibrios* (Blake 1980, Desmarchelier 1984). However, *Vibrio* is a large genus containing 28 species plus numerous biotypes an chemovars (Oliver 1985). At least 11 species of *Vibrio* are recognized as pathogenic or potentially pathogenic to humans (Table 1).

Vibrios may cause a variety of diseases including gastroenteritis, wound infection, ear infection, and primary and secondary septicemia (Table 1) (Morris and Black 1985). Of the eleven species pathogenic for humans only six are associated with foodborne disease; *V. cholerae*, *V. hollisae*, *V. mimicus*, *V. parahaemolyticus*, *V. vulnificus*, and perhaps *V. furnisii*. These foodborne species will be the focus of this section.

Vibrio cholerae

V. cholerae is usually divided into two groups, serotype 01 and non-01 *V. cholerae*. Those groups can be further subdivided as toxigenic and non-toxigenic. Toxigenic strains are capable of producing cholera toxin or a very similar toxin.

V. cholerae 01 is the causative agent of endemic or asiatic cholera. The 01 serotype contains two biotypes; classical and El Tor, both of which may contain toxigenic and non-toxigenic strains. The biotypes are differentiated by sensitivity to polymyxin B and Murkee's group four phase and by the ability to agglutinate chicken red blood cells (Sakazaki 1979). The classical biotype predominated world wide until the 1960's. The El tor biotype is currently predominant world wide and is the biotype with associated with recent cases in the U.S. (Blake et.al., 1980, Levine 1981, Morris and Black 1985, CDC, 1986).

Symptoms of *V. cholerae* 01 infection can range from asymptomatic or mild diarrhea to severe cases (cholera gravis). In severe cases, *V. cholerae* 01 can cause profuse watery diarrhea, dehydration and death if not promptly treated. The incubation period varies from 6 hours to five days. Initially, the stool is brown with fecal material but it quickly assumes the classic "rice water" appearance. Enormous amounts of fluids are passed effortlessly and the victim may lose 1 liter per hour or more of fluid, resulting in dehydration and circulatory collapse. The stool is rich in potassium and bicarbonate. Renal function is suppressed and patient suffers from severe thirst, leg cramps, hoarse speech, weakness and rapid pulse (Morris and Black 1985, Blake et.al., 1980, Sakazaki, 1979).

Fortunately, cholera gravis is relatively uncommon. Cholera gravis results in only 1 to 25-100 infections from the El tor biotype and in 1 in 5-10 infections by the classical biotype. People with type O blood type are more susceptible to the severe disease. (Sakazaki 1979)

The infective dose for V. cholerae is estimated to be approximately one billion cells; however, consumption of antacids or medication to lower gastric acidity markely lowers the infective dose (Blake 1987). V. cholerae 01 induces illness by elaborating cholera toxin which stimulates the production of cyclic AMP (Holmgien, 1981). Therefore only toxigenic strains can cause cholera. Non-toxigenic strains of V. cholerae can cause diarrhea but not cholera and have also ben implicated in wound infections.

Cholera in the United States is relatively rare. The U.S. had been spared any identified cholera outbreak from 1911 until 1973, then a single unexplained case occurred in Texas. A second cholera outbreak occurred during August, September, and October of 1978 when 11 people were infected with V. cholerae 01 El Tor from recontaminated cooked crabs (Blake et.al., 1980). In 1981 there were two cases of cholera involving residents of the Texas Gulf Coast and 17 additional cases on an oil rig in the Gulf (Morris and Blake, 1985). Thirteen cases of domestically acquired cholera occurred in 1986; 12 in Louisiana and one in Florida (CDC 1986). Inadequate cooking or improper handling of crustaceans seems to have been the vehicle in this outbreak. Ten of the patients has severe diarrhea and 7 required hospitalization. The V. cholerae 01 was of the El Tor biotype.

Cholera was once thought to be mostly a water borne disease but in recent years the transmission of V. cholerae by food has been well established (Kolvin and Roberts 1982). Outbreaks of cholera have occurred in several countries where food was the vehicle of transmission. Foods involved include raw or partially cooked mollusks, other raw seafood, recontaminated cooked crabs and even raw vegetables. V. cholerae 01 has a relatively short generation time and can grow quickly if foods are temperature abused.

V. cholerae 01 is widely distributed and is probably part of the indigenous bacterial flora in estuarine waters (APHA 1985, Clowell 1984). There is evidence of seasonal variation and most cases of domestically acquired cholera have occurred during the late summer and fall; with August being the month for infection (Madden et al. 1982).

Current methodology for the isolation of V. cholerae from the environment may not adequately recover all viable cells. Research at the University of Maryland has demonstrated that V. cholerae may undergo a nonrecoverable stage that is probably associated with nutrient depletion. This group has combined the methods of immunofluorescent microscopy, acridine organ direct counting and direct viable counts. Using these methods they were able to detect viable cells that could not be detected by normal isolation procedures. The cells can revert to recoverable cells when special procedures are used. This research may explain why outbreaks of cholera may occur in areas where V. cholerae could not be previously recovered from the environment (Colwell et. al 1985, Xu et al. 1982).

Non 01 V. cholerae

At least 70 other groups of V. cholerae are known to exist. They are referred collectively as non-01 V. cholerae or non-agglutinable (NAG) V. cholerae. The majority of the strains isolated from seafood and patients are non-toxigenic strains; less than 5% of the non-01 strains from human sources in the United States produce cholera toxin. The non-toxigenic strains are principally associated with gastrointestinal illness; but in the U.S. about 1/3 of the human isolates are from extraintestinal sources, including wound infection, ear infection and primary and secondary septicemia (Morris and Black 1985). Associated symptoms of gastroenteritis have included diarrhea (100% of cases; 25% have bloody stools), abdominal cramps (93%) and fever (71%). Nausea and vomiting occurs in 21% of the victims. The diarrhea may occasionally be severe; with as many as 20-30 watery stools per day (Morris and Black 1985).

Almost all of the cases of non-01 V. cholerae infections in the U.S. have been associated with eating raw oysters; but egg and asparagus salad and potatoes have also been vehicles for the bacteria.

Considering the relative frequency of isolates from seafood, the incidence of illness is very low. There is evidence that victims often have an underlying liver disease, which might be a host factor for the disease. Also, in most cases the disease may not be severe enough to warrant medical attention and therefore the incidence may be unreported.

Non-01 V. cholerae strains are widely distributed in the environment of the United States, Asia and Europe. They occur most frequently in bays and estuaries with salinity in the area of 0.4-1.7% (Colwell and Kaper 1978); but have also been found in rivers and brackish inland lakes of salinity levels as low as 0.1%. Their presence in oysters and water samples does show a seasonal variation with the highest numbers being isolated June-August (Madden et al. 1982). Non-01 V. cholerae are free living organisms and are part of the autochatonous flora.

Vibrio parahaemolyticus

V. parahaemolyticus was first associated with food poisoning in 1950 in Osaka Japan (Fujino et al. 1974). Since its discovery, V. parahaemolyticus is implicated in greater than 1000 outbreaks per year in Japan and accounts for

45-70% of that country's bacterial food poisonings. Food poisoning in Japan is usually related to the consumption of raw seafood during the warm months. Typical symptoms include diarrhea (sometimes bloody), abdominal cramps, nausea, vomiting, headaches, fever and chills (Fujino et al. 1974). The infective dose for humans is between 10^5 and 10^7 viable cells; however, a decrease in stomach acidity may decrease infective dose. The time for onset of symptoms is usally 9-25 hours and the duration of the illness is usually 2.5-3 days. No deaths have been reported in the United States, but a death rate of 0.4% is reported for Japan. In Japan, raw seafood is the usual vehicle for the organism, but in the U.S. most of the foods implicated in V. parahaemolyticus outbreaks are cooked seafoods that have been recontaminated; although raw oysters and raw crabs have been implicated in some outbreaks (Barker 1974, Blake 1980, Spite et al 1978).

V. parahaemolyticus is widely distributed in nature and has been isolated from coastal waters world wide. Its presence has been documented in virtually all the marine coastal environs of the United States from the coast of Maine, south to the Gulf of Mexico, all along the west coast and from the coastal waters of Hawaii (Fujino 1974, Blake 1980). It is not considered to be a microorganism of the open sea because of cool temperatures and high hydrostatic pressure (Kaneko and Colwell 1978, Colwell 1984, Schwarz and Colwell 1974). Its presence in estuarine environments and in the seafood harvested from these environments usually shows a seasonal variation, being present in the highest numbers during the summer months (Kenako and Colwell 1978, Hackney et al. 1980). Thompson and Vanderzant (1976) did not observe a positive correlation between numbers and season in the waters of the Gulf of Mexico off the Texas coast. However, Paille et al (1987) observed seasonal variation in numbers of V. parahaemolyticus in oysters and waters of Louisiana.

While V. parahaemolyticus is a common contaminant of seafood, often present in high numbers, almost none of the isolates from seafood are capable of causing gastroenteritis in man (Fjuino et al. 1974, Blake 1980, Hackney 1981). The test most widely used to differentiate between virulent and a virulent strains is the Kanagawa reaction, which tests a strain's ability to produce a heat stable hemolysin in an agar medium containing 7% NaCl, mannitol and fresh human or rabbit red blood cells. The heat stable hemolysin is the main virulence determinant for V. parahaemolyticus. Isolates from the marine environment and seafood are predominantly Kanagawa negative. Thompson and Vanderzant (1976) reported only 0.18% of the solates from water, shellfish and sediments of the Gulf of Mexico were Kanagawa positive. In Japan 99% of the sea and fish isolates are Kanagawa negative (Sakazaki 1979).

Food poisoning victims usually only excrete Kanagawa positive isolates. Studies have demonstrated that isolates do not change in the intestines and that Kanagawa positive types are probably part of marine V. parahaemolyticus populations, but present in low numbers. Methodology is needed to selectively isolate Kanagawa positive isolates. Studies in our laboratory have indicated that enrichment in glucose salt tee pol broth, as is currently recommended, actually favors the growth of Kanagawa negative strains. On the other hand, media which do not contain surface active agents such as teepol do not favor Kanagawa negative strains. In laboratory studies, Dicharry (1983) observed that 150 ug Streptomycin /ml in trypticase soy broth containing 1% mannitol favored the growth of Kanagawa positive isolates. She was able to selectively isolate Kanagawa positive strains from laboratory cultures having a ratio of 1000 Kanagawa negative cells to one Kanagawa positive cell. However no Kanagawa positive strains were isolated in later field tests.

V. vulnificus

V. vulnificus has been called the new "terror of the deep" and is one of the most invasive species ever described (Oliver 1985). It has been identified as a halophilic "lactose-positive" marine vibrio. foodborne infection may result after consuming contaminated, raw or undercooked seafood, particularly oysters and clams, with illness usually starting 16-48 hours after ingestion. The organism penetrates the intestinal tract and produces a primary septicemia. The illness usually begins with malaise, followed by chills, fever, and prostration. Vomiting and diarrhea are uncommon, but sometimes occur shortly after chills and fever. Hypotension (systolic blood pressure 80 mmHg) is present in approximately 33% of the cases (Blake et al 1979). The fulminating infection progresses rapidly and may cause death in 40-60% of the patients (Oliver, 1985). Infection by V. vulnificus is RARE in normal healthy people and is usually associated with certain risk factors including; liver disease, gastric disease, malignancy, hemochromatosis and chronic renal insufficiency. (Oliver 1985, Blake et al, 1979). The most common vehicle for the organism is raw oysters.

V. vulnificus is wide spread in the environment and has been isolated from estuarine wears of most coastal states. Infection via the intestinal tract is most often associated with the consumption of raw oysters, but is is sometimes difficult to isolate from the mollusks. Oliver (1981) demonstrated that antimicrobial factors in oysters could be lethal to V. vulnificus when the oysters were homogenized for analysis. Kelly and Dinuzzo (1985) demonstrated that the presence of V. vulnificus in oysters was probably due to filtration of the bacterium from sea water rather than active multiplication in oysters.

The presence of V. vulnificus in water and shellfish is seasonal being most prevalent when the water temperature is high (20°C). Low salinity (0.5-1.6%) also favors the presence of V. vulnificus in seawater (Kelly 1982). Some strains of V. vulnificus show bioluminescence and these strains may also be pathogenic (Oliver 1986). Environmental isolates are phenotypically indistinguishable from clinical isolates and produce virulence factors identical to clinical isolates (Tison and Kelly 1986).

V. mimicus

V. mimicus is biochemically similar to V. cholerae, with the exception that the strains are sucrose negative. In earlier publications, they were listed as V. cholerae of the Hieberg group 5; however DNA homology studies demonstrated that many of the sucrose negative strains were a separate species and in1981 the name mimicus was proposed because of their similarity to V. cholerae (Shandera et al. 1983, Colwell 1984). Both toxigenic and non-toxigenic strains have been isolated, however, the food poisoning cases have been mostly from the non-toxigenic strains. Symptoms of the illness have included diarrhea in most cases, abut approximately 67% of the cases had nausea, vomiting and abdominal cramps. Diarrhea may be bloody and will last 1 to 6 days.

Ray oysters and boiled crawfish (crayfish) have been implicated as vehicles for the organism. V. mimicus is widely distributed in nature and can be found in fresh as well as brackish waters. It does show seasonal variation, being present in highest numbers in the warmer months (Bockemuhl et al. 1986, Colwell 1984)

V. hollisae

V. hollisae (formerly EF 13) has been implicated in approximately 36 cases of food poisoning. Symptoms have included diarrhea and in approximately half the cases vomiting and fever. Seafood is implicated as the vehicle for V. hollisae, including raw oysters, clams and shrimp (Morris et al. 1982).

The ecology of V. hollisae is not well understood because it grows poorly or fails to grow in TCBS, the medium most used in isolation of members of the genus Vibrio.

V. furnissi

V. furnissi was previously classified as biovar II of V. fluvialis. V. furnissi has been implicated in food borne illness (Brenner et al. 1983). It produces gas from glucose, which is an unusual characteristic among Vibrio species. Symptoms of illness include diarrhea, abdominal cramps, and sometimes nausea and vomiting.

Effect of Processing on Survival

Members of the genus Vibrio are sensitive to many of the methods used to process food. All are relatively sensitive to heat, acid, radiation and subfreezing temperatures. Shultz et al. (1984) observed that V. cholerae was heat sensitive, having a D value of 8.15 minutes at 49°C, 2.65 minutes at 60°C, and only 0.30 minutes at 71°C in crabmeat homogenate. Boutin (1986) further showed that preparation of oysters by common recipes effectively eliminates 10^5 V. cholerae 01/g of naturally contaminated oysters. However, Blake et al. (1980) observed that crabs that had been inoculated by placing them in sea water containing 10^4 V. cholerae 01 cells per ml and cooked by boiling for 8 minutes or by steaming 25 minutes at atmospheric pressure contain viable V. cholerae cells. Of course the size of the crab affects heat penetration. Himelbloom et al. (1983) observed that the internal temperature of a large crab (340 g) only reached 50°C after 8 minutes in boiling water. The above date of Shultz et al. (1984) suggests that V. cholerae would survive at this temperature.

V. parahaemolyticus is more heat sensitive than V. cholerae. Delmore and Crisley (1979) observed D values for V. parahaemolyticus in clam homogenate of 0.70 minutes at 49°C, 0.54 minutes at 51°C, 0.31 minutes at 53°C and 0.24 minutes at 55°C. This study shows that the organism is killed be relatively mild heating process. Other work that supports these findings include the work of Goldmintz et al. (1974) who demonstrate that steaming crabs for 5 and 15 minutes (internal temperature 88°C and 95°C) reduced V. parahaemolyticus populations by 6 log cycles. Hackney et al (1980) observed that commercial. practice of heat shocking of oysters to facilitate opening, reduced counts of all vibrios to non-detectable levels, suggesting that most members of the genus vibrio would be killed by cooking. However, it should be noted that steaming of shellfish usually does not provide enough heat to kill vibrios or other pathogens.

Kilgen et al. (1987) demonstrated that radiation levels of 100,000 rads was lethal to V. cholerae, V. parahaemolyticus, and V. vulnificus in live oysters. V. cholerae were slightly more resistant that either V. parahaemolyticus or V. vulnificus. The oysters were still viable up to a level of 250,000 rads. It is suspected that other Vibrio species are similarly sensitive, which suggests that radurization will render seafood safe from vibrios.

Many of the vibrios are somewhat sensitive to subfreezing temperatures. Vanderzant and Nickeson reported a 2 log reduction in counts of V. parahaemolyticus after 8 days of storage at -18°C. Thompson and Thacker (1973) observed that oysters held at -20°C for more than two weeks seldom contained viable V. parahaemolyticus cells. V. vulnificus is also sensitive to cold, Oliver (1984) observed death at refrigeration temperature (0.5-4°C). Freezing can also be lethal and rapid die off is observed at -20°C (6 logs in 40 days) (Boutin et al 1985). However, freezing cannot be relied upon as a method of eliminating vibrios. For example, Reily and Hackney (1985) demonstrated that V. cholerae will survive freezing in seafood homogenate for greater than two months.

V. parahaemolyticus's minimum temperature for growth is 8°C, and it will survive at refrigeration temperatures. In shellstock oysters, V. parahaemolyticus was observed to survive for at least 3 weeks with little or not decrease in numbers, and it has been shown to grow slowly at 10°C in homogenate oysters (Johnson, et al. 1973, Thomson and Thacker 1973). Temperatures below 8°C will usually stop growth, but it has been observed that the organism can still survive (Matches et al. 1971). V. cholerae survives refrigeration temperatures very well and it has even been suggested that cold enrichment will enhance recovery by decreasing competing Vibrio species. V. vulnificus is sensitive to cold. Oliver (1984) and Boutein et al. (1986)

observed rapid decreases in counts at refrigeration temperatures.

V. parahaemolyticus is sensitive to low pH. Vanderzant and Nickelson (1972) reported that in shrimp homogenate no survivors could be recovered at pH values of 4 or less and a rapid drop in viable counts at pH 5 within 15 minutes. Beuchat (1976) also observed sensitivity to acid at pH values of 4.4 or less.

Pleisomonas shigelloides

P. shigelloides (formerly Aeromonas shigelloides) has been implicated in human gastroenteritis for 40 years (Miller and Koberger 1985). Symptoms of the infection include diarrhea (94%), abdominal pain (74%), nausea (74%), chills (49%), fever (37%), headache (34%), and vomiting (33%) (Miller and Kobruger 1985). The onset of symptoms usually occurs 24-50 ours after ingestion of the food. Foods implicated as vehicles for P. shigelloides include cuttle fish salad, salt mackerel, raw oysters and undercooked oysters. In the U.S. raw oysters are probably the most implicated food.

P. shigelloides is widespread in nature, being mostly associated with fresh surface water, but may also be found in seawater. It is more often isolated during the warmer months (Miller and Koburger 1985). Most strains of P. shigelloides have a minimum growth temperature of 8°C, but at least one strain has been reported to grow at 0°C. The organism is sensitive to pH of 4 and salt concentrate of 5% (Miller and Koburger 1986)

Clostridium botulinum

Human botulism is relatively rare; however, the control and prevention of botulism is one of the most important considerations in food processing. History has shown repeatedly that an outbreak of botulism can cause severe, often ruinous economic problems for processors. When problems arise, a whole section of the food industry is often affected, in addition to the processor involved (Eklund 1982, Eyles 1986).

C. botulinum, the etiological agent of botulism, is divided into eight types, based on serological differentiation of the neurotoxin, A, B, C_1, C_2, D, E, F and G (Sakaguchi 1979). The types have been divided into 4 groups by Smith (1977) according to proteolytic activity. Group I and II are the most important with respect to human botulism. Group I includes type A and proteolytic strains of type B and F. This group is strongly proteolytic and produces putrid, unpleasant odors. This group produces highly heat resistant spores and has a minimum growth temperature of about 10°C. Group II includes all type E and non-proteolytic strains of B and F. Group II is neither proteolytic nor gelatinolytic and cultures do not produce putrid odors in food. This group can grow at temperatures as low as 3.3°C and the spores of members of this group are heat liable.

C. botulinum is widely distribute in soils and all types may be isolated from the aquatic environment (Dolman 1964). Type E is th most frequently isolated from aquatic environments and is most often implicated in botulism associated with seafood products. The spores of type E are most often isolated from fresh water and marine sediments in temperate zones (Dolman 1964).

Most outbreaks of botulism associated with fishery products have implicated semi-preserved products, i.e, smoked, salted or fermented products that are eaten without further cooking (Eklund 1982, Lynt et al. 1982). Type E is inhibited by water activity of 0.975 (5% NaCl) and pH value of less than 5.3. (Emodi and Lechowich, 1969). The spores are sensitive to heat. Decimal reduction times at 82.2°C (180°F) range from 0.49 minutes to 6.6 minutes, depending upon the heating medium and the strain (Lynt et al 1982, Simunovic et al. 1985). The spores are most resistent in tuna packed in oil. For foods not packed in oil a D value of 4.3 minutes at 82.2°C is usually considered the maximum. Z values range from 4.8°C to 9.6°C (Simonvic et al 1985). For comparison, other members of Group II produce slightly more heat resistant spores with D-values for nonproteolytic type B ranging from 1.49-32.3 minutes at 82.2°C. The D-values for nonproteolytic F are similar to nonproteolytic B.

Most of the heat processes applied to seafood during processing will destroy C. botulinum type E. Hot smoking at a temperature of 82.2°C for a minimum of 30 minutes is assumed sufficient to destroy 10,000,000 spores of type E (conn and Tayler 1979). Placing crabs in boiling water for 15 minutes will provide a process equivalent of 37.5 minutes for a large crab (340 g) and 319 minutes for very small crabs (120g) (F values calculated by the author from heat penetration data of Hemelbloom et al 1983, using a Z value of 16). Steam cooking of crabs under pressure in a retort is even more effective. F_{16} calculated from heat curves values of Dickerson and Berry (1976) show steam cooking under pressure in a retort for 10 minutes provides a process equivalent to 40,435 minutes at 180°C for a 240g crab and 27,785 minutes for a 300g crab. Pasteurization of crabmeat to a temperature of 185°C for one minute at hot cold point in a one pound 401x301 cn, provides a process equivalent to at least 63.7 minutes at 82.2°C. If one used the D-value of 4.3 minutes at 82.2°C then it is easy to calculate the large safety factor provided by these processes. (74 D - 8.7 D for boiling; 9401 D - 6462 D for steam retorting; and at least 14 D for pasteurization). A 12 D process is considered adequate in canning.

Other forms of preservation processes may not provide safety. Radurization will kill spoilage bacteria but not destroy spores or toxin of type E (Eklund 1982; Skulberg 1965). Modified atmosphere storage, coupled with temperature abuse may create unsafe conditions (Garcia et al. 1987). Post et al (1985) used inoculated and uninoculated fillet and demonstrated the formation of toxin population before or simultaneously with sensory rejection. Therefore storage at a temperature of 3.3°C is critical.

In conclusion, every commodity has microorganisms associated with it that might cause potential safety problems. This review, briefly covers bacterial pathogens of marine origin. It is important that scientists, processors and consumers be aware of potential safety problems so that food poisoning can be prevented. Overall, seafoods have a good safety record and even seafoods that are consumed raw are usually safe for the general public. Verba (1983) reviewed all the shellfish-borne diseases from 1900 to the present. Seawage-born pathogens are by far the greatest hazard. Bacteria of marine origin accounted for only a small number of the cases. However, our present knowledge of V. vulnificus makes it important that people in higher risk categories avoid raw shellfish.

[Source: Cameron R. Hackney, Virginia Polytechnic Institute and State University, Seafood Agriculture Experiment Station, Hampton, Va., and Angela Dicharry, Gulf Coast Research Laboratory, J.L. Scott Marine Education Center, Biloxi, Mississippi.]

APPENDIX

United States Department of Agriculture

Human Nutrition Information Service

HNIS/PT-103

Provisional Table on the Content of Omega-3 Fatty Acids and Other Fat Components in Selected Foods

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Nutrition Monitoring Division
Slightly revised May 1986

Content of Omega-3 Fatty Acids and Other Fat Components (100 Grams Edible Portion, Raw)

Dashes (—) denote lack of reliable data for nutrient known to be present.
Tr = trace (less than 0.05 grams per 100 grams of food.)

Food item	Total fat	Fatty Acids: Total saturated	Fatty Acids: Total monounsaturated	Fatty Acids: Total polyunsaturated	Fatty Acids: 18:3	Fatty Acids: 20:5	Fatty Acids: 22:6	Cholesterol
	g	g	g	g	g	g	g	mg
Finfish								
Anchovy, European	4.8	1.3	1.2	1.6	--	0.5	0.9	--
Bass, freshwater	2.0	.4	.7	.7	Tr	.1	.2	59
Bass, striped	2.3	.5	.7	.8	Tr	.2	.6	80
Bluefish	6.5	1.4	2.9	1.6	--	.4	.8	59
Burbot	.8	.2	.1	.3	--	.1	.1	60
Capelin	8.2	1.5	3.8	1.5	.1	.6	.5	--
Carp	5.6	1.1	2.3	1.4	.3	.2	.1	67
Catfish, brown bullhead	2.7	.6	1.0	.8	.1	.2	.2	75
Catfish, channel	4.3	1.0	1.6	1.0	Tr	.1	.2	58
Cisco	1.9	.4	.5	.6	.1	.1	.3	--
Cod, Atlantic	.7	.1	.1	.3	Tr	.1	.2	43
Cod, Pacific	.6	.1	.1	.2	Tr	.1	.1	37
Croaker, Atlantic	3.2	1.1	1.2	.5	Tr	.1	.1	61
Dogfish, spiny	10.2	2.2	4.2	2.7	.1	.7	1.2	52
Dolphinfish	.7	.2	.1	.2	Tr	Tr	.1	--
Drum, black	2.5	.7	.8	.5	Tr	.1	.1	--
Drum, freshwater	4.9	1.1	2.2	1.2	.1	.2	.3	64
Eel, European	18.8	3.5	10.9	1.4	.7	.1	.1	108
Flounder, unspecified	1.0	.2	.3	.3	Tr	.1	.1	46
Flounder, yellowtail	1.2	.3	.2	.3	Tr	.1	.1	--
Grouper, jewfish	1.3	.3	.3	.4	Tr	Tr	.3	49
Grouper, red	.8	.2	.1	.2	--	Tr	.2	--
Haddock	.7	.1	.1	.2	Tr	.1	.1	63
Hake, Atlantic	.6	.2	.2	.1	Tr	Tr	Tr	--
Hake, Pacific	1.6	.3	.3	.6	Tr	.2	.2	--
Hake, red	.9	.2	.3	.3	--	.1	.1	--
Hake, silver	2.6	.5	.7	.9	.1	.2	.3	--
Hake, unspecified	1.9	.5	.6	.5	--	.1	.4	--
Halibut, Greenland	13.8	2.4	8.4	1.4	Tr	.5	.4	46
Halibut, Pacific	2.3	.3	.8	.7	.1	.1	.3	32
Herring, Atlantic	9.0	2.0	3.7	2.1	.1	.7	.9	60
Herring, Pacific	13.9	3.3	6.9	2.4	.1	1.0	.7	77
Herring, round	4.4	1.3	.8	1.5	.1	.4	.8	28
Mackerel, Atlantic	13.9	3.6	5.4	3.7	.1	.9	1.6	80
Mackerel, chub	11.5	3.0	4.7	3.0	.3	.9	1.0	52
Mackerel, horse	4.1	1.2	1.4	.9	Tr	.3	.3	41
Mackerel, Japanese horse	7.8	2.5	2.4	2.3	.1	.5	1.3	48
Mackerel, king	13.0	2.5	5.9	3.2	--	1.0	1.2	53
Mullet, striped	3.7	1.2	1.1	1.1	.1	.3	.2	49
Mullet, unspecified	4.4	.3	1.3	1.5	Tr	.5	.6	34
Ocean perch	1.6	.3	.6	.5	Tr	.1	.1	42
Perch, white	2.5	.6	.9	.7	.1	.2	.1	80
Perch, yellow	.9	.2	.1	.4	Tr	.1	.2	90
Pike, northern	.7	.1	.2	.2	Tr	Tr	.1	39
Pike, walleye	1.2	.2	.3	.4	Tr	.1	.2	86
Plaice, European	1.5	.3	.5	.4	Tr	.1	.1	70
Pollock	1.0	.1	.1	.5	--	.1	.4	71
Pompano, Florida	9.5	3.5	2.6	1.1	--	.2	.4	50

Data for the following omega-3 fatty acids are included in this table:

18:3 linolenic acid
20:5 eicosapentaenoic acid (EPA)
22:6 docosahexaenoic acid (DHA)

Food item	Total fat	Fatty Acids: Total saturated	Total monounsaturated	Total polyunsaturated	18:3	20:5	22:6	Cholesterol
	g	g	g	g	g	g	g	mg
Finfish—Con.								
Ratfish	1.2	0.3	0.4	0.1	Tr	Tr	0.1	--
Rockfish, brown	3.3	.8	.8	1.0	Tr	.3	.4	--
Rockfish, canary	1.8	.4	.5	.6	Tr	.2	.3	34
Rockfish, unspecified	1.4	.2	.3	.6	Tr	.2	.3	--
Sablefish	15.3	3.2	8.1	2.0	.1	.7	.7	49
Salmon, Atlantic	5.4	.8	1.8	2.1	.2	.3	.9	--
Salmon, chinook	10.4	2.5	4.5	2.1	.1	.8	.6	--
Salmon, chum	6.6	1.5	2.9	1.5	.1	.4	.6	74
Salmon, coho	6.0	1.1	2.1	1.7	.2	.3	.5	--
Salmon, pink	3.4	.6	.9	1.4	Tr	.4	.6	--
Salmon, sockeye	8.6	1.5	4.1	1.9	.1	.5	.7	--
Saury	9.2	1.6	4.8	1.8	.1	.5	.8	19
Scad, Muroaji	8.7	2.8	2.2	2.6	.1	.5	1.5	47
Scad, other	.5	.1	.1	.1	--	Tr	Tr	27
Sea bass, Japanese	1.5	.4	.3	.5	Tr	.1	.3	41
Seatrout, sand	2.3	.7	.8	.4	Tr	.1	.2	--
Seatrout, spotted	1.7	.5	.4	.3	Tr	.1	.1	--
Shark, unspecified	1.9	.3	.4	.8	--	Tr	.5	44
Sheepshead	2.4	.6	.7	.5	Tr	.1	.1	--
Smelt, pond	.7	.2	.1	.3	--	.1	.2	72
Smelt, rainbow	2.6	.5	.7	.9	.1	.3	.4	70
Smelt, sweet	4.6	1.6	1.2	1.0	.3	.2	.1	25
Snapper, red	1.2	.2	.2	.4	Tr	Tr	.2	--
Sole, European	1.2	.3	.4	.2	Tr	Tr	.1	50
Sprat	5.8	1.4	2.0	1.5	--	.5	.8	38
Sturgeon, Atlantic	6.0	1.2	1.7	2.1	Tr	1.0	.5	--
Sturgeon, common	3.3	.8	1.6	.5	.1	.2	.1	--
Sunfish, pumpkinseed	.7	.1	.1	.2	Tr	Tr	.1	67
Swordfish	2.1	.6	.8	.2	--	.1	.1	39
Trout, arctic char	7.7	1.6	4.6	.9	Tr	.1	.5	--
Trout, brook	2.7	.7	.8	.9	.2	.2	.2	68
Trout, lake	9.7	1.7	3.6	3.4	.4	.5	1.1	48
Trout, rainbow	3.4	.6	1.0	1.2	.1	.1	.4	57
Tuna, albacore	4.9	1.2	1.2	1.8	.2	.3	1.0	54
Tuna, bluefin	6.6	1.7	2.2	2.0	--	.4	1.2	38
Tuna, skipjack	1.9	.7	.4	.6	--	.1	.3	47
Tuna, unspecified	2.5	.9	.6	.5	--	.1	.4	--
Whitefish, lake	6.0	.9	2.0	2.2	.2	.3	1.0	60
Whiting, European	.5	.1	.1	.1	Tr	Tr	.1	31
Wolffish, Atlantic	2.4	.4	.8	.8	Tr	.3	.3	--
Crustaceans								
Crab, Alaska king	.8	.1	.1	.3	Tr	.2	.1	--
Crab, blue	1.3	.2	.2	.5	Tr	.2	.2	78
Crab, Dungeness	1.0	.1	.2	.3	--	.2	.1	59
Crab, queen	1.1	.1	.2	.4	Tr	.2	.1	127

Food item	Total fat	Fatty Acids: Total saturated	Total monounsaturated	Total polyunsaturated	18:3	20:5	22:6	Cholesterol
	g	g	g	g	g	g	g	mg
Crustaceans—Con.								
Crayfish, unspecified........	1.4	0.3	0.4	0.3	Tr	0.1	Tr	158
Lobster, European...........	.8	.1	.2	.2	--	.1	.1	129
Lobster, northern	.9	.2	.2	.2	--	.1	.1	95
Shrimp, Atlantic brown......	1.5	.3	.3	.5	Tr	.2	.1	142
Shrimp, Atlantic white.......	1.5	.2	.2	.6	Tr	.2	.2	182
Shrimp, Japanese (kuruma) prawn...........	2.5	.5	.5	1.0	Tr	.3	.2	58
Shrimp, northern	1.5	.2	.3	.6	Tr	.3	.2	125
Shrimp, other	1.3	.4	.3	.3	Tr	.1	.1	128
Shrimp, unspecified	1.1	.2	.1	.4	Tr	.2	.1	147
Spiny lobster, Caribbean	1.4	.2	.2	.6	Tr	.2	.1	140
Spiny lobster, southern rock	1.0	.1	.2	.3	Tr	.2	.1	--
Mollusks								
Abalone, New Zealand	1.0	.2	.2	.2	Tr	Tr	--	--
Abalone, South African......	1.1	.3	.3	.2	Tr	Tr	Tr	--
Clam, hardshell	.6	Tr	Tr	.1	Tr	Tr	Tr	31
Clam, hen...................	.7	.2	.1	.1	--	Tr	Tr	--
Clam, littleneck	.8	.1	.1	.1	Tr	Tr	Tr	--
Clam, Japanese hardshell	.8	.1	.1	.2	--	.1	.1	--
Clam, softshell	2.0	.3	.2	.6	Tr	.2	.2	--
Clam, surf	.8	.1	.1	.2	Tr	.1	.1	--
Conch, unspecified	2.7	.6	.5	1.1	Tr	.6	.4	141
Cuttlefish, unspecified	.6	.1	.1	.1	Tr	Tr	Tr	--
Mussel, blue	2.2	.4	.5	.6	Tr	.2	.3	38
Mussel, Mediterranean	1.5	.4	.4	.3	--	.1	.1	--
Octopus, common	1.0	.3	.1	.3	--	.1	.1	--
Oyster, eastern	2.5	.6	.2	.7	Tr	.2	.2	47
Oyster, European	2.0	.4	.2	.7	.1	.3	.2	30
Oyster, Pacific	2.3	.5	.4	.9	Tr	.4	.2	--
Periwinkle, common..........	3.3	.6	.6	1.1	.2	.5	Tr	101
Scallop, Atlantic deepsea	.8	.1	.1	.3	Tr	.1	.1	37
Scallop, calico	.7	.1	--	.2	Tr	.1	.1	--
Scallop, unspecified	.8	.1	.1	.3	Tr	.1	.1	45
Squid, Atlantic..............	1.2	.3	.1	.5	Tr	.1	.3	--
Squid, short-finned	2.0	.4	.4	.7	Tr	.2	.4	--
Squid, unspecified	1.1	.3	.1	.4	Tr	.1	.2	--
Fish Oils								
Cod liver oil	100	17.6	51.2	25.8	0.7	9.0	9.5	570
Herring oil	100	19.2	60.3	16.1	0.6	7.1	4.3	766
Menhaden oil	100	33.6	32.5	29.5	1.1	12.7	7.9	521
MaxEPA™, concentrated fish body oils	100	25.4	28.3	41.1	0	17.8	11.6	600
Salmon oil	100	23.8	39.7	29.9	1.0	8.8	11.1	485

Food item	Total fat	Fatty acids: Total saturated	Total monounsaturated	Total polyunsaturated	18:3	Cholesterol
	g	g	g	g	g	mg
Beef						
Chuck, blade roast, all grades, separable lean & fat, raw	23.6	10.0	10.8	0.9	0.3	73
Ground, regular, raw	27.0	10.8	11.6	1.0	.2	85
Round, full cut, choice grade, separable lean & fat, raw	17.5	7.4	7.8	.7	.2	66
Separable fat from retail cuts, raw	70.9	31.0	32.4	2.6	1.0	99
T-Bone steak, choice grade, lean only, raw	8.0	3.2	3.4	.3	Tr	60
T-Bone steak, choice grade, separable lean & fat, raw	26.1	11.2	11.7	1.0	.3	71
Cereal Grains						
Barley, bran	5.3	1.0	.6	2.7	.3	0
Corn, germ	30.8	3.9	7.6	18.0	.3	0
Oats, germ	30.7	5.6	11.1	12.4	1.4	0
Rice, bran	19.2	3.6	7.3	6.6	.2	0
Wheat, bran	4.6	.7	.7	2.4	.2	0
Wheat, germ	10.9	1.9	1.6	6.6	.7	0
Wheat, hard red winter	2.5	.4	.3	1.2	.1	0
Dairy and Egg Products						
Cheese, Cheddar	33.1	21.1	9.0	.9	.4	105
Cheese, Roquefort	30.6	19.3	8.5	1.3	.7	90
Cream, heavy whipping	37.0	23.0	10.7	1.4	.5	137
Milk, whole	3.3	2.1	1.0	.1	.1	14
Egg yolk, chicken, raw	32.9	9.9	13.2	4.3	.1	1,602
Fats and Oils						
Butter	81.1	50.5	23.4	3.0	1.2	219
Butter oil	99.5	61.9	28.7	3.7	1.5	256
Chicken fat	99.8	29.8	44.7	20.9	1.0	85
Duck fat	99.8	33.2	49.3	12.9	1.0	100
Lard	100	39.2	45.1	11.2	1.0	95
Linseed oil	100	9.4	20.2	66.0	53.3	0
Margarine, hard, soybean	80.5	16.7	39.3	20.9	1.5	0
Margarine, hard, soybean and soybean (hydrog.)	80.5	13.1	37.6	26.2	1.9	0
Margarine, hard, soybean (hydrog.) & palm	80.5	17.5	31.2	28.2	2.3	0
Margarine, hard, soybean (hydrog.) & cottonseed	80.5	15.6	36.1	25.3	2.8	0
Margarine, hard, soybean (hydrog.) & palm (hydrog.)	80.5	15.1	32.0	29.8	3.0	0
Margarine, liquid, soybean (hydrog.), soybean, & cottonseed	80.6	13.2	28.1	35.8	2.4	0
Margarine, soft, soybean (hydrog.) & cottonseed	80.4	16.5	31.3	29.1	1.6	0
Margarine, soft, soybean (hydrog.) & palm	80.4	17.1	25.2	34.6	1.9	0
Margarine, soft, soybean, soybean (hydrog.) & cottonseed (hydrog.)	80.4	16.1	30.7	30.1	2.8	0

Food item	Total fat	Fatty acids: Total saturated	Total monounsaturated	Total polyunsaturated	18:3	Cholesterol
	g	g	g	g	g	mg
Fats and Oils—Con.						
Mutton tallow	100	47.3	40.6	7.8	2.3	102
Rapeseed oil (Canola)	100	6.8	55.5	33.3	11.1	0
Rice bran oil	100	19.7	39.3	35.0	1.6	0
Salad dressing, comm., blue cheese, reg.	52.3	9.9	12.3	27.8	3.7	17
Salad dressing, comm., Italian, reg.	48.3	7.0	11.2	28.0	3.3	0
Salad dressing, comm., mayonnaise, imitation, soybean, w/o cholesterol	47.7	7.5	10.5	27.6	4.6	0
Salad dressing, comm., mayonnaise, safflower & soybean	79.4	8.6	13.0	55.0	3.0	59
Salad dressing, comm., mayonnaise, soybean	79.4	11.8	22.7	41.3	4.2	59
Salad dressing, comm., mayonnaise-type	33.4	4.7	9.0	18.0	2.0	26
Salad dressing, comm., Thousand Island, reg.	35.7	6.0	8.3	19.8	2.5	0
Salad dressing, home recipe, French	70.2	12.6	20.7	33.7	1.9	0
Salad dressing, home recipe, vinegar & soybean oil	50.1	9.1	14.8	24.1	1.4	0
Shortening, household, lard & veg. oil	100	40.3	44.4	10.9	1.1	56
Shortening, household, soybean (hydrog.) & cottonseed (hydrog.)	100	25.0	44.5	26.1	1.6	0
Shortening, special-purpose, for bread, soy (hydrog.) & cottonseed	100	22.0	33.0	40.6	4.0	0
Shortening, special-purpose, for cake mixes, soybean (hydrog.) & cottonseed (hydrog.)	100	27.2	54.2	14.1	1.1	0
Shortening, special-purpose, heavy-duty, frying, soybean (hydrog.)	100	18.4	43.7	33.5	2.4	0
Soybean lecithin	100	15.3	10.9	45.1	5.1	0
Soybean oil	100	14.4	23.3	57.9	6.8	0
Soybean oil (hydrog.) & cottonseed oil	100	14.9	43.0	37.6	2.8	0
Soybean oil (partially-hydrog.)	100	14.9	43.0	37.6	2.6	0
Spread, margarine-like, about 60% fat, soybean (hydrog.) & palm (hydrog.)	60.8	14.1	26.0	18.1	1.6	0
Spread, margarine-like, about 60% fat, soybean (hydrog.), palm (hydrog.), & palm	60.8	13.5	24.1	20.4	1.6	0
Tomatoseed oil	100	19.7	22.8	53.1	2.3	0
Walnut oil	100	9.1	22.8	63.3	10.4	0
Wheat germ oil	100	18.8	15.1	61.7	6.9	0
Fruits						
Avocados, California, raw	17.3	2.6	11.2	2.0	.1	0
Raspberries, raw	.6	Tr	Tr	.3	.1	0
Strawberries, raw	.4	Tr	Tr	.2	.1	0
Lamb and Veal						
Lamb, leg, raw (83% lean, 17% fat)	17.6	8.1	7.1	1.0	.3	71
Lamb, loin, raw (72% lean, 28% fat)	27.4	12.8	11.2	1.6	.5	71
Veal, leg round with rump, raw (87% lean, 13% fat)	9.0	3.8	3.7	.6	.1	71

Food item	Total fat	Fatty acids: Total saturated	Total monounsaturated	Total polyunsaturated	18:3	Cholesterol
	g	g	g	g	g	mg
Legumes						
Beans, common, dry	1.5	0.2	0.1	0.9	0.6	0
Chickpeas, dry	5.0	.5	1.1	2.3	.1	0
Cowpeas, dry	1.9	.6	.1	.8	.3	0
Lentils, dry	1.2	.2	.2	.5	.1	0
Lima beans, dry	1.4	.3	.1	.7	.2	0
Peas, garden, dry	2.4	.4	.1	.4	.2	0
Soybeans, dry	21.3	3.1	4.4	12.3	1.6	0
Nuts and Seeds						
Beechnuts, dried	50.0	5.7	21.9	20.1	1.7	0
Butternuts, dried	57.0	1.3	10.4	42.7	8.7	0
Chia seeds, dried	26.3	10.5	7.3	7.3	3.9	0
Hickory nuts, dried	64.4	7.0	32.6	21.9	1.0	0
Soybean kernels, roasted & toasted	24.0	3.2	5.6	12.7	1.5	0
Walnuts, black	56.6	3.6	12.7	37.5	3.3	0
Walnuts, English/Persian	61.9	5.6	14.2	39.1	6.8	0
Pork						
Pork, cured, bacon, raw	57.5	21.3	26.3	6.8	.8	67
Pork, cured, breakfast strips, raw	37.1	12.9	16.9	5.6	.9	69
Pork, cured salt pork, raw	80.5	29.4	38.0	9.4	.7	86
Pork, fresh, ham, raw	20.8	7.5	9.7	2.2	.2	74
Pork, fresh, jowl, raw	69.6	25.3	32.9	8.1	.6	90
Pork, fresh, leaf fat, raw	94.2	45.2	37.2	7.3	.9	110
Pork, fresh, separable fat, raw	76.7	27.9	35.7	8.2	.7	93
Poultry						
Chicken, broiler fryers, flesh & skin, giblets, neck, raw*	14.8	4.2	6.1	3.2	.1	90
Chicken, dark meat, w/o skin, raw*	4.3	1.1	1.3	1.0	Tr	80
Chicken, light meat, w/o skin, raw*	1.7	.4	.4	.4	Tr	58
Chicken, skin only, raw*	32.4	9.1	13.5	6.8	.3	109
Turkey, flesh, with skin, roasted*	9.7	2.8	3.2	2.5	.1	82
Vegetables						
Beans, Navy, sprouted, cooked	.8	Tr	Tr	.5	.3	0
Beans, pinto, sprouted, cooked	.9	.1	Tr	.5	.3	0
Broccoli, raw	.4	Tr	Tr	.2	.1	0
Cauliflower, raw	.2	Tr	Tr	Tr	.1	0
Kale, raw	.7	Tr	Tr	.3	.2	0
Leeks, freeze-dried, raw	2.1	.3	Tr	1.2	.7	0
Lettuce, butterhead, raw	.2	Tr	Tr	.1	.1	0
Radish seeds, sprouted, raw	2.5	.7	.4	1.1	.7	0
Seaweed, Spirulina, dried	7.7	2.6	.7	2.0	.8	0
Soybeans, green, raw	6.8	.7	.8	3.8	3.2	0
Soybeans, mature seeds, sprouted, cooked	4.5	.5	.5	2.5	2.1	0
Spinach, raw	.4	Tr	Tr	.1	.1	0

* Contains trace amounts of 20:5, 22:5, and 22:6.

GLOSSARY

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.

ANTIOXIDANT: A substance that prevents another substance from combining with oxygen by taking up the oxygen itself. Example: Vitamin E.

AUTOLYTIC ENZYMES: Chemical splitting of the tissue of an organ by the action of an enzyme peculiar to it.

BHA and BHT: Antioxidants that prevent rancidity in bakery and snack food.

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.

CHOLESTEROL: A fat related substance. It is synthesized by the liver and found in animal tissue.

CIS FIGURATION: Having certain atoms or radicals in a chemical structure on the same side.

CLOSTRIDIUM BOTULINUM: The bacteria that causes botulism.

COENZYME: A substance that helps an enzyme start a reaction.

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.

COLLAGEN: The protein that forms the structural material of tissue.

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.

DENATURED: Means changed. A denatured protein is one where the arrangement of amino acids have been altered. This change can be the result of exposing to heat, acid, base, alcohol, heavy metals, and other substances.

DEPURATION: The process by which shellfish cleanse themselves of microbiological contaminants in a controlled process water environment.

EFFLUENT: The outflow of a sewer.

ELASMOBRANCHS: Having cartilagenous skeletons and lacking air bladders. A class or subclass of sharks, rays.

ELASTIN: A protein found in animal connective tissue. Has a tendency to be rubbery.

ENZYME: A substance (a protein) produced by cells to speed up a metabolic reaction.

ESTER: A compound that is formed as the result of the interaction of an acid and alcohol.

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 of 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.

FREEZER BURN: Drying out of surface of food due to exposure to cold temperature.

GILLS: The respiratory organs of water-breathing animals.

GLYCOPROTEIN: A compound of protein and carbohydrate.

HEMOCYAMIN: Copper-containing chromaprotein found in the blood of some invertebrates.

HEMOLYSIS: Liberation of hemoglobin from the red cells and its appearance in the plasma.

HYDROXYPROLINE: An amino acid produced in the digestion of hydrolytic decomposition of protein especially collagens.

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.

LIPOPROTEIN: A combination of protein and a lipid that is more readily transported in blood than lipids alone.

LOW ACID FOODS: Those foods having a pH value of 7 to 14. Example protein foods are all vegetables, except tomatoes.

MAILLARD REACTION: A non-enzymatic browning resulting from an interaction of proteins with reducing sugars or some other products of lipid material. Can occur during cooking or during the improper storage of dried fish.

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 of volume.

MUNSELL VALUE: A numerical representation of color based on a standardized color scale.

MYOFIBRILLAR PROTEIN: proteins of a skeletal muscle.

OSTAOBLAST: bone forming cells.

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.

PHOSPHOLIPIDS: A lipid related compound composed of glycerol, a phosphate molecule and other chemical groups.

PLANKTON: Passively floating or weakly moving aquatic plants and animals, usually microscopic.

POLYUNSATURATES: Fats containing fatty acids having more than one unsaturated bond is a chemical structure into which additional hydrogen can be incorporated. In general, polyunsaturated fats tend to be liquids of vegetative origin.

PROTEIN EFFICIENCY RATIO (PER): A measure of protein quality that is assessed by determining how well it supports the weight gain of a laboratory animal.

PUFA: Means polyunsaturated fatty acid.

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.

REDUCING SUGAR: Any carbohydrate that can be oxidized without having to be hydrolyzed itself.

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 the 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.

THIAMINEASE: An enzyme that splits or destroys thiamin.

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.

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Alaska Fisheries Development Foundation
805 West 3rd Ave.
Anchorage, AK 99501
907-276-7315
Executive Director: Christopher Mitchell

Great Lakes Fisheries Development Foundation
P.O. Box 658
Grand Haven, MI 49417
616-842-2440
Executive Director: Claude VerDuin

Gulf and South Atlantic Fisheries Development Foundation
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5401 West Kennedy Blvd.
Tampa, FL 33609
813-870-3390
Executive Director: Thomas Murray

Mid-Atlantic Fisheries Development Foundation, Inc.
2200 Somerville Rd., Suite 600
Annapolis, MD 21401
301-266-5530
Executive Director: Kerry Muse

New England Fisheries Development Foundation
280 Northern Ave.
Boston, MA 02210
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Pacific Fisheries Development Foundation
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STATE AGENCIES

Alabama Dept. of Conservation and Natural Resources
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Montgomery, AL 36104
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Alaska Dept. of Fish and Game
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California Dept. of Fish and Game
1416 Ninth St.
Sacramento, CA 95814
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Connecticut Dept. of Environmental Protection
Bureau of Fisheries
State Office Bldg., Room 255
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Hartford, CT 06106
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Delaware Div. of Fish and Wildlife
Dept. fo Natural Resources and Environmental Control
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3900 Commonwealth Blvd.
Suite 905
Tallahassee, FL 32303

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Coastal Resources Division
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Brunswick, GA 31520
912-264-7218

Idaho Dept. of Fish and Game
600 South Walnut
Boise, ID 93707
208-334-3771

Food Marketing Institute
1750 K St., NW
Washington, DC 20006
202-452-8444

Gloucester Fisherman's Wives Assoc.
27 Chapel St.
Gloucester, MA 01930
617-281-2384

Halibut Assoc. of North America
309 Maritime Bldg.
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Seattle, WA 98104
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Maine Fisherman's Wives Assoc.
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Maine Sardine Council
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