SEAFOOD QUALITY
A Practical Guide
BY JOHN SACKTON

Seafood isn't "fishy." There is nothing about seafood that makes quality-control more difficult than it is with other foods. Yet, for years, American consumers have had quality problems with fish. As a result, people think fish is more likely than other foods to be of marginal quality. It is unfortunate that this perception extends into the language — where something "fishy" means something not quite right.

Interest in seafood in the United States is now at an all-time high, and per capita consumption has set records for the past two years. Seafood suppliers — from the producer on a vessel to the operator of a take-out stand — must share the responsibility to overcome negative consumer perceptions by understanding and maintaining seafood quality. Otherwise, further increases in seafood consumption will be jeopardized.

WHAT IS QUALITY SEAFOOD?
Quality exists in any food when it is kept at its peak of flavor and wholesomeness, so that its distinctive character comes through. Quality meat and poultry are produced when animals are bred and fed with care, and slaughtering, processing, and packing are strictly controlled. Such control is possible in the meat and poultry industries because the animals are raised and killed in completely structured environments. Also, the range of species or varieties presented to the consumer is narrow. Most cattle and poultry slaughtered in the U.S. are members of a very few breeds.

The seafood industry, on the other hand, is extremely varied. Americans eat hundreds of varieties of fish and shellfish, from all the oceans of the world. Each species has a distinctive eating character and quality. And, because most are wild animals, the fish themselves vary from month to month and year to year. They are affected by what they eat, by spawning and migrating, by water temperature, pollutants, and salinity. In short, the entire ecological system in which a fish or shellfish lives, together with the particular characteristics of the species, determines the quality of that animal as seafood. This system is not controlled by the people who harvest the product, with the significant exception of those in the aquaculture industry.

Seafood quality, then, means harvesting, handling, processing, packing, transporting, and storing products in a manner that maintains their distinctive character and keeps them as fresh and wholesome as possible. In the seafood business, it is not unusual for a single seafood product to come under the control of three or four companies before reaching the final consumer. Seafood buyers must know the factors that affect the quality of seafood throughout its distribution chain. If not, no matter how well the final seller may care for the product, he cannot guarantee its quality to the customer.

MAJOR FACTORS AFFECTING QUALITY
Bacteria are the principal cause of spoilage in fresh seafood. Virtually all quality-control efforts are devoted to retarding or preventing the growth of spoilage bacteria in fish. Although the natural enzymatic processes that lead to bacterial growth cannot be stopped, temperature control and sanitation can prevent large numbers of bacteria from multiplying too rapidly.

In live fish and shellfish, enzymes in the digestive tract help break down food molecules; enzymes in tissue help build proteins from amino acids. These enzymes continue to work after fish and shellfish die, but in an uncontrolled way. The digestive enzymes attack the stomach lining, then the flesh of the improperly handled fish is easy to spot. The bottom cod fillet is from a fish that was bled soon after harvest and handled with care. The middle fillet is from an unbled fish, and the top fillet shows gaff wounds and bruises caused by improper handling.
belly cavity. This is particularly likely to occur when fish have been feeding heavily just before capture. If the fish is not gutted promptly upon being caught, it may develop belly burn, a condition in which the flesh surrounding the belly cavity partially disintegrates or is made excessively soft. Belly burn may be found in fish such as herring, sardines, mackerel, and other fish that generally are not gutted. However, fish gutted at sea will not develop the problem.

Autolytic enzymes are present in the tissues of fish. When a fish dies, these enzymes break down the amino acids in the tissues into smaller molecules, allowing bacteria to feed and multiply more rapidly.

Bacteria are present on the gills and skin and in the digestive systems of fish. After death, the natural mechanisms that keep these bacteria in check are gone, and they begin to multiply, eventually invading the flesh of the fish. Two factors contribute to more-rapid bacterial growth on fish than on some other protein foods. One is that fish contain protein molecules of small molecular weight that are relatively easy for bacteria to eat. Beef, on the other hand, contains mostly larger protein molecules that must be broken down before bacterial growth can occur. The second factor is that fish are often contaminated with cold-tolerant bacteria, which remain active at low temperatures. By contrast, only warm-temperature bacterial organisms are present in warm-blooded animals at death; as a result, it takes longer for cold-tolerant bacteria to grow and spoil the meat.

Spoilage bacteria are responsible for the odors associated with decomposition in fish. In whole or dressed fish, spoilage may be detected first in the gill area and along the front part of the backbone. To check for spoilage, snap back the head of the fish, breaking the backbone. If no odors are present in the area of the break, the fish is in excellent condition. If a slight odor is detectable, the fish is still in good condition but is beginning to age. If strong odors are present, the rest of the fish should be checked for other signs of deterioration, such as soft flesh or protruding or separated bones in the belly area.

All fish contain significant amounts of unsaturated fats.
Wherever these rats are exposed to air, they oxidize far more quickly than the saturated rats found in meats, causing rancidity and an off-flavor. Oxidation is often accompanied by a yellowing of flesh color. This process continues after fish is frozen, and the only remedy is to develop an effective oxygen barrier such as a glaze.

Because both bacterial growth and biochemical reactions are sensitive to temperature, the temperature at which fish is held is the most important determinant of quality and shelf-life. For every 10-degree F. rise in temperature above freezing, spoilage rates increase approximately by a factor of two.

Action required by seafood handlers is summed up in the saying, "Keep it cold, keep it clean, keep it moving."

### Origins of Quality in Seafood

#### The Fish Itself

A buyer must determine how seafood varies intrinsically in quality. One of the key factors is the spawning cycle of the fish. As fish prepare to spawn, fat content decreases, water content increases, and muscle loses tone. The flesh becomes soft and watery. A fish in this condition produces a much-reduced yield, since so much of its weight is in its gonads. Fillets from fish that have spawned recently are prone to gaping, a condition in which muscle fibers separate because the connective tissue is no longer able to hold them together. Gaping is also common in fillets that are getting old.

Spawning affects the fat or oil content of the fish, which is lowest during and just after spawning. For some species, such as tuna, oil content greatly affects marketability. Monitoring the increasing oil content in these fish as they regain strength after spawning is crucial to buying correctly.

Other intrinsic factors that affect quality include the food a fish eats and the quality of the water it lives in. Striped bass, for example, are known to tolerate polluted waters, and they can pick up oily flavors. Catfish are also sensitive to off-flavors caused by a type of blue-green algae found in ponds.

Shellfish such as clams, oysters, and mussels go through similar physiological changes during spawning. A recently spawned

### Quality Checklist

<table>
<thead>
<tr>
<th>GOOD QUALITY</th>
<th>FRESH WHOLE FISH</th>
<th>POOR QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear, bright, bulging, black pupil</td>
<td>EYES</td>
<td>Dull, sunken, cloudy, gray pupil</td>
</tr>
<tr>
<td>Bright red, free of slime, clear mucus</td>
<td>GILLS</td>
<td>Brown to grayish; thick, yellow mucus</td>
</tr>
<tr>
<td>Firm and elastic to touch, tight to the bone</td>
<td>FLESH</td>
<td>Soft and flabby, separating from bone</td>
</tr>
<tr>
<td>Ocean-fresh, slight seaweed scent</td>
<td>ODOR</td>
<td>Ammonia, putrid smell</td>
</tr>
<tr>
<td>Adhere tightly to skin, bright color, few missing</td>
<td>SCALES</td>
<td>Dull, large quantities missing</td>
</tr>
<tr>
<td>Complete washing and evisceration</td>
<td>BELLY CAVITY (gutted)</td>
<td>Cuts, bones loose from flesh, incomplete evisceration</td>
</tr>
<tr>
<td>Varies with species, but should be consistent, bright</td>
<td>COLOR</td>
<td>Brusing, red spots, yellowing or browning at edges</td>
</tr>
<tr>
<td>Ocean-fresh, slight seaweed scent</td>
<td>SMELL</td>
<td>Ammonia, putrid smell</td>
</tr>
<tr>
<td>Clean-cut, free of skin (if skinless), no bones: firm, moist</td>
<td>FLESH</td>
<td>Ragged, traces of bones and skin (if skinless), soft and mushy, dried out</td>
</tr>
<tr>
<td>Legs move when tickled, lobster tail curls under, heavy weight, hard shell</td>
<td>CRABS AND LOBSTERS</td>
<td>No movement, lobster tail hangs limp, light weight, soft shell (except for blue soft-shelled crab)</td>
</tr>
<tr>
<td>Shells tightly closed, or close when tapped, clean, mussels bearded. The neck of a soft-shelled clam should twitch when touched</td>
<td>MOLLUSKS</td>
<td>Gaping shells that do not close when tapped; strong, fishy odor</td>
</tr>
<tr>
<td>Plump, clear liquor, free of shell particles; liquid less than 15% of volume</td>
<td>SHUCKED MOLLUSKS</td>
<td>Sour odor, shell particles, signs of drying, opaque liquor, excessive liquid (more than 15%)</td>
</tr>
<tr>
<td>Firm texture, mild odor, cleaned of sand vein if cooked and cleaned</td>
<td>FRESH SHRIMP</td>
<td>Black spots, soft flesh</td>
</tr>
<tr>
<td>SOLIDLY FROZEN, GLOSSY. When thawed, should pass same criteria as for fresh</td>
<td>FRESH</td>
<td>PARTIALLY THAWED, WHITE OR DARK SPOTS, SIGNS OF DRYING SUCH AS CRYSTALLINE EDGES, DISCOLORATION, TOUGH WHEN COOKED</td>
</tr>
<tr>
<td>Tight, moistureproof wrapping, complete packaging</td>
<td>PACKAGING</td>
<td>Buildup of ice crystals, loose wrapping</td>
</tr>
</tbody>
</table>
mussel or oyster is weak and watery. Filter-feeding mollusks, in particular, are able to concentrate pollutants, both natural and man-made. Harvests of these types of shellfish are regulated by the states, which impose closures and heavy fines for harvesting from closed beds. Clams have the ability to cleanse themselves partially, if moved to a cleaner area. In states where shellfish are harvested from marginally contaminated waters, they must undergo depuration, which means holding in clean, circulating water for 24 to 48 hours to remove contaminants.

**Method of Catch**

The method of catch can have a major impact on fish quality. Most groundfish and shrimp are caught by trawl. The longer the trawl or drag is towed without being hauled back, the more likely it is that the catch will be damaged by crushing, by bacterial deterioration, or by debris dragged up in the net. On Georges Bank a two- to four-hour tow is standard. When tows are longer than four hours, the fish in the net can become bruised; soft, and otherwise damaged. Shrimpers that tow all night, without hauling back, land catches with a large number of damaged and broken pieces, which detract from the value of the shrimp.

Gill nets capture fish by trapping them in mesh that they cannot pass through or back out of. They generally cause fish to drown. When nets are not hauled promptly, the quality of the fish declines. Generally a fish expends tremendous energy trying to escape from the net. That struggle and the drowning of the fish, combined with the fact that the fish begin to decompose in warm water, all lower the quality. Gill-netted salmon, for example, are less valuable than troll-caught salmon. Gillnetted swordfish are valued less than harpooned swordfish. And gillnetted groundfish are of lower quality than the best trawl-caught groundfish.

The fishing methods that produce the highest quality are those that bring live fish into the vessel. Hook-caught fish — whether caught by trolling, as salmon are, or by long-lining, as are halibut, some groundfish, and many warm-water species, such as grouper — are brought on
board with minimum damage. Pot fishing for black sea bass, sablefish, king crab, and lobster is also a high-quality method of capture.

A buyer should know the catch methods that produce premium quality in order to know which products deserve premium prices, such as troll-caught salmon and certain types of long-lined or boxed and bled groundfish. A buyer should also know which practices can produce lesser-quality fish, such as poor tending of gill nets, or towing overnight for shrimp. Some fishermen consistently produce premium-quality seafood, while others do not. It takes time, trial and error, to identify the best sources of good-quality seafood.

HANDLING ON BOARD

How seafood is handled on board the vessel is the most important controllable factor affecting quality. The sooner fish are gutted, washed, chilled, and stored, the better.

Fish should be completely gutted, to remove all viscera in the gut cavity. But the cut made to gut the fish should not penetrate the fillet. Proper cutting removes a major source of bacterial contamination and prevents the flesh from being inoculated with bacteria. The receiver should check for a clean, washed gut cavity and an accurate cut.

Many fish are both bled and gutted. Bleeding involves cutting an artery to allow the heart to pump out blood before the fish dies. Bled fish have whiter meat, do not exhibit bruises, and may have longer shelf-life. In Norway and Iceland, bleeding is required for top-grade groundfish. Certain vessels in New England have also begun bleeding their catches.

The more quickly fish are brought down to a temperature of around 32°F., the better their keeping quality. Certain inshore fisheries land their fish in open boats without ice. Large tows of fish can take six to ten hours to gut and stow away. In both cases, quality suffers.

The best storage methods for iced fish protect the fish from excessive crushing. The hold of a typical offshore dragger contains pens that can be 12 or even 16 feet deep. If fish and ice are simply loaded into these pens without any other protection, the fish at the bottom will bear several tons of weight for the duration of the trip. The result is loss of up to 10 percent of the weight of the fish during the trip, and less desirable fillets. When buyers ask for the "top of the trip," they want fish from the top of the pens, which are also the fish most recently caught.

However, the problem of crushing can be avoided through the use of shelves, which provide support for every two or three feet of depth that fish are loaded, or rigid plastic boxes. In Norway and Iceland, boxes must be used in order for fish to receive the standard price, and use of boxes is increasing in both Canada and the U.S.

UNLOADING

Boxed fish can be unloaded from the hold of a vessel with no damage
Shipping and Storing of Whole Fish

Whole fish should be shipped surrounded by ice in boxes or totes. As the ice melts, the water cools the fish and maintains it at a very low temperature. Temperatures during shipping and storage of iced fish should not be so low that there is no melting of ice. When whole fish are shipped by air, they are generally packed in insulated containers and kept cold with gel packs, a reusable ice that is sealed in plastic and does not drip on the fish. It is vital that fish already be as cold as possible before being packed. Gel packs can only help to maintain temperature, they cannot bring a warm fish down to the proper temperature.

Processing

The quality of products turned out by processing plants varies widely from one plant to another. Workmanship, temperature control, and sanitation are the deciding factors when it comes to quality in processed seafood.

Proper workmanship is important because it ensures that a boneless fillet is truly boneless, that a fillet is free of parasites, and that product is cut and packed correctly. The quality of workmanship determines whether or not picked crabmeat is free of shell fragments, or the 6-to-8-ounce fillets actually weigh between 6 and 8 ounces. A large variety of filleting, skinning, sorting, and packing machines are used to accomplish these tasks. Workmanship also determines the quality of the pack. Some shrimp packers, for example, always pack overweight, making sure that their customers will get slightly more than 5 pounds in every 5-pound box. Other packers overglaze their shrimp, giving short weight.

Temperature control remains critical in processing. The best processing plants have temperature-controlled cutting rooms. As fish is cut and washed, too-warm water will rapidly warm the fish. Another important factor in temperature control is maintaining a steady flow of product through the plant. If large numbers of fillets pile up on the canning table when workers take a lunch break, the fillets will warm to an undesirable temperature.

Sanitation is extremely important. Bacteria do not exist in the flesh of fresh fish unless they have been introduced in some manner or the fish is so old that bacterial invasion has had time to occur. Once fish is cut, however, fillets are exposed to bacteria. A plant with poor sanitation will produce fillets that spoil rapidly.

Processors use a variety of food chemicals to prevent drip loss in fish and shellfish, and to prevent bacterial buildup. The most common is sodium tripolyphosphate, which is the basic ingredient in several branded dips for seafood products. However, it can be abused. For example, scallops soaked too long in tripoly will gain weight. Often fillets that have been treated with tripoly will foam or have a soapy appearance when washed. This is because tripoly interacts with the natural proteins of the fish to produce a slime layer that feels like soap.

Another important additive is sodium bisulfitite, which is added to raw headless shrimp to prevent development of black spots on their shells. The Food and Drug Administration has recently imposed regulations limiting the amount of bisulfitite on shrimp to no more than 100 parts per million.

Used properly, food additives enhance the appearance and shelf life of seafood. When abused, they can temporarily mask product spoilage or cause a product to absorb water.

Four Types of Freezing

There are four types of freezing commonly used for seafood products: blast freezing, plate freezing, cryogenic freezing, and brine freezing. Maintaining excellent quality in frozen seafoods depends on rapid freezing of the product. Most fish flesh — approximately 60 to 80 percent — is water. As the temperature drops below 32°F., ice-crystal formation damages the cell walls of the fish. The faster the freezing process, the smaller the ice crystals, and the less damage the expanding water will cause to cell walls. The freezing processes used for seafood are generally designed to bring the temperature of the product down as rapidly as possible. Different processes work best with different sizes and types of seafood.

Blast freezing blows very cold air (—40°F.) over the product. It is used with larger, thicker products such as...
halibut and salmon and with some IQF products.

Plate freezing is the principal method used in the seafood industry. In a plate freezer, refrigerant is circulated through metal plates. The freezer looks like an old-fashioned pie safe with many narrow shelves. Cartons of seafood are placed on the shelves and the shelves are compressed, slightly compressing the seafood products. The contact between the cold metal plate and the carton of seafood ensures rapid freezing. Plate freezing is used for block-frozen product, such as shrimp and scallops, for layer-pack and cello-pack fillets, and, of course, for fish blocks.

Cryogenic freezing uses supercold nitrogen or carbon dioxide to freeze seafood as it passes through a tunnel on a conveyor belt. It freezes individual pieces efficiently and is used for IQF seafoods such as shrimp, shellfish, and portion-controlled fillets. It is also used to refreeze many breaded products, such as fish sticks, that are cooked and then refrozen.

Brine freezing also works well, because brine can be maintained as a liquid near 0°F. It makes an excellent medium for freezing seafood because it cools the fish rapidly. Tuna, salmon, and swordfish are frozen in this manner on board ship. Swordfish frozen in brine is known as clipper swordfish. Some king crab sections are also brine-frozen.

Conventional storage freezers do not freeze seafood adequately from the fresh state. Designed to hold seafood that is already frozen, they take hours, or even days, to freeze fresh seafood thoroughly. Any large fish can spoil on the inside, even though the outside is frozen, if it takes too long for the center of the fish to freeze. Even where spoilage is not an issue, slow freezing damages seafood when ice crystals expand and burst cell walls. The storage freezers in supermarkets, when used to freeze fish at the store level, will invariably produce inferior-quality product.

PACKAGING

Packaging fillets in a retail container at the end of the processing line provides an attractive, protected seafood product that can have excellent shelf-life. Forms of this type of packaging range from standard tray packs with oxygen-permeable film, to modified-atmosphere packaging and fresh vacuum packs. The major factor inhibiting greater use of modified-atmosphere or vacuum packaging for fresh fillets is the cost, which can add between 10 and 35 cents per pound to the cost of the fillet.

It is extremely important that tray-packaged product be maintained at proper temperatures. Most coolers and self-service display cases are too warm for this product. Like chicken, tray packs should be shipped at a temperature close to 30°F.

All seafood has some drip loss as it ages. When fish is packed in a retail tray for more than one or two days, it is extremely important that the diaper (the pad in the tray) be changed, even though it means rewarping the fish.

The principal concern with packaging for frozen product is not the outer carton, but the degree to which a product’s glaze protects that product from oxidation. Glazing is a process in which a frozen block of shrimp, for example, is dipped or sprayed with a water solution, which freezes and forms a barrier to oxygen. Well-glazed product will not experience the dehydration known as freezer burn, or oxidation and rancidity, for a reasonable amount of time.

STORAGE AT RETAIL OR FOODSERVICE LEVEL

Maintaining quality at a retail or foodservice establishment involves preventing dehydration and maintaining proper temperature. Refrigerated cases can be very hard on product, literally drying it out. The best cases for display of fresh fish either have no refrigeration, relying on ice alone, or have refrigeration simply for the purpose of retarding the melting of the ice.

Within a display case, fillets should be placed in trays rather than directly on ice. This helps maintain temperature, as the metal tray is an excellent conductor, and also prevents drips directly on the ice, which can lead to odor buildup.

In a restaurant cooler, whole and dressed fish should be rinsed in cold water and packed in flake ice in a container that has drainage holes. If ice is not available, the fish should be put on trays and covered with wet towels. Fillets and steaks should
Improper thawing can also degrade the quality of seafood. Seafood should be thawed as slowly as possible, preferably under refrigeration. Thawing in a warm environment can lead to the warming of the outside of the fish before the inside has thawed completely.

Federal Seafood Inspection Programs

Unlike meat, seafood is not subject to mandatory federal inspection. Seafood does come under the authority of the Food and Drug Administration, however, and a major voluntary inspection program is offered to buyers and suppliers by the U.S. Department of Commerce.

The FDA is responsible for the wholesomeness and proper labeling of seafood products. It sets plant standards and operating procedures commonly known as "good manufacturing practices," the enforcement of which actually falls on the individual states. The practices cover proper sanitation and cleanliness.

The FDA is also responsible for monitoring levels of toxic substances in seafood. When mercury, PCBs, or other contaminants appear, the FDA establishes maximum allowable limits and inspects products in interstate commerce to ensure that they are within the proper limits. The FDA also inspects imported products for excessive levels of additives, toxic substances, and bacteria.

In addition to these statutory duties, the FDA administers the voluntary National Shellfish Sanitation Program. While inspection and regulation of the shipping of oysters, clams, and mussels is primarily up to the individual states, the FDA reviews the state programs and certifies that they meet agency requirements.

The largest seafood inspection program is the voluntary program run by the National Marine Fisheries Service in the Department of Commerce. Users pay hourly fees to cover the costs of the NMFS inspection program. Federal meat inspection programs, by contrast, are funded partially by tax dollars.

NMFS provides the following types of inspection services:

**Sanitarily Inspected Fish Establishment** — This program provides for inspection of a plant for a minimum of 12 hours per month; it allows the processor to have his plant designated an official establishment that meets the proper building and sanitation standards for fish processing plants.

**Packed Under Federal Inspection** — A plant that contracts for inspection for a minimum of 4 hours per week is eligible to label inspected products with a PUFI seal. This means that the products are guaranteed to be safe, wholesome, of good flavor and odor, properly labeled, and produced in an official establishment.

Grade A — The Grade A shield goes one step further. Product that bears the Grade A shield must meet existing federal standards for that product, as well as be packed under federal inspection.

The Grade A program is very popular with major users, from foodservice chains to retail grocery stores. The inspection seal is used as a marketing tool with their customers, or as one means of maintaining quality control. Total costs of the inspection program are estimated to be about 1 cent per pound of inspected product.

There are federal standards for the following:

- Whole or dressed fish
- Halibut (frozen steaks)
- Salmon (frozen steaks)
- Fish fillets (general standards)
- Cod fillets (fresh and frozen)
- Flounder and Sole fillets (fresh and frozen)
- Haddock fillets (fresh and frozen)
- Ocean perch fillets (fresh and frozen)
- Fish blocks
- Fish portions (raw)
- Fish sticks (breaded, raw)
- Fish portions (breaded, raw)
- Fish sticks (fried)
- Shrimp (raw, breaded)
- General standards for grades of shrimp
- Scallops (raw, frozen)
- Scallops (fried)
- Catfish

A number of these standards are currently being revised, and new standards are being developed for fresh and frozen fish steaks, oysters, and blue crab.

Finally, NMFS offers lot inspection of product held in a warehouse or cold storage. This service is available for both domestic and imported product, and the company hiring the NMFS inspector will frequently submit a spec sheet that may ask for bacteriological analysis or evaluation of cooked product. Lot inspection certifies only the quality of the product as it appears to the inspector, not the condition of the plant where the product was packed.