Gulf of Mexico Finfishery – Harvesting, Processing and Quality

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INTRODUCTION

The Gulf of Mexico is a very productive body of water in that it supports a variety of finfish species which are harvested commercially. In 1975, United States fishermen harvested 1.66 billion pounds of fish and shellfish from the Gulf representing 34.5% of the fishery catch, by weight, for the entire United States. The Pacific Coast fishery produced 1.52 billion pounds of fish and shellfish in 1975, and ranked a close second to the Gulf in total U.S. production (U.S. Dept. Commerce, 1975).

Commercial finfisheries, as they are operated in the Gulf of Mexico differ significantly from their temperate water counterparts. In temperate zones, many table fish (fish for human consumption) of the same species congregate, and production and processing methods can be geared toward one type of fish. Classic examples of these types of fisheries are the cod and herring fisheries of the Northeast United States and Canada (Holt, 1969). Such is not the case in the Gulf where fishing techniques must vary from species to species, and large-scale production and processing of one table fish species is uncommon. This results in a multitude of independent fishermen and scattered small fish houses, each using their own specialized methods of harvest and processing.

Gulf fisheries at both the production and processing levels have changed very little over the last several decades. Generalized methods for care of fish on the boat and in fish houses have basically remained static. Yet, these practices have often led to poor quality finfish. With the growing possibility of regulations related to seafood processing and increasing consumer demand for consistently high quality products, the commercial finfish industry must begin modifying traditional procedures to meet changing times (Nickelson, 1973). This paper will describe generalized current methods used by the United States finfish industry in the Gulf of Mexico and identify some of the quality control considerations created by such methods.

GULF FINFISH HARVESTING

Commercial harvest of finfish in the Gulf is basically confined to nearshore and bay areas. Table fish species which make up the bulk of the harvest are the Spanish mackerel (*Scomberomorus maculatus*), red fish (*Sciaenops ocellata*), red snapper (*Lutjanus campechanus*), spotted sea trout (*Cynoscion nebulosus*), southern flounder (*Paralichthys lethostigma*), black drum (*Pogonias cromis*), mullet (*Mugil cephalus*), king mackerel (*Scomberomorus cavalla*), Atlantic croaker (*Micropogon undulatus*), and grouper of various species. Over 90% of the value of table fish in the Gulf can be attributed to the fish listed above.

Gill and trammel nets, fish trawls, trotlines, and long lines are all commercial methods of table fish harvest in the Gulf. Most bay or nearshore Gulf fishermen transport their fish to shore without ice. The exception is in Florida, where quality control laws require that fish be iced aboard a vessel, even if fish are off-loaded daily at a fish house or processor. A lag time from harvest to processing occurs in Louisiana, Mississippi, and Alabama. In these states, the daily fish catch is left "in-the-round" (viscera and gills not removed), and shipped on ice in wooden boxes to fish processors. Depending on the geographic location of fish harvests and processors, the range of lag time from harvest to processor may be from 1 to 10 days.

The off-shore red snapper and grouper fishermen may or may not eviscerate and gill their catch. As a general rule, most fishermen dress their catch on fishing trips longer than 5 or 6 days. Fish are then iced aboard the vessel. Extended fishing trips (3 to 18 days) in the Gulf necessitate icing to avert spoilage of the product. Figure 1 depicts the general steps used by most Gulf fishermen in handling their catch.

GULF FINFISH PROCESSING

Around the Gulf of Mexico there exist many independent processors, and methods of processing are varied. However, general patterns or standard procedures can be identified.

Processors, or fish houses, receive fish which are dressed (gilled and/or eviscerated), and fish which are in-the-round. Fish received are sometimes visually inspected for quality and rejected by standards formulated by each processor. After inspection, fish are generally separated by size and species, weighed, and washed. Fish may be washed with tap water or with water containing anti-bacterial additives. Processors will either store fish on ice in coolers until further processing or begin processing immediately.

The type of processing is determined by the market to be served. Certain species of fish may be sold in-the-round at fresh fish markets. Other fish may be eviscerated and sent to fresh fish markets with gills left intact. Such is the reported practice of the Louisiana, Mississippi, Alabama, and Florida processors, but is not the custom of most Texas processors who both gill and eviscerate fish before they are marketed.

Fish may also be eviscerated, gilled, scaled and then filleted with the skin left on the fillet. Some markets may demand dressed, non-scaled fish, while others require skin-off fillets. Figure 2 identifies the general steps followed by a typical Gulf of Mexico fish processor.

Some mackerel processors in Florida use a slightly different approach. In this case, mackerel are brine frozen in-the-round, then filleted while still frozen.

Methods of freezing, packaging and transporting fish products are quite variable. Some processors blast freeze, glaze, and package in plastic bags, then in wax-impregnated cardboard boxes (WIC). Other processors individually wrap fish or fillets in a "cling wrap," and then blast freeze. Brine freezing, as previously mentioned, is a process sometimes used in the mackerel industry of Florida. Frozen fish are usually shipped by freezer truck in WIC boxes.

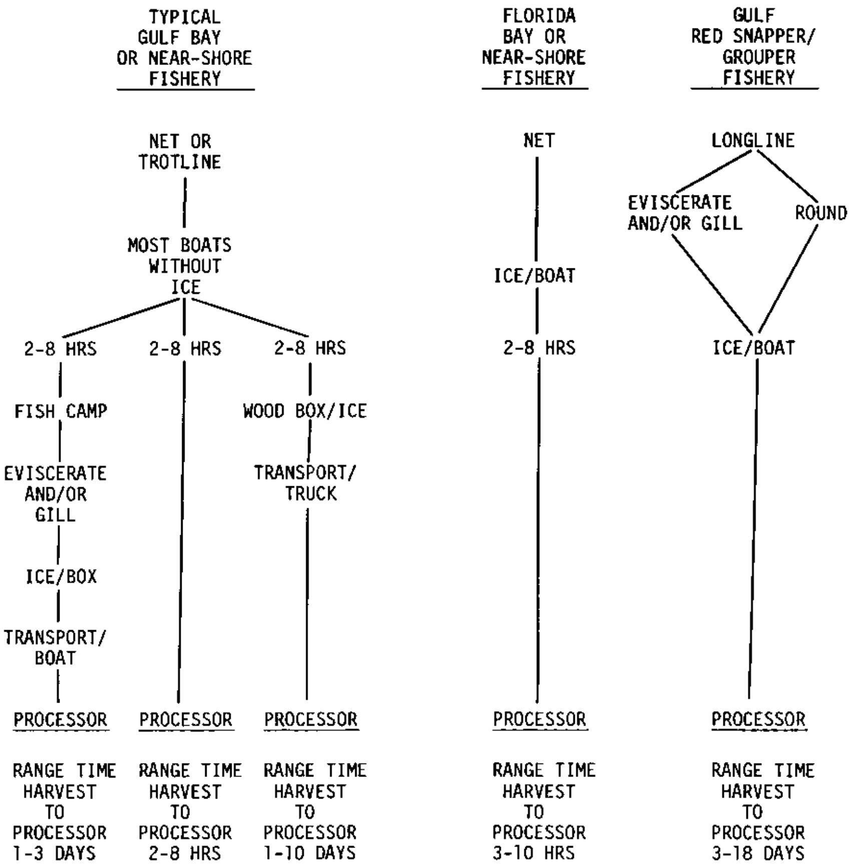

Fig. 1. Steps taken in the harvesting of Gulf of Mexico finfish.

Fresh fish in plastic bags are sometimes transported on ice in WIC boxes. Bulk shipping of fresh fish (in-the-round or dressed) is also commonplace. Bulk shipping is a process in which ice is layered on the floor of the insulated truck hold, followed by a layer of fish. This layering technique is continued until all fish are loaded.

GULF FINFISH QUALITY

The quality of any fish, whether warm-water or cold-water, is dependent upon factors that can be placed into three major categories. For the purpose of this presentation, the categories will be referred to as (i) prior to harvest, (ii) harvest and handling, and (iii) processing. Factors from these categories often

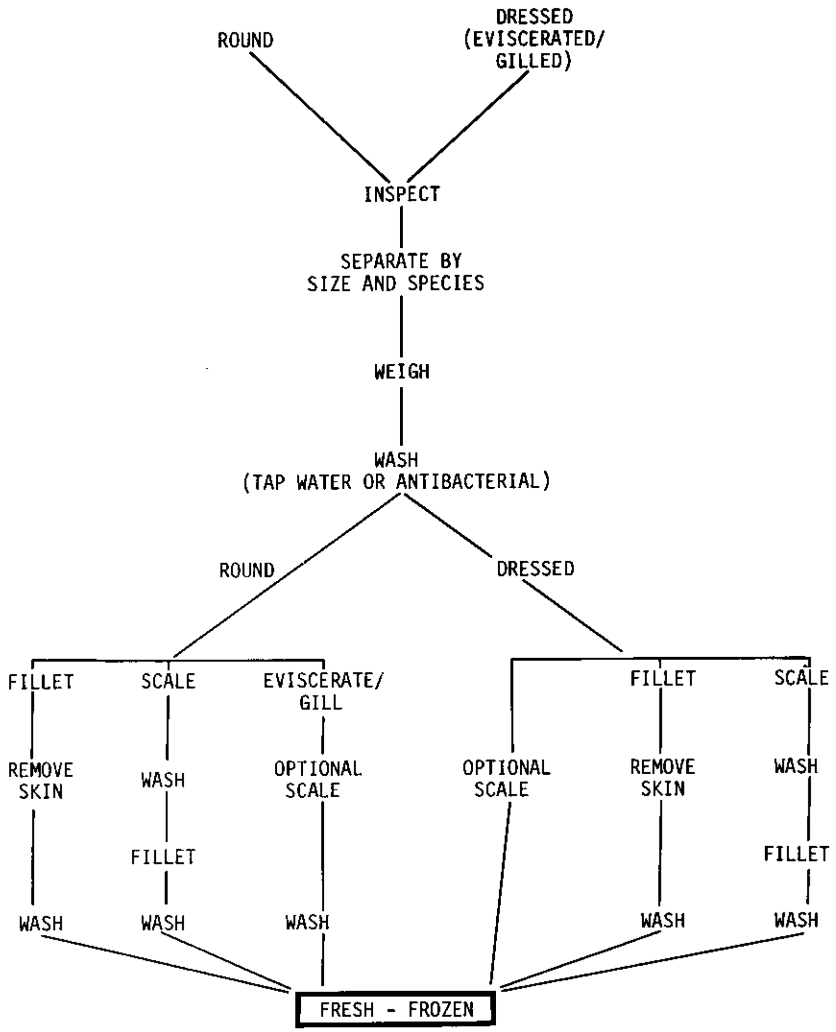

Fig. 2. Methods used by a typical Gulf of Mexico processor.

react in combination to produce cumulative effects on quality. Little scientific data is available that deals specifically with fish from the Gulf of Mexico. Most of the information to be quoted relates to fish from other parts of the world but should provide a background for present interpretations and future investigations.

Prior to Harvest

Most of the factors affecting quality prior to harvest cannot be controlled by the fisherman or processor. It is important, however, to keep these factors in mind when discussing the quality of fish. Differences in fish quality prior to harvest are usually caused by changes in the physiological status of the fish. Castell (1971) indicates that the physiological status is influenced by: (i) sexual maturation, (ii) the types and amounts of feed consumed, and (iii) environmental conditions such as water temperature and pollutants.

The most dramatic change occurring in sexual maturation is in the Pacific salmon. Once the spawn has been completed, the fish become so depleted and susceptible to disease or adverse conditions that they die. Less dramatic changes are noted in other fish species. Most notable are changes in fat and water composition (Castell, 1971; Love, 1970). Prior to spawning much of the body fat in fish is used in the production of milt and roe. Since there is a reciprocal relationship between fat and water, the fat is replaced by water. At the time of spawn, the fat content is low and the water content is high. Fish in this condition are often referred to as "spent" and are soft and mushy in texture. This condition applies to the already soft-tissued spotted sea trout that at certain times of the year becomes impossible to fillet. After spawning, fish begin to actively search for and take in feed to replace lost nutrients. Changes in the feeding habits and the nutritional status of fish can also affect quality.

The diet of the fish is important for it has often been stated that "a fish is what it eats." As examples, freshwater fish often become unpalatable due to earthy odors caused by the consumption of certain actinomycetes (Bligh, 1971), and cod fisheries have been completely halted because of kerosine-like odors created through their consumption of certain pteropods (Castell, 1971). Some researchers have noted differences in the fat composition of croaker from the Gulf. Croaker from the Western Gulf of Mexico are believed to contain higher amounts of saturated fats as a result of their diet. The nutritional status of the fish can influence the final pH of the muscle tissue which in turn influences the texture of the flesh. Fish in a good nutritional state will tend to have lower muscle pH's. As pH drops, so does the capacity of the proteins to hold water. The results are high drip loss and tough flesh (Jones, 1969; Kelly, K., 1969). If the fish is nutritionally depleted, the pH will be higher and the flesh softer (Kelly, K., 1969; Love, 1969). The pH of the flesh has also been shown to be influenced by the fishing ground (Love, 1969).

The effects of the fish's environment on concentrations of heavy metals, pesticides and public health significant bacteria are well documented in many different publications and will not be elaborated on in this paper. A recent review (Cobb, 1976) describes the effects of the environment on the quality of the mullet.

Harvest and Handling

The method of harvest and subsequent handling of fish can greatly influence the quality of the fish. These are factors over which the fisherman can exert some control. The method of harvest influences the stress a fish goes through before death. The amount of stress affects the onset, severity, and duration of rigor mortis or death stiffening. Changes can occur during the rigor process that alter the quality of the product. As with the nutritional status of the fish, these alterations can be related to the pH of the flesh. If a fish is stressed, such as dragged in a trawl or left on a trotline until exhausted, its energy stores are depleted. The fish will then undergo a rapid and short phase of rigor mortis. Disadvantages in such cases are damage incurred through the handling of fish in rigor, excess drip loss, and a higher pH that is conducive to the growth of spoilage bacteria. Quality has been shown to be improved by chilling fish prior to rigor (Bykov, 1974).

Times and temperatures of fish on deck can influence the rate of quality change. Changes in quality were accelerated when fish were exposed to the hot rays of the sun, left in large piles at ambient temperatures, and when placed on steel versus wooden decks (Kordyl and Karnicki, 1969). It has been estimated that as much spoilage takes place during each hour's holding at ambient temperatures as would take place on a daily basis on ice (Disney et al., 1974).

It is generally accepted that the more rapidly a fish is gutted (eviscerated) and gilled, the higher the quality and subsequent shelf life will be. The practicality of performing this task in the smaller vessels found in the Gulf finfishery is almost non-existent. Another consideration is the fact that an improper job of gutting (spreading intestinal material and not properly washing) is more detrimental than not gutting. The intestines and gills of fish contain large numbers of bacteria and a high concentration of digestive enzymes. This is especially true if the fish is feeding. After the fish dies, these enzymes and bacteria remain active and can create off-odors and a condition referred to as "belly burn." Proper removal of the intestinal tract or retardation of bacteria and enzymes by cooling must occur at some point in the handling process. Some delays in gutting and gilling can be tolerated, but discretion should be used in determining prior holding conditions and the proper time and place.

Gutting and gilling may also facilitate bleeding. Improper bleeding has been shown to cause discoloration and enhance oxidative rancidity in fish (Kelly, T., 1969).

Processing

Some of the above-mentioned practices could be considered as a part of the processing procedure because they are not performed until the fish reach the processing facility. The same principles apply in that the fish should be handled as rapidly as possible; care should be taken not to damage or bruise the flesh; intestines and gills should be removed as rapidly as possible; the product should be adequately washed prior to storage; and in addition, optimum icing or freezing procedures should be followed.

Fish arrive at processing facilities in varying vehicles and under varying conditions. The first step is a visual inspection of the product. Those showing signs of quality deterioration are rejected. Next, the fish are sorted according to species and size. If the fish have already been eviscerated, they should be adequately washed prior to further processing. The simple physical removal of dirt, bacteria and slime does much toward enhancing the future quality of the product. Anti-bacterial compounds are somtimes used in the wash water but their effectivensss may be negated by infrequent changes of water. The wash tank then becomes a source of contamination.

Fishery products from tropical and subtropical waters should enjoy an advantage over colder water products in iced storage. The bacteria associated with fish from warm waters are not as well adapted to growth at cooler temperatures (Cann, 1974; Disney et al., 1974; Nickelson, 1976). For this reason, properly handled warm-water fish have a longer shelf life in iced storage than do fish from colder waters. To achieve maximum quality, fish should be iced as soon as practically possible. The ice should be of a good quality and used in adequate amounts. Icing boxes and icing bins constructed of wood or other porous material can be significant sources of spoilage bacteria if they are not properly maintained and cleaned. Each fish that comes into contact with a surface that has soaked up moisture and slime from previous loads of fish will have a shortened shelf life.

Most Gulf finfish processors use freezing as a means of preserving fish. Low temperatures extend the shelf life of the product by reducing or eliminating the action of bacteria and enzymes responsible for quality changes. Processors must be cognizant of the fact that freezing is a means of maintaining quality and not improving it. There are also changes in quality that occur during the freezing process or frozen storage.

Freezing rates have been shown to have considerable effect on quality, especially in texture and appearance (Dyer, 1971). The freezing point of fish flesh is about -0.9 °C. As the water freezes, organic and inorganic compounds in solution become more concentrated and slowly lower the freezing point. This phenomenon creates what is often referred to as as the critical zone (-1 to -5 °C) in freezing fish. A freezing process should be used that reduces the length of time a product is in the critical zone. Speed of freezing can be increased by reducing the bulk of the product to be frozen, increasing the air circulation (blast), and/or lowering the temperature of the freezer. Bose (1969) showed that higher product temperatures prior to freezing reduced the time a product remained in the critical zone. He also cautioned against the adverse effect of accelerated deterioration when fish are kept at a higher temperature before freezing.

Slow freezing is also reported to cause tissue damage and excess drip through large ice crystal formation (Dyer, 1971). Rapid freezing causes the formation of smaller ice crystals and less tissue cell damage.

The quality of a frozen product will be the combined result of the quality of the raw product, the storage temperature, fluctuation in temperature, and packaging material. Research on haddock fillets (Dyer and Peters, 1969) showed that longer storage in ice prior to freezing reduced frozen storage shelf life. In the same study, the importance of storage temperature was also indicated. Fillets stored on ice for one day prior to freezing had frozen storage lives of 8, 30, 37, 76, and greater than 86 weeks at -7, -12, -18, -23 and -29 °C, respectively. Most investigators feel the lowest optimum storage temperatures are -23 to -29 °C.

Temperatures of storage can vary greatly in storage vaults, transporting vehicles, retail stores, shopping carts, etc. These fluctuations in temperature can be very damaging to the quality of the product. Dyer (1971) has shown that frozen fish, when allowed to warm from -23°C to -10°C for 1 to 2 weeks before being returned to -23°C, dropped appreciably in quality.

Packaging materials are used to protect frozen fishery products from dehydration and oxidation in frozen storage. Dehydration (freezer burn) causes an irreversible denaturation of proteins, plus weight loss, while oxidation creates off-odors and flavors, often referred to as rancid. Wraps, glazes, plastic bags, and wax-impregnated boxes are used to prevent these reactions. Any moisture and oxygen-impermeable material, fitting snug against the product, is effective. Glazing, the dipping or spraying of frozen fish with water to form a thin ice layer around the product, is also an effective and often-used procedure for protecting against dehydration and oxidation. Other coatings such as alginate gels, acetylated monoglyceride, and methoxy cellulose have all been evaluated for this purpose. Dyer and Peters (1969) stated that in view of the difficulties involved in mixing the solutions and the expense of materials used, it was evident that a plain water glaze, renewed when necessary, would give protection at least equal to that of the solutions tried in their experiment.

Thawing, whether by the processor or by the consumer, can also affect quality. For the same reasons that apply to rapid freezing, rapid thawing should be practiced for optimum quality. Thawing in water seems to be feasible on a commercial basis (Hewitt, 1969).

CONCLUSIONS

The finfishery of the Gulf of Mexico is a valuable resource. Unlike other world fisheries, it is extremely diverse in species, harvesting techniques, and processing procedures. Little scientific data is available concerning the quality of these fish per se, but volumes of information are available on other fish. This data can and should be used to evaluate and assess present problems plus develop meaningful research for future use.

LITERATURE CITED

Bligh, E.G.
1971. Specific problems in the quality assessment of freshwater fish. Pages 81-86 *in* Rudolf Kreuzer, ed. Fish inspection and quality control. Fishing News (Books) Ltd, London.

Bose, A.N.
1969. Freezing of tropical fish. Pages 179-188 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Bykov, V.P.
1974. Initial treatment of some fish species caught in the Indian ocean. Pages 77-80 *in* Rudolf Kreuzer, ed. Fishery products. Fishing News (Books) Ltd, Surrey, England.

Cann, D.C.
1974. Bacteriological aspects of tropical shrimp. Pages 338-344 *in* Rudolf Kreuzer, ed. Fishery products. Fishing News (Books) Ltd, Surrey, England.

Castell, C.H.
1971. Some fundamental problems in the quality assessment of fishery products. Pages 9-13 *in* Rudolf Kreuzer, ed. Fish inspection and quality control. Fishing News (Books) Ltd, London.

Cobb, B.F.
1976. Effects of environment on mullet – a review. Pages 72-82 *in* James Cato and William McCullough, eds. Economics, biology, and food technology of mullet. Report No. 15, State University System of Florida.

Disney, J.G., R.C. Cole and N.R. Jones
1974. Considerations in the use of tropical fish species. Pages 329-337 *in* Rudolf Kreuzer, ed. Fishery products. Fishing News (Books) Ltd, Surrey, England.

Dyer, W.J.
1971. Speed of freezing and quality of frozen fish. Pages 75-80 *in* Rudolf Kreuzer, ed. Fish inspection and quality control. Fishing News (Books) Ltd, London.

__________ and J. Peters
1969. Factors influencing quality changes during frozen storage and distribution of frozen products, including glazing, coating and packaging. Pages 317-321 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Hewitt, M.R.
1969. Thawing of frozen fish in water. Pages 201-205 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Holt, S.J.
1969. The food resources of the ocean. Pages 356-368 *in* Readings from scientific American: oceanography. W.H. Freeman & Co., San Francisco.

Jones, N.R.
1969. Fish as a raw material for freezing: factors influencing the quality of products frozen at sea. Pages 31-39 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Kelly, K.O.
1969. Factors affecting the texture of frozen fish. Pages 339-342 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Kelly, T.R.
1969. Discolouration in sea-frozen fish fillets. Pages 64-67 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Kordyl, E. and Z. Karnicki
1969. Factors influencing quality of frozen fish at sea in subtropical and tropical areas. Pages 189-195 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

Love, R.M.
1969. Condition of fish and its influence on the quality of the frozen product. Pages 40-45 *in* Rudolf Kreuzer, ed. Freezing and irradiation of fish. Fishing News (Books) Limited, London.

———— 1970. The chemical biology of fishes. Academic Press, London and New York.

Nickelson, R.
1973. Quality control – a solution to fish inspection. Proc. Gulf Carib. Fish. Inst. 25:100-108.

———— 1976. Microbiology of the mullet (*Mugil cephalus*) – a hypothesis. Pages 131-137 *in* James Cato and William McCullough, eds. Economics, biology, and food technology of mullet. Report 15, State University System of Florida.

U.S. Department of Commerce
1975. Current fishery statistics No. 6900: fisheries of the United States, 1975. National Marine Fisheries Service, Washington, D.C.