The rapid perishability of fish, as compared with meat, for example, has at all times and places made preservation against putrefaction an urgent necessity. Historical aspects of the various techniques that have been evolved up to the present day have recently been discussed at some length, mainly from the British point of view (Cutting, 1955). This chapter attempts to summarize the principal developments, giving special attention to recent contributions to the subject (Bridbury, 1955; Wentworth, 1956; Doorman, 1957; Chimits, 1957).

I. Early History

A. Prehistoric Times

Man has always exploited for food the aqueous phase of the earth's surface. Fortunately, early men made no attempt to dispose of refuse, and we, therefore, know from kitchen middens that shellfish have been gathered from ponds, rivers, and sea coasts since the very beginning of mankind and must, in fact, have been the chief source of animal protein in the first and much the longest food-gathering stage of human history.
The bones of fish and marine mammals, which can still be identified, testify to the advance in skill and intelligence implied by active hunting, as compared with mere collection. At a very early stage, however, men must have learned the survival value of storing day-to-day and seasonal surplus. Fish decay so rapidly that storage in itself presupposes some form of preservation. The sea fish, whose bones are found in the refuse heaps of the Late Old Stone Age cave dwellers in the Dordogne, dating from about 40,000 B.C., must have been preserved in some way to have travelled so far inland. One can only guess by analogy with the practices of primitive peoples that the process used was probably drying, either in the sun and wind when the climate was suitable, or over smoky fires. There is indirect evidence of the latter in the wood ash deposits found alongside the River Bann in Northern Ireland, which may have been the result of salmon smoking in New Stone Age times (about 2,000 B.C. in western Europe). The product might have been made into a fish pemmican, similar to that made from salmon by the American Indians of the Northwest, who first sun-dried or smoke-dried the fish, then soaked it a little before pounding finely in stone mortars, and either stored it in baskets or mixed it with oil from sturgeon or seal, after the manner of a true meat pemmican (Wentworth, 1956).

B. Bronze Age

Preservation by salt is not likely to have emerged until the Bronze Age, as its production and use imply a more highly organized economy. 

The great urban civilizations of Ancient Egypt, Mesopotamia, and the Indus valley (founded about 4,000 B.C.) were based on river systems whose seasonal flooding first made agriculture possible. Although these economies chiefly depended on the organized production of cereals by irrigation systems, exploitation of the waters for fish must have played an essential role. Alongside improved methods of catching fish were developed techniques for preserving them by salting and drying. Salt fish, known as “ukas” in Egypt, was an important supplement to the staple diet of bread.

Along the Nile, fish were sometimes cut in half and suspended on ropes to accelerate natural drying in the sun and wind. Sometimes, the body of the fish is depicted in the tombs as laid open with a knife from head to tail, the two sides being divided to the backbone. In other instances, the process consisted solely of taking out the intestines, removing the head and the tip of the tail and exposing the fish, when salted, to the sun. Mackerel were not dry-salted like other fish, but were pickled in brine, as are fatty fish to this day, no doubt to protect the fat from atmospheric oxidative rancidity. Pickling was a skilled “art,” associated
with the priesthood. There were religious observances connected with
fish-eating. At a later date, the Ptolemies held salt monopolies, and guilds
of fish-salters existed. As might have been expected, fresh fish was also
much eaten in Ancient Egypt, and fish intended to be consumed unsalted
were sent off to market at the end of the day's fishing.

Although preservation of fish by smoke seems to have been unknown
in Egypt, it was used in early Mesopotamia along with salting and drying.
Dried fish were also traded from settlements on the Persian Gulf. Simi­
larly, Mohenjo-Daro, on the Indus, was supplied with dried fish from the
coast of the Arabian Sea, 150 miles away.

In the Mediterranean, the Phoenicians (about 1250 B.C.), and later
the Carthaginians, were notable seafarers and colonizers. Many famous
cities owed their origin to fishing settlements, including Sidon (i.e., "the
fishers' town"), Gades (Cádiz), Málaga (i.e., "the salting place"), Sinope,
on the Black Sea, and even Byzantium, later Constantinople.

C. CLASSICAL TIMES

Iron Age Greece (commencing about 1,000 B.C.) comprising so many
islands, developed a considerable trade in dried, salted, and smoked fish
("tarichos") from colonies in the eastern Mediterranean from Sicily to
the Bosporus. Under Roman rule (about 400 B.C. to 450 A.D.), the fish
industry and the production of salt for it became still more highly or­
ganized. Colonies from southern Spain to the Black Sea, including places
already famous for their fish, supplied Rome with "salsamentum," or
preserved fish, of a variety of types, made from numerous classes of fish,
including tuna, swordfish, sturgeon, mackerel, pike, mullet, "scarus" (a
wrasse), "asellus" (hake?), bream, eel, sea-eel, oysters, and even sea
urchins. Whales, seals, and sharks were also taken in the Atlantic, and
the Carthaginians stayed out for considerable periods, salting at sea.

Although the classics contain a good deal of incidental commentary
on fish, there is tantalizingly little detailed information on the actual
methods of preservation employed (Smidth, 1876; Radcliffe, 1926; Bryant,

Plain brine seems to have been used on dolphin (not strictly a fish
but a mammal, of course) and "scarus." For sea-eel (conger, presumably,
or possibly even the electric eel) marjoram was added to the salt, al­
though the lavish use of herbs and spices was condemned by some epi­
cures. Tuna and other large fish, such as sturgeon, were cut into cubes or
slices. Tuna seems to have been the most important sea fish all over the
classical world, and salt fish is usually synonymous with salt tuna. Salted
cubes of tuna appear to have been fairly cheap and plentiful and were
preferred even to the fresh fish, which is rather tough, and was regarded
as rendered more easily digestible by salting. After removing the throat and belly (as delicacies), says Pliny (A.D. 23–79), “all the rest is preserved in salt; these pieces are called ‘melandrya,’ as resembling splinters of wood. The cheapest of them are the parts next to the tail, because they lack fat, and the parts most favored are those next to the throat.” The best cut of a Byzantine swordfish, on the other hand, was adjudged to be a “slice of the back, nearest to the tail.”

One writer implies that pike was dry-salted. Although this may be no more than a stray reference and not evidence that this was the characteristic process for this species, it is, nevertheless, a fact that tuna, by comparison, contains more oil, which would be better protected from atmospheric oxidation by a brining process, whereas pike, being less oily, could perhaps better withstand dry-salting.

“Half-salt” (sometimes termed “half-fresh”) cures, made from sturgeon and other species, were somewhat uncommon, probably because they were rather perishable. A half-salt mackerel removed from the brine before it was fully cured was highly esteemed, and must have resembled our “matje” herring.

“Garum,” mentioned as early as Aeschylus (525–456 B.C.), was a thick sauce, or runny paste, which was originally made from the salted blood and entrails of a fish called “garon” or “garos” by the Greeks. There were numerous recipes for this preparation, the comparative merits of which were a matter of opinion. Two of the most popular were made from the gills and entrails of the mackerel and tuna. In one recipe, the blood and viscera of the tuna, among other things, were tightly packed into a vessel, which was hermetically sealed, and allowed to decompose completely (Radcliffe, 1926). The process, which presumably was largely autolytic, is similar to that used in Indochina today for the preparation of “nuoc mam.” It was obviously a convenient way of dealing with smallish fish such as anchovies. The fish viscera would have furnished a potent source of proteolytic enzymes. Presumably, sufficient salt would have been incorporated to discourage anaerobes.

The greatest delicacy of all was the “garum sociorum,” so-called because it was produced, under conditions of some secrecy, by a kind of fisherman’s cooperative. Compounded of the intestines of Spanish mackerel, it was exported from southern Spain all over the empire. The “garum” of Mauretania (North Africa), Antipolis (modern Antibes), Pompeii, Dalmatia, Clazomenae (Asia Minor), and other places, was also highly commended by Pliny.

“Alec,” like “garum,” once the name of a fish (possibly the anchovy), came to signify only the sauce from it, and subsequently from other cheap fish. It differed from “garum” chiefly in being thicker, more like a paste
1. HISTORICAL ASPECTS OF FISH

(cf. "nam pla"), and was made, like second-grade "nuoc mam," from the residue left after the autolyzed liquor had been decanted. Brine was then added and more fish to produce a semisolid, aptly named "putrilago." With such piquant sauces, says one writer, "they drenched their subtly conceived dishes . . . so . . . that it would have been hardly possible to distinguish a fresh fish from a putrid cat—except by the bones."

Vinegar was also used extensively for shorter-term preservation. The Romans learned from the Greeks a method of preserving tuna and mackerel by first frying in oil, treating with bay leaves, salt, and spices and then pouring boiling vinegar over it. Vinegar was also used sometimes for making "garum," and was combined with salt and honey as a preservative. Cooked fish were often packed with herbs only, and although some herbs have a slight bactericidal effect, such products could have only a very limited "life."

Mullet roe, when salted, was a favorite dish, but there is no mention of caviar, made from the roe of sturgeon, until the ninth century. Salt fish were usually packed in some form of earthenware jar, which was the commonest and cheapest container of the Greco-Roman world. The most likely type seems to have been the wide-necked wine jar, or "pithos" (also "bikos"), which stood nearly 5 feet tall. Tuna were packed in these jars "alternately," i.e., presumably head to tail, but the fish must surely have been relatively small to be able to do this.

Fresh fish could not penetrate far inland on account of poor transport and perishability. In Rome, it cost several times as much as salted fish and, as at all times in history, the "fresh" fish on sale is the butt of frequent gibes which show that it must often have been in quite an advanced state of decomposition, in spite of regulations adjuring quick sale.

Keeping the fish alive until it was to be cooked was the only sure way of obtaining really fresh fish, although such a practice could be afforded by few. This presumably was the raison d'être of one of the entertainments of a Roman banquet, which was to observe the color changes of red mullet as it expired, before cooking and eating it. Elaborate fresh- and salt-water fish ponds ("vivaria") were laid out to maintain supplies of live fish. The mortality was considerable and it has been suggested that the popularity of the "muraena" (related to the eel) was due not so much to its flavor as to the fact that it stood up well to fish pond existence. Fresh fish, however, were a luxury. Most people, if they tasted fish at all, did so only if it were salted, brined, or pickled in vinegar.

Rome generally was well provided with snow and ice which, as in recent times, were collected in the winter and stored in "ice-houses" until the summer. The emperors organized regular supplies from the Alps by relays of chariots. Dug-out "frigidaria," or cold stores, using ice-
cold water or snow, were in use as early as 100 B.C., but there is no specific mention of their use for fresh fish.

The salt fish industry and export trade played an important part in the economic life of the ancient world. The Black Sea (or Pontus) and the Sea of Azov were particularly prolific, and have been compared in importance to the Newfoundland Banks in more recent times (Smidth, 1876). Sending “fish to the Hellespont” became a byword similar to “coals to Newcastle.” In Sicily, the ruler of Syracuse built a cargo vessel to carry 10,000 jars of salt fish and 60,000 measures of grain, together with wool, freight, and provisions for the crew. Alexandria was about the only port large enough to berth it safely. In Egypt under the Empire it was almost entirely fresh-water fish that was salted and exported. If caught at any distance, it was hung up on cords to dry strung across the rigging; if nearer at hand, the dealer did the splitting, and hung it on lines to dry in the sun.

At Athens, and also probably in Rome, there existed a Society, or Corporation, of Fishmongers. Herodotus mentions salt fish (“tarichos”) as an item in the diet of the Athenian army in the fifth century B.C., when it was usually eaten without cooking, apparently. Cato’s not over-generous list of the stocks of food to be laid in for vintage workers includes salt fish. However, salt fish was not overpopular and draws insulting epithets from the writers. On the other hand, fabulous prices could be paid by wealthy gourmets for fish products. One small flask of Pontic “salsamentum” could fetch more than a hundred sheep. The Licinian Law (A.D. 318) decreed certain days of the year on which only salt fish could be eaten.

Recipes for using salt fish involve washing with water and cooking with various seasonings, such as cheese, or sauces made from eggs, wine, honey, oil and herbs. Salted mullet was boiled or fried in oil.

Fish cakes were made from “tursio” (possibly either sturgeon, porpoise, or dolphin). A kind of fish sausage, “insicia” or “isicia,” was also held in great favor in Rome.

II. Middle Ages

A. General

During the Middle Ages the center of gravity of the fishing industry of the western world shifted from the Mediterranean to the more prolific North Sea, where the course of development can be taken to epitomize the general pattern of events. Right up until the railway era, commencing about 1840, salting, drying, and smoking remained the staple methods of long-term preservation, with “potting” in vinegar for shorter periods. It
was discovered empirically that certain sequences and combinations of treatments possessed special advantages in the particular geographical, technological, and social environment in which they had to operate. It is, therefore, possible by the end of the Middle Ages to distinguish, amidst numerous variants, certain distinct processing patterns, which became fixed over comparatively long periods of time. Thus, in the North Atlantic countries, methods of salting and drying, whether combined together (as in dried salt cod, etc.), or with smoking (as in “red herring”) or alone (as in salt pickled herring and wind-dried cod—“stockfish”) have persisted practically unchanged for a number of centuries down to the present day.

Drying and salting also held, and in fact still hold, the stage throughout Asia. Marco Polo (about 1300) and later Hakluyt (about 1600) gave accounts of the salting of tuna, etc., on the Arabian Sea and Persian Gulf and the drying of salted sturgeon and the preparation of caviar from its roe on the shores of the Caspian Sea.

Throughout the Middle Ages, and for long after, fresh fish was mostly of fresh-water origin and very expensive. Practically every species inhabiting river, ditch, and millstream, even the tiny minnow, was eaten, and ponds, or “stews,” were kept artificially stocked for the well-to-do. “Coarse” fish, such as pike and tench, were transported alive by road to London as late as the eighteenth century. Sea fish were also brought to port alive in boat bottoms wherever possible. Most of the population, however, ate only hard-dried, salted, and smoked products, and though at coastal villages mildly cured varieties were prepared for local consumption, the slowness of medieval transport, whether by land or water, confined trade to products that could be kept for several months without going bad.

Practically all species of sea fish and shellfish were preserved for eating, but the principal catches were white fish, chiefly cod and related species, such as haddock, whiting, and hake, which are plentiful in the North Sea and adjacent waters and which can be taken more or less all the year round; and the herring and pilchard family, which are more abundant, but very seasonal in occurrence and subject to natural fluctuation from year to year.

In England, Hull, Grimsby, Scarborough, and Whitby, and the Norfolk coast on the east of England, Barking and Greenwich in the Thames estuary, Rye and Winchelsea on the south coast, and Devon and Cornwall in the southwest were already noted for fish from the twelfth century onwards.

All types of fish, including turbot, plaice, and dogfish, were preserved by salting, but drying was confined mainly to the leaner species of white
fish. Herring, and also salmon, are rich in oil and prone to oxidation, with resulting rancid flavor, and could not, therefore, be preserved for very long by simple drying, even with salt. They kept much better if the access of atmospheric oxygen was impeded by covering with a strong salt brine in a tight vessel, such as a wooden barrel. Rancidity could also be retarded by the antioxidant affects of wood-smoking.

B. HERRING

1. Salt Herring

a. Baltic Industry

Although salt herring were an object of trade at North Sea ports as early as the seventh century A.D., they were first prepared on a really large scale at Scania (Schonen) at the western end of the Baltic during the twelfth century, where the trade was organized by North German merchants from the ports of the Hanseatic League.

The earliest products probably consisted merely of ungutted herring sprinkled or strewn with salt ("steurharing" in Dutch) in irregular heaps on the ground. "Ghescudde harinc" ("roused" herring), lightly sprinkled with salt and turned over and over, are mentioned at Dordrecht in the thirteenth century. Such fish were transported in wickerwork baskets (or "Korven," hence "Korfharing," or "corved herring," in English). Such methods would do little more than delay putrefaction, and if distribution took longer than a few weeks the condition must have been very questionable. Often such fish were hard-smoked as soon as possible to confer an additional few weeks' life. This was the case with the Baltic "Stroh-bücklinge" ("hart geraucherte Bücklinge in Korben mit stroh verpackt") and the equally hard-smoked "Kappeler Bückling" (from Kappeln near Kiel), both ancestors of the more sophisticated and milder smoked Bucklings of Bornholm and elsewhere at the present day. The Dutch, too, made a similar smoked product, called "bokking," for home consumption only.

b. Improved Methods of Salting Herring

Controversy still rages as to whether Hanseatics or Dutch initiated the radical improvements in the process during the fourteenth century, as a result of which salt herring became the foremost mass-produced food of the late Middle Ages, and the Dutch the pre-eminent producers. Since a recent review (Cutting, 1955), interesting new evidence has been presented by Doorman (1957). Beukels of Biervliet, a village on the West Schelde, then part of the county of Flanders, is traditionally associated with the revolution in technique which gave the Netherlands
the undisputed lead for the next few centuries. It seems incontestable that the Dutch had something to do with such innovations as eviscerating the fish prior to salting and the use of wooden barrels to hold fish covered in brine in place of the open wicker baskets, a development credited to the fishermen of the Zierikzee on the East Schelde. Thus, from 1252 onward "tonharing" (barrel herring) is mentioned in connection with a toll at Zwin, and a document of 1320 refers to "harenc in tonniaus," and although this was probably still ungutted "steurharing," if the fish were covered with brine the resulting protection from oxidative rancidity, and the rather different osmotic balance of a product coming to equilibrium in a salt solution, would have resulted in a more attractive commodity. Another tradition associates the shift of the center of activity from Scania to Zeeland early in the fifteenth century with a change in the habits of the herring in the Baltic. But although there may well have been some long-term fluctuation from natural causes characteristic of the clupeoid family, it is quite certain that the Baltic herring fishery did not in any sense disappear. Thus, in 1432 and 1445 yields were apparently excellent; in 1463, 20,000 men are reported to have been involved in rioting between Danes, who did the fishing, and Germans, who did the curing; there are records of gluts of herring at Scania in the years 1485-1486 and 1492-1494; and in the eighteenth century again Sweden had developed a considerable herring industry—indeed, she still has at the present day. It has been suggested by Bridbury (1955) that the basis of this legend of the decline of the Baltic herring catch is the decline of the native North German salt industry for other reasons (see Section II, B, 4). Nevertheless, it is quite possible that the economic changes coincided with, and may have been affected by, a lull in the fishing, even although the latter was not the determining factor. The latest picture of the facts as seen through the mists of time and polemic seems to be somewhat as follows. Sometime between 1315 and 1330, i.e., the best part of a century earlier than hitherto established, an important innovation, known as "haring-kaken," was introduced in Flanders, possibly by the Willem Beukels who is mentioned in papers of 1308 and 1312 and appears to have been a man of some substance, although there is no direct documentary evidence that he had anything to do with herring-curing. "Kaking" consisted of gutting herring by a cut with a special knife just behind the gills by means of which the stomach, heart, liver, and part of the intestine and gills were taken out with one movement, leaving the head on and the pyloric caeca intact. The importance of retaining the latter appendages was perpetuated armorially in the heraldic device of the village of De Rijp, which, in a plaque dated 1652 now in the museum at Rotterdam, shows two "kaked" herring with part of the intestines attached to the cut.
"Kaken" seems to mean "jaws" and, in this sense, "gills." "Kaecharinx" is first mentioned in 1332. Subsequently "kaken" (and the cognate French "caquer") became synonymous with the salting and barreling of herring.

This operation of partial gutting, or "gipping" as it was eventually termed in Britain, had two advantages. First, it was much quicker than a complete gutting process, speeds of up to 40 fish per minute being attainable with practice. This in itself enabled the process to be carried out at sea on the fishing vessel and thus rendered the Dutch fishermen pursuing the prolific fishery off the British coasts independent of shore bases at Yarmouth and elsewhere, which held many unsatisfactory features. Second, the proteolytic enzymes of the pyloric caeca were active even in saturated salt solution, softening the flesh and producing a characteristic and much relished "gamey" or "cheesy" flavor, which was something new in medieval provender, and is still today an attraction to those that have acquired the taste. Apparently herring caught in the Zuyder Zee did not mature in this way and were therefore disposed of fresh, or used for "bokking," thus commanding a lower price. The lag between the actual invention of 1315 to 1330 and the flourishing of the method in the following century can be attributed to opposition inspired by the German Hansa and Flemish merchants associated with it (and admitted by them in a letter dated 30th June, 1425), who saw a threat to their trade in Baltic herring, which in the event was largely taken over by the fishermen of the neighboring Zeeland islands.

This effective way of dealing with large quantities of fish was geared to a highly productive fishing technique, using sizable vessels (termed herring "busses" from Dutch herring "buizen") operating as "factory ships" and employing a "vleet" (Anglicized to "fleet") consisting of upwards of 50 nets. The often-quoted statement that the large herring net ("grote net") was first made at Hoorn in 1416 (which is derived from Velius' "Chroniick van Hoorn," running until 1630) can be interpreted to mean no more than that whereas previously small ships landed there inshore herring (caught in the Zuyder Zee, for example) which were used fresh or smoked, in that year ships first sailed from Hoorn into the North Sea using the "great net." This does not necessarily mean that people did not earlier than this sail from other ports on the North Sea with large ships and large nets. Evidence to the effect that the "great net" was not an invention of Hoorn in 1416, but was known earlier, seems to be afforded by the records of complaints from named skippers of Flemish ships in 1314, 1317, and 1318 that they have been robbed of 40, 45, or 55 nets "with ropes," suggesting that their fishery along the English coast was based on the drift net. However, it was in the early part of the fifteenth century that the Dutch fishing really established itself.
c. **THE SCANIA FISHERY**

The alternative view has it that the improved technique was developed at Scania and then transferred to the North Sea fishery, perhaps by Beukels, and possibly accelerated by a sequence of poor seasons in the Baltic. Dutch vessels from the Zuyder Zee and Ijssel towns certainly participated in the Scania herring trade in the twelfth and thirteenth centuries. Danish fish on Scania appear to have been packed in barrels with salt when they were not dried or smoked. In 1262, herring were traded in barrels, but whether gutted or salted whole is not known. "Grumagield," mentioned in 1339, was the profit from the herring offal, from which herring oil was obtained, but again whether from surplus herring or viscera from "kaking" is not apparent. However, by 1365 the Dutch overseer from Kampen on Scania is instructed to see that the "ghellecoen" (literally "gall-wives," i.e., "gutting women") were well paid. There were also "leggecoen" ("laying women," i.e., packers into barrels). In 1379, the English, too, asked for permission to gut and salt herring on Scania, but it is not known whether this gutting was in fact "kaking" or some other treatment, or whether it had been borrowed from the Dutch or vice versa. In any case, the course of events showed that the various improvements in technique fell on the most favorable soil for their fullest organization and exploitation in Holland, although for some considerable time the Baltic industry was proceeding along parallel lines, based, however, on curing on shore from a small-boat fishery. The Hansa merchants were able to maintain and regulate quality of product and thus protect its reputation.

After the fish were brought ashore, they were eviscerated, washed in sea water, "roused" in salt, and finally packed with salt in barrels. The barrel, when full, was allowed to stand for 10 days, after which the herring had sunk a little as a result of shrinkage due to osmosis, so the barrel was then opened and refilled. Hanseatic laws forbade the placing of small or inferior herring in the middle of the barrel and the fish had all to be salted alike and packed in regular layers. "Full" herring, containing fully developed roe or milt, were distinguished from "Spents," i.e., those which had just spawned. At first the fish were exported in the barrels in which they had originally been packed, but later on, the majority were sent to the Hanseatic towns to be sorted and repacked in specially stamped barrels. In 1375, at a conference at Lübeck, the "Ros­tocker Band" was adopted as the standard measure.

d. **DUTCH SALT HERRING**

The Dutch Grand Fishery, which monopolized the herring trade of Europe for several centuries, was prosecuted off the Shetland Islands
and northeast Scotland in the summer and East Anglia in the autumn, where herring still congregate at the same seasons today. The “buss” carried a crew of about fifteen men, including skilled picklers and coopers, together with the nets, salt, and barrels required for a season’s work, which resulted normally in a production of about 35 to 40 “lasts” (a “last” comprising 12 barrels, totalling about 2 tons). At the peak of this industry, in the first half of the seventeenth century, there were probably about 2000 of these busses employed, Enkhuizen alone having 700 in 1637. Nearly half a million persons were employed directly or indirectly, or one-fifth of the total population; hence it was said, figuratively, that Amsterdam was “built on herring bones.”

Although there was a certain amount of secrecy about the precise practical details of the Dutch process, it can be seen from their public ordinances that the underlying reason for the predominance of this Grand Fishery was once again the strict system of “quality control” with stringent regulations defining standards for product and process, providing for severe penalties, e.g., a month on bread and water (1651). Various legislation was promulgated by successive rulers from the Counts of Flanders to the Holy Roman Emperor, Charles V. The Dutch Republic consolidated this legislation, and in 1620 the College of Fisheries was invested with full powers to make regulations and settle disputes. The College met annually at Delft at the beginning of each season to decide on the date for the commencement of the fishing (which was related to the “quality,” and in particular, probably, the fattiness of the fish), to issue instructions and grant licenses.

The sequence of operations, which is exactly the same as is still used to this day, bears a strong resemblance to that already described for the Baltic. Immediately after the herring had been shaken out of the drift net onto the deck of the ship, they were “gipped,” and then sprinkled with salt and “roused,” sorted and packed regularly head to tail in barrels with salt sprinkled between the layers, which were arranged alternately across one another. Finally, the barrels were topped up and made airtight (to minimize oxidative rancidity) and branded with the date of catch. The barrel of Brielle, in the northwest corner of the island of Voorn, was adopted as the standard. All herring had to be taken back to the Netherlands for branding (by specially swift vessels, “ventjagers,” from about 1602 onward) and could not be sold at sea or shipped directly to foreign markets. First-caught herring could not be sold until they had been in pickle for at least 10 days. Repacking on shore had to be completed within three weeks of landing. The number and size of staves for making barrels were specified, and not more than three pieces of wood were allowed in the bottom of the barrel. Only dry, heavy wood could
be used, and all faulty barrels were broken up. The use of old barrels was strictly prohibited. Any fault in the packing which could have resulted in the brine leaking out would have let in air and the consequent oxidation would have been fatal to the reputation of the product.

The packing of poor-quality herring along with good herring was severely forbidden, but the former could be packed separately provided they were correctly labeled, as for example “nachtshamel” (i.e., “overdays”), and “kuytsieck” or “melksieck” (“ripe-running,” or “mazy,” i.e., so close to spawning that the milt is squeezed out over the fish on capture). No one, according to a Placart and Ordinance of 1651, should lay the herring crosswise (thereby giving poor weight for measure), or falsify or change them, put the old under new, lay those bitten by dogfish or ones that were “sickly” along with sound fish, nor pack fish which were caught on one night with those of another night’s taking. No herring could be “heightened” with fresh pickle, nor packed but in the public street, on the quays, or in “such places as are customary with open doors,” thus facilitating inspection. This carefully controlled technique resulted in a keeping quality of 12 months in any climate. The Dutch could thus distribute their product up all the principal rivers of Europe from the Vistula to the Seine, but especially up the Rhine, Meuse, and Schelde. Such pickled herring was one of the first foodstuffs to become a major item of international trade, and thus revolutionized the economic conditions of the time.

e. RISE OF BRITISH FISHERY

Successive British government from Elizabethan times onward made various attempts to encourage the development of a herring industry around our coasts by systems of subsidies (called “bounties”). The Dutch fishery did not survive the wars of the late seventeenth and eighteenth centuries, and Swedish products ousted the Dutch in importance. It was not until after the Napoleonic Wars that Scotland was finally able to establish a native industry, backed by government supervision of quality by a system of “branding” with a hot iron the barrels containing fish of the required quality. Within a century, first through the pre-eminence of the sailing drifter and aided just before 1900 by the change over to the steam drifter, Britain became the greatest herring-curing nation in the world. Pickled herring salted on shore and exported chiefly to eastern Europe accounted in 1913 for some 300,000 tons of a total annual catch of 550,000 tons. Following the two World Wars, however, this trade has declined to the merest shadow of its former magnitude.
One of the earliest mentions of the smoking of herring relates to Fécamp in 1230. The relation of the German Bückling and Dutch "bokking" to the more important salt herring industry has already been indicated. Britain, however, while not competing to any extent with the Dutch in the production of salt herring (also known as "white" herring), developed a characteristic hard-salted, smoked, and dried ungutted product, called the "red" herring, although the product after cold-smoking for some weeks was dark brown rather than red. In fact, "black" herring was another name for it, and, "blackhouses" for smoking are mentioned in an English will of 1349. After salting, the herring are given a preliminary soaking before smoking; otherwise, the drying results in excessive salt crystallization. The Statute of Herrings in 1357 set out maximum wholesale prices and profit margins for the sale of "white" and "red" herring at Great Yarmouth, which early became the most important center for the production of "reds." Thomas Nashe, the poet and contemporary of Shakespeare, who was born at Lowestoft, wrote in 1599 a curious work entitled "Lenten Stuffe; containing the description and first procreation and increase of the towne of Great Yarmouth, in Norfolke; with a new play never played before of the Praise of the Red-Herring." In it he says that "it is most precious merchandise because it can be carried through all Europe. Nowhere are they so well cured as at Yarmouth. The poorer sort make it three parts of their sustenance." However, he observes that "reds" did not keep as well as salt herrings, presumably because the physical barrier to fat oxidation presented by complete submersion in brine was more effective than the chemical barrier provided by the phenolic antioxidants absorbed from wood smoke.

Two reasons given (in 1670) why the Dutch did not capture the British trade in "reds" as they had that of salted herring were that the fish had to be brought to the land to be cured, as at Yarmouth, which the Dutch could not do; and that they must be smoked with wood, whereas Holland was not a woody country, although this argument is not very convincing, as one would have imagined from its activities in shipbuilding that there would have been ample supplies of fuel to support a fish-smoking industry, as is indeed evidenced by the "bokking." Furthermore, they were in fact producers of red herring.

Allowing for the unreliability of production statistics until recent times, Daniel Defoe (the author of "Robinson Crusoe") writes in 1724 of Yarmouth that "the merchants . . . have cur'd, that is to say, Hang'd and dry'd in the smoak 40,000 barrels of merchantable red herrings in one season," each barrel containing about 1,000 herring (i.e., a total of
1. HISTORICAL ASPECTS OF FISH

about 7,000 tons). Scottish summer herring have always been regarded as less suitable for "redding," being fattier, softer, and subjected to higher temperature than the East Anglian autumn herrings, "which makes it more difficult to cure them so as to keep in a hot country and on a long voyage . . . as to Venice and Leghorn." The demand for "reds" in Mediterranean countries continues unabated at a much more stable, though lower, level than the trade in pickled herring. Yarmouth is still a major producer and so are the Dutch, using methods that have changed little in centuries, although with more rapid transport the product today is becoming somewhat less hard and salty than that of former times.

3. Other Fatty Fish Products

Although "white" and "red" herrings were the outstanding products, there were numerous other allied products. Pilchards were preserved in Cornwall, either by smoke ("fumadoes," corrupted to "fair maids"), or by salting in barrels combined with pressing to remove surplus oil. There were also various intermediate products, such as the "bloater," which contained more salt, but had less smoking than the "red." Salmon, too, were either smoked to produce the original of the "kipper," or salted in barrels, in which they were conveyed with the brine produced.

Fatty fish were also subjected to less severe processes using vinegar, with or without a cooking process. Salmon, trout, and char "potted" in this way for short-term storage were popular in the eighteenth century, as "Newcastle salmon," for example. Herring, treated with spices of various sorts, and known as "Marinaden" became popular on the continent, particularly in Germany and Sweden which still consume a variety of such "semi-conserves." Toward the end of the nineteenth century, an export trade developed in "Klondyked" herring, which were merely sprinkled with salt after icing in boxes for a quick journey to Germany, where they were mostly smoked as Bückling or marinated.

4. Salt for Fish Curing

Salt was a key commodity throughout the Middle Ages, largely because of its importance in the preservation of herring. Prior to about 1350, there were three main centers of production in western Europe, and it is no coincidence that each of these was situated in close proximity to a center of the herring fishing industry (Bridbury, 1955). Scania herring were treated with salt made at Lüneberg, where natural brine was drawn from wells in buckets and boiled over fires of brushwood and faggots in rectangular caldrons made of thin iron sheets as described by Agricola (1556). This process was expensive in labor, materials, and fuel. In the Low Countries, they used salt extracted from the peat impregnated
by the action of the sea. This material, termed *darinck*, or *zelle*, dug from the banks and marsh flats, was first dried or burnt, the ash was dissolved in salt water and the solution evaporated in small light-weight pans over turf fires to produce a fine white salt. The island of Tolén was a great center for this industry, which, however, could only be followed in the summer months. So great did this industry become in the fourteenth and fifteenth centuries that restrictions had to be imposed, first at Brielle, and then elsewhere, to protect the dikes from being undermined. In four­teenth-century England, salt was produced from the brine springs of Worcestershire and Cheshire, and also from sea water practically all around the coast, but chiefly in Lincolnshire, Norfolk, and Sussex.

From about 1350 onward, these local industries were largely supplanted by the output of salines along the Biscayan coast, but chiefly by the “Bay Salt” from the Bay of Bourgneuf between Brittany and Poitou, where sea water was allowed to evaporate continuously in shallow lagoons by means of solar heat. The product, however, was very crude and in particular would have contained calcium and magnesium salts. The Dutch, therefore, developed a method of dissolving away these impurities by boiling in sea water. This “salte-upon-salte” ultimately replaced the more-expensive-to-produce native products in the Baltic, Dutch, and English herring-curing industries.

C. White Fish

1. Stockfish

Of the white fish products, available in the Middle Ages, the most primitive was stockfish, which was plain sun- and wind-dried, whole, gutted cod, and similar species, produced notably in Norway and Iceland. After some 6 weeks or so, the water content was reduced to about 15%, below which even molds can no longer multiply. In the course of the prolonged drying process considerable spoilage occurs, accompanied by a strengthening of flavor which was no doubt a not unwelcome feature considering the monotonous medieval dietary, and stockfish is still relished today by the initiated who have acquired the taste for this product in the form of a dish called “lütefisk,” made after soaking in lye. The climate of the northerly countries with a cold, dry, and sunny spring was advantageous for the evolution of such a product, which would have decomposed excessively if subjected to higher temperatures and humidities, not to mention the attentions of blowflies in warmer weather. German merchants handled the Norwegian product from the twelfth century onward, and finally about 1350 the Hansa established its office at Bergen, where cod liver oil (“tran” or “train oil”) for illumination and leather dressing was also an important by-product. This monopoly lasted
until 1550 when Hanseatic power finally collapsed. The trade in stockfish, however, has persisted down the centuries in a remarkable manner and still accounts for a large export from Norway and Iceland to the Mediterranean countries, particularly Italy, the Scandinavian element in the United States and, since the early years of the present century, to West Africa, particularly Nigeria (as “Afrikafisk”).

Not until the seventeenth century did the Norwegians learn from English merchants how to salt and dry cod, although by the end of the fifteenth century they had adopted the Dutch method of wet-curing herring.

2. Salted Cod

a. Iceland

Iceland was first visited by English merchants early in the fifteenth century, trading their goods in exchange for stockfish, e.g., three fish for a pair of ladies’ shoes, fifteen for a firkin of honey, etc. Fish was defined as “piscis durus vocatus stockfysch.” English line fishermen, too, began to sail from Thames and East Anglian ports for a season lasting from February or March to October or November, in vessels carrying from 5 to 10 men along with a summer’s provisions and supplies of salt. Although the industry was known as the “Stockfischery of Yseland” (Hakluyt, 1589), the use of salt shows that the method employed in this instance was not simply one of drying alone but salting at sea. At the end of the season each vessel hoped to bring back all the cargo of salt absorbed into about 15 lasts (30 tons) of fish which would in many cases be dried and kept for sale in Lent. It could be kept subsequently for a year or more if properly dry.

Throughout the fifteenth century, many flourishing little English ports, now sadly derelict and silted up, sent their quota of ships on this “Iceland trade.” A writer at the end of the sixteenth century attributes the prosperity of Hull largely to “their trade in Iseland-fish, dry’d and harden’d, term’d by them Stockfish; which turns to great gain and has strangely enrich’d the town.”

However, there was constant political trouble with the King of Denmark. It is clear from contemporary accounts that Tudor voyages of discovery to Muscovy, Greenland, etc., had the dual objects of promoting trade, in English woollens for example, and of discovering lucrative fishing grounds.

b. The Northwest Atlantic Cod Fishery

The discovery of Newfoundland in 1497 by Cabot on an expedition financed by Bristol merchants was no exception. It was reported on his return “that the sea there is swarming with fish (chiefly cod) . . . (and)
... that they could bring so many fish that this Kingdom would have no further need of Iceland.” However, although the French, Portuguese, and Spanish were soon fishing on the new banks, it was not until the end of the sixteenth century that the English southwest ports really obtained a footing, literally with the occupation in 1583 of Newfoundland itself, partly with the object of securing drying grounds for English fishermen to cure their fish.

The French had access to plenty of solar salt, made by the evaporation of seawater in the Biscayan marshes. They therefore went in for the “green” fishery, or “core” fishery, as it was also called, the fish being brought back and sold wet but permeated with salt. According to a typical account their process was as follows. The fish after landing on deck were placed on narrow tables where one man cut off the heads and threw them in the sea, a second cut open the bellies and eviscerated them, and a third cut out the backbone, after which they were passed below deck to the salter. On the bottom of the hold, fish were arranged head to tail and covered with a layer of salt. Successive layers of fish were laid on top and similarly salted until the end of the day. After the fish had been left three or four days and the brine formed by the water drawn out of the fish by the osmotic action of the salt had been drained away, the surplus salt was removed and the fish were put down in new layers and covered with new salt as before. After this “Kench-curing,” as it became called in North America, the fish were ready to be taken back to France where it seems they were sold in barrels because it was said of the English at the end of the sixteenth century they “had not the use of barrelling up of cod, and if it be not barrellled it is not vendible in France.” It was chiefly consumed in Paris during Lent.

British fishermen were short of suitable salt, and at first traded with the Portuguese fishermen (who “made all wet” fish but “dried it when they got home”) for their surplus. They therefore made a less salty cure, which had to be dried in order to complete the preservation. The history of the New World was largely influenced by the requirements of the cod-salting industry and the international rivalries that resulted. In the early seventeenth century, New England was first colonized by some fishermen because the climate was more suitable for drying than that of Newfoundland, and in addition there were numerous rocky beaches on which to lay out fish. The French, when driven away by the English from the coast of Newfoundland, discovered the prolific Grand Bank. They also settled in Cape Breton Island, Nova Scotia, and the Gaspé Peninsula, but the climate there was poorer and fish had commonly to be dried on hurdles, known as “flakes,” because of the lack of suitable beaches. The rivalry between English and French fishermen was not the
least of the causes of the War of the Spanish Succession and the Seven Years' War. Under the provisions of the Treaty of Utrecht (1713), the French were allowed "to catch fish and to dry them on the land" only on the west coast of Newfoundland, which was less favorable climatically. The Treaty of Paris (1763) led to their forcible eviction from Cape Breton, although they were still allowed a foothold on St. Pierre and Miquelon. On the less accessible Gaspé Peninsula, the combination of climate and shortage of salt led to rather a hazardous cure, with what has come to be regarded as a specially attractive flavor to the present day.

With the French threat finally removed, the friction between England and New England came to a head. One of the bones of contention was the mother country's determination to monopolize the West Indian trade. New England, perhaps on account of the warmer climate, produced a high proportion of unmarketable salt fish, which was used to feed the plantation slaves, who were not, however, too servile to complain about this "refuse fish." After the Declaration of Independence, the House of Representatives of Massachusetts at Boston in 1784 decided in a resolution "to hang up the representation of a cod fish in the room where the House sits, as a memorial to the importance of the cod fishery to the welfare of this Commonwealth."

D. CONSUMER ASPECTS

Dried and salted fish were sold under a number of popular names, the origin and meaning of which is often obscure. "Lochefisshe" sold at Blakeney (Norfolk) fish fair in 1357 was apparently of three types, "lob," ling, and cod, while "orgeys" were fish larger than "lob." Unspecified "pecys of salt fisch" are a common entry in the account books of Bristol merchants. "Poor John" (referred to in Shakespeare's "The Tempest") seems to have been chiefly small cod or hake. "Stockfish" occurs in "Henry IV" and "old ling" in "All's Well that Ends Well."

"Haburden" or "haberdine," possibly so called from the Basque province of Labourd, was a larger variety of hard-dried salt cod. "Millwell" or "mulvel" was probably something similar, perhaps made from whiting. "Ling," although a definite species, was a term apparently used for dried fish generally. "Mudfish," like "green fish," was undried, wet salted fish. "Bacalao" was the Spanish word for dried salted cod.

Throughout the eighteenth and nineteenth centuries, salt was heavily taxed in Britain, as in most other countries. This led to all sorts of complications for the fish industry.

Although in the sixteenth and seventeenth centuries there were in England religious injunctions, backed by political expediency, to enforce the regular eating of fish, which for most people meant the hard-smoked,
salted, and dried products, numerous literary allusions make it obvious
that these were consumed with resignation, because they were all that
was available, rather than enthusiasm.

III. Modern Era

A. The Rise of the Fresh Fish Trade

1. Introduction

Most people, at all times, have preferred fresh fish to salted, smoked,
or dried fish if given the choice. Consequently, the history of the
development of the fishing industry in modern times has been a succes­sion of attempts to keep fish fresh between catching and consumption.
The following account relates to the experience of Britain in particular,
but the same general pattern of development was followed in North
America also. Roads were bad until the beginning of the nineteenth
century and transport either by packhorse or by water was so slow
that such perishable goods as fresh fish could not penetrate very far from
the port.

2. Live Fish

One way of diminishing the effects of the well-known perishability
of fresh fish is to keep it alive until the last possible moment. Bringing
sea fish to port in the live state developed into a large-scale industry in
the North Sea in the eighteenth and nineteenth centuries and somewhat
later in New England. "Well-vessels," consisting of large tank amidships
in which holes were bored to allow free circulation of sea-water, were
introduced at Harwich from Holland about 1712. Soon after this,
Daniel Defoe noted similar "fish pools" at Barking, which was thus able
to land fish alive at Billingsgate for the London market. In the second
half of the nineteenth century, Grimsby became the premier port for
the "live fishing." Hull was too far up the Humber estuary to participate,
as the water was too fresh.

The fish were caught on baited hooks fitted with a gorge to prevent
swallowing, thus minimizing internal damage. They were handled
carefully and thrown into the tank tail first so that they did not break
their necks. Cod was the principal species brought back in this way. If
catched at not too great a depth, it survived the change in pressure on
being brought to the surface and could normally be kept alive in the
well for a week or so. The swim-bladders, which were distended after
catching, had to be punctured so that the fish could right themselves.
Flat fish, which lay on the bottom and blocked the holes, were stowed
in boxes. Large predatory fish, such as skate and halibut, were tethered
by a cord at the nose and tail respectively. Fish that died were removed daily and salted or, later on, iced. At port, fish were taken from the well by means of a net and transferred to large crates, called “chests,” which floated anchored in the harbor. Each chest held 40 to 100 fish, according to size, which could be kept for a further week or two without adverse effect. Up to 400 such chests were in use at Grimsby. These “live cod” were highly esteemed in London and a large fish would sell at Billingsgate for over £1. New England ports similarly for a period developed a flourishing trade in live halibut.

However, although there still continues to be a small trade in live sea fish, in Norway and Denmark for example, the process has obvious limitations. The revolution in technique, which, in the second half of last century converted fresh fish from an expensive luxury into a staple food of the poorer classes, was associated with the spread of trawling, the use of ice, and rapid transport by rail. Since about 1850, therefore, the market for salted fish has declined in industrial countries, although the total world demand for such products has by no means decreased and in the case of salt cod still accounts for over a half of the total catch of that species.

3. Trawling

Catching fish by dragging a net over the sea bottom had been a method practiced since the fourteenth century in sheltered waters such as the Thames estuary and the Zuyder Zee. By the end of the eighteenth century the fishermen of Barking and Brixham were having success in coastal waters with a much larger net of this type, kept open by means of a beam of wood. They extended their operations to the North Sea and discovered rich fishing grounds, to exploit which they settled at Hull, Yarmouth, etc. Trawling was a more productive method of fishing than lining. The fish, however, were mostly dead when they were landed on deck and they could be distributed in sound condition to centers of population inland only if they were handled expeditiously, as by “fleeting,” or if chilled by means of ice. Small fish, otherwise unwanted, were absorbed in Britain by the growing number of fried fish shops, which vended cheap food to the masses. Small haddocks found an outlet as “finnans.”

4. “Fleeting” and Steam Power

The firm of Samuel Hewett (1797-1871) of Barking, which owned a number of North Sea sailing trawlers, first organized the system of fishing as a fleet, under an “admiral,” in which the catch from every ship was collected daily and sent to Billingsgate market by special, swift, cutter-
rigged carrier-vessels, which after 1864 were steam-powered. The trawlers themselves continued for some time to be sail-driven, despite a number of sporadic attempts to apply steam power to them from about 1860 onwards. After a period in which steam paddle-tugs of the rivers Tyne and Wear were used to assist the trawlers when it was too calm, the tugs themselves began to be fitted with trawls about 1877. Steam-powered capstans and winches, too, made operations at sea easier and further increased productivity. The first successful steam trawlers were built in 1883, and steam drifters for herring soon after. Fleeting survived the transition from sail to steam trawling and continued from Hull, although on a decreasing scale, until the 1930’s.

5. Icing

All these improvements in the productivity of fishing led to the need for improved methods of preservation, and this was met in the first instance by the use of natural ice. The first use of ice to preserve fish during transport was in 1786 when, following a report by a captain of an East Indiaman that it was commonly used in China, salmon were first sent from the North of Scotland to London packed in ice in boxes. The ice was collected from lochs during the winter and stored in earth houses. Such ice is also reported to have been used for herring just before 1800 and it was becoming common in the normal fresh fish trade by about 1820.

About mid-century it began to be used systematically by Hewett’s for the preservation of fish at sea. Ice from the Thames marshes was collected as a crop by the farmers and brought in carts to a large store at Barking. Ice-lugs then took it out to the cutters in the river, for use in the “fleeting” operations. When trawlers operated on their own (“single-boating”), supplies of ice were scarcely adequate for requirements, and it had to be used sparingly and only on the most valuable species. “Offal fish,” including plaice and haddocks, often had to be thrown overboard for lack of ice. Hull and Grimsby trawlers first started using ice about 1860, relying on increasing imports from Norway. By 1900, however, factories were erected at the ports for making ice artificially for supply to the fish trade. More ample supplies made it possible for British trawlers to go farther afield in search of fish, thus developing distant but prolific trawling grounds off Iceland (1891), Barents Sea (1905), and Bear Island (1920’s). Larger steam trawlers with constantly improving fishing gear, such as the otter-trawl (1895), steel warps, Vigneron-Dahl trawl (1920’s) and more recently the echo-sounder, radar, etc., have brought back greater and greater quantities of fish, although in some areas, such as the North Sea, the intensity
of fishing effort has led to a reduction in the yield per unit of effort to a barely economic level. In addition to Britain, such countries as France, Germany, and Iceland have similarly developed an Arctic fishery with large trawlers, while others have continued either to exploit principally coastal waters (as in the case of Norway) or at most engage in 8- to 10-day fishing trips to the grounds and back (as in the case of Canada). British distant-water trawlers average something like 20-day trips, including, say, 5-day trips each way, to and from the grounds. However, even with the use of ice to delay decomposition, there are difficulties in landing and marketing this distant-water fish in fresh condition, with the result that the sanitary authorities take a regular toll of a per cent or so of the supplies, and a proportion of that which is passed as fit for human consumption is of indifferent quality.

B. FISH MEAL

The filleting of white fish at the ports developed greatly in the mid-1920's, to some extent perhaps an expedient for marketing distant-water cod which would often have appeared stale and unsavory if despatched with head, gills, belly-wall, etc., intact. This development led to an industry for the organized collection and treatment of the filleting offal, by drying and grinding into a meal for animal fodder. Increasing demands for such a protein supplement for stock feeding were also met by the drying of whole fatty fish, such as herring, where surplus to the normal requirements of trade and distribution, usually after a process of cooking, followed by pressing to remove the majority of the oil, which is also a valued product.

C. FRIED FISH TRADE

The large quantities of small fish, first produced by trawling operations in the 1840's, were bought up and marketed cheaply by itinerant costermongers amongst the industrial proletariat. This, too, seems to have been the origin of the fried fish trade, so characteristic of Britain. Charles Dickens (1838) mentions a “fried fish warehouse” in a “narrow and dismal alley” in Holborn. Little capital was required to start in business, it was reported by Mayhew (1861), only a “frying pan 2s. (secondhand 9d.), tray 2s. 6d. (secondhand 8d.); salt box 6d. (secondhand 1d.); and stock money 5s. 0d. in all 10s. 0d. A man has gone into the trade, however, with 1s. 0d., which he expended in fish and oil, borrowed a frying pan (and) . . . an old tea board.”

Today a major proportion of the trade in British distant-water cod fillets is marketed by the widely distributed fried fish trade.
D. Freezing

The freezing of fish by natural means has long been known as a method of preservation in countries with cold winters, such as Russia, Siberia, and Canada. Also in the Great Lakes area, this method of weather freezing was common. In Newfoundland, herring were allowed to freeze in the open air for subsequent use as bait.

Such stiff-frozen fresh fish were also marketed commercially and are still encountered in the north of the Soviet Union. At the start, various mixtures of ice and salt were employed for the freezing of fish on a commercial scale. This was the case in 1865 in the United States (Tressler and Evers, 1957). Soon after the invention of the machine compressor, this was put to use for freezing food, and experimentation, primarily with meat and fish, paved the way for its industrial use. This happened simultaneously in Western Europe, the United States, and Russia. At the end of the century, fish freezing was quite important in the United States and Russia (Zaitsev and Pavlov, 1958; Stevenson, 1899). Some enterprises were also operating in Western Europe (the United Kingdom and Scandinavia) at this time. Some frozen fish also trickled into the world market. In 1880, freezing machines were installed on barges which were towed along the Volga from Astrakhan up this river collecting raw material for the canning industry. Similar practices were applied in the Yenisei River fisheries in 1905 (Zaitsev and Pavlov, 1958).

It is likely that the quality of this frozen fish reaching the retail market was not entirely satisfactory. The classic histological work of Plank et al. (1916) and Reuter (1916) demonstrated the need for freezing this tissue quickly in order to minimize damage to the structure and texture. Largely as a result of this discovery, an industrial development started between the two wars by such pioneers as Harnsworth (1925; quoted in Huntsman, 1931), Birdseye (1929), and Zarotschenzeff (1930), directed toward devising special plants for commercial freezing.

At the start, fish were frozen whole. Later, filleting was introduced. This was done almost simultaneously in the United States and the Soviet Union (Astrakhan and Murmansk). "Quick-freezing" resulted no doubt in a great improvement over the former process of merely placing fish to freeze slowly in cold stores, often in large wooden boxes which further retarded the removal of heat. However, there was for a period a tendency to place undue emphasis on "quick freezing" and its associate problems of packaging as the sole guarantee for excellence.

Further patient scientific work in the 1930's in a number of countries led to the realization that frozen fish needed cold storage at a distinctly lower temperature than was regarded as acceptable commercially for
meat and other foodstuffs. Not until after 1945 did this principle begin to win wide acceptance in industry.

For a country with a distant-water fishery, such as Britain, the establishment of a freezing industry on shore obviously cannot be expected to result in a material improvement in the quality of the fish marketed, except insofar as it can smooth out day-to-day and seasonal surpluses and eliminate the deterioration that inevitably occurs during normal distribution in the fresh state. The freezing of fish at sea on the fishing vessel or on a “mother-ship” has been attempted from time to time since the late 1920's as a means of preserving fish better during the voyage home and thus facilitating the exploitation of the distant-water Arctic fishery. The latest British and United States developments in this field are described in Volume III, Chapter 25.

E. MILDLY SMOKED FISH

Just as the advent of the railway network in Britain in the 1840's made possible the rapid inland distribution of fish in the fresh, un-preserved condition, so, too, the development of less heavily smoked products can be associated with the same period. Thus, the red herring of former times gave way to “Newcastle Kippers” (invented 1843) and “Yarmouth bloaters” (about 1835). “Finnan haddocks,” originally a local product made on a domestic scale near Aberdeen, provided an outlet for surplus, trawled haddocks landed at London and Hull (where smokehouses were erected in 1847) and Grimsby (1856). Both Yarmouth bloaters and “finney” haddock were already conspicuous amongst the “dried fish” (i.e., smoke-cured fish) on sale at Billingsgate in 1851.

On the continent of Europe a preference developed for hot-smoked products, such as the Bornholm Bückling, which likewise replaced the earlier, much-harder-cured Baltic product.

In all these products the chief purpose of smoking is to impart an agreeable flavor, the shelf-life at ordinary temperatures being only a few days in most cases. In recent years, the tendency towards ever lighter and milder-smoked products has continued with the result that the smoke serves more as a condiment than as a preservative. The development of freezing, particularly in consumer packs, which in itself effects the preservation, has furthered this trend. The accepted degree of coloration of the “fully” smoked kipper, etc., is in most cases maintained by the use of artificial coloring. This practice is at least 60 years old (Stevenson, 1899), such colorings as saffron and annatto having now been superseded by various “permitted” coal-tar dyes, although in some countries,
notably the United States of America, the practice is not allowed, on the grounds that it represents a deception of the consumer.

F. CANNING

Canning was the result of an attempt to preserve satisfactorily without adversely affecting palatability by undue desiccation, toughening, and salting.

Fish and lobsters were among the preserved food delivered by Nicholas Appert to the French government soon after the publication of his method in 1810. His results aroused interest in Britain, and several firms were soon canning salmon, trout, lobsters, etc., in Scotland. An Aberdeen firm supplied Parry the explorer with victuals in 1824. In order to obtain higher temperatures for quicker sterilization, sodium chloride, sodium nitrate, and calcium chloride were first added to the heating bath to raise its boiling point. Although anticipated by Papin's "digestor" (1681), cooking under pressure was first employed about 1840, and not until 1875 were proper steam kettles devised, the forerunners of the modern retort.

Fish canning was introduced to the Atlantic seaboard of America by English immigrants and the tin "cannister," invented in 1810, first received its abbreviation "can." in New England about 1840. These "cans." were hand-made by tinsmiths from sheets of tinplate (60 being a good day's production), until the pressed-out, open-topped, "sanitary can" was developed toward the end of last century, and thereafter mechanization proceeded apace.

Canning of Pacific salmon, from small beginnings in 1865, later supplied one of the principal canned commodities entering world trade, spreading to Japan and Siberia. Canned "sardines" (immature pilchards) cooked and packed in oil, which were supplied from Nantes for a sea expedition as early as 1822, became the second main line of canned fish, later extending across the Mediterranean to Morocco. Norway originated about 1880 a similar process, involving light smoking for sprats ("brisling") and immature herring ("sild"), and smallish fish in other parts of the world are treated in a like manner.

In the last 20 years the pack of salmon has suffered a curtailment consequent upon the fall-off in catch, and tuna, not canned before about 1900, has now replaced it as the leading pack of the world, mostly produced in the United States.

Mature herring, pilchards, and similar species are also canned on an appreciable scale. Other species, such as lobsters and oysters, although canned from the beginning, have remained at a relatively low level, restricted by availability and price.
Although fish canning originated and first established itself on an empirical basis, by the turn of the century the need exerted itself for a scientific study of the bacteriological problems posed by the canning of lobsters, among others, and canning continues to be one of the most rationalized and scientific sections of the fish industry.

IV. The Future

At all times the rapid perishability of fish has constituted a problem for the human race, although the degree of pretentiousness as regards freshness has varied considerably with time and place.

All the methods of preservation referred to above appear capable of continued application and further development. Salting and drying, either individually, in combination, or along with heavy smoking, although superseded in the most advanced countries, promise to have a long lease of life still in relatively undeveloped parts of the world where communications are poor and climatic conditions severe.

Even in Western European countries, considerable improvements are possible in the application of chilling to preserve freshness to the utmost during distribution. Furthermore, the economic advance of countries at present underdeveloped will make enormous demands on ice as an agent for retarding spoilage. In fact, the industrial application of present knowledge of temperature control, combined with what is now only common-sense hygienic handling (using common sanitizers such as chlorine) would probably result in a greater ultimate improvement in short-term preservation than, for example, the possibilities opened up by the use of antibiotics as adjuvants to ice. Similarly, although revolutionary new methods of preservation, such as perhaps radiation sterilization, or some superdehydration, combining perfect reconstitutability with good storage properties, may some day radically alter the situation, the extended application of existing methods of freezing and canning for long-term preservation could satisfy all reasonable needs for many years to come.

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