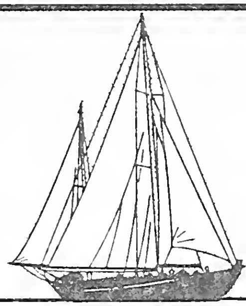
THE · WEALTH · OF · THE · SEAS

· DONALD · K · TRESSLER ·

Given in
Loving
Memory of



Daniel Merriman

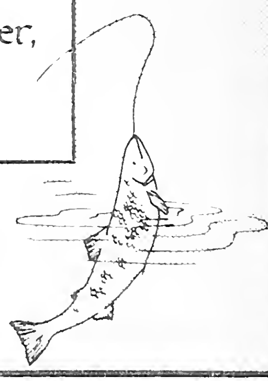
Crew Member on
the maiden voyage
of the R/V Atlantis

◆

Corporation Member,
1944-79
Trustee, 1944-64
Honorary Trustee &
Corporation Member,
1979-84

◆

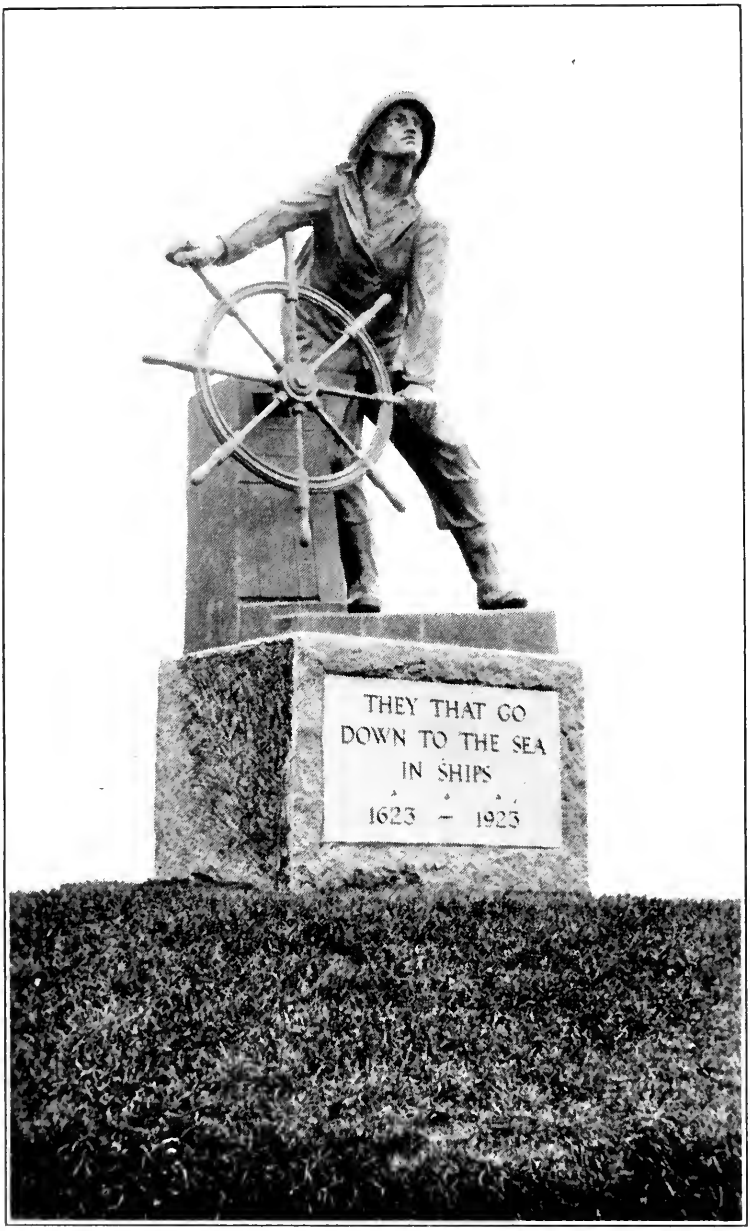
Oceanographer, Writer,
Editor, Fisherman,
Educator, Mentor



Woods Hole
Oceanographic
Institution

Daniel Merriman
July 27, 1933.

THE WEALTH OF THE SEA



Photograph by Dr. A. D. Holmes

THE GLOUCESTER FISHERMAN

Monument to the eight thousand who have been lost at sea

THE WEALTH OF THE SEA

BY

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Illustrated with photographs and drawings

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PREFACE

This book is a popular presentation of many interesting facts concerning the production, nature, and uses of the great variety of commercial products of the sea. These marine treasures include jewels, buttons, ornaments, perfumes, tortoise-shell, foods, condiments, medicinals, chemicals, oils, fats, waxes, glues, jellies, sizes, cements, stock foods, fertilizers, leather, furs, lime, poultry grit, sponges, and whalebone. The production of each one of these is an important industry. In most of these industries one finds lively sport and gripping romance. Whaling is as thrilling as elephant hunting. Pearl fishing offers as much romance as diamond mining. Ocean fishing has a fascination which holds many of our bravest and strongest men. The source of this great wealth, the restless, ever changing sea itself seems to enchant every one who once comes within its spell.

The author has attempted to present these industries in such a way as to furnish both information and entertainment, and hopes that this book will be of interest not only to those who are primarily interested in marine products, but also to the general reader and to students of commercial geography, biology, geology, chemistry, oceanography, and navigation. Obviously in a general survey such as this it is impossible to enter into great detail in the consideration of the multitude of marine products. This book, however, will give the reader a general conception of the fishery and marine products industries. If further details or statistical data are desired, they may be found in the author's "Marine Products of Commerce." [1]

Since it is not possible to discuss the fishery methods employed in all parts of the world in the space of a few hundred pages, American methods and products have been described in most instances. In the case of products which are not produced in quantity in this country, such as pearls and coral, the more important foreign methods have been given consideration.

In order to make the book interesting to the general reader, the descriptions of technical processes have been made simple, non-technical, and brief. Scientific names and technical terms have been omitted in nearly all cases, and care has been used to define all unusual words and phrases. While the author has attempted to make the book a readable one and has for this reason included some unusual and curious tales of the fisheries, those which are not absolutely authentic are clearly indicated.

The author owes much to those who aided in the preparation of this book. Special thanks are due Dr. Samuel F. Hildebrand, of the U. S. Bureau of Fisheries, for the preparation of the sections "Fishes" and "Marine Turtles and Terrapins." Mr. M. P. Greenwood Adams, of Melbourne, Australia, Mr. Lewis Radcliffe, U. S. deputy commissioner of

[1] Published by Chemical Catalog Company, New York, 1923.

fisheries, and Dr. Arthur D. Holmes, of The E. L. Patch Company, were very kind to aid in supplying the illustrations. The author also wishes to thank Mr. Ernest F. Holt, of the Carnegie Museum, Mr. Hugh A. Wing, of the University of Pittsburgh, and Miss C. H. Watkins, of Ellicott City, Maryland, for their invaluable aid in revising the manuscript.

D.K.T.

CONTENTS

ILLUSTRATIONS

THE WEALTH OF THE SEA

THE WEALTH OF THE SEA

CHAPTER I

The Sea

THE ocean has often been said to be the seat of enduring power, for the nation that is able to rule the ocean rules the world. Even small states, able by their powerful navies to maintain control of the sea, have dominated the world. Greece, Tyre, Pisa, Genoa, Venice, Portugal, and Holland were all great powers merely because they ruled the waves. When Carthage lost control of the Mediterranean she soon bowed to Rome. The defeat of the Spanish Armada marked the end of the ascendancy of Spain. The failure of Germany in the World War may be largely ascribed to her inability to wrest control of the sea from the British either by submarine or marine warfare.

The best schools for hardy, daring sailors are fishing and whaling fleets. Such men come to know the sea, and easily learn how to sail ships of war. Skill in the construction of war-ships is obtained by the training gained in the building of fishing and merchant vessels. The captains of fishing and whaling vessels are excellent navigators, for they are more familiar with the coastal waters than any one else.

Oceanography and navigation are sciences which go hand in hand in the development of both fishing fleets and navies. Since the location and extent of the fisheries are controlled largely by the temperature, depth, salinity, purity, and amount of plankton (minute organisms which float with the currents) of the waters, brief mention of these factors will be made in this section. Their consideration will be worth the while of any one interested in the fisheries. Such a survey will also give much information concerning the various forms of marine life and the conditions under which it exists.

The early Greeks and Phenicians laid the foundations of oceanography. In the fourth century B.C., the astronomer Pytheas sailed from the Mediterranean to the North Sea and made notable contributions to the oceanography of the Atlantic Ocean and the North Sea. He learned how to determine latitude and discovered that the tides were caused by the moon.

Later, in the first century B.C., the Greek geographer Strabo made the first deep-sea soundings, measuring depths down to 1000 fathoms. Pliny, in his "Historia Naturalis," recorded 176 marine animals, and was well pleased with his catalogue, as he believed that he had listed all the important marine species.

Ptolemy, who lived in the second century A.D., prepared a map indicating that eastern Asia came near to the west coast of Europe. This idea persisted until the time of Columbus and had much to do with the voyages of Columbus. Men like Vasco da Gama, Magellan, and Cook, who came after Columbus, learned much about the sea; but, during the last hundred years, oceanographers with a knowledge of the modern sciences of physics, chemistry, astronomy, and biology have vastly increased our knowledge of the ocean. Edward Forbes, C. Wyville Thomson, John Murray, Louis and Alexander Agassiz, the Prince of Monaco, Anton Dohrn, Johann Hjort, William A. Herdman, and others have cleared up many of the mysteries of the briny deep. These men have amassed an amazing amount of information concerning the sea, which would require a lifetime of study to master. The reports of the *Challenger* expedition alone fill fifty large quarto volumes. Therefore, in an account such as this, we shall be able to consider only a few of the most interesting facts concerning the ocean.

Area and Depth of the Ocean

Few of us have an accurate conception of the size of the sea. A long voyage impresses the average person with the great size of the ocean compared to that of the land. The sea is 139,000,000 square miles in area, and covers about seventy per cent of the surface of the earth.

The globe may be divided into a land hemisphere, with its pole near London, and a water hemisphere, having its pole near New Zealand. The former contains Africa, Europe, Asia, North America, and most of South America. The only land occurring in the water hemisphere is the East Indies, Australia, the South Sea Isles, the southern part of South America, and that around the South Pole.

Around the edges of the continents the oceans are relatively shallow. These marginal portions down to 600 feet in depth are really parts of the continental platforms and are called continental shelves. In depths beyond 100 fathoms the bottom usually drops off rapidly. Most of the ocean is very deep, its average depth being 1916 fathoms; about three fifths of it is between 2000 and 3000 fathoms. Little of the floor of the ocean lies below this depth. There are, however, fifty-seven known deeps, or valleys in the ocean floor, which lie at depths of more than 3000 fathoms. Thirty-two of these deep places are in the Pacific, the deepest of the oceans. The largest and one of the deepest of them, the Tuscarora Deep, is a depression running north and south in the North Pacific to the east of Japan. Mount Everest, the highest mountain on earth, could be dropped into this deep, and its peak would be more than half a mile below the surface. The Aldrich Deep, which lies in the South Pacific, contains several places more than 5000 fathoms in depth.

For the most part, however, the floor of the ocean far from land is a nearly flat plain which might be compared to the level parts of the Mississippi Valley in which the gradients are so slight as to be scarcely noticeable. On approaching the continents, the slope rises steeply up to the continental shelf.

As yet, comparatively little of the floor of the ocean has been sounded. Instruments have recently been perfected which enable navigators to make soundings while their ships are proceeding at full speed. These instruments, variously called "sonic depth finders" and "fathometers," measure the time elapsing between the emission of a sound and the return of the echo from the bottom of the sea. Sound travels in water at the rate of 4800 feet a second. Thus, if two seconds elapse between the emission of the sound and the return of the echo, a depth of 4800 feet is indicated. Of course the instruments required to produce the sound, to hear the echo, and to measure the time interval are rather complicated, but they have been designed to work continuously and automatically, and indicate depths without adjustment or attention as long as they are allowed to operate.

Before many years topographic maps of the floor of all the important parts of the ocean will be prepared by the use of this instrument. Such maps will be a great boon to navigation, as they will enable navigators to find their exact position at any time by noting the character of the bottom over which their ships are passing. Navigators will be warned by the depth finder as soon as their boats reach shallow water; thus few ships will run aground, and many wrecks will be prevented.

The exact volume of the ocean cannot be estimated until a topographic map of its floor is prepared. Scientists have variously estimated the volume to be between 300 and 320 millions of cubic miles, whereas the volume of the land above sea-level is only 23,000,000 cubic miles. If the earth were leveled off, the ocean would completely cover it to a depth of about 1450 fathoms.

Fossil remains of many marine animals which lived millions of years ago are found in the sedimentary rocks underlying great areas of the continents. This indicates that much of the earth's surface that is now dry land has been under the ocean at some time during the ages. A part of the surface that is now submerged was once dry land, but it is doubtful if any of the true ocean basins have ever been above the surface of the sea.

Temperature and Salinity

We never think of the temperature of the ocean except when we are at the sea-shore trying to decide whether or not to bathe in the surf. Yet the most important factor in our daily life, the weather, is largely controlled by the temperature of the surface water of the ocean. England is as far north as southern Labrador, but it does not suffer similar rigors of climate. New York has colder winters than London.

Such conditions result from ocean currents. The British Isles benefit from the Gulf Stream, which flows through the Straits of Florida as a river 50 miles wide and 350 fathoms deep, at the rate of five miles an hour, in a northerly course past Cape Hatteras toward the Banks of Newfoundland, where it turns more to the east, gradually widening and losing speed and heat as it goes. Off Cape Hatteras it is 75 miles wide and flows at about three miles an hour, while to the south of the Grand Banks of Newfoundland its rate is only one and a half miles per hour. Although it changes in depth and width and speed, it preserves its individuality for more than 3000 miles. New York, on the other hand, is cooled by the Labrador Cold Current, which flows southward inside the Gulf Stream along the New England coast to the Carolinas, and dips under the Gulf Stream as it emerges from the Straits of Florida.

Meteorologists sometimes speculate as to what would take place in the climate of the eastern part of the United States, if the Labrador Cold Current were diverted from its course. Doubtless the Gulf Stream would then swing in closer along our coast, and make the winters in the Eastern States almost as warm as those of Florida.

Throughout the oceans, the water at or near the surface is generally warmer than that below. In the tropics, the temperature of the surface water may be 80° F. or over, and at the bottom as low as 28° F. Usually the temperature decreases from the surface to the bottom. Murray reported the following mean temperatures for the whole ocean as found on the *Challenger* expedition:

100	fathoms	60.7° F.	1000	fathoms	36.5° F.
200	"	50.1° F.	1500	"	35.3° F.
500	"	40.1° F.	2200	"	35.2° F.

The bottom temperatures are below 30° F. in the polar seas. In the Antarctic and Indian oceans and parts of the Atlantic and Pacific oceans, the bottom temperature is between 30° and 35° F. In the North Atlantic and parts of the Pacific the bottom temperature is between 35° and 45° F. Thus it is seen that all deep-sea water is very cold. While the temperature of the sea bottom, at depths of 2000 fathoms or more, does not vary more than 12° F. (between 28° and 40° F.), there is no such uniformity of temperature of the surface waters. The highest surface temperature, 96° F., was recorded in the Persian Gulf, and the lowest on record is 26° F. in the polar regions. The seasonal variation in the surface temperature of the sea is least in Arctic and Antarctic waters and in the tropics where it is less than 10° F. In the northern temperate zone the variation is from 10° to 50° F., and in the southern temperate zone it is from 10° to 30° F.

In ancient times the source of the salts of the sea was a great mystery. Modern geology has, however, explained their origin. Time was when the ocean was composed of fresh water, but all through the ages the rivers have been carrying into it the dissolved salts which the rain has leached from the earth. Although the rivers contain but a small percentage of saline matter, and although much of this is deposited in the ocean near their mouths in the form of lime and magnesium salts (limestone, etc.), the total amount of salts in solution in the ocean is very great.

Since we can estimate with some exactness the total amount of sodium in the sea, if we assume that it has been added in a constant manner without serious losses, we can also estimate the age of the ocean if we know the amount of sodium added annually by the rivers. Dr. F. W. Clarke has carefully considered all the information at hand, and has concluded that the age of the ocean, since the earth assumed its present form, is somewhat less than a hundred million years.

Sea salt is not almost pure sodium chloride, such as the salt we use as a condiment, but is a mixture of a large number of compounds of which common salt, Glauber's salt, Epsom salt, gypsum, and potassium chloride and sulphate are the principal components. Approximately three fourths of the saline matter is sodium chloride or common salt, and it is in the preparation of this important substance that sea-water finds its principal use. In nearly all warm dry countries salt has been prepared from sea-water since prehistoric times. Even in this country, in the State of California, salt is prepared on a large scale from sea-water.

In addition to the compounds named above, sea-water contains appreciable amounts of bromine, iodine, iron, silicon, carbonates, and phosphates. The presence of the following elements has also been demonstrated: fluorine, nitrogen, arsenic, boron, lithium, rubidium, cæsium, strontium, manganese, barium, aluminium, copper, zinc, silver, lead, cobalt, nickel, gold, and radium.

The total amount of any of these elements occurring in the entire ocean is stupendous even though it may be present in an extremely small proportion. Iodine exists in sea-water to the extent of only about two parts per million. Yet the entire ocean contains some sixty billion tons of iodine. Science has not developed a profitable method of extracting this iodine from sea-water, but nature has. Many sea-weeds extract iodine from the sea-water in their life processes. By burning the seaweed and extracting the ash, we obtain iodine commercially.

Gold, silver, and radium are contained in sea-water. The amounts of these extremely valuable elements are very small, and are ordinarily listed as traces; nevertheless their presence has attracted much attention. From time to time, various schemes have been devised for obtaining the gold and silver from sea-water. Many of these processes are successful in obtaining the precious elements, but no one has ever been able to do the trick profitably. The amounts of gold found vary from a tenth of a grain to a grain per ton of sea-water. The man who first succeeds in profitably obtaining gold from this source will revolutionize gold mining.

The composition of sea salt has been the subject of many elaborate investigations which have shown that, although ocean water varies considerably in concentration, the composition of its saline matter is remarkably uniform.

Dittmar, of the *Challenger* expedition, made a large number of analyses of sea-water from many parts of the globe, and found that the density, and therefore the salinity, of ocean water diminishes from the surface to a depth of 800 to 1000 fathoms, and then increases to the bottom. Around the poles there are areas of concentration because of the freezing of the surface, which removes nearly pure water and leaves a large part of the salts behind.

The uniformity of composition of ocean water is of much greater importance than most people suspect. Dr. Edwin B. Powers, of the Puget Sound Biological Station, finds that fish are very sensitive to changes in the carbon dioxide content of the water, and suggests that the desertion of the shores by herring after storms may be due to the mixing of the carbon dioxide of the air with the sea-water by the breakers, thus causing the herring to seek deeper water of lower carbon dioxide content. Doubtless slight changes in the composition of the ocean water in one part of the sea accounts for some of the sudden unexplained migrations of fish.

The average salt content of a gallon of sea-water is about a quarter of a pound. And, since the average density of rock-salt is 2.24 times that of water, the entire ocean, which has a volume of about 300,000,000 cubic miles, if dried up would yield approximately four and a half million cubic miles of salt. In the face of these figures, the extensive beds of rock-salt at Stassfurt, Germany, and in Ohio, Michigan, New York, and Kansas, seem trivial.

In addition to the large number of salts, sea-water contains considerable amounts of dissolved gases, principally oxygen, nitrogen, and carbon dioxide, and some small amounts of the inert rare gases, argon, neon, krypton, and xenon. These gases are derived chiefly from the atmosphere, but are not in solution in the water in the same proportion in which they occur in the atmosphere, as a larger proportion of oxygen than nitrogen is dissolved. Moreover cold sea-water dissolves much more gas than warm water, and on this account the waters of the polar regions contain much more dissolved air than do the waters of the tropical seas.

The presence of the gases dissolved in sea-water is of utmost importance to the animal and vegetable life of the ocean. All marine animals breathe, although few have lungs. The true fishes absorb oxygen from the water through their gills and thus are able to maintain their bodily functions.

Color and Pressure in the Ocean Depths

A curious popular misconception is that ships which sink in the deeper parts of the ocean do not reach bottom but float submerged at a great depth, where the density of the water is very high because of the enormous pressure. Nothing can be farther from the truth, for any object that will sink in shallow water will certainly sink to the bottom of the ocean, even though it may be six miles deep.

The reason for this is not hard to find: water is almost incompressible. Under one additional atmosphere it is compressed only about one twenty-thousandth of its bulk. At the greatest known depth of the ocean, about 5348 fathoms, the water becomes only four and a third per cent heavier than at the surface. The floor of the ocean at great depths is often covered with delicate shells which are only slightly heavier than water, and yet they have sunk from the surface to the bottom.

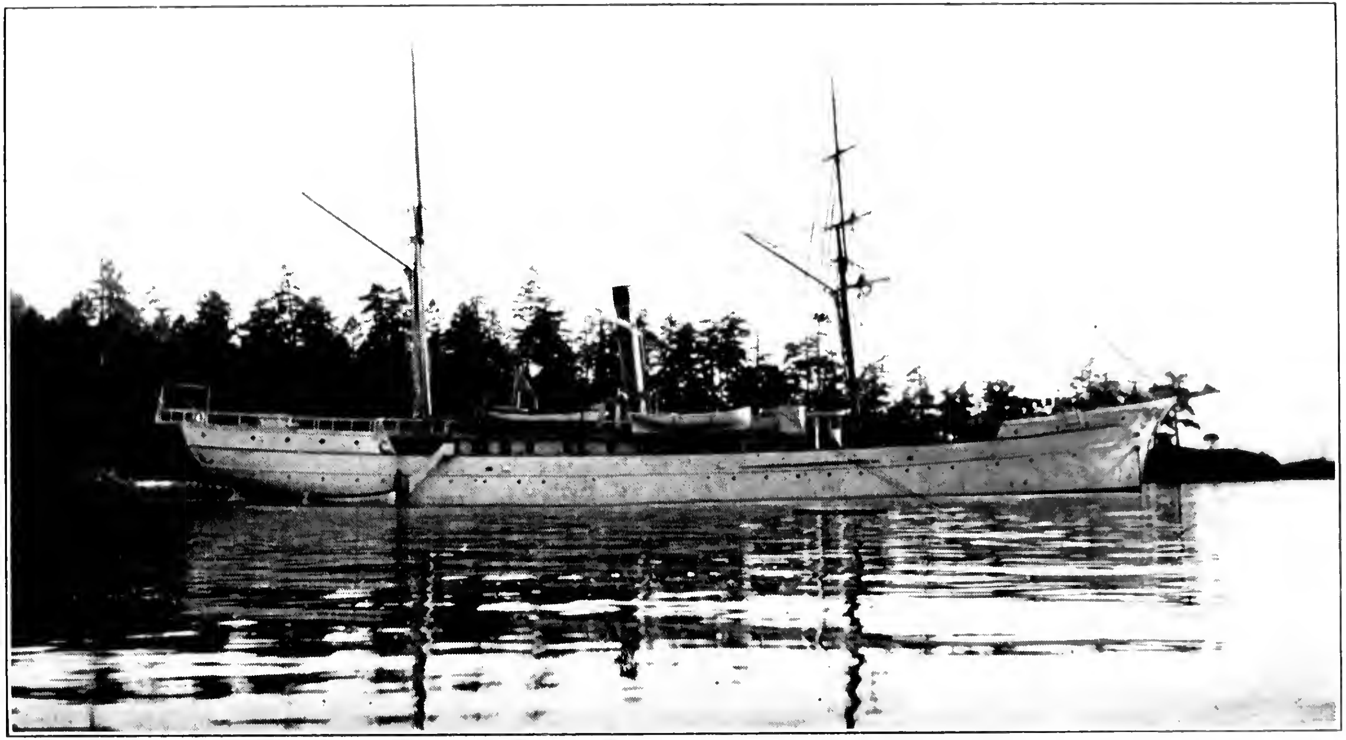
The pressure in water increases rapidly as the distance beneath the surface increases. At the surface the atmosphere exerts a pressure of fifteen pounds per square inch. Beneath the surface the pressure increases fifteen pounds per square inch for each ten meters (32.8 feet). Thus at 1000 meters (3280 feet) the pressure is that of a hundred atmospheres or 1500 pounds per square inch, and at the greatest depths the pressure is about six and a half tons on each square inch.

Solid objects or objects that are freely permeable to water throughout, as animal bodies, remain practically unchanged when they sink to great depths. But objects having internal cavities containing air are strongly compressed and distorted when subjected to the enormous pressure at the bottom of the ocean. Wood used in deep-sea trawls is so much compressed that the denser knots stand out from the surface. Closed glass tubes dropped to great depths are crushed to powder. Scientific investigators on the famous *Challenger* expedition sent a rabbit down on a line to a depth of 500 fathoms. The body came up very little altered in appearance; the bones were all intact, and the lungs were the only viscera that seemed to be affected by the pressure. Deep-sea fishermen are aware that the eyes of fish, brought rapidly to the surface, "pop out," and the fish are killed by the disorganization of their tissues caused by the sudden release from pressure. If deep-sea fishes accidentally get above their accustomed depth, the expansion of air in their swim-bladders renders them so buoyant that they continue to tumble upward to the surface, and are killed by the distension of their bodies and the disruption of their tissues from diminished pressure. One might say that they die a violent death from falling upward!

A landlubber's first impression of the ocean is one of striking beauty, and those who were reared near the sea love it and are seldom content far from it. Few scenes surpass the beauty of a sunset at sea. Although the great body of the open ocean has a definite, clear blue color, its apparent color is always changing; and, because it is so changeable, we never grow tired of it. Its diversity in appearance is caused partly by the reflection of the constantly changing sky and partly by varying light conditions.

Some parts of the ocean are variously tinted because of impurities in the water or minute organisms present in great quantity. The Red Sea is so named because of the reddish color given it by certain plankton. Different intensities of green and yellow tints occur near land. The olive-green tint of the Antarctic Ocean is caused by enormous quantities of diatoms suspended in the water. Streaks of unusual colors are also noted occasionally in the open ocean; many travelers have observed stretches of water of a brilliant red tint. Oceanographers who have towed their plankton nets through such waters have found large numbers of minute red organisms, usually dinoflagellates.

Light from the sun penetrates the ocean to varying depths, depending upon the clarity of the water



Courtesy of Bureau of Fisheries

U.S.S "ALBATROSS"

In which the Bureau of Fisheries investigates the life of the sea

THE SURF

Wave crests topple forward as they approach the shore and the angle at which the rays enter. Off Capri in the Mediterranean, photographic plates were not affected by exposure at depths greater than 164 fathoms (300 meters), but in the Atlantic, light rays have affected a plate exposed for eighty minutes at a depth of 547 fathoms (1000 meters).

The red and yellow rays are absorbed by water more readily than the blue and violet; consequently the latter penetrate to a greater distance. This has an important effect upon the animal and vegetable life of the sea. Green algæ require yellow light rays for their photosynthetic processes and are on this account found near the surface only. On the other hand red algæ can utilize blue light and therefore live in deeper waters. It is probable that the rays used by plants in photosynthetic processes do not reach deeper than 600 feet, even in the clear water of the tropics. In the polar regions, where the light from the sun strikes the water at an oblique angle, these rays do not penetrate nearly so far.

The colors of marine animals are well adapted to these conditions. Dr. Hjort, a famous oceanographer, made a study of the colors of fishes of the Atlantic living at various depths, and found that most of the surface fishes, down to 75 fathoms, are colorless; from 150 to 250 fathoms the fishes are silvery or gray; and at depths where little light penetrates they are black or dark colored. At these great depths the crustacea are red in color, but they appear black because no red light rays penetrate the upper layers. Many of the animals, other than fish, living near the surface are blue or bluish violet and so tone in with the sea; others, such as the jellyfishes, are quite transparent.

Movements of Ocean Waters

Those who visit the sea-shore for the first time are greatly impressed with the height and regularity of the tides. The tidal wave rises and falls every twelve hours, twenty-five and a half minutes. In the Antarctic Ocean it moves from east to west in a free and uninterrupted course around the earth. In the other oceans the tidal wave is more or less modified because of the continents, which interrupt its passage around the earth. When the tidal wave strikes the shore it is reflected and moves back into the ocean, meeting and modifying the incoming tidal wave. Irregular coasts have tides very different from those of regular coasts. Some places, such as the eastern coasts of Scotland and England, receive their tides by two separate waves that reach them by different routes from the north and south; at some places along these coasts a tide of double height occurs; other places are almost without tides; while at still other points four separate and distinct periods of high water occur in every twenty-four hours and fifty-one minutes.

The tides are caused by the attraction of the sun and moon. Since the moon is so much closer than the sun, the tides produced by it are about two and a quarter times greater than those produced by the sun. When the sun and moon act simultaneously, the tidal wave is higher than usual. Such tides are called spring tides. They occur twice during each revolution of the moon, once at full and once at new moon. The highest spring tides occur a short time before the March and September equinoxes.

The tides are lowest in mid-ocean, where they range from two to three feet. On the coasts of continents they rise to much greater heights, and when forced up narrow, shelving bays, deep gulfs, or broad river mouths, they attain considerable heights. In the Bay of Fundy the spring tides, aided by favoring winds, sometimes reach seventy feet in height.

Although the water of waves appears to move forward, it really moves up and down vertically. There is a slight surface drift, however, as is shown by the finding of golf balls from Scotland off the coast of the Lofoten Islands in the north of Norway. On approaching the shore the wave breaks, and its crest topples forward, and gives rise to a distinct horizontal movement of the water.

In the open sea, with a moderate wind, the height of the average wave is only about six feet. Reasonably authentic cases of waves measuring fifty feet above the level of the trough have been reported, but such waves occur only during exceedingly violent storms.

True ocean currents are bodies of water of definite constitution, often differing markedly from the surrounding water, through which they flow like a river. The Gulf Stream, which has already been discussed, is a typical ocean current. Other important Atlantic Ocean currents are the North Equatorial

Current and the South Equatorial Current, which cross the ocean from east to west, the Labrador Cold Current, and the Antarctic Current.

The Pacific Ocean has three equatorial currents: a powerful Northern Equatorial Current and a powerful Southern Equatorial Current, which flow from east to west; between these two flows a smaller, less powerful counter-current from west to east. On reaching the Philippine Islands, the North Equatorial Current flows northeast along the Asiatic Coast as the Japan Current, the Pacific counterpart of the Gulf Stream. At about Lat. 50° this current flows eastward as the North Pacific Current until it reaches the shores of North America, where it divides, a part flowing southward along the coast of California as the California Current, and a part flowing northwest, warming the Alaskan Coast.

Thus it is seen that the North Atlantic, South Atlantic, and North Pacific oceans have important equatorial currents flowing from east to west to the eastern shores of the continents, and then flowing along the shore until the fortieth parallel is reached, then turning eastward and flowing in an enormous ellipse. These currents exert important influences on the earth's climate, cooling the tropical shores and warming the temperate shores. In this way the sea acts as a great distributor of the heat of the sun, conveying about half of that which is received in the tropics to higher latitudes.

Definite currents are phenomena occurring only in the surface waters of the ocean. Nevertheless there is a general tendency for the colder, denser water of the polar regions to sink and move slowly toward the tropics, replacing the warmer surface water of the tropics, which flows toward the poles.

In the future, greater knowledge concerning the ocean currents ought to enable the "weather man" to predict average seasonal temperatures months in advance. We might also be able to predict the distribution of icebergs in the North Atlantic and perhaps the prospects of the marine fisheries.

Life in the Sea

When we collect all of the evidence of the evolutionary development of plants and animals found by biologists and place it side by side with the facts revealed to us by geology and oceanography, the irresistible conclusion is reached that the sea was the cradle of life upon the earth and that all plants and animals were originally derived from ancestors that lived in the sea. Curiously enough, the salts found in sea-water are found in human blood-plasma in almost exactly the same proportions. This physiological fact seems to confirm the biological evidence tending to prove that man has evolved from simpler marine animal organisms.

It is also interesting to note that the depths of the sea have revealed a few survivors of earlier geological periods whose histories are written in stone. Crinoids, or sea-lilies, have existed since early geologic times and are still found in the sea; one important bed of these curious animals has been discovered off the coast of Cuba. Yes, sea-lilies are not plants but animals related to the starfishes. As their name indicates, however, they are plant-like in appearance, having a long-jointed calcareous stem, supported in the ooze by root-like branches. The top is capped with what has the appearance of an inverted starfish. The fossil forms of sea-lilies are very abundant, showing that they once existed in enormous numbers. Evidently they are dying out, for of the two hundred genera, which are known to have formerly inhabited the ocean, only twelve still remain.

One of the most important facts established by modern oceanographers is that there is no region of the sea that is entirely devoid of life. Wherever the trawl or dredge is used, some representatives of the various classes of marine animals are found. The shallow waters of the coasts, and the greatest depths of the ocean, the dense warm waters of the Mediterranean and Red seas, the cold and comparatively fresh waters of the Norwegian fiords, the surface waters of the equatorial seas, and the cold waters in the depths of the Arctic, all contain characteristic forms of living creatures.

The ocean, however, resembles the land in exhibiting so many varying conditions that the animals which characterize one region are absent from another. In some places animal and plant life is abundant, while in others it is very scarce. When we ascend great mountains the vegetation and animals change with increasing altitudes. Broad belts of approximately equal temperature have the same species of plants and animals. As might be expected, it is much the same with various depths of the ocean.

The lighted zone along the shore has a fauna unlike that at a hundred fathoms, while at a thousand fathoms another world is seen, and so on with increasing depth.

The variety of marine plants and animals is so great that it is only possible to consider the subject briefly here. The largest and smallest animals and the tallest and smallest plants live in the sea, and an amazing number and variety of both plants and animals are found there. Even the surface water collected in mid-ocean, which is seemingly devoid of life, is teeming with minute living organisms.

Life is most abundant in the relatively shallow water close to shore, and it is from these waters that most of the products of economic importance come. The fish, lobsters, shrimp, crabs, oysters, clams, mussels, abalones, sponges, turtles, terrapins, squid, and algæ utilized by man are all taken in fairly shallow water close to shore or on the banks—areas of shallow water farther from shore, which are extensions of the continental shelves. The largest animals found in the sea are whales, which are not fish but mammals especially adapted for life in the ocean. Many other mammals are found in the ocean, the most important of which are the seals, walruses, sea-lions, porpoises, and dolphins. Whaling and sealing are important marine industries. Approximately nineteen thousand different species of fish exist, many of which are found in enormous numbers. The various species of fish differ greatly in size, form, color, and habits.

Nearly all marine plants require light for their growth. On this account practically all marine vegetation is near the surface, and the dark abysmal depths of the sea are devoid of plant life, except perhaps bacteria and other low fungoid forms. Marine plants with very few exceptions are very simple organisms. Seaweeds, or marine algæ, although resembling many land plants in appearance, have nothing in common with the higher terrestrial types, for they are composed of but one class of cells. Algæ have no roots in the true sense of the word, for the holdfasts merely act as anchors, and do not absorb nourishment from the sea bottom. The food required by the algæ is obtained by the individual cells composing the plant from the substances held in solution by the surrounding water.

Although vegetable life is so exceedingly scarce in the profound depths of the ocean, animal life, not requiring light for its existence, is plentiful. Yet it is not surprising that less than a century ago scientists believed that life at great depths was impossible, for in the deeper parts of the sea the pressure is tremendous, and it is totally dark and very cold. At a depth of a mile, the pressure amounts to a ton to the square inch, yet with a perfectly uncanny adaptability many species of delicately constructed animals thrive. Fish, tunicates, crustaceans, mollusks, echinoderms, worms, cœlenterates, and protozoa are found at great depths, but nearly all of these are so modified, either in form or color, or in the structure of their organs of sense, or in other ways, that they can be recognized at once as deep-sea animals. The enormous pressure of the great depths does not crush them, for their bodies are in many cases thoroughly permeable to water. Many deep-sea animals are totally blind, while many others are phosphorescent.

Deep-sea animals are much more delicately constructed than their shallow-water relatives. The crabs have very spindling legs and frail bodies. The fishes have very soft and velvety skin, with either a very few scales or none at all. The shells of the mollusks are very thin and brittle.

One phase of aquatic life, seldom considered by most persons, is of great economic importance. Vast numbers of minute organisms float or drift in the sea with little or no power of independent locomotion, and are known collectively as plankton. The organisms composing plankton are chiefly minute algæ (diatoms, desmids, and filamentous algæ), protozoa (flagellates and rhizopods), rotifers, and minute crustacea (cladocera and copepoda). These minute organisms constitute the chief food of many species of fish, and indirectly constitute the bulk of the food of all fish, for those which do not feed on plankton live on fish or other organisms which subsist on these small plants and animals. Plankton is most plentiful near the mouths of large rivers, as it depends for its food to a large extent upon the combined nitrogen brought in by the rivers.

The ocean is so vast, its conditions are so varied, and its forms of life so multitudinous in number that it is impossible to give more than a brief survey of the interesting facts about it in this chapter.

CHAPTER II

Fishery Products in Everyday Life

Early Importance of Marine Products

ONLY a few of the myriads of plants and animals found in the ocean are utilized by man. Some products of the sea, however, such as fish, oysters, and many other shell-fish, have been made use of by man since the earliest times. The first articles bartered by savage men included amber, coral, salt, fish, and shell-fish. Wampum, or strings of shell beads, were used as money by many tribes of North American Indians.

The ancients even extracted their most important dye from a shell-fish. This dye, now known as Tyrian purple, was obtained by an extremely laborious process and consequently was very expensive. It was so costly that it could be afforded only by the very wealthy; and so originated the phrase, "born to the purple."

We have no records to show when man first sailed the ocean, but doubtless fishing was his object. Fishing fleets have often grown into great merchant marines. Such was the origin of the fleets of the Phenicians and the early Greeks. When Attila the Hun swooped down on Italy and sacked the cities on the northern shore of the Adriatic, the people took refuge on the barren islands of the lagoons. Here they had little food except fish [1] and no minerals but salt and sand. The Venetians learned to catch fish in the sea and to preserve them with salt prepared from sea-water. Their fishing-smacks grew into fleets and navies, and soon Venetian vessels dominated the sea.

The Hanseatic League, the powerful confederation of commercial cities about the Baltic, owed its rise largely to the herring which its fishermen caught in the Baltic. But early in the fifteenth century the herring migrated to the North Sea, from which they did not return. This brought the fall of the Hanseatic League, and the rise of the Dutch and British sea-power.

Fishing rights have always been a source of international rivalry and disputes, and have caused many wars. Great Britain's navy was started by Charles I to keep the Dutch from fishing in what were claimed as British waters. This led to a long war between the English and Dutch, and to a conflict of international law which was finally settled by allowing the freedom of the seas beyond the three-mile limit. Thus it is possible to trace the present-day discussion of the three-mile or the twelve-mile limit to the early fishery disputes.

In ancient and medieval times, the fisheries were relatively more important than they are to-day. Although the quantity of fish taken was much smaller, the human race was more dependent upon

[1] E. E. Slosson in "Industrial and Engineering Chemistry," Vol. XVI (1924), pp. 447-450.

products of the sea, since manufacturing and agriculture were then only in the early stages of development. Whale-oil, sperm-oil, and spermaceti were essential for illuminants. Indeed as late as the early nineteenth century pessimists were forecasting dark streets and homes on account of the gradual diminution of the numbers of whales because of over-fishing, just as many are now forecasting the decline of the automobile industry in the near future by reason of the exhaustion of our petroleum supplies.

The influence of fish and other products of the sea upon the history of North America dates from a time before the white man set foot upon the continent. Enormous shell heaps or kitchen-middens are found at various places along the Atlantic coast. They occur on the sites of the ancient villages of the shore dwellers and indicate that these Indians depended to a considerable extent on shell-fish for their sustenance. The Indians taught the early settlers to fertilize their crops with the alewives and other fishes which could be caught in enormous quantities in the bays and coastal streams in the spring. The Pilgrim Fathers had difficulty in obtaining sufficiently large crops on the rocky soil of New England and might have starved if it had not been for the bountiful supply of sea-food close at hand. Fish, lobsters, crabs, mussels, scallops, and clams were very plentiful all along the coast. Oysters were easy to get almost anywhere from Rhode Island southward. The proximity of the banks, where cod and other ground-fish were so plentiful, encouraged the building of sailing-vessels. Yankee ingenuity invented the schooner, and soon America became an important maritime nation. The people of Massachusetts have recognized their debt to the cod and have hung a model of it in the hall of the House of Representatives.

Such is the importance of marine products in history. Even to-day sea products are of far greater importance than most people realize. We little guess to what extent the sea and its products enter into our daily life.

Fishery Products in Our Daily Life

Consider fish-oil and its many uses. Twenty-five or more important industries use it in the manufacture of products as varied as patent leather and candles. Many of our paints, varnishes, stains, enamels, baking japans, and driers contain it. Either fish-oil or fish-liver oil is used in the finishing of all leathers.

When we rise in the morning we may use a soap made from fish or whale oil for our bath. The razor we shave with was tempered in fish-oil. The cold cream or other toilet preparation used after we shave contains glycerin which may have been obtained from menhaden or some other fish. We put on shoes which were finished with menhaden oil.

We go to our door, painted perhaps with a salmon-oil paint, and get a newspaper printed with ink made from fish-oil and lampblack. If we eat herring or mackerel for our breakfast, we obtain much nutriment from the fat and vitamines of the herring or mackerel oil.

We may ride to work in an automobile painted with a baking japan containing fish-oil, and sit on imitation leather seats prepared by the use of menhaden or other fish oil. Even if the car has real leather upholstery, fish and fish-liver oil were used in the final tanning and finishing processes.

We enter our office building painted perhaps with menhaden oil paint containing driers made from fish-oils. The linoleum on the floor may have been made with fish-oil. The greases used in the lubrication of the elevator machinery probably contain fish-oil.

If it is raining when we come from work in the evening, we put on a rain-coat which may have been made from cloth covered with many coats of a fish-oil varnish.

Our feet may get wet on the way home. To prevent catching cold we take a tonic. One of the best we may choose is cod-liver oil, which contains the fat-soluble vitamines needed to build up vitality and resistance to disease.

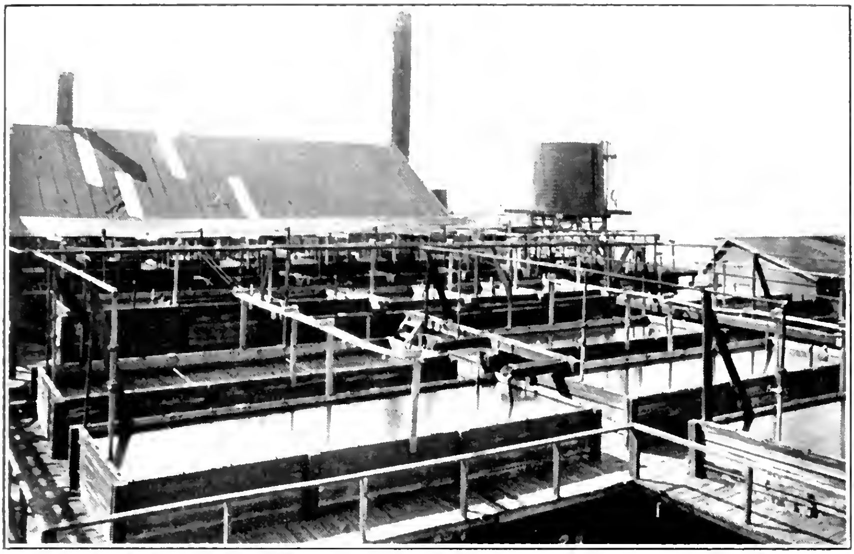
Perhaps we shall have candles on our dinner-table; if so, it is likely that they were made from stearin obtained from fish or whale oil. Our furniture may be finished with a menhaden oil varnish. And the oilcloth which covers the kitchen table was probably made by painting cloth with special menhaden oil paints.

When we prepare for bed we put on slippers made soft and comfortable by treatment with fish and fish-liver oils, and as we switch off the electric light we may touch an imitation rubber knob of fish-oil composition.

Fish-glue, the true liquid glue, has uses nearly as extensive. It is also used in the manufacture of shoes and slippers and in the preparation of paints. It is not, however, a component of oil paints, but is used in the preparation of cold water paints or calcimines. Other important uses are the preparation of flexible glues for book-binding, the manufacture of court-plaster, the chipping of glass, box making, sizing, and general repair work. It is the only ready-to-use glue that is suitable for the many purposes for which a quick-drying strong adhesive is needed. Another important use of fish-glue that is unknown to most persons is in the preparation of enamels on half-tone and zinc-line plates for use in photo-engraving. Some potassium dichromate is dissolved in a fish-skin glue solution. This solution is spread uniformly on an absolutely clean copper plate, which is then dried in a dark room over a low flame. Such a plate is sensitive to the light, since the glue becomes insoluble in water upon exposure to light; it is exposed behind a specially prepared plate in much the same way as an ordinary silver chloride plate such as is used for the making of lantern-slides. Another curious use of this glue is in the manufacture of belt cement for joining leather belts, for which use an especially strong flexible adhesive is required.

Common salt is the most important inorganic product obtained by the evaporation of sea-water, some being prepared in every warm, dry country bordering the sea. The American sea-salt industry is centered near San Francisco and San Diego, California. We may be proud of the California sea-salt, for American ingenuity and modern scientific methods have revolutionized this the most ancient of industries, and now we produce salt of exceptionally fine quality. The California salt makers have made some use of the mother liquor from the salt crystals, and they now prepare several by-products of considerable value from this liquor which was formerly wasted. The most important of these is magnesium oxychloride cement, which is finding wide use in our industries. Potassium chloride, magnesia, Epsom salts, and bromine are other by-products which have been produced.

Vegetable life exists in the sea in such great abundance that various observers have estimated the marine vegetation to be equal in quantity to the plant growth of the land. The multitudinous species of marine plants are utilized scarcely at all. The very name, seaweed, by which they are ordinarily called, indicates that these plants, like the weeds of the fields, are commonly considered to be of little if any value. In Europe and Japan, however, iodine is prepared from certain seaweeds. The weeds are burned, and the ash obtained by this procedure is leached with water. Potassium salts are crystallized from the resultant solution, and the residue is used for the preparation of iodine and potassium iodide. Iodine, agar-agar, and Irish moss are the only seaweed products sold in America on an important scale. Irish moss, which is prepared in Massachusetts, is used for the preparation of blanc-mange. Recently



MENHADEN OIL SETTLING TANKS

Where the oil from the cooked fish is separated from the water

FISH SKINS FOR GLUE MANUFACTURE

Use found for cod and cusk skins removed in process of salting fish

A BRAZILIAN SEA SALINE

Huge piles of harvested salt ready to be loaded into barges

HUGE CRYSTALS OF SEA SALT

When sea-water is slowly evaporated by solar heat, a solid mass of large crystals results.

HARVESTING SALT IN CALIFORNIA

The old-fashioned method of harvesting salt with pick and shovel at San Mateo a factory for the preparation of agar-agar has been established in California. Agar is used in medicine and is also the base of very important bacteriological media.

The Orientals, especially the Chinese and Japanese, have always utilized large quantities of marine algæ. They use algæ for food, medicine, glue, and size, for decorative purposes, for the preparation of a varnish and of an alcoholic beverage, as a clarifying agent for wines and liquors, for the manufacture of iodine, bromine, and potassium salts, and for many other purposes.

Chinese cooks are expert in the preparation of seaweed dishes and dainties. Most of their soup stocks are made from it. Many rice, fish, and vegetable dishes and sauces are mixed with seaweed preparations. The seaweeds give to the food a pleasing aromatic flavor resembling the taste of dried fish. Seaweed isinglass, or agar, is used not only for bread and cakes but also for candies.

The Japanese prepare certain kinds of food called kombu from various laminaria. This dried seaweed product is cooked with meats and soups, and is also served as a vegetable. Moreover powdered kombu is extensively used in the preparation of a drink resembling tea.

The Japanese are also important producers of the most valuable marine product, the pearl. Recently they have discovered means of causing the pearl-oyster to grow pearls. It may be that the growing of cultural pearls will become so successful that these beautiful jewels will cease to be the most costly of gems.

The pearl-shell or mother-of-pearl fishery is always carried on simultaneously with the pearl fishery. It is of considerable importance in many countries, and the world's production is valued at approximately one hundred million dollars. There are extensive pearl and pearl-shell fisheries in Australia, Ceylon, Japan, California, Mexico, Venezuela, and the Persian Gulf. The pearl shell obtained in California is the abalone, which is manufactured into a large variety of ornamental and useful objects.

Not only is the sea the source of true pearls and of mother-of-pearl, but it also furnishes the material from which imitation pearls are made. Fish-scales are covered with a nacreous substance which gives fish much of their beauty. Clever chemists have learned how to transfer this lustrous substance from the scales to beads. The chief difficulty lies in obtaining a permanent, uniform, waterproof coating on the bead. Recently economical methods of preparing pearl essence have been perfected so that it is now cheap enough to be used for general decorative purposes, such as the ornamentation of pyralin.

Beautiful ornaments are also made from the precious coral, which is the skeleton of a curious little animal that grows in branching colonies, and, because of this characteristic, was formerly thought to be a plant. Rose-pink coral usually commands the highest price. It is extensively used in the making of beads, cameos, and many other ornamental objects. The carving and engraving of coral requires great skill.

The Italians possess the greatest skill in this trade, which is centered in Naples, Genoa, Torre del Greco, Leghorn, and Trapani.

Fish and Fishery Products

Although the number and importance of the vegetable and mineral products of the sea is considerable, their economic value is overshadowed by the products of the commercial fisheries. Fish are marvelously abundant; approximately nineteen thousand distinct species have been catalogued. Some of these fish are exceedingly numerous, as, for example, the herring, menhaden, and pilchards. Approximately a billion menhaden are caught by American fishermen annually. The herring fisheries of the North Sea have furnished enormous quantities of fish for over five hundred years and still over a billion pounds of these fish are caught each year. Relatively few of the large number of species of marine fishes are utilized to any considerable extent. Only about a hundred species are caught in appreciable quantities by American fishermen.

The most important use of fish is as food for man. Fish is a food, high in protein, which may be prepared for the table in a great variety of ways and gives a welcome relief from a steady meat diet. Fish are preserved by freezing, canning, salting, pickling, smoking, drying, and even fermenting.

Canning is the most important method of preserving fish in America. In 1926, 7,488,620 cases of salmon, valued at about $50,000,000, were canned.

The sardine pack is very valuable, and about three million cases valued at more than twelve million dollars are canned annually. In Europe, where the people are accustomed to eating salted fish, salting is still the most important means of preserving fish. More than 500,000 barrels of herring are salted annually in Scotland alone. In Europe many smoked fish are also consumed; approximately 200,000 barrels of herring alone are preserved by smoking in Scotland. During periods when the supply exceeds the demand, many fish are frozen in America and held until a time when the supply diminishes. In 1925, 91,165,068 pounds of fish were frozen.

The by-products of the fishery industries include several interesting products that have multitudinous uses. The importance of fish-oil and fish-glue in our daily life has already been discussed. Fish waste has been used as fertilizer since prehistoric times. In recent years the oil has been extracted from this waste, which is then dried and sold as meal for animal feed. This change is gradually revolutionizing the whole by-products industry, for meal is worth much more than fertilizer. By feeding meal to his stock, the farmer is able to utilize all of the valuable components of the scrap, for by fertilizing his land with manure from his stock, he uses again much of the nitrogen of the meal which has already served in the nutrition of the stock.

Shark leather has recently become very popular. Cod, salmon, and other fish skins may be tanned into excellent leather. The air-bladders of the sturgeon, hake, and other fishes are made into isinglass.

Only a few of the thousands of species of marine mollusks are utilized commercially as food, but those which are taken are of great importance. Each year more than seventeen million bushels of oysters valued at over twelve million dollars are produced in the United States alone. Oysters are sold in the shell, shucked, canned, and dried. Shucked oysters are transported more easily than those in the shell; consequently more oysters are sold in this way than in any other. Oyster shells also constitute an important commodity, being used extensively as poultry grit, agricultural lime, building lime, and as a road material.

Four species of clams are taken commercially in America: soft, hard or quahog, razor, and skimmer or surf. Massachusetts produces more clams than any other State, but Maine is a close second. Some clams are taken in every State on both the Atlantic and Pacific coasts. Soft clams are most abundant in Maine, New Hampshire, and Massachusetts. Hard clams are more abundant than the soft species in the other States on the Atlantic coast. Razor clams are most abundant in the Pacific Northwest.

Scallops are utilized principally as food, although a limited amount of the ornamental shells are also made into useful articles. The American scallop fishery is located chiefly on the Massachusetts and New York coasts.

Sea mussels are considered excellent food in many European countries, but the fishery is especially important in France, where much attention has been devoted to mussel culture. France alone produces approximately 400,000,000 pounds of mussels. In the United States, only one State, New Jersey, produces many mussels. In 1921, 791,000 pounds of this shell-fish were taken in that State; most of these were sold in New York City. A few mussels were canned.

Small quantities of many other marine mollusks are utilized commercially in America. Chief among these are the following: natica, cockle, periwinkle, piddock, squid, donax, cephalopods, and chiton. The most important of these is the squid, a most curious shell-fish belonging to the devil-fish family. In China and many other countries of the Orient, this mollusk is a favorite marine delicacy. In America it is used chiefly as bait by many of the trawl and hand-line fishermen of New England, eastern Canada, and Newfoundland, but it is now eaten by our Oriental population. Some squid is canned in California.

Although our lobster and crab fisheries are declining, they are still of considerable importance. Formerly lobsters were exceedingly plentiful all along the coast of New England, but in recent years the American lobster has been over-fished, until to-day our fishery is entirely overshadowed by the Canadian fishery. Now the Canadian fishery is threatened by over-fishing. The open season is now very short, yet Canada still produces many more lobsters than all the rest of the world.

Crabs are caught all along our coasts and are now considered a delicacy by most connoisseurs of sea-food. Until 1873, crabs were seldom eaten. In recent years, however, the demand has grown rapidly until now the blue crab is threatened with overfishing. The present annual production of crabs in the United States is approximately thirty million pounds.

Three species of shrimp are taken commercially in American waters. The bulk are obtained from the South Atlantic and Gulf States, where about two million dollars' worth of this crustacean are marketed fresh, and more than four million dollars' worth are canned.

Few of us realize where and how the green turtles, which are so highly prized for soup, are obtained. Most of them come from Key West, having been caught in Caribbean waters. They are enormous animals, many of them weighing more than two hundred pounds, and are extremely clumsy on land, where they are barely able to drag themselves about. They are often caught on sandy beaches at night when they come ashore to lay their eggs. Turtle eggs are usually highly prized by the inhabitants along the beaches where they are found.

Tortoise-shell has been so widely imitated by manufacturers of celluloid that many persons do not know the genuine article when they see it. It is obtained from the shields of the carapace, or back shell, as it is commonly called, of the hawk's-bill turtle. These turtles are found in nearly all parts of the tropical seas, but the best grades of tortoise-shell are obtained from the Malay Archipelago.

The diamond-back terrapin is one of the most valuable marine delicacies marketed in the United States. At one time it was abundant in the salt and brackish marshes along the Atlantic coast in the Southern States, but now it is very scarce. On this account attempts are being made to propagate it.

Whale and Other Animal Products

Whaling played a very important part in the early history of our republic.. The New Bedford whalers searched the seven seas for whales, and supplied a large part of the world with illuminating oil, candles, and whalebone. With the development of the petroleum industry, deep-sea whaling suffered a rapid decline, for whale-oil was no longer a necessary illuminant. The invention of the harpoon-gun by Svend Foyn in 1864 made it easier to capture whales and gave the industry new life, and the discovery of practical means of converting whale-oil into solid fat brought about the rejuvenation of whaling. At present about seventy million dollars' worth of whale products is prepared annually. Whales are hunted as never before, and so great is the slaughter that unless some form of protection is immediately devised the whale will become commercially extinct within a decade or two. Protection will have to be brought about by international agreement, for few whales are found within the three-mile limit, and whalers of any nation may take those found outside this limit. Whale meat is a popular food in Japan and is eaten extensively in Norway. It was introduced into this country during the war, and at that time whale steak could be had in many of the large hotels in our big cities, but it never attained much popularity. Many whale tails are pickled in brine at the whaling stations on our Pacific coast and are exported to Japan, where they are considered a delicacy. Other important whale products are spermaceti, whalebone, sperm-oil, ambergris, glue, whale meal, and bone meal. Ambergris is often worth its weight in gold. It is a gray substance found in the intestines of diseased whales, but it is also often found floating on the sea or washed upon the shore. It is used in fine perfumes to prevent the fragrance from being quickly dissipated after use.

Porpoises, dolphins, blackfish, and other relatively small animals belonging to the whale family are hunted in a few localities for their hides and oil. The oil obtained from the jaws of these animals is the most valuable liquid fat known in commerce.

Since 1909, Uncle Sam has been in the fur business, for in that year the Bureau of Fisheries took control of the Pribilof Islands of Alaska, and has had complete charge of the fur-seals of the islands, which furnish nearly the entire world's supply of seal fur. By careful protection, the number of seals on the islands has been increased from 132,000 in 1910 to more than 700,000 at present. During the past few years, the government has had a tidy income from this source. Only the surplus male seals are killed, so that the number of seals in the rookeries is likely to continue to increase.

Hair-seals are captured for their hides and blubber. The hides are tanned into beautiful leather, and the blubber is rendered into oil. The only important hair-sealing grounds remaining lie in the North Atlantic Ocean off the coast of Newfoundland, Labrador, and Greenland.

Walruses are hunted for their hides, blubber, and ivory. These animals have been killed so ruthlessly that they are nearly extinct. It is now illegal to kill walruses in Alaska. A few are still captured on the Labrador coast and in Spitzbergen, Nova Zembla, and the smaller islands of the Arctic Ocean.

Sponges are obtained chiefly from the Mediterranean Sea, Florida, the Bahama Islands, and Cuba. The sponges of commerce as they appear on the market are but the skeletons of the living sponge, from which the soft fleshy matter of the living animal has been removed. The most important commercial sponges are the sheepswool, yellow, velvet, grass, glove, wire, reef, hardhead, Turkey cup and Turkey solid, Turkey toilet, zimocca, honeycomb, and elephant-ear sponges. The annual production of sponges in Florida is valued at nearly a million dollars.

Such is the great variety of fishery products which enter into our daily life; their total value is about a billion dollars a year. The sum may seem small when it is compared with the value of the products of many other industries, but if the supply of marine products were cut off, most of them would be badly missed.

When the great size of the ocean is considered, the areas that are now being exploited seem very limited.

Only the Mediterranean, North Atlantic, North Sea, and North Pacific Oceans have been extensively fished. Further, thousands of species of fish and shell-fish occur in large quantities which are scarcely utilized at all. Among fishes the outstanding example of one that is caught in large numbers, yet is seldom utilized, is the dogfish. It is very voracious and destroys large numbers of young food fish. Sea mussels are very plentiful along the coast of the United States and are very good to eat, yet most of those that are taken are used as bait.

CHAPTER III

The Manufacture of Salt from Sea-Water

WHEN man first learned to cook his food, the boiling removed a considerable proportion of the salt contained in his meat and vegetables, and it became necessary for him to make up the deficiency. This was usually obtained from the water of the ocean or from the numerous salt springs. Inland savage tribes often had to travel long distances to obtain their salt. Those who ran short of salt obtained this necessary condiment from other tribes by trading furs and other valuable materials for it. Thus it is probable that salt was one of the first commodities bartered by savage man. Because of its value in ancient times, salt was used as a sacrificial offering by the adherents of various religions. The Jews offered it to Jehovah in covenants. That good word "salary" is derived from the ancient Roman practice of giving the soldiers as part of their pay money to buy *sal* (salt).

Salt is even more essential to the welfare of civilized man than it is to the savage. When salt is mentioned, table, dairy, ice-cream, and packing-house salts immediately come to mind. Many of its most important uses are unknown to the average man. Various grades of salt are used in the making of brick, tile, pottery, textiles, paper, soap, ice, oil, leather, dyes, chlorine, soda, lye, sodium sulphate, and practically all the sodium compounds with the exception of sodium nitrate. It is also the source of the chlorine of most of the chlorine compounds of commerce, the most important of which are bleaching powder, sodium hypochlorite, sodium chlorate, sodium perchlorate, hydrochloric acid, and silver chloride. Indeed its uses are so numerous and varied that it is difficult to find an industry in which some salt or product made from salt is not used. Consequently the quantity of salt produced is much greater than most people realize. In 1925, for example, the United States alone produced 7,397,498 tons. Most of this was low-priced salt used for industrial purposes, the total value being only $26,162,361, or less than four dollars a ton.

Salt making is one of the most widely distributed industries, some salt being prepared in almost every country of the world. In addition to the United States, China, Japan, India, Germany, England, France, Portugal, Spain, Italy, Brazil, and many other countries have important salt industries. In some places salt is heavily taxed. In Italy, Austria, Turkey, and China, the salt industry is a government monopoly.

The important sources of salt are (1) mines, (2) wells or springs, and (3) sea-water. Rock-salt is obtained from mines in the salt deposits in the earth's crust. Wells are usually operated by drilling into salt deposits, pumping water down into the wells, and simultaneously pumping up the saturated salt solution. Most of the salt produced in the United States is either mined or taken from wells. Some, however, is prepared from sea-water by solar evaporation; in 1925 California produced 2,089,171 barrels of sea-salt, while in Utah 629,679 barrels were obtained in the same way from the Great Salt Lake.

All salt deposits are the remains of dried-up seas. In many cases, arms of the ocean were cut off by the elevation of certain areas. The inland seas formed in this way slowly dried up, leaving immense beds of salt which later became covered with rock. High pressures changed the salt deposits to rock-salt.

The Manufacture of Salt in the Orient

It is often said that the amount of soap used by any people is a measure of its degree of civilization. It may also be said that the purity of the salt used is a similar criterion. Savages are not particular about their salt and often use salty earth in seasoning their food. The ancient civilizations seldom prepared clean salt, and pure salt was unknown. The ancient Hebrews used salt containing much earth. This accounts for Jesus' parable: "Ye are the salt of the earth; but if the salt have lost his savour, wherewith shall it be salted?" If, in some way, the earthy salt had become wet, the salt was washed out, leaving the earth; thus the salt had "lost his savour." In many Oriental countries very impure salt is still used in cooking. Dirty salt is almost the only salt used by the Filipinos, Chinese, and Indians. Wet salt is still used by the peoples of southern Europe and South America. Since the food is salted thoroughly when it is prepared for cooking, salt-shakers are seldom seen on the tables.

But in Great Britain, Germany, France, and the United States, salt of the highest purity, practically free from calcium and magnesium chlorides, is demanded for household and dairy use. Impure salt always becomes wet in damp weather and clogs a shaker.

Most of the Oriental peoples have lagged far behind the Occidentals in modern civilization. So it happens that much of the salt produced in the Orient to-day is obtained by methods which are extremely crude, and whose origin dates from prehistoric times. In the Philippine Islands, large areas of sandy lands along the coast, approximately at the level of high tide, are cleared of vegetation and cleaned. The surface of the prepared land is loosened, and water is led in from the sea through canals and sprinkled over the soil, where it rapidly evaporates. This process is repeated four times a day until a quantity of salt has accumulated on the surface. The loose earth, together with the salt, is then scraped into heaps and collected into leaching-vats, where it is leached with sea-water or weak brine until most of the salt has been extracted. The leachings are collected in a shallow cement, earthenware, or clay-lined well. The weak brine obtained is poured back over the leaching-vat, and the operation is repeated until it becomes strong, when it is transferred to shallow crystallizing ponds.

These ponds are floored with smooth broken pottery, set in lime mortar to retard seepage and to prevent the admixture of sand with salt, and are surrounded with bamboo fences covered with grass to prevent the wind from blowing dust into them and to keep the floating crystals from congregating on the leeward side. More brine is added as required. When salt begins to crystallize out, the crystals are raked into heaps every day after sundown, gathered into baskets to drain, and finally conveyed into warehouses. In some parts of the Philippine Islands and in Japan, this simple, picturesque method is modified by evaporating the leachings in pans or kettles over fires built in furnaces.

In China most of the solar salt is made by the simplest possible process, employing methods which have been used without change for a thousand years or more. In fact, there is no record to show just when the salines were established. The salt is made by solar evaporation of sea-water without any attempt at the separation of the impurities. Sea-water is pumped into large evaporation basins by means of windmills. The basins are constructed along the sea-coast and resemble innumerable tennis courts of great size; they are arranged in groups, so that several may be filled by a central pump. These basins, which are constructed by leveling the ground and rolling it with a stone roller until it is hard, are separated from each other by ridges of mud about eight inches high. Two or three inches of sea-water is pumped into the ponds; this evaporates in about a week, leaving a coating of salt on the bottom. After this salt has been scraped into a pile and shoveled into small boats, the bottom of the basins is then rolled again, more sea-water is pumped in, and the salt making continued. The ponds are connected to the main salt yards by means of small canals through which the salt barges can be propelled.

The European Solar Process

In France, Spain, Portugal, Italy, and other countries bordering on the Mediterranean, sea-salt has been prepared by the solar process for several centuries. The methods used in these countries are also in use in many other parts of the world, e. g., the West Indies, South America, and Africa. A modification of the process has been used in California for many years.

Since sea-water contains only about three per cent of salt, thirty-two tons of water must be evaporated for each ton of salt produced. The use of coal or other fuel to effect the evaporation of this enormous amount of water would make the cost of the salt produced almost prohibitive. For this reason the manufacture of salt from sea-water can compete successfully with the mining of rock-salt and the production from salt wells only when that industry is located in warm dry countries where solar evaporation of the water is practicable. Moreover the salt works must be constructed on level land adjoining a bay or the ocean. The ground underlying the site of the salt works must be nearly impervious to water. Clays and clayey marls are most satisfactory.

The amount of salt which can be produced on a given area of land depends upon the rate of evaporation and the amount of rainfall during the salt-making season. Since the rate of evaporation usually is rather low, a large area of evaporation ponds is required to produce a comparatively small quantity of salt.

Salines are found along the coasts of southern France, Spain, Portugal, and Italy wherever there are suitable areas of low-lying land. The salt gardens, as they are called, are very picturesque with their succession of reservoirs, old-fashioned windmills, and piles of glistening white salt. Many of them have been operated continuously for several centuries.

Southern Europe produces an enormous quantity of solar sea-salt. The salines of Trapani alone yielded 300,000 tons in 1922. Sicilian solar salt is bought largely by the Scandinavians, who use it in the preservation of fish. Trapani and Iviza ship large quantities of salt to America, where it is used principally in the curing of cod, haddock, herring, and other fish. In the construction of these salt works, low-lying flats are inclosed by high dikes to prevent flooding by high tides or storms. Each salt meadow or "garden" is subdivided into several ponds of different levels, connected by canals through which the brine may be run from one pond to the next.

The first pond in the system, the concentration reservoir, is large and deep, and usually at a higher level than any of the subsequent ponds, so that the brine may be run by gravity to the other ponds.

This pond acts as a reservoir and sedimentation compartment, where clay and other suspended matter settle. Here the preliminary evaporation takes place.

From this pond, the concentrated, clarified sea-water is run out into a series of shallow reservoirs, where the sun and wind effect further evaporation. During this concentration, iron sulphide, calcium carbonate, and calcium sulphate are precipitated and settle to the bottom. The brine in these ponds is usually pink in color because of the presence of innumerable red bacteria and the so-called brine-worms.

As the concentration of the brine proceeds, it is run from one reservoir to another until it reaches saturation, when pure salt, sodium chloride, begins to crystallize. At this stage of the process, the saturated brine is allowed to run into crystallization ponds, where the salt crystallizes as evaporation proceeds. Here the brine remains until the impurities in the solution become so concentrated that they begin to crystallize with the salt; at this point the mother liquor, or bittern (from which the crystals have been formed), is drawn off and either used in the manufacture of magnesium and potassium salts or discarded.

The salt obtained by this process is of 93 to 97 per cent purity. The impurities are principally calcium and magnesium salts, which absorb moisture from the air. Accordingly this solar salt is hygroscopic and is of little use except for the curing of fish and the salting of hides.

Solar Salt Manufacture in the United States

Solar salt is produced in California and Utah. The Utah industry operates on the shore of Great Salt Lake. Here the water is much denser than that of the ocean, and, since the climate of Utah is arid, solar salt can be produced rapidly.

The California industry is located near San Francisco in Alameda and San Mateo counties, and in the southern part of the State near Long Beach and near San Diego. The waters of San Francisco Bay are less salty than those of the ocean; yet because of the absence of fogs, and the adaptability of the marshlands to the construction of salines, the solar salt industry has thriven there. The San Diego Bay region is an unusually fine location for salines, as it is a long, narrow arm of the Pacific Ocean. The inflow of fresh water is very slight, and consequently the salt content of the water at the southern end of the bay is somewhat higher than that of the ocean. The net annual evaporation of this district is unusually high, about fifty inches.

The American methods of pumping the water and handling the salt are modern in every regard. Large centrifugal pumps, capable of handling thousands of gallons of sea-water a minute, are used on many salines to pump the water to large reservoirs, which are called storage, intake, receiving, or tide ponds. On other salt farms, sea-water enters the works at high tide through canals provided with flood-gates that open and close automatically as the tide flows and ebbs. After the bay water has deposited its sediment on the bottom of the storage reservoir, and the preliminary evaporation has taken place, the dilute brine passes into a series of concentrating ponds in which carbonate of lime and then gypsum crystallize out. The brine is held in the last of the concentrating ponds, called the pickling pond, until all of the gypsum has crystallized. The "pickle" is then nearly saturated with salt, and is run into the crystallizing ponds. As long as the brine in the crystallizing ponds continues to deposit pure salt, it is permitted to crystallize. When impurities begin to come down with the sodium chloride, the pickle or mother liquor is drawn off and utilized for its magnesium chloride content. About an inch of salt is deposited for each six inches of net annual evaporation; therefore in the San Diego Bay region the annual deposit of salt is about eight inches. This may seem like a shallow layer of salt, but an acre of this depth yields 880 tons of salt. The pond area of the California plants varies from 500 to 2000 acres. Crystallizing ponds constitute approximately one tenth of the total area.

Many of the San Francisco Bay plants are very picturesque, as they have installed a considerable number of small windmills to pump the brine from one pond to another. The huge piles of salt as they glisten in the sun look like mountains of snow mirrored in the ponds.

In the smaller salines, the salt is harvested with picks and shovels and is hauled to the piles in wheelbarrows. The larger and more up-to-date plants use small dump-cars running on movable rails and hauled by small gasoline or electric locomotives.

Recently some of the larger salines have employed the mechanical salt-lifter for harvesting the salt. This machine consists of a horizontal scraper mounted on a large caterpillar automobile truck. As the truck moves slowly along, the scraper takes up the salt and throws it on a conveyer, which empties it into dumping-cars on movable tracks. Such a machine eliminates a great amount of hand labor. Its invention has done much to aid the California salt-making industry to keep pace with the times. Usually the salt deposit is first harvested to within two inches of the mud floor. Then the remaining salt is lifted and sold as a lower grade for use as ice-cream or stock salt.

The salt is harvested more rapidly than it can be refined. On this account it is dumped in piles near the mill. Some plants have a number of small piles, while others stack all the salt in one huge pile. A large stack is considered to be more economical of salt, as there is less surface exposed to the weather, and less salt has to be broken in the subsequent refining operation. The latter consideration is rather important, for the surface of a salt pile soon hardens so firmly that it can be broken only with great difficulty.

Crude sea-salt as it is removed from the crystallizing ponds contains considerable adhering pickle and is usually somewhat pink in color. Therefore it is carefully washed before it is shipped. This is accomplished by spraying it with brine as it is conveyed on a belt toward the rolls which crush it. The crushed salt is usually washed again with brine made from fresh water and nearly pure salt. After the second washing, the salt is stacked in heaps to drain. The lower grade salts receive no further refining but are screened after draining. The common sizes of crushed salt are "half ground" and "three-quarters ground."

The better grades of salt are carefully dried. The preliminary drying is accomplished in centrifugal machines, which whirl the salt free from all adhering liquor. The drying is completed in cylindrical steam-heated driers, which revolve slowly as the salt passes through. After drying, the salt is crushed, sifted, graded, and packed for shipping.

American solar sea-salt is superior to that which is manufactured in other countries because of the greater care used in the crystallization and harvesting, and also on account of the careful washing and drying that it receives. Our American salines were constructed more recently than those in Europe, and, further, American salt users are more fastidious. For these reasons the California salt makers use the most up-to-date scientific methods known and produce the finest sea-salt made.

The uses for which a salt is suited depend upon the size, shape, and purity of the crystals. Crushed and screened solar salt consists of irregularly shaped grains, many of which have sharp, jagged edges produced by the crushing process. Such salt cannot be used for many purposes. On this account, much sea-salt is refined by solution and recrystallization, either in grainers or in vacuum evaporators, or pans as they are usually called.

Soft-grained, flaky salt may be prepared by recrystallizing solar sea-salt in steam-heated grainers. The crude solar salt is dissolved in fresh water until no more will be dissolved. This brine is limed and allowed to settle; it is then preheated and evaporated in the grainers. A grainer consists essentially of a long, narrow, shallow vat built of wood or metal containing a number of pipes which carry the steam required to evaporate the water. Automatic scraping conveyers carry the salt to one end and then out of the grainer. Curiously, this soft-grained, flaky salt does not taste as salty as crushed solar salt or the cubical vacuum-pan salt crystals. Dairymen prefer this grade, as it mixes well into butter. When the butter is eaten, the teeth do not grate on hard crystals.

Vacuum-pan salt is preferred for shaker-salt for dining-table use. This may be produced by recrystallizing solar salt in single or multiple-effect vacuum pans. In the multiple-effect system, each vacuum-pan (except the last one) acts not only as an evaporator but also as a boiler producing steam for boiling the brine in the next succeeding pan, and as the condenser for the pan immediately preceding. In such an apparatus one pound of steam may evaporate several pounds of water. This arrangement is made possible by having a slight vacuum on the first pan and gradually increasing the vacuum on each succeeding pan. Since the temperature of the saturated brine falls rapidly when it is introduced into a vacuum-pan, and because it is kept rapidly boiling, vacuum-pans produce very fine cubical grained salt.

By-Products of the Sea-Salt Industry

Although salt has been produced by the solar evaporation of sea-water since prehistoric times, no use had been made of the bittern or mother liquor from the crystallization of salt until about 1850. In that year an unusually clever chemist named Balard worked out a process of separating potassium chloride, magnesium chloride, sodium sulphate, and bromine from the bittern. Despite the fact that the science of chemistry has made great advances since that time, Balard's process is still in use at Giraud, France. Many chemists have studied the problem, but no one seems able to get more from the mother liquor than Balard. The procedure followed by him is rather complicated; on this account his process has not been adopted elsewhere.

In California, bath-salts, magnesium chloride, magnesium oxychloride cement, and artificial stone are produced from the bittern. Magnesium oxychloride cement is a valuable product used in the preparation of composition floorings, artificial stone, cement for joining metal to glass, and for other adhesive purposes. It is prepared by mixing finely powdered, dry, calcined magnesite and dry magnesium chloride; or, if it is to be used immediately after preparation, it may be made by mixing calcined magnesia with an aqueous solution of magnesium chloride.

During the World War, when potassium salts were so scarce, a process of recovering potassium chloride from bittern was developed in California. At the close of the war, when the price of potash dropped, this process was discontinued.

The discard of the bittern from the salt works represents a tremendous waste. A single large solar salt works near San Diego, California, produces 40,000 tons of salt each year. Such a plant throws away 1120 tons of potassium chloride, 10,920 tons of magnesium chloride, 6400 tons of magnesium sulphate, and 96 tons of bromine. At the present price of bromine (40 cents per pound), this substance alone would be worth $76,800. When one stops to think of the tremendous amount of these salts thrown away by the thousands of salines throughout the world, it is difficult to conceive of the total waste.

At one time the Stassfurt, Germany, salt mines were considered to be low-grade mines because of the difficulty of obtaining pure common salt from them. After the chemists had studied the utilization of potassium salts, they found that the impurities in the salt, which had given so much trouble, were more valuable than the salt itself. Sometime, in the same way, chemists may be able to separate from the bittern chemicals of greater value than the salt obtained from the original sea-water.

CHAPTER IV

Iodine and Other Chemicals from Seaweed

RECENTLY, since science has discovered that iodine is one of the essential elements for the growth and health of man and animals, the public has become interested in it. A lack of iodine in food and drinking-water causes disorders of the thyroid gland commonly known as goiter and cretinism. The soil, rocks, and the plants grown on the earth contain, in general, but extremely minute amounts of this valuable element. The only important deposits containing iodine found on the earth are the Chile nitrate beds, and those are doubtless of marine origin.

Despite the fact that the ocean contains sixty billion tons of iodine, which is practically all of the iodine of the earth's surface, no iodine is obtained directly from the sea. Although sea-water contains only two parts of iodine per million, certain seaweeds have the remarkable ability to extract iodine from the ocean. A seaweed called tangle possesses this power to a marked degree; its ash contains more than twenty thousand parts of iodine per million.

Ever since its discovery in 1812, iodine has been manufactured from the ashes of seaweed. Until that time seaweed was burned to produce lye. The seaweed-burning industry is a curious survivor from the days when large factories were unknown. In those days farmers and fishermen were manufacturers of chemicals. The farmers prepared potash for use in the making of soap, glass, and alum by leaching hardwood ashes, and the fishermen made potash similarly by leaching the ashes of seaweed. Even as late as the beginning of the nineteenth century, seaweed burning was one of the most important industries of Scotland, and twenty thousand tons of kelp ashes valued at four hundred thousand pounds sterling were produced annually. When the manufacture of soda from common salt commenced, the value of the seaweed ashes dropped rapidly, and the production declined until 1841, when large amounts of iodine began to be produced from this source. The demand and the price for iodine increased until 1873, when the supply was greatly increased by the recovery of this element from the mother liquors left after the extraction of sodium nitrate from caliche, which is found in the arid regions of Chile.

To-day the seaweed-burning industry is located principally in Scotland, Normandy, Norway, and Japan; small amounts of seaweed are also burned in Sweden, Denmark, and Norway. Since about 400,000 long tons of green seaweed are annually collected in Europe, each ton yielding about a pound of iodine, the entire European production of iodine is approximately 400,000 pounds. Japan produces an equal amount.

Algæ are relatively simple plants, commonly called seaweeds, which ordinarily grow either under or partly under water. They differ from land plants in that they lack true differentiation into root, stem, and leaf; reproduction takes place by means of spores. Algæ, however, resemble the plants with which we are familiar in that they are able to synthesize carbohydrates, such as sugars and pectins, from carbon dioxide and water by means of the energy which they receive from the sun's light rays. The blue-green and green algæ live only in shallow water at depths where they receive blue light. Red algæ are found at much greater depths where only the red rays penetrate. Brown algæ are found at the intermediate depths.

The algæ burned in the preparation of iodine are green or brown in color, usually fuci or laminaria, which grow in relatively shallow water. Three species of laminaria are commonly burned in Europe for the production of iodine; their common names are sea-girdles or tangle, bulbous-rooted tangle, and sweet tangle. Four fuci also are commonly collected, which are known to the kelp-burners as black wrack, yellow wrack, bladder fucus, and siliquosa. Other species of algæ are also used; in fact, almost any seaweed found on the beach may be utilized in this way.

Harvesting of Seaweeds

Since the seaweeds are widely scattered along the shores, they are cut by hand by the poorer classes of people living in the neighborhood of the beds.

Most of the weed that is cut is reaped with sickles and scythes when it is exposed at low tide. Since the algæ grow on irregular rocks, no one has been successful in devising a machine for harvesting it. The larger species of seaweed growing in somewhat deeper water are harvested by men in boats who cut the tangle with sickles attached to long poles and then pull it into their boats. After storms much driftweed or deep-sea tangle is washed upon the beach, and is collected, dried, and burned by the kelp-burners.

Seaweeds are dried in the same manner as hay. The same care is taken to prevent their being wet by rain or heavy dew, since this leaches out much potash and iodine. Because of the difficulty in drying the weeds in bad weather, no seaweed is collected or burned in winter.

In Japan the harvesting and burning of the seaweeds is done chiefly by commercial firms who obtain the exclusive privilege of harvesting the seaweed growing along a section of the coast. This is accomplished in much the same manner as in Europe, the algæ being cut from the holdfast by fishermen in small boats, using sickles or hook-like knives attached to the end of long poles. Some seaweed is also obtained by dragging weighted hooks behind small boats.

The concession for the cutting of the algæ does not include the right to gather that which is washed up on the beaches. On this account, the collection of the driftweed is done by individuals living in close proximity to the beaches. After storms, when a large amount of weed has been washed up, whole families go to the beaches and pull the algæ out of the surf.

In the early days of the European potash industry, the dried seaweed was burned in large heaps or piles. From time to time more seaweed was added, until all had been burned, and a hard cake of fused ashes had been obtained. The product was called kelp and usually contained much sand and foreign matter.

Now most of the seaweed is burned in long low kilns. After a fire has been kindled with brush or straw, the dried algæ are slowly added until the fire has been burning for six or eight hours, or until all the dried seaweed has been added. The porous ash in the bottom of the kiln is then worked with a rake until all of the dried weed has been burned and the resultant ash is all melted. A single burning of seaweed forms a cake of kelp from three to six inches thick. When more weed has been dried, it is burned on top of the ash from the first burning. This is repeated until a cake of ash about two feet thick has been built up. This cake is broken up while hot by throwing cold water on it. The kelp is stored in a dry place until it is shipped to a chemical plant, where it is made into iodine, bromine. potassium sulphate, and potassium chloride.

The Manufacture of Iodine

The process by which iodine, bromine, and potassium salts are obtained from seaweed ashes is rather simple. The seaweed ash is broken up and dissolved in hot water. The saturated solution is then evaporated, and the potassium salts are crystallized out. The mother liquor is acidified with sulphuric acid, mixed with manganese dioxide, and heated in an iron retort; iodine and bromine are obtained in the distillate.

Iodine is purified by sublimation, which is accomplished by heating it and condensing the resulting fumes. It is sold either as sublimed iodine or as a salt, such as potassium iodide. Externally it is usually administered in the form of tincture of iodine, which is a solution in alcohol with or without the addition of potassium iodide. When iodine is taken internally, potassium iodide is usually prescribed. In addition to its use in medicine, iodine is utilized in photography and in the manufacture of many dyes and chemicals.

The time-honored method of obtaining iodine and potassium salts by burning seaweed and extracting the ash is not economical, since nearly half of the iodine and some of the potash contained in the algæ are lost by volatilization during the combustion of the weed. Moreover the seaweed must be dried before it is burned; on this account the process can be carried out only during the summer months. For this reason, no weed is gathered in winter, when large amounts usually are available because of the severe storms which dislodge much seaweed and wash it ashore.

On account of this waste a clever British chemist named Stanford devoted the greater portion of his life to an effort to invent a method of treating the weed which would yield more iodine and potash. His efforts resulted in a process resembling the by-product coking of coal, by which iodine, bromine, potassium salts, an illuminating gas, light and heavy oils, ammonia, acetic acid, and charcoal were obtained. The dried seaweed is destructively distilled, that is, heated in air-tight retorts, and the distillate is caught in special condensers. The residue consists of charcoal, potassium salts, and iodides. These salts are leached out of the charcoal and separated by fractional crystallization according to a process similar to the one used in the treatment of seaweed ashes.

Stanford also discovered a method of obtaining alginic acid, iodine, and potassium salts from seaweed.

Potash and Other Products from the Giant Kelp

The outbreak of the World War cut off America's supply of potassium salts, which had formerly been obtained from the Stassfurt mines in Germany. Since potassium salts are essential for agriculture and many industries, it became necessary to develop the American potash resources. The high potassium content of a giant Pacific coast seaweed, called kelp, was one of the first sources of potash to attract attention. Because of the acute shortage of all potassium salts, the Department of Agriculture made a general survey of the various kelp beds along the coast and established an experimental factory to demonstrate methods of producing potash and other products from the kelp. The survey located approximately 390 square miles of kelp on the Pacific coast, about half of which was in the vicinity of San Diego. These immense beds seemed to offer an almost inexhaustible supply of kelp from which the potash requirements of the United States could be met. Later the actual harvesting operations indicated that the amount of kelp commercially available had been greatly overestimated. Around San Diego, however, a great deal of kelp was harvested. In 1918 alone, 14,029 tons of potassium salts were produced from this source, and during the war this industry ranked second among the potash industries of the United States.

The giant kelp called macrocystis is the only important species commercially harvested for its potassium content. It grows from a sort of anchorage called a holdfast, sometimes as much as two feet in diameter. A number of stipes (corresponding to the stems of land plants) grow from a single holdfast. These stipes are about half an inch in diameter at the base. They vary from twelve to nearly a hundred in number, and are very long, sometimes reaching a length of a thousand feet. The serrated leaves are about a foot in length and four inches wide. The leaves are held at the surface by a bulb-like float called a pneumatocyst. Since this kelp is a perennial, the beds may be harvested three or four times a year without danger of exhausting them.

Another kelp called nereocystis often grows around the edge of the beds of macrocystis. This plant consists of a holdfast from which stretches a long stipe that terminates in a nearly spherical float from which a number of long string-like leaves grow. Small amounts of this kelp were harvested along with the macrocystis. It contains more potassium salts but much less iodine than macrocystis.

As harvested, a ton of kelp contained about seventeen hundred pounds of water, fifty pounds of potassium chloride, fifty pounds of alginic acid, and a half-pound of iodine.

In the early days of the industry the kelp was reaped by hand with large scythes from scows. Some drift kelp was also collected on the beaches. The kelp was partially dried either on the beach or upon frames, and then chopped and sold as a fertilizer or burned upon open hearths to obtain the ash which was then used as fertilizer. Such methods are practicable only when potassium salts are very dear, as the cost of harvesting kelp by such crude methods is very high. During the growth of the industry, various types of harvesting equipment were tried out. The most satisfactory device for this work resembles mechanically the ordinary hay-mowing machine. This mowing machine, with a cutter-bar about twelve feet in length, was mounted in front of a belt conveyer placed before a scow in such a position that the cut kelp was carried upon the scow. As fast as the kelp accumulated at the bow of the scow, it was hauled back by means of a grab-hook operated by a winch. A harvester of this type could harvest about fifty tons of kelp per hour.

At most plants the kelp was unloaded by means of a clam-shell bucket operated by a double drum electric hoist. The large plant of the Hercules Powder Company chopped the kelp finely on board the scow, thus reducing the kelp to a fluid mass which could be unloaded by means of a pump.

Potash was recovered from kelp by several different methods. The first operation of all the processes, except the fermentation process, was the drying of the kelp in horizontal rotary direct-heat driers. The dried kelp was usually burned in rotary incinerators or in reverberatory furnaces. In some plants the ashes were leached and the potassium chloride obtained fom the solution by crystallization.

The United States Department of Agriculture constructed an experimental kelp-potash plant at Summerland, California. This factory was built for the purpose of demonstrating the production of by-products by the destructive distillation of kelp. According to this process, the dried kelp is distilled at a high temperature in vertical fire-clay retorts. The vapors are led into condensers and scrubbers, where ammonia, volatile oils, tar, and creosote are obtained. The residue in the retort consists of kelp charcoal and inorganic salts. The salts are extracted with water, thus obtaining a solution from which potassium chloride is crystallized. The charcoal residue is washed with hot acid and then again with water. After drying, it is ready for use as a decolorizing carbon, or for absorbing carbon for gas-masks. Iodine is obtained from the mother liquor from the crystallization of the potassium chloride.

During the World War the shortage of acetone and other organic solvents suitable for use in the manufacture of smokeless powder was acute. The Hercules Powder Company endeavored to partially fill their own requirements by manufacturing calcium acetate and acetone from kelp. This was carried out at San Diego on a tremendous scale by an ingenious process involving the fermentation of the kelp and the separation of the fermentation products.

The process involved the following steps: The macerated kelp was brought to the plant in barges, from which it was pumped by rotary pumps to large redwood tanks, where it was diluted and allowed to ferment under the proper conditions of temperature and acidity. About 150 tanks of 50,000 gallons capacity each were required to hold the enormous amount of kelp which was harvested. After two weeks practically all of the kelp was in solution. The solution was then filtered and evaporated. As the evaporation proceeded, a mixture of calcium acetate, propionate, and butyrate separated; then calcium acetate and potassium chloride crystallized successively. Iodine was obtained from the mother liquor.

The products of this remarkable process included potassium chloride, acetone, acetone oils, organic esters and acids, iodine, algin, and common salt. Acetone and certain mixed ketones, which possess much value as solvents for the smokeless powders and airplane dopes, were obtained by heating the calcium acetate in retorts. Algin or alginic acid was obtained from the leaves of the kelp which remain unfermented. The properties and uses of this substance are described below. The mixture of the calcium salts of acetic, propionic, and butyric acids was manufactured into esters, which were used in the preparation of lacquers.

Immediately upon the cessation of hostilities this plant suspended operations and has since been dismantled. Such a process seems to be economically practicable only when the prices of organic solvents and potassium salts are abnormally high.

Algin

Algin or alginic acid is an organic substance, possessing unique properties, found in large quantities in many seaweeds. It was discovered by Stanford in 1883, who noticed that when certain laminaria were soaked in fresh water a viscous liquid formed in the sacks of the fronds of the algæ. When this liquid was evaporated to dryness a substance "resembling albumen" remained. This substance, which was named algin, is insoluble in water and acids, but dissolves readily in solutions of the alkalis or alkali carbonates.

Stanford recognized the commercial possibilities of algin and its compounds and carried on extensive researches to determine their properties and uses. Later he began to manufacture it, but his factory was not successful financially. More recently algin has been manufactured in Ireland and in America.

During the World War, much algin and sodium alginate was prepared as a by-product of the manufacture of calcium acetate by the fermentation of kelp. This process has been described above. The kelp residue (unfermented leaves) was treated with washing-soda solution until the leaves were disintegrated; then the solution was filtered and acidified. The acidification precipitated the alginic acid, which was separated by filtration. Sodium alginate was prepared by treating the alginic acid with soda.

The preparation of alginic acid is now carried on in connection with the manufacture of iodine and potash from laminaria and fuci in Ireland. The laminaria are macerated for twenty-four hours with one tenth of their weight of washing-soda. This converts the algæ into a very viscous, semigelatinous mass, which must be heated before it can be filtered through coarse bags. The alginic acid is separated from the solution by the addition of a mineral acid, and is obtained in a compact cake resembling new cheese. Algin may be sold in this form, or it may be converted into sodium alginate.

The filtrate from the alginic acid is evaporated and burned. Potassium salts and iodine are obtained from the ash according to the method described elsewhere.

Alginic acid may be molded while wet and retains its form when dry. In this way it can be made into many useful articles, which are hard and horn-like, insoluble in water, resistant to the action of chemicals, and of high dielectric strength.

Sodium alginate is one of the most useful of the alginates, as it is soluble in water, but can be easily converted into either alginic acid or insoluble alginates. It is a valuable sizing material, as it imparts a thick clothy feeling to the cloth without the stiffness given by starch. It may be used for the fixing of mordants in cloth. With shellac it makes a desirable lacquer.

Recently a method of clarifying solutions by the precipitation of alginic acids in them has been patented. This process is based on the principle involved in the clarification of solutions with alum.

Fabrics may be made waterproof by treatment with a solution of ammonium aluminium alginate. Since this and other ammoniated alginates become insoluble upon drying, they are used for the preparation of waterproof varnishes.

So many uses for algin and its compounds have been found that its value should increase from year to year as its utilization becomes more general.

Seaweed Glue and Other Curious Seaweed Products

The Japanese manufacture an important sizing material, or seaweed glue, called funori, from certain seaweeds belonging to the genus *Glœopeltis.* These seaweeds grow chiefly on the rocks in the shallow water on the Pacific shores of the Japanese islands, from which they are gathered either by men in boats, who use long-handled hooks and rakes to tear it from the bottom, or by divers who cut it loose. After the seaweeds have been dried on the beach, they are sold to funori factories.

The algæ are sorted and cleaned before being made into funori. The Japanese prepare the seaweed glue by soaking the washed algæ in fresh water, and

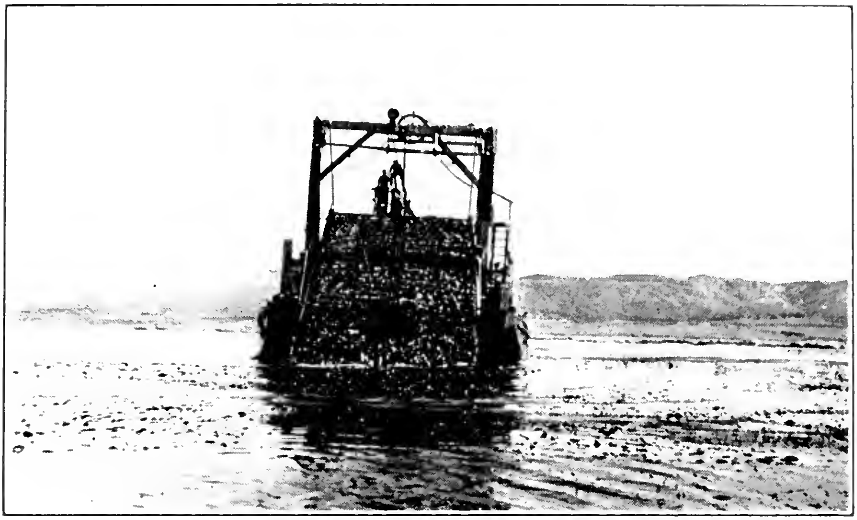
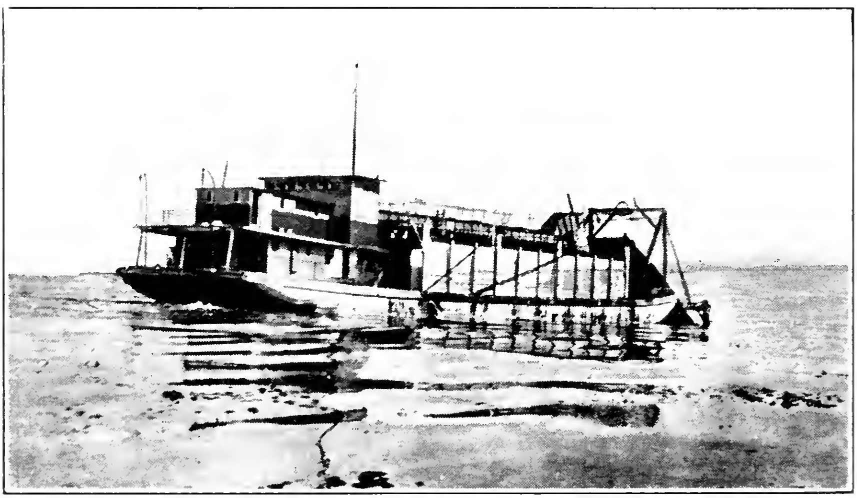


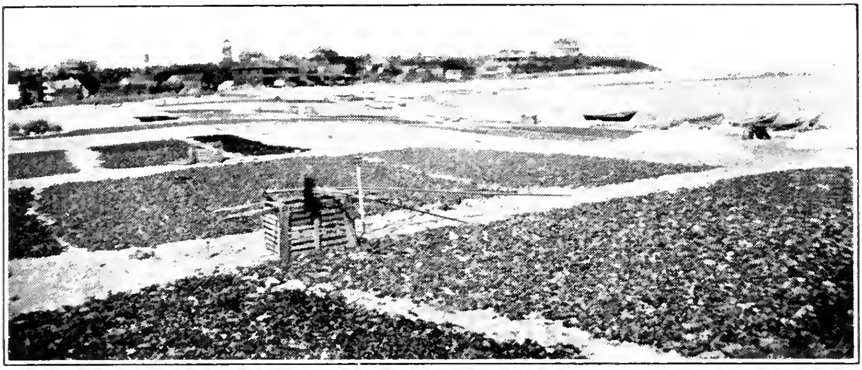
Photo by J. W. Turrentine

FRONT VIEW OF KELP HARVESTER



SIDE VIEW OF KELP HARVESTER

Harvesters such as this were used in harvesting kelp on the Pacific coast during 1917 and 1918



DRYING IRISH MOSS AT SCITUATE

The process is repeated until the seaweed is thoroughly bleached

BUNDLES OF DRIED AGAR READY FOR MARKET

then spreading them out in thin layers in the sun, where they are bleached by alternate wetting and drying. When the sheets are completely bleached they are dried and rolled up into bundles resembling Japanese matting. Nearly a million dollars' worth of funori is manufactured every year. Osaka is the principal center of the industry.

Funori is prepared for use as a size by dissolving in boiling water. It is used chiefly as a substitute for starch in laundering, for sizing cloth and paper, and for the preparation of calcimines.

The American Indian utilized the Pacific coast kelps for several purposes. The stems were not only used as bait in fishing for sea-urchins, but were also made into fairly good fishing-lines. The long rope-like stipes of the giant kelp *Nereocystis luetkeana* were prepared for use as lines by first washing them in running water for several days, then partially drying and smoking them, and then knotting them together. In order to reduce the size of the lines, the smoked stems were stretched and then dried further in the sun. Such lines were strong and flexible while wet but became brittle when dried. The Indians also used eel-grass in basket-weaving. The Eskimos coil the long hollow stems of kelp and use the coil as a worm condenser for distilling hoochena, a popular Arctic drink.

For many centuries seaweeds have been used as fertilizer in Japan, China, Great Britain, France, and many other countries. They increase crop yields because of their water-soluble potassium content and also on account of their nitrogenous constituents. Algæ contain so much water and so little solid matter and are so difficult to dry that they are usually not transported far from the coast but are used by farmers in the immediate vicinity.

In Norway and Ireland, Irish moss and other rockweeds are gathered, boiled, and mixed with meal for use as cattle and hog feed. Wrack and other seaweeds are components of certain commercial stock feeds prepared in Norway and Denmark. Seaweeds, however, are rather poor animal feeds, as they are too high in inorganic constituents and are not easily digested; few animals like them.

Although the most important use of the Irish moss is as a food, much is utilized in many other ways. In the British Isles it is used as a size. Some is also used as an ingredient of shaving-soaps, calcimines, shoe stains, and certain cosmetics. Its aqueous solutions are rather viscous; on this account, it is used for thickening dye solutions used in printing calico.

From time to time processes of manufacturing paper from algæ and other marine plants have been suggested. Excellent paper has been prepared from the eel-grass (*Zostera marina*), a grass-like plant of the pond-weed family.

One of the most interesting uses of algæ is for decorative purposes. The Japanese use several species, which remain green when dried, for the decoration of their homes on New Year's day, in much the same way that we use holly.

Many species of algæ are used in the manufacture of ornaments and curios. The giant kelp, *Macro-*

cystis pyrifera, is leached with water, until most of the salts are washed out, and then highly compressed and dried. The dried product resembles in appearance ebonite or vulcanized fiber. Certain species of laminaria, which have a hollow stipe and when dry are hard and horny, are made into knife-handles.

A submarine plant known as *Posidonia australia*, found on the southern coast of South Australia, contains a valuable fiber which is used in the manufacture of cloth, rope, twine, mats, paper, and stuffing. The fiber which is used commercially is obtained from large deposits of the dead plant in Moonta Bay, South Australia, where it is found to a depth of nine feet.

Certain laminaria contain a considerable amount of the sugar, mannite; methods have been proposed for preparing manna from these algæ. The natives of Kamchatka prepare an alcoholic drink by the fermentation of the dulse.

In the British Isles, France, and Holland, large quantities of eel-grass are dried and used in the stuffing of mattresses and upholstery. This marine plant thrives only on muddy bottoms in shallow water in protected places. Since the grass does not grow above the low-water mark, it is necessary for the men who harvest the plant to mow the grass in shallow water at low tide. It is cured by alternate drying and soaking. Immediately upon harvesting, the grass is dried upon the beach. When nearly dried it is soaked in ditches filled with fresh water. Then it is dried again; this process is repeated until it is very black. After the final drying it is taken to warehouses, where it is pressed into bales of one hundred pounds each and sold for use as a substitute for hair.

When one considers the wide variety of uses to which seaweeds are put and the large number of valuable products made from these marine plants, it is a wonder that larger quantities of these algæ are not utilized. Perhaps, as the world grows more crowded, we will look more and more to the ocean for food and raw material for our manufactures.

CHAPTER V

Edible Seaweeds

SO little seaweed is eaten in America that most persons do not know that many species of algæ are edible. Some Irish moss is prepared in Massachusetts, and agar is manufactured in one factory in California. In many parts of the world, however, large quantities of seaweeds are eaten as vegetables, in soup, in jellies, and in many other ways. The Hawaiians are especially fond of all sorts of seaweeds, utilizing more than seventy species in all sorts of dishes. The local production is not sufficient to supply the demand, so that much seaweed is imported from Japan.

Because of the mountainous character of the Japanese islands, their agricultural products are insufficient to supply the needs of the dense population. For this reason, the Japanese have given more attention to aquiculture than has any other nation. Since the Japanese islands are so numerous, the total extent of the coast-line is very great, being about eighteen thousand miles; thus the area available for seaweed culture is very large. Red laver is the most important species of algæ cultivated for use as food. The Japanese cook seaweeds in a great variety of ways. Red laver (various species of *Porphyra*), kelp (*Laminaria*), and agar (certain species of *Gelidium*) are those which are most highly valued for food.

It is said that the Japanese have learned from the Chinese the varied uses of seaweed. Whether or not this is true, it is known that the Chinese have utilized seaweeds for many centuries. Chinese cooks are expert in serving seaweed dishes. A "cabbage" called *pak-soy* is made from dried seaweed. Algæ are used in nearly all of the Chinese soup stocks, and in many sauces. They cook rice, fish, and vegetables with many species of seaweeds. Agar is used in bread, cakes, and also in candies and other sweets.

The Malays and other peoples of the Indian Archipelago collect great quantities of seaweeds from the warm tropical waters where algæ flourish abundantly. They boil them to obtain a jelly, which is either used as such, or frozen, then thawed, and dried. Large quantities of the weeds are also dried for general cooking purposes.

A peculiar sauce, called *noachman*, is prepared by the inhabitants of Cochin China. One can scarcely believe that this odoriferous sauce is used as a condiment, as its odor is obnoxious to most persons from the Occident. It is manufactured on a very large scale from mixed seaweeds, which are reduced to a jelly by boiling and then mixed with a concentrated sauce made from garlic. The mixture is emulsified with fish-oil and water. This powerful condiment is to be found on all of the restaurant tables of the Far East, where it is used as Worcestershire sauce is in England and America.

Seaweeds are somewhat more popular in Europe than in America. Irish moss, dulse, and laver are the algæ most widely used in the British Isles and along the coast of the mainland. But nowhere along the coast are marine vegetables so popular as they are in the Orient.

The energy-yielding food constituents of seaweeds consist chiefly of carbohydrates together with some proteins. Because neither the carbohydrates nor the proteins are completely digested, these foods must be considered as poor sources of energy.

Their value lies in their antiscorbutic vitamines and in their content of iodine, bromine, and other inorganic elements, especially their calcium, magnesium, and potassium salts. Algæ have long been used for preventing scurvy and goiter. Peoples whose dietary includes a liberal amount of algæ are surprisingly free from goiter and other diseases of the thyroid. For many centuries the Swiss and Chinese have eaten seaweeds in order to prevent and cure goiter, but only in recent years has the cause of its value in the prophylaxis of goiter been known to be its iodine content. Algæ vary widely in their iodine content, but as a class they contain a great deal more of iodine than other foods.

They possess one other physiological property which makes them valuable for certain purposes, inasmuch as they add bulk to the food and absorb much water, thus counteracting constipation. Agar and Irish moss are extensively used for this purpose. Because seaweeds produce little heat when digested and assimilated by the body, they are highly recommended as hot-weather foods for those who do little manual work.

Algæ as Food in America and Great Britain

Before 1835, Irish moss was considered a luxury in America; its price was always a dollar or more per pound, for the entire American supply was imported from Europe. In that year Dr. J.V.C. Smith, at one time mayor of Boston, found it in considerable quantities on the Massachusetts coast and suggested curing it. Since then Scituate, Massachusetts, has furnished sufficient Irish moss for American needs. Because of the abundance of the moss on the Massachusetts coast, the price rapidly dropped, and in 1880 it sold for three cents a pound.

Formerly the Massachusetts industry produced nearly a million pounds of the dried and bleached moss annually, but in recent years the production has decreased until in 1919 only about two hundred thousand pounds was produced. The center of the Irish moss industry is still at Scituate, but small amounts are also harvested at Cape Porpoise, Portsmouth, Gloucester, Marblehead, Nahant, Cohasset, Plymouth, White Horse Beach, and Cuttyhunk Island, Massachusetts, and at Block Island and Montauk, New York.

Most of the crop is gathered by men in boats, who rake the moss from rocks in shallow water. For this purpose they use a long-handled rake with long fine teeth. When brought ashore, the moss is washed in sea-water and then spread out on the beach to dry.

After drying for a day or two, it is raked up and again washed and spread out on the sandy beach to dry. This process is repeated until the seaweed is thoroughly bleached; sometimes seven washings are required. Strange to say, fresh water cannot be used for the washing of the moss, as its use alters the jellying properties of the dried weed.

In America, Irish moss is used chiefly for making blanc-mange and other puddings and jellies. For this purpose it is prepared in two forms: the rough dry, bleached moss, which is usually sandy, rather troublesome to prepare, and very cheap; and sea-moss farina, a powdered form, which is prepared with a cereal and is usually sold in one-ounce packages. The latter product is more expensive, but it possesses the advantage of requiring little preparation and of being very effectual for most purposes.

Sea-moss farina makes excellent blanc-mange with either fresh or evaporated milk. Blanc-mange is eaten either as a dessert or as a substitute for breakfast cereal in hot weather. Farina custard is a desirable filling for cream-puffs; it also makes an excellent cold pudding. The rough dry Irish moss or sea-moss requires more time for its preparation as blanc-mange and is not so convenient for use in general cooking. For the latter purpose, some cooks prepare a jelly in quantity from the dry moss, and seal it in glasses in the same way as sugar jellies; it finds use in all sorts of gravies, soups, and bouillon.

Dulse, a species of *Rhodymenia*, is found abundantly on the rocky shores of the Atlantic Ocean from North Carolina to Maine. More of it is utilized in New England than in any other part of the country. In some places along the coast of the North Atlantic States, it is dried in the sun, and then made into a relish. In Philadelphia dulse is eaten as a vegetable under the name of sea-kale.

Agar is the only other seaweed product extensively used as food in America. Some of this algal preparation is manufactured on the coast of southern California.

As in America, Irish moss is the most popular edible alga in Europe. It is obtained chiefly from County Clare and the western coast of Ireland and is used in much the same way as in the United States.

In the days before tobacco chewing became common, dulse was often chewed by the Scotch and Irish. This habit has now been replaced by the tobacco habit. At present its chief use is as a condiment in many dishes; it is a favorite ingredient in ragouts, to which it gives a red color, pleasant taste, and thick consistency.

Laver, or porphyra, oyster green, and murlins are eaten like spinach. A fucus, commonly called bladder-wrack, and certain laminaria are used in the treatment of goiter and also as antiscorbutics.

Pepper dulse is a rather pungent condiment which is used in Scotland in much the same way as ordinary dulse.

Small amounts of many other algæ are eaten in various parts of Great Britain, but the quantity harvested for food is very limited.

The Japanese Edible Algæ Industry

Although algæ grow wild along the great extent of the Japanese coast, the cultivation of the more valuable species is a profitable industry. Red laver or porphyra is extensively cultivated in Tokio Bay and in many other sheltered coastal waters.

The methods of cultivating seaweeds are quite different from those used in agriculture. In aquiculture the farmer does not sow seeds or cuttings but fixes in the bottom in sheltered areas of shallow water bundles of bamboo poles or brush on which the spores of porphyra are caught and supported while they grow. The bundles of brush are planted in October and November in regular lines of deep holes in the muddy bottom. The porphyra spores which lodge on the brush grow rapidly, and in a few months the laver is ready to harvest.

Some porphyra or amanori, as the Japanese call it, is eaten fresh, but most of the crop is preserved by drying in the sun. Preparatory to drying, it is carefully washed in fresh water, finely chopped with knives, and then placed on small mats made of fine bamboo splints. After the chopped algæ have been pressed into thin sheets, the mats are placed on inclined frames in the open air, where the sheets are completely dried. The dried sheets of amanori are stripped from the mats, pressed flat, and packed for market in bundles of ten. The sheets of amanori are thin and flexible, like writing-paper, having a glossy surface and a mottled brownish color. Amanori is prepared for the table by baking it until it becomes green and crisp. It is often eaten with soup much as Americans eat crackers.

The Japanese also use it in the preparation of a sort of sandwich called *sushi,* which is prepared by placing a thin layer of boiled rice on a sheet of amanori, with strips of meat or fish on top of the rice. The *sushi* is then rolled up and cut into transverse slices.

The Japanese dry certain species of laminaria and prepare a food known as kombu. This industry is located chiefly in Osaka, Tokio, and Hakodate. In Osaka alone there are about forty-five factories each employing at least ten persons.

The laminaria are gathered in summer by men in open boats, who tear or cut the algæ by means of hooks attached to long poles. Some is also harvested by means of rakes dragged along the bottom. The laminaria are spread on the beach to dry. When completely dry the stems are cut off and discarded, and the fronds are sorted as to size and quality. The trimmed, sorted kelp is then packed into long flat bundles and shipped to kombu manufacturers.

Kombu is a product peculiar to the Orient and seems to appeal only to the Oriental taste. It is prepared from the dried laminaria fronds in several ways. The most popular product is shredded green kombu, which is prepared by dyeing the dried laminaria in a boiling solution of the dye, malachite green. The dyed fronds are partially dried and then flattened out and compressed in piles in wooden frames. The laminaria are then shredded by means of a hand plane, the shredded product being dried on platforms or mats. The dried product resembles in color, shape, and feel the Spanish moss which hangs from many of the trees in our Southern States.

Kombu is prepared in many other ways. It is treated with vinegar, then dried and shredded. The outer part of the frond is scraped off and sold as black pulpy kombu. The lighter-colored kombu which is removed next is called white pulpy kombu. After the green kombu has been removed, the remaining part of the frond is scraped with a very sharp knife, and the exceedingly delicate and thin shavings are sold as filmy kombu. The core of dried kombu is sometimes powdered and put through a sieve. The product is called *saimatsu* or finely powdered kombu. Shredded kombu is sometimes cut into short lengths. After drying, the curled product resembles in appearance the rolled leaves of green tea, and is known as *cha* (tea) kombu.

Kombu is used in many various ways by the Japanese. The green shredded product is cooked with meats and soups and is also served as a vegetable. The powdered kombu is used in soups, in sauces, and on rice. The *cha* kombu is used like tea in the preparation of a hot drink. Dried kombu is often coated with sugar or an icing and eaten as a confection.

The Japanese eat about twenty other algæ and also many products prepared from seaweeds; but amanori, kombu, and agar are by far the most important.

Agar and Other Oriental Seaweed Industries

Seaweeds are also extensively eaten along the seacoast in nearly all Oriental countries. Seaweeds are harvested in large quantities by the Chinese, who have devised a multitude of instruments for securing the algæ from the sea bottom. They prepare jellies by cooking seaweeds and use them for making puddings, cakes, and candies. Seaweeds are used to flavor their soup, rice, fish, and many other dishes. Many seaweeds are eaten as fresh vegetables, and some are preserved by drying.

The Hawaiians, like the Japanese and Chinese, are very fond of all sorts of seaweed, which they call *limu*. They eat forty species of algæ regularly and occasionally cook about thirty others. *Limu* is eaten both raw and cooked. Sometimes it is boiled with squid or some other devil-fish, thus producing a jelly of which the Hawaiians are very fond. They sometimes preserve the algæ in about the same way in which we make sauerkraut from cabbage; the seaweeds are broken, pounded, and chopped into small pieces, then salted and preserved in calabashes or glass jars. Much seaweed is also preserved by salting and binding it with leaves.

Seaweeds are popular foods in the islands of the Indian Archipelago and all around the coasts of Australasia. Agar, or seaweed isinglass, is extensively used in every part of the Orient for culinary and confectionery purposes. Delicious jellies, jams, candies, beverages, and many attractive dishes are prepared from it.

The Japanese manufacture about two million dollars' worth of agar each year and export much of it to Europe and America. Agar manufacture is one of the curious Japanese industries which have developed without the application of modern science.

The red algæ, which are used in its manufacture, grow on rocks in relatively shallow water and are gathered from small boats either by rakes with long handles or by diving. The gathering season extends from May to October; July and August are the best months. After cutting, the weed is spread out on the beach to dry. The dried algæ are sold to manufacturers, whose factories are located back from the ocean in the hills and mountains, where cold nights come early in autumn, and where the winter is long.

The first operation in the Japanese process of making agar consists in beating and pounding the seaweed until most of the foreign matter, such as shells and sand, has been removed. After being washed with cold water, the cleaned *tengusa* is spread out to dry in the sun. It is then bleached by alternately sprinkling with water and drying in the sunshine. The bleached raw material is boiled for five or six hours with about fifty times its weight of water and a little acid. The solution produced in this manner is filtered and then cooled in wooden trays. When cold, a firm jelly is produced which is called *tokoroten* by the Japanese. This is cut into various shapes, depending upon the use for which it is intended. The strips or blocks of jelly are then placed out of doors on a cold night and frozen.

The freezing operation is the trick in the manufacture which not only effects a remarkable change in the structure of the agar but purifies it. The freezing causes the water to crystallize out, so that when the jelly thaws, most of the water runs out, taking with it the substances which are soluble in cold water. After thawing, the agar is left to dry in the sun. The dried agar is tied into bundles and marketed in this form. In some of the more modern factories, artificial refrigeration is employed for the freezing of the agar jelly. This permits the factories to operate the whole year, as the manufacturers do not have to wait for cold weather to freeze the *kanten*.

The agar industry is one of the American industries which have been introduced since the World War. In 1920, a factory having a capacity of approximately a ton a day was built at Tropico, California. In that vicinity are large quantities of red algæ suitable for the manufacture of this valuable seaweed jelly. The factory is of modern design and manufactures agar of high quality. Here the seaweed is bleached by spreading it out in the sun and washing it with a whirling spray of water. The plant is equipped with a modern refrigerating system, so that it is independent of weather conditions. Agar is so expensive that, even though the daily production is small, the value is great.

Chemically agar consists chiefly of a carbohydrate, a galactan called gelose, resembling in many of its properties the pectins, which are the jelly-forming components of fruits. Agar must be pure to be of value, as small amounts of many impurities cause it to lose its power of forming a jelly with water.

Agar, or *kanten* as it is called in Japan, has long been used as a food in the Orient, and is one of the favorite seaweed foods of the Japanese and Chinese. It is eaten in the form of jellies, and as a thickener in soups, sauces, and gravies. In recent years this seaweed product has found wide application in all civilized countries. In Europe and in the United States it is utilized in food preparations such as ice-cream, jellies, candies, pastries, and many other desserts. It is also used in fish canning to prevent the soft canned fish from being shaken to pieces in transportation; agar fills this purpose very well, since a dilute solution forms a very firm jelly upon cooling. It is far superior to gelatin, because the jelly strength of gelatin is rapidly destroyed at the temperature at which canned fish is sterilized. Some agar finds use in the clarification of liquors. A limited amount is used as a sizing material. Its chief uses in Europe and America are for the preparation of bacteriological media for scientific use and in medicine as a laxative. Its action as a laxative is dependent upon the fact that it has the property of absorbing and holding water, becoming at the same time a lubricant and a mild stimulant. Recently agar has been used with considerable success as a dressing for certain types of wounds.

CHAPTER VI

Pearls, Mother-of-Pearl, and Imitation Pearls

IT is said that "imitation is the sincerest form of flattery." If this is true, pearls have held a very high place in the esteem of beauty lovers, for jewelers and scientists have been trying for many centuries to make perfect imitations.

Pearls have been used as ornaments by many races since prehistoric times. Many of the burial mounds of the Ohio mound-builders contain pearls which were buried with the dead. Some of these were loose; others had been strung and used as necklaces and wristlets. These indicate that long ago, when unbroken primeval forests covered much of our land, the savage men and women adorned themselves with these beautiful jewels just as we do to-day. The mound-builders possessed a higher degree of civilization than did the later North American Indians, who did not learn to appreciate pearls, although they utilized shells in the making of beads for wampum which they used as a medium of exchange.

The Indians of Mexico and South America were of a higher plane than those of North America. This is evidenced by their love of gold, silver, pearls, and precious stones. When Cortés visited Montezuma he found the Indian prince decorated with gold, silver, and precious stones, while his cloak and sandals were adorned with pearls.

No one knows when pearls were first used as ornaments in the Orient. The Hindu princes have surprising quantities of large, beautiful pearls which have been handed down from generation to generation for many centuries. The rajah of Dholpur possessed pearls valued at $7,500,000. During the reign of Louis XIII, Tavernier, the celebrated Frenchman, traveled into Asia in search of pearls and precious stones. He found that the Arabians and other Asiatics possessed an amazing number of very fine pearls, and he brought back to France more than half a million dollars' worth of them.

It is probable that pearls were utilized for ornamental purposes in the tropics many centuries before their use became general in cooler climes, for pearl-bearing shell-fish are much more numerous in warm waters than in the cooler waters of the temperate and frigid zones. Perhaps pearls were the playthings of the children of the prehistoric shell-fishermen. At all events, savage men did not prize them highly; such pale, delicate gems were not gaudy enough to attract them. But, with the growth of intelligence and refinement, there came increasing appreciation of these lovely jewels, until now the pearl is considered to be one of the most precious and beautiful of all objects of human adornment.

The early Egyptians used pearls as ornaments, but it was not until the age of the Ptolemies that they became plentiful. Cleopatra, famous queen of Egypt, had many pearls of great size and fine quality and is said to have been lavish in their use, a notable instance being the banquet which she gave to Mark Antony, at which she dissolved and swallowed a large pearl. The ancient Persians, Babylonians, and Assyrians valued pearls and used them as ornaments.

When Alexander conquered Persia, pearls were introduced into Greece. Soon thereafter the Macedonians established fisheries in the Red Sea, from which it is said the Egyptians obtained their chief supply.

The pearl was an important jewel in imperial Rome. As the riches of the countries which she conquered came into the hands of the Roman merchants, an extravagant civilization was developed in which large numbers of persons lived in great luxury. Under these conditions the extreme excesses of the rich became ludicrous almost to the verge of insanity. Pearls were lavishly flaunted in many unusual ways. The Emperor Caligula had a necklace of pearls placed around his favorite horse. Clodius, best known from his gluttonous habits, dissolved them in wine, contending that they improved the flavor. Clodius's contention may be true, but a little lime would do equally well for the purpose. Clodius is said to have dissolved a pearl worth forty thousand dollars in a cup of wine and then drunk it in order to have the pleasure of having consumed so much value at once.

During the past two thousand years pearls have been so highly prized as jewels that they have had much influence in political history. It is said that they were commonly given as bribes in obtaining political influence in ancient Rome. Some historians assert that one of the important motives which prompted Cæsar's conquest of England was the Roman desire for British pearls. The search for pearls drew many Spanish colonists to South America during the sixteenth and seventeenth centuries. The fisheries of Venezuela and Panama were found especially attractive.

It is difficult if not absolutely impossible to obtain really reliable information concerning most of the large historic pearls. Descriptions of pearls are likely to run more to fancy than to fact. The size of pearls is often multiplied in describing them. Relatively few large perfect pearls have been found; invariably the very large ones are unsymmetrical. The largest pearl known to exist to-day is the Hope Pearl, a drop-shaped baroque in the Beresford Hope collection at the South Kensington Museum of London. It weighs 1887.70 grains (94.385 grams or about 3.5 ounces). La Pellegrina, now in the Museum of Zosima at Moscow, is reputed to be the most perfect large pearl in existence. It weighs 114.45 grains (5.7 grams) and is so lustrous that it appears to be transparent.

Although to-day we value pearls much more highly than the mother-of-pearl shells from which they come, the savage races prefer the shells. For this reason it is not surprising to know that mother-of-pearl shells were utilized as ornaments by prehistoric peoples long before the less conspicuous pearls came into favor. No one knows when shell beads were first used for ornamental purposes, nor when their use as a medium of exchange became common.

The chank (*Turbinella pyrum*), or Indian conch, has been used in India for ornamental and other purposes for many, many centuries. Those shells which have the whorl running from right to left are especially prized and are often worth their weight in gold. The Hindus consider the chank sacred, for in their mythology Shankar the Destroyer and Vishnu are pictured as holding a chank shell in one hand; the Buddhist priests have, besides, used these shells as horns for many centuries.

Abalone or haliotis shells were used for ornamental purposes in China, Japan, New Zealand, and the South Sea islands long before Europeans learned of their beauty and iridescence.

Nature of Mother-of-Pearl

Before it is possible to understand the nature of a pearl and appreciate its beauty and color, it is necessary to examine the shell of the mollusk in which the pearl was formed. Pearls grow in nearly all bivalves (mollusks with two valves or lateral shells hinged together) and in some univalves, but only those found in mollusks with mother-of-pearl shells are of commercial value. Commercially most of the pearls come either from the so-called pearl-oyster or from certain fresh-water mussels. These mollusks are marvelous creatures which build beautiful, strong houses for themselves out of the water in which they live. The exterior of their habitations is coarse and rough, but the interior is such smooth mother-of-pearl that it does not injure their delicate bodies.

The shells of all mollusks are constructed of calcium carbonate and other materials extracted from the surrounding medium by the shell-fish. The membranous covering of the mollusk, called the mantle, takes the carbonate of lime and other mineral elements from the water and deposits them at the different parts of its folds in the form of the shell. Nature takes an infinite amount of care in arranging the crystals of calcium carbonate in such a way as to form mother-of-pearl. The calcium carbonate crystals are deposited in regular overlapping layers, the shell being constantly enlarged at the edge by the exudations of the mantle, which deposits a protein called conchiolin for the epidermis, and calcium carbonate for the prisms and inner layers of transparent plates, until the shell has attained its growth.

Placed under a microscope, the outer shell is seen to be composed of a large number of overlapping horizontal composite plates, which penetrate the shell to the mother-of-pearl. The edge of a composite plate appears as a number of prisms placed side by side lengthwise across the plate edge, but showing dark intersecting lines where the plates divide. On the face of the plates these prisms appear as translucent hexagons cemented together by darker organic matter. The outer portion of the shell contains much more organic matter and is of coarser texture than the inner part of the shell. In certain species of shell-fish the exterior of the shells is composed of nearly pure conchiolin, a horn-like organic substance. In some mollusks this epidermal covering may be stripped off easily, while in others it cannot be separated from the plates of calcium carbonate prisms. In the interior of the shell the plates of the calcium carbonate prisms are much thinner and are attached together so firmly that they cannot easily be separated. The inner series of these plates as they near the nacreous lining become harder and more compact, so that the exact place where they join the nacreous layer is difficult to determine. The nacreous lining of the shells has the same general composition as the coarser outer part of the shell except that it contains less organic matter. It is harder, finer, and more compact than the outer shell, and is constructed of nacreous plates which are composed of very thin waves of calcium carbonate set in a small amount of animal tissue. These waves are very numerous and produce a series of fine irregular lines which tend generally to be straight but often curve as do the edges of the waves of water when they run on the sands of the sea-shore. The overlapping of these thin transparent waves, and the minute undulations of the layer edges reflecting through the transparent plates, produce the soft luster known as pearly. The minute prisms of calcium carbonate also aid in producing the chromatic or iridescent effect by splitting the white light into the several colors of which it is composed.

Origin and Nature of Pearls

The pearl and the nacre of the shell in which it grows are of essentially the same composition and structure. Pearls are more or less spherical formations constructed by the mollusk in the same way and from the same secretions with which it lines the shell, misdirected by abnormal conditions. Ordinarily the mollusk secretes nacre merely for the construction of the shell; but if some foreign object gets within the shell it is covered with a deposit of nacre, and thus a minute pearl is formed. Probably the oyster covers the object with nacre as a means of self-protection, alleviating the irritation caused by foreign matter within the shell. The mollusk deposits layer after layer of nacre on the nucleus, and thus the pearl grows larger and larger. Until recently the nuclei of pearls were thought to be grains of sand, but careful research by modern scientists has shown that there are several conditions which may cause the formation of a pearl. The irritating granule may result from the decomposition of an organism or may be generated in the mantle of the pearl-oyster as material for the outer shell, which, failing to be utilized in this way, becomes a source of irritation to the tender mantle and therefore is provided with a nacreous coating.

While the structure and composition of a pearl are similar to those of the shell of the mollusk in which it was formed, yet there is a distinct difference. The mother-of-pearl lining of a shell is composed of a series of horizontal layers, or *skins*, as they are called. Moreover in the shell nacre the wave edges tend generally in one direction, whereas in the pearl the lines twist and curl with a concentric tendency.

Chemically the composition of pearls is identical with the nacreous portion of the pearl shell of the oysters in which they are found. Both contain about ninety-two per cent of calcium carbonate, six per cent of organic matter, and two per cent of water. Their density is about 2.75 times that of water, and their hardness is comparable to that of fluorite. Since pearls consist largely of calcium carbonate, they are easily attacked and destroyed by all the strong acids. Even some relatively weak acids have a slight action. For instance, there is sufficient acid in the perspiration of certain individuals to affect their luster. Because of the relative softness of pearls, they must be kept from contact with precious stones. A pearl ring should never be worn on the same finger with a ring set with a diamond, ruby, or other stone setting. No abrasive should ever be used in cleaning or polishing pearls. Likewise, since chemicals may stain or dull them, no cleansing agents of unknown composition should ever be used on them. Ordinarily soap and water or dilute alcohol should be used in cleansing pearl necklaces or other pieces of jewelry containing pearls. Pearls should never be left wet, nor should they be stored in an absolutely dry atmosphere. When pearls are stored in a safe-deposit vault, moist blotting-paper is sometimes placed in the box so as to prevent them from becoming thoroughly dried out.

The Fisheries

Since the only shells which yield valuable pearls are those containing mother-of-pearl, and but a small proportion of these contain pearls, pearl fisheries are almost invariably carried on in conjunction with pearl-shell fisheries. Few fisheries could be made to pay if they were operated for pearls alone. In some fisheries the shells yield ninety per cent of the value of the total product. For these reasons the shell fisheries and pearl fisheries will be considered together.

Marine pearl shells are always gathered by divers, either naked or dressed in diving-suits. For some reason dredges are almost never used, probably because the oysters seldom are thick enough to make dredging pay. Where the pearl shells are found in relatively shallow water, they are usually taken by naked divers; but if the oysters are found at depths of more than fifty feet, the divers must dress in scaphanders, as native naked divers cannot work long enough at such depths. Naked diving is the common method followed throughout the Orient and has been practised in the Red Sea, the Persian Gulf, and the Gulf of Manar for many centuries. Naked divers need few accessories. They merely grease their bodies, put greased cotton in their ears, and place some sort of clamp—a forked stick or a tortoise-shell clip—upon their nostrils. A wicker basket or net, hung at the waist, serves as a receptacle for the catch.

The Malabar Hindus and some Egyptians dive head first from a spring-board attached to the side of the boat, passing smoothly and rapidly through the water straight to the bottom. The diver gathers quickly as many oysters as possible while his breath lasts, and places them in the net at his waist, and then swims rapidly to the surface.

In Indian, Egyptian, and Arabian waters, many divers use heavy stones to pull them to the bottom. These divers have an attendant called a *manduck*. The *manduck* suspends a stone weighing forty or fifty pounds from the boat by means of a rope. The diver then drops into the water feet first, places his foot in the line over the stone, takes the net basket and a second rope in his hand, releases the line, and sinks to the bottom. Loosening his foot, he searches for pearl shells, while his attendant pulls up the stone and adjusts it for the next dive. The diver places the shells in the basket attached to the line from the boat. When he is ready to return, he signals his attendant and, holding on to the line fastened to the basket, is drawn to the surface by the *manduck*.

The Polynesians are said to be the most expert of all the naked divers. Whole families engage in the search for pearls; the boys and girls and women are almost as expert as the men. These divers hang in the water by one hand, grasping the gunwale of the boat while they examine the bottom for oysters through a glass, which they hold below the surface with the other hand. When shells are seen, the glass is put into the boat, the lungs are filled several times, and the air is slowly expelled. Then the diver takes a deep breath, and sinks a few feet below the surface, turns quickly, and swims head first to the bottom, where he collects as many shells as possible. When he can stay under no longer, he straightens himself and shoots to the surface with astonishing speed.

Most of the marvelous stories told concerning the ability of naked divers to work at great depths for long periods of time are gross exaggerations. They are tales which have been told over and over again, growing in the telling. As a matter of fact, naked divers seldom go deeper than fifty feet, and in many of the fisheries thirty feet is considered good diving. Few divers remain under water for longer than ninety seconds, although experts have been known to stay under for 160 seconds.

The use of scaphanders or diving-suits possesses many advantages and is gradually becoming more general. They have been exclusively used for many years in Australia, where the shells are taken at great depths. The diving-suits enable a diver to work at much greater depths for an hour or two at a time, and to work all the year round.

A man in a diving-suit is a queer clumsy giant. The outfit is so heavy that the diver has difficulty in walking while out of the water. The scaphander is composed of a one-piece rubber suit which the diver gets into through the neck, a helmet, a corselet to which the helmet is screwed, leaden-soled boots, and chest and back weights to aid the diver in maintaining an upright position. When dressed, the diver steps upon a ladder hanging over the side of the boat; the air-pipe, life-line, and helmet are attached; a man begins pumping air by means of a pump in the boat, and the face-glass is screwed up. The diver drops into the water and then sinks quickly to the quiet depths below. The man at the air-pump must be alert, for the diver's life is in his hands. If he fails to notice signals on the life-line, or stops pumping air for a minute or so, the diver may lose his life.

Only persons with strong constitutions can continue to follow the diving profession for many years without permanently injuring their health. The ill effects arising from injuries are a much greater danger than sharks, or other fishes, or possible fouling of the air or life lines.

Divers attired in scaphanders can work comfortably at as great a depth as 125 feet. Recently it has been learned that divers can work at even greater depth without great danger, provided they ascend to the surface very slowly, thus permitting the air to be released from the blood gradually. The danger appears to lie in the sudden change in pressure which the diver undergoes, and not in the great pressure itself.

The pearl oyster prefers tropical seas and is found more or less abundantly on the shoals and reefs about the shores of every land lying between thirty degrees north and thirty degrees south of the equator. It prefers coral reefs and limestone bottoms. The largest and finest pearl shells are nearly all found in the Pacific Ocean within a range of twenty degrees south of the equator. The best white mother-of-pearl shells are found on the northern and western coasts of Australia and on the Aru Islands. The abalone is usually found in cooler waters, being abundant on the coast of California and Japan.

Among the fisheries which are especially well known for the quality and quantity of pearls produced are those of the Persian Gulf, Ceylon, Venezuela, Panama, Mexico, and Malaysia. Those known especially for their mother-of-pearl but which also yield pearls of value include those of the Australian, Society, and Philippine islands, the trochus shell fisheries of New Caledonia, and the abalone fisheries of California and Japan.

Cultured Pearls

One of the greatest triumphs of modern science has been the discovery of methods of making artificial gems. An artificial gem is not an imitation but is the genuine article made by a process controlled by man. Artificial rubies, emeralds, and sapphires are the result of marvelous inventions by chemists, whereas the biologists have discovered how to produce cultured pearls. This is not surprising, since the pearl is a biological product.

Cultured pearls have been produced since 1894, and cannot be distinguished from natural or accidental pearls except by an examination of the center or nucleus. Ever since cultured pearls appeared on the market, there has been much discussion as to whether they should be considered true pearls or not. Recently the French courts have decided that for legal purposes a cultured pearl is a pearl. This decision should be of considerable aid to the cultured pearl industry.

The method of causing pearl oysters to grow pearls was discovered by Japanese biologists; one Kokichi Mikimoto began the commercial cultivation of pearls in the meleagrina oyster in 1894, developing the industry in a scientific manner at his submarine gardens in the Bay of Gokasho, in the Prefecture of Miye. According to Mikimoto's process, a shred of pallial epithelium cut from one oyster is wrapped deftly around a minute nucleus of mother-of-pearl, thus forming a germinal pearl sack, or "seed." A strong, sturdy pearl oyster is opened and an incision made in its outer mantle. The seed is then inserted through the aperture made by the cut to a sufficient depth to insure that it will be entirely enveloped by the subepidermal tissues of the mollusk. The incision is then closed, and the oyster is placed in a tray or cage, where it is protected for about seven years, during which the meleagrina continues its growth. The oyster secretes concentric pearl layers around the nucleus of mother-of-pearl or seed, and eventually it produces a good-sized pearl.

Successful pearl-culture requires not only great skill in the surgery of the oyster and the insertion of the properly prepared nucleus, but also much knowledge and experience in the culture of the meleagrina or other species of pearl oysters. Mikimoto used bamboo poles as spat collectors, on which the set of meleagrina spat is obtained. When the oysters are three years old, the nuclei are inserted and the meleagrinæ are placed in specially designed baskets, which are coated with coal-tar to prevent corrosion and the growth of algæ. Seven of these trellised trays are suspended vertically one below the other by steel wires from rafts floated on cork buoys.

Each raft supports sixty cages containing a total of about seven thousand pearl oysters. The oysters are carefully guarded, and the water in which they are grown is examined often. Sudden changes in temperature are very destructive to the young meleagrina; and if for any reason the temperature of the section of the bay where the cages are anchored changes suddenly, the rafts are shifted to a more favorable location. The water must also be examined often to determine whether or not it contains sufficient of the marine fauna on which the oysters feed. If the water is found deficient in nourishment, the rafts are towed to a more desirable place.

Evaluation of Pearls

Pearls are graded much more closely and critically to-day than they formerly were. The business is now well organized, and much of the sentiment and superstition of the trade has disappeared. For these reasons it is difficult to compare prices of pearls in ancient times with those of to-day. For while perfectly spherical pearls of high quality command higher prices than ever before, imperfect ones are difficult to sell at any price. Large irregularly shaped pearls which were valued highly when Roman glory was at its height would attract little notice now.

The value of a pearl depends upon its shape, size, color, luster, and perfection; consequently, since it is exceedingly difficult to find two pearls exactly alike, it is very hard to formulate rules for the evaluation of pearls. Large spherical pearls are worth much more than small ones, the value increasing approximately as the square of the weight. Usually, in estimating the value of a pearl, a base value for a gem weighing one grain (fifty milligrams) is established, and this figure is multiplied by the square of the number of grains that the pearl weighs. For example, if a one-grain pearl is valued at ten dollars (called the base price), then a three-grain pearl of the same quality would be worth ninety dollars ($3^2 \times 10 = 90$). As a rule marine pearls are of greater value than those from fresh-water mussels, other considerations being equal. Spherical pearls with imperfections in one spot are worth nearly as much as perfect pearls, for the defects can be hidden by setting.

Seed pearls are those which weigh less than a quarter of a grain each. These small pearls are of relatively little value and are often sold in bulk. Baroque pearls are those which do not have any typical form, and usually they are of relatively little value unless the form is that of a flower or animal, in which case they are prized as curiosities.

Utilization of Pearls and Mother-of-Pearl

Pearls are either utilized for necklaces or are mounted on pegs or rings or on studs. Strung pearls may also be made into collars.

When pearls are taken from the shells they require no polishing or other preparation as do precious stones. If they are to be strung, they must be drilled. Formerly this was accomplished by means of a bow-drill operated by hand. This operation is so slow and tedious that one man can drill not more than fifty pearls of average size in one day. But since machine drills have been adopted, one man can pierce that number of pearls in an hour. Experts do the drilling and take great care to drill in such a way as to improve the quality of the pearls. This is accomplished by starting the hole at the poorest part or spot. In stringing pearls for a necklace, a silk thread is passed through a metal eye or other object designated to serve as a clasp; a knot is then made, and the end pearl is added, after which another knot is made, and so on until the pearls have been strung. The threads on which the pearls are strung gradually stretch, so that the necklaces must be restrung about once a year.

Inasmuch as claws hide part of the pearls, those which are set in rings or on studs are usually placed on pegs. Double pegs are often used, as they prevent the pearl from turning and thus becoming loose and falling off the peg. Great care must be used in mounting a pearl to prevent the scratching of the pearl by the setting.

The most important use of mother-of-pearl is in the manufacture of buttons, although large quantities are also used for the making of knife handles, inlaid articles, and ornaments of many sorts.

The shells are classified according to their source, size, color, and quality. The white shells come principally from West Australia, Port Darwin, and Macassar. The yellow shells come from Manila, Mergui, Bina, and Singapore. Green shells are inferior white ones, often with a greenish tinge having a dark outer rim or edge. These shells come principally from Egypt, Bombay, Panama, La Paz, and Costa Rica. Black shells are shipped from Tahiti, the Gambier Islands, and many other islands of the South Pacific.

The manufacture of mother-of-pearl buttons is a rather modern industry, for it had its beginning in Austria only about two centuries ago, the material used being shells from the Red Sea. The industry has grown rapidly, however, until now it is the most important button industry. It is well established in the United States, France, England, Germany, Austria, Japan, Italy, and Spain.

In the larger button factories, the shells are first classified according to species and quality. Then they are soaked in water for a week or more in barrels or tanks, thus softening the shells so that they may be cut more readily. Blank disks, of the size of the buttons desired, are then cut by means of a lathe fitted with a tubular saw having a ratchet handle for gradually forcing the rougher shell against the rapidly rotating saw. The blanks are classified according to their thickness by a machine and are then cleaned by churning with water and pumice-stone or sand in slowly revolving barrels. The cleaned blanks are then ground on an emery wheel to remove the horny backs and reduce the blanks to uniform thickness. After grinding, the blanks are softened by soaking in water and are then ready for the finishing machine. This machine is a marvel of ingenuity, for it rounds the edges, carves out the center in the desired pattern to make the face of the button, and drills the holes, and yet finishes from thirty to seventy buttons a minute. The finished buttons are cleaned again with water and pumice and are then polished by treatment with dilute mineral acid in a churn.

Handles for knives and other ornamental implements are cut and polished in much the same way. Often the better parts of the large shells are cut into handles, and the inferior and thinner parts of the same shells are made into buttons. In this way the maximum value is obtained from each shell.

Musical instruments, umbrella handles, picture frames, and many other useful and ornamental objects are often inlaid with mother-of-pearl. Jewelers use it for the manufacture of bar pins, combs, shoe buckles, belt buckles, fountain pens, beads, studs, cuff-links, hat-pins, and the like.

The Italians carve beautiful cameos from pearl shells. The French use mother-of-pearl to make a coarse variety of mosaic called *nacre chinois*. The Japanese make similar ornamental work on lacquer, forming designs of flowers, fruit, and other figures by lining the interior surface with layers of pearl.

The sacred chank shell of the Hindus is utilized in a number of curious ways. Every married Hindu woman of Bengal wears a pair of chank bracelets lacquered in vermilion as a token of her state of matrimony. The custom seems curious to Americans, but perhaps our American wedding rings seem just as strange to the Hindus. In other parts of India the kind of chank bangle worn indicates the caste of the wearer. The shells are supposed to have miraculous medicinal powers and are used for the treatment of a number of diseases. The Hindus also use them in many religious ceremonies, including marriage and funeral rites.

The mother-of-pearl of the abalone is highly prized for its beauty and great brilliancy. So great is the demand for this mother-of-pearl that the shells are worth more than the meats. Some of the shells are black, some red, and others green. They are ground on a carborundum wheel until the desired color is reached, and then are polished further on a felt wheel sprinkled with carborundum dust. Finally the shells are polished on a wheel made of many layers of cotton, on the edges of which tripoli has been rubbed. A single shell yields about fifteen pieces of mother-of-pearl, from which buckles, buttons, watch-fobs, knife handles, ink-stands, cuff-buttons, and napkin-rings are made. Scimitar-shaped paper knives are often cut from the larger shells. In Europe and the Orient abalone shells are also used in the making of inlaid work, such as opera-glass coverings.

Blister pearls are those which are formed on the inner side of the shell of the pearl-bearing mollusk. Their origin is much the same as that of true pearls, for they are formed by the oyster around some irritating object on the inner shell. The excrescence conforms in a general way to the shape of the irritating object.

Abalone blister pearls are very popular in America, where they are utilized in jewelry in many ways for the manufacture of such things as brooches, rings, pins, and cuff-links.

Imitation Pearls and Pearl Essence

The imitation-pearl industry is one of America's novel industries, having been developed during the past ten years. When the World War demoralized the French *essence d'Orient* industry, American chemists at once worked out commercial methods of preparation of this valuable lustrous lacquer, and soon large quantities of it were being manufactured. The Japanese also began making imitation pearls of excellent quality. To-day imitation pearls are cheap because of the stiff competition between the American, French, and Japanese products. Even the poorest country maiden can afford to wear a string of "indestructible pearls" which can be distinguished from those of her wealthy sisters only by an expert.

Few ladies ever dream that the nacre of the pearl is obtained from supposedly useless, foul-smelling fish-scales. Miladi's indestructible pearls are merely solid opal glass beads coated with a lacquer the pigment of which is crystalline guanine prepared from the silvery sheen of fish scales.

The lustrous substance of *essence d'Orient*, with which the imitation pearls are coated, occurs on the scales of most fishes and gives them their characteristic brilliance. When examined under the microscope, this nacreous substance is seen to be composed of various sizes of small blade-like crystals. When the epidermis of the scales is scrubbed off under water, the lustrous particles are suspended in the liquid. The crude liquor so obtained is strained through cheese-cloth and allowed to settle. After the crude essence has been washed several times by decantation, strong ammonia is added and the essence is allowed to stand for a considerable time to permit the digestion of the proteinaceous material. The concentrated suspension is pearl essence.

By other improved methods the lustrous crystals are suspended in acetone, amyl acetate, or other organic solvents, which are solvents of the nitrocellulose or cellulose acetate lacquer. Pearl essence lacquer possesses many advantages over the aqueous suspension, as it may be applied with a brush as ordinary lacquer.

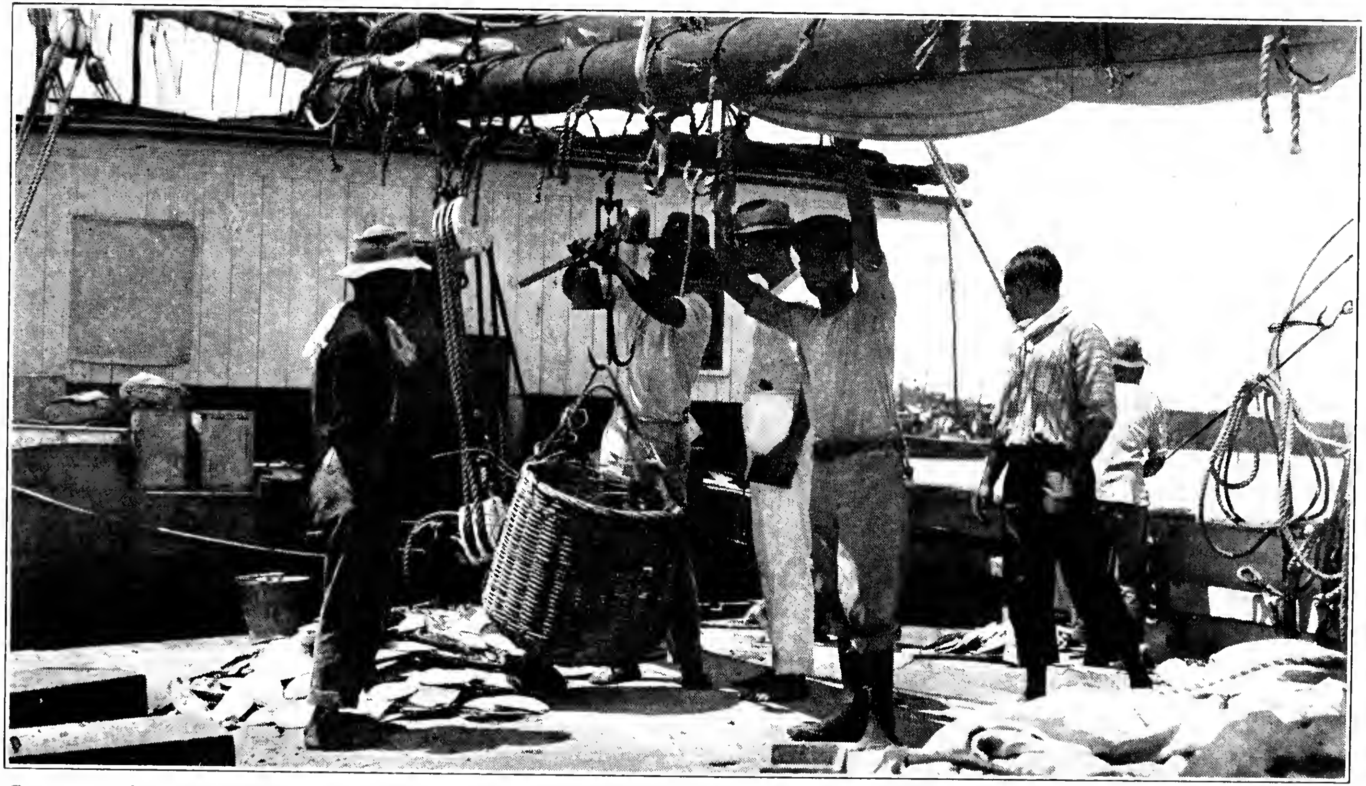
Various grades are made, the distinction resting upon freedom from color and upon the fineness of the crystals. The best pearl essence possesses a brilliant luster and when slightly agitated gives a unique and most beautiful "whorly effect." The most desirable colors are silvery white and slightly pink. Gray or brown shades of color are undesirable. The better qualities of pearl essence have uniformly small crystals. The crystals are roughly proportionate to the size of the fish from which they are obtained. Those from the herring and alewife are smaller and make a fine-grain essence of higher quality than those obtained from the shad.

In making the wax-filled beads, the essence is allowed to settle, the ammonia is decanted off, and pure gelatin or fish-glue is put in, so that a concentrated gelatin solution is made; an antiseptic is

Courtesy of M. P. Greenwood Adams

MALAY PEARL DIVER

Most of the pearl shell obtained on the coast of northwestern Australia is gathered in this way



Courtesy of M. P. Greenwood Adams

WEIGHING MOTHER-OF-PEARL SHELL

At Broome on the coast of northwest Australia added, and if a flesh tint is desired a very small amount of eosin or safranine is added. While hot this mixture is injected with a fine pipette into the bead, which is being revolved on a toothpick spindle. As the gelatin spreads over the inside of the bead, it may be caused to set quickly by brushing a little ether on the outside. The rapid evaporation of the ether chills the gelatin and sets it. When the beads are dry inside they are filled with wax. A mixture of equal parts of Japan wax and paraffin is often used to fill the beads. The cheaper grades of hollow glass beads are blown in molds from tubing. The finer grades are blown individually of a specially prepared soft, colorless glass.

"Indestructible pearls" are made in several different ways. By one process, solid "milk" or "opal" glass beads are dipped in ordinary pearl essence containing some gelatin and allowed to dry. A protecting lacquer of pyroxylin or cellulose acetate in a suitable solvent is then applied to make the coating waterproof. These coatings may be applied alternately several times, and the finished pearl polished with chamois skin and fine chalk.

Another method consists of incorporating the lustrous material directly into amyl acetate, in which the pyroxylin may be dissolved directly, making a lacquer that is applied to the bead. When these solvents are used, the lacquers may be tinted any desired shade of color by the addition of minute quantities of dyes.

The beads for "indestructible pearls" are, as has been stated, of solid opal or milk glass. They are made from tubing, with the hole of a size suitable for the hole through the bead. Appropriate lengths are cut off, the holes are plugged with a refractory material, such as fire-clay or graphite, and the pieces are then heated to the softening point in a revolving iron drum partially filled with powdered talc. The drum is revolved until the beads are all shaped: the heating is then stopped, but the revolution of the drum is continued until they are cooled.

H. F. Taylor, formerly of the United States Bureau of Fisheries, has recently devised a very simple method [1] of preparing a pearl lacquer which possesses certain advantages over other methods. According to his process the fish scales are rubbed in water to remove the valuable lustrous particles. The suspension obtained is drained off and allowed to settle, and the supernatant water, containing whatever blood has been present, is decanted off. The remaining heavy suspension, containing the lustrous particles of guanine, is treated with a digestion mixture of pepsin and glacial acetic acid, and allowed to act forty-eight hours. This completely digests and removes all the proteinaceous matter from the guanine crystals. After the digestion, the surfaces of the crystals are clean, and they now possess the peculiar property of being more readily wetted by ether and certain other non-aqueous solvents. Advantage is taken of this property to obtain clean crystals suspended in solvents of nitrocellulose lacquer: ether is poured into the digestion mixture and

[1] "Pearl Essence: Its History, Chemistry, and Technology," by Harden F. Taylor, Bureau of Fisheries Document 989 (1925).

stands as a separate layer on top. When the container is gently rocked, the lustrous crystals pass from the water into the ether layer, leaving all dirt, organic matter, and the like in the water. Any fatty or waxy substances dissolve in the ether, but these may be removed by allowing the crystals to settle out, decanting the oily ether, and replacing it with clean anhydrous ether. The lustrous crystals are now clean and brilliant, and can be kept indefinitely in the ether or can be easily transferred to ethyl or amyl acetate. Nitrocellulose or cellulose acetate may be dissolved in these solvents, thus forming a pearl lacquer, which is applied directly to the bead.

While *essence d'Orient* may be prepared in unlimited quantities from fish scales, yet it could probably be prepared at a lesser cost from synthetic guanine.

Pearl essence is used in the manufacture of many ornaments other than imitation pearls. Buckles, hat-pins, stick-pins, watch-fobs, and many other objects are often ornamented with this, the most beautiful lacquer. It adds a novel luster to transparent celluloid and bakelite articles. If it were a little cheaper it would find many uses in household decoration.

Glass beads are also covered with the swim-bladder membrane from certain fishes, thus producing the so-called Roman pearls. The swim-bladders of fish are composed chiefly of collagen containing a brilliant natural deposit of guanine crystals. Their principal use is in the preparation of isinglass, but the air bladder of the European smelt (*Argentina sphyræna*) is used in the covering of beads in the manufacture of Roman pearls.

Detection of Imitation Pearls

Although the uninitiated cannot distinguish real pearls from the imitations, a jeweler or any other person familiar with pearls can do so at a glance. The genuine pearl is 2.6 times as heavy as water, is opaque, and is not affected by acetone or amyl acetate, but is readily attacked by strong acids. The hole in a genuine pearl is drilled and therefore does not resemble a hole in a glass bead. The surface of true pearls is somewhat iridescent, giving a faint play of colors, and does not give a well defined reflection; it can be scratched by a sharp knife.

Since the hollow glass bead imitations are glass outside, they give sharp, well defined reflections, and cannot be scratched except with the substances that will cut glass. They are usually light; the wax-filled ones often float on water. The surface is not attacked by any acid except hydrofluoric.

The "indestructible" imitation pearls are lacquered opalescent glass beads; for this reason they are usually translucent and appear yellowish when held before a light. They owe their luster to their coating of pearl essence lacquer, which can be cut or peeled off or dissolved off with amyl acetate or acetone. This coating is inflammable and seldom extends smoothly up to the very edge of the hole. To distinguish between an imitation of this type and a genuine pearl, the two are immersed in acetone; the true pearl will not be affected, but the coating of the imitation will be dissolved.

CHAPTER VII

Precious Coral

CORAL has been taken commercially from the African, Corsican, and Sicilian coasts of the Mediterranean since the time of the earliest records. The ancient Greeks and Romans attempted to account for its origin in their mythology. Ovid relates that when Perseus cut off the head of the Medusa the dreadful face never lost the power of turning things to stone, so that when he hung the head in the branches of a tree the tree was turned to stone. Later the nymphs threw these petrified branches into the sea, where, growing and spreading, they became coral. A variation of this legend has it that the blood which dripped from the head fell upon the shrubs, changing them into coral flowers and seeds, which were drawn beneath the waves by the sea-nymphs.

Pliny says that the Gauls used coral for the decoration of their weapons and helmets, and that the Romans exported large quantities of it to India, where it was highly prized. The Romans hung branches of it around their children's necks to preserve them from dangers such as the falling-sickness and other infantile diseases. Roman women wore it to protect them from sterility and the influence of the evil eye.

In the Middle Ages, even more miraculous powers were attributed to precious red coral. Bartholomeus [1] states that this "stone" was supposed to protect ships and houses from lightning, whirlwind, tempest, and storms. Homes that contained coral were not affected by plagues, feuds, envy, and other influences. Many medicinal properties were attributed to this beautiful substance. It was given powdered as a cure for epilepsy, stomach complaints, night sweats, sores, diseased gums, whooping-cough, disorders of the spleen, teething troubles, insanity, and many other disorders. Even as late as the seventeenth century, powdered coral was administered as a cure for colic and vomiting.

Of course nearly all of the properties attributed to it are without foundation in fact. Since it is merely impure carbonate of lime, a little ground limestone or powdered marble would be just as efficacious a medicine as the finest of coral. The taking of carbonate of lime, however, gives immediate relief from certain stomach disorders caused by the presence of too much acid. In such cases, coral really would possess therapeutic value.

The belief in the miraculous properties of coral is not confined to ancient and medieval times. Even to-day it is worn in Italy to ward off the influence of the evil eye, and by many women as a cure for sterility. In India there are many superstitions connected with its uses. Worm-eaten coral is believed to have magical properties, for many of the natives think that spirits take up their abode in the little

[1] "De Proprietatibus Rerum" (1536).

cavities of the coral. It is also supposed to keep away evil spirits, and on this account it is given as a gift to the dead. It is popularly regarded as possessing the power of warding off cholera and other plagues. A change of color of the coral is supposed to indicate the presence of poison or the danger of illness.

From the Middle Ages to the present time, the control of the coral fisheries has been an object of much rivalry among the Mediterranean communities of Europe. During the Middle Ages the fisheries were dominated by the Italian states. Charles V of Spain obtained control of the Tunisian fisheries, but the Spaniards were unable to hold them, and soon lost them to the French, who retained them until the French Revolution threw the trade open. The British dominated the coral fisheries for a short period early in the nineteenth century, but soon left them to the French and Italians, who have held them ever since. Until the French Revolution, Marseilles was the most important center of the coral trade, but since then the Italian cities of Torre del Greco, Genoa, Naples, Leghorn, and Trapani have become the leading centers.

Nature of Coral

Coral looks like a stone and appears to grow like a plant, yet it is of animal origin. A single branch of living coral is made up of a large number of very small animals, called polyps, which form a sort of colony. When one considers the large islands, such as the Bermudas, that have been raised out of the ocean by these minute polyps which can scarcely be seen by the naked eye, it is extremely difficult to conceive of the tremendous numbers of the little organisms that lived and died in order to rear these beautiful monuments. The huge coral masses commonly known as madrepores, out of which coral islands and reefs are constructed, all commence as a single coral animal which grows by budding; the buds remain attached to the parent, which soon dies, leaving its limestone skeleton.

Biologically, an ordinary coral animal, or polyp, does not differ from a sea-anemone except for the possession of a calcareous skeleton secreted within its basal tissues. The sea-anemones and corals are almost the lowest organized group of living animals. The body is really a simple sac, the orifice of which is inverted and held in position with relation to the outer wall by a series of radiating partitions. One or more rows of tentacles, varying in number and character according to the species, surround the mouth of the sac. It does not possess a distinct intestinal tract; the whole space inclosed within the outer wall contains the digestive juices. The reproducing elements are located on the surfaces of the radiating membranous partitions, which also, in the case of the corals, partly secrete the symmetrical radiating calcareous plates.

The form and color of colonies of coral animals differ widely, depending on the species. Most of the common names of the various species are derived from either the form or color of the colonies, some of the common species being mushroom coral, staghorn coral, star coral, brainstone, and flexible coral.

The *precious coral*, or coral of commerce, is not found in such enormous quantities as the species listed above. This coral differs from the common corals, for the solid, brilliantly colored calcareous skeleton is deposited as a supplementary basis outside the tissues. The colonies of precious coral branch out and appear to grow as a plant or vine. The coral branches, however, do not seek the light as plants do, but spread horizontally along the main stem or trunk, which consists of the lime carbonate secreted by coral polyps which lived many years ago, and is very hard and stone-like in appearance. The branches are covered with a thin, fleshy, reddish rind in which live polyps are embedded. The slender ends of the branches are so soft that they can be easily cut by a knife, since the polyps in this part of the branch have not yet secreted much calcium carbonate. As the coral branch becomes older, these polyps secrete their carbonate, thus forming the stone-like precious coral.

Precious coral is obtained by trimming, cutting, and polishing the branches of coral taken from the ocean bottom. Since it has about the same composition as the mineral calcite, which is composed of crystalline calcium carbonate, it has approximately the same hardness and density as this mineral. Compared to the precious stones, coral is rather soft, but as it possesses some toughness and tenacity it wears fairly well. Although it scratches easily, the scratches do not show, because it is slightly translucent. On account of its carbonate of lime content, mineral acids attack it readily. Formerly it was thought that the coral owed its color to its iron content, but recently it has been shown that the depth of color varies with the amount of organic matter. Black coral and red coral, for instance, have nearly the same composition, except that the former contains about twice as much organic matter. Red coral contains approximately 87 per cent of calcium carbonate, 7 per cent of magnesium carbonate, 1.5 per cent of calcium sulphate, 1.5 per cent iron oxide, 1.5 per cent of organic matter, and 1 per cent of silica and phosphoric acid. The silica, iron oxide, and phosphoric acid do not exist in the coral as such, but as no one knows just how they are combined they are reported in the conventional way.

The Fisheries

Precious coral comes chiefly from the Mediterranean and the Japanese seas. Some also is taken from the Red Sea, but this is black in color, and is not as valuable as the Mediterranean and Japanese coral.

Coral has been fished in many parts of the Mediterranean for many centuries. The most important coral banks are those on the Algerian and Tunisian coasts. Here the coral fisheries are carried on as far as six or even eight miles from the shore and at depths varying from ninety to nine hundred feet. Important coral banks also lie on the coast of Sicily; the most productive is near Sciacca. These have been actively exploited only for the past fifty years, although they were well known even in the Middle Ages. An important fishery also exists along the coasts of Sardinia and Corsica. Ustica and Lipari, small islands north of Sicily, also yield some coral.

Japanese coral is produced chiefly in the southwestern waters affected by the warm ocean current. The Formosa industry is of recent origin and now produces large quantities of excellent coral.

Coral growing in shallow water near the shores is often collected by divers working from small boats, but the largest and most beautiful coral grows in water so deep that it is inaccessible even to divers working in diving-suits. This coral is taken by dredging with curious devices. The dredge boats operating in the Mediterranean are of two sizes; the larger ones are Italian vessels, sailing from Messina, Genoa, Leghorn, and Naples, and range from six to sixteen tons in capacity. They carry a large lateen sail, a jib, and a staysail, and are manned by six to twelve persons, who have eighteen hours' hard work daily for little pay. The smaller boats, which are of only three to six tons in capacity, fly the French flag, although their crews are usually Italian. The larger vessels operate only during good weather, the season being from March to October; and usually they are able to take seven or eight hundred pounds of marketable coral during this period. The smaller vessels often fish the year round and are thereby able to collect four or five hundred pounds of precious coral.

The dredge used in the coral fishery is much different from that employed in taking oysters and scallops. The framework of the Italian *ingegno* is constructed of two crosspieces of oak firmly bound together in the middle, thus forming four long arms, to which ropes about twenty feet in length are attached. Strong, square, wide-meshed nets are fastened to the ropes. A heavy stone or piece of lead fixed to the intersection of the arms of this curious type of dredge causes the *ingegno* to sink and to remain on the bottom while being dragged behind the boat.

As this instrument is hauled over the bottom, coral coming in its path becomes enmeshed in the nets and is carried along until the machine is hoisted to the surface. As might be supposed, many other objects, such as rocks, bits of wreckage, cans, and crabs, are also caught. The procedure is very slow, for the *ingegno* is so cumbersome that much time is required for sinking, raising, and cleaning the instrument and repairing the nets. Usually the process can be repeated only six or seven times each day. Moreover sometimes the nets catch on some snag and are torn completely off, causing the loss of many nets and requiring much time for repairs.

The Japanese use a somewhat similar apparatus, but one which is much lighter and easier to handle. In this fishery, the drag consists of about sixteen nets, each about six feet square, fastened to a strong pole by means of ropes and wires. Each net is weighted, as is also the bamboo bar. The nets are arranged so that those attached close to the pole brush the coral off the rocks, and those which follow catch it and bring it to the surface, when the apparatus is hauled in. Small boats manned with only three or four men are employed in this fishery, for larger boats are not required to carry the relatively light fishing gear.

The Grading and Working of Coral

The rough coral taken by the fishermen is sorted into four grades as follows: (1) dead or rotten coral, which consists of the main stem and the disk-like foot of the coral stock; (2) black coral; (3) red coral of all kinds, with the exception of pieces of remarkable size; (4) the unusual pieces of special size or beauty, which are sold as selected coral.

The working of coral is an important industry in the Italian city of Torre del Greco, where thirty-two hundred workers are employed in the workshops. There are also many establishments in Genoa, Naples, Leghorn, and Trapani. The Italian government has established a school of engraving at Torre del Greco known as the Royal School for Coral Engraving. Instruction is given in the engraving of coral and other materials, such as mother-of-pearl, tortoise-shell, ivory, and hard woods. Clay modeling, designing, inlaying, and other art subjects are also taught. Many experts in carving have graduated from this school, which has aided Italy to retain its leadership in the working of coral.

Many Japanese are also skilled in the carving of coral. They are famous for their miniature human and equestrian figures done in pink coral. The Matsumae collection, which was sold in London recently, was one of the most valuable ever gathered. Single pieces in this collection sold for five thousand dollars. One of the most beautiful of these carvings is that of the God of Wealth, one of the seven gods of luck, which is carved from dark salmon-pink coral. The Japanese produce about sixty thousand pounds of coral and work much of this into beads, cameos, and similar jewelry. Some of the finished product is exported to China and India.

Precious coral is used principally in the manufacture of beads and cameos. Coral beads are made in either spherical or oval form and are strung as necklaces, bracelets, or rosaries. The polished ends of coral branches are often used as watch charms. Larger pieces are sometimes polished and set in the handles of brushes, hat-pins, and the like.

Although coral is highly prized in all civilized countries, the Italians, Spanish, Portuguese, Indians, and other dark-skinned peoples value it most highly for personal adornment, as it shows off to better advantage on dark skins than on light ones. In Turkey it is not only used for personal adornment but is also inlaid in the decorated walls of rooms and employed for the ornamentation of many objects, such as pipes, handles, and the like. The peoples of northern Africa, with the exception of the Egyptians, esteem it highly.

The value of coral varies greatly according to its color and the uses to which it is put, the latter depending mainly on the size. Just now pure white Japanese coral is in vogue; white beads having a small spot of pink are especially popular in America and Europe. Rose pink coral is popular in earrings and in the form of cameos, which are worn as brooches or set in rings. Cameos are also hung as pendants for necklaces and watch-fobs and even for earrings. The Chinese formerly used the finest of coral beads for buttons on the official caps of the mandarins. The use of coral in the making of nursery rattles and bells is a custom which has survived from medieval times, when coral was generally believed to protect children from harm.

Selected pieces of coral of the color in vogue sometimes command as much as five hundred dollars an ounce. The average-sized pieces of common red coral usually sell at about ten dollars an ounce, while the small fragments, called collets, often used for the making of children's necklaces, are worth only a dollar an ounce.

CHAPTER VIII

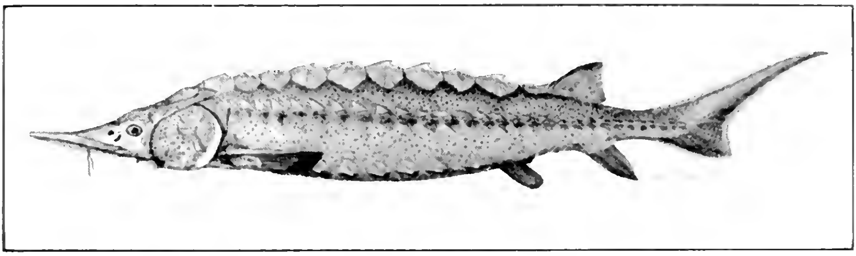
Fishes [1]

FISH interest nearly every one. Some enjoy watching them play in a sparkling brook, others devote a large part of their vacations to the catching of game fish, while those of a practical and mercenary turn are more interested in the food value of the fish which are caught in such enormous quantities.

In their anatomy, growth, reproduction, and habits, fish are so different from the other common animals with which every one is familiar that they make a fascinating subject for study. How many persons can explain just how a flying fish flies, or how to tell the age of a fish? Some may know why the salmon leaves its happy home in the ocean to make a hazardous journey a thousand miles up a river, but few can tell why the eel goes to sea or where he goes when he is in the sea. Such points are not only important from the biological point of view but are also of great interest to the sportsman and the commercial fisherman.

The food and life history of our commercial fish are of more public importance than most persons

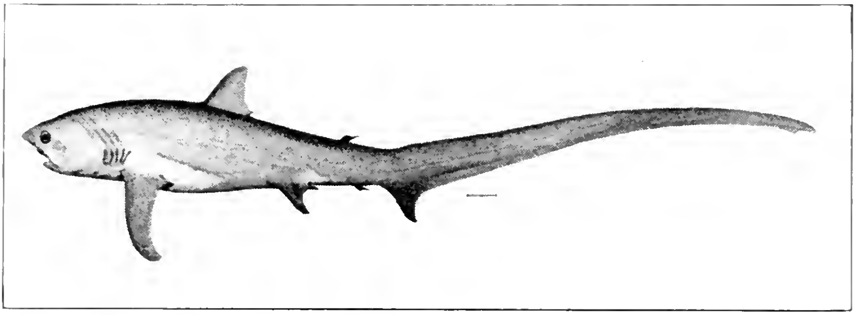
[1] This chapter was prepared mainly by Dr. Samuel F. Hildebrand, director of the U. S. Bureau of Fisheries Biological Station at Beaufort, North Carolina.



Courtesy of U. S. Bureau of Fisheries

A YOUNG POTOMAC STURGEON

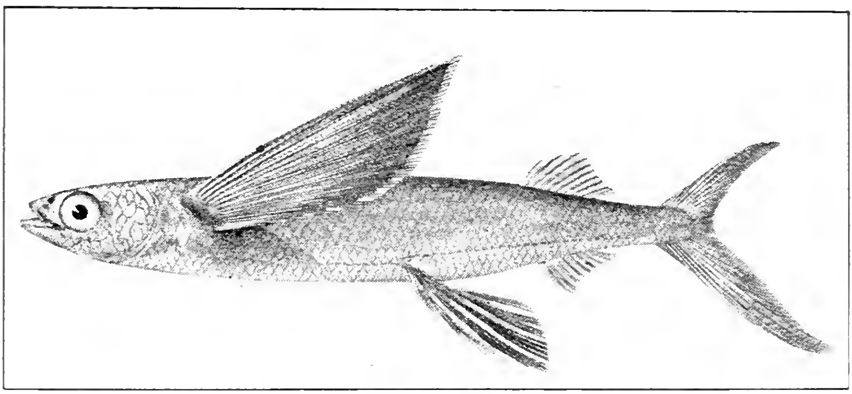
This fish has long rows of bony plates instead of scales



Courtesy of U. S. Bureau of Fisheries

A FIVE-FOOT THRESHER SHARK

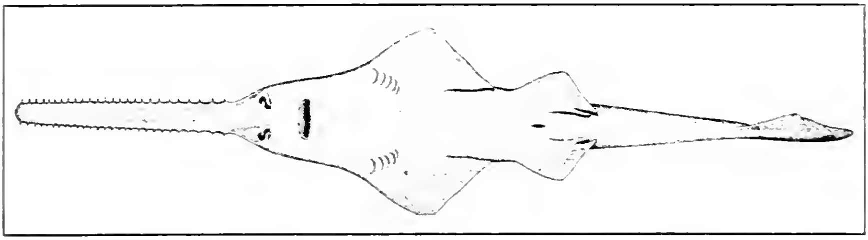
This fish has an unusual tail fin



Courtesy of U. S. Bureau of Fisheries

A FLYING FISH

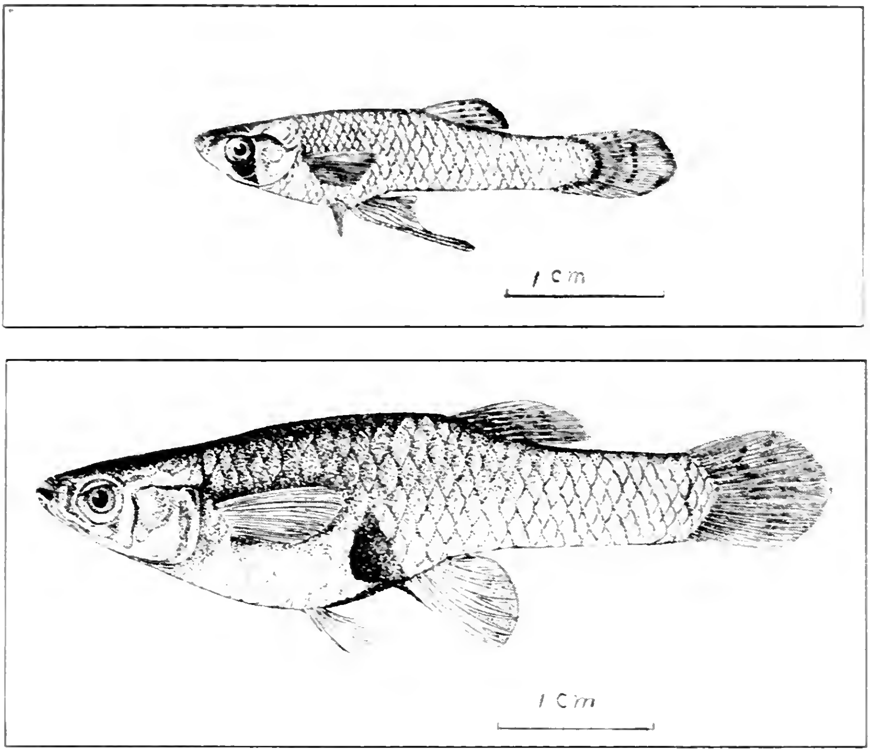
By use of its wings, this fish can soar considerable distances through the air



Courtesy of U. S. Bureau of Fisheries

A SAW-FISH

This fish uses its grotesque jaw for both defensive and offensive purposes



Courtesy of U. S. Bureau of Fisheries

MOSQUITO-EATING TOP MINNOWS

Of the genus *Gambusia:* the upper is the male and the lower the female realize; their study is of great value in preventing the destruction of our fisheries by the pollution of the waters and by over-fishing.

Since fish are the animals of greatest economic importance found in the sea, a whole section has been devoted to a consideration of their characteristics. In this chapter will be presented, in a rather abridged and simplified manner, the more important and interesting facts concerning the physiology, life history, and habits of fish.

Characteristics of Fish

What is a fish? This question immediately brings to mind animals that live in the water. However, all that glitters is not gold; similarly, all animals that live in the water are not fish. Our definition, therefore, must be so worded that it will include only those aquatic animals which form the subject of this chapter and which, for present purposes, we may call *true fish*. This group of animals may be briefly defined as cold-blooded creatures with a backbone, with legs and arms represented by fins or rudiments of fins, and living in the water in which they breathe by means of gills. This definition excludes many forms frequently called fish, as for example the oyster and clam, which are often spoken of as shell-fish. It also excludes the starfish and the jellyfish, as none of these animals have a backbone. The whales and their allies are excluded because they have lungs and do not breathe by means of gills.

It is utterly impossible to describe the shape or form of the body in answer to the question, What is a fish? For the shapes are too various. Some species are very long and slender, others are plump, still others are narrow and deep, or low and broad. The eels, although not related to the snakes, are similar in shape and serve as examples of very long slender fish. The long slender body enables these animals to enter comparatively small crevices, dense vegetation, and débris, and to seek food in places commonly inaccessible to other fish.

Most of our common food fishes are more or less roundish but frequently somewhat deeper than broad, tapering both toward the head and the tail. Since such a shape offers little resistance in the water, the roundish species often are able to swim with great speed, which is a marked advantage, as many of them prey on other fish.

The butter-fishes, the beautifully colored angel and butterfly fishes, and the porgies have very deep and narrow bodies. Fish of this shape cannot enter very shallow water, but they can pass through narrow passageways, and the compressed body does not prevent rapid swimming.

The skates and rays compose a group that is the opposite in shape from the ones just described, for they are very broad laterally and thin vertically. The fishes of this group have their mouths more or less underneath the head, and they usually lie close to the bottom where they obtain their food.

The flat fishes, that is, the flounders and the soles, are all deep and narrow and are peculiar in that they swim on one side instead of vertically. Their anatomy is remarkable, for they have a twisted skull with both eyes on one side of the head. The very young, however, have the eyes on opposite sides as in ordinary fishes. As the fish grows and habitually swims on one side close to the bottom, the eye on the downward side, that is, the one turned away from the light, begins its migration toward the light, for of what use would an eye be that is turned away from the light and more or less buried in the sand? Nature usually is economical and makes every organ serve a purpose. Therefore in the flat fishes provision is made to bring the otherwise worthless eye around to the light, even though such a drastic measure as the twisting of the skull is involved.

The lump-fishes, the puffers, the burr-fishes, and the porcupine fishes are all rather globular in form. They cannot swim rapidly, and they cannot escape from their enemies effectually through rapid retreats. Therefore nature has provided them with other means of defense. The lump-fishes are covered with bony plates and the burr and porcupine fishes with spines. The puffers, the burr, and porcupine fishes are all capable of inflating the body, thereby making themselves much larger in size and causing the spines and bristle to stand erect.

The most peculiarly shaped fishes live in the deep seas. Some of these are nearly all head, others have enormously large mouths, still others are provided with very long tails of many shapes, each species being adapted to the peculiar life it leads.

It is an interesting fact that in many species the males are smaller than the females. The greatest difference in size of the sexes occurs among the top-minnows, for the male is often not much more than half the length of the female.

Animals living on land generally are covered with hair or feathers. Fishes, however, are, with some exceptions, covered with scales. Scales in fish are very diverse. The tarpon, for example, has very large scales, whereas the cod has small ones. Scales generally are roundish. The common eel, however, has elongate and somewhat rectangular ones, partly buried in the skin. Scales are very helpful to the student in classifying fish and are also very useful in determining the age of a fish, for they bear markings which are usually significant. In determining the age of a fish special attention is given to the rings in the scales, for these form very close together when growth proceeds slowly, and when growth is rapid they form further apart. Therefore, during winter, when the weather is cold and digestion proceeds slowly—for the fish is a cold-blooded animal—little growth is gained, and the rings become very crowded. Similarly, during the summer when foods are plentiful and the weather is warm, digestion is much more rapid, and growth is quickly made, the rings form much further apart. Although the study of the scale for determining the age of fish is still quite new, it is now possible to state the age of a given specimen of several different species with a considerable degree of certainty.

The chief value of the scale to the fish is for protection, and those that have no scales generally have other means of protection. The catfishes, for example, have large fin spines which bear barbs and are formidable weapons. In some of the catfishes poison glands in addition are provided, and an extremely painful poison is introduced with each prick of the spines. The porcupine-fish, which has no scales, is covered with long quill-like spines; the sturgeons bear long rows of bony plates; the trunk-fish is incased in a bony box; and the sharks have an extremely tough skin covered with shagreen.

The fins, as stated in our definition of a fish, take the place of the limbs in higher vertebrates and serve a similar purpose, for they are the organs by means of which the fish balances and propels itself in the water. The fins are commonly seven in number. Three fins are single and in a vertical plane, and the other four are paired. One pair is attached to the shoulder girdle and corresponds to the fore limbs of mammals; the other pair is attached to some sort of pelvic girdle and corresponds to the hind limbs.

The herrings and many other fish have a single fin on the back. Others like the mullets have two such fins. When two such fins are present, the anterior one generally is composed of spines. The codfishes, however, have three fins on the back and two below the body, behind the vent, all composed of soft rays. The mackerels differ from other fish in having a whole series of small fins both above and below the tail. The skates and rays, which live and feed on the floor of the waters they inhabit, have no fin underneath the body, probably because such a fin would be an obstacle subject to injury, rather than an aid. The shoulder fins are very small or wanting in some of the flatfishes (soles), but are present in a variety of shapes and forms in other fishes. In the skates and rays they form a very broad wing-like fleshy expansion. In the flying fishes these fins are also long and broad but not fleshy, resembling the wings of birds. As a matter of fact they are used in a measure as wings, for the flying fishes are capable of "flying" a distance of a hundred yards or so. The "wings" in these fishes, however, are not capable of movements like the wings of a bird; all the momentum is gained in the water, principally by the tail fin supported by powerful muscles, the shoulder fins merely aiding the fish to stay in the air after it has made its powerful leap, just as the motionless expanded wings of a bird keep it from falling directly to the earth.

All the other fins, likewise, are subject to great variations. The tail fin is forked in some species, round or pointed in others, with all manner of intermediate shapes. This fin quite probably is the chief organ of propulsion, whereas the other fins more nearly serve the purpose of balancing organs. In the top-minnows which give birth to live young, the fin situated just behind the vent has a peculiar connection with sex, for in the adult male it is always modified and serves as an intromittent organ in conveying the sperms from the male to the female. The top-minnow now commonly known as *Gambusia*, widely used for destroying the immature mosquito, which lives in the water, belongs to this interesting group of little fishes.

The fins in fishes, unlike the arms and legs of higher vertebrates, regenerate; that is, they very conveniently grow back when broken or bitten off. The regenerated parts, however, are often more or less twisted and do not always look quite like normal fins.

Fish usually are so intent on finding something to eat and so persistent in their search for food that one is led to believe that they live only to eat. If that is the main purpose of their lives, then it follows that the mouth is the most important part of their anatomy, for the food of fish is not won by the toil of the hand, as in man, but is captured as well as eaten by the mouth. Some fish feed on very small animal and plant life, and others feed on large organisms. Fish having small mouths generally feed on small animals and plants. Since fish usually gulp their food, instead of taking it a bite at a time, their mouths must be large enough to receive whole whatever is eaten. It does not follow, however, that all fish with large mouths feed on large organisms, for some fish with big mouths merely take great mouthfuls of water and pass it over their gills, which are provided with a special screening apparatus whereby minute organisms are removed from the water, and then, instead of swallowing the water, they let it pass out at the gill openings. The pipe-fish and the goose-fish offer two extremes in size of mouth. The pipe-fish has only a very small opening for a mouth at the end of a long tube-like snout, whereas the goose-fish has such a large mouth that in some regions it is known as "allmouth." Mouths of many intermediate sizes and shapes are numerous. Some fishes have inferior mouths, that is, mouths below the head, as in the sturgeons, sharks, and skates. Others have mouths opening upward, as in the goose-fish already mentioned. The most common form of mouth is of moderate size, and is terminal and directed slightly upward.

Interesting, in fact, grotesque developments of the jaws take place in some fishes. In the half-beaks, for example, the lower jaw is developed as a toothless, sword-shaped appendage, reaching far beyond the mouth and frequently being longer than the rest of the head. In the saw-fishes the upper jaw is greatly extended. Furthermore the sword-shaped projection is provided on each edge with a row of large teeth giving it the appearance of a double-edged saw. In the gars, both jaws are excessively elongated, and each is provided with long slender teeth. The purpose of the unusually developed jaws, in at least some of the species, is difficult to explain. In some they serve as weapons of defense, in others of offense, and in still others of offense and defense.

Many fish, as already stated, gulp their food and therefore do not need teeth to masticate it. Nearly all fishes, nevertheless, have some sort of teeth, varying greatly in size and shape among the species. Frequently the teeth serve only to grasp and to hold the prey until it can be swallowed. Such teeth generally are sharply pointed and directed inward and backward, as in the weakfishes. Sharks often have teeth directed inward and backward, with broad bases surmounted by triangular cusps with finely and sharply notched cutting edges. Teeth of this description not only are suitable for grasping but they also will cut. Sharks with such teeth, therefore, are able to take big bites from other sharks and other animals. The barracuda of the tropics is another fish with large sharp cutting teeth set in powerful jaws. This fish with its ferocious-looking mouth is feared more by bathers than the most vicious shark.

Large coarse teeth, suitable for cutting as well as crushing, are found among the trigger-fishes. A trigger-fish occurring on the Pacific coast of Central America, at the size of about thirty inches, has teeth not very unlike those of man and certainly quite as large and massive. Teeth suitable only for crushing also occur among fishes. The eagle-ray, for example, which feeds largely on hard clams, has broad blunt teeth arranged like bricks in a pavement. Finally very small teeth are present in the herrings, mullets, and other fishes which feed very largely on minute animal and plant life screened from the water or extracted from the mud. The common shad, for example, has minute teeth only when young, losing even these as it matures.

Many fishes have teeth on the bones in the roof of the mouth, on the tongue, or on the bones in the throat, in addition to the ones on the jaws. The most peculiar place of all for teeth occurs in the butter-fishes, which have hooked teeth in the sacs situated in the esophagus.

It has been shown that some fishes have little or no use for teeth. Similarly some fishes have no use for eyes. Those species that live continuously in the dark, such as the cave-dwelling fishes, for example, have only rudiments of an eye and are entirely blind. Even the species living in shallow water where there is an abundance of light generally have eyesight rather poorly developed. Movements in the water and no doubt some movements above the water are detected, but it is doubtful that there is any accuracy about their vision.

The eye, as well as other organs mentioned, presents great variations. Some fish have very small eyes, as in the star-gazers whose eyes are mere dots on the dorsal surface of the head. In the catalufas the eye is proportionately very large, for a specimen eleven inches in length has an eye approximately one and one eighth inches in diameter.

The sense of hearing, like that of sight, appears to be imperfectly developed. In fact, it is doubtful if it consists of much more than detecting disturbances in the water. Fish have no external ear, but have an inner one, consisting of a chamber in which are situated the ear-stones or otoliths. The sense of hearing may be assisted in some species by certain sense organs located in the lateral line that consists of a series of pores along the side, connected with tubes richly supplied with nerves.

It has been quite definitely proven that some fish, at least, can detect odors, but this sense is probably even more imperfectly developed than sight or hearing. Nostrils in fishes are visible externally only as pits in the snout, or rarely they project in short tubes; but they never have a communication with the throat, as in the higher vertebrates.

The gills, as has already been stated, have the same function in fish that lungs have in the air-breathing vertebrates. Most of our common food fishes have four pairs of gill-arches, all those of one side being in a common gill-chamber which has a single external opening. The gill-chamber is situated just back of the mouth and is well protected by bony plates known as gill-covers.

The gills consist of bony arches to which reddish fringes are attached. Each fringe is provided with a small bloodvessel. The fish, as it swims with open mouth, "drinks" great gulps of water. It, however, does not swallow this water, but lets it flow over the gills and out at the gill-openings. In this way the fish breathes, for the flow of water over the gills means exactly to the fish what inhaling and exhaling air means to man. The constant flow of water over the gills brings the free oxygen in the water very close to the blood which circulates through the minute bloodvessels present in the almost countless gill-fringes. It is through the thin walls of the gill-fringes that the exchange of oxygen and waste gases takes place. This process, therefore, is very similar to that which occurs in the lungs of air-breathing animals.

Many fishes, in addition to the gill-fringes, have at least the anterior arch provided with teeth or bristles, called gill-rakers. In those species in which they are numerous and close set, they serve the purpose of a screen for removing from the water the small free swimming organisms which constitute their food.

Many fishes have a transparent or translucent body in the abdominal cavity, close to the back. This body, which is inflated with gas, is called the air-bladder. It is in a measure comparable with the lungs of air-breathing vertebrates and occupies a similar position. When rudimentary lungs are developed in fishes, as for example in the fresh-water gar, they consist of a modified air-bladder.

The air-bladder probably has no connection, when normally developed, with breathing. It seems to be chiefly an organ of equilibrium, aiding the animal in rising and sinking in the water; and in some species, as in the croakers, it is associated with the voice. The sound made by the croaker, which probably denotes distress, is so loud that it can be heard at a considerable distance.

It has already been indicated that the food of fishes is varied. Obviously various digestive systems are required. In general, a short alimentary canal is associated with an animal diet and a long one with a vegetable diet. A few fishes, living largely on food extracted from mud, like the mullets, have a gizzard something like a chicken; the sharks and skates, as well as a few fresh-water forms, have "leaves" in the intestines, forming what is known as the spiral valve. Many fish also have at the pyloric end of the stomach blind sacs which are sometimes quite long and numerous. They correspond somewhat to the troublesome appendix in men.

The color in fishes varies as greatly as it does in birds, ranging from a somber gray to snow white, metallic blue, green, purple, and crimson. Nearly all fishes are darker above than below, many of them being pale underneath.

The most brilliantly colored fishes are found in the tropical seas and principally among the inhabitants of coral reefs. Many fishes bear protective colors, as is shown by the fact that individual fish of the same species vary in color according to the surroundings in which they are taken. In other words, fishes like the chameleons change their color more or less to correspond to the background upon which they dwell.

Color changes are much more highly developed in some species than in others. Perhaps the most striking example of color adaptation among the fishes occurs in the flounders. It has been shown experimentally that the southern flounder, if placed on backgrounds of various shades and patterns, simulates them to a surprising degree; that is, when placed on red, it turns red, on yellow it turns yellow, and so on, making it possible to produce in this fish any color desired. Furthermore when it is placed on fine sand it not only acquires the color of the sand but the markings on the body become small; when placed on coarse shells the markings become larger, showing that both the color and the pattern are simulated.

Foods

Fish eat a very large variety of foods, including many plants and practically all aquatic animals of suitable size. The majority of the species subsist on an animal diet and are said to be carnivorous. Those feeding on plants are referred to as herbivorous fishes.

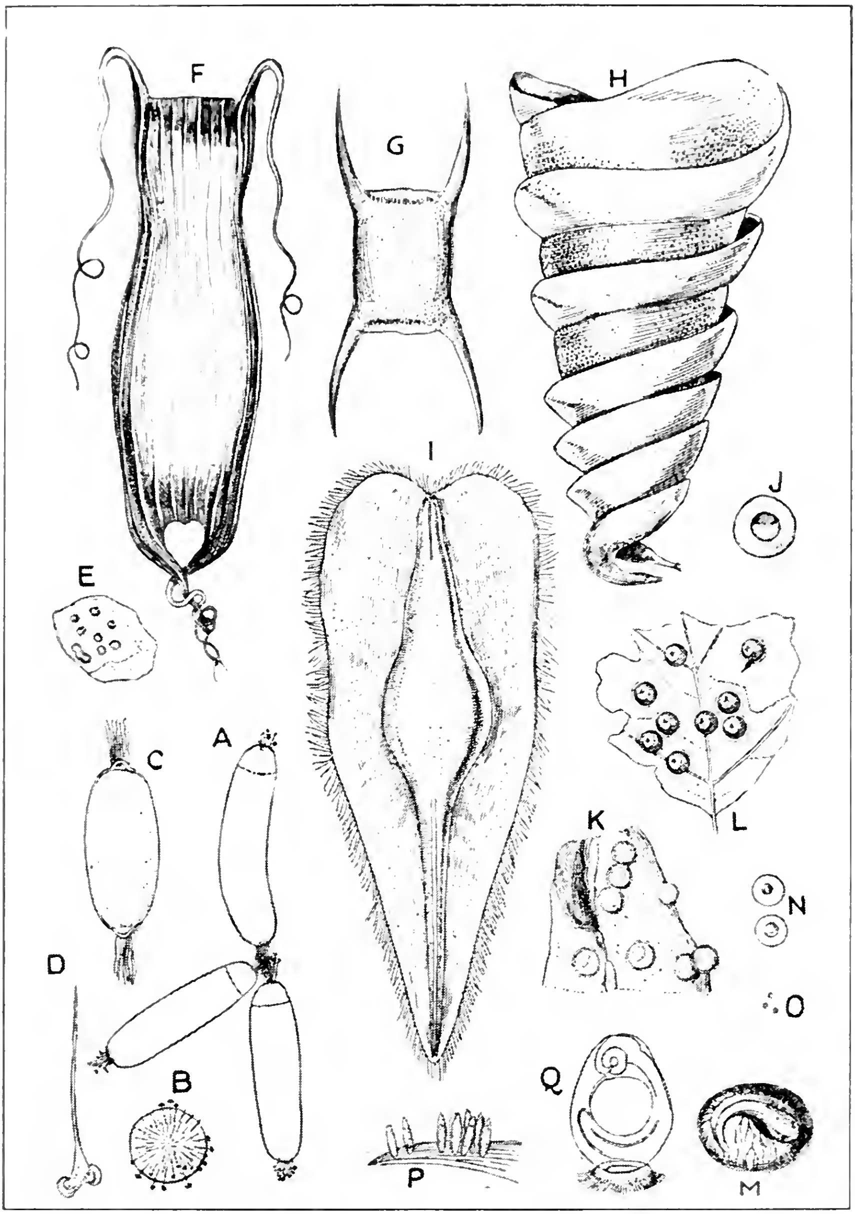
The size of the fish generally offers no suggestion at all as to the kind of food consumed, because some large fish feed only on minute organisms, whereas some small ones feed on comparatively large forms of life. The structure and size of the mouth, the teeth, the gill-rakers, and the alimentary canal, however, frequently afford a clue to the general type of food eaten. To determine the particular animals and plants upon which the various species subsist is much more difficult, for it requires an examination of the contents of numerous stomachs. Certain species, as for example the menhaden and the mullets, feed on minute organisms. In the study of the stomach contents of such fishes a microscope is required. This adds to the difficulty and greatly to the tediousness of the work. In those species which feed on large foods, the undigested parts often are fragmentary, making identification difficult and uncertain. Furthermore the food of the young usually differs very considerably from that of the adults, and not infrequently stomachs are empty.

It is an interesting fact that whereas some species, including large ones, feed on microscopic organisms, others take tremendously large forms in proportion to their size. Certain fishes at times have been known to swallow other fish longer than themselves. The writer once caught a tropical fresh-water goby fourteen and a half inches long which had partly swallowed a goby of a different species eight and a half inches in length. The head of this "morsel" was in the stomach and partly digested, whereas the tail still projected from the mouth.

Some species, particularly those that strain their food from the water in the form of microscopic organisms, appear to feed constantly, for they do not acquire their food in large quantities at one time. Others, as has been already shown, gorge themselves at one gulp and then, of course, cease feeding until their meal is digested and hunger prompts a renewed search for food. The goose-fish, which feeds on almost any kind of animal life of suitable size, frequently contains within its stomach a quantity of food equal to half its own weight.

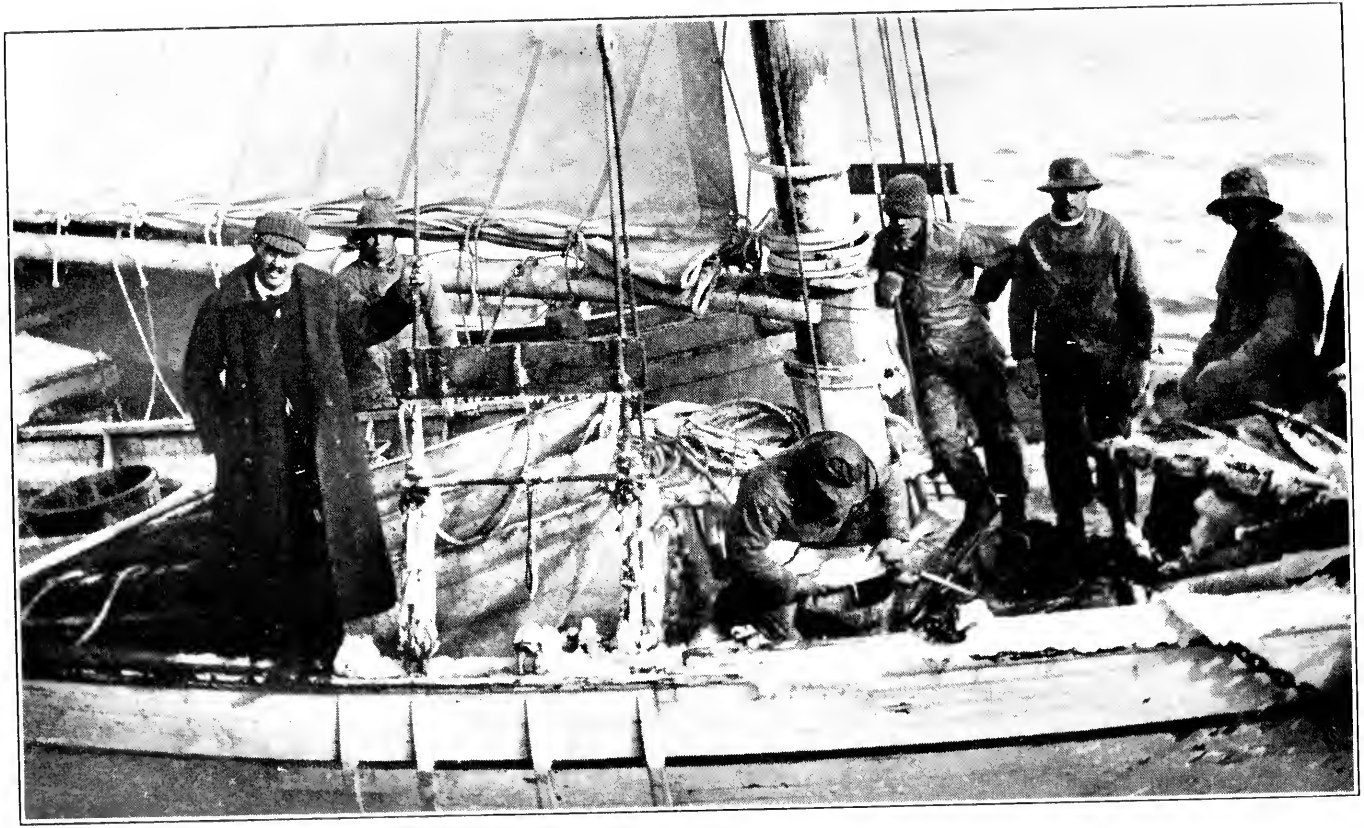
It has already been stated that the majority of our fishes live wholly or partly on an animal diet. Many animals eaten by fish in turn feed upon other animal life. The original source of food of all animals consists of plants, and therefore, in the final analysis, all fish depend upon the plant kingdom for food. The close relationship, that is, the dependence of one form of animal life upon another and their final dependence upon plant life, has generally not been given sufficient study. The decline in the abundance, or the total disappearance, of certain fishes from various waters has been charged to over-fishing, or to the presence of introduced species, whereas in reality the main cause of the decline was a break somewhere in the chain of food supply. Pollutions incident to an ever-increasing population and consequent industrial development without doubt constitute the chief cause for the scarcity of certain fish foods, resulting in a decline in previously abundant species of fishes. Some of our waters have become so strongly polluted that adult fish, even, are unable to survive at or near the source of contamination. It is highly improbable that young fish, or the minute organisms upon which they feed, could live in such waters. It is evident, then, that a study of the effects of wastes thrown into the waters must go far beyond a test of the toxic effects they have upon adult fishes. It is also clear that the absence of dead fish does not necessarily indicate an absence of pollutions harmful to the fisheries. It is evident furthermore that pollutions may affect our fisheries to a far greater extent than is generally known.

Pollution and a consequent shortage of food is not, however, the sole cause for the decline of some of our most important fisheries. Over-fishing, fishing during the spawning season, reckless destruction of young and undersized fish by certain types of fishing gear, all contribute toward the same end. The clearing of forests and drainage for agricultural purposes, too, are contributing causes. Dams and other obstructions which prevent fish from reaching their spawning grounds are not to be overlooked as important causes for the decline, for such obstructions are especially detrimental to the perpetuation of the species which come from the sea and ascend fresh-water streams to spawn. The salmons, shad, alewives, striped bass, and sturgeon, all included in this class, are of first-rate importance among food fishes. Interference with the migrations of these species to their spawning grounds, and pollutions preventing the hatching or the development of the



EGGS AND EGG-CASES OF FISHES

A and *C*, Hag-fish. *B* and *D*, Terminal processes of hag-fish eggs. *E*, Sea lamprey. *F*, Shark. *G*, Skate. *H*, Port Jackson shark. *I*, Chimæra. *J*, Lung-fish. *K*, Fresh water gar-fish. *L*, Sturgeon. *M*, Catfish. *N*, Sea bass. *O*, Shad. *P*, Blenny. *Q*, Enlarged blenny egg showing mode of attachment.



Courtesy of U. S. Bureau of Fisheries

TAKING COD EGGS FOR BUREAU OF FISHERIES

The Bureau annually hatches a billion eggs and releases the young fish in the sea young, cause a great economic loss to the fisheries of the United States.

Migrations

It has been shown that some fish make migrations for the purpose of spawning. The salmons, shad, alewives, striped bass, and sturgeons migrate from salt to fresh water for that purpose, and are said to be anadromous. The fresh-water eel, on the other hand, is catadromous, for it migrates from fresh water to the sea to spawn. The general movement of the cod is reported to be shoreward during the spawning season. All species, however, do not make special migrations for the purpose of spawning, but deposit their eggs on suitable grounds in the general vicinity of their habitat.

Migrations for food are made to a greater or lesser extent by all species. It is readily conceivable, however, that fish which travel in schools have to cover more space to find sufficient food than the solitary dwelling ones. Migrations brought about by the season of the year, or by temperature, are so closely associated with migrations for food that it is frequently difficult to determine whether the movement toward warmer water is for the purpose of escaping from a low temperature or to find a more abundant supply of food.

It is not surprising that some marine fishes wander considerable distances in their watery home. It is even possible that occasionally a few of the wandering species may cross an ocean. On the other hand, the majority of marine fishes probably do not travel far; and, remarkable as it may seem, they generally stay within comparatively restricted areas.

In general the geographical range of fishes appears to be limited, first, by barriers of some sort; second, a fish may reach a certain locality and be unable to maintain itself there; and, third, it may maintain itself but undergo such pronounced changes in the new environment that in time a species distinct from the original type may be evolved. The most common barriers hindering fish from becoming more widely distributed consist of land, of higher and lower temperatures, and of shallow and deep water. It is, of course, well known that some species cannot withstand a high temperature while others require warm water. A fish from tropical waters would meet death just as certainly as an Arctic fish, if an exchange of waters at their normal temperatures were to take place. Similarly deep water would mean death to the shoal-water fish just as surely as shoal water would be fatal to the deep-sea fish.

Most of our common food fishes live in comparatively shallow water near shore; many enter bays and inlets; some enter estuaries of streams; and several ascend fresh-water rivers. The swordfish, the tilefish, the red snappers, the halibut, and to a certain extent the cod, however, are common and important food fishes which generally remain some distance offshore.

Some of the common marine fishes are pelagic in their habits; that is, they swim and feed in open water at or near the surface. The menhaden, the mackerels, and the common herring, all highly important commercial species, belong to the pelagic group. Examples of the opposite extreme, namely, of fishes dwelling on the bottom, are the flatfishes, the croakers, the black drum, the kingfishes, and the skates and rays. Many marine fishes cannot be classed either as surface or bottom dwellers, for they may be at the bottom or at the surface, or they may occupy intermediate depths. Among this large and varied group are the cod, the sea-basses, the weakfishes, the bluefish, the mullets, the spot, the butterfishes, the groupers, the grunts, the snappers, the porgies, and numerous others.

Spawning and Reproduction

Spawning in fishes occurs at more or less definite periods of the year, the season varying among the species. The majority, however, spawn in the spring and summer. Most of the salmons, the striped mullet, the cod, the spot, some of the flounders, and the menhaden are among the exceptions, as these all spawn during the fall and winter. The spawning period in some species is very short; in others it is so protracted that it extends over several months.

Nearly all fishes have more or less definite spawning grounds. The spawning grounds also are the feeding grounds for the young for some time after hatching. As the early larval stages, when the fish first begin to feed, are probably the most critical of their lives, the condition of the spawning grounds is extremely important. It is readily understood that if the proper food on account of weather conditions, pollutions, or other causes is not present, the young fish will perish. The periodical fluctuations in the abundance of various species which frequently are noticed are probably in a large measure due to favorable or unfavorable conditions prevailing on the spawning grounds. An unfavorable spawning season of any species is certain to be reflected in the commercial catch at a time when the fish of such a season should reach a marketable size.

In most fishes the eggs are fertilized at the time they are laid. In some forms, as in some of the skates and rays, the eggs are fertilized internally and sometime before they are laid. In some of the top minnows, as for example in *Gambusia,* the important mosquito-eating fish, the eggs are fertilized and also hatched internally. The young are then brought forth alive as well formed fish. Many of the sharks also produce live young, and it is among these animals that the nearest approach to the process of reproduction in mammals is found in fishes, for the embryo shark probably obtains a part of its nourishment from the blood of the mother shark. The baby shark, however, is not suckled and receives no attention whatever from the parent after birth.

The care of the eggs and the young for some time after hatching is not unusual among fishes. The members of the large sunfish family and the sticklebacks build nests and guard their eggs and young, and many of the marine catfishes have the interesting habit of transferring the eggs to the mouth of the male, where they are hatched and where the young are guarded until they are ready to go out and shift for themselves. In the pipe-fishes the male has a pouch, consisting of membranous folds, under the tail or under the abdomen for receiving the eggs from the female. The eggs are fertilized and neatly placed in rows in the pouch where they remain until hatched. The majority of fishes, however, prepare no nests and leave the eggs to their fate after they are laid.

The number and size of the eggs produced vary greatly. They are fewest in those species in which they are fertilized and hatched internally, and in general they are fewer in those species which produce large eggs than in those which produce small ones. In some of the species, as for example the cod, one female may have several millions of eggs during a single spawning period, whereas the red salmon, which produces comparatively large eggs, probably rarely has more than about three thousand.

Many marine species produce floating eggs; others have demersal eggs. The floating eggs generally are single. Occasionally, however, they occur in gelatinous masses. The eggs of the goose-fish, for example, are enveloped in a gelatinous, floating veil, often measuring over a yard in width and eight to ten yards in length. The demersal eggs, also, may be laid singly or in masses. Some species deposit their spawn on a sandy or gravelly bottom, and others seek vegetation. The silversides, for example, deposits its eggs among vegetation to which they adhere by means of gelatinous threads.

Some of the skates lay eggs which have horny shells and are more or less rectangular in shape with a projection at each corner and are often three or four inches long and two inches in width. The gaff-topsail catfish has large spherical eggs about an inch in diameter. The foregoing are examples of the largest eggs produced in fishes. Most fishes have much smaller eggs, the majority producing eggs less than a tenth of an inch in diameter.

The time required to hatch fish eggs varies from several hours to a month or more. In general, small eggs have a shorter period of incubation than larger ones. The development of the egg is generally affected by heat, as high temperatures hasten and low temperatures retard development. A single degree in temperature lengthens or shortens the incubation period in salmon about five days.

Newly hatched fish usually are quite transparent; they have relatively large heads and eyes, and the fins are not separate at first but appear as fleshy folds. Generally when the young fish is a few weeks to a month or so of age, it resembles the adult sufficiently to admit of its identification. In a few species, however, the young are very different from the adults and pass through a metamorphosis before acquiring the adult form. In the eels, the lady-fish, and the big-eyed herring the young are ribbon-shaped and transparent. In this stage they grow to a length of three inches or more. Then, in the process of becoming rounded and shaped like the adult, an actual shortening of the body takes place.

The early growth period in fishes, also, frequently is accompanied by changes in the mouth, the teeth, the gill-rakers, and the alimentary canal. Such changes usually are accomplished for the purpose of making provision for a new diet, for it has already been shown that the food of young fishes is often different from that of the adults.

Effects of Fishing

Over-fishing, fishing during breeding seasons, taking and destroying young fish, have been carried on to such an extent that previously important fishes have ceased to be of commercial value. This appears to have taken place in some localities with respect to the salt-water sheepshead. The bluefish and the halibut appear to be destined to suffer the same fate. The possibility of exterminating a species through fishing, however, seems very remote. The destruction of spawning grounds, or making them inaccessible by dams and other obstructions, or by destroying their usefulness through pollutions, may in the end exterminate species spawning in the rivers and near shore.

The status of our fisheries is such that conservation deserves renewed, intelligent, and earnest attention. Our knowledge of the habits and life history of many species is still inadequate. The effects of agricultural drainage, of the disappearance of our forests, and of industrial development upon our fisheries has not been adequately studied. Sane and sound means of conservation have not been fully developed, and much work remains to be done.

Present-day measures of conservation consist mainly in restricted fishing; that is, in providing a closed season when no fish may be caught, or in making fishing illegal in certain waters which are known to be passageways for the fish to their spawning grounds, or to be actual spawning areas. Another measure consists in setting a size limit below which individuals of any given species may not be caught or marketed. The elimination and prevention of pollutions, too, are receiving considerable attention. In the conservation of our marine fisheries particularly, the utilization of many species which are now wasted deserves consideration.

It is a sad fact that many fishermen do not appear to understand the necessity of conservation. Too many of them are concerned only with the present and are quite willing to let the future take care of itself; consequently many of them are inclined to regard such measures as restricted fishing, the setting of size limits, and other regulations as an encroachment upon their inalienable rights. It is evident that most measures of conservation will be largely ineffective without the support of those who are engaged in the industry. Therefore a contribution toward the awakening of all fishermen for the necessity of conservation will be a contribution toward preserving an industry and a source of food for the future.

CHAPTER IX

America's Fisheries

THE origin of the fresh-water and coastal fisheries dates from remote antiquity. Savage tribes in all parts of the world, when first visited by the white man, were already skilled in the art of catching fish in streams and lakes. Long before America was discovered by Columbus, the Indians had learned how to catch fish in the rivers, lakes, and coastal waters. They used very crude lines and hooks, it is true, but they were very adept in the use of spears and thus were able to capture many species of fish.

Ocean fishery, or fishing in the large areas of relatively shallow water far from shore called banks, is of comparatively recent origin, however. Large seaworthy vessels manned by expert navigators and daring seamen are needed for fishing at sea, and such ships can be built only by civilized peoples.

There are no records to indicate what people first practised ocean fishery, but many historians believe that the Norse vikings were the first to sail great distances to sea in quest of fish. Even in the Middle Ages these daring navigators sailed to banks near Iceland and Greenland, and it is probable that the Norsemen knew of America many years before

Columbus set forth on his eventful voyage. Norway is a cold mountainous country in which agriculture is carried on only with the greatest difficulty. For this reason the Norwegians since the earliest times have obtained a large part of their food from the sea. Twenty-five thousand fishing-vessels now sail or steam to and from Norwegian ports. Every year they catch about a billion pounds of fish, consisting chiefly of cod and herring.

The United Kingdom leads the world in ocean fishery, with a tremendous annual catch of more than a million tons, approximately two thirds of which is made up of herring, haddock, and cod. In 1913 more than six hundred thousand tons of herring were caught by the British. Assuming that the average herring weighed six tenths of a pound and was ten inches in length, we see that this catch included two billion fish.

Canada and Newfoundland are close to some of the world's richest fishing grounds. The Grand Banks, the Gulf of St. Lawrence, and the Bay of Fundy yield large quantities of valuable fish. Further, British Columbia possesses important salmon fisheries and is near the important Alaskan banks. The Canadian fisheries yield about two hundred million pounds of cod and an equal quantity of herring, nearly a hundred million pounds of salmon, and in addition large quantities of halibut, haddock, mackerel, pollack, hake, and cusk.

Germany, France, Holland, and Sweden also possess important herring and cod fisheries. The German fishermen catch considerable quantities of lemon sole and other flatfishes. The French and Portuguese have important sardine fisheries. Their canners use more care in the preservation of the fish and thus are able to command a higher price for their product than do the American canners.

Aside from those of Europe and North America, the only other fisheries of importance are those of Japan. The Japanese catch about five hundred million pounds of herring and an equal quantity of sardines each year. Mackerel, bonito, tuna, porgy, and yellowtail are also taken in large quantities.

Inasmuch as our own fisheries are completely overshadowed in importance by our agricultural products, they receive relatively little attention. When compared with other fisheries, however, they are found to be as valuable as those of any other nation with the exception of the United Kingdom. No other country produces such a great variety of fish and fishery products. Our annual catch of salmon is very great, often exceeding half a billion pounds, and when canned it is valued at about fifty million dollars. Nearly a billion pounds of menhaden is taken annually, but, since this fish is much less valuable than salmon, the product is worth only about five million dollars. A hundred million pounds of herring is caught by American fishermen each year. Many of these are immature fish and are therefore used in the preparation of canned sardines. Approximately fifty thousand tons of cod and an equal amount of haddock are captured annually. The haddock all come from the Atlantic, but the Alaskan banks yield many cod. One of our most highly prized fishes is the halibut, which is caught both on the Atlantic coast banks and the Alaskan banks; the total catch is approximately sixty million pounds.

In addition to these fishes there are at least a hundred others that are caught in commercial quantities either along our coasts or on the banks. It is obviously impossible, in a brief survey of the fisheries such as this, to enter into a detailed consideration of so large a number of minor species.

Location of the Fishing Grounds

As is indicated by the list of countries possessing important fisheries, the valuable fishing grounds lie almost wholly in the north temperate zone between the fortieth and sixtieth parallels of latitude. Taken as a whole, the fisheries of the tropics are unimportant, and it is unlikely that they will ever produce large quantities of fish. Relatively little is known about the fisheries of the south temperate zone, but since no large banks are known there it is unlikely that the zone will ever furnish any considerable proportion of the world's fish and fishery products. The large continental shelves surrounding Europe and America, the extensive coastal indentations, and the large rivers pouring immense quantities of fish food into the sea support an extensive fish life in the north temperate waters far beyond what is possible in tropical and south temperate waters.

The great fisheries of the British Isles and of the European continent are conducted principally on the banks of the North Sea and those surrounding

Iceland, although the French carry on extensive operations on the Newfoundland banks. The banks of the North Sea have furnished immense quantities of fish for more than five hundred years. These banks lie on the Atlantic continental plateau, an extension of the continental shelf, or intermediary ledge between the coast and the great oceanic depths, which extends from the west coast of Spain along the coast of France and to the north, supporting the British Isles. The greatest depth of this great continental shelf is not more than a hundred fathoms; its average depth is about fifty fathoms. As the water is shallow, the sunlight penetrates to the bottom, so that much of it is covered by an abundant growth of marine plants, which aid greatly in the nutrition of large numbers of fish and other marine animals. These vast fishing grounds, 134,000 square miles in area, yield enormous quantities of cod, herring, haddock, whiting, flounders, soles, halibut, pollack, ling, plaice, sprat, anchovies, and many other fishes.

America's ocean fisheries are conducted chiefly on Georges Bank, Brown's Bank, and the Newfoundland banks of the Atlantic, and the Alaskan banks in the Pacific Ocean. The Newfoundland banks are of great area. Fishing-vessels not only from the United States, Canada, Newfoundland, and Labrador, but also from France and other European countries come here to reap a bounteous harvest from the sea. The French value these fisheries so highly that they have maintained small colonies at St.-Pierre and Miquelon as bases for the fishing fleets and as centers for the sale and preservation of fish caught on these banks. The important food fishes caught in these shoal waters include cod, haddock, cusk, pollack, halibut, and swordfish.

The Georges Bank, which lies in the ocean about a hundred miles east of Cape Cod, Brown's Bank, and the South Channel, between Nantucket and Cape Cod, furnish Boston, Gloucester, and Portland with large quanties of cod, haddock, hake, cusk, pollack, and halibut. The Georges Bank is one of the richest fishing grounds of the world. It is rather shallow, averaging about one hundred and fifty feet in depth, and there are spots with as little as fourteen feet of water over them. Between these shoals and the mainland are depths of more than a hundred fathoms.

The waters of Georges Bank are often exceedingly rough. The strong tide, shallow water, and frequency of gales make fishing here a hazardous occupation, especially during February and March. On February 24, 1862, for instance, a terrible storm from the northwest suddenly struck the seventy fishing-vessels anchored on the shoals, and thirteen vessels with their entire crews were lost.

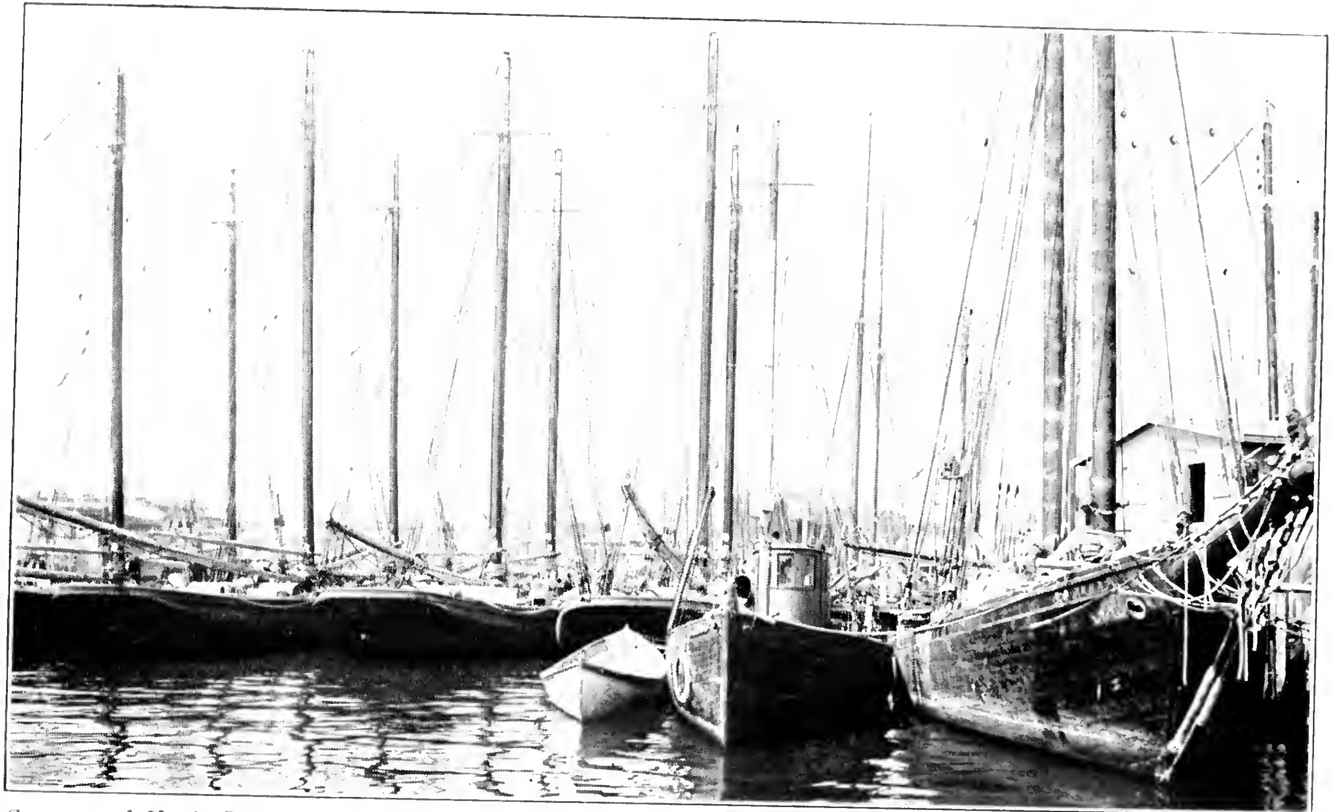
Brown's Bank lies about sixty miles north and east of Georges Bank. It is similar to it in depth and character but is only about one third of its area. It yields the same fishes as are caught on the Georges Bank.

The Alaskan bank fisheries are relatively undeveloped and have been extensively fished only for the past fifty years. They offer great opportunities and will doubtless furnish America with a larger and larger proportion of her fish and other marine products. The principal species caught on these grounds are herring, halibut, and cod.

America is especially fortunate in possessing the world's finest coastal fisheries. The Atlantic coastal waters from the Gulf of St. Lawrence to Florida are excellent fishing grounds. The Bay of Fundy yields immense quantities of mature herring for smoking and salting and small herring for sardines. Large numbers of whiting, mackerel, shad, smelt, scup, flounders, and alewives are taken along the New England coast. The Middle Atlantic States yield a great variety of fishes, the more important being alewives, bluefish, butter-fish, croaker, flounder, menhaden, scup, shad, squeteagues, and whiting. The Chesapeake Bay is an especially fine fishing ground, in which large quantities of menhaden, croaker, squeteague, alewives, and shad are captured. These fishes are also caught as far south along the coast as Florida. Many bluefish, catfish, Spanish mackerel, and spot are also caught in the coastal waters of the South Atlantic States. The Gulf of Mexico supports an extensive fishery yielding drum, grouper, menhaden, mullet, sharks, sheepshead, Spanish mackerel, red snapper, and squeteague in astonishing numbers. The fishes caught along the coasts of California, Oregon, and Washington include bonito, tuna, mackerel, flounder, pilchard, rock-bass, salmon, smelt, and squeteague. In southern California such large quantities of pilchards are caught that the canners cannot make use of all of them, so that many are converted into meal and oil.

While Alaska's bank fisheries have not been extensively exploited, her coastal fisheries constitute her most important industry. The prepared fishery products of this territory are of greater value than those of any other part of the country; they are now even greater than those of New England. In 1867, when Alaska was purchased from Russia, most persons could not see what value it could have. It was called "Seward's icebox" and similar derogatory names. We paid $7,200,000 for Alaska; and now we obtain five times this amount of revenue each year from her fisheries. We think of Alaska as a great producer of gold, yet compared with the value of her fisheries the gold production seems negligible.

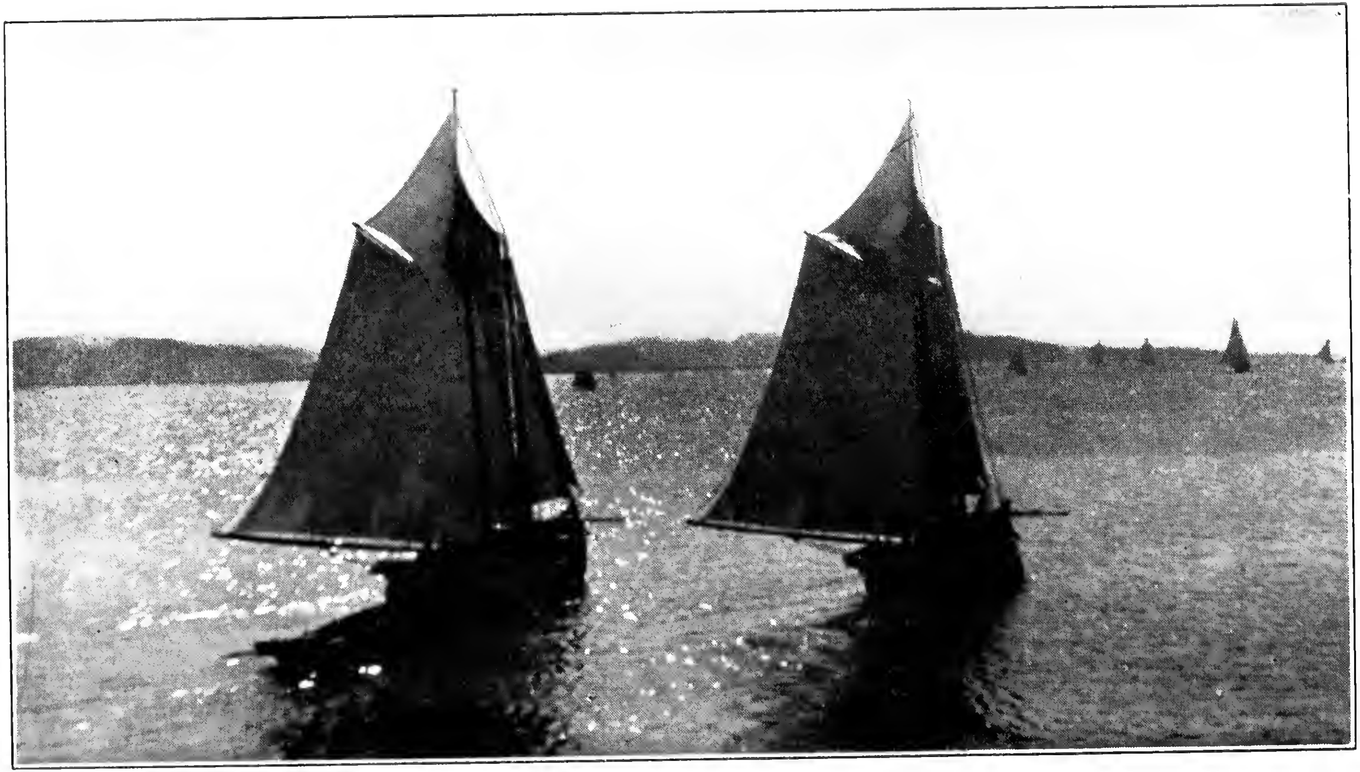
Alaska's many thousand miles of coast-line, extensive rivers, and vast banks are excellent fishing grounds. Here fish are so plentiful that only the choicest of food fishes are taken. The finest of these is the salmon, which is taken commercially along the Pacific coast from the Sacramento River northward, though nearly three fourths of the total catch now comes from Alaska, which produced thirty-five million dollars' worth of salmon products in 1925. More than four hundred million pounds of the fish were caught. Such a large quantity is hard to appreciate; it is easier, perhaps, to try to visualize it in larger units. If these two hundred thousand tons of fish were placed in barrels holding two hundred pounds each, and the barrels were stacked end on end one



Courtesy of U. S. Bureau of Fisheries

SCHOONERS IN GLOUCESTER HARBOR

A large proportion of the fish brought into Boston are caught by Gloucester schooners



NEWFOUNDLAND SCHOONERS OFF THE BANKS

The proximity of the Newfoundland banks enables the fishermen to make large catches on short trips above the other, the height of the column would be about twelve hundred miles. The fish would fill ten thousand freight cars.

Fishery Methods

Although in Europe steam and motor-propelled trawlers and drifters have long since replaced sailing-vessels using hook and line, the American, Canadian, and Newfoundland fishermen have been slow to adopt these modern innovations in fishing methods. Recently practically all of the schooners have been equipped with auxiliary engines, but relatively few steam trawlers are used. A large part of the bank fishermen still use hooks and lines, probably because this method of fishing yields a larger proportion of cod, whereas the otter-trawls catch more of the less valuable haddock.

The actual fishing is done from flat-bottomed, high-sided rowboats called dories, which are from eighteen to twenty-two feet in length. From six to twelve of these small boats are carried by each schooner. When no fishing is being done, the dories are nested on the deck of the schooner.

Dory fishing makes the American, Canadian, and Newfoundland fisherman a distinct type, for it adds great hazards and labor to his already arduous life. Once at the banks, the fishermen work from their dories, which are towed by the schooner early each morning to the place where the lines are to be set. These long-lines or trawls are very long, ranging from 2100 to 2400 feet in length, and are made of thin but extremely strong tarred cotton. Into these ground-lines are spliced, at thirty to forty inch intervals, lighter lines, called snoods or gangings. Each snood is about twenty-five inches long and has a strong steel hook attached. When not in use the long-line is coiled in a tub.

When the line is set, the end is attached to a light iron anchor, to which a buoy-keg is fastened in order to mark the location of the trawl. The anchor and buoy are thrown overboard; then as one fisherman rows away from the anchored end of the line, the other dexterously proceeds to whirl the coils of line and baited hooks into the sea by means of a short stick which he holds in his right hand. Three or four long-lines may be joined together and set in this fashion; another anchor and buoy is attached to the last end. The trawl now lies on the sea bottom and is prevented from drifting or becoming tangled by the anchors at each end.

After being set for an hour or so, the lines are brought in by the fishermen. As one of the men pulls up the line and takes in the fish, the other knocks off the untouched bait and coils the long-line in a tub. The unmarketable fish, dogfish, sculpin, skate, and the like, are knocked off into the sea. When fish are plentiful, the trawl is not taken up but is underrun; this operation consists of removing the fish and rebaiting the hooks, and makes it possible to use the line continuously without resetting it.

At the end of the day's fishing, the dories are picked up by the mother ship. Then the fishermen wash and clean the fish and pack them with chopped ice. After this has been accomplished, the fishermen bait and coil the gear for the next day's fishing. Vessels fishing far from the home port usually salt their catches, and thus are able to remain on the banks until their vessel is filled.

A few fishermen still fish by means of hand-lines from dories. Each hand-line is equipped with two or three hooks and a lead sinker. Usually one man fishes from a dory, using several lines at a time. Fish caught on hand-lines are somewhat superior to those caught on long-lines, probably because they do not remain on the hook so long.

The great danger in fishing in dories comes from sudden storms and fogs. In such cases the schooners have great difficulty in finding their dories. Fishermen lost in this way have been known to row without food or water 175 miles back to land. Fishing in winter on the banks is about as hazardous an occupation as can be conceived. Many of the Newfoundland banks lie in the path of the transatlantic liners, thus adding the peril of being run down by some great ship. Nothing will bring fishermen out of their bunks quicker than the fog-horn of a ship close at hand. Often the schooners are becalmed and lie helpless, unable to get out of the way.

The American fishing schooners are the finest commercial sailing-vessels in the world. They are able to withstand severe storms, but even then many are wrecked every year by the terrific storms of the North Atlantic. One of the most dangerous places is Sable Island, where dozens of wrecked schooners lie partially exposed to view. Dense fogs, heavy seas, exceptionally high tides, and the rock-bound coast make it exceedingly difficult to land even a small boat on this island. Thus, if a vessel is in distress and the fishermen are forced to take to their dories, they have little chance of making a safe landing.

While coastal and river fisheries are usually conducted on a small scale by fishermen residing near the water, the bank fisheries are in most cases well organized and are operated by companies owning several schooners or fishing-vessels of some other type. Such a system is necessary since few fishermen possess the capital required to purchase a seaworthy vessel and operate it on voyages requiring weeks and even months. In most cases, however, the captain of the vessel and his men are not ordinary employees of the corporation owning the vessel, but are really partners in the fishing enterprise, for they receive a share of the catch. In some instances the crew share equally what is left from the proceeds of the catch after the owner of the schooner has been paid a quarter of the gross returns and after the bills for food, ice, salt, bait, cook's wages, and other incidentals have been paid. On other vessels a wage is guaranteed and augmented by a share in the profits. This arrangement adds to the romance of the fishermen's work, for occasionally they are fortunate enough to fill their schooner with marketable fish in a short time and thus receive a big return for their trip. Captains with a reputation for large catches have little trouble finding men for their crews.

Halibut, tuna, and red snapper are also caught on hooks and lines. Halibut fishing is a dangerous business, and so full of thrills that it might be called a sport. Some of these large and powerful fish can put up a mighty struggle which will give the fisherman more than he can do. Sometimes the fisherman is forced to cut the line and allow the fish to go free to prevent the upsetting of the dory.

Strange as it may seem, steamships using the most modern fishing gear, the otter-trawl, operate on the same grounds fished by the hand-line and long-line fishermen. Both catch large quantities of cod and haddock, although the trawls take a larger proportion of haddock than the lines, as more fish of this species are found near the bottom. The otter-trawl is little more than a huge, flattened conical bag made of netting which catches all the fish that come in its path as it is towed along the bottom behind a steamer called a steam trawler. The mouth of the bag is held open by two large doors which are attached to the towing-warps by chain bridles. The bag net is made of strong manila twine and is about a hundred and fifty feet long. The forward end is of three-inch mesh, whereas the smaller or cod end is made of one-and-one-half-inch mesh twine.

The net is towed along the bottom at the rate of two to three miles an hour for an hour or two, or until the smaller end is thought to be full of fish; then it is hauled in and the fish dumped on deck, after which it is again put overboard. The trawling continues day and night, weather permitting, until a ship-load of fish has been caught.

Where large numbers of fish are to be found over a smooth bottom, this method is far more rapid than long-line fishing. A single steamer sometimes catches as much as two hundred and fifty thousand pounds of fish while on a trip of only a few days' duration. However, both the trawls and the steamers are very costly compared to schooners, dories, and hand-lines. Moreover, if a steamer is unfortunate enough to fish on a rough, rocky bottom, the net is usually torn and sometimes lost.

The hauling of a trawl net is always of great interest not only to fishermen but also to naturalists, for the net always catches many different species of fishes and other marine animals. Often representatives of as many as twenty-five different species are caught in a single haul. Sea-mice, sea-urchins, starfish, zoöphytes, sponges, jellyfish, dead-men's-fingers (*Alcyonium*), sea-pens, heart-urchins, sea-cucumbers, nereids, sea-acorns, hermit-crabs, and cuttlefish are some of the curious forms of marine life that are often found in the trawl. Small otter-trawls are often used for catching flounders and shrimp. Bag nets called paranzella nets, similar to the trawl nets, are used on the Pacific coast for flounders and soles.

Pound-nets, trap-nets, floating traps, and weirs all operate on the same principle. An obstruction in the form of a fence or net is placed across the natural course of fish; and the fish, in trying to swim around it, are led into a pound or trap from which they have great difficulty in escaping. Since there are so many variations in the form and construction of these traps, only three typical ones will be mentioned.

Brush weirs are commonly employed in Maine for catching herring. They are usually located either at a point of land that extends out into the water for some distance, or in channels where the tide is strong. The trap is a large circular or heart-shaped inclosure constructed by driving posts into the bottom, with smaller stakes between them. Fine brush is then interwoven horizontally between the stakes in order to make a primitive sort of fence. A long fence or "lead," constructed of brush in a similar way, extending from the shore to the mouth of the trap, deflects the fish into the pound. In order to remove the fish from the weir, a net is placed over the mouth of the trap, and the fish are captured with a small seine.

The pound-net is one of the most common forms of gear used in the fisheries, being employed both in fresh and salt water fishing. The usual type has a long leader made of poles driven into the bottom connected with coarse netting, which deflects the fish into the first inclosure or heart. Once they have entered the heart, the fish can only find their way into the mouth of the crib in which they are captured. The bottom of the crib is covered with netting, which may be raised when the fish are to be removed.

In deep water, or where the bottom is rocky so that piles cannot be driven, floating traps are used. The framework is made of small logs, bolted and braced together in one solid frame and is of the same general design as the ordinary pound-net. The netting is attached to pipes which pass through the logs and down into the water for about thirty feet. The leader is also constructed of logs bolted together with webbing fastened to suspended pipes.

Pound-nets are used for catching river herring, whiting, herring, shad, squeteague, and many other kinds of fish. Floating traps are operated chiefly in the salmon fisheries of the Pacific coast.

The gill-net is a relatively inexpensive form of gear which is popular with fishermen possessing little capital. These nets are made of very fine, strong thread which is invisible in the water. Their mesh is of such a size that it permits the passage of the head of the fish but not the body. In trying to swim through the net, the fish become entangled in the nets, either by the gills or by the fins, and are thus rendered as helpless as a fly caught in a spider's web. These nets are usually placed across a channel or other place where fish are passing. In some fisheries they are anchored or staked; in others they are allowed to drift with the tide or current. In fishing with this type of net, the fisherman rows along it, raising the net to the surface as he goes, removes any fish that it may hold, and then drops it into the water again.

Gill-nets are commonly used for the capture of shad, salmon, mackerel, herring, mullet, and several other fishes.

Seines are long nets with the upper edge kept afloat by means of corks or floats of some other material, and with the lower edge weighted down by sinkers which keep the netting distended. Seines are of two kinds; viz., haul or beach seines which are employed close to shore in relatively shallow water, and purse-seines which are used to surround schools of fish in deep water.

When using a haul-seine, the fishermen lay out the net either parallel to shore or in a semicircle with each end on shore, and then rapidly pull the ends up on the shore, thus hauling the net and its catch upon the beach. These seines vary in size from the small minnow seines used in catching bait to nets two thousand yards or more in length. Especially long seines are used in the Columbia River salmon fisheries and in the river herring and shad fisheries of the Chesapeake Bay and North Carolina. Mullet and squeteague are also caught in this type of seine.

The purse-seine, as its name implies, is a net which may be drawn together at the bottom with a line, just as an old-fashioned purse is closed with a cord. This type of seine is used chiefly in the mackerel and menhaden fisheries. In fishing with this seine a school of fish is surrounded with the net, and then the seine is rapidly "pursed." When the catch has been drawn into a small section of the net, the fishing-vessel comes alongside, and the fish are removed by means of a bailing-net hung from a boom.

The Fish Business

Commercial fishing is a business and not a sport. Although the fishermen use very effective means of taking fish, they usually work long hours and in most cases receive relatively little for their efforts. The men who catch the fish do not get much for them; usually, in fact, they do not receive more than a small fraction of the price the fish bring at retail. Neither do the retailers get rich, for fish is a perishable commodity and must be packed in ice and shipped by express. If the market is poor, the fish must be sold nevertheless, even though their sale entails a loss. Express rates are high because fish must be handled expeditiously and re-iced often. When one considers the great distances which the fish must be transported by water and by rail, it seems remarkable that fresh marine fish in excellent condition may be purchased in every city in the United States. And even more remarkable is the fact that in most places their cost is no more than that of meat. In many cities, even as far as three hundred miles from the coast, fish caught one day are eaten the following day. Few persons ever consider the systematic effort necessary to place fresh ocean fish upon the tables of the inhabitants of inland cities. If the diner in a restaurant orders halibut, it must have been brought from either the Alaskan banks or those of the North Atlantic. If he orders salmon, it must have come from the Pacific coast. The order of red snapper must have been brought from the Gulf of Mexico. When these facts are taken into account, it is really amazing that a fish dinner costs less than a steak dinner.

CHAPTER X

The Value of Fish and Shell-Fish as Food

FISH, mollusks, and crustaceans have constituted an important article in the food of man since remote antiquity. In prehistoric days, when agriculture was practised but little, sea-foods were relatively more important than they are to-day. But even now no dinner is entirely complete without fish or shell-fish in some form. The cookery of fish and other sea-foods is an art about which many books have been written. There are many, many ways of cooking every fish and shell-fish. Cooks of each nationality prepare sea-food for the table in their own distinctive ways.

Some sea-foods, such as cod, herring, halibut, flounder, and salmon, are staple articles of the diet of many classes of people in several countries, whereas others are considered as delicacies by connoisseurs of fine foods. Lobsters, crabs, anchovies, tuna, caviar, green turtles, terrapin, shrimp, and scallops fall in the latter class. As oysters and clams get scarcer, they are coming to be considered luxuries.

Because of the abstinence of Catholics from eating meat on Friday, this day has come to be a fish day in nearly all civilized countries. This has worked a hardship on the fishing industry, for it has created an abnormal demand for sea-food on Friday with only a slight call for these products on other days.

In Japan, Norway, Scotland, Newfoundland, and many other countries, sea-foods are more important factors in the diet than in this country. The quantity of fish and shell-fish consumed in Japan is especially great; this may not be entirely a matter of choice, however, as relatively little meat is produced in that country. The Scotch, Dutch, Germans, and Scandinavians eat enormous quantities of salted and smoked fish, especially herring. The Portuguese and Spanish peoples of Europe and America consume much salted cod, haddock, cusk, and pollack; in fact, in many West Indian and South American cities, salted cod is the only fish available on the markets.

It is not my purpose to consider the preparation of fish for the table or to discuss the kinds of sea-foods eaten by peoples of various nationalities, but rather to deal with the food value of the common fish and shell-fish. Many persons have never considered the nutritive value of fish but eat them merely because the eating of fish on Fridays is a long-established custom. Therefore it may be worth while to see what part sea-foods play in our nutrition.

Composition of Fish

Fish contain large amounts of protein, varying amounts of fat and fat-soluble vitamines, and much mineral matter. Fish resemble meats in being deficient in carbohydrates, but oysters, clams, and other mollusks contain a considerable amount of glycogen, or animal starch. Some of this carbohydrate is also found in crabs, lobsters, and other crustaceans.

Fish differ greatly in their fat content. Not only does the average fat content of the various species of fish vary widely, but there is a definite seasonal variation in many species, and even the individual fish of a school caught at the same time contain different percentages of fat. Certain species of fish, however, are always lean, whereas others always contain much fat. Still others of medium fatness usually contain four or five per cent of fat when fresh. The more common fatty fishes are the mackerel, Spanish mackerel, herring, sardine, salmon, butter-fish, alewife, eel, and shad, while the more common lean sea fishes are the cod, cusk, haddock, pollack, hake, flounder, grouper, sea-bass, red snapper, and tomcod.

Curiously the protein content of various fishes is nearly constant, for as the fat content of a fish increases its moisture content decreases. Thus the consumer gets more food for his money by buying fatty fish, in preference to lean ones at the same price.

In general, the composition of fish is approximately the same as that of meat; both are high in protein and have a variable fat content. The composition of fatty fish may be compared to that of the fatter cuts of pork, and the composition of lean fish resembles that of beefsteak. In many cities protein may be purchased for less money in the form of fish than as meat.

The value of a given substance as food depends not only upon the nature of its digestion products but also on the ease with which it is digested. Leather contains much protein, yet its nutritive value is negligible because it is indigestible. Before we can evaluate the fats and proteins of fish we must consider their digestibility. Contrary to what many persons believe, scientists have found that both the fat and protein of fresh and canned fish are as easily and completely digested as the fats and proteins of meat.

Dr. Holmes, of the U. S. Department of Agriculture, studied the digestibility of the fat and protein of mackerel, grayfish, butter-fish, and salmon, and reported that they were easily and completely digested. Dr. Holmes concluded: "the very complete utilization of the proteins and fat supplied by the fishes studied offers additional experimental evidence that fish is a very valuable food and that its extensive use in the dietary is especially desirable."

Nutritive Value of Fish

Since the chief food constituent of fish is protein, it is interesting to examine these proteins to see whether or not upon digestion they furnish all of the amino-acids needed for the building up of the complex protoplasmic structure we call our body. Perhaps, before going further, it would be well to indicate the nature of amino-acids, the wonderful compounds of which our muscles and many of our other tissues are constructed. These acids are inert, colorless solids which contain nitrogen, being very unlike the familiar strong mineral acids that "eat" metal. Since all proteins are composed of various combinations of these essential amino-acids, animal life cannot exist without an ample supply of all of them. Seventeen of the eighteen common amino-acids are found in fish proteins. Only one, the simplest of the amino-acids and one that can be synthesized by the human body, is not found in the digestion products of fish. All of the amino-acids needed for the construction and repair of our bodies occur in ample proportions. Curiously the composition of fish proteins resembles that of chicken muscle. This fact is especially important when we consider the high nutritive value ordinarily assigned to chicken meat.

Fish is an excellent food to supplement a vegetable diet, as it furnishes the amino-acids lacking in cereal proteins. The ability of the Japanese to subsist on a vegetarian diet supplemented by fish is attributable to the fat-soluble vitamines found in the fish fats and to certain amino-acids obtained from fish proteins.

Recently the inorganic constituents of fish and other sea-foods have been recognized as having considerable nutritive value. Calcium, phosphorus, magnesium, sodium, chlorine, iodine, potassium, and sulphur are found in all fish. These elements are all required for human nutrition, but all except three of them occur in sufficient quantities in most foods. Many foods, however, are deficient in phosphorus, calcium, and iodine.

Canned fish is an especially valuable source of calcium and phosphorus, for the bones are usually eaten as well as the flesh. Fish bones consist largely of calcium phosphate, which is needed by the human body for the growth and repair of bones and teeth. It is therefore fortunate that many persons prefer canned salmon and tuna to fresh fish, probably because they are well cooked, and the bones do not cause any bother. Pressure cookers should be used for cooking bony fish. When a fish containing many fine bones, as the shad, is cooked with steam under a few pounds pressure, the bones become almost as soft as the flesh, and are then quite edible. This eliminates the tedious and disagreeable operation of picking out the bones, and thus not only adds to the pleasure of eating fish, but also increases their nutritive value.

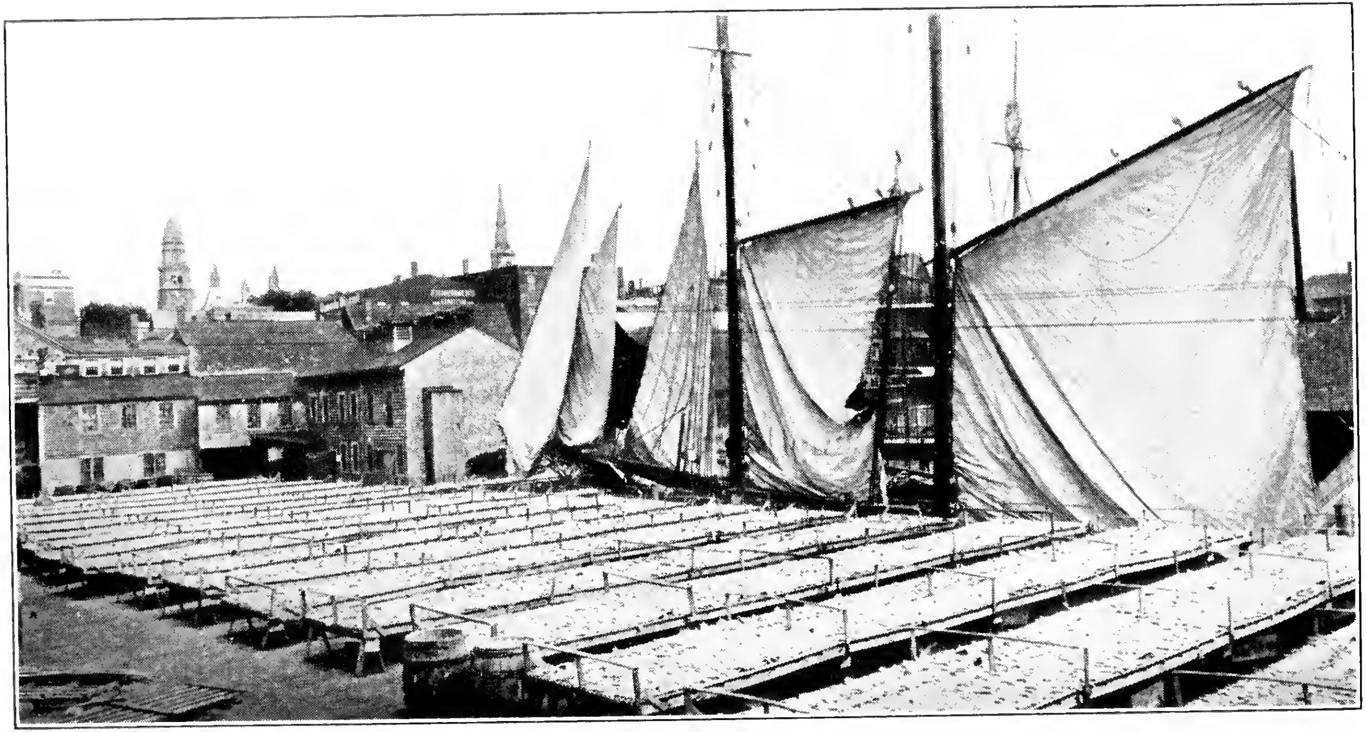
The old idea that fish is a "brain food" probably has little foundation, but perhaps fish roe may have that distinction. For the roe contains certain organic phosphorus compounds also found in the human brain, which are called phospholipins because they resemble fats chemically. It is likely that the human body utilizes these unusual compounds for building up the gray matter in which so many persons are deficient.

Recently a lack of iodine in food and drinking water has been recognized as one of the principal causes of endemic goiter, cretinism, and other diseases of the thyroid gland. The active principle of the thyroid gland, thyroxin, is an iodine compound. If our food does not contain sufficient iodine to

Courtesy of E. L. Patch Company

VITAMINES AND THE LACK OF THEM

The rat on the right was fed on a diet deficient in fat soluble vitamines



DRYING SALT COD AT GLOUCESTER

After being salted in brine, the salted fish are drained, pressed, and spread out to bleach and dry enable the thyroid gland to make the normal amount of thyroxin, we become diseased.

Goiter and other diseases of the thyroid are much more prevalent than most persons realize. Few persons in Pittsburgh considered goiter to be of common occurrence until the school-children were given a careful medical examination. The data obtained indicated that 42 per cent of the children had enlarged thyroid glands, commonly known as goiters.

Dr. Hall examined 3339 students of the University of Washington, at Seattle, Washington, and found that 18 per cent of the men and 31 per cent of the women had goiter. In Wexford and Houghton counties, Michigan, more than 50 per cent of the school-children have goiter. In Ontario and Michigan, goiter occurs not only in human beings but also in animals, especially dogs and sheep.

Goiter is most common in the Great Lakes and St. Lawrence River basins and in the northwest Pacific region, where the drinking-water contains little iodine. It has been found that the prevalence of goiter is roughly inversely proportional to the iodine content of the drinking-water and food. Most common foods such as meat, bread, milk, and most fruits contain very little iodine. It would take several tons of meat or flour to furnish the human body with the amount of iodine found in a normal thyroid gland.

Perhaps the reader is asking what this has to do with the nutritive value of fish. Foods containing iodine have been of great help in preventing and controlling goiter. Fish and other sea-foods have been shown to be unusually high in iodine. Recently a large number of sea-foods were analyzed for their iodine content, using a novel method of analysis by which it was possible to measure accurately the iodine content of foods even when this element was present in amounts as small as one millionth of one per cent. Oysters, clams, and lobster were found to be unusually high in iodine, containing approximately two hundred times as much as beefsteak. Shrimp contain about half this amount, and crabs somewhat less. Marine fishes are also high in iodine, containing fifty times as much as milk or beefsteak. Fresh-water fish contain much less iodine, the amounts found being about the same as in meat. These results indicate the value of marine fish, mollusks, and crustaceans in the diet of the inhabitants of regions where goiter is common. It is likely that the reason for the freedom of the Japanese from goiter is the large per capita consumption of fish and other sea-foods.

Cod-liver oil was the first fishery product to gain recognition as especially valuable in nutrition. For more than a hundred years the therapeutic value of this oil in the treatment of certain diseases has been known to the medical profession, but only for the past fifteen years has it been known that its value lies in its high fat-soluble vitamine content. Butter is one of the most potent common sources of the fat-soluble vitamines, yet samples of cod-liver oil have been found which have two hundred times as high a vitamine content as butter. Because of its fat-soluble vitamines, cod-liver oil is highly effective for curing certain diseases of the eyes, especially xerophthalmia, and for the prevention and cure of rickets. The prevalence of rickets among city children is not generally realized. Most of the children of the poor in the great cities have rickets at some time or other.

Although fatty fish have not nearly so high a fat-soluble vitamine content as cod-liver oil and other fish-liver oils, they contain much larger amounts of these vitamines than most other foods. The importance of the vitamine content of fatty fish can hardly be overestimated; for in many countries where dairy products are scarce, as in Alaska, Labrador, and Iceland, all of the common foods are deficient in the vitamine which cures rickets, with the exception of herring, mackerel, and other fatty fish. Doubtless its presence in fish fat prevents the outbreak of rickets and other diseases directly or indirectly caused by a deficiency of fat-soluble vitamines.

Dr. E. V. McCollum, in his consideration of "Vitamines in Fish and Shell-Fish,"[1] makes the following statement regarding the efficacy of a fish diet in the prevention of rickets: "Even in those parts of the world where the climatic and hygienic conditions are such as to favor the development of bone defects, these are rare among children where fish forms a prominent article of diet. The administration of cod-liver oil is an effective substitute for the eating of fish for this specific purpose."

All fats and oils from fish or other marine animals have been found to be rich in the fat-soluble vita-

[1] U. S. Bureau of Fisheries Document 1000 (1926).

mine A, which prevents certain eye diseases and aids in growth. For centuries it has been the custom in Japan to give eel fat to children suffering from a disease known as *hikan*, which has recently been found to be caused by a lack of vitamine A.

Shell-fish, such as oysters, clams, and lobsters are of great dietary importance. Oysters contain both the water-soluble vitamines B and C. When eaten raw, oysters and clams are especially valuable foods, for they furnish the water-soluble vitamine C, ordinarily obtained only from fresh raw fruits and vegetables.

The Place of Sea-Foods in the Diet

The nutritive value of fish and other sea-foods has already been discussed in detail. It remains, however, to consider specifically their place in the dietary.

A monotonous diet is dangerous, for if a person always eats the same proteinaceous, fatty, and vegetable foods, his diet is likely to be deficient in some essential amino-acid, mineral constituent, or vitamine. A diet lacking in any one essential nutritive factor is a failure; any one taking it will suffer from some form of malnutrition. The deficiency disease may take a great variety of forms. Its symptoms are legion, and may appear to be trifling, as for example, nervousness, bad teeth, headaches, and flat feet.

No one should ever continue to eat day after day exactly the same foods for breakfast, lunch, or dinner. Any satisfactory diet must be varied, and must contain a variety of proteinaceous foods, such as meats, eggs, and fish, many fruits and vegetables, and several starchy and fatty foods. Each meal should consist of (1) a dish high in protein, such as meat, eggs, fish, or some other sea-food, milk, or beans or other leguminous vegetable, which will furnish a variety of amino-acids required for the construction and repair of tissue; (2) potatoes, cereals, or other starchy foods, to furnish fuel and energy for the body; (3) fat, such as butter or fish fat, to supply fuel, energy, and fat-soluble vitamines; (4) fruits and vegetables to furnish the water-soluble vitamines, inorganic constituents, and roughage essential for the proper digestion and assimilation of the food.

At least once a week fish or some other sea-food should be cooked as the main dish of a meal. The occasional substitution of fish for meat furnishes a greater variety of amino-acids, increases the amount of iodine in the food, and, if fatty fish are chosen, increases the supply of fat-soluble vitamines. Fish roe is an excellent substitute for eggs, as it is high in phospholipins and is a very potent source of the fat-soluble vitamine. Canned fish contain calcium phosphate, which is used so extensively in the construction and repair of bones and teeth, and should be supplied freely during growth and pregnancy.

From the foregoing discussion it should be evident that sea-foods are easily digested proteinaceous foods resembling meats in composition and in addition contain much higher amounts of fat-soluble vitamines, iodine, and other valuable inorganic substances.

CHAPTER XI

The Preservation of Fish

NO one knows when man first learned to preserve his surplus of fish on the day of plenty for his future needs, for the earliest records indicate that he was already versed in the arts of preserving food by freezing, drying, smoking, and salting. The prehistoric savage used crude methods such as the smoking and drying of small fish strung on sticks over an open fire. Some of these simple methods are still in use to-day, the only changes being adaptations which permit the preservation of large quantities of fish with a minimum of labor.

The only method of preserving fish which has been invented during the past century is that of canning. This art, that of the preservation of a food product, sterilized by heat, in a hermetically sealed container, is a modern invention discovered in 1810 by Nickolas Appert. His researches, which lasted fifteen years, were encouraged by the French government, which offered a reward for the discovery of an improved method of preserving foods. This prize was offered in the hope of finding a method of preservation which would reduce the loss of foods through spoilage in military and naval stores.

Canning is the most important method of preservation of fish employed in the United States, but salting is far more important in most other parts of the world. The smoking of fish is relatively unimportant in America, whereas in Scotland and Germany immense quantities are smoked. The freezing and cold storage of fish is practised more extensively in the United States than in any other country in the world. Nearly a hundred million pounds of fish are frozen in this country each year.

Freezing and Cold Storage of Fish

While it has been known for many centuries that freezing and cold storage will preserve fish, it has been only since the invention of mechanical processes of refrigeration that the cold storage of fish has become of commercial importance. Prior to that time, fisherfolk living in cold climates froze any surplus catch and kept the frozen fish in unheated rooms until needed. Now cold storage and refrigeration of fish is employed in all civilized countries, as refrigeration serves to take fresh fish from the class of extreme perishables, and enables the fish dealer to supply all sorts of fishes throughout the year. It reduces the cost of fresh fish to the consumer and increases the value of the fisherman's catch, as it greatly reduces the waste because of spoilage.

Fish are frozen principally in the summer and autumn and are held in cold storage until winter and spring, but there is some freezing every month in the year. Salmon, cisco, herring, mackerel, whiting, halibut, scup, lake-trout, whitefish, cod, haddock, and pollack are the chief species frozen.

Unfortunately, in the early days of the industry, fish unfit for sale were frozen and stored until there was a greater demand for the product. Naturally when thawed these fish were in no better condition than when frozen. Because of such practices people came to believe that the freezing of fish injured them. In this way cold-storage fish acquired a bad reputation which it will take many years to live down. This prejudice has no foundation in fact. The freezing under proper conditions of freshly caught fish does not injure them in the slightest. Properly frozen fish, when stored under carefully controlled conditions, remain in excellent condition for a year or longer. In fact not one person in a thousand can distinguish between freshly caught fish and frozen fish after both have been cooked.

Refrigeration and cold storage of fish involve more than the freezing and storage of fish at low temperatures. The fish must be carefully handled before freezing, for bruises cause deterioration during storage. They must be quickly frozen; usually this is accomplished by placing them in extremely cold rooms, although in some of the more modern processes the fish are frozen by immersion in very cold brine. Brine freezing possesses several advantages over air freezing, for the fish freeze much more rapidly, and therefore fewer changes take place in the tissue of the fish.

Frozen fish must be glazed, or covered with a thin layer of ice, if they are to keep well during storage. Glazing is usually accomplished by dipping the very cold fish into fresh water. The water in immediate contact with the fish freezes, covering the fish with a glassy layer of ice. The ice glaze brightens the color of the fish and prevents them from drying out. It also prevents discoloration of fatty fish by the phenomenon known as rusting, which is caused by the fat becoming rancid.

During storage, fish must be kept at a very low temperature to preserve them in perfect condition. Further, since the glaze evaporates, they must be reglazed from time to time.

There is much disagreement as to the best method of defrosting frozen fish. Some authorities recommend slow thawing in a refrigerator or in ice-cold water. Others do not trouble to defrost the fish, but cook them without thawing. In America cold-storage fish are usually defrosted before being sold to the consumers.

The Salting of Fish

What industry brings to mind more of the quaintness and romance of the ancient European fishing ports than the business of salting fish? Modern industrial methods have come into use in almost every other industry, but still the herring and cod salters handle the fish entirely by hand.

The salmon canner has invented machines which clean the fish automatically, but these appliances have never been adopted for use in eviscerating cod and haddock. The methods of handling and salting fish have not changed for several centuries. The connoisseur of cured fish has become accustomed to certain distinctive flavors and demands them. The introduction of modern scientific methods into the salting of fish would produce salted fish which when freshened would not differ greatly from fresh fish, yet at present there is no great demand for such improvements.

In Europe salting is still the most important method of preserving fish. The ports of Grimsby, Lowestoft, Yarmouth, Hull, Ramsgate, Scarborough, and Whitby in England; Lerwick, Aberdeen, Leith, Buckie, Peterhead, Frazerburgh, and Wick in Scotland; and Ijmuiden in Holland; Stavanger, Bergen, Aalesund, Kristiansund, and Tromso in Norway; and Geestemünde, Nordenbram, Auzhaven, and Altona in Germany are all important fish-salting centers.

The salting of fish is on the decline in America. Quaint old Gloucester, which was formerly the leading American fishing port, still retains its prestige as the great fish-salting center, but even there some of the fish salters have learned to can their fish. Other centers, such as Portland, Boothbay Harbor, and Eastport, Maine; Havre de Grace, Maryland; Reedville, Virginia; Edenton, North Carolina; and a few places further south still retain some activity in the fish-salting industry, but the business is also shrinking. Recently, on the other hand, the salting of herring has become one of the important Alaskan fishery industries. Many salmon are also salted on the Pacific coast, where the industry is operated in conjunction with the salmon-smoking business.

The preservation of fish by salting is no more difficult than the curing of hams or the drying of beef, and can be used by any housewife to preserve a surplus of fish. Generally speaking there are but two methods of salting. According to the more common procedure, the cleaned fish are packed in barrels in layers between thin layers of salt. The salt extracts sufficient water from the fish to form a brine or pickle, and the salt passes into the fish. If sufficient salt has been added, the fish are dried out enough to keep them for a year or more if stored in a cool room. When no more pickle is formed, that which formed during the salting operation is usually removed, and fresh brine made from clean salt is added. The other general method of salting fish is by placing the fish in a large vat, covering them with brine, and then placing a surplus of salt on the fish. When thoroughly salted, or struck, the fish are packed in barrels with either dry salt or fresh brine.

More herring are salted than any other fish. In Scotland alone about five hundred thousand barrels are preserved by salting. Large quantities of herring are also salted in England, Ireland, Holland, Germany, France, Denmark, Norway, the United States, Canada, and Newfoundland. The Scotch, Norwegian, and Dutch-cured herring are the best known, and most of those salted in America are packed according to one of these three processes.

Scotch-cured herring possess a distinctive flavor desired by certain connoisseurs of cured fish. The fish are not washed after the removal of the gills and the stomach; thus the salted fish contain all of the blood. Since the fish are packed in the original pickle, they retain a peculiar flavor caused by the preserved blood. Because this flavor of salted herring has become very popular in America, the Scotch cure has been introduced in Alaska, and nearly all of the herring cured in that territory are packed according to this process.

As a result of the ease with which fresh fish can be obtained, the consumption of salted cod in America has greatly decreased during recent years, but in southern Europe and Latin America it is still very popular. It may be purchased in all of the small interior towns of semi-tropical Europe and America, and in many instances is the only fish offered for sale.

In the United States, where canned salmon and other canned fish are cheap, the salter of cod and other ground-fish, such as haddock, hake, and pollack, has been forced to improve the quality of his product or quit business. This improvement has been effected by the more careful selection of the fish to be salted and by less drying of the salted fish.

Visiting Gloucester, Massachusetts, and seeing this ancient industry operating to-day on a big scale, carries one back two centuries or more. Most of the cod are still caught from dories on hand-lines or trawl-lines. The fishermen sail to the banks in schooners which resemble those used a century ago, except that they are now equipped with auxiliary gasoline engines. Once on the fishing grounds, the fishermen leave the schooners and fish from their dories. Most of the catches are eviscerated, iced, and placed in the hold of the schooner. But when the schooners are to be away from the home port for a long time, the fish are split and lightly salted and then piled either in the hold or on the deck. Upon arrival in port, the fish are hoisted out of the hold in large baskets. After the weight has been taken, the heads are cut off, and the fish are thoroughly cleaned, washed, and placed in layers in large casks called butts. Salt is sprinkled over each layer of fish, and a pile of salt is placed on top. The salters prefer sea salt from Turk's Island or Spain to domestic salt for curing the fish.

Much of the work of salting the cod is done by fishermen who are too old to endure the hardships of the long perilous trips to the banks. You need never hesitate in addressing one of these old heroes of many a terrific storm; call him captain, and you will seldom miss your guess. Even if he never went to sea he will smile, for in Gloucester the sea-captains come first in the public opinion.

After the cod have remained in their own pickle in the butts until they are thoroughly salted, they are removed and stacked in large piles, where the pickle drains and is pressed out of them. Curiously this operation is called water-horsing. When no more pickle runs from the fish they are spread out on the flakes to dry. This is one of the most picturesque features of the industry, as the flakes usually are built on the roofs of the buildings, where the drying fish are visible for miles around. A flake is a rack or lattice bed, three to five feet wide, constructed of triangular wooden strips about an inch wide, nailed about three inches apart to a substantial framework built about thirty inches above the roof or floor.

The salted cod must be carefully watched if a good quality of dried fish is to be produced. They must not be permitted to be wet by rain or dew, nor must bright sunlight strike them, for the direct rays of the sun cause the fish to become yellow or sunburned. Each evening, and whenever a rain-storm is imminent, the fish are collected, placed in piles, and covered with small rectangular boxes with peaked roofs called flake-boxes. While on the flakes, the fish become lighter in color and dry out so that they will keep when packed dry in boxes if stored in a cool place. The length of time required for the drying and bleaching process depends chiefly upon the weather and the amount of drying and bleaching desired. If the fish are to be sold in the Southern States they must be dried more than if they are to be marketed in cooler climates. When sufficiently dry, the fish are carted to a storehouse where they are kenched (stacked like fire-wood) until required for market, or until they are skinned and boned.

The better grade of salt cod is prepared for market by removing the skin and bones and cutting into strips. The salted fish are carefully sorted as to quality and size before being carted to the skinning loft. First quality cod are thick, uniformly white, have no blood-stains, and possess a sweet odor. Considerable skill is required in the preparation of boneless cod. First, the dorsal and ventral fins are removed. Then the skin is pulled loose at the napes and in toward the middle of the back and then toward the tail, care being taken not to tear the flesh. After the tail has been cut off, the large nape bones are removed with a bone-hooker, and the remaining portion of the backbone cut out. The fish are then passed on to other workers, who remove the larger bones one at a time with small pliers.

After the yellow and stained portions of the fish have been cut away, the fish are cut into strips. Since the large, thick "middles" or "steaks" command the highest prices, the cod are cut so as to obtain as much of this meat as possible, which is packed either in five or ten pound boxes. The smaller pieces are packed in one and two pound boxes. The white trimmings are made into "fibered codfish" or "fluff" and then packed either in cartons with parchment paper lining or in glass jars. "Not a bone" salted cod contains less bones than the "boneless" grade and consequently commands a higher price. "Hard dried" cod prepared especially for export is packed either in large boxes or drums. That which is shipped in drums is tightly compressed in hydraulic presses. Nothing is wasted, for the skins, bones, and yellow trimmings from the salted fish are sold to the glue manufacturer for use in the making of liquid glue.

Such is a brief picture of the ancient salt cod industry, which is slowly passing out in America, mainly because the taste in preserved fish has changed to canned fish. Two of the leading fish-salting establishments in New England have read the handwriting on the wall and now operate canneries in conjunction with their factories.

Haddock, cusk, pollack, and hake are salted along with cod in the same establishments according to the same methods. Recently, since the general introduction of steam trawlers, which catch principally haddock, feeding near the sea bottom, this fish has become very plentiful, with the result that many more are now salted than formerly. The average annual catch of the mackerel has diminished greatly during the past decade, whereas the price has steadily increased. For these reasons a much smaller quantity is now salted. The salting of alewives or river herring is still an important industry in Boothbay Harbor, Maine, Havre de Grace, Maryland, Reedville, Virginia, and Edenton, North Carolina. Many mullet are salted along our South Atlantic coast. Formerly many shad were salted, but this fish is now so valuable that few are preserved in this manner.

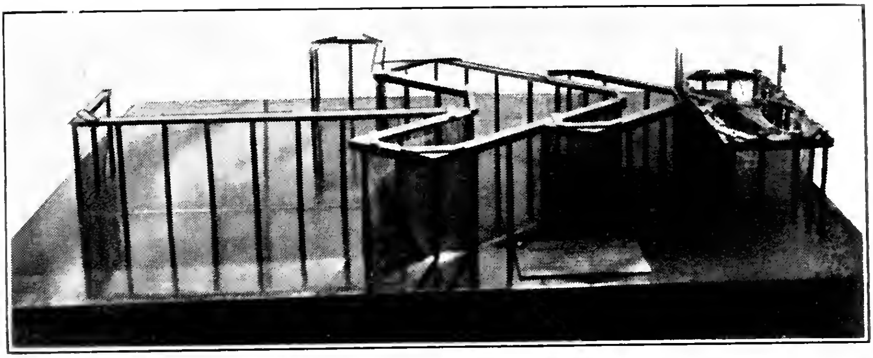
The three important fish-salting industries of the Pacific coast deal with herring, salmon, and cod. Salmon salting is carried on mainly in conjunction with the salmon-smoking industry. Most of the salted salmon are shipped either to New York or Germany, where they are freshened and smoked. Salmon salted primarily for smoking are called mild cured.

The Smoking of Fish

The methods employed in the present-day fish-smoking industry are much the same as those which were used thousands of years ago when savage man smoked and dried his surplus fish over an open fire, except that the process has been commercialized. Now the fisherman seldom smokes his own fish, for smoking is a business carried on on a large scale. Smoke-houses holding as many as one hundred thousand fish are sometimes employed for the smoking of herring.

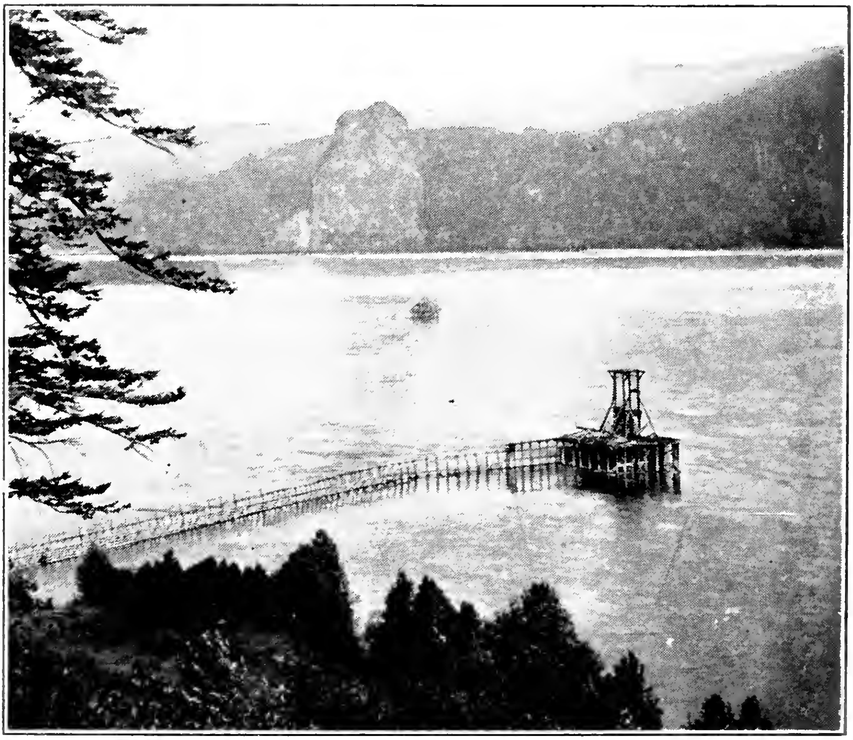
MAINE HERRING WIRE

Brush wires such as this are commonly used for the capture of mature and young herring



MODEL OF SALMON TRAP

Many tons of salmon are often taken in a single haul of a trap of this type



FISH WHEEL ON COLUMBIA RIVER

The revolving wheel automatically scoops out the salmon which enter the trap

The Scotch are very fond of smoked herring and preserve an immense quantity of them. Kippered herring are most in demand; approximately two hundred thousand barrels of these are smoked each year. Since there are about seven hundred herring in a barrel, one hundred and forty million of these kippered fish are consumed, or thirty herring for each man, woman, and child in Scotland. England, Holland, Germany, Norway, and Denmark are other important herring-smoking centers.

The American smoked fish industry is relatively unimportant when compared to the European industry. The total annual production of smoked fish in the United States is only about forty million pounds, valued at about five million dollars. Smoked haddock, the so-called finnan haddie, is very popular in the United States. Smoked salmon, one of the most valuable smoked fish, is very popular in New York City, and is prepared in large quantities. Maine leads the States in fish smoking. About two and a half million pounds of smoked herring valued at a quarter of a million dollars is produced annually in that State.

The smoking of herring is one of the ancient industries for which the quaint old town of Eastport, Maine, is noted. Most of the herring smoked in this vicinity are caught in the Canadian waters of Passamaquoddy Bay, the Bay of Fundy, and along the border river, St. Croix; the remainder is caught in weirs along the Maine shores. The smoking industry is operated in conjunction with the sardine industry; the herring which are too small for smoking are canned as sardines.

Herring are prepared by smoking in three different ways. The bulk of the herring is thoroughly salted, and smoked until hard and dry; the product is termed red or hard herring. Much of the red herring is boned, skinned, and packed in small packages. This grade is sold as boneless. Lightly smoked herring are prepared in two ways. The heavily salted, lightly smoked round herring prepared for immediate consumption are termed bloaters. Kippered herring are usually prepared by splitting and eviscerating the fish before lightly salting and smoking them. Some lightly salted and smoked herring are canned in one-pound oval tin cans. After being sterilized with heat, this product will keep indefinitely.

The first step in the smoking process is salting. This is effected by placing the fish in pickling vats partially filled with weak brine. Salt is also sprinkled over each layer of herring. When the tank has been filled with fish, three or four bushels of salt is piled on top of the fish. Altogether from six to nine bushels of salt is used on each vat of fish (about four hogsheads). The fresher the fish and the cooler the weather, the less salt is required. Most of the salt is placed on or near the top of the vat of fish, so that, in working down, it will dissolve before it reaches the bottom. If the fish are small they are removed in twenty-four or thirty-six hours, whereas the larger herring are kept in the brine for forty-eight hours or slightly longer. In cool weather the fish are salted for a longer period than in warm weather. The herring are removed from the vats by means of dip nets or wash nets in which they are washed by a brief immersion in sea-water or dilute brine. After washing, they are laid on the stringing tables, where they are allowed to drain.

They are then strung on slender sticks by men, women, girls, and boys who are very adept at this work, some of them being able to string twenty-five thousand herring a day. Holding the stick in his right hand, the stringer raises the left gill cover of the herring and inserts the pointed end of the stick through the gill slit and then through the mouth, at the same time shoving the fish to the opposite end of the stick. The sticks, which are about three feet four inches in length and three quarters of an inch square, hold from twenty-five to thirty-five herring. The average price paid for stringing is forty cents per hundred sticks.

After stringing, the herring are again washed by dipping in a trough of sea-water; then they are hung on rectangular frames called herring horses, which hold about forty-five sticks, or one barrel of fish. When filled, the herring horses are carried out into the open air, where the fish are partially dried. This preliminary drying hardens the gill covers, thus strengthening them, so that the herring do not fall off the sticks in the smoke-houses.

When the herring have been sufficiently dried outdoors, they are carried into the smoke-houses and hung on scantlings, which are just far enough apart so that either end of the sticks, on which the herring are hung, rests on a scantling. The lower part of the "bays," as the compartments of the smoke-house are called, is filled first. After smoking for twelve or fifteen hours, the fires are allowed to go down, and the partially smoked herring, which have been placed in the lower part of the smoke-house on the previous day, are shifted to a place nearer the top of the smoke-house. Another lot of fish is then placed in the lower part of the smoke-house, and the preliminary smoking is repeated. These operations are continued from day to day until the smoke-house is entirely filled with fish, after which the smoking fires are kept burning for about three weeks or until the fish are thoroughly cured.

The smoke-houses usually are ordinary frame buildings having a single gable with ventilators at the top. In addition to the ventilators, the houses have many doors and windows which are opened when especially good ventilation is required. Since the fires are built on the ground, the smoke-houses have no floors.

Hardwoods are used for the fires. White birch is generally preferred, but almost any kind of hardwood may be used. In building the fires, small logs from four to eight inches in diameter are arranged in heaps a few feet from each other and about four feet from the side of the building. Two or three logs are placed together, with sufficient kindling to ignite them. After the fires are burning well, large pieces of water-logged or decayed timber are piled on the fire to smother the flames and generate a dense smoke.

Usually the herring are not taken from the smoke-houses until required for packing or boning. If the fish are not packed soon after the smoking is completed, great care must be taken to prevent their spoiling. During fair weather the doors and windows of the smoke-house are opened. If the weather is damp the fires are kindled to prevent the absorption of moisture by the herring.

The red herring are either sorted into grades according to fatness and size and placed in wooden boxes, or skinned and boned and sold as boneless herring. Boneless herring are prepared in large quantities in Eastport, Lubec, and other herring-smoking centers of Maine. More than half of the smoked herring are used in the production of this grade of prepared fish, which commands a relatively high price. The preparation of boneless herring is carried out during the fall and winter, when there is little else for the smokers to do. Boning and skinning is also done by the farmers along the coast who do the work for the smokers. Skinning bees are common in Washington County, Maine, where the farmers invite their neighbors to aid them in preparing herring during the long winter evenings. The crowd spend part of the evening in skinning and boning the herring and the remainder in amusing themselves.

Much of the boneless herring is packed in wooden boxes lined with paper, containing ten, twenty-five, and fifty pounds each. Some smokers pack the fish in small attractive glass jars and tins. Approximately three hundred pounds of boneless herring are obtained from each thousand pounds of whole smoked fish. Formerly the refuse was sold to farmers for fertilizer at a small price. In recent years much of it has been rendered into oil and fertilizer, for herring oil has been recognized as possessing considerable value. Fertilizer prepared in this way is of much greater value than the original waste, as the oil is of negative value as a fertilizer.

Large whole herring which have been lightly smoked and well salted are known as bloaters. In the preparation of this grade of smoked herring, the fish are placed in strong brine containing some solid salt for two or three days. Then, after being taken in dip-nets and washed in sea-water, they are strung on sticks in the same manner as in the preparation of hard herring. When they have drained sufficiently on herring horses, they are hung in the lower part of the smoke-house where they are close to the fire. Bloaters are smoked for at least three and not more than seven days. Since this grade of fish is prepared for immediate consumption and cannot be stored for very long, the length of the smoking period depends to a large extent upon the distance of the market and the demands of the particular trade to which it is sold. Bloaters are packed soon after smoking, usually in paper-lined boxes each holding one hundred fish, or about thirty-five pounds.

Recently kippered herring have come into favor among connoisseurs of smoked fish. In Maine, the fish intended for kippering are split down the back from head to tail in the same way in which mackerel are split, and then placed in strong brine for about an hour. After draining and drying, they are hung in the smoke-house for at least six and not more than sixteen hours. The slightly smoked fish are then packed in wooden boxes for immediate shipment. Such a process will not preserve the fish for more than two or three days at ordinary temperatures; on this account kippered herring cannot be transported long distances except in cold storage unless they are canned.

About the middle of the eighteenth century smoked haddock in Findon, Scotland, became very popular. The smoked fish were known as Findon haddocks; later this was abbreviated to Findon haddies, and then to finnan haddies, by which name smoked haddock is known to-day. The industry was introduced into the United States about 1850, but did not become of much importance until 1875. It has grown until now about thirteen million pounds of haddock are smoked each year in this country. The industry is still of great importance in Scotland, where nearly forty million pounds are prepared annually.

Smoked salmon is considered a great delicacy by most connoisseurs of smoked fish. Large quantities of mild cured (lightly salted) salmon are exported from the United States to Germany, where they are smoked. Formerly much halibut was preserved by smoking, but the fishery has been unable to keep up with the demand for fresh fish. For this reason the fish has become so expensive that relatively few are now smoked. Other fish smoked in limited quantities include cod, ling, saith, whiting, catfish, mackerel, eel, sturgeon, shad, flounder, butter-fish, bonito, tuna, whitefish, and trepang (sea-cucumber). The Norwegians prepare an unusual delicacy by smoking cod roe.

Fish Preservation by Drying

Fish drying, like fish smoking, is a very ancient industry, having been discovered by wild tribes in the tropics who found that their surplus of fish could be cured in the sun either with or without salting. Because of the hot climate and the abundance of food that may be had in the tropics for the gathering, the natives are not inventive and seldom take the trouble to improve their methods of preparation of food. In cold climates, on the other hand, where fresh foods can be obtained in certain seasons only with great difficulty, the inhabitants have been forced to study food preservation. Thus it has come about that although few fish are dried in temperate zones, all the improvements in the processes of dehydration have been invented by the people of these regions. Dried fish prepared by the ancient processes employed in the tropical climates are not especially palatable. On this account there is much prejudice against dried fish. For this reason, the recent improved processes of dehydrating fish have not gained much headway in the United States.

Since dehydrated fish weighs only about a tenth of the original weight of the fresh fish, it is economically transported in this form. For this reason, during the World War, when the transportation system of the country was overtaxed, comprehensive researches were carried out to determine methods of preparing dehydrated fish which when rehydrated would be as palatable as salted or smoked fish. The methods which were invented produced a palatable product, but the quality of the product deteriorated in storage. Improved methods of storage will have to be devised before the novel processes of dehydration will come into general use.

Much fish is dried in Scandinavian countries; some is dehydrated by the modern processes in Germany; and in the warmer Oriental countries, particularly in India, China, Japan, and the Philippine Islands, dried fish is one of the staple articles of diet of all classes of people.

In Bengal, Bihar, and Orissa immense quantities of fish are dried on mats placed in the sun just as they were thousands of years ago. These Orientals store their dried fish according to methods peculiar to that region. Some are packed into large earthenware jars smeared with fish oil inside and are then buried in a shallow trench in a shady place. A large proportion of the fish is not packed in jars but buried in the ground. The dried fish are placed in shallow trenches about two feet deep, lined with mats and straw, and covered with straw and then with matting. When the trenches are filled, the earth is thrown over the fish. Fish stored in this way is supposed to keep for a year or more, but it soon acquires a brownish red color, together with an odor and taste which are not relished by persons who have not acquired a liking for it.

In contrast to this crude process is that which is used to a limited extent in Germany. According to this method, the cleaned, pressed fish are hung on lath racks built on trucks, which are run into dehydration chambers, through which warm, dry air mixed with ozone is blown by powerful fans. The ozone partially sterilizes the fish and thus increases their keeping qualities.

Fish Canning

Although canning is a relatively modern means of preserving fish, it is already the most important method employed in America, and is gaining in importance in several other countries. Canned salmon is by far the most important American fishery product, the annual pack being valued at about fifty million dollars. American sardines are not known the world over as is salmon, yet the canneries receive about thirteen million dollars for their annual production. Much tuna and shrimp and large quantities of crabs, clams, and oysters are also canned in the United States.

Sardines, mackerel, anchovies, herring, tuna, and certain fish roes are canned in various ways in several European countries, while salmon and swordfish are canned in Japan and along the Asiatic coast. Much salmon is also canned along the Canadian Pacific coast.

Recently fish canning has gained a foothold in Portland, Maine, and in Gloucester, Massachusetts, two of the leading fish salting and smoking centers. Many kinds of prepared cod and haddock products are now canned, and canned alewives and shad are increasing in popularity.

No consideration of fish canning would be complete without a consideration of the salmon-canning industry, for this is one of the world's leading fishery industries, although it is only about sixty years old.

Salmon are taken commercially along the Pacific coast of North America from the Sacramento River northward and along the Asiatic coast of the North Pacific, but Alaska is now by far the greatest producer of salmon. At the time of the purchase of Alaska, the fur-seals of the Pribilof Islands were considered to be Alaska's greatest resource. No one foresaw the extensive development of Alaska's salmon fisheries. The growth of the canning industry has been especially rapid. The first salmon were canned in Alaska in 1878, when eight thousand cases were thus preserved. From that small beginning the industry has grown until now the pack averages five million cases.

The Pacific salmon are fish of a different sort from the Atlantic salmon, being of the genus *Oncorhyncus*, whereas the Atlantic salmon belongs to the genus *Salmo*. Five different species of Pacific salmon are found in Alaskan waters. The chinook, king, or spring salmon is the largest of these, averaging twenty pounds, although individuals weighing a hundred pounds are caught occasionally. It is the principal species taken in California and in the Columbia River, but relatively few are caught in Alaska. The red or sockeye salmon is the species most sought after by Alaskan canners. It is much smaller than the king-salmon, averaging only about seven pounds; but, since its flesh is red in color, it is preferred for canning to the species with lighter meat. The humpback or pink salmon, so-called because of the color of its flesh, is the smallest and most numerous of the Alaskan salmon, averaging only about four pounds in weight. The chum or dog salmon is a medium-sized fish, averaging about nine pounds in weight. Since its flesh turns nearly white during the canning process, it is the least valuable of the salmon. Some coho, silver, or medium red salmon are also caught in Alaska. Western Alaska produces about two thirds of the red or sockeye salmon, whereas central and eastern Alaska is the native habitat of the humpback and chum salmon.

The life history of the Pacific salmon is very interesting. The female salmon deposits her eggs in shallow streams usually a hundred miles or more from the ocean. The smaller male salmon swimming over the salmon-colored eggs fertilizes them, and in about two months they hatch and swim and feed together in schools in the streams. When they are two to three inches in length, they gradually find their way out to sea. Formerly the disappearance of the salmon in the sea was a mystery, unsolved by the leading ichthyologists. The extensive fishing operations conducted along the Pacific coast, however, have disclosed that the vast majority of the salmon are comparatively near the coast, while others stay in the bays, straits, and sounds virtually all the time when not in the rivers. Some years ago it was noticed that king-salmon would take a hook while in salt and brackish waters. At first only sportsmen were interested in this fishing, but, as the demand for the giant king-salmon increased, commercial fishermen began to troll for salmon, and now trolling is an important branch of the industry.

While in the sea the salmon grow to be large handsome fish. When they reach maturity at the age of two to seven years, the age depending upon the species, they again return to fresh water, usually swimming up the same stream from which they came. By this time the roe is fairly well developed, and when the salmon reach shallow water in the upper reaches of the river, which sometimes necessitates a journey of fifteen hundred miles, they spawn. The salmon do not eat after they have entered fresh water, and by the time they reach the head-waters of the rivers they are weak and emaciated. Soon after spawning, they die, having accomplished their life work.

Each female salmon that is permitted to do so spawns two thousand or more eggs. And yet, so thorough is the fishing, not enough eggs are spawned to maintain the fishery. For this reason, the United States Bureau of Fisheries, the several state fish commissions, and the Canadian government maintain fish hatcheries in which eggs taken from salmon are fertilized and hatched. Later, when they are large enough to take care of themselves, the fry are returned to the stream. Thus the young fish are cared for until they have passed the age at which so many are destroyed by trout and other predatory fishes.

Salmon canning is a seasonal business. During the autumn and winter, when the salmon are not running, the canneries are deserted save for a watchman or two. But late in the spring the first of a fleet of vessels arrives bringing the salmon fishermen and their equipment to Alaska. The trap-nets are soon set and are ready for the first run of fish. Other vessels arrive, bringing labor and equipment to man the canneries.

The salmon swim up the rivers in great schools, which swim past for days at a time. Each species arrives in a given locality at a definite season of the year. The Chinook or king salmon is the first to arrive in most localities. The run of red or sockeye salmon sometimes begins as early as May and extends usually to the middle of August. The silver or coho salmon runs later in the season than any other species.

When taken from the traps, the fish are placed in large scows in which they are transported to the canneries, which are often large factories where the salmon are canned on a big scale. The first step of the canning process is the cleaning of the fish, which is accomplished by the use of modern labor-saving devices. After the head and tail are cut from the fish by means of a band-saw, the fish enters an automatic dressing machine which removes all entrails, fins, blood, and slime from the salmon. Formerly this work was done by hand by Chinamen, vulgarly known as "Chinks"; for this reason these salmon-cleaning machines are known as "iron chinks."

From the iron chink, the fish pass on to another machine in which they are scaled, scraped, brushed, and washed. From here, continuous belts carry the fish to cutting machines, which cut the fish transversely into sections of the exact length of the cans to be filled. The sections of the fish are then conveyed to the filling machines, which pack the proper weight of fish in the cans. The filled cans pass on to the sealing machines, which attach the tops loosely. The cans are then exhausted with steam and hermetically sealed by a machine called a double seamer. The canned salmon is then cooked in large autoclaves, with steam under pressure. After cooling, the cans are tested and then labeled in automatic machines.

Few of us when we eat a sardine sandwich think of the great care required in producing sardines of a high grade. These little fish are very delicate and require careful attention throughout the canning process in order to keep them intact and in good condition, and to obtain the desired delicate flavor.

All sardines are of the herring family. Those caught in California are called pilchards or California sardines. The Maine canners pack young sea herring; in France and Portugal the pilchard is canned, and in Norway the sprat is used. The differences in taste between sardines from various countries depend more upon the methods used in packing than on the species used.

The American sardine industry, which is centered in northeastern Maine and in southern California, produces nearly half of the world's sardines. Sardines were first canned in France in 1845, and until 1880 France had a virtual monopoly of the industry, but between 1880 and 1887 the French catch was very small. For this reason some of the French packers moved to Spain and Portugal. The

American industry, which had begun in 1875, took advantage of the opportunity to capture some of the trade which the French were unable to supply. The industry grew rapidly until the quantity of sardines packed in the United States exceeded that of any other country.

Spain, Portugal, and Norway also possess important sardine-canning industries. Moreover some sardines are canned in Canada, Chile, India, Sweden, and Algeria.

In France, Spain, and Portugal the fish are dried, fried in oil, and packed in cans, which are then sterilized by heat. In Scandinavia a smoking process is generally used to cook and dry the fish before packing. This method produces a sardine of a distinctive and desirable flavor.

In Maine some sardines are packed in mustard or tomato sauce, and some are fried in oil without steaming; but most of them are spread on flakes and cooked with live steam for ten to fifteen minutes, and, after drying, they are beheaded and packed in oil in cans, which are sealed and sterilized by heating in autoclaves.

Most of the sardines packed in California are cleaned, brined, dried, and then fried in cotton-seed oil. The cooked fish are packed in one-pound cans with tomato sauce; after which the cans are sealed and sterilized. Some small sardines are packed in oil in quarter-pound cans. Since the California industry has developed largely since 1916, the factories are quite modern and are equipped with the latest labor-saving machinery.

Curiously most of the pilchards caught in the waters along the coast of southern California are captured at night. The schools of sardines are located by the phosphorescent light produced by the movement of the fish through the water. This light can be observed only when it is very dark, for even a small amount of moonlight or even bright starlight makes it difficult to see. The running-lights of the fishing-boats are even darkened by covering them with cloth, so that they will give only enough light to be seen at a short distance by other boats, but not enough to obscure the evidence of fish. At night it requires great skill to distinguish between schools of sardines and schools of other small fish. The fishermen note the differences in the trails of light as the fish swim away from the boat. Sardines are powerful swimmers and leave long slightly curved trails resembling the luminous paths of skyrockets.

The California sardines are caught in huge lampara nets, which are laid out in a circle about a school of fish. Occasionally as many as a hundred tons of sardines are taken in a single haul. Such a catch would fill a half-million quarter-pound cans of sardines! But the fishing business is a precarious one, and for every time such an enormous catch is made a hundred hauls are made in which none at all is caught.

Most of the California sardine canneries also can tuna of which about fifteen million pounds is canned each year in the State. At first only the albacore or "white-meated tuna" was canned, but for the past ten years the supply of this fish has been insufficient to meet the demand. For this reason, large quantities of blue-fin tuna, yellow-fin tuna, and striped tuna have been packed. Yellowtail and bonito are also canned. Fishing for tuna is great sport, as the fish are of large size and are caught on hook and line by men in motor-boats. These fish range in size from twenty to more than two hundred pounds. Because of the bad taste of the oil which these fish contain they are cooked with steam before they are packed into cans. This effects a partial extraction of the oil. After the cooked tuna has been packed into cans a vegetable oil is added.

Canned mackerel is becoming popular. Much of this fish is canned in California and Japan. Recently the fish salters have begun to can both fresh and slightly salted cod and haddock. This industry promises to give the cod-salting business much competition.

Miscellaneous Preserved Fishery Products

The Europeans preserve fish in many ways that are almost unknown in America. Marinated or pickled fish are very popular in continental Europe, especially in Germany. In Italy and other countries of southern Europe, fish are marinated by frying in hot oil and then packing in spiced vinegar; in Germany the fish are prepared for the vinegar pickle either by baking and frying or by salting in salt brine or in brine containing some vinegar. Russian sardines are also pickled fish prepared by first salting the sardines or young sea herring in strong salt brine and then pickling in spiced vinegar. Bismarck herring are prepared from large sea herring by a similar process. "Rollmops" is a popular marinated product which appeals to the German taste. It is prepared by rolling a boned and vinegared herring with a slice of cucumber pickle or onion.

Many other interesting preserved fish products are prepared on a large scale in Germany, Norway, Denmark, and Russia. Among the more important may be mentioned anchovy paste, fish sausages, Christiania anchovies, German delicatessen, and caviar. The Japanese pickle fish by merely covering them with hot vinegar according to a process resembling that of the preparation of cucumber pickles. Other curious fishery products popular in the Orient are canned fish pudding, shark-flesh paste, dried shark fins, and bagoong (fermented anchovies). The Chinese are especially fond of soup prepared from shark fins and dry large quantities of them.

CHAPTER XII

By-Products of the Fishery Industries

FEW of us realize the extent to which the numerous by-products of our fisheries enter into our daily life and aid in the enjoyment of many of our modern conveniences. Fish oils, meals, liver oil, fish scrap, fish glue, isinglass and shark-skin have many important uses with which most persons are not familiar. In Chapter II many of the everyday uses of fish oil were pointed out. Fish glue has nearly as many and as varied uses as fish oil; these uses also have already been indicated. Fish scrap prepared from fish waste and from fish not commonly eaten, such as the menhaden, finds extensive use as meal for the feeding of cattle, sheep, hogs, and chickens, and in the preparation of all sorts of fertilizers.

Isinglass, prepared from fish sounds (swim-bladders), no longer possesses great commercial importance, but its uses are varied. This curious substance is used in the preparation of the better grades of court-plaster, for the clarification of certain beverages, especially fine wines, and in the preparation of certain adhesives, especially belt cements.

Recently leather manufactured from the skins of fish has become very popular. Shark-skin leather has been manufactured in large quantities in recent years, and shark-skins have come to be of considerable value. Thus the demons of the sea which are so destructive of fishermen's nets have been found to be a blessing in disguise. Until their skins became of value it was thought that sharks were exceedingly numerous, but now that a shark fishery has been established, the shark fishermen have found difficulty in catching sufficient sharks to keep up with the demand.

Despite the very low price at which most fishery by-products are sold, their total annual value to the American manufacturers of these products is about twelve million dollars. About half of this is obtained from fish and whale oils, of which more than thirteen million gallons are produced annually. The quantity of fish scrap produced is also very large, amounting to more than two hundred million pounds. The bulk of this scrap commands a rather low price, as it is sold for fertilizer.

About half a million gallons of fish glue is produced each year. The manufacturers estimate its value at about six hundred thousand dollars, but the cost to the consumer is several times this amount. An immense quantity of cracked shells is sold as poultry grit, the annual production of about five hundred million pounds bringing more than two million dollars. A large amount of oyster shells is also made into lime, which is used for mortar, for plaster, and for agricultural and other purposes. Some clam shells are also crushed and used for the same purposes. Other fishery by-products include shark fins, herring scales, stearin, fish flour, and shrimp bran.

Fish-Oils

Fish-oil has long been considered an unpleasant subject of conversation. Dark of color and foul of odor, it formerly reminded one of unsightly back alleys strewn with rotten garbage and decaying fish. The research chemist has taken the putrid odor from fish-oil, but its evil reputation has stuck. Despite the fact that paints prepared with refined fish oil can scarcely be identified by their odor, it is difficult to sell to the general public paints known to contain fish-oil. It is possible, by chemical processes invented during the past few years, to make fish-oils into light-colored, sweet-smelling oils or into solid white fats resembling lard or tallow. A given sample of fish-oil may be made into beautiful white "wax" candles, or into soft edible lard-like fat. Or, if you prefer, the chemist can bleach the oil and destroy its odor without changing its properties.

Fish-oils are obtained from the entire bodies of certain fatty fish. By far the most important of these is the menhaden, which is also known as the pogy, hardhead, hardhead shad, bony-fish, whitefish, moss-bunker, bunker, chebog, marshbanker, alewife, old-wife, bug-shad, bughead, fat-back, shiner, and herring. Its average length is from ten to twelve inches, and it usually weighs nearly a pound. Menhaden are caught in the Gulf of Mexico and along the Atlantic coast of the United States as far north as Massachusetts. Formerly the fishery extended as far north as Maine, but in recent years sufficient fish have not been caught there to justify a fishery. As the menhaden is a migratory fish, the season differs on various points along the coast. Some are caught in Florida throughout the year, but most of them are caught between April 1 and November 1. In North Carolina, the northward movement of the fish ends about the middle of June. From then on little fishing is done until autumn, when the fish return. In the Chesapeake Bay region, where most of the fish are caught, the season begins about the middle of May, when the fish usually appear at sea, where they are captured during the latter part of May and June. In July, August, and September, the fishing is carried on chiefly in the bay. From then until the end of the season, usually about the middle of November, the fish are again caught at sea.

Large steamers have gradually supplanted the motor-boats, schooners, and sloops formerly used in the fishery. The fish are caught in purse-seines, from eighteen to twenty yards in depth and 270 to 400 yards in length. Attached to the bottom of the net are lead sinkers which keep the net submerged in the water, while at the top are numerous corks which keep it on the surface.

The menhaden swim near the surface in large schools. When a school of fish is sighted by the lookout in the crow's-nest, two seine-boats, each carrying half of the net, leave the steamer and encircle the school. When the two boats meet, a large piece of lead called the tom is attached to the purse-lines and dropped overboard to hold the ends of the net. The net is then pursed; that is, the bottom of the net is pulled together so that the fish cannot escape. After this has been accomplished, the steamer comes alongside, and the fish are dipped out of the purse by means of a bailing net and placed in the hold of the vessel. When possible, the menhaden steamers return to the factory every evening to unload their catch.

The conversion of the fish into scrap and oil is a relatively simple process, involving merely the cooking of the fish, the pressing of the cooked mass, the drying of the scrap, and the separation of the oil and water by settling. The modern machinery used for rendering the fish into oil and scrap looks very complicated, but it handles immense quantities of fish rapidly with very little labor.

In most up-to-date factories the fish are cooked by live steam as they are being conveyed through a stationary horizontal steel plate cylinder by a conveying screw. This type of cooking machine receives its supply of fish by means of a mechanical conveyer directly from the fish bins, and delivers the cooked fish directly to the continuous screw press which presses the oil and water from the hot fish. The oil and water flowing from the press are conducted through a trough to a receiving tank, where a preliminary sedimentation takes place, and a considerable quantity of solid matter that has been forced through the press with the liquid is separated. From the receiving tank the emulsion passes to a series of tanks in which the separation of the oil and water gradually takes place. The pressed cooked fish is dried in rotary driers, in which the scrap is heated by hot air as it gradually works its way toward the lower end of the cylinder.

Menhaden scrap is sold chiefly to fertilizer manufacturers, who mix it with potassium salts and acid phosphate. In recent years much scrap has been sold to stock feeders as meal for hogs and cattle. It also is a popular chicken feed.

In California the surplus pilchards or sardines are cooked and rendered into oil and scrap by a process similar to the one described above. Much sardine scrap is also made by an extraction process in which the fish are cooked and dried by direct heat in a continuous cooker. The cooked, dried scrap, which is known as unfinished meal, is extracted with gasoline or low-boiling naphtha. After dissolving out practically all of the oil, the naphtha is separated from the meal and distilled. Thus the naphtha is recovered, and the fish-oil is left in the still. The extracted scrap is heated with steam until all of the gasoline is driven off. This scrap is much lower in oil content than pressed scrap and for this reason is preferred for chicken feed, nearly the entire production being sold for this purpose.

In Washington and some places in Alaska, the inedible parts of salmon are manufactured into scrap and oil by cooking and pressing. Large quantities of Alaskan herring are also converted into meal and oil. The part played by fish-oil in American industries has already been discussed, but no mention of its valuable properties has been made. Menhaden, salmon, herring, and sardine oil which have been freed from stearin are very valuable succedanea for linseed and china-wood oils for use in the preparations of paints and varnishes. Old linseed-oil films become very brittle and crack because of the expansion and contraction caused by alternate heating and cooling. Fish-oil films are more elastic and consequently do not check so quickly. On this account they are used in nearly all paints exposed to extreme changes of temperature, such as those for roofs and smoke-stacks.

Liver Oils

Cod-liver oil, like fish-oil, has had a bad name for a long time. Its undesirable reputation is not entirely deserved but is largely a heritage of the early days of the industry when it was made by placing the livers in barrels and allowing them to rot. Under these conditions the liver cells burst, and the oil which extruded was skimmed off. In winter, the first oil obtained was light in color and was used as medicinal oil. The darker oil obtained later was called cod oil and was used for the curing of leather. When no more oil exuded, the remainder was obtained by placing the residue in an iron kettle and heating it over a fire. This dark rancid oil was also sold as cod oil for industrial purposes.

All this has been changed within the last few years. A hundred or more chemists have been studying methods of production, processes of removing the color and odor, and methods of separating the vitamines to which this oil owes its valuable therapeutic properties. These researches have accomplished wonders, resulting in novel processes of manufacture which have greatly improved the quality of the oil, so that now the best oil has relatively little odor and taste.

New methods of refining the oil have produced entirely colorless and tasteless oil, which may be taken by the most sensitive persons without nausea. The oil has also been hardened by treatment with hydrogen and thus transformed into a colorless, odorless, solid fat resembling tallow. Indeed all of the various consistencies, from a limpid oil to a mushy fat, a lard-like substance to an exceedingly hard fat such as stearin, may be obtained. Such solid fats are suitable for increasing the fat-soluble vitamine content of margarin and other vegetable fats. The semisolid fats may be used for the preparation of tasteless emulsions for medicinal purposes. Methods of separation of the fat-soluble vitamines have been discovered which have enabled chemists to obtain solid vitamine concentrates that can be conveniently administered in tablet form.

Modern manufacturing processes for the production of medicinal oil require the use of strictly fresh cod livers. Such livers are available chiefly in cold weather. For this reason medicinal cod-liver oil is prepared only in late autumn, winter, and early spring. The livers are carefully heated in steam-jacketed kettles, after which the oil is separated from the tissue by pressing under moderate pressure in bag presses. Still better oil may be made by rendering the livers in vacuum boilers. This treatment prevents overheating and thus insures a light-colored oil. Some cod-liver oil factories operate a small refrigeration outfit in conjunction with their plants. In these factories, the room in which the livers are pressed is kept cold, thus preventing decomposition.

Cod-liver oil and other fish-liver oils owe their therapeutic value to their fat-soluble vitamine content. These liver oils are high both in the antixerophthalmic, growth-promoting vitamine A, and the anti-rachitic vitamine D. Cod-liver oil is especially valuable in the nutrition of children, since it aids in the proper growth of bones, thus preventing rickets. Furthermore it stimulates growth because of its content of the growth-promoting vitamine. Cod-liver and other fish-liver oils are also used in the treatment of all forms of malnutrition, various forms of tuberculosis, chronic rheumatism, and gout. Cod oil, or the technical grade of cod-liver oil, finds extensive use in the manufacture of "chamois" leather, in the currying (finishing) of all leathers, and in the manufacture of oiled cloth and low-grade soaps.

Commercial cod-liver oil and cod oil are seldom made from cod livers alone. Inasmuch as the oils obtained from the livers of the haddock, hake, pollack, and cusk can scarcely be distinguished from cod-liver oil, and since these fish are caught on the same grounds, the livers are seldom kept separate. Thus commercial medicinal cod-liver oil is really a mixture of several liver oils. Two other liver oils, those from the shark and skate, are of commercial importance, finding use in the finishing of leather. Some shark-liver oil is now manufactured in America in connection with the shark leather industry. Most of it, however, comes from the Orient, where shark meat and fins are valued highly for use as food. The Japanese produce large quantities of shark-liver oil from many different species of sharks. Liver oils prepared from most species of sharks resemble cod-liver oil in appearance and composition. Some shark-liver oil finds use medicinally in the Orient, but most of it is utilized in the currying and tanning of leather. Skate-liver oil is manufactured chiefly in India, although some is occasionally prepared in North Carolina. This oil is also used medicinally in the Orient.

Fish Scrap

Fish scrap is a by-product of fish-oil manufacture. An immense quantity of fish scrap is manufactured; more than a hundred thousand tons is produced annually in the United States alone. The two important uses of this product are for meal and as fertilizer. Somewhat more care is used when fish scrap is prepared especially for meal, but most fish scrap is now of a good enough quality to make a satisfactory feed.

Fish have been used as manure almost since the beginning of agriculture. When the colonists first came to America, they found the Indians putting a fish beneath each hill of corn. The fish rotted and caused the corn to grow much faster. Just why the decaying fish caused an increased growth of corn was not understood by the Indians. An early German chemist, Liebig, often called the Father of Agricultural Chemistry, was one of the first to show that decaying fish furnishes plants with two important elements required for growth; namely, nitrogen and phosphorus, elements lacking in most soils. Nitrogenous fertilizers such as fish scrap aid in the growth of all crops on nearly all soils, except those such as muck soils which already contain an excess of organic matter and consequently much nitrogen. Phosphorus-containing fertilizers stimulate the formation of fruits and grains. Thus fish scrap is an excellent fertilizer for corn, which requires much nitrogen for growth and also phosphorus for grain formation.

Relatively little fish scrap is sold direct to the farmers, however; most of it is bought by manufacturers of mixed fertilizers, who grind it and mix it with potassium salts and other fertilizer ingredients in order to make a complete balanced fertilizer. Some fish scrap is not dried but after being thoroughly pressed is acidified with sulphuric acid. This product, which is termed green or acidulated scrap, is sold direct to the farmers. Such scrap cannot be mixed with other fertilizer ingredients, as it contains too much moisture, but the acid acts as a preservative and keeps it from rotting. This grade of fish scrap is seldom shipped any great distance but is sold to the farmers residing near the menhaden factories.

Most of the fish scrap produced along the Pacific coast of the United States is prepared especially for use as feed. Some menhaden scrap is now used as meal, and each year more is used in this way. The ordinary menhaden scrap is suitable for the feeding of animals, but it can be made much more palatable by improved methods. Menhaden scrap is ordinarily dried in rotary hot-air driers, in which the products of combustion of coal or oil enter the same end of the revolving driver. The gases are very hot and often scorch the scrap, making it unfit for use as meal. Steam-heated driers must be used if a high-grade meal is to be produced. Inasmuch as these are somewhat more costly than direct-heat driers, manufacturers have been slow to install them.

In California, Oregon, Washington, and Alaska, much fish meal is manufactured. In California much meal is prepared especially for chicken feed by the extraction process. Much meal is also prepared in special continuous units designed to handle relatively small amounts of fish and fish waste with a minimum of labor. Although heated air is used to dry the waste in most of these outfits, the products of combustion are not permitted to pass over the fish. These continuous fish-meal reduction units are also in general use in Oregon, Washington, and Alaska.

Fat-free fish meal makes an excellent feed for hogs, sheep, cattle, and chickens. Meal containing fresh fat (not rancid) is a still better feed for hogs, sheep, and cattle. Considerable care must be used, however, in storing fatty fish meal, as the presence of rancid fat in animal feeds gives the fat of the animal a slightly fishy taste.

Fish meal is an excellent source of protein for poultry and for growing live stock, since not only is the protein in a readily digestible form but this feed contains a high percentage of calcium phosphate, which is needed for the formation of eggs and bones.

Fish Glue

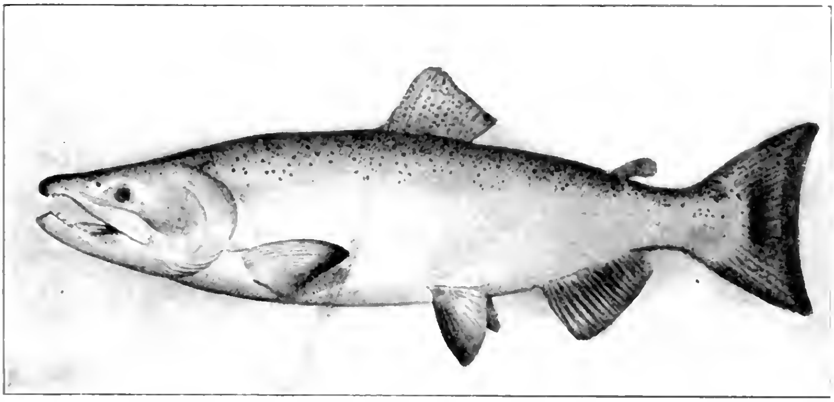
Fish glue is another fishery by-product which has an evil reputation because of the foul odor commonly associated with it. It need not have an especially bad odor, for if unspoiled fish waste or trimmings from salted fish is used in its manufacture, the product does not possess an unpleasant smell.

The best grade of liquid glue is the one known as skin glue. This glue is prepared from the skins of salted cod and cusk. The second-best grade is prepared from the skins of salted haddock, hake, and pollack, mixed with trimmings from all kinds of salted ground-fish (cod, cusk, haddock, pollack, and hake). This grade is known as waste glue.

The same general process is used in the manufacture of both of these grades of glue. First the stock is thoroughly washed with fresh water. This operation is accomplished by placing the stock in a large circular tank, covering it with water, and rolling it with a heavy wooden roller. The stock must be washed for at least twelve hours in order to remove all the salt. When it is completely freshened the stock is thrown into steam-jacketed, false-bottomed, rectangular galvanized iron cookers, where it is covered with water and then heated with steam. After about six hours the steam is shut off and the glue liquor drawn off. The stock is then cooked a second time.

The glue liquors, formed by the solution of the fish in hot water, are strained through excelsior, and then evaporated to a viscous syrup. After evaporation the glue is preserved by the addition of phenol and some essential oil such as camphor or sassafras.

Fish-head glue is made by washing and cooking fish heads. The fresh heads and backbone of cod, cusk, haddock, hake, and pollack are principally



Courtesy of U. S. Bureau of Fisheries

ADULT MALE CHINOOK SALMON

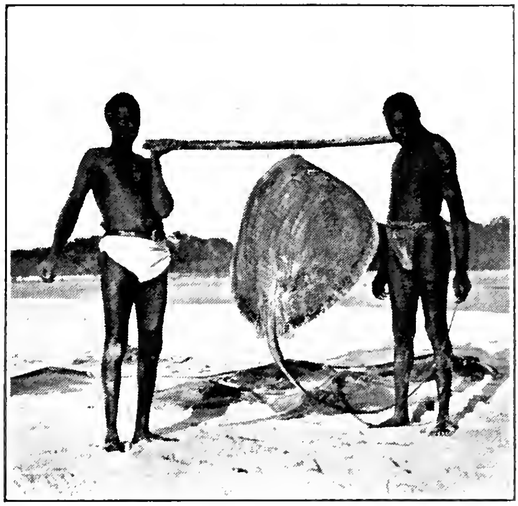
The principal species taken in California, Oregon, and Washington

AN ALASKAN SALMON CANNERY

Salmon canneries are often built out over the water

A TIGER SHARK

A shark of this size yields much valuable leather



A STING RAY

This fish also has a skin used for the manufacture of excellent leather

SEA-LIONS

Although these mammals are less valuable than fur-seals, their skins may be tanned into leather used in the manufacture of this glue in the United States.

Fish glue is the only common liquid glue. The so-called animal glues (hide and bone glues) will not dissolve in cold water and, when dissolved in hot water, form jellies when cooled. For this reason fish glue is adapted for uses to which other glues are unsuited. It is a strong adhesive, yet it is sufficiently flexible to be used in the preparation of flexible glues. It is used wherever a strong, ready-prepared adhesive is required.

Isinglass

Many persons confuse isinglass with mica. True isinglass is prepared from the sounds or swimming-bladders of the sturgeon, hake, and other fishes. It is often said that the large meat-packing houses utilize everything except the squeal of the pig; on the other hand, the fish packers utilize even the sounds of the fish. There is some truth in this pun, for in the large fishery centers, such as Gloucester and Eastport, the fish packers do not waste any part of the fish. But the fishing industry is so widely scattered along thousands of miles of coast-line that the waste of many fishery products in out-of-the-way places is unavoidable.

The best isinglass is made in Russia from the sounds of the sturgeon. The manufacturing operations are simple, the sounds being split open, carefully washed, cleaned, and dried. The prepared sounds are treated in various ways, depending upon the form desired. Long staple, short staple, leaf, book, and cake isinglass are the chief forms in which it is marketed. These trade names refer simply to the form and method of packing the product for the market.

American isinglass is prepared principally in Massachusetts, where the quaint old town of Rockport is the principal center of the industry. This isinglass is marketed chiefly in the form of ribbons. Such isinglass is prepared by soaking the previously dried sounds in water until they become soft, after which they are chopped into pieces and rolled many times until they are converted into a very thin ribbon, which is wound on a wooden spool.

Isinglass is often considered to be gelatinous or gluey in nature; but, although it may be converted into glue or gelatin by boiling with water, it is neither glue nor gelatin. It is similar in composition to fish skin. It does not dissolve in water unless it is heated, whereupon it takes on gelatinous properties, forming a tough jelly when cooled. It is used in the clarification of fine wines and other beverages. Formerly it was used for the preparation of edible jellies and in the manufacture of marshmallows and other candies, but since gelatin has become so inexpensive these uses have become obsolete. It also finds use in the preparation of high-grade glues and special cements. Some is still used in the preparation of high-grade court-plaster.

Shark and Other Leathers of Marine Origin

Although the skins of certain marine animals (seals and walruses) have been tanned for many centuries, it is only recently that any attention has been given to the tanning of the skins of true fishes. It required the services of the modern chemist to make leather from shark skins, for the outer covering is very hard and difficult to remove. This hard rough coating, called shagreen, was formerly used as an abrasive and for sword-hilts. Until the scientist studied the problem, the only known way to remove the shagreen was to scrape the surface with a heavy rasp or file. According to the more up-to-date processes the skins are first tanned with a vegetable tanning extract, and then the shagreen is removed by milling with an acid solution. Inasmuch as the shagreen is calcareous in nature, this treatment quickly removes it. After the removal of the rough coating, the tanned skins are then treated with certain fatty liquors which make them soft and pliable.

A slightly different process is carried out in producing chrome tannage. In this case the shagreen is first removed, after which the skins are pickled in dilute acid and then placed in the tanning solution, which contains a basic salt of chromium. After tanning is complete, the skins are treated with a soda solution and then dyed.

The shark fishery has been of much assistance to the other fisheries, as sharks are very destructive of the relatively frail nets set for other fishes, often tearing them to pieces. The sharks are usually caught in wire nets, which are so strong that they cannot be torn, and which have such large meshes that the smaller fish can pass through.

North Carolina and Florida are the centers of the shark fishery. The fishermen seldom tan the skins, but remove them from the sharks, carefully salt them, and then ship them to the tanneries.

Shark leather finds use in the manufacture of ladies' hand-bags, men's bill-folds, brief-cases, the uppers of shoes, card-cases, and slippers. It adapts itself readily to all sorts of grains and finishes and for this reason is a popular leather for the manufacture of all sorts of novelties.

Skate, devil-fish, saw-fish, and ray skins resemble those obtained from the shark, and are prepared for tanning and tanned by the same processes. They possess a calcareous layer of shagreen, which is removed by an acid treatment in the same way that this layer is taken from shark's skin. These leathers are used in much the same way as shark leather. They are especially popular when made up into novelties.

A limited amount of cod, cusk, haddock, hake, and pollack skins are tanned and the resultant leathers made up into small novelties such as bill-folds and card-cases. Since such leather is really so beautiful and useful, it seems a shame that so little fish skin is utilized.

Hair-seal and walrus skins are not covered with fur, and, since they resemble closely the skins of land animals, they are tanned into excellent leather. A century ago walruses were plentiful in Greenland, Labrador, and other countries of the far north. But they were so easily captured that relatively few of them are left. Hair-seals were much smaller and were not nearly so valuable, and accordingly they were not pursued so relentlessly; for this reason there are still many large herds.

The process used in the preparation and tanning of seal skins is practically the same as the process employed in the tanning of the skins of land animals, except that the finishing process is somewhat different. After the tanning process is completed, the skins are dampened with a coat of season containing blood albumen and are then rolled on the glazing jack until a bright finish is obtained. When an especially bright finish is desired, the skins are dampened a second time and again rolled. The final finish which is so characteristic of seal leather is obtained by a process known as boarding. This is accomplished by rolling the skins in such a manner as to produce miniature wrinkles running at different angles along the grain. Seal and walrus leathers are used in suitcases, traveling-bags, and the like.

Porpoises, dolphins, blackfish, and whales are marine mammals which resemble each other in many respects. Porpoise, dolphin, and blackfish skins have been used in the preparation of high-grade leathers for many years, but whale leather has never found an important use. Porpoise leather has been made to imitate cordovan, and produces a very worthy substitute. But since it is exceedingly strong, it finds its principal use in the preparation of lace leather, which is used for lacing up machinery belting. Porpoise lace leather is prepared by tanning the skins first with alum and salt and then with cod oil, after which the leather is oiled with a mineral oil. The product is very strong and flexible.

CHAPTER XIII

Oysters, Clams, and Other Mollusks

OYSTERS, like many other fishery products, have been eaten since prehistoric times. The ancient Greeks and Romans were very fond of oysters. The origin of the culture of oysters is shrouded in antiquity; some writers say that the Chinese first practised the art, while others contend that the Romans cultivated oysters before the Orientals learned to do so. The answer to the question seems to depend upon the definition of oyster culture. If one defines it as the putting out of cultch or spat collectors and the care of the oyster from the spat stage, ancient Rome probably led.

Oysters are taken along the coasts of nearly all temperate countries. Europe, Asia, Africa, Australia, and North and South America all have oyster industries, although the bulk of the production comes from North America and Europe.

Europe produces about five million bushels of oysters annually. France, England, Holland, and Italy furnish nearly all of these. The French industry is highly developed, and is the greatest in Europe.

The United States now produces annually about seventeen million bushels of oysters, valued at twelve million dollars. At the close of the nineteenth century the production was approximately twenty-seven million bushels. Since that time the quantity taken has decreased because of pollution of the coastal waters and over-fishing.

Maryland, Virginia, New Jersey, and New York taken together produce about two thirds of the American production, although some oysters are grown in every coastal State except New Hampshire and Maine, where the water is too cold for oyster culture.

Each oyster-producing center is very proud of its product, and usually asserts that its oysters are the best in the country. In some places the opening of the oyster season is a time of ceremonious feasting. In Colchester, England, the mayor dredges the first oysters and eats the first one opened. The neighboring oyster center of Whitstable also conducts special ceremonies at the opening of the oyster season.

The development of an oyster industry depends to a considerable extent upon transportation facilities. A perishable product, such as the oyster, must be marketed soon after it is taken from the water. Oyster beds located in out-of-the-way places are often unprofitable because of the difficulty in shipping the fresh oysters to market. Such beds are often exploited by canners who are unable to pay high prices for their raw material. For this reason the canning industry is located principally in South Carolina, Louisiana, and Mississippi.

Nature does her best to keep us bounteously supplied with oysters. A full-grown female Atlantic coast oyster produces annually about sixty million eggs.

If all of these eggs grew to be mature oysters, there would be no water in our harbors, for they would be entirely filled with oysters. About the same time that the female spawns her eggs, each male oyster discharges billions of sperms into the water, which swim around until they come in contact with an egg. A few hours after fertilization of an egg, a swimming embryo is formed. The tiny oyster develops rapidly, soon growing shell valves. Even when the shell has grown so that it covers the little oyster, the larva is very, very small, being only about one four-hundredth of an inch long. For the first two weeks of the oyster's existence, it swims rapidly around, propelled by a fine hair which resembles a tail. At the end of this period it attaches itself to some clean solid object on the bottom, and loses its power to swim. This stage in the oyster's life is known as the spat or set stage. When the oysters are large enough to be handled individually, they are called seed-oysters. In Northern waters, these little oysters grow to be market oysters in about four years, but in the warmer waters of the South they grow much faster, attaining market size in two years.

The shell of the oyster is lined with a thin membrane called the mantle, which is fringed all around the edge and unattached along the margin. The oyster possesses four gills which are excellent filters, removing from the water the exceedingly small living animals, chiefly diatoms and dinoflagellates, which the shell-fish eats. The gills are covered on both sides with very fine hairs arranged in rows, which beat back and forth, causing a current of sea-water to pass through the gills into tubes and thence into the cavity above. As the water passes through the gills, the colorless blood of the oyster is aërated. Thus the oyster uses the same organs for eating and breathing.

In the early days of the American industry, oysters were very plentiful in all of the bays and harbors from Massachusetts southward along the Atlantic coast. Oysters could be taken in large quantities from the public waters. But as the demand for this delectable shell-fish increased, fishing on the public grounds became so intensive that large areas became exhausted. Many harbors became so polluted with trade wastes that oysters could not live.

When the value of oysters became sufficiently high to warrant the expenditure of the necessary effort, oyster culture in privately owned or controlled waters became the general order of the day. If it were not for the commercial growing of oysters in protected waters, these shell-fish would be very scarce indeed. Oysters are still taken in large quantities from many public grounds, but as the years pass a larger and larger proportion are grown by the oystermen.

The first operation in the growing of oysters is the planting of old shells, which act as spat collectors. The oysters spawn during July and August; consequently the oysterman must have his beds of shells ready at that time. The shells must not be placed too soon, else the shells become covered with dirt and then the set will not stick to them. If the oysters do not spawn soon after the shells have been deposited on the ground, they are stirred up with dredges to brush the dirt from them. If conditions are right, the tiny larval oysters settle to the bottom and attach themselves to the shells that the oysterman has planted. At this stage the little oysters are so small that they are invisible to the naked eye. In most localities, in the autumn, the oystermen move the shells, to which the young oysters have attached themselves, to deeper water where the little shell-fish will be safe from the winter's storms. Even there the oysters are not entirely free from danger, for many enemies prey on them. The starfish, to which every visitor to the sea-shore is attracted, is one of the most persistent. The villainous creature wraps itself around the oyster, strangling it. When the oyster has been killed, its shell opens, and the starfish eats the fresh meat. The oysterman must watch his oysters or the starfish will eat them all up. When the starfish becomes troublesome, the oysterman mops his beds with huge stocking-yarn mops. The back of the starfish, which is rather thorny, becomes entangled in the mop, which is then drawn to the surface and immersed in boiling water or treated in some other way so that the starfish are killed.

Another powerful enemy of the oyster is the mussel. Mussels, like oysters, fasten themselves to shells or other objects, and often attach themselves to the shell of a young oyster. Sometimes a number of small mussels completely surround an oyster and grow so fast that they smother it. To rid the oysters of mussels, the oystermen must dredge up the oysters, pick off the mussels, and then return the oysters to the bottom.

The drill is another dangerous enemy of the oyster. This little shell-fish belongs to the conch family and looks a great deal like a periwinkle. It has a spiral drill like an auger and bores through the oyster's shell, thereby killing him. If drills attack an oyster bed, about the only thing to be done is to move the valuable shell-fish to another bottom.

When the oysters are about two years old they are transplanted. The oysterman attempts to spread them out so that all of them have room to grow. Care must be used in handling oysters, or they will be injured, and a considerable number will be lost.

The oysterman must not only watch the living enemies of the oyster, but he must also guard his waters from pollution by sewage and trade wastes turned into the bays by towns and factories. Many wastes from chemical plants will kill the larvæ before they settle to the bottom, and some will destroy fully grown oysters.

Pollution by sewage seldom kills oysters, but it renders them unfit for consumption. The fine straining apparatus of the oyster takes from the water many bacteria and other microscopic organisms; and if the water contains disease germs, such as those which are found in sewage, they may be found in the oysters living in the polluted waters. Recently a method of disinfecting living oysters has been invented by which the oysters are treated with small amounts of chlorine.

Oil from vessels of all sorts floats on the surface of all harbors which have much shipping. This oil forms a thin, nearly continuous film which prevents the absorption of air by the water. Thus, while the oil may never touch the fish and shell-fish in the water beneath, it may kill them by suffocation.

Oysters are usually taken for market at the age of four or five years. Before being marketed, they are often placed in less brackish water, which causes them to swell. This process is erroneously called "fattening," the increase in size resulting merely from absorption of water. "Fattening" is sometimes carried out by placing the oysters on a slatted float anchored in relatively fresh water.

In this country oysters are taken either by tonging or dredging. Tongs are employed chiefly by oystermen of small means who take oysters from shallow beds. Oyster tongs are long, scissor-shaped instruments with toothed iron baskets fitting together at the lower end. The handles vary in length from twelve to more than twenty feet, depending upon the depth of water in which they are used. The baskets, which catch and hold the oysters, are about ten inches wide and three feet long. Usually, when tonging for oysters, the oysterman works in a flat bottomed skiff, often called a bateau.

The great bulk of the oysters taken in America are removed from the beds by means of dredges, which vary in size from light hand dredges, with a capacity of two or three bushels, up to huge dredges which hold thirty bushels. The larger dredges are operated either by means of a donkey-engine or by the steam engine of the dredge-boat. The boats vary in size from small sloops, nicknamed skipjacks, to the large steam vessels which operate six big dredges simultaneously. When dredging for oysters, one or more dredges are dragged behind the boat as it proceeds at reduced speed, until the dredges are thought to be full; then they are hauled in and the contents dumped on deck, where the oysters are sorted out of the débris.

Oysters are usually unloaded from the deck or hold of the boat by means of bucket and hoist upon the wharf, or directly into large steel wheelbarrows in which they are conveyed into the oyster house. In some of the larger houses the oysters are hoisted into bins in the uppermost story of the building, from which they are automatically carried by means of conveyers to the culling and shucking benches.

Oysters are sold both in the shell and as shucked oysters. Whole oysters are sold for eating in the half-shell. The shell trade demands the best oysters, which must be carefully selected. American oysters which have a good reputation because of their flavor are the Blue Points, Cotuits, Maurice Rivers, Lynnhavens, Chincoteagues, Cape Cods, and Rockaways. Blue Point oysters are grown in Great South Bay and take their name from Blue Point on its northern shore. Blue Points are of medium saltiness and possess a very delicate flavor. The usual Blue Point oyster is small and well rounded. Cotuits, obtained in Cotuit Harbor, Massachusetts, are larger and more pointed.

The people of Philadelphia are the greatest consumers of oysters in the world, although Baltimore and New York are not far behind. "Oyster bars" dot the Philadelphia streets throughout the market section, and a large number of its restaurants make a specialty of sea-food. Baltimore and New York are likewise noted for the excellence of their sea-food.

Because of the great bulk of the shells, whole oysters are seldom shipped great distances. The principal demand in the United States is for shucked oysters. The oysters are opened or shucked in the oyster-house. The arrangement of the oyster-house depends to a large extent on the capacity of the plant. The actual operation of opening the oyster is always carried out by hand, as no one has devised a satisfactory machine for the purpose. The chief obstacle which stands in the way of the invention of a mechanical opener is the variation in the size and shape of the shells.

The workmen, called shuckers, work at benches, where they crack the thin end of the shell and insert their oyster knife. Some shuckers do not take the trouble to break off the ends but force the knife between the shells at the side or at the thin end. The knife cuts the large adductor muscle and thus frees the shell. Another cut through the same muscle completely removes the oyster meat from the other shell. A fast shucker can shuck about eight bushels of oysters a day, thus producing ten to twelve gallons of meats. The shells are dropped upon a moving belt which carries them out of the house to a huge pile where they are dumped. The meats are washed in fresh water usually first on a perforated table and later in tanks. Often the water is aërated during the washing process. The washed oysters are graded according to size, from the smallest, "standards," through "selects," "counts," to "extra selects." They are then carefully drained, placed in containers, packed in ice, and shipped. Recently, small, sealed tin cans of oysters have become very popular. Such containers permit the retailing of the oysters without exposing them to the air. Non-returnable tin cans of one, three, and five gallons capacity are also in common use.

It is hardly necessary to mention the many delicious dishes prepared from oysters. In Europe, oysters are a food enjoyed only by the rich; but in America they are commonly eaten all along the Atlantic and Gulf coasts and in many inland cities. The Europeans usually eat oysters raw, either in cocktails or on the half-shell. In the coastal cities of the United States, many oysters are eaten in this way, but even there more are cooked. In the interior, oysters are more commonly served in soup, chowder, stews, fricassees, pot-pies, fritters, and as fried and scalloped oysters. There are at least a hundred inviting dishes which may be prepared from oysters. There is a single bulletin [1] that tells how to cook them in ninety-eight ways. Some of these will arouse one's curiosity; surely "angels on horseback" and "pâté à la princesse" are dishes fit to set before any king. For those of more plebeian tastes, "oyster sausages," "oysters and spaghetti," and "oysters à la Kirkpatrick" will be more likely to appeal. New Englanders will be

[1] Bureau of Fisheries, Economic Circular No. 58 (1923).

pleased with "Yankee oyster pie"; Baltimoreans are sure to want "Maryland stew"; and Southerners will cook their "oysters à la créole."

Practically all the world's production of canned oysters is prepared in the United States. About seventy-five oyster canneries operating in nine different States produce a total of a half million cases of oysters each year.

Since the shucking of live oysters requires considerable strength and great skill, the canners steam the oysters before removing the meats. This is accomplished by pushing latticed iron cars loaded with the live oysters into a large steaming room, in which the oysters are steamed for about five minutes. When the oysters die, their shells open, and it is then an easy matter to remove the meats with a knife. The oysters are then washed and packed into cans. The tops are loosely attached to the packed cans by an automatic machine. After the air has been driven out by steam, the cans are run through a sealing machine, which crimps the tops on so as to make a tight seal. The sealed cans are sterilized by heating in an autoclave under pressure, and, after cooling, are labeled for packing. The canning of oysters requires considerable care, as it is difficult to retain the firmness of the raw oyster. Modern scientific methods have greatly aided the canner.

Inasmuch as the whole oyster is eaten except for his shell, the only by-products are the many shell products. Perhaps the most important use for the shells is as cultch to catch the young oysters at the time they change from free-swimming larvæ to the

TONGING OYSTERS

Tongs are often used for taking oysters from beds in shallow water

DREDGING OYSTERS

In deep water, oysters are taken in dredges secondary "set" oysters. Other shells, rocks, stakes, or even brush would answer this purpose, but, since most oystermen have a surplus of oyster shells, these are usually spread on the bottom selected for the new ground. Another use of great importance is as grit for poultry. Both oyster and egg shells consist largely of calcium carbonate. Chickens and other domestic birds have difficulty in obtaining sufficient calcium to form shells for their eggs. In order to aid the birds to get an ample supply of this element, poultrymen feed cracked oyster shells to them. Shells are prepared for cracking by drying in a rotary drier, and are then crushed and screened into various sizes of grits. Oyster shells are also made into lime by strongly heating in a kiln. This process, called burning, destroys the organic matter of the shell and converts the carbonate of lime into the oxide. Lime prepared in this way is used for plaster, fertilizer, and the like. Formerly many oyster shells were used in the construction of roads, the well known shell roads of the South being built of this material. Superior road materials are now available, so that oyster shells are used less and less for this purpose.

The American Clam Industry

Long before the arrival of the first white man in America, clams were the favorite food of the Indians along the coasts. The sites of the old Indian villages are still well defined by huge piles of clam shells, or kitchen-middens, as they are called. Clams were not only a source of food but also of "suckawhock," or black money. Wampun or white money was also a shell product, for it was made from periwinkle shells. Suckawhock had about twice the value of wampun. The manufacture of these belts of beads required an enormous amount of labor. A half-inch of shell was worked down into a cylindrical bead, bored with a drill made of splinters of flint, and then polished with great care. One hundred and eighty beads strung on a sinew and woven on a strip of deerskin with twelve similar rows of beads made a belt of suckawhock or wampun, depending on the kind of beads used in its preparation. These belts of beads were used by the Indians, not only as money, but also for ornamental purposes, keeping records, sealing friendships, and concluding treaties. They were more useful to the Indian than gold and silver are to-day. In early colonial days, the colonists used this shell money as a medium of exchange, giving each belt the value of about five shillings.

To-day clam shells are worth but little, but the clams themselves are of considerable value. The United States produces annually about ten million pounds of clams, valued at two million dollars. Maine, New York, New Jersey, Virginia, and Massachusetts lead in clam production. Massachusetts alone yields half a million dollars' worth of this shellfish.

Four species of clams are of commercial importance in the United States. In Connecticut and the States farther north on the Atlantic coast, more soft clams (*Mya arenaria*) are taken than hard clams (*Venus mercenaria*). From Delaware southward, the hard clam is the only one of commercial importance. Some surf-clams, "skimmers," are marketed in New York. A long, narrow clam called the razor is the principal species taken in Washington. Mya, the soft clam, is known by many local names; the more common are long clam, long neck, squirt-clam, maninose, sand-gaper, and old maid. Venus, the hard clam, is commonly called quahog or quahaug, round clam, and, in the smaller sizes, cherry-stone and little-neck clam.

Larval clams resemble young oysters in that they pass through a free-swimming stage. These minute clams rotate spirally as they move through the water. When the little clam is only one three-hundredth of an inch in diameter, it grows little shells. Millions of the free-swimming clams can be found over the clam flats during the summer months. After swimming for a few days, the young clams settle to the bottom and attach themselves to shells, seaweeds, or pebbles by means of minute threads which they spin. At this stage, the young clams do not remain stationary but often detach their anchors by means of their feet. When the young clam has become about a hundredth of an inch in length, it burrows into the bottom. Newly buried, soft clams occasionally come to the surface, creep a short distance, and then burrow in again. Once the clams have reached a half-inch in length, they burrow in deeper and never rise to the surface again. Soft clams grow from a length of one inch to three inches in a single year, but the growth of the hard clams is much slower.

The culture of both the hard and the soft clam is carried out in a limited way in New England. Small areas are found on almost every flat where small soft clams are found in enormous numbers at certain seasons of the year. Sometimes as many as two thousand seed-clams per square foot of surface are obtained by washing the sand or mud through a cradle-shaped sieve. Seed-clams obtained in this way are planted on suitable tidal flats, and grow to market size within a year or two.

A somewhat similar system of culture has been suggested for the hard clam but has never proved profitable. Box spat collectors are used which sometimes catch as many as seventy-five young hard clams per square foot of bottom, but as a rule the catch is insufficient to warrant the requisite expenditure of labor.

The history of the soft clam industry is quite similar to that of most of our fishery industries and may be summarized in a single sentence: The supposedly inexhaustible supplies, rapidly exhausted by over-fishing, were saved from complete exhaustion by conservation and culture. The period of plenty extended from colonial times to about 1875, when improved transportation facilities opened up larger markets. The over-fishing that followed soon depleted many of the finest beds, and, by the beginning of the twentieth century, much attention was given to restocking the beds.

Soft clams are dug both on exposed tidal flats and on flats covered with shallow water. Submerged clams are dug with a very large clam hoe called a sea-horse, which is worked deep into the sand and then dragged through the shallow water. The clammer's partner follows, collecting the clams upturned by the sea-horse.

Dry digging on flats left exposed by the tide is a much more common practice. The clammers push a "hoe" resembling a potato-digger into the sand for the length of the tines and then turn up the sand, thus exposing the clams. The clam-digger picks up the marketable clams and places them in a lath basket. When the basket is filled, the clams are carefully washed to remove all mud and sand.

Soft clams are either marketed alive in the shell or shucked out. The smaller white clams of pleasing appearance are usually sold in the shell for steaming. A bushel of clams yields about seven quarts of clam meats. Shucked clams are usually shipped either in kegs or butter tubs.

During the summer season, when the best prices are paid for clams, the clammers are able to make very good profits from their small investment.

The Indians fished for hard clams by the primitive method of treading. The treader waded about barefooted in shallow water, feeling with his toes in the soft mud for the quahogs. Such a simple method is not applicable to commercial fishing to-day, as there are few flats where sufficient clams can be found in shallow water. The colonists preferred soft clams to the hard species and so gave little attention to this fishery. Indeed it was not until the beginning of the twentieth century that hard clams became popular.

About that time the little-necks or small quahogs came into favor, and the demand soon grew so great that the natural clam beds could scarcely supply it. The hard clam fishery is an important one in Massachusetts, Rhode Island, New York, North Carolina, and Florida. There are still many great beds of these clams along the coasts of the Southern States that have never been disturbed.

Inasmuch as quahogs are usually found in rather deep water, much more complicated equipment is required for their taking than for soft clams. Where the clams are taken in relatively shallow water, various types of rakes are used. For deeper water, small dredges are in common use. Both rakes and dredges are operated from boats. As soon as the clams are brought ashore, they are washed and graded. In Massachusetts, the quahogs are graded into small and large "little-necks," medium and large "sharps," and large "blunts." The little-necks are the smallest and most valuable grade. Blunts and sharps are alike except for the difference in the thickness of the edge of the shell. The blunts are thick-lipped and have a somewhat heavier shell than the sharps, which have sharp edges. Little-necks vary from 1.5 to 3 inches in length, whereas medium sharps and blunts range from 3 to 3.75 inches and large ones from 3.75 inches up.

If the market is dull, the quahogs are often either bedded in sand or spread on floats submerged in protected waters. The clammer has only to spread his clams out on a tidal flat, and they will burrow into the sand and continue their growth. The use of floats possesses the advantage that the clams need not be dug again.

Razor-clams, so called because of their long, narrow shape, are taken chiefly on the coasts of Oregon, Washington, and Alaska. An important canning industry has been developed on the Pacific coast, which now produces about a million dollars' worth of canned razor-clams each year. Razor-clams are chiefly found in the sand between the tide lines. They are usually most numerous near the low-water mark, and so are taken in the largest quantities during the spring tides when the run-out is the greatest. Razor-clams dig large elliptical holes which extend about two feet into the sand. When all is quiet and the clam feels secure, he remains at the top of his hole so that the shell extends an inch or two above the surface of the sand. But, if anything startles him, he quickly sinks deep into the hole. These clams are usually dug with short-handled spades. Over-fishing has threatened this clam fishery; for that reason, Washington now has a closed season from June 1 to September 1.

Soft clams are canned in Maine, Massachusetts, and Rhode Island; Florida and Washington produce canned hard clams. Razor-clams are packed in Oregon, Washington, and Alaska. The combined production is about four hundred thousand cases, valued in excess of two million dollars.

Clams are canned whole and minced, and as chowder and soup. A limited amount of clam bouillon and juice is also preserved by canning. The packing of clams requires much more tedious labor than the canning of oysters, for the meats are dressed and cleaned. The visceral mass, siphon, and side walls are cut out and discarded. Some of the juice of the clams which runs out during the dressing process is added to the filled cans. The remainder is canned separately and sold under the name of clam nectar.

Clam chowder, which is also canned in large quantities, is usually prepared from the hard clam because it has the most pronounced clam flavor. A large number of ingredients enter into the preparation of this favorite New England dish. Clams, bacon, fresh potatoes, onions, tomatoes, parsley, thyme, sweet marjoram, salt, and pepper are common components of chowder prepared especially for canning. The mixture is boiled with water for a few minutes and packed in cans, which are then topped, sealed, and processed.

Clam extract finds extensive use, not only for its clam flavor, but also as a food for invalids and convalescents. It is prepared by steaming clams placed on racks or gratings. This cooking causes much of the juice to run out into pans placed under the racks. After filtering, the juice is concentrated by evaporation, and then placed in cans, which are topped, sealed, and sterilized.

Scallops

Nature not only furnishes us with a great variety of good things to eat, but often wraps them in beautiful packages. Scallops and abalones are delicacies incased in beautiful shells. The beauty of scallop shells, otherwise known as frills or fan shells, has been known for many years. Centuries ago the medieval pilgrims, returning from the shrine of St. James at Compostella, Spain, decorated their hats with scallop shells. The American Indians used scallop shells as the raw material for the making of many of their shell ornaments. Even to-day the ingenious Yankees make many beautiful ornaments from these shells. In colonial times, scallops were much more plentiful than they are to-day. During severe storms large numbers of these mollusks were killed and washed ashore. The farmers residing along the coast utilized some of them as fertilizer and as feed for their hogs and chickens. It was not until 1870 that the scallop came to be generally eaten as human food. To-day scallops are rather scarce and are highly esteemed as one of the finest delicacies among sea-foods.

Although four species of scallops are found along the Atlantic coast, only two are of commercial importance. The shallow-water scallop, *Pecten*, is found from Massachusetts to the Gulf of Mexico. The sea-scallop, *Placopecten*, lives in deeper and somewhat colder water.

Scallops are much more independent than clams and oysters, as they are able to swim through the water. This is accomplished in a curious manner. The shell-fish rotates slowly, opening and closing its shell, alternately discharging water first near one lobe and then the other, until it reaches the surface, when its motion ceases, and it slowly sinks to the bottom. Shallow-water scallops often lie on the eel-grass near the surface; when disturbed, they drop quickly to the bottom. The bay scallop is short lived, seldom living more than two years. Sea scallops probably live somewhat longer, although no one has accurately determined their average length of life.

Curiously, the shallow water scallop is hermaphroditic, each individual being both male and female. The spermatozoa and ova are discharged alternately, so that there is little danger of self-fertilization. The young scallops grow rapidly, reaching maturity in less than a year. Comparatively few live to spawn the second year.

Bay scallops are mainly taken in dredges operated either from a type of sail-boat called a cat-boat, or from a motor-boat. Six or more dredges are dragged along the bottom by a single boat. When the dredges are hauled in, the catch is dumped on a culling board. The catches are often very interesting; sometimes the dredge contains fish, lobsters, crabs, tin cans, bottles, stones, bits of wreckage, and so forth, though, when the boats are over good grounds, but little trash is hauled up with the scallops. While the dredges are being pulled back over the grounds, the rubbish is separated from the scallops, which are then transferred to bags or dumped into the cockpit of the boat.

The fisherman takes his catch of scallops to his shed, where the scallops are opened, and the "eyes" (adductor muscles) are removed. The remainder of the scallop is either discarded or used as bait. Prejudice is curious, for it dictates that only the adductor muscle of the scallop be eaten, but finds no objection to the eating of whole oysters. The remainder of the scallop is edible and has an agreeable flavor but nevertheless does not find use as food. The scallop openers become very skilful and are usually able to cut the eyes from fifteen bushels in a day, thus obtaining about eleven gallons of scallop eyes.

Scallop eyes are usually soaked in fresh water before they are marketed. In this way the large plump eyes demanded by the trade are obtained. Unfortunately this treatment greatly reduces the length of time the scallops may be kept without spoilage, and thus makes it impossible to ship them great distances. Notwithstanding this, the practice of plumping is practically universal. Probably the fishermen's greediness has as much to do with the continuance of the practice as anything else, for a gallon of fresh scallops upon being plumped becomes a gallon and a half, thus increasing the apparent quantity of scallops by fifty per cent.

Because of their larger size, sea scallops are more valuable than bay scallops. Formerly it was thought that these scallops occurred only from Massachusetts northward, but in recent years large beds have been found along the coast of Long Island, and off the coasts of New Jersey and North Carolina. The fishing methods are similar to those just described, except that larger dredges and boats are used. Large trawl nets are also used in the Southern fisheries.

Portland, New York, and Boston are the best markets for scallops.

The California Abalone Industry

The abalone industry has already been mentioned in the chapter on pearls and mother-of-pearl. In the United States, abalones were taken for their beautiful shells long before the food value of their flesh was recognized by Americans. Just as the American Indians residing on the Atlantic coast utilized clam shells for ornamental purposes and for the manufacture of shell money, so the Indians of the Pacific coast used abalone shells for these purposes.

The early Chinese immigrants first recognized that the California abalones were quite as valuable as food as the Oriental *Haliotis*, and began to gather these mollusks for their meat. The Chinese built up an important abalone drying and smoking industry, which still exists to-day. It is only recently that the abalone has become a popular American dish.

The abalone is a large marine snail. Six species are found on our Pacific coast but none on the Atlantic. The abalone, like the common snail, has a well developed head and a powerful adhesive creeping foot. Many tragic tales have been told of the adhesive power of the abalone's foot. Various writers record the drowning of Chinese fishermen by the incoming tide while they were held fast to the bottom by an abalone. While such an occurrence is possible, it is highly improbable, and it seems likely that these tales were invented by persons with fertile imaginations to account for the mysterious drowning of abalone fishermen.

Some abalones are taken by fishermen wading in shallow water at low tide, but they are much more plentiful in water from eighteen to sixty feet in depth. Most of the fishing is done by the Japanese, who go down to the bottom in diving-suits and detach the abalones by slipping a steel chisel under the expanded foot of the shell-fish. When the diver has filled his net basket with shell-fish, he signals to his assistant, who hoists the shell-fish to the boat and then lowers an empty basket.

The abalones are so large that small steaks may be cut from them. After the mollusk has been cut from the shell, the visceral mass and the mantle fringe are cut away from the large central muscle, which is then sliced into small steaks, ready for frying. Stewed abalones and abalone chowder are also excellent dishes.

A large proportion of the abalones taken in California are cooked, dried, and smoked by the Chinese. The product is exported to the Orient. The first step in the preparation of this Oriental delicacy is the salting of the fresh meats in brine. After being thoroughly salted, they are washed and soaked, and then spread on shallow trays to dry in the sun. After four or five days, the abalones are cooked again, then smoked and thoroughly dried. This process converts the abalone meat into a tough, hard, brown product which is difficult to slice, even with a sharp knife. The Chinese either stew the dried product after soaking, or grind it into a powder and make soup of it.

Canned abalone has recently become a popular American food and would be much more popular if it were better known. Much canned abalone is also exported to the Orient. For the American trade, only the foot muscle is minced and packed in cans, but the abalones packed for export to the Orient contain both the mantle and the foot muscle.

Sea Mussels

Curiously, while oysters, clams, scallops, and abalones have been so generally exploited that the important beds have been seriously threatened with entire depletion, the enormous beds of sea mussels widely distributed along the coast of North America have scarcely been touched. Some are sold in New York, San Francisco, and Seattle, but they have never come into general use as food.

In Europe, however, the demand for mussels for food and bait is so great that the natural supply cannot meet it; for this reason, much attention has been given to mussel culture. France alone produces about four hundred million pounds of mussels.

The invention of the system of mussel culture now practised by the French dates from the thirteenth century, when an Irishman named Patrick Walton was shipwrecked on the French coast. Fortunately he decided to make his home where he was stranded. With inventive genius that would be a credit to a Yankee, Walton immediately sought ways of increasing the food supply of the region. His first invention was the "alluret," a large net, a quarter of a mile long and ten feet wide, for catching birds. Walton noticed that young mussels attached themselves to the stakes of the bird traps in great numbers. These mussels grew more rapidly and were better flavored. This gave him the idea which he developed into a practical system of mussel culture that is still in use. Walton drove rows of stakes into the bottom, arranged in the form of a V, with its apex pointing toward the sea. Branches of chestnut or other trees were woven in and out between the stakes. The seed mussels attached themselves to the lower stakes. When they had grown to the size of an ordinary bean, they were transplanted to other higher *bouchots* or rows of stakes. Walton's ingenuity is indicated by his arrangement of the rows of stakes in such a way as to act as cultch for mussels and also as a fish trap.

In Europe, sea mussels are a popular food and are eaten in the same way as clams. Fried mussels, steamed mussels, mussel chowder, mussel fritters, and pickled mussels are favorite dishes in France and Holland. Raw mussels are also served on the half-shell in the same way as oysters.

On the Atlantic coast of the United States, mussels are utilized principally as bait for fish and as fertilizer. Some mussels are preserved by pickling and canning. Canning mussels does not cause them to shrivel; the canned product possesses an attractive appearance and a pleasing taste.

Other Shell-Fish Industries

In America, large quantities of squid, a small mollusk of the devil-fish family, are taken for use as bait. On the Pacific coast and in New York they are also used as food. Some are sold fresh, but the bulk of those sold for food are dried and exported to the

Orient. In China, Japan, and the Philippines, squid and other larger devil-fish are highly prized for food; large quantities of devil-fish are preserved there by drying and smoking. This strange mollusk does not look like anything on the land or in the sea, and so gets its name of devil-fish. When attacked, it discharges an ink-like fluid, which muddies the water so that its enemy cannot see it.

Many other shell-fishes are found on our coasts, the most important being cockle, periwinkle, whelk, piddock, natica, donax, and chiton. Cockles are commonly eaten in Europe and are a popular shell-fish in England and Ireland. They are found on the Pacific coast from Coos Bay, Oregon, northward, but are utilized only in a very limited way. Piddocks, periwinkles and whelks are also eaten in Europe but are seldom used for any purpose in America. The piddock possesses remarkable skill in boring a hole in a rock for a home. He starts the hole by rubbing the surface of the rock with a few grains of sand held in his foot. When the hole is well started, he burrows into the rock by constantly turning his rasp-like shell in the cavity. A small mollusk called the donax is taken on the California and Florida coasts. This shell-fish is used in the preparation of soup which is made by boiling the mollusks in a pot of water. In certain districts this soup is preserved by canning.

CHAPTER XIV

Lobster, Crab, and Shrimp

Lobster and the American Lobster Industry

IN colonial days lobsters were exceedingly plentiful along the coast from Delaware to Labrador. It is said that after severe storms the beaches were littered with dead lobsters which had been killed and washed ashore. Such tales seem rather fanciful but probably are true, for these lobster grounds were the finest ever known. One hundred million lobsters have been captured on the Canadian coast in a single year. In the eighteenth century many of the lobsters taken were of great size. In fact, the little lobsters weighing a pound or less such as we get to-day were considered too small to be of value. Lobsters weighing twenty-five pounds were occasionally taken, and those weighing six to eight pounds were often sold in the markets.

Even in the nineteenth century, lobsters of great size were sometimes taken. One lobster which weighed thirty-four pounds was caught at Atlantic Highlands, New Jersey, in 1897. Its body was twenty-four inches long, and with outstretched claws its entire length was about four feet. Its crushing claw was fifteen inches in length with a girth of over twenty inches.

The American lobster fishery first reached important proportions in Massachusetts early in the nineteenth century. The fishery was not extended to Maine until 1840. Here it grew very fast and soon overshadowed in importance that of Massachusetts. The Massachusetts fishery is now nearly exhausted, and the Maine lobster catch is rapidly decreasing from year to year.

About 1870 the Canadian fishery became of importance and soon the Canadians were catching more lobsters than were taken in all the rest of the world. This lobster fishery is still far more important than any other; but, unless conservation is practised, the annual catch will rapidly dwindle, for the lobsters are being caught more rapidly than they are multiplying.

Several steps toward conservation have already been taken. Laws have been enacted in both the United States and Canada which forbid the taking of both immature and egg-bearing or "berried" lobsters. Further, closed seasons have been inaugurated. These regulations have retarded the decline of the fishery, but either they are not rigorously enforced or have not been sufficiently stringent to maintain the fishery even at its already low level.

If the lobster were a rapidly growing crustacean like the crab, the existing regulations would prevent the decline of the fishery. But the lobsters grow very slowly and do not reach sexual maturity until they are about six years old and from seven to twelve inches in length. If most of the lobsters over eight inches in length are caught and sold, few can reproduce their kind. Further, since the young lobsters grow so slowly, and have so many enemies which are constantly diminishing their number, many larval lobsters must be hatched in order to have one survive to reach maturity.

The lobster industry of northern Europe has passed through the same stages as that of America. Lobsters, which were once very plentiful, have been decimated by over-fishing, and are now very scarce and high in price.

Lobsters are in many respects the most curious creatures that live in the sea. Many biologists have studied their growth and life in order to find means of propagating these crustaceans. Much has been learned that has aided in the solution of the problem, and recently the Rhode Island Commission of Inland Fisheries has been successful in rearing lobsters to the fifth or bottom-seeking stage of development.

Female lobsters spawn a large number of eggs in a single batch, the number depending upon the size of the lobster and varying from 3000 to 100,000. The eggs are not discharged into the water to sink to the bottom or float with the currents, but are attached to the swimmerets on the under side of the mother's tail by a waterproof cement. The eggs remain attached to the mother's tail for ten to eleven months, during which they slowly develop until they hatch.

The newly hatched larval lobster is transparent and has a short shrimp-like body, with a ringed tail stretched out almost horizontally, and a huge pointed snout. It has gleaming emerald eyes and a bright yellow liver. It looks more like a shrimp than a lobster and is often mistaken for a larval gurnard.

The little lobsters grow very fast, their development taking place in stages. The end of each stage is marked by a molt; the little lobster discards its shell and, while it is growing, gradually goes through several changes. At first the larval lobster swims aimlessly about, but soon it learns to swim in search of food. It continues swimming about until at the end of the fifth stage, when it is eight to ten weeks old, it seeks the bottom and comes inshore.

During the rest of its life the lobster remains on the sea bottom unless it is forcibly withdrawn. Lobsters do not migrate up and down the coast at definite periods as do many fishes and other marine animals, but in warm weather they come in closer to the shore, and in autumn they retire to deeper, warmer water.

Lobsters continue to molt and grow throughout their lives. After each molt they grow a new shell just a little larger than the old one, and increase a little in length and weight. The very fact that there are so few large lobsters caught is an indication that very few mature lobsters escape the trap for more than a year or two.

We think of lobsters as extremely awkward creatures that are scarcely able to move because we have seen them lying helplessly on ice in some fish market. But in the water, where they are buoyed up by the weight of the liquid they displace, they are very active creatures, walking nimbly over the bottom on the tips of their slender legs. Lobsters are agile, wary, pugnacious, and able to defend themselves against many larger enemies. Like many crustaceans they are cannibalistic and often destroy injured or smaller lobsters. This tendency is not especially evident in their natural abode, but when large numbers are cooped up in live-cars or pounds awaiting sale, the larger lobsters usually kill and eat the smaller ones.

Lobsters are, for the most part, carnivorous animals, living upon the fish and invertebrates which inhabit the bottom and come within their reach. Although they are great scavengers, it is probable that they always prefer fresh food to stale. They are very fond of clams and other mollusks and often dig up the bottom in search of shell-fish. Lobsters not only eat the meat of the shell-fish but also consume fragments of the shells. It has been suggested that the lime for the hardening of the shell after molting is obtained from this source.

Nature has endowed the lobster with some remarkable powers. Inasmuch as the lobster grows very slowly and does not reach maturity until it is five or six years old, he would have great difficulty in surviving the many perils that constantly beset him if he did not possess the wonderful power of regeneration or replacement of lost parts. Thus, if a lobster loses a leg, a claw, or an eye, a new one soon sprouts and is regenerated. Further, if a lobster gets caught, he drops the leg or claw which is held, and thus often manages to escape with his life. Later the missing member is regenerated. Curiously the regenerated claw is not always similar to the lost one; occasionally an individual is found with two crusher claws or two toothed claws.

The normal color of the living adult lobster is a deep green, although in some individuals it varies to dark blue and nearly black. Occasionally red and cream-colored lobsters are taken, but such colors are abnormal. When lobsters are cooked their color changes to bright red, because of a chemical change in the pigment of the shell.

Lobsters are caught in baited traps called pots or creels which operate on the principle of the old-fashioned rat-trap, and are adapted for taking an aquatic animal of dull wit but keen scent. These traps vary somewhat in size and shape in different parts of the country, but, in general, they consist of oblong lath boxes having in one or both ends a funnel-shaped opening, usually inclined obliquely upward, through which the lobsters pass in quest of the bait.

The common Maine lobster-pot has a flat bottom and is semi-cylindrical in shape, being about four feet long, two feet wide, and eighteen inches high. It is constructed of common house laths nailed to a hardwood frame. In each end is a coarse-meshed, funnel-shaped net, the larger end of which is of the same diameter as the pot, whereas the smaller end is only six inches in diameter. These funnels are about a foot deep and thus extend about half-way to the center of the trap.

Each trap is weighted down to the bottom with two bricks. Attached to each pot is a relatively short rope which reaches to the surface, where it is attached to the runner or main line, which is a thousand or more feet in length. The traps are attached at fifty-foot intervals. Either end of the runner is made fast to a buoy, which in turn is anchored to the bottom. Some lobster fishermen mark their buoys with a home-made flag by which they can identify their gear even when they are some distance away. Others paint the corks and buoys in a distinctive manner.

The location and depth at which the pots are placed depends upon the season, the shore, and the nature of the bottom. In winter, as the lobsters then retire from the shore, the traps are set in water from sixty to one hundred and fifty feet deep. In the summer the pots are placed in water varying from ten to sixty feet in depth. Many fishermen set a hundred or more traps; and as lobsters become more and more scarce, a larger and larger number of pots are set in order to maintain the fishery at its present level.

The length of the intervals between the fishing of the pots depends upon the number of lobsters in the locality, the season, and the weather. During rough weather it is not easy to pull the pots and remove the lobsters, for it is very difficult to handle a skiff or a small motor-boat in a sea churned into fury by fierce winds. Foggy weather is also bad weather for fishing, for the lobsterman has difficulty in finding his buoys and in avoiding collisions with other vessels.

All sorts of fresh, salted, and stale fish are used as bait. In New Jersey menhaden are commonly used for this purpose; but in Maine, where herring are cheap, this fish is often used. The fish used as bait are placed in the center of the trap and are either threaded on a copper wire and suspended from the roof or fastened upon a peg or spear fixed upright.

Although the lobster cannot see far through the water, he is guided to his food by his strong power of scent. Traps placed in currents where the odors coming from the bait are widely diffused usually catch many more lobsters than those set in quiet water, other conditions being equal. The crustaceans are often sly and wary, and walk around the trap many times before yielding to the temptation it presents.

Once taken, lobsters must be handled with care or they will seize a finger or two in their scissor-like claws; and, as one can easily imagine, shaking hands with a lobster is not likely to be a pleasant experience. The lobsters of marketable size are placed in the well of the fishermen's boat, while smaller ones taken from the traps are tossed back into the sea. When the fisherman returns to port, the lobsters are either sold to wholesalers or placed in a live-car or pound to be kept until the market improves. The live-cars in which lobsters are kept are large rectangular slatted boxes constructed of heavy lumber. These cars are moored close to shore in quiet waters where there is little danger of their being wrecked in heavy seas. Dealers handling large quantities of lobsters sometimes fence in areas of quiet water, thus making a pound where large numbers of these crustaceans may be kept for long periods.

Lobsters are usually packed with ice in barrels before shipping. They are covered first with seaweed or paper and then with cracked ice. Burlap is tacked over the top of the barrel. Lobsters are marketed alive, boiled, and canned. In America most of the lobsters are sold alive, and prepared for the table by boiling. Since boiled lobsters are easier to handle than live lobsters, one might expect that boiled ones would be more in demand than live ones. But because of a fear that the lobsters might have been dead before they were placed in the boiler, boiled lobsters do not find a ready market.

The demand for live lobsters in the United States exceeds the supply. On this account none are canned. But in Canada a large number of short lobsters are taken. Since these little lobsters are too small to be legally sold in the United States they are canned. Since there is no law to prevent the sale of small canned lobsters, a large proportion of the canned lobster is sold in the United States.

The first step in the canning process is the boiling of the live lobsters. This is carried out by immersion for thirty minutes in weak brine heated to the boiling point. After cooling, the meat is removed from the shell, and packed in cans lined with parchment paper, some tail, claw, and arm meat being put in each can. After the covers have been crimped on, the cans are exhausted, sealed, and sterilized by heating with steam under pressure.

The American Crab Industry

When the present size and importance of the American crab industry is considered, it is hard to believe that this has all been developed within the past fifty years. Until about 1875, crabs were seldom seen in any fish market except those in the cities along the coast. Even in these markets, crabs were not important items of trade. From that time until 1915 the fishery grew rapidly. In that year the production reached fifty million pounds; from this peak the catch has diminished until now it is only about half that figure.

The crab industry of the Atlantic coast is located chiefly in the Chesapeake Bay. The village of Crisfield, Maryland, is the center of the soft-crab industry. Although only a town of four thousand inhabitants it possesses a very important crab and oyster industry and wholesale fish business, with more than fifty dealers in crabs and crab meat located here. Crabs, oysters, and fish taken in this part of the bay are brought to Crisfield for shipment to Baltimore, Norfolk, Philadelphia, and New York. Few other towns are so dependent upon the fishing industry. Some crabs are also caught on the Pacific coast, but the industry there is not of great importance except in Washington.

The blue crab, *Callinectes sapidus*, is the important crab of the Atlantic coast. A different species, *Cancer magister*, is the common crab on the Pacific side. This crab is exceedingly abundant on the Alaskan coast, but the fishery has not been developed to an important extent, chiefly because of the great distance from the markets.

Crabs are very interesting crustaceans. They are hatched from very small eggs, which are only about one one-hundredth of an inch in diameter, not as large as the period at the end of this sentence. No one has yet counted the number of eggs in the average sponge, as the egg mass of the female crab is called, but the number has been variously estimated as between 1,750,000 and 4,500,000. After being attached to the fine hairs of the swimmerets on the under side of the abdomen of the mother for about two weeks, the little eggs hatch. The mortality of the young crabs must be very high, for if all the crabs hatched in one season grew to maturity, they would crowd all of the water out of the Chesapeake Bay.

The life history of the crab resembles in many respects that of the lobster. The growth proceeds in stages, taking place immediately after each molt, just as in the case of the lobster. The growth of the crab, however, takes place much more rapidly than that of the lobster. Immediately after the first molt, the young crab increases in length more than two hundred per cent. From then on its growth is somewhat less rapid, as its average increase in width from one stage to another is only thirty-two per cent. At the age of one year, when about fifteen moltings have occurred, the crab reaches maturity and does not molt again. By this time, the crab is about six inches in width. Individual male specimens are found which are somewhat larger than this, sometimes attaining a width of eight and a half inches and a weight of one and a quarter pounds. Females seldom exceed seven inches in width.

Young crabs also resemble lobsters and many other crustaceans in possessing the power of regenerating lost legs and claws. If a crab is caught and held by a leg or claw, it throws off the appendage and thus escapes with its life. The loss is not a serious matter, for a protuberance forms in the end of the old stump, which enlarges and becomes a thin-walled sac. At molting-time the sac is discarded with the old shell, and the new limb, which was folded up in it, appears in its normal shape. The new limb is somewhat smaller than the corresponding member of its pair, but at subsequent molting it gradually increases in size until it eventually attains full growth. Adult males which have molted for the last time do not possess the power of regeneration, or at least grow appendages very slowly.

Curiously a crab can walk forward, backward, and sidewise; the usual direction is sidewise. The crab swims either backward or sidewise.

In winter, crabs retire to deeper water, where they lie on the bottom in a dormant condition. In summer they migrate to shallow water, where they mate or spawn. Sponge-crabs (female crabs with eggs attached) are found chiefly in the southern part of the Chesapeake Bay. The young crabs slowly migrate to the northern part of the bay, where they are found in great abundance during the latter part of the summer. At first the young crabs molt every ten days or two weeks, but as they near maturity the period gradually lengthens until it reaches a month. The shell of a soft crab hardens in two or three days after molting.

In this, the most important crab fishery, crabs are taken by means of scrapes, dredges, dip-nets, and trot-lines. Scrapes and dredges are the most rapid means of taking crabs, but require the use of larger boats and more valuable equipment than the other two methods. Soft crabs are taken principally with scrapes and dip-nets, since crabs do not bite just before and immediately after shedding, and so cannot ordinarily be caught on trot-lines. Dredges are used chiefly for taking hard crabs found in deep water. They offer the only means of capturing crabs in winter, when they lie inactive, on the bottom, or partially buried in it.

A trot-line consists of a light rope, about a quarter of an inch in diameter, varying in length from eight hundred to two thousand feet, to which bait is attached at intervals of three or four feet. The line is anchored at each end, thus holding it in place while on the bottom; a buoy is also attached to the line near the anchor in order to mark the location of the trot-line. The trot-line is set very early each morning and lifted when the crabs cease biting. The crab is a very stupid creature indeed, for, once he has seized the bait, he will not let go until he has devoured it. Thus, when he has found the bait on the trot-line, he will cling to it even though it is drawn to the surface. As the crabber moves his boat along the trot-line, he lifts the line and catches the crabs in a short-handled dip-net while they are still clinging to the bait.

The crabber classifies his catch of mature crabs into six groups: (1) hard crabs, which are those with the ordinary hard shell; (2) snots, which have just entered the molting stage; (3) peelers, molting crabs whose shells have begun to break; (4) busters, molting crabs whose new shells can be seen; (5) soft crabs, newly molted; (6) buckrams or paper-shells, whose shells have begun to harden.

Soft crabs are much more valuable than hard ones, but much more care must be taken in handling, packing, and shipping them. Some soft crabs are taken in dip-nets and scrapes, but most of them are obtained by keeping peelers and busters in shallow floats until they shed their shells. The usual float is about four by twelve feet, and fifteen inches in depth, and is made of pine or cypress.

The crabs are sorted into several lots before being placed in the floats. Those about to shed are placed in the shedding floats. Other floats contain those which will molt in a day or two while still others hold the green peelers. The crabs in floats are not fed, and the water is often so warm that the mortality is high. Much of this loss might be prevented if the floats were made deeper and shaded from the hot sun; and as crabs become more and more valuable, it is likely that greater care will be taken.

When first molted crabs are too soft and weak to stand shipment, they are allowed to remain in the floats a few hours before being removed for packing. Soft crabs are always shipped alive, packed in shallow wooden trays each containing one layer of crabs. A layer of seaweed is placed over the bottom of the tray on which the crabs are placed, each one resting on its apron and lapping over the next in the row. The crabs are covered with a sheet of parchment paper upon which seaweed and crushed ice are placed. When soft crabs are shipped long distances in hot weather, many of them die. In any case, they must be treated as a very perishable commodity.

Some hard crabs are marketed alive; but, since they are neither so perishable nor so valuable as soft crabs, less care is taken in packing and shipping. Usually they are shipped in barrels, with ice or leaves or both. Most of the hard crabs are cooked and the meat picked out of the shell. The cooking is usually accomplished by steaming strap-iron baskets full of crabs placed in a metal tank or cooker. Steaming for thirty minutes changes the color of the crab from blue to bright red. After cooking, the crabs are placed on the picking tables, where skilled women pick out the meat from the body of the crabs. Three kinds of meat are obtained, which are sold separately. The lump meat, the muscles that operate the swimming legs, commands the highest price. The flake or white meat, which is next in value, consists of the remaining muscles of the body with the exception of the claws. The claw meat is dark in color and therefore is the cheapest.

A barrel of crabs yields three to four gallons (fifteen to twenty pounds) of meat. Crab meat is packed in tin cans with perforated bottoms. The cans are in turn packed in barrels with ice and shipped by express. Some of the shells are cleaned and washed and shipped with the meat for use in the preparation of deviled crabs.

Hard crab meat is also preserved by canning. This industry is located principally at Hampton, Virginia, the center of the hard crab fishery. The cooking and picking operations are performed in the same way as in the preparation of crab meat, except that all three grades of meat are canned together. Some crab meat is also canned in Maryland, Maine, Mississippi, and Alaska. In most cases, however, the business is carried on merely as a side-line to a fresh crab meat or some other canning industry. The total volume of business is small, usually being less than fifty thousand dollars a year.

There are many crabs other than the blue crab found on our shores. Various crabs are thought to resemble such things as bugs, spiders, and horseshoes and for this reason have been given curious names. Thus we have fiddler, hermit, king, horseshoe, Jonah, lady, sand-bug, and spider crabs. The popular names of other crabs are indicative of their color or habitat, such as green, yellow-shore, purple-shore, red, kelp, sand, mud, mussel, oyster, rock, and stone crabs. Most of these crustaceans are of little economic importance. The rock-crab, Jonah-crab, stone-crab, and the common Pacific crab, *Cancer magister*, are all fished commercially to some extent.

The fishery for the common crab of the Pacific coast is of importance in Washington and Alaska. The methods of catching this crab resemble more closely those employed in the lobster fishery than those of the blue-crab fishery, for these crustaceans are caught in hoop-nets and traps. The Pacific crab attains a somewhat larger size than the blue crab of the Chesapeake Bay.

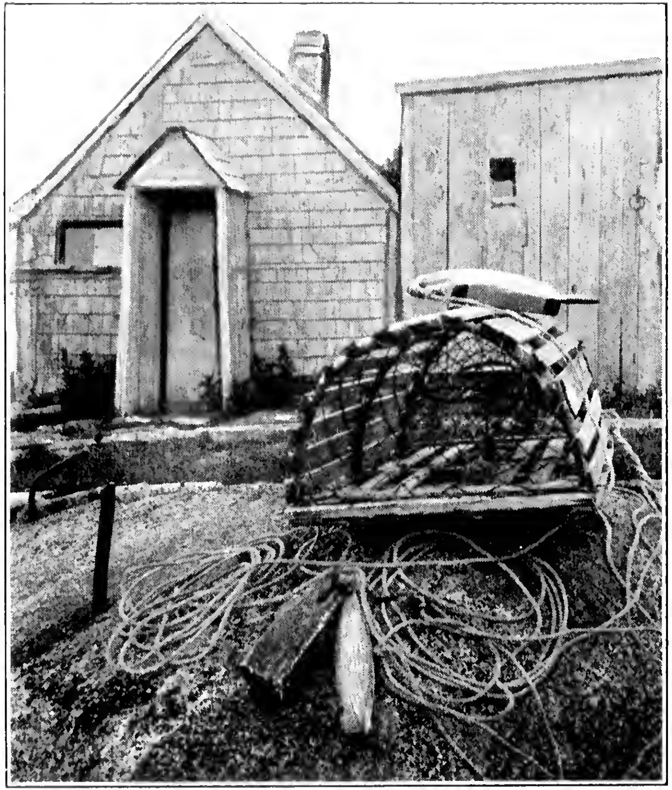


Photo by F. H. Herrick

A LOBSTER-POT

This trap operates on the principle of the old-fashioned rat-trap

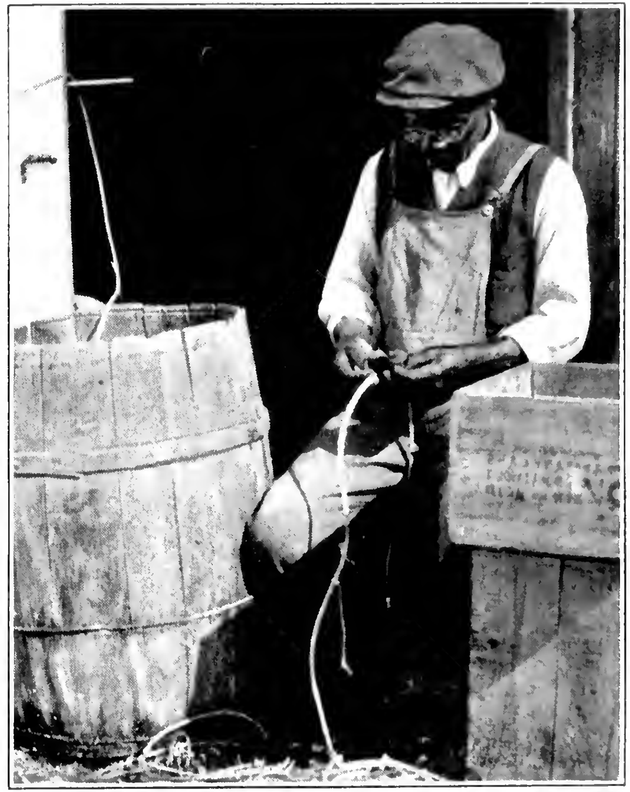


Photo by E. P. Churchill, Jr.

BAITING TROT-LINE FOR CRABS

Crabs cling to the bait even though the line is drawn to the surface

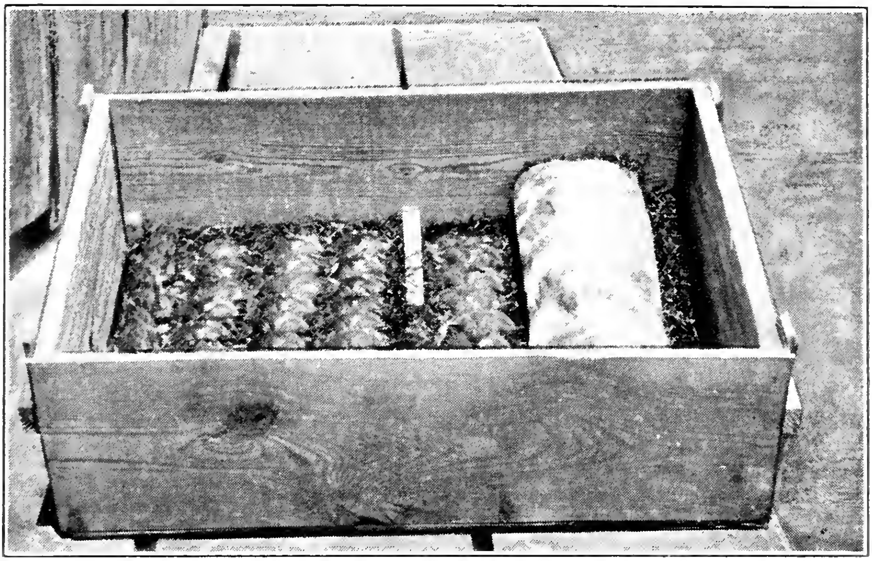


Photo by E. P. Churchill, Jr.

SOFT CRABS READY FOR MARKET

They are packed in trays upon a layer of seaweed

Photo by E. P. Churchill, Jr.

CRAB FLOAT

Crabs about to molt are retained in slatted live-cars until they have shed their shells

Our Shrimp Fisheries

Although "shrimp" is a derogatory term commonly used to denote an undersized, undesirable person, marine shrimps are considered a delicacy by connoisseurs of sea-foods. Shrimps are little crustaceans found all along our coasts but caught in commercial quantities only in the Southern and Pacific States. Large numbers are also found in Alaskan waters, but a fishery has not yet been developed.

The commercial shrimp fisheries are located chiefly in Louisiana, Florida, Georgia, Mississippi, Texas, and North and South Carolina. Mississippi and Louisiana lead in the production of shrimp. The Mississippi fishery is concentrated at Biloxi, where an important canning industry is located. In the spring the Mississippi fishermen confine their operations to the Mississippi Sound, but in autumn they visit the Louisiana marshes, often going a hundred miles from port for a week's fishing. Barataria and Timbalier Bays are the most important fishing grounds of Louisiana. Fishing camps are established on the shores of these bays, from which the fishermen go daily to the fishing grounds. Larger boats from New Orleans visit the camps periodically and transport the shrimp to the canneries. Fernandina, Florida, and Brunswick, Georgia, are the principal shrimp-fishing ports of the Atlantic coast.

Haul-seines are used in the shallow-water fishery of Louisiana and Mississippi, whereas shrimp taken in deep water are caught in otter-trawls. Formerly all of the shrimp caught by the Biloxi and New

Orleans fishermen were taken in haul-seines, but in recent years the otter-trawl has been found to be more efficient and is now used wherever the water is of sufficient depth to permit it.

The otter-trawls used in shrimp fishing are similar to those of the haddock fishery on the Grand Banks, except that they are much smaller, usually being about fifty feet long and forty feet across the mouth, and are made of smaller meshed netting. Briefly the otter-trawl used in this fishery is a huge, open-mouthed, flattened, conical bag which strains nearly everything out of the water as it is drawn behind a power-boat at the rate of about four miles an hour. After the trawl has been towed for thirty minutes or so, the engine is stopped and the slack of the net hauled in. The tail end of the bag, which contains the catch, is worked around to the side of the boat and finally hauled aboard.

Haul-seines are used in an entirely different manner. When the fishing grounds are reached, the boats patrol up and down until a school of shrimp is found. The shrimp are located by means of a cast-net, which the captain continually throws and hauls in his efforts to find shrimp. When a school is found, the haul-seine is paid out around the shrimp. As soon as the school has been nearly surrounded, the seine is usually drawn in close to the shore, where it is entirely closed up and the shrimp crowded into the bag.

Shrimp are marketed fresh (both whole and headed) packed in ice, cooked packed in ice or brine, dried, and canned. Most of the shrimp caught on the Atlantic coast are packed in ice in barrels and then shipped immediately. Since the heads constitute from forty to forty-five per cent of the weight of shrimp, they are ordinarily removed before shipment.

Shrimp keep better if they are cooked prior to shipment. This is accomplished either by dipping into boiling brine for fifteen minutes or by steaming for half an hour. Cooked shrimp are cooled and then packed in one to five gallon shipping tins which are lined with paper. The filled tins are sealed and then packed in barrels with ice. Cooked shrimp may be transported long distances even in warm weather. The surplus of fresh shrimp is either dried or canned. Formerly the bulk of the surplus was dried, but recently canned shrimp has become very popular, until now about seven hundred thousand cases valued at four million dollars are thus preserved each year.

Freshly caught shrimp are packed in ice until they are needed in the cannery. The first step in the canning operation is the removal of the heads and shells. These are picked off by women and boys who work at the picking tables. Many of the pickers are very expert, being able to separate 250 or more pounds of meat in a single day. The meat is carefully washed and then cooked for a short period, after which it is cooled and packed into cans. Some packers pack the shrimp dry, whereas others fill the cans with weak brine. The filled cans are capped and preserved by processing in retorts heated with steam under pressure. Canned shrimp are commonly used in places located some distance from markets where fresh shrimp cannot be obtained for the preparation of shrimp salad and other shrimp dishes.

The drying of shrimp is a much older industry, but the product is not so generally used. Dry shrimps are not as valuable as fresh or canned shrimp, so that only the surplus shrimp and those which are too small to be canned, or those which are caught far from a canning factory, are preserved in this way.

Shrimp are dried on large wooden platforms erected near the water's edge. Occasionally a single platform is forty thousand square feet in area, holding a hundred thousand pounds of shrimp, but most of them are much smaller. The floor of the platform is gently undulating in an ocean-wave effect, with the waves about two feet in height and thirty feet apart.

As the shrimp are unloaded they are washed in dip-nets. They are then placed in large kettles filled with boiling brine and boiled for half an hour, during which they turn from colorless to bright red. When sufficiently cooked, the shrimp are dipped from the kettles into wheelbarrows, in which they are drained and then transported to the drying platforms, where they are spread out in layers two to three inches in depth. The shrimp are turned by means of rakes several times every day. At night, and whenever rain threatens, the shrimps are pushed on to the ridges in long windrows. An A-shaped truss is placed astride each windrow, which is then covered with tarpaulin to keep off rain and dew. Even though it rains hard, the shrimp are not wet, since the water all drains away from the ridges. When the shrimp are thoroughly dry, they are pushed into large round piles. The next operation, the separation of the meat from the shells, is carried out in a very interesting manner. The workmen tie cloths around their shoes and proceed to tramp the shrimp, going round and round the piles in a slow trot, or dance as it is called. This breaks off the heads, shells, and legs from the meat. The shells and other inedible parts are then separated from the meat by screening through a coarse wire screen of about a quarter-inch mesh. Since the dancing process does not detach all of the shell from the meat, it is necessary to give it a still further cleaning by placing it in sacks and beating with boards, after which it is again sifted. The product is then packed in large barrels.

Dried shrimp is sold mainly to the Latin and Asiatic races. Much of it is exported to Central and South America, Cuba, Porto Rico, and the Hawaiian Islands. The shells and other inedible parts, commonly called shrimp bran, are packed in burlap bags and sold to farmers, who use it either as stock feed or fertilizer.

CHAPTER XV

Marine Turtles and Terrapins [1]

OF all living animals none is quite so suggestive of the large, clumsy, lumbering creatures of prehistoric times as the turtles, terrapins, and tortoises. Some of the turtles and tortoises still attain a large size, for the leather-turtle reaches a weight of more than a thousand pounds, and the loggerhead and green turtles about half that weight. The terrapins, however, are small, rarely exceeding a weight of ten to fifteen pounds. In clumsiness and awkwardness they are nevertheless quite the equal of their larger relatives.

The turtles, terrapins, and tortoises differ from all other living reptiles in possessing a hard shell which forms a strong bony "house" in which they live, and from which the head and limbs are extended when they are moving about. It is indeed very convenient to have a house always present into which to retreat when the day's work is done or when an enemy is near. When danger is past and hunger calls, it is necessary only to extend the head and legs, and the hunt is on once more. These animals, as a result

[1] This section was prepared by Dr. Samuel F. Hildebrand, director of the U. S. Bureau of Fisheries Biological Station, Beaufort, North Carolina.

or carrying a house, however, are obliged to sacrifice looks, grace, and speed. Imagine for a moment a man taking his house with him on all his wanderings!

The marine turtles and terrapins live in or near the waters of the tropical or semi-tropical seas and only occasionally stray to temperate waters. The turtles are equipped with flippers, which are used only for swimming, except about once a year when the female comes ashore to deposit her eggs. The terrapins, on the other hand, have feet with claws, which are not as well adapted to swimming as flippers, but which are much more convenient for walking, for these animals come ashore more frequently and therefore have need for better walking feet.

All marine turtles and terrapins come ashore one or more times during the summer to lay their eggs. A sandy beach is always selected for this purpose, and the "nest," which consists of a hole dug into the sand with the flippers or feet, is generally made at or somewhat above high-water mark. When the eggs have been deposited in the hole, the animals cover them and carefully conceal the nests by walking over and around them several times. Here the parental care ends, for the mother never revisits her nest. The heat of the sun incubates the eggs, and in a few months they hatch. The young work their way out of the sand and crawl away into a near-by marsh or into the water. Because they are thrown on their own resources at once, the loss among these young, soft-shelled, clumsy, helpless creatures is probably very great. Fortunately they can live for a long time without eating, and should they not succeed in finding food for a week or two, or even a month or two, they apparently do not suffer greatly. Their chief problem seemingly is to keep out of reach of enemies.

Turtles and terrapins are skilful in hiding their nests. However, when the tracks are discovered by men who make a practice of hunting the eggs of turtles, they are able to locate the nests by probing the sand with a cane until the place is found where it is still loose, because it was dug up recently. Here they dig down and gather the eggs. The egg hunters are mainly responsible for the ever decreasing numbers of turtles found along our shores.

The green turtle is the only one of the turtles whose flesh is extensively eaten. The loggerhead is eaten by fishermen and others living on the sea-shore where it is caught, though it is rarely shipped to the larger markets. The meat of the hawk's-bill turtle is rarely if ever eaten, but this animal furnishes the valuable tortoise-shell of commerce. The marine terrapins, that is, the diamond-backs, possess meat which is unexcelled in flavor and has for many years been a much prized delicacy of the connoisseur.

The Green Turtle and the Fishery It Supports

The green turtle is an inhabitant of tropical seas. On the Atlantic coast of America it occasionally strays north as far as Massachusetts. Because of the demand for its flesh and eggs it has been overfished and the number now taken on our shores is very small. At present the principal fisheries for the green turtle are in the West Indies and along the coast of Central America.

Most of the turtles are caught with gill-nets. On the shores of Costa Rica, however, they are caught principally at night when they come ashore to lay their eggs. The fishermen simply locate the animal with lanterns, and then turn it on its back, thereby rendering it helpless. Later a strong line with a wooden float attached at one end is fastened to the turtle's flippers. Then it is turned back on its belly and allowed to scramble off into the water. The animal, of course, heads for the open sea, but, because of the floats, it makes slow progress. Turtle boats lie at a safe distance offshore, and when the animals with the floats attached reach the water where the boats can ply, the floats are picked up, and the animals at the other end of the lines are hauled aboard by means of block and tackle. This is a rather ingenious way of getting the turtles, but also a destructive way, as many of the animals are caught before they have had time to lay their eggs.

The principal market for green turtles is Key West, Florida, where a cannery is located and where pens of palmetto logs are provided. The turtles are landed here by schooners, known as turtle boats, and placed in the log pens, where they are held until the operators of the cannery are ready to can them, or to ship them to a more northern market. Although the shell of the green turtle is smooth, and attractively marked with brown, yellow, and white, it has practically no commercial value. This animal has only a single claw on each flipper, whereas the loggerhead and the hawk's-bill have two claws on each foot. The fat of this turtle, greenish in color, gave the turtle its name.

Turtles are always shipped alive and while on the way are turned over on their backs. This may seem rather cruel, but is necessary, since the animals die if allowed to lie in the normal position, as the lower shell is too weak to bear the great weight of the body, and the pressure on the heart and lungs causes the animals to die. At the cannery in Key West, the turtles that are to be slaughtered are laid on the dock on their backs. Then the heads and flippers are severed with a sharp ax. Next the shells and entrails are cut away with sharp knives. The flesh is washed in sea-water and then taken to the cannery, where it is hung up to drain until the next day, when it is canned.

The females contain eggs during May, June, and July, and their value is greatly increased at that time, as the eggs are locally much in demand. A female contains from six to thirty pounds of eggs. The small, yellow, immature eggs are especially well liked and generally bring around sixty cents a pound, whereas the white or mature eggs sell at approximately twenty-five cents a dozen. The mature eggs are about as large as a golf ball and are covered with strong parchment-like skin which is rather difficult to break.

The Hawk's-Bill and Other Turtles

The tortoise-shell that is used for fancy combs, brushes, and other articles is derived from the shields of the upper shell of the hawk's-bill turtle. This is the smallest of the marine turtles, the lower shell rarely reaching a length of more than thirty inches. It is easily distinguished from other marine turtles by the rough appearance of the upper shell, whose shields overlap like shingles in a roof. This turtle lives in nearly all tropical and semi-tropical seas. It occurs on the Florida and Gulf coasts of the United States and occasionally strays northward as far as Massachusetts. It is hunted everywhere. The principal fisheries for the hawk's-bill in the New World are along the coasts of tropical America and in some of the larger islands. The bony shields are removed by the application of heat. This method frequently is used on live animals by the fishermen, whose belief it is that the turtles will grow new shields. At least some of the animals survive the ordeal, but authorities who have studied the question have declared that new shields are not developed. The tortoise-shell is a horny, flexible, semi-transparent substance, beautifully mottled, and dark brown to light yellow in color. By the application of heat and pressure the shields may be flattened, molded, or welded. Tortoise-shell has been highly prized for ornamental purposes since early times. It was one of the treasures of the Far East brought to Rome through Egypt. In the manufacture of various decorative articles, designs are frequently carved into the shell and then inlaid with gold and other precious metals. A high polish adds much to the attractiveness of the articles made from tortoise-shell. In some of the Central American countries, where many articles are made entirely by hand, the polish is produced by the use of rough leaves from native trees. This process, though slow, produces a beautiful lustrous finish. The horny shields of other turtles are sometimes used as tortoise-shell, but they are either opaque, or soft and leathery, and therefore poor imitations.

The loggerhead turtle, which has already been mentioned, is a carnivorous reptile, feeding largely on fish. It reaches a large size; individuals with a shell three and a half feet long and a weight of five hundred pounds have been reported. The loggerhead also inhabits warm seas and is common as far north as North Carolina and ranges even to Massachusetts. It is of limited value, for as has already been stated, its meat is not extensively shipped to the larger markets, although it is eaten by people living along the sea-shore. Its eggs are quite extensively sought and are sold locally. The upper shell is brownish and the lower one yellowish. The shields of the upper shell are opaque and of little or no value.

Kemp's turtle, also known as hawk's-bill in some regions, is one of the smaller turtles. It inhabits the Gulf of Mexico and ranges northward to New Jersey. Its meat is considered superior to that of the loggerhead by many persons, but its commercial value is only slight.

The largest of all turtles is the luth or leathery turtle, most common in tropical seas and ranging northward on our coast to Maine. It reaches a length of eight feet and a weight of a thousand to sixteen hundred pounds. It gets its name from the leathery appearance of its skin, which is bare of the horny shields found on other marine turtles. This huge reptile has no commercial value, for its flesh is unfit for food, and its covering worthless.

Diamond-Back Terrapins

The diamond-back terrapins are the smallest of the group of animals discussed in this chapter, for they seldom exceed a length of seven and a half to eight inches on the median line of the lower shell. (This measurement is given, because it is the only one used in determining the value of diamond-back terrapins on the market.) Although the smallest of the group, they are nevertheless by far the most valuable economically, for, as has already been mentioned, their flesh is unexcelled in flavor and is in very great demand.

The great demand and the fancy prices paid for diamond-back terrapins has led to over-fishing, with the result that these animals have become very scarce in many localities where they once were plentiful. A quarter of a century or so ago Chesapeake Bay and North Carolina were the centers of the terrapin industry. The Chesapeake supply is practically exhausted, and the Fish Commission of North Carolina is making a desperate effort, first to save what is left of a once plentiful supply, then to rebuild the fishery by prohibiting the sale of the animals for a period of five years, and furthermore to restock the waters through artificial culture. Because of the scarcity of the Chesapeake and Carolina terrapins, the more southern varieties, although regarded as inferior, have come into demand, and at present the principal supply comes from the Gulf States.

Because of the great decline and the threatened extinction of this valuable animal, which often brings as much as six dollars a head on the market, the United States Bureau of Fisheries at its Biological Station at Beaufort, North Carolina, several years ago undertook extensive studies of the habits and requirements of terrapins. It has been found from these studies that terrapins may be hatched and grown in captivity nearly as easily and successfully as chickens. It is believed by the investigators of the Bureau of Fisheries that terrapin "farming" could be made a profitable business. It is thought, furthermore, from the evidence which has been obtained, that the natural waters may be repopulated through artificial culture. To this end the Fish Commission of North Carolina is now coöperating with the United States Bureau of Fisheries. As a first step it is planned to hatch and to liberate young terrapins in the salt marshes of the sounds of North Carolina. This work has already been begun; and several thousand young animals which had been held in captivity until they had attained a considerable size, have been liberated.

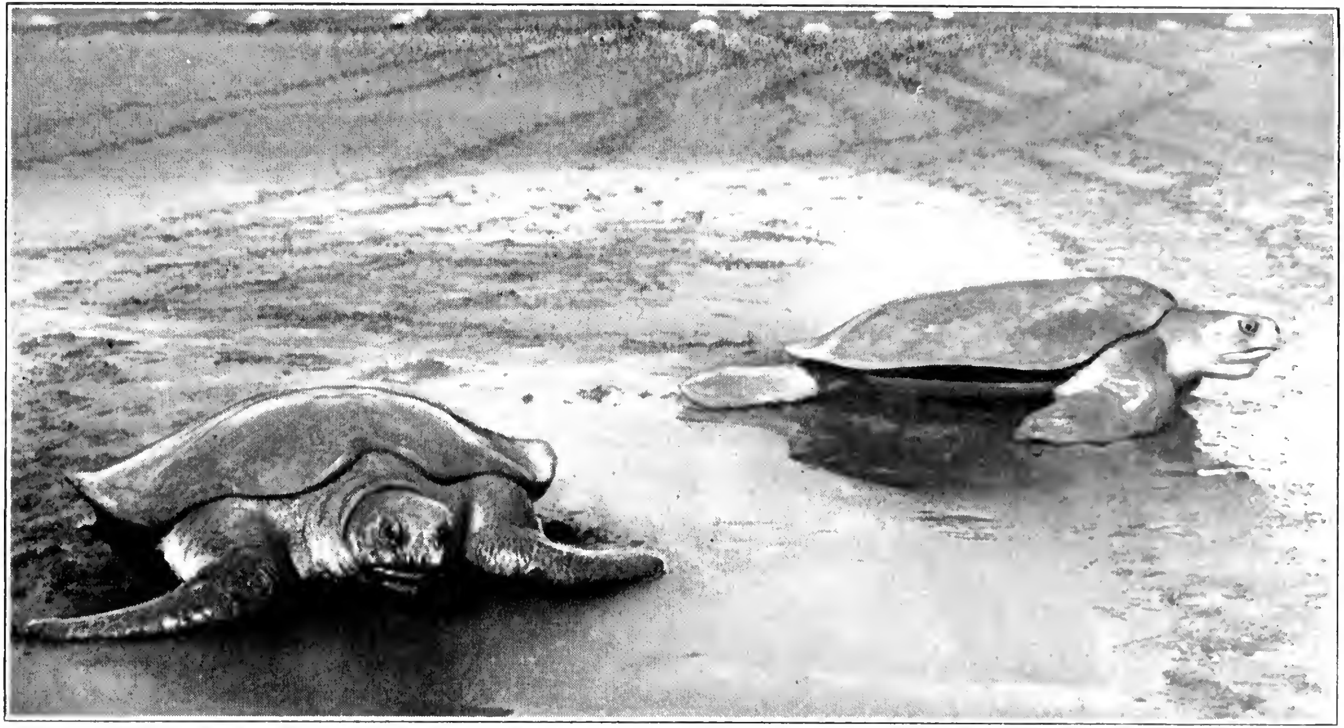
Adult terrapins to be used in artificial culture are confined in concrete inclosures on gently sloping shores of sand or sand and clay. The pounds are so constructed that a part of the inclosure is dry all of the time, while a part always holds some water. In the highest part of the pound there is built a sand-bed, which should be above high-water mark. When laying time comes, early in the summer (late in May, through June, and most of July), the females crawl into the sand-bed and scoop out a jug-shaped hole, about six inches deep and three inches in diameter, using their hind feet. The animals then back into the hole as far as they can, lay the eggs, and cover them. When the hole is partly or nearly filled, the animal packs the sand by raising itself on its feet and then coming down with its full weight, striking the sand with its lower shell. After the hole has been refilled, the animal walks back and forth over the nest and around it several times, thereby concealing it so effectually that the exact spot is difficult to find. Then, instead of walking away in the usual manner, the terrapin walks high on its feet so that the shell will not drag and leave a conspicuous track. Diamond-back terrapins generally lay twice during one summer; some animals lay three times, and unusually healthy young females may even lay four times. Ordinarily about eight eggs are laid at a time.

The eggs are allowed to remain in the sand and hatch by the heat of the sun. Some of the young dig their way out of the sand soon after hatching; others do not emerge until spring. At Beaufort they are not allowed to remain in the sand through the winter, for the egg beds are dug over each fall, and all the young are removed, either to be placed in a nursery house to be fed during the winter, or to be placed in a safe place to hibernate.

A nursery house, modeled somewhat after the type of hothouse generally used by florists, has been constructed at Beaufort. Young animals are placed in tanks inside the house, kept at a temperature of eighty to ninety degrees Fahrenheit. When kept warm, the young animals feed all winter, with the result that a year's growth is gained by the terrapins during their first winter. The winter feeding of older animals has not yielded practical results.

Diamond-back terrapins grow slowly. Only a few reach a marketable size and sexual maturity in five years; others require twice or even three times as long to mature. How great an age a terrapin may reach is not yet known. Some of the wild terrapins confined in pounds at Beaufort have been held since 1902, others since 1909, and still others since 1911. No disease has ever occurred among them, and about ninety-five per cent of them are still living in 1927 and producing eggs. Slow growth offers the greatest obstacle in practical terrapin farming. This is largely offset, however, by the small amount of care the animals require and the very low cost for food. Records have been kept at Beaufort showing that food costs around six cents a head per year for adults and three mills a head for very young animals.

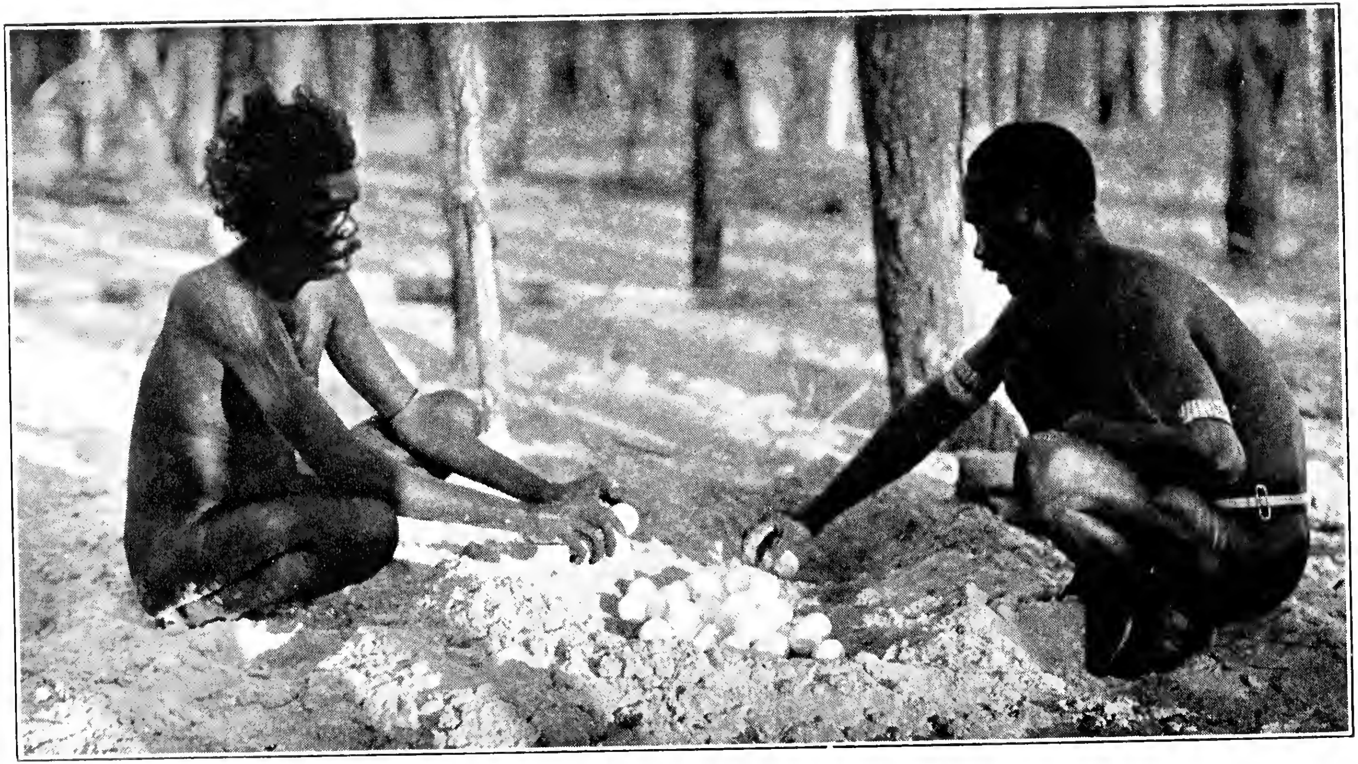
The terrapin fishery, because of the scarcity of the animals, is of comparatively little importance, and only a relatively few men engage in terrapin fishing as a part-time occupation. The animals are sometimes seen swimming or crawling about in the marshes and are caught with dip-nets. Others are taken in drag-nets that are hauled principally for fish. Sometimes nets are stretched across the lower



Courtesy of M. P. Greenwood Adams

GREEN TURTLES ON AUSTRALIAN BEACH

These turtles are returning to the sea after laying their eggs



Courtesy of Commonwealth of Australia

AN AUSTRALIAN TURTLE'S NEST UNEARTHED

A favorite food of the natives; each egg is about the size of a golf ball part of tide streams, while the men rout the terrapin out farther up-stream and drive them toward the net, in which they become entangled. A common method of fishing, and a particularly destructive one, is followed at low tide by men who wade in the mud and feel with their feet and with sticks for partly buried animals. Formerly, when terrapins were more plentiful, large catches were often made in this way in the autumn, when the animals had become sluggish from the cold; and this, probably more than anything else, caused the rapid decline in the abundance of terrapins.

Diamond-back terrapins, like turtles, are shipped to market alive, and, as the animals will stand much abuse, they are generally packed for shipment in barrels, bags, or deep boxes like so many potatoes. The principal markets for diamond-back terrapins are the big Eastern cities, where most of the animals are used in high-class hotels and restaurants.

CHAPTER XVI

Whales and Whaling

THE capture of whales and the manufacture of whale products played an important part in our colonial history. In the seventeenth century whales must have been very plentiful along the New England coast, for whale carcasses were often washed ashore. Disputes concerning the ownership of drift whales were common. The colonists had not yet learned to capture whales at sea, and they confined their efforts to the capture of the small whales which could be caught offshore. In calm weather the fishermen would sometimes venture in their open boats nearly out of sight of land in their search for whales.

Early in the eighteenth century, the whalers began to sail farther from shore, until by the middle of the century, when the New Bedford and Nantucket whaling industries were well established, these hardy sailors were, as Burke told the English Parliament, sailing from pole to pole in quest of whales. From then on the industry grew rapidly until it reached its zenith in 1850. In that year 736 vessels, hailing from a dozen or more New England ports, returned with 14,744 barrels of sperm-oil, 39,215 barrels of whale-oil, and 894,700 pounds of whalebone. Nearly half of these ships sailed from New Bedford, which was then enjoying a period of great prosperity.

From the small sloops of early days the vessels were gradually increased in size until large barks, ships, and brigs were fitted out for cruises of a year or more in duration. In those days, the whalers must have had indomitable courage and reckless daring to enable them to carry on through the grave dangers, unspeakable hardships, and heartbreaking labor which came all in their day's work.

The methods of capturing whales were much more primitive than those that are now employed. In those days the whalers sailed hither and yon in their large barks or ships until a whale was sighted. Then the most active men of the crew set out in small boats and followed the whale until they caught up with it. This was not so easy as it sounds, for the whales swim mostly under water at considerable depths. A whale comes up to blow, exhales the foul air, breathes deeply several times, then sinks far below the surface where he cannot be seen and swims elsewhere in search of food. Meanwhile the whalers could only guess which way and how far the whale would go. If the whalers guessed correctly where the whale would come up, they would be close enough to hurl a harpoon into its enormous hulk. Occasionally the whale rose directly under the small boat, smashing it to pieces and throwing the occupants into the icy water. The harpoon seldom seriously injured the whale, but enabled the whalers to retain hold of the whale by means of a rope attached both to the harpoon and the boat. Often the whale would swim away and tow the boat for miles before the whalers could get close enough to lance their quarry. Sometimes the whale would sink so deep that the rope would all be run out, and the boat would be in danger of being pulled under. Then the rope would have to be cut, and the chase begun again. Even after the whale was killed with the lance it would occasionally sink and be lost before it could be brought to the schooner. Such a chase involved a multitude of dangers. Probably it was the most dangerous occupation of the eighteenth century.

Each ship was a floating factory; as soon as a whale had been killed, it was towed to the ship and made fast to the side by means of a chain around the narrow portion of the body next to the tail. Then the work of cutting up the whale and hoisting the valuable parts of the carcass aboard was begun.

As fast as the blubber was taken from the whale it was hauled aboard and lowered into the hatch, where it was cut into chunks of about a cubic foot. These horse-pieces were then minced into small bits which were rendered in the kettles placed on brick fireplaces near the foremast. The heat caused the separation of the oil, which was ladled out into a cooler and then placed in casks. The fires were fed by the scraps or cracklings left in the kettles after oil had been rendered. This work was continued night and day until all the whale had been worked up. At night, pieces of blubber were burned in an open iron frame, lighting the scene with a weird glare.

Oil, whalebone, and ambergris were all that were prepared from the whales in those days. The bones and flesh were not utilized. The spermaceti was not separated from the sperm oil on board the whaler, but the crude oil was taken to the home port, where it was refined in a sperm-oil factory.

In 1850, when oil was worth more than a dollar a gallon, voyages yielding three thousand barrels of oil worth a hundred thousand dollars or more were not uncommon. Under those conditions many fortunes were made in whaling. New Bedford, Nantucket, and the other whaling ports enjoyed prosperity hitherto unknown.

During the Civil War the New England whaling industry received a blow from which it never recovered. Many whalers were either burned or seized as prizes by the Confederates, and, in addition, about forty of the whale-ships were purchased by the federal government for use as war-ships. Many whalemen, besides, joined the navy and aided the Northern cause.

Later, with the general introduction of kerosene, whale oil, sperm oil, and spermaceti were no longer absolute necessities and soon rapidly dropped in price, with the result that the whaling business slumped still more.

Modern Whaling

The invention of the harpoon gun by Svend Foyn in 1864 completely revolutionized the industry, however. While modern whaling still offers many thrills, it is not nearly so dangerous as formerly, for the whaler does not chase the whales in frail row-boats but remains secure in a much larger craft propelled by steam. The steamer is armed with a small cannon, called a harpoon gun, with which a large harpoon is shot into the whale. The harpoon, which usually weighs a little more than a hundred pounds, has a cast-iron head or shell filled with powder. This is exploded by a time fuse about three seconds after the harpoon has left the cannon. Attached to the harpoon is a rope which is also fixed to the boat. When the harpoon is in the gun, forty to sixty fathoms of the rope are coiled on a pan under the gun. This acts as slack when the harpoon is fired through the air. The harpoon has four prongs which fold up behind the shell, but which spring out at right angles to the harpoon when the line is tightened after the whale is harpooned.

Do not go whaling unless you are a very good sailor, or you will be more seasick than you ever were before. For the whalers are so designed that they can turn easily; on this account they roll and pitch worse than a destroyer. The steamships are fast enough to keep up with any whale, for all species are sought. Before the day of steamers and harpoon guns, only the more sluggish whales were hunted. The giant blue or sulphur-bottom whale was too fast and too vicious for the men in small boats. For this reason more of these large whales are living to-day than of any other species. Some species of whales, as the right whale and the sperm-whale, which have been hunted for several centuries, are now nearly extinct.

Most of the whalers operate from a whaling station located near the whaling grounds. When a whale is captured it is inflated with compressed air, marked with a flag, and allowed to float until the whaler has captured sufficient whales. Then the ship collects the whales which have been previously taken and tows them to the whaling station, where they are converted into whalebone, oil, and meal.

A few large ships, which are in reality floating whaling stations, still sail great distances in search of whales, returning with a cargo of whale oil, meal, and whalebone. Small steamers resembling tugboats act as tenders for these large whalers, capturing the whales and bringing them to the mother ship, where the blubber is cut off and rendered into oil. The meat and bones are cooked, dried, and ground into meal and fertilizer.

The steamer *Falk*, which sailed into New York not long ago with nineteen thousand barrels of oil aboard, is one of these floating whaling stations, which resemble in many respects the old-time whaling vessels. This Norwegian ship had captured three hundred whales and rendered their blubber into oil while on an eight months' cruise in the vicinity of the South Shetland Islands.

There are very few whales left in the North Atlantic Ocean or in the North Sea. The great whaling grounds lie far to the south in the neighborhood of the subantarctic islands, known as the South Shetlands, South Orkneys, and Falklands. American whalers seldom visit this region, the Norwegians now taking most of the whales. The few American whalers that still search for the largest game in existence now sail either from California or Alaska, visiting the various whaling grounds of the North Pacific.

Whales Are Mammals

A school of whales playing at sea is a thrilling sight that one never forgets. At a distance, about all that can be seen is a black hulk or two, with occasional spouting here and there. But, if one is fortunate enough to be close at hand when the whales are spouting, the sight is thrilling. Can you imagine an animal seventy-five feet long and ten feet wide, with lungs big enough to exhale a cloud of vapor? Many persons not familiar with the whale think that it spouts water. Unless you are lucky enough to get close to it you cannot see that the "spout" is really condensing vapor. The whale takes a very deep breath and then sinks below the surface, swimming hither and thither in search of food. During submersion, the air in the lungs becomes warm because of the heat of the whale's body, and likewise saturated with water-vapor from the moisture in the lungs. When the whale comes to the surface to exhale, he blows a large volume of this warm moisture-laden air into the much cooler atmosphere. This causes the moisture to condense in fine droplets, giving the appearance of a spray of water.

In many respects the whale is the most interesting and wonderful of all living creatures. Although it looks like a fish because it is adapted to live in the sea, it is really a mammal and resembles a cow more than a fish. In the illustrations you see that whales are fish-like in form, with an enormous head and almost no neck at all. They have very large mouths which make them look rather ferocious, but you need not worry about being attacked by a whale, for only one rare species, called the killer whale, ever eats warm-blooded animals. Most whales live on little shrimp and cuttlefish, which they strain from the water by means of the whalebone attached to their upper jaw. Their throats are so small that they cannot swallow any animal as large as a man. Two common species of whale, the sperm and the white whale, have teeth instead of whalebone.

Their skin is smooth and slick, having no hair or scales. Immediately beneath the skin is a thick layer of fat called blubber. This fat, being a poor conductor, serves to retain the heat of the body, and thus enables the huge warm-blooded animals to keep warm in the icy waters of the temperate and frigid zones.

The whale has gradually developed from a creature having legs. The flippers of the whale are in fact fore limbs functionally reduced to mere paddles with no power of motion except at the shoulder-joint, although they have all the bones, joints, and even most of the muscles of the human hand and arm.

They swim mainly by means of the tail, which differs from that of most fishes, being expanded horizontally in order to facilitate their continual upward and downward motion. Nature has placed the whale's nose on the top of his head, where he can breathe easily without shoving his head out of the water.

Young whales are much larger than any other babies, often weighing 16,000 to 20,000 pounds.

They are so large that twins are seldom born. Mother whales nurse their young at sea, but few persons have ever seen this interesting sight.

There are more than thirty known species of whales, not counting the many related species of sea mammals such as porpoises and dolphins, but only seven species are of commercial importance. The sperm-whale, the North Atlantic right whale, and the bow-head or Greenland right whale have long been considered the most important. But since, whale meal and other products have become of considerable value, the humpback, the sulphur-bottom or blue whale, the sei whale, and the finback have come to possess great value.

Of these the sulphur-bottom or blue whale is the largest. Indeed this whale is not only the largest animal that lives to-day, but is also the largest animal that ever lived. Contrary to the general belief, the gigantic lizards called dinosaurs, which formerly inhabited the swamps and rivers of the western part of North America, were neither so long nor so heavy as the blue whale. The largest authentic specimen of blue whale that has been measured was eighty-seven feet in length and weighed about seventy-five tons. This whale is found in almost all seas, and is now captured in larger numbers than any other whale. About two thousand of these whales are taken each year in the vicinity of the Falkland Islands. The blue whale belongs to the whalebone class, but the whalebone taken from its jaw is short and of little value.

The North Atlantic right whale, sometimes called the black whale because of its color, is somewhat smaller, seldom exceeding fifty feet in length. Its head is about a quarter of its whole length. The right whale is so named because it is a valuable whale and, in the early days of the industry, was considered the right one to capture. The bow-head, or Greenland right whale, has an enormous head and yields excellent whalebone sometimes fifteen feet in length. This whale is somewhat larger than the right whale, often attaining sixty feet in length. The humpback whale, the principal species taken on the coast of California, is also found in nearly all of the seas, being especially common in the South Atlantic, off the coasts of South America and Africa. It usually attains a length of fifty feet; it is short and thick and has a large head with a flat forehead. The finback whale is taken in large numbers in the vicinity of the Falkland and South Orkney Islands. It is sometimes called the razor-back because of its slender form. It is one of the largest whales, averaging more than sixty feet and sometimes attaining eighty feet in length.

The sei whale was formerly thought to be the young of the blue whale. "Sei" means black cod in Finnish. The name is given to it because it arrives on the coast of Finland at the same time as the black cod. When whaling was confined chiefly to the North Atlantic, the sei was thought to be rare, but since whaling has been extended to all parts of the sea, many of these whales have been taken in all the seas. The sei whale is relatively small and is therefore not hunted as extensively as the larger, more valuable species.

The only toothed whale considered of much importance commercially is the sperm-whale, which is one of the strangest of whales. On each side of the lower jaw it has eighteen to twenty-five massive teeth, which fit into sockets in the upper jaw. The upper teeth are seldom well developed. It feeds on giant squid and cuttlefish, which are usually found in warm currents. Sometimes this large-toothed whale eats sharks and other fishes and large spiny lobsters. This whale is much more ferocious than any of the whalebone whales and occasionally attacks its pursuers, destroying small boats with smashing blows from its powerful tail. Bull sperm-whales attain great size; specimens seventy feet long and weighing about eighty tons are sometimes captured. Its head is enormous, being one third of its total length, and contains an immense tank filled with a liquid wax known as spermaceti. The wax is obtained by cutting an opening in the head-case and dipping out the ten or fifteen barrels of oil that it contains. When freshly taken, the spermaceti is liquid; but on standing, it congeals and after refining becomes the spermaceti of commerce.

The Manufacture of Whale Products

The first step in the manufacturing process is that of butchering, or "cutting in" as it is called. This operation was formerly accomplished under the most trying circumstances; the whalers had to work at sea while the whale was floating in the water lashed to the side of the vessel. As has been previously explained, the modern whaler tows his catch to a whaling station, where the whale is slowly hauled up on the flensing-slip by means of a steam winch. The blubber, which lies just under the skin, is first stripped off in long strips and cut up into small pieces. The head is chopped off and the whole of the meat stripped off in four huge pieces. Finally the bones are cut up and hoisted to huge boilers.

In Japan, Norway, and certain other countries where beef is scarce, fresh whale meat is generally eaten. During the World War some whale meat was used in the United States and Canada as a substitute for beef and mutton. Most of the fresh whale meat was marketed in the large cities of the Pacific coast, although some was sold in New York and other Eastern cities. It even found its way to the tables of some of the large hotels, but it was more of a curiosity than a staple article of diet.

Whale meat is prepared for market by cutting the enormous strips of meat into chunks weighing about forty-five pounds each, which are then chilled and packed into boxes. Some whale meat is canned in much the same way as beef, and some is salted. Pickled whale tails are an Oriental delicacy and command a high price. Many whale tails are pickled in salt brine on the Pacific coast of the United States and exported to Japan.

Whale steak is similar in appearance to beef, although it is darker and somewhat coarser grained. Its taste resembles that of venison, although it would not be mistaken for it. The meat of the humpback is the best for eating, though the fin-back, sei, and California gray whales yield excellent meat. About six tons of edible meat are obtained from an average-sized humpback; a fin-back furnishes somewhat more, and a sei whale somewhat less. Whale meat should be cooked slowly with moist heat. Roasts, pot-roasts, and steaks are the most popular whale dishes.

When whales are taken far at sea or in a region where whale meat is not eaten, the flesh is converted into scrap, which is commonly used as stock feed, but it is also mixed with other plant nutrients and used as fertilizer. The process used in the manufacture of scrap is similar to the process employed in the preparation of fish meal, except that much more cooking is required. The meat is cut into small pieces and placed in a pressure cooker, where it is cooked for about ten hours with steam under about forty pounds pressure. After the water and oil have been drawn off, the cooked meat is pressed, usually in hydraulic presses, until most of the water has been forced out. The pressed scrap is thoroughly dried in rotary hot-air driers, and then is finely ground and sacked for shipment.

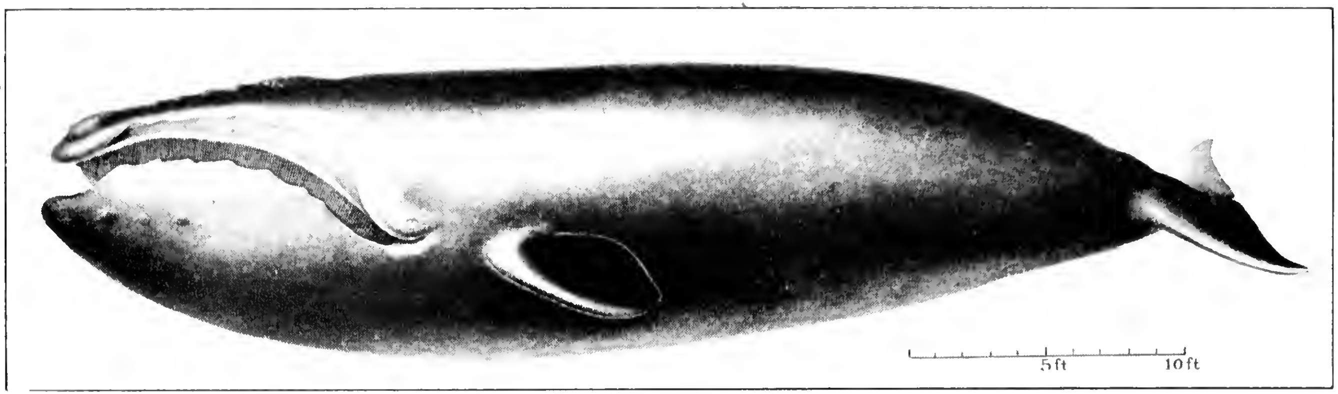
No part of the whale is wasted. The tongue and kidney fat are cooked with the blubber, thus rendering the oil. The viscera are cooked, pressed, dried, and then ground into fertilizer. The bones, which are spongy and contain much oil, are cut up and then cooked under steam pressure. Pressure cooking extracts the oil, which is then run off and separated from the water. The steamed bones, after being dried in the same type of drier that is used for drying the scrap, are finely ground, thus producing bone meal which is extensively used as a fertilizer. Whale bone meal furnishes the crops with phosphorus and nitrogen, two plant nutrients that are often deficient in soils.

The most valuable product obtained from the whale is the oil, which has a multitude of uses. The oil rendered from the blubber of whalebone whales is a liquid fat known as whale oil; the sperm-whale yields a liquid wax known as sperm oil. Whale oil is now steam rendered and is a product far superior to the oil made by boiling the blubber in open kettles. Fresh steam-rendered oil is light in color and does not possess an unpleasant odor, whereas the oil heated in kettles over open fires is dark in color and foul in odor. Whale oil is similar in composition and properties to the slow-drying fish and fish-liver oils. Much stearin may be separated by cooling and racking the oil. The stearin is largely used in the finishing of leather. Whale oil itself is also extensively used in the tanning and finishing of leather.

The chemist has done much to aid the whaling industry. For even the darkest, foul-smelling oil may now be converted by treatment with hydrogen into a colorless, odorless, solid fat, suitable for the manufacture of high-grade soaps. These hardened fats are so white and sweet that they are used in Europe as lard substitutes. Hydrogenated whale oil may be made so hard that it can be molded into candles, and much of it is used for this purpose.

Sperm oil is rendered from the blubber of the sperm-whale in much the same way as whale oil is obtained from the blubber of the baleen or whalebone whales. When crude sperm oil is chilled, spermaceti separates out as a solid wax, and is filtered off. Sperm oil is more valuable than whale oil, as it is a wax. It absorbs very little oxygen from the atmosphere and therefore does not thicken when exposed to the air. When cooled, it becomes slightly more viscous but still retains its lubricating power. On account of these properties, it is a valuable lubricant for many kinds of machinery.

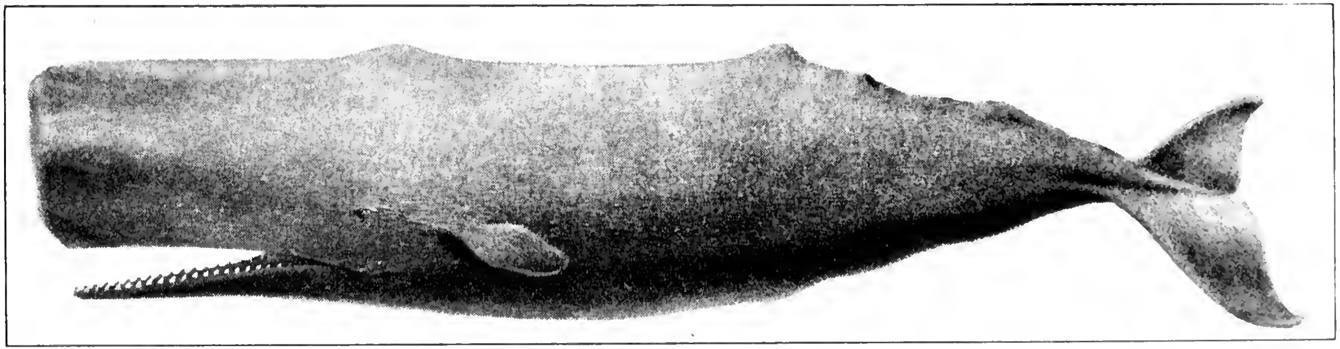
Several cosmetics are prepared from certain whale products. Crude spermaceti, obtained from crude sperm oil, is refined by melting and heating with a dilute caustic soda solution. After the caustic has been washed out, the wax is run into molds. When cold, the cakes are pulverized and pressed. Refined spermaceti is a very beautiful wax, being a white, lustrous, translucent, crystalline substance. It is tasteless and odorless and so brittle that it can be rubbed into powder between the fingers. Its most important use is in the preparation of face-creams of the cold cream type. These creams are made by preparing an emulsion of spermaceti and other waxes in perfumed glycerin. Much glycerin is also prepared from whale oil as a by-product of the manufacture of soap. Glycerin is used as the base of many cosmetics. Shaving and other lotions, shaving soaps of all kinds, vanishing creams, beauty creams, transparent soaps, tooth-pastes, and many other toilet preparations contain varying amounts of glycerin.



Courtesy of Boston Society of Natural History

NORTH ATLANTIC RIGHT WHALE (MALE)

This whale furnishes exceptionally fine whalebone



Courtesy of U. S. Bureau of Fisheries

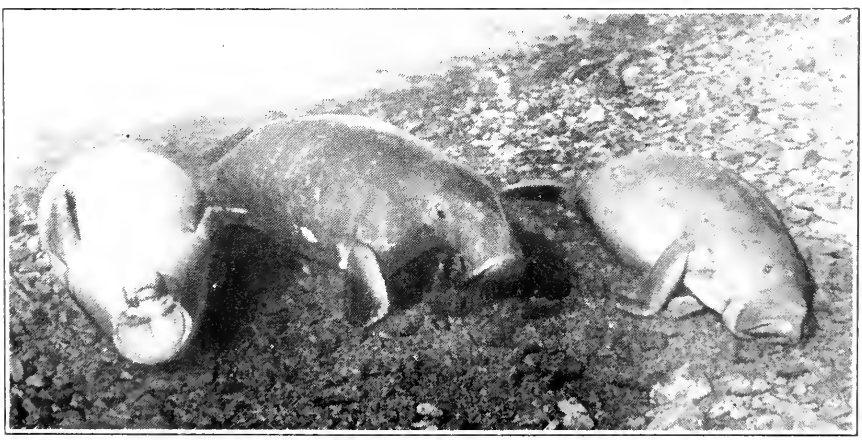
A SPERM-WHALE

The source of spermaceti, which is used in the manufacture of cold creams and other cosmetics

Courtesy of Underwood & Underwood, N. Y.

WHALE'S JAW SPLIT TO SHOW WHALEBONE

The whalebone enables the whale to strain out of the water the little shrimp and cuttlefish upon which he feeds



Courtesy of M. P. Greenwood Adams

DUGONGS CAPTURED IN AUSTRALIA

Australian dugongs are hunted for the oil and hides which they yield

Ambergris, the most valuable whale product, is obtained from the intestines of the sperm-whale. The real nature and origin of ambergris is somewhat in doubt. It is usually taken from sick whales but is sometimes found floating on the sea or washed upon the shore. Some scientists have assumed that the wax is the indigestible portion of the devil-fish, or cuttle-fish, which comprises a large part of the food of the sperm-whale. This theory is strengthened by the fact that the small bones of the cuttlefish are found in ambergris. This waxy substance is often worth its weight in gold. Gray ambergris is much more valuable than the black product. Ambergris is also used in the preparation of a toilet article, for its principal use is as a fixative in fine perfumes. Its odor is often bad, but it holds the perfumes as no other substance does. Ambergris has had many other curious uses. Formerly it was supposed to possess wonderful medicinal properties. The Asiatics have used it as a spice in cooking; pilgrims who traveled to Mecca sometimes brought it as an offering.

Contrary to what one might think, whalebone is not the bone of whales, but is the strainer-like appendage attached to each side of the upper jaw of the whalebone whales. The baleen or whalebone consists of two parallel rows of thin horny plates which hang from the roof of the mouth. Each plate is roughly triangular, wide at the base and narrow at the tip. The inner edges are frayed out into long fibers or hair-like bristles, forming a thick mat inside the mouth, which strains out of the water the small shrimps and other animals upon which the baleen whales feed. Whalebone is similar in composition to hair, finger-nails, and toe-nails, consisting of keratin; on this account, whalebone is very strong and flexible.

The baleen obtained from the Greenland right whale is of better quality than is obtained from any other species, as it is very long, sometimes as much as fifteen feet. An average-sized whale of this species yields a ton of whalebone. Formerly baleen sold at four to five dollars a pound, and thus these whales yielded about ten thousand dollars' worth. The other right whales and the humpback also yield valuable whalebone. The whalebone obtained from the blue, finback, sei, bottle-nosed, and California gray whale is short and of relatively little value.

After the whalebone has been removed from the jaw, it is separated into pieces containing three to six slabs each, and freed from flesh and blubber. It is then washed with salt water and thoroughly dried. The dried product is shipped to factories, where it is manufactured into useful articles. Its great value lies in its lightness, elasticity, flexibility, and its property of permanently retaining any shape that may be given it when it is heated and then cooled under pressure. The most important uses of whalebone are for the manufacture of corset and dress stays and whips. The Japanese are unusually clever at working whalebone, and make cigar and cigarette cases, sandals, and many other novelties from it. For such articles they are able to utilize the short, lower grades such as are obtained from the finback and blue whales.

Dolphins, Porpoises, Blackfish, and Dugongs

Many other marine mammals yield oils of commercial value. The most important of these are dolphins, porpoises, blackfish, manatees, and dugongs. The oil obtained from the jaws of these animals is the most valuable oil known and is used chiefly for the lubrication of fine machinery such as watches, clocks, and typewriters.

Porpoises and dolphins are curious animals about which many legends have grown. These sea-pigs, as they are often called, are playful, sometimes gamboling about in shallow water close to the shore. Divers fishing for pearls, sponges, or coral look on them with much favor, as their presence is a favorable omen indicative of the absence of sharks. Manatees and dugongs are even more interesting than porpoises. These animals, often called sea-cows or cowfish, are rather sluggish mammals which live principally on sea grasses and algæ. Dugongs are found on the coasts of northern and western Australia, in many parts of the Indian Ocean, and in the Red Sea. Manatees are seldom found on the open coast but hug river estuaries and even travel many miles up large rivers such as the Amazon. At times porpoises and other mammals of related species are taken in considerable numbers off the North Carolina and Massachusetts coasts. A regular fishery for porpoises is carried on in Finmark each year from September to March. Many dugongs are taken on the western coast of Australia.

The jaw-oil of these animals is prepared by cooking with water the fat obtained from the jaws; only about half a pint is obtained from each animal. The ordinary porpoise oil and dolphin oil is prepared by heating the minced blubber from the bodies of these animals in a try-pot over a fire or by cooking it with water. The oil obtained in this manner resembles whale oil in many respects and is used for the same purposes.

The ancient Jewish Tabernacle in Jerusalem is said to have been roofed with the skins of dugongs caught in the Red Sea. Dugong leather still finds a limited use in the industries of regions where they are captured. This use has already been considered.

CHAPTER XVII

The Fur-Seal Industry

ENWRAPPED in constant sea mists, which hitherto had concealed them, the breeding grounds of the Alaskan fur-seal were finally discovered in 1786 by a patient and persistent fur hunter, Gerassim Pribilof, after whom the group of four islands is named. The first sight of these small barren islands nearly covered with millions of fur-seals must have brought a great thrill to Pribilof. At that time the value of seal skins was not generally recognized; only the Chinese utilized them, and they did not use the fur as we do now, but plucked out the long silky hairs.

At the time of the purchase of Alaska by the United States, more than two million seals inhabited the islands. For the next forty years, sealing privileges were granted to lessee companies, which took more than two million skins. Because of the reckless slaughter of the seals by the companies, and by the sealers hunting on the open waters of the ocean, who shot many seals which sank and therefore could not be recovered, the seal herd was seriously reduced. In 1910 the United States government undertook to manage the seal rookeries, giving control to the Bureau of Fisheries. Pelagic sealing was stopped in

1911 by an international agreement between Great Britain, Japan, Russia, and the United States. According to the present practice, only the surplus young male seals are killed for fur, and the older bulls and the females are carefully protected. By this method the number of seals has been increased from 132,000 in 1910 to more than 700,000 at present. During this period about sixty-five million dollars' worth of pelts has been taken. As the seal herd grows in size, more and more seals may be killed. Thus protection has not only proved to be the means of saving the seals, but it has also been very profitable.

A century ago fur-seals were found in great numbers on nearly all the islands on the west coast of South America, from Cape Horn to the Equator. Many were also found on the South Shetlands, the Falkland group, the South Georgia Islands, and the Sandwich group. Fur-seals were also eagerly hunted on Kerguelen Land, the Aucklands, the Antipodes, the Crozet group, and other islands in this vicinity.

Everywhere the slaughter was so indiscriminate and reckless that the seals were rapidly exterminated. Now only a few seals are to be found in the Southern Hemisphere. The only important herd is the one on Lobos Island in the mouth of the La Plata River, which has been protected for a number of years by Uruguay.

In addition to the rookeries on the Pribilof Islands, there are two other important breeding grounds in the Northern Hemisphere. Japan has a small herd of about twenty thousand seals on Robben Island, and

Russia has one of about the same size on the Commander Islands. These rookeries are now carefully protected and may increase in size.

Family Life of the Fur-Seal

Fur-seals are curious gregarious animals. During the winter they migrate at sea to warmer waters. As the breeding season approaches, the males arrive first and take up definite stations, which they hold and protect. The younger males are not allowed to come upon the breeding grounds but are driven aside to form colonies of their own. During the time that the bulls, as the mature males are called, are on land, they neither eat nor drink, and their sleep is limited to a few minutes at a time. During this long period, usually about four months, they are sustained by a thick layer of fat or blubber, which is stored up during their migrations.

The cows, as the female seals are called, come ashore a short time before their young are born. Each bull keeps from one to seventy-five cows in his harem, zealously guarding them and their pups day and night lest some other bull take some of them away from him. Being several times the size of the cows, the bull has little trouble in keeping them together. The number of cows to the harem depends upon the location of the harem in the rookery and the size and age of the bull. The older and stronger bulls close to the water have larger harems than the young bulls on the edge of the breeding grounds.

A female seal produces her first offspring in her third year. But a single pup is born annually. The new-born pup is jet black in color and weighs about ten pounds. At first the mother is careful to keep her pup out of the way of the fighting bulls; but as the pup grows older she pays much less attention to it, allowing it to shift for itself for the most part.

When the pups are about six weeks old, they learn to swim, and as the summer progresses they swim farther and farther out; in October they swim in schools completely around the islands. But they always return to the rookery to nurse their mothers. Seal milk must be very rich, for, although the pups eat nothing else, they grow very fast, gaining about ten pounds a month. By the first of October, their color has changed to a glistening silvery gray, and in November they go south through the Aleutian passes, from which they do not return until the middle of the following August.

The mature cows are not much larger than four-months-old pups, for they weigh only from fifty to a hundred pounds. The bulls are very much larger than the cows, weighing four or five hundred pounds. They are usually of a rusty red color and have a bristly mane about two inches long on the back of the neck. The bulls are very ferocious and do not permit intruders on the rookeries until the height of the breeding season is past. Much quarreling takes place between neighboring bulls on the breeding grounds, and occasionally a pair fights until the loser gives up his place and goes to sea.

The seals on the Pribilof Islands are carefully protected by the United States government. A special permit is necessary to land on the islands. A census of the seal population is taken once a year. This is not as simple a matter as it might seem, for the bulls will not permit any one on the breeding grounds until about August 1, and soon afterward the pups begin swimming. There are more than seven hundred thousand seals to count, and they are widely scattered over the rocks and beaches of St. Paul and St. George Islands. If the census is not taken quickly it is of little value, for the seals will have moved around and thus may be counted two or more times, or may not be counted at all.

The number of skins taken annually is set in advance, so that the animals needed for propagation will not be killed. Only three-year-old males are killed, and a breeding reserve of five thousand male seals of this age is required by law to be set aside. The purpose of these restrictions and regulations is to protect the seals from disturbance on their breeding grounds, to prevent the killing of seals by unauthorized persons, and to permit the herd to increase to its former numbers.

Killing

Inasmuch as one bull may have fifty or more females in his harem, there is a great surplus of males over the number actually required to maintain the herd at its present level. A large number of young males may therefore be killed without diminishing the rate of propagation. Killing is done on land during the breeding season by employees of the United States Bureau of Fisheries. The young bachelors who are not permitted by the mature bulls to come on the actual breeding grounds play near-by on the "hauling grounds." From here they are driven like sheep to the killing fields, which are located some distance from the rookeries in order to avoid disturbance of the breeding grounds. The animals are first rendered unconscious by a blow on the head, and they are then bled. The skin is pulled off after cutting around the head and flippers and down the belly. After the adhering blubber has been removed from the skin, it is salted down, allowed to cure for ten days, and rolled up into a compact bundle. The skins are packed into water-tight barrels and shipped to St. Louis, where they are put through many very elaborate and complicated processes before becoming the beautiful fur-seal skins of commerce.

Some of the meat of the seals is eaten by the native Aleut Indians who live on the islands. The blue foxes are also fed from the meat of the seal carcasses. The residue is converted into oil and fertilizer. The oil obtained from the carcasses is shipped to St. Louis and used in tanning the skins. Until 1915 the seal skins were all shipped to London, where they were sold at auction and then tanned, dyed, and finished. In that year a number of the best seal dressers and dyers of London came to this country and the industry was moved to St. Louis. With the British dressers and dyers as a nucleus, an excellent organization has been formed. Many researches have been conducted which have produced a much finer product than had ever been made before. A strong, thin, light pelt is now produced which weighs little more than the same area of the imitation, Hudson seal or dyed muskrat.

Seal skins are classified according to size and are graded as to quality of fur and condition of the pelt. The main points considered in determining the quality of a pelt are silkiness, denseness, and length. The pelt is also carefully examined for defects which would offset any good qualities resulting from fine fur. Good raw skins should be thoroughly cured, free from all traces of taint, and the flesh side should be free from any cuts made during skinning. The grading of seal skins requires great skill and experience. Few persons are able to grade the skins accurately before they are dressed and dyed. For this reason the seal skins are finished before being sold at auction. This makes the grading much easier, and thus a much larger number of people are able to bid on the skins. The buyers are now for the most part manufacturers of garments, and as they are experienced in handling and using finished seal skins, they are capable of accurately judging the fur in this condition.

Preparation of the Fur

The fur of the seal consists of two kinds of hair: a soft, downy undergrowth of fur, and a long, coarse, harsh guard hair. Most fur-bearing animals have two such kinds of hair in their fur, but the difference in fineness between the two growths is greater in the fur-seal than in most other furs.

The first operation in the preparation of the raw fur is the removal of the outer guard hair. This is accomplished by placing the pelt on a beam and then pushing the guard hair off with a curved blunt knife. The hairs are not cut, but are drawn out by the roots; the follicles then close up, thus producing a smooth velvety fur. The skins of the unhaired furs are then tanned with seal oil. The oil is painted on the flesh side of the skins and combines with the skin, forming a leather resembling the so-called chamois-skin or leather. The oil is worked into the skins by working them in a mill; formerly this operation was carried out by men treading on the skins with their bare feet. After the skins are completely tanned, the surplus of oil is removed by rolling the seal skins with hardwood sawdust in a mill several times. Between the runs, the dirty sawdust is shaken out in a tumbling mill, so that fresh clean sawdust can get down into the fur and absorb the oil.

The fur is then dyed. The skins are not dipped in a dye bath, but are brushed first with the mordant and then with a solution of the dyes. The first dye used is a vegetable black, which is brushed upon the upper half of the fur. The final application is a rich brown vegetable color which is applied the whole length of the fur from tips to the roots. Thus a half-brown and half-black fur is produced which finds such general favor that it is often imitated in other furs.

The leather of the pelt is still too thick to be used by the furrier, and so it is reduced in thickness by buffing on a large revolving cylindrical drum covered with an abrasive. This operation removes the black surface of the leather and exposes a light yellow chamois leather.

The first unhairing process removes only the coarse hair which is longer than the fur. In addition to the long coarse guard hairs, the pelt contains many short coarse hairs which must be removed before the final finishing operation. For the removal of these hairs, the seal skin is passed several times through a machine consisting of an ingenious arrangement of air-blasts, combs, and revolving knives. In passing through the machine, the pelt is bent sharply over a dull knife-edge, and the downy fur is parted and blown down by the blast of compressed air. The short coarse hairs, because of their relative stiffness, are not blown down by the blast but stick up and are clipped off by the revolving knives. This operation greatly improves the softness and smoothness of the fur. The final finishing operation consists of working the pelt into an extremely soft and pliable condition and setting the fur so that all the strands lie parallel. The finished skins are now sold at public auction by the government and are ready to be made into garments. The efforts of the United States Bureau of Fisheries to conserve the fur-seal have greatly increased the potential supply of this fur and have thereby reduced the cost. Perhaps some day it may be no more expensive than its imitation, Hudson seal.

Hair-Seals and Sea-Lions

There are fifteen species of hair-seals, two species of sea-elephants, and five species of sea-lions which are valued for their blubber, from which oil is made. Since leather has become very valuable, the skins are now also utilized in the manufacture of seal leather. This operation has already been considered in Chapter XII.

Hair-seals are like sheep in their peaceful social instincts. They are gregarious, at least during the breeding season—patient and submissive, harmless to man, and fond of basking in the sunshine while out of the water. Their affection for their young is almost human. On land they are very clumsy and awkward, as their flippers can hardly touch the ground. But in the water they swim with grace and ease, and are able to stay under the surface for several minutes. Their food consists of fishes, crustaceans, and mollusks.

Although the hair-seal industry is almost a thing of the past—for the seals have nearly been exterminated—more than a hundred thousand seals are still taken annually. The only important sealing grounds now are in the North Atlantic off the coasts of Newfoundland, Labrador, and Greenland. Many of the sealers sail from St. John's, Newfoundland. One famous sealing-vessel, the *Terra Nova,* has already taken many more than a million seals. Single trips have brought her owners a hundred thousand dollars' worth of seal oil. As late as 1924 she took oil valued at eighty thousand dollars. But the glory of the sealer is gone, for such trips are the exception, and often the vessels do not make expenses. The *Terra Nova* is a historic ship. In 1905 she brought Scott and Shackleton back from the Antarctic, and in 1909 she carried Scott on his ill fated expedition to the

South Pole. She is a bark-rigged, three-masted steamer of four hundred tons, carrying 160 men for a sealing crew. She is an old-timer, for she was built in Scotland in 1884.

The crews of the sealers are hardy, adventurous men, since they are continually beset with perils and hardships. The seals are usually hunted on ice-floes where a misstep means a plunge into icy water. The most common weapons used in hunting seals are rifles and clubs. The killing is in most cases little more than butchery, for most species of seals are dull-witted creatures that are not greatly disturbed by the approach of the hunter. The bladder-nose seal and the saddleback are exceptions to this rule and are so wary that they are approached with difficulty. These seals are usually taken with a rifle. Nets, seal boxes, seal hooks, and harpoons are also used for the capture of seals.

Formerly seal oil was prepared by stripping the blubber from the seal and placing it in large tanks where it was allowed to decompose. From time to time, the oil, liberated by the decomposition of the tissues, was drained from the tank. After about three months, the remaining decomposed fatty mass was boiled with water to render the remainder of the oil. Such a procedure was very crude and produced a very poor quality of oil. Now the oil is obtained by treating fresh minced blubber with live steam in large inclosed tanks. The oil and water emulsion obtained in this way is separated by passing it through a series of settling tanks. The finished product is termed steam-refined oil. Upon cooling to low temperatures, fresh seal oil deposits stearin. This is removed by filtration, and the product is known as racked seal oil.

Seal oils resemble cod-liver oil in composition and properties, and for this reason are often used as adulterants of medicinal cod-liver oil. Chemically it is difficult to distinguish between seal oil and the liver oils. Cod-liver oil, however, contains a much larger quantity of fat-soluble vitamines and is therefore much more valuable for medicinal purposes. Seal oils are used in the tanning of hides and pelts, in the currying of leather, in the manufacture of dégras and sod oil, in soap making, and sometimes as burning oils for the lights of lighthouses.

Walruses

The walrus and the polar bear are the animal monarchs of the Arctic. Polar bears are often able to kill young walruses, but when a bear attacks a full-grown walrus he is sure to get the worst of it. An adult walrus weighs a ton or more and is about fifteen feet in length. While a walrus is stupidly slow on ice, in the water he is perfectly at home and is able to defend himself against all comers with his two powerful tusks projecting downward from the upper jaw, which are admirably adapted to slashing and goring.

For downright daring, few sports compare with walrus hunting as practised by the Eskimos of North Greenland. They hunt in a kayak, a native one-man canoe made of seal skins stretched over a light wooden frame. The little boat, which is about eighteen feet in length, is decked over all, excepting

Photo by E. C. Johnston

PRIBILOF FUR-SEAL ROOKERY

The large, dark colored seals are the bulls; the medium-sized animals are the cows; the small seals are their pups

Photo by E. C. Johnston

A GROUP OF FUR-SEAL COWS

On the Vostochni Rookery, St. Paul Island, Pribilof Islands, Alaska

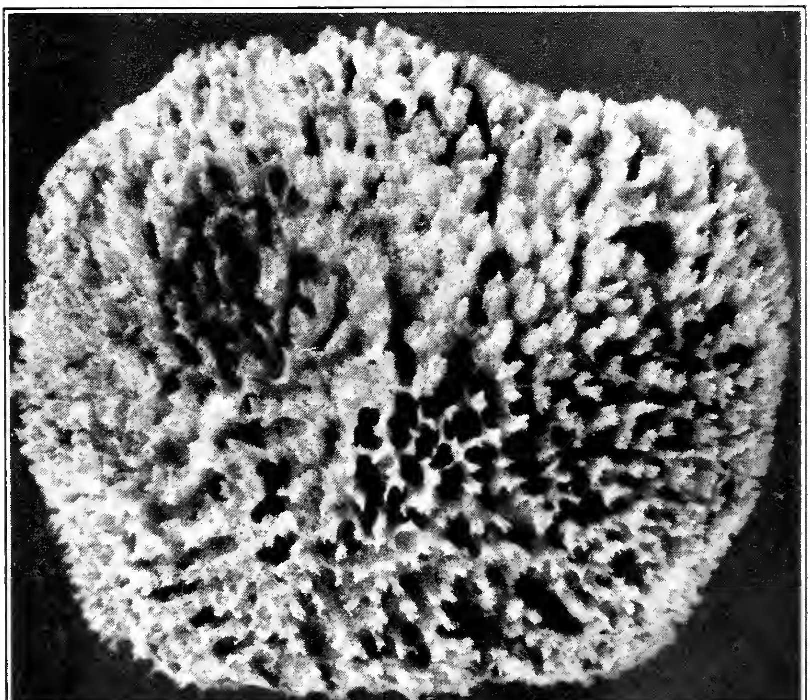


Photo by H. F. Moore

SHEEPSWOOL SPONGE FROM FLORIDA

The production of these sponges constitutes over ninety per cent of the sponge production of the United States a cockpit amidships. Here the Eskimo sits, his legs extended forward beneath the skin deck, with a sort of apron of hide fastened around the edge of the cockpit and secured tightly about his waist so that no water can get in. He uses a double-bladed paddle, dipping first on one side and then the other.

With this primitive fragile craft the Eskimos go after their walrus. The danger is evident when one considers that one swipe of a walrus's tusks can smash the kayak and finish the hunter's career. Nevertheless the Eskimos have nerve and never falter; they paddle their kayaks behind a herd of walruses until they get close enough to hurl a harpoon into the broad back of one of them. The harpoon head carries a line of walrus hide, the other end of which is fastened to a bladder float. When the harpoon strikes the walrus, he usually turns and madly charges the float, which is so light that it bounces away as soon as it is struck. The Eskimo hunter is wise enough to keep out of reach of the wildly charging beast and waits for the wounded animal to tire. Eventually, when this occurs, the Eskimo comes close to the beast and finishes him with a thrust of his lance. Sometimes the hunt does not end so happily for the Eskimo; the walrus may manage to charge the canoe and destroy it, or the other members of the herd may come to the aid of the wounded one and force the hunter to flee for his life.

In 1870 white men began hunting for walruses in the far north, using rifles, and since then they have more than decimated the great herds of walruses which formerly inhabited the frozen northland. Many of those which were shot in the water sank and could not be recovered. For this reason they were more easily captured while on the ice. Often an entire herd, found asleep on the ice, would be caught unawares and annihilated. Walruses are so near-sighted, they do not see the hunters, and if the marksmanship of the shooter is good, so that the animals are instantly killed, the others pay little attention to the reports of the gun. The bellowing of wounded animals at once scares the whole herd into the water. Their scent is much keener than their sight; when the hunters are on the windward side, the walruses are disturbed by the scent of the men, even though they are some distance away.

From 1870 to 1880, the height of the walrus industry was reached; the Pacific fleet captured 100,000 walruses, producing 400,000 pounds of ivory and 2,000,000 gallons of oil. Now the walrus has become so scarce that he is protected by law in many parts of the north. Such protection cannot prevent the natives from killing whatever animals they require for food, but it does keep the sealers from hunting them in the forbidden regions.

After a walrus has been killed, the hide with the blubber is stripped off the carcass. The blubber is then removed from the hide, and the ivory tusks are cut off. The blubber is usually converted into oil in a try-pot. The strips of blubber are first minced, or cut into small pieces about a half-inch thick. These are placed in the pot, which is then heated over an open fire until the oil has been cooked out. The pot must be well stirred and slowly heated to prevent the blubber from sticking. About twenty gallons of oil are obtained from a walrus. The oil is used for many of the purposes for which seal oil is used.

Walrus ivory is much inferior to elephant ivory in that it becomes yellow with age and the tusk contains a large core of little value. The tusks of the female are smaller than those of the male, but are of finer texture and have fewer cracks.

CHAPTER XVIII

Sponges and the Sponge Industry

The sponge is not, as you suppose,
A funny kind of weed;
He lives below the deep blue sea,
An animal like you and me,
Though not so good a breed.

And when the sponges go to sleep,
The fearless diver dives;
He prongs them with a cruel prong,
And, what I think is rather wrong,
He also prongs their wives.

I know you'd rather not believe
Such dreadful things are done;
Alas, alas, it is the case;
And every time you wash your face,
You use a skeleton.

So that is why I seldom wash,
However black I am,
But use my flannel, if I must,
Though even that, to be quite just,
Was once a little lamb.[1]

Although the silly little poem at the head of this chapter is very short, and is intended to be merely a bit of humor, it tells much about the sponge and something of sponge fishing. For the sponge of com-

[1] A.P.H. in "Punch," 1921.

merce is merely the skeleton of a curious animal that lives in the sea. Sponges have been taken by divers in the Mediterranean Sea since prehistoric times. Sponges and their utilization in the arts were known to the ancient Greeks. Their use is mentioned several times by Homer.

Glaucus of Anthedon, one of the characters of Grecian mythology, was a sponge diver. Many marvelous tales are told of this fisherman, boat builder, sailor, and warrior. He is said to have constructed the *Argo* of the Argonauts, which carried Jason in search of the Golden Fleece. When Jason fought the Tyrians, Glaucus was the only one who was not wounded. Glaucus excelled in diving, and is said to have been able to remain on the bottom a very long time. Palæphatus relates a mythical tale of how Glaucus once dived into a tempestuous sea and swam to the bottom, where he spent several days with Oceanus, returning later with many fish that he had caught while on the bottom. Later, Glaucus dived to the bottom and never returned. His comrades thought that he preferred to live in the sea and attributed supernatural powers to him, placing him with the deity.

Aristotle tells much about sponges and the methods of sponge fishing employed in his time. He even describes briefly a diving apparatus by means of which air from the surface was furnished the diver on the sea bottom, apparently a tube with an arrangement for pumping down air. The soldiers in the Roman army were supplied with sponges, which they used for two purposes: they were placed inside the knee-shields to prevent the knees from becoming cut; moreover they were used instead of a cup for drinking while on marches. This explains why the Roman soldier gave a sponge soaked in vinegar to Christ during the crucifixion.

The Industry

As indicated above, sponge fishing was first practised in the Mediterranean, where it originated in the eastern part of the sea and was followed by the Greeks in the Ægean. The field of operations was gradually extended to the African coast and the central Mediterranean. A race of daring and hardy divers has been developed which has earned its livelihood in the sponge fishery for more than twenty centuries. Curiously these sponge fishers continue their work in the same districts where their ancestors fished in ancient times. Symi, the principal market of to-day, was a sponge market in the days of Glaucus. This is probably the only industry that has been carried on continuously in one location by one people throughout ancient, medieval, and modern times.

Until 1841 the entire world's sponge supply came from the Mediterranean. In that year a French sponge merchant who had been shipwrecked in the Bahamas in the vicinity of Nassau was attracted by the quality of the sponges found in these islands, and shipped a trial lot to Paris. From this small beginning the production of sponges in the Bahamas has steadily grown until now more than a million pounds are exported annually. Large quantities of grass, wool, velvet, reef, hardhead, yellow, and glove sponges are taken in the sponge fields around these islands.

In 1849 the fishery extended to Florida. The initial shipment was sold in New York, but it narrowly missed being thrown away as worthless. The development of this fishery was very slow indeed, probably because of the low price of the product. But with the introduction of divers in 1905, and the discovery of sponges of better quality, the industry has grown until now the annual value of the raw product is about a million dollars. The bulk of the product consists of sheepswool sponges. The Cuban sponge fishery became of importance in 1884 when important sponge beds were discovered between the main island and the Isle of Pines. Batabano is the center of the sponge fishery.

Few persons except those who have lived on the shores of a tropical sea would recognize a common bath sponge if they were to see it in its natural environment. In fact many would mistake it for a piece of raw beef liver, for it is a fleshy body, slimy to the touch, varying in color from grayish yellow through various shades of brown to black. All shapes and sizes are found, depending upon the species, age, and habitat.

A living sponge has a skin which is raised at intervals into blunt little cones, and perforated by pores that lead to canals running into the interior. The walls of the canals are punctured by innumerable minute holes, each of which leads into a tiny pear-shaped chamber and thence into another canal which leads to a vent or opening in the skin. Water carrying food and oxygen enters the pores and is drawn through the canals to the pear-shaped chamber and then expelled through the vents.

Relatively little is known concerning the life of the sponge. The young sponges which are hatched from eggs are minute free-swimming organisms. When still very small, they settle to the bottom and attach themselves to some solid object, where they live the rest of their lives. The shape, size, and outward appearance of a sponge depends to a large extent upon its environment. Sponges transplanted to different waters often change their general characteristics. Many sponges can tolerate exposure to the air for considerable periods and thus are able to grow at the low-water mark. They are found in water up to six hundred feet in depth.

The skeleton of the commercial sponge consists chiefly of spongin, a protein related to conchiolin, which is found in the shells of mollusks, and fibroin and sericin, the principal constituents of silk. Certain compounds of sponges contain a relatively large amount of iodine in organic combination.

Methods of Fishing

Probably the earliest method of taking sponges was that of hooking or cutting them from the bottom while wading in shallow water along the seashore. Even to-day in the southern part of Tunisia the natives follow a similar method, wading until they find a sponge, detaching it with their toes, and then kicking it within reach of their hands.

Nude diving has always been one of the most important methods of taking sponges in the Mediterranean. The natives of Calymnos and Symi are expert divers, and some are said to be able to descend to the great depth of a hundred feet. They ordinarily work under water about two minutes at a time, but a few of the more expert can remain on the bottom for four minutes. Nude diving is also practised by the Syrians, Tripolitans, and Tunisians.

To enable them to reach the bottom quickly, the divers carry flat stones attached to a line. As soon as the diver reaches the bottom, he drops the stone but either retains hold of the line or has it attached to his wrist by a short lanyard. The diver quickly detaches all the sponges within his reach. When he can remain under water no longer, he jerks on the rope and is rapidly drawn to the surface by his attendant in the boat. After resting for twenty or thirty minutes he makes another trip to the bottom.

Solon Pelecanos tells an extraordinary tale that rivals that of Jonah and the whale and is so remarkable that it may be of interest:

It happened that a diver named Latari, from the island of Calymnos, on a certain day, although he could not see clearly through the water, took the stone and plunged. The man who held the rope in the boat perceived that the rope was not drawn by the diver, and, on looking into the water, to his horror saw a huge shark which had swallowed the diver. Fortunately for the latter the large flat stone which he held in his hands proved perhaps too much for the shark, and he immediately vomited his victim, who was instantly drawn up to the boat by the rope holder alive. He had received severe wounds on both sides of his body from the teeth of the shark. He was removed at once to a hospital at a neighboring port for a month, and then was sent to his native island where his convalescence lasted three months. This may seem an incredible story, but it is a true one. The man still lives in the island of Calymnos and still follows his dangerous profession. One of the two doctors who attended him was Dr. A. Pelecanos, since dead, who was the father of the narrator of the incident.

Nude diving requires great skill and training from youth but is not as hazardous as diving in suits or scaphanders; but neither is it so productive, for the machine diver can work on the bottom a much greater portion of the day. The diving-suit or scaphander was introduced into the sponge fisheries of the Ægean Sea and the Levant about 1866 and has been a very important and productive adjunct of fishing ever since. Divers dressed in suits can explore much greater depths than most of those that work without suits, and so their use vastly extends the available sponging grounds. The use of diving-suits in the pearl fisheries has already been described; the suits used in sponge fishing and the methods employed are similar.

The hazards of machine diving are not caused by failures of the pump or life-line, or by the presence of sharks, but because of the deleterious physiological results of the changes of air pressure on the body. Sooner or later the divers get the bends, or caisson disease, which often leads to paralysis.

Harpooning, or hooking, is a method of taking sponges commonly practised in shallow water. The harpooner or hooker peers through a water telescope, merely a bucket-like instrument with a glass bottom, until he sees a marketable sponge, and then, using a long harpoon or hook, tears the sponge from its anchorage and raises it to the surface. The European fishermen use various types of harpoons for the purpose. The instrument of ancient times was a trident with a relatively short handle, and differs from those used to-day chiefly in the length of the handle. The instrument now used by the Tunisian fishermen has only two straight barbed points, whereas the one used by the Greeks has four. In Florida and the Bahamas the instruments used have curved prongs and thus resemble hooks rather than harpoons. Hooking is the only method of taking sponges permitted by law in the Bahamas.

In the Mediterranean large quantities of sponges are taken by the less picturesque method of dredging or trawling. The gangava of the Greeks, or gagova or cana of the Italians, is a special dredge which has been developed for this fishery. It is employed only on smooth bottoms, for the frame and net are likely to catch on rough rocks, but it can be used in all seasons except during storms.

Preparation of Sponges for Market

Early methods of preparing the sponges for market were rather crude. The live sponges were allowed to lie on the deck of the boats until killed by prolonged exposure to the air, after which they were placed in inclosures built in shallow water until the fleshy part of the sponges rotted. They were then removed from the water, beaten with a club, and squeezed repeatedly under water until all the fleshy matter was removed, leaving only the skeleton.

A somewhat more scientific procedure is now employed. The live sponges are placed on deck, and, after being killed by continuous treading under the bare feet of the crew, they are strung and then hung over the side of the boat for some time. Then they are thoroughly washed on deck in tubs of sea-water. The cleaned sponges are strung on cords six feet long. The ends of the cord are tied together, thus forming a wreath or bunch. When the bunches of sponges are partially dried, they are sold in lots at auction to the dealers. The wholesalers trim the sponges with sheep shears, removing the irregularities, torn parts, and foreign bodies, such as shells and pieces of coral. They are then graded as to size, color, and quality, and packed in bales for shipment.

Some sponges are bleached by treatment with a mineral acid, potassium permanganate, and oxalic acid. The bleached sponges are washed in a washing-soda solution to neutralize any acid that may remain, and finally are thoroughly washed in water to rinse out any chemical that may be left. Bleached sponges are somewhat more attractive in appearance but are less durable than those which have not been bleached.

There are many commercial varieties of sponges. Dealers in different localities may classify sponges differently, but the following varieties are generally recognized as the most important: sheepswool or wool, yellow, velvet, grass, glove, wire, reef, hard-head, Turkey cup, Turkey solid, Turkey toilet, zimocca, honeycomb or bath, and elephant-ear. Of these the Turkey solid and Turkey cup, which are produced in the eastern Mediterranean, are the finest and softest, and two of the most elastic sponges known to commerce. The massive ones are known as solids, and the cup-shaped ones as cups. Honeycomb or bath sponges are also important Mediterranean sponges. They are very soft but are not especially durable.

The sheepswool is the most important American sponge, constituting about ninety per cent of the value of the American product. When unbleached it is used for washing automobiles, railroad cars, and other vehicles; by painters, decorators, potters, tanners, tile and brick layers; and for other purposes. Bleached wool sponges are utilized principally for the bath and other household purposes.

Sponges up to eight inches in diameter are commonly used entire and are called forms, whereas larger ones or those that are irregular or torn are usually divided into pieces called cuts. The more valuable sponges are regular in form and of fair size. Some are spheroidal, some are cake-shaped, and others are conical or cupped.

Light colored sponges are more valuable than dark ones, although intrinsically there may be no difference. Naturally light sponges are more valuable than bleached ones. For most purposes soft sponges are desired, and therefore soft ones command the highest price, other considerations being equal. Fine-textured sponges are more valuable than coarse ones.

American sponges are not only classified as to the place where they were taken but also into forms, cuts, and seconds. Mediterranean sponges are usually subdivided into "fines," "commons," "seconds" or "rejects," "plongees," "harponees," etc. Sponges taken by harpooning and hooking often are torn, and for this reason they may not be so valuable; therefore the method used in fishing is often mentioned in the classification.

INDEX

G

H

I

K

L